MUGONGO WAAZI BRINING AND SOLAR DRYING IN UGANDA

A Thesis

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In Partial Fulfillment of the Requirements for the Degree of

Master of Engineering

by

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ABSTRACT

The traditional method of salting and drying fish carcasses, known as Mugongo Waazi (MW), in Jinja, Uganda has proven to hurt the local environment, be financially inefficient and result in an unhygienic product. MW dry on open tarps which allows soil particles and other atmospheric pollutants to settle on them as well as disease carrying flies. The salt solution drains directly into a wetland before the Nile River and is visibly destroying it. Wasting the huge amount of salt used in MW processing is costly. The land where the MW is processed is not used to its total capacity which limits production, and the odor from the MW causes issues with the neighbors and an unpleasant working environment. This paper explores an alternate process of brining and solar drying the MW which is proposed as a way of alleviating many of these issues.

After researching past experiments, two solar dryer designs-rectangular and triangular, were built with inexpensive and local materials. With a few revisions, the dryers were used in 5 experiments to dry cut and cleaned fish carcasses after the carcasses were soaked in brine over night. The inside temperatures of both dryers as well as the ambient temperature were recorded with weather, insect, and overall observations.

After slightly adjusting the brining and drying process, the MW were successfully dried even in non-optimal weather, amount of salt used was decreased, and a more appealing product (by sight and touch) was produced. The triangular solar dryer proved to be the optimal design. Unfortunately, the number of flies inside the dryer and the short preservation period was still an issue. Future experiments should work with pickle curing and a further revised version of the triangular dryer.

The improved salting and solar drying technology can develop the MW market substantially as well as improve on environmental and worker concerns if logistical issues between the Jinja MW processing groups, fish factories and the municipality of Jinja can be resolved.

BIOGRAPHICAL SKETCH

Allison Muehe, born November 12, 1982, grew up in Canandaigua, NY with her parents, Kim and Martin, and older brother, Matt. She graduated from Carnegie Mellon University in Pittsburgh, PA in May 2004 with a bachelors of science in chemical engineering and a minor in manufacturing management and consulting. During her time at Carnegie Mellon, she played two years of varsity soccer and co-founded the women's lacrosse club. Embracing her interest in conservation and green living, Ms. Muehe decided to enroll in Cornell University's Master of Engineering (MEng) program in environmental engineering. She completed the course work in May 2005 for the MEng program while playing on the Cornell women's club lacrosse team and refereeing intramural soccer. After working for 9 months, Ms. Muehe left for Uganda to begin her Peace Corps service as a primary teacher trainer. In addition to her Peace Corps obligations, she completed her MEng project by working with the Municipality of Jinja to investigate the process of salting and drying of mugongo waazi. Returning from Uganda in June 2008, Ms. Muehe arrived in Ithaca to finish project work to graduate with her MEng degree in December 2008.

Dedicated to munange wange, Tenwya Rogers,

kubanga sasobola kumala kukola ne mugongo

waazi singa nakola ssooka, webaale nnyo.

ACKNOWLEDGMENTS

There are many people who made the completion of this study possible that I would like to recognize. My parents Kim and Martin Muehe were the biggest supporters of my MEng project and Peace Corps service and helped me endure my time in Uganda. All of my friends and family morally supported me throughout my service and continuously kept my spirits high. Also, I cannot give enough thanks to my academic advisor Prof. Mike Walter for being so understanding and helpful, he truly cares about his students and wants to make sure they succeed and make a difference in the world. My friend and colleague Alley Pelletier and other coworkers at Riley Robb have been wonderful and accommodating while I wrote this report. In Uganda I had enormous help from many people, some who surprised me with their generosity and commitment to this project. Without the hard work and emotional support of Tenywa Rogers this whole study would have ended in failure. The Principal Environmental Officer, Nabihamba Ernest, Mayor, and Town Clerk of Jinja gave financial and moral support to this study and it gives me confidence that they truly want their district to improve. Madina, Masitula, and the other mugongo waazi workers assisted me so much during the experiments with preparation and evaluation. My CCT, Kayegi Beatrice, encouraged all my efforts away from the school and I thank her immensely for being so patient. All of the administrators and workers at Peace Corps fully supported my academic pursuits from the start of my service and helped me with many cultural issues that enabled me to stay content and productive during my service.

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CHAPTER 1

INTRODUCTION

Mugongo Waazi (MW) in Uganda are fresh fish carcasses (the heads, bones, tail left after filleting) that are salted, dried, and sold to neighboring countries as a low cost protein source for human consumption. In Jinja there are two fish factories that sell the fish carcasses to MW processing groups. These groups work separately on the banks of the Nile River and Lake Victoria. For a few reasons, the current process of salting and drying is environmentally damaging, economically inefficient, and not accepted well by the local community.

Social Concerns

The MW workers do not have land or facilities of their own so they use deserted land that is close to a water source. One group in Jinja uses an area, known as Loco Village, that used to be a railroad station and is located near a tanning factory. The land is deserted because the railroad company does not run there, use, or monitor that land and because of the smell coming from the neighboring tannery. Another group has temporary approval to use an area, known as Masese, that is owned by the government. With the smell of the fish, the birds with diseases that are attracted to the fish, the waste products of the fish and the overall unsanitary conditions of the work the MW workers are not welcome anywhere and do not have enough money to buy a piece of land. Using the brining and solar drying process the workers will have a more sanitary, less odorous and more protective way to produce the MW and therefore be more accepted by society.

Economical Inefficiencies

With the current process of producing MW the workers use a lot of salt and are limited in the amount of MW produced by the amount of land available. For 1 tonne of fish carcasses from the factory they use around 150 kilos salt. The proposed brining method they would use around 80 kilos. With almost half savings on salt more fish can be purchased. Without solar dryers, the fish are laid in a single layer on a tarp placed on the ground to dry and take up a large amount of land, as seen in Figure 1-1.

Figure 1-1: Mugongo Waazi laid out to dry at Loco Village January 31, 2007

Solar dryers will enable the workers to utilize the space wisely with vertical shelving and dry more fish at one time.

Environmental and Sanitation Issues

A frequent complaint to the Municipality of Jinja Environmental Officer is the smell of the fish by neighbors of the MW processing site. The stench of fresh or rotting fish also brings vectors like flies and various birds, both of which carry diseases. Since the fish are laid out to dry openly these vectors along with soil and other air pollutant from the nearby road are able to contaminate the fish. The tarps themselves that the fish lay on area are filthy from being constantly dragged around the soiled ground.

Workers need water to clean the fish before salting and drying so the area chosen to work is near a water source. Both groups in Jinja work on the shore of the Nile River

and each have a wetland area between the work zone and the river; however, it is apparent that in both areas the land is being degraded by the salt runoff and the water used to clean the fish is unhygienic.

Figure 1-2: View of salted fish under a tarp with runoff flowing into the Nile River at Masese.

Figure 1-3: View of area where the salt water runoff flows on way to Nile River in Masese.

As seen in Figures 1-2 and 1-3, the wetland that the MW workers use is being destroyed because of salt overload. Using the brining method, the salt water runoff will decrease dramatically and the brine has potential for reuse.

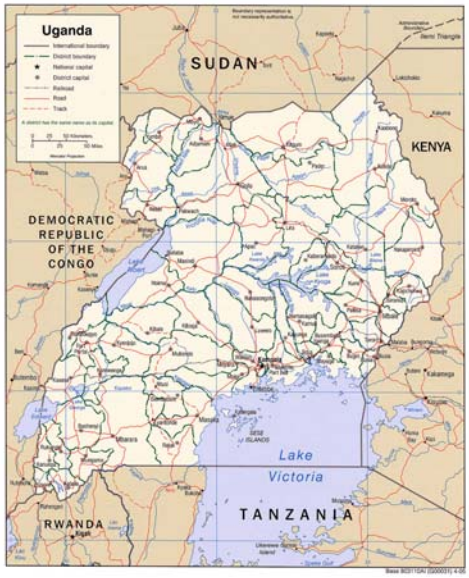
CHAPTER 2

BACKGROUND

Profile of Uganda and the City of Jinja

Located in eastern Africa, Uganda is a land locked country on the North West shore of Lake Victoria and the home to the source of the Nile River. Kenya, Sudan, Democratic Republic of the Congo, Rwanda, and Tanzania border Uganda, as seen in the political map of Uganda, Figure 2-1(R2). Although landlocked, Uganda has a vast

Figure 2-1: Political map of Uganda.



amount of lakes and rivers including Lake Albert, Lake Bunyonyi, shown in Figure 2-2, and the Victoria Nile River. Some of the main exports are matooke (plaintains),

Figure 2-2: Fisherman on Lake Bunyonyi, a freshwater lake in the south western part of Uganda.

coffee, fish and fish products, and tea (R2). With heavy rainfall and, fertile soils and a tropical climate, Uganda is mainly an agricultural based country with a large ecotourism potential due to the national parks, (Figure 2-3) and available water

Figure 2-3: Allison Muehe seeing elephants at Queen Elizabeth park in western Uganda.

activities. In 2007 the population of Uganda was 30.9 million in a country of 93 thousand square miles (R2), roughly the size of the state of Oregon. There are around 42 local languages in the country with Luganda as the most common bantu language spoken and English as the official language. The English influence began in 1875 but Uganda didn't become a British protectorate until 1894 (R2). In 1962 Milton Obote helped Uganda achieve independence then became a violent leader himself who was only overthrown in 1971 by Idi Amin, one of the most infamous dictators in Africa's history. Obote regained power in 1980. The current President, Yoweri Museveni, came into power in 1985 after overthrowing Obote with the National Resistance Army party (R2). Since 1985 Uganda has kept peace in the country as much as possible, even with wars and other violence occurring in bordering nations, like the LRA located in southern Sudan.

The capital city, Kampala houses 1.4 million people while the 2nd largest urban center, Jinja, located 80 kilometers east of Kampala, has almost 83 thousand city residents (R3). Jinja is the home to the Owen Falls Dam at the Source of the Nile that produces

hydropower for Uganda and its neighbors. Jinja became a municipality in 1957 and has a population growth rate of 2.8% a year with 90% of the population using tapped city water (R4).

Lake Victoria and the Nile River

Fish population

Fishing has historically been a popular profession in Uganda because of the many bodies of water within the country and because fish is an excellent protein source. The past few decades Uganda's economy has benefitted by the large export business provided by fish and fish products. In order to boost profits, in the 1980s the number of Nile perch stocked in the lake was increased. This method worked to raise fish exports but the unbalancing of the lake's ecology coincides to a huge decrease or extinction of indigenous fish species, including a species of tilapia. Experts agree that the disproportional amount of Nile Perch in the lake has disturbed the aquatic system and other fish species are not able to prosper as they once did (R5). In the past few years the Nile perch has grown in popularity and is now being overfished, as noted in a survey with a general manager of a Jinja fish factory in Appendix A. A ecological study of the trophic state of Nile River and Lake Victoria needs to be conducted to ensure the continuity of the fishing industry and economy of Uganda.

Major changes in past 10 years

Owen Falls Dam

The original Nalubaale hydropower station at Owen falls dam was built in 1954, refurbished in 1980 and extended with the construction of Kiira hydropower station in 2000. Reports have surfaced that the power stations have been running over the agreed capacity and subsequently lowered the level of Lake Victoria so far that the recent 2 year draught has led to power shortages and hydrology issues that affect countries along the Nile River (R6).

Weather patterns

Uganda has a bimodal climate with two wet and two dry seasons, with the wet seasons historically occurring from March until June and October/November until January/February (R7). In the past two decades noticeable changes in weather patterns has caused distress for Uganda. Farmers and fisherman alike who have been relying rains to come during the same months for generations are suffering because of the erratic rains and temperatures. Farmers have a hard time estimating the best time to plant crops and fisherman are seeing a decline in daily fish catches. Warmer temperatures and erratic weather can have many affects on the fish reproduction schedule, percent of hatchings, and vegetative diet.

Marine and Agro Fish Factory

One of the largest fish factory companies in Uganda is 'Marine and Agro'. A survey completed with the general manager of the factory can be found in Appendix A. Jinja contains 2 of their 6 factories around Uganda, with others located in Entebbe, Masindi, Mayayi, and Kasenyino that all began in 1994. Since opening, the factory has noticed a high catch rate during the months of May to December and a lower number of daily fish caught between January and May. The general manager, Mr. Nitim, commented on the lower numbers than normal in the past couple of years and blames the lower catch rate on overfishing and keeping immature fish. Since starting the factory in 1994 the market for Mugongo Waazi (MW), or fish carcasses, has been strong in Jinja. Selling prices depending on the availability of the fish-more fish means a lower sell price. Daily customers earn the right to purchase the fish first, even during the decreased fishing seasons, because they gave the factory a monetary deposit to ensure their commitment to buy MW every day.

CHAPTER 3

CURRENT PROCESS

From Fresh Fish to Mugongo Waazi

To fully understand the way MW is prepared before working, I visited each site and conducted a survey with the managers of each site. The MW preparation process at both Loco Village and Masese are the same, as seen in the surveys in Appendix B. The process begins at one of the fish factories on the banks of Lake Victoria in either Jinja or Kampala. The fish caught that day have the fillets cut off immediately in the factories and the carcasses are collected near a back entrance in the factory grounds. If the workers buy the MW from a Jinja factory they buy the carcasses by the kilo and transport them by stuffing them in plastic rice bags and using a hired pick-up truck, as seen in Figure 3-1. If the workers buy the MW from a Kampala or Entebbe fish

Figure 3-1: Workers at Marine and Agro fish factory in Jinja load the weighed fish carcasses systematically onto the bed of a pick-up truck.

factory the truck bed will be filled with ice provided by the fish factory and covered with a tarp for protection during the 2-4 hour drive to the work site. Once the fish

reaches the work site, it is unloaded onto tarps and men use a panga (machete) to separate the fish's head from the body and split the head in half length wise. Figures 3-2 and 3-3 illustrate the workers cutting and cleaning the fish carcasses on soiled wooden platforms and tarps.

Figure 3-2: Worker at Loco Village cutting a fish head with a panga (machete).

Figure 3-3: Workers at Masese cutting and cleaning fish on filthy wooden platforms.

On the same wooden platform, workers use plastic basins full of salt to take handfuls of salt to rub over and coat the entire piece of MW. The salted MW is piled under a tarp overnight and the next morning placed out to dry on tarps laid out on the ground (Figure 3-4). If the sun intensity is high the MW will be flipped halfway through the

Figure 3-4: Mugongo waazi heads sun drying on a tarp placed on the ground at Loco Village.

day to reduce drying time by exposing both sides of the fish to sun radiation. If the sun intensity is low (cloudy or raining) the fish will be flipped the next day. At the end of each day the fish are piled on the wooden platforms and covered by a soiled tarp so the next morning they can be redistributed on the tarps to finish drying. Once the MW are dry, or when transportation to the market arrives, they are methodically stacked into square bushels inside of re-sewn rice sacks (Figure 3-5). From the work

Figure 3-5: Loco Village workers preparing the dried mugongo waazi for shipment to the market.

sites the MW are transported via lorry or large truck to a fish market in the Congo twice a week to once every other week depending on the season.

Problems Facing Workers

In addition to the MW processing survey, I conducted a questionnaire about the challenges the workers face on a daily basis while preparing the MW, seen in Appendix C. The most common complaint is about the fish rotting, smelling, and breaking. During the rainy season fish obviously cannot dry as well as during the dry season and the MW rots. Rotten or even fresh MW has a strong fish odor that is unpleasant for the workers and seeps into their clothing, hair, and skin. Once the fish start to dry, especially the body section, they become brittle and can break easily. The other complaints include: working in the sun, fish bones cutting their hands, and the effects of salt on their skin. When asked about finding solutions previously, they have tried covering the MW when it rains with tarps but this is difficult because of the vast quantity of fish to collect and cover in such a short time. For the salt effects and bone pierces, the workers have attempted to use gloves but claim they inhibit productivity and quality of cutting.

CHAPTER 4

METHOD OF EVALUATION - SOLAR DRYERS AND BRINING

Literature Review

After listening to the workers' current challenges, I decided to investigate more efficient and realistic modes of drying. Most wind or heating systems that I researched required expensive and hard to fix machinery that need electricity. Located on the equator, Uganda has a lot of solar potential and past experiments in other countries have had a lot of success with fresh and salted fish drying using solar dryers. An experiment conducted by Doe et. al in 1972 tested the solar dryer illustrated in

Figure 4-1: Diagram of a single shelf triangular dryer studied in Bangladesh (R8)

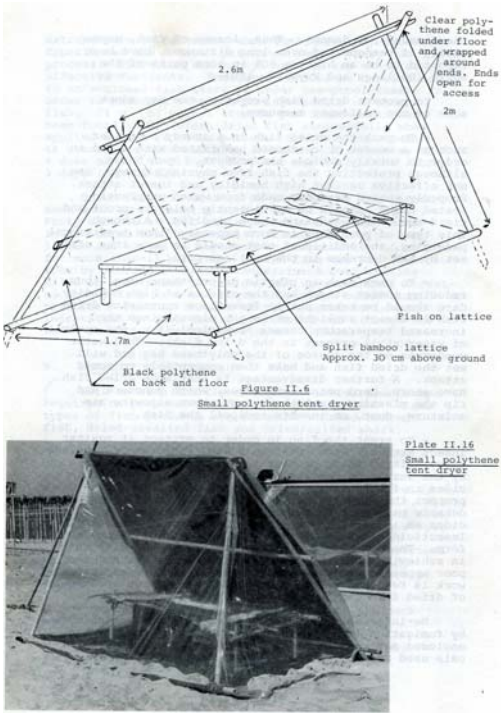


Figure 4-1 in Bangladesh. This particular experiment focused on achieving high temperatures and keeping insects away from the fish, indicating a lack of ventilation and convective heat transfer via air flow. The inside temperature reached 48°C

(118°F) while the outside temperature stayed around 27°C (81°F) and was used to disinfect fish infested with fly larvae (R8). A study done in Sao Tome, Angolares in 2001 also used tent-shaped dryers but both sides were clear plastic, had two levels of mosquito net racks, and had holes in the plastic on the top and bottom to promote ventilation. These dryers decreases drying time and protected the fish from insects and air borne contaminates (R9). Again, a study in Nigeria tried solar drying with the tent design but made out of wood instead of bamboo and instead of black polyethylene at the base of the dryer they used dyed black rocks. The higher quality fish was able to sold at a higher price than the traditionally prepared fish (R9).

Figure 4-2: Diagram of a solar dome dryer studied on Caltex Island, Yemen (R10)

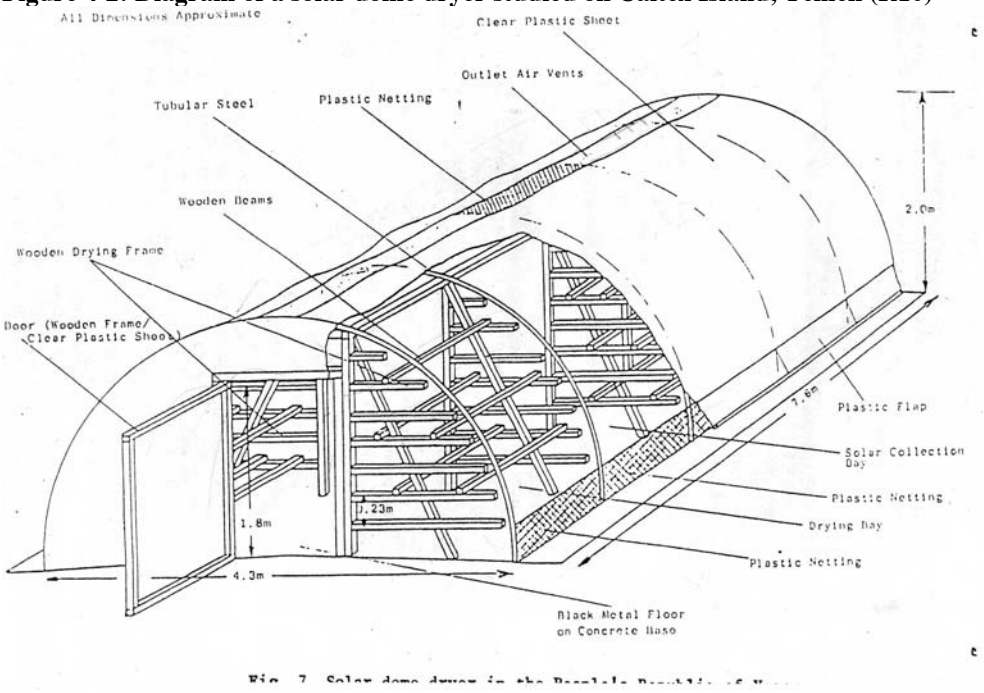


Figure 4-2 illustrates another solar drying technique of a solar dome that was studied on Caltex Island, People's Democratic Republic of Yemen. This dome had clear polyethylene for the half cylinder covering with a black polyethylene base. It was able to dry a tonne of fish in a shorter time with less insect infestation and produced a fish with less moisture content than traditional sun drying (R10). An analysis of the last decade of solar drying experiments done in Southeast Asia includes a summary of the

challenges people have found while solar drying and what features to include in the dryer design, shown in Table 4-1 (R11).

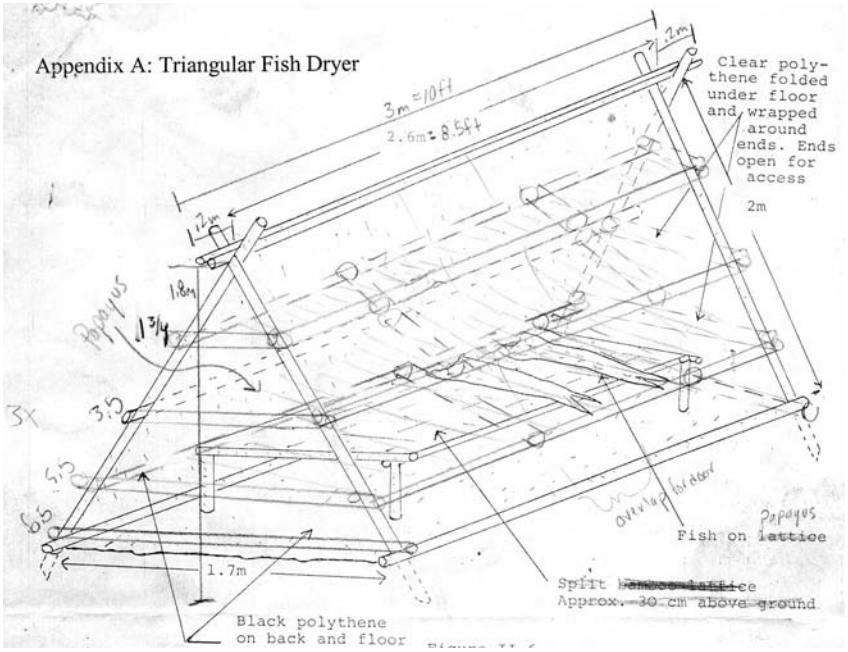
Table 4-1: Summary of solar drying challenges and desirable dryer features.

Reasons for sub-par dried salted fish	Dryer features that must be included
- High salt content - Inefficient drying - Insect infestation - Microbial Spoilage - Formation of toxic compounds - Nutritional losses	- Low capital cost - Local construction materials - No fuel cost or moving parts - Low running and maintenance cost - Built and fixable by local workers - Low additional costs vs sun drying

Design of Two Solar Dryers

Since the majority of successful studies in the past used a tent or triangular shaped solar dryer, I wanted to make one design similar to one in the past with some adjustments. The diagram I based my triangular dryer on was from the Bangladesh study. From the solar dome design, I wanted to incorporate air vents at the top and the bottom of the dryers. The Sao Tome experiments influenced me to include multiple racks or shelves in the dryer. The Nigerian study gave me the idea to use timber instead of poles. The modified tent dryer is displayed Figure 4-3. Knowing the

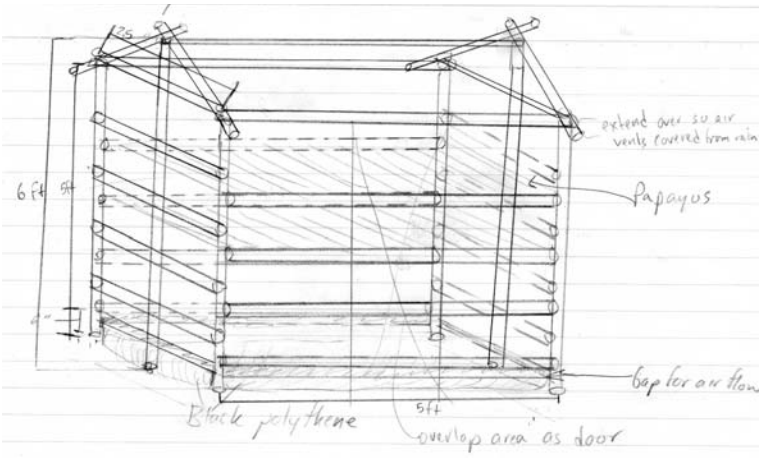
Figure 4-3: Diagram of the triangular fish dryer based upon a previous model.



dimensions of available polyethylene sheets are the exact size to cover the sides, to make sure rain does not enter the top, a section of sheeting wrapped over the uppermost timber like a top. The two sheets overlapped without touching so that the hot, humid air could have exited the dryer. To be able to open the dryer, the front side clear polyethylene sheet extended over the sides so nails could hook into holes secured with duct tape. The three shelves made of papyrus mats had a piece of timber perpendicular to the papyrus to help support any weight.

Although the solar dome shape seemed like a great idea the dimensions seemed too large and without knowing literally how much a tonne of fish was, I decided that dryer was too big but wanted to use some of its characteristics. Since the tent dryer was designed for a degree of sunlight angle, I wanted an upright dryer that could absorb direct sunlight with little or no angle, as Uganda is on the equator. Illustrated in Figure 4-4, I designed a rectangular dryer that has the light absorbing black plastic on

Figure 4-4: Diagram of the rectangular solar dryer.



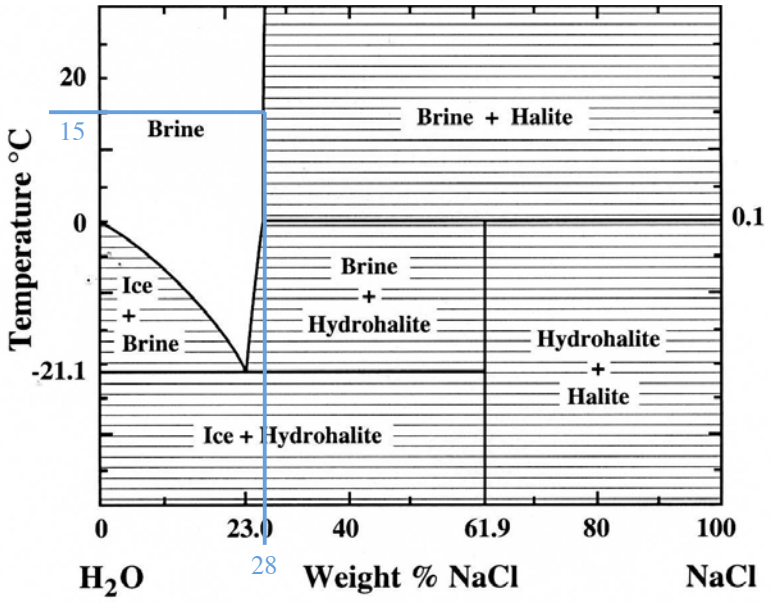
the short sides but the long sides all the way over the top would be clear polyethylene. Like a house overhang, the sheet that acts as a roof extended over the side and the same non-touching overlapping occurred so hot and humid could leave the dryer. The bottom was black plastic and the shelves were also papyrus mats supported in the middle by timber. The first version of both dryers are shown in Figure 4-5.

Figure 4-5: Finished dryers based upon previous models.

Determining Brining Solution

To maximize the effect of the salt and prolong the shelf life of the MW a saturated salt solution needed to be determined. Table 4-6 (R12) shows a solubility curve for salt

Figure 4-6: Saturation diagram for NaCl in H_20 including hydrohalite behavior.



(sodium chloride) in water at various temperatures. The water used for brining at the different points varied in temperature on a daily basis at each testing site. At Masese and Loco Village the temperature of the swamp or wetland water was based upon weather and at Amber Court the tap water from the city of Jinja also gave a different temperature relative to the other sites. With the variable water temperature expected, an estimate of 15 degrees Celsius was used. On Table 4-1 the blue line indicates the solubility of 28 % weight salt, therefore for every 72 grams water 28 grams salt can dissolve under the right conditions. Using this solubility and a salt density of 1.200 kilograms salt per liter salt (R13), the following equation was used to determine the amount of salt to add to a 20 L gerican for a saturated brine solution, with L_s as liters

Equation 4-1 $$L_s = L_w \times \rho_w \times s_s \times \rho_s$$

salt, L_w as liters water, ϱ_w as density of water, s_s as solubility of salt, and ϱ_s as the density of salt. That gives us an equation that looks like the following equation and

Equation 4-2 $$L_s = 20 \times 1.0 \times 28/72 \times 1.0/1.2 = 6.4\ L_s$$

gives an answer of 6.4 L salt per 20 L gerican. Unfortunately, when calculating this number in Uganda I did not have a calculator with me and missed the number by a factor of ten and used 0.64 L salt for the first two experiments.

Realizing that the salt dissolved easily in the first two experiments and was not enough salt to keep the fish fresh for the third experiment I decided to manually test to find the saturation point for the water solution (tap water) available for experiments 3,4 and 5. Using a 1.5 L bottle, I filled it with 1 L of tap water and added a tablespoon of salt until the salt would not dissolve after repeat shaking of the bottle. This method produced 13 tablespoons per liter or 16.3 T per 20 L gerican. I reached the apparent saturation point with 3.8 L salt instead of 6.4 L salt. There are many factors that can attribute to the different solubility like temperature, pressure, size of solute, mixing rate, or presence of other species dissolved in the solvent (R14). In this case I believe

the larger salt crystals, the presence of other salts in the water and the lack of mixing time led to a lower solubility than tabulated values.

Since leaving Uganda I have looked at other sources for the solubility of sodium chloride in H_20 and more accurate numbers have surfaced. For 15 degrees Celsius the correct solubility for salt in water is 36 % weight (R13), and with all the other numbers correct, Equation 4-4 shows a revised Equation 4-2 which gives us 9.4 Liters salt per

Equation 4-4 $$L_s = 20 \times 1.0 \times 36/64 \times 1.0/1.2 = 9.4\ L_s$$

20 liter gerican of water-a significant difference from 6.4 L salt. Even with the increase of salt, a 100 kilos MW needs around 1.25 gericans brine in a barrel of packed MW which would mean around 11.7 liters salt, with the density of salt 1:1.2, each 100 kilo MW requires almost 14 kilos salt. Therefore, for a tonne of MW the workers will still save salt, 140 kilos verses the current 180 kilos.

Method of Brine Preparation

Making a brine solution is a simple activity of adding salt to water and mixing until all the salt dissolves. In Uganda where equipment is expensive and sparse, the best procedure to make brine uses as many local and replaceable tools as possible. The most logical process to making brine is to use the readily available 20 L gerican and use a funnel method to pour salt that is measured volumetrically with a horizontally cut plastic water bottle. If the volume of salt is known by the workers, they can estimate to the nearest 100 ml inside a water bottle and cut the bottle horizontally so that salt can be leveled in the bottle at the measured volume. As seen in Figure 4-7, the brine solution can be mixed on site and once the gerican is significantly shaken with as much of the salt dissolving as visually possible, the mixture is ready to be poured into the brining barrels, as seen in Figure 4-8. Once the brine is poured the fish will soak for up to 12 hours before being placed in the solar dryers.

Figure 4-7: Allison Muehe showing workers at Loco Village how to make the brine solution.

Figure 4-8: Allison Muehe pouring fresh brine solution into a barrel filled with mugongo waazi.

Preparation of Experiments

After the researching the various methods of drying, choosing 2 dryer designs, and calculating the brine solution, the physical building of the dryers needed to begin.

Working with the Jinja Municipal Principal Environmental Officer, Nabihamba Ernest, we budgeted and wrote a proposal for the Jinja Town Clerk to help fund the building of the dryers and conducting the experiments, see Appendix D. The generous Town Clerk approved partial funding of the project and with a small group of helpers led by Tenywa Rogers we began building the dryers. As seen in Figures 4-9 to 4-16,

Figure 4-9: Getting timber ready at Amber Court; Figure 4-10: Starting to build at Amber Court.

Figure 4-11: A. Muehe and Tenywa Rogers building a dryer; Figure 4-12: Dryer frames finished.

Figure 4-13 and 4-14: Tenywa Rogers and Allison Muehe attaching plastic sheets to dryer frames.

Figure 4-15: Tenywa Rogers and Allison Muehe successfully finished constructing both dryers.

Figure 4-16: Transporting the dryers from Amber Court to Loco Village for Experiment 1.

the construction of the dryers involved a lot of planning, measuring, sawing, nailing and even some ingenuity like using papyrus to act as washers when nailing the plastic sheeting to the timber frame.

After the dryers were transported to the experiment site, the barrels sold to us by the tannery, with salt, basins and gloves bought, we were ready to purchase fish carcasses to begin brining and drying. The fish carcasses were bought at Marine and Agro and transported to the site in rice bags via bicycle, motorcycle or in the bed of a pick-up truck.

CHAPTER 5

EXPERIMENTS

Loco Village

Process

Experiment 1 was conducted from November 6 - 9, 2007 at Loco Village with the leader of the group a woman named Masitula. The experiment started with preparation of the dryers and estimating the amount of fish able to fit in the dryers using dried MW on November 6, as seen in Figure 5-1. The

Figure 5-1: A. Muehe and a worker use dried MW to find the amount of MW to fit in the dryers.

next day we found the dryers with slashes in the plastic and after they were fixed the fish carcasses were delivered at 4:30pm in rice sacks, shown in Figure 5-2. Workers chopped and cleaned the fish until 6pm when we made the brine solution and combined the carcasses with the brine solutions in 100 L barrels to soak overnight. At 7am on November 8 I arrived at Loco Village to transfer the MW from the barrels to

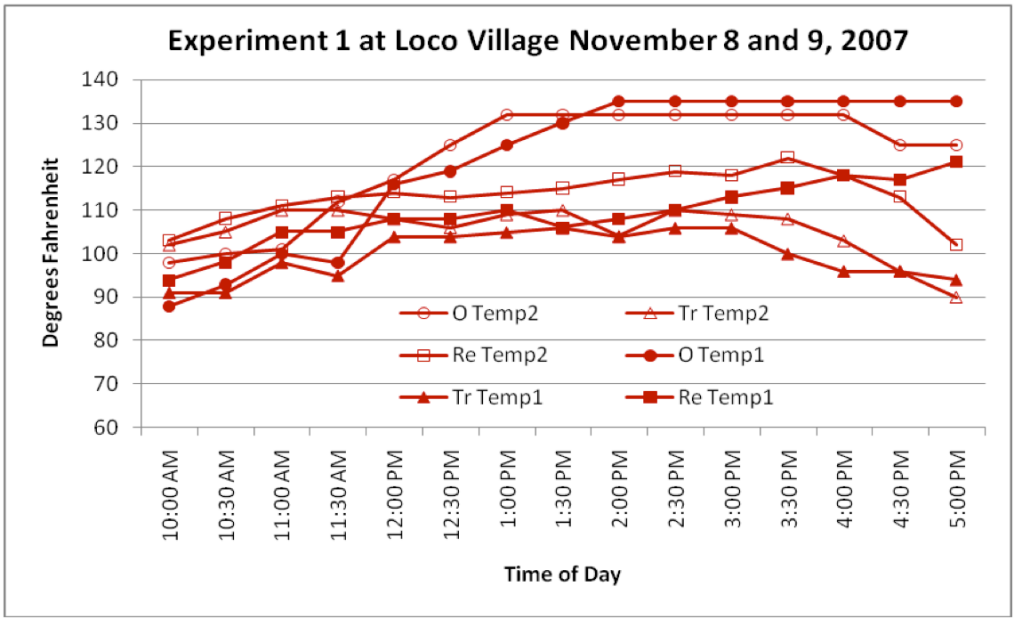
Figure 5-2: Fish carcasses delivered in plastic rice bags to Loco Village strapped to a bicycle.

the dryers. Over the next two days I took readings of three thermometers, noted weather conditions, and insect number each half hour. The fish stayed in the dryers overnight and by 5pm on November 9 all of the MW were dried and given to Masitula to pack and sell at the market.

Data and Analysis

The temperature readings and other condition descriptions for the duration of the drying process from November 8-9 can be found in Appendix E and other comments during the experiments in Appendix F. Chart 5-1 displays the temperature data for

Chart 5-1: Temperature readings for both dryers and outside during the first experiment.



both the rectangular and triangular dryer as well as the outside temperature. The solid points are the data for November 8 and the unfilled points are the data for November 9. From this graph we can see that around midday the outside temperature jumps above both dryer temperatures which can be attributed to direct verses indirect sunlight because this is when I noted the outside thermometer losing shade, seen in

Figure 5-3: Triangular dryer with thermometer in sunlight; Figure 5-4: View of inside Tri dryer.

Figure 5-3. Since the temperatures of both dryers are above the outside temperature to begin with it proves how it can keep heat inside the chamber and be helpful in drying fish overnight. Also to note is that the rectangular dryer is consistently higher in temperature than the triangular dryer, seen in Figure 5-4. According to the wetness test (pushing toilet paper to the surface of the fish to indicate moisture), in both dryer the MW on the top shelves can dry within a day but the middle shelves need a little more than a day and the bottom shelves need 2 full days to dry. The number of fly observations concludes that the wetter the fish is the more a fly is drawn to it as the

first day attracted more flies than the second, logical because flies want to lay eggs in warm and wet conditions.

Challenges and Improvements

Water: The water used to clean the fish and the water to brine the fish comes from the wetland close to the processing site and it is filled with many unknown and visible biological contaminates. Such impure water affects the amount of salt that can be dissolved and effectiveness of the brine solution of the fish to absorb salt. The water is also very polluted because the fish wastes like guts, brains, scales, etc. are dumped in or next to the wetland within 15-10 feet of where the workers collect the water.

Uniformity: Drying time as a whole is difficult to measure because each batch of MW consists of different sized fish with different shapes and thicknesses. The fish bodies dry quicker than the large heads because of the thickness and the amount of meat on the piece. Placement within both dryers is also a factor because the MW on the top shelves and near the edges of each shelf receives the most direct sun and dry quicker.

Protection: The dryers themselves need to be protected from both the intense sun rays and from vandalism by people or animals. As seen in Figure 5-5 the black plastic

Figure 5-5: The top of the triangular dryer after a month in partial shade.

increased brittleness and needed to be changed to clear which can avoid the molecular changes because it absorbs less heat. The damage to the dryers after one night left at

Loco Village was significant enough to change the plastic but not bad enough to leave the area. The site has no gate and is public land and even though the workers claim to protect it from grazing cows, goats, and pigs and neighboring children, less than a week later the same thing happened again. After the second vandalism I asked the environmental officer to help me move the dryers from Loco Village to Jinja City Hall. It took the city a more than a month to transfer the dryers and I was able to work on the dryers again in mid January and found the dryers in terrible condition, as seen in Figures 5-6 and 5-7. Because of the severity of the vandalism I was forced to

Figures 5-6 and 5-7: The triangular and rectangular dryers after staying at Loco Village.

reconsider the workers themselves. Each time the plastic sheets are destroyed they need to be repurchased, reconstructed and it wastes a lot of time, money and delays scheduled experiments.

Improvements: To maximize the direct sunlight, for all sides of both dryers we replaced the black plastic with clear. In order to increase the amount of direct sunlight with proper angles, the lowest and second highest shelves were removed to give more sunlight to the second lowest shelf.

Masese

Process

After an unfavorable experience at Loco Village, I met with the leader of the other Jinja MW group, a woman named Nakayiza Madina, in January to make sure she understood the experiment and that the dyers needed protection. Since Madina showed up on time in January for our initial meeting and when we dropped off the dryers, so we agreed for experiment 2 to be held during February 10-12, 2008 at Masese. We bought fish carcasses from Marine and Agro fish factory and transported the fish to Masese by hiring a pick-up truck on February 10. Finding the dryers in disarray with workers' belongings in and on the dryers and the plastic slashed, I wanted to move the dryers once again and conduct the experiments at Jinja City Hall as seen in Figure 5-8. After deliberating, I decided to conduct one experiment at

Figure 5-8: Slashed plastic sheets and broken papyrus found at Masese upon arrival for exp. 2.

Masese and move the dryers soon after. We made the brining solution and the workers prepared the fish to soak overnight in the same barrels shown in Figure 5-9.

Figure 5-9: Chopped and cleaned MW packed in brining barrels for overnight soaking.

On November 11 I arrived at 7am to arrange the dryers and load the brined MW into the two dryers and extras to dry on a tarp, as seen in Figures 5-10 and 5-11. Up close

Figure 5-10: Solar Dryers and soaking barrels at dawn in Masese. Figure 5-11: MW on a tarp.


the MW head look like Figures 5-12 and the MW body look like Figure 5-13. As in

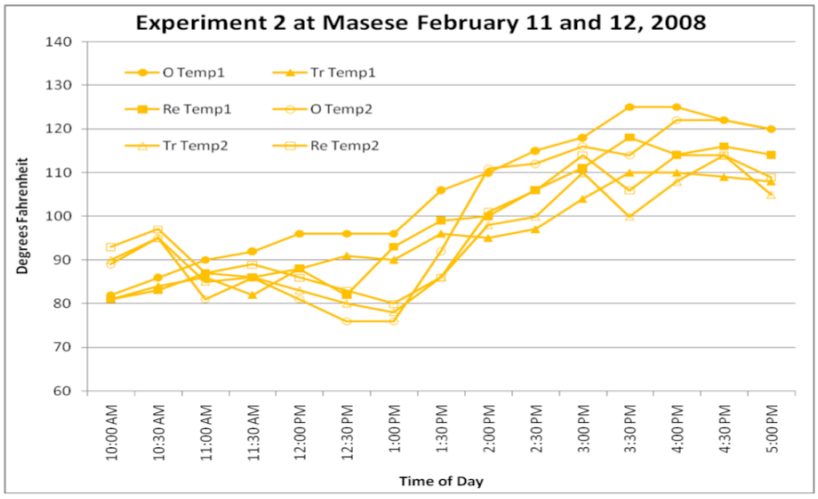
Figure 5-12: MW head lying scale side down on a tarp; Figure 5-13: MW bodies lying on a tarp.


experiment 1, for the duration of daylight on February 11 and 12 I recorded the temperatures of both dryers and outside, noted weather conditions, and insect number each half hour. Again, the fish stayed in the dryers overnight and by 5pm on the second drying day all of the MW were given to Madina to pack and sell at the market.

Data and Analysis

All data and observations for experiment 2 are located in Appendices E and F. Chart 5-2 shows the temperatures of both the rectangular and triangular dryer as well as the outside temperature. The solid points are the data for February 11 and the unfilled

Chart 5-2: Temperature readings for both dryers and outside during the second experiment.



points are the data for November 12. All temperatures for both days are lower than experiment two and the outside temperature does not overcome the dryer temperatures until after 1pm. The weather conditions on both days involved many more clouds, a few drops of rain on the second day, more breeze, and overall less sunlight. Flies accumulated in very large numbers with the lower dryer temperatures and higher moisture content of the MW. By appearance there seemed to be more flies in the rectangular dryer than in the triangular dryer and, as shown in Figures 5-14 and 5-15,

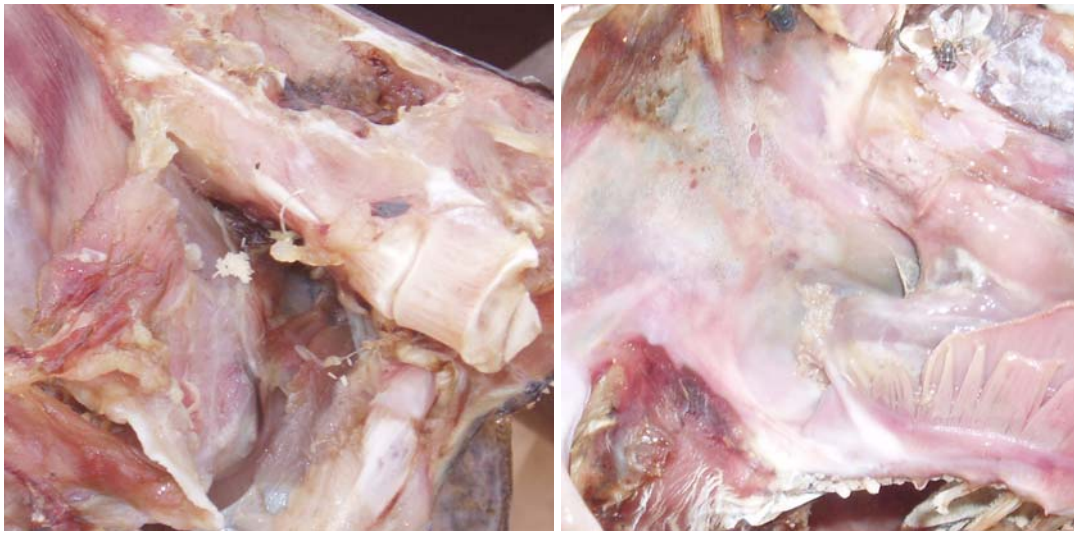
Figure 5-14: Flies on timber in triangular dryer; Figure 5-15: Flies inside rectangular dryer.

in both dryers flies liked to congregate on the timber frame next to the exit points. The wetness test for both dryers showed damp MW everywhere with signs of drying only on top shelves of both dryers at the end of the first day but the MW bodies drying on the tarp both had mostly dried. On the second day, the wetness test showed by the end of the day MW on both top shelves dried, middle shelf of the triangle dryer and the sides of both bottom shelves almost dried, indicated by small spots on the toilet paper in Figure 5-16. The middle area of the bottom shelf in both dryers had MW that

Figure 5-16: An example of conducting the wetness test and what spots indicate.

did not dry completely after two days and Madina pointed out the presence of fly larvae in a couple of the damper pieces and even found one with the maggots already

Figure 5-17: Fly larvae found in a MW head; Figure 5-18: Hatched maggots in a MW head.



hatched, as seen in Figures 5-17 and 5-18. On February 15 I visited Madina and she showed me a piece with grown maggots, shown in Figure 5-19 and indicated that she

Figure 5-19: A piece of MW dried in a solar dryer with grown maggots.

can still sell the MW found with maggots but for a lower price.

Since I had extra brined MW I dried some on a tarp and noticed a few differences between the tarp drying and the solar dryers. If it is really sunny the MW dry as quick on the tarp as the top dryer shelves because they are single layered. I noticed more flies lingering longer on the tarp pieces except when birds come around. Even with me sitting 20 yards away and throwing stones at them, birds still were able to sneak up and steal over 5 pieces of fish a day from the tarps. The birds are harmful because they eat the product but they also keep them a bit more sanitary by repelling the flies. After completing an experiment at both MW processing sites, Chart 5-3 shows an assessment of various factors at each site with favorable conditions at Loco Village except that the water source is very close to the dumping site.

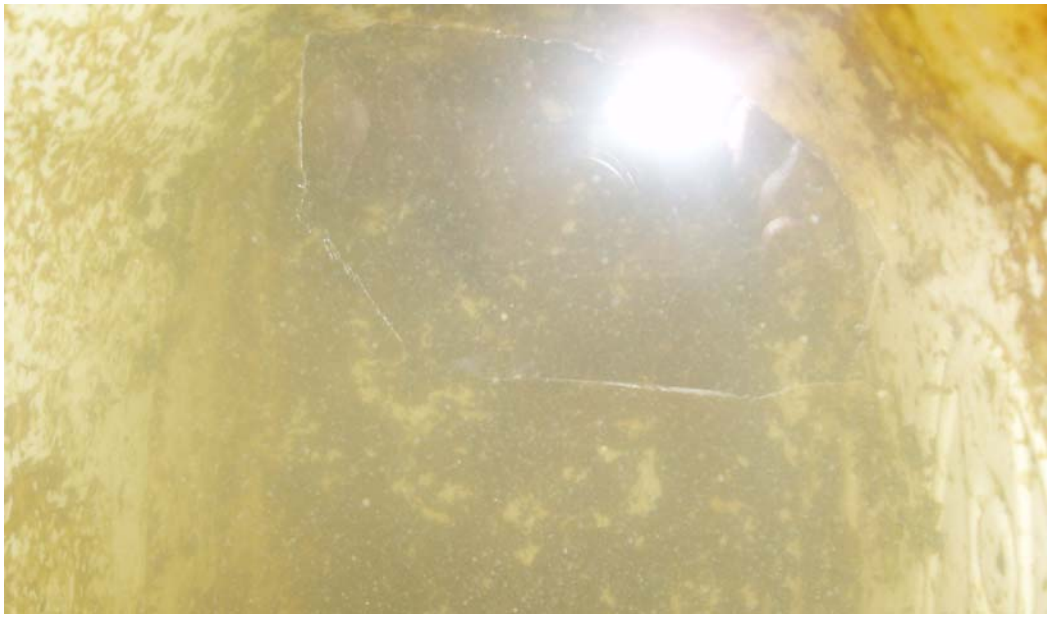
Chart 5-3: Comparison of the 2 Jinja Mugongo Waazi preparation sites and experiments 1 and 2.

Loco Village	**Masese**
Many flies	Disgusting number of flies
Dry season	Wet season
Excruciatingly hot (constant sweat)	Tolerably hot (little sweat)
Small breeze	Moderate breeze with chance of high wind
Many trees and bushes around	No tall foliage for coverage near by
Few animals	MANY birds-small white & marabou stork
Workers get water there at inlet of lake or in wetland area 15-10 feet away	Hire a man to get water from lake about 100 meters away

Challenges and Improvements

Water: Like the water at Loco Village, the water source is at the edge of the wetlands between the shore and the Nile River and is very impure, as shown in Figure 5-20.

Figure 5-20: Inside view of a gerican full of water from the wetland area near the Nile river.



Although visibly clearer than the water at Loco Village, it still contaminates the cleaning and brining process and makes each salt solution inconsistent and contents unknown. The water needs to be at least filtered for washing the MW and treated for brining.

Weather and Slow Drying: In addition to water, the weather was a large challenge that cannot be controlled and no longer predicted accurately. The lack of intense sun

prevented the temperature of the dryers to increase enough for the MW to dry properly. When faced with uncooperative weather, three ways to help the fish dry are to increase the salt concentration, increase the sun exposed surface area and increase the convective heat transfer through wind currents. Madina and Masitula both noticed that the amount of salt used in each gerican was low and I agreed to find another measure of salt to reach the saturation point (see Determining Brining Solution in Section 4). In order to increase the area that is directly exposed to sun the MW must be flipped during the day to alternate the side facing the sun. During experiments 1 and 2 the decision to provide more air vents throughout the dryer or to close up the air vents so the temperature can rise has been a consistent question and needs further study. Madina claims that large amounts of salt helps keep away the flies. There are studies linking fly preferences to sugar over salt but nothing to prove that salt deters flies, this also needs further investigation.

Protection: As described above, after only a few days at the Masese site the dryers were unguarded and again the plastic sheeting on the dryers were slashed and had to be replaced. Not wanting to have another Loco Village experience, I decided that the solar dryers cannot stay in public land without a security guard because people or animals do not leave them alone even though the workers claimed to have warned the community. As I was unwilling to pay for a guard, the other logical option was to move the dryers to a private residence after the second experiment concluded.

Amber Court

Process

Due to security measures the solar dryers were moved for a third time to private land for experiments 3, 4, and 5. The move to the home of Tenywa Rogers at Amber Court was successful in protecting the dryers for the remaining duration of the experiments thanks to the fence surrounding the land and the residents of the home to

make sure no person or animal disturbed the dryers. Figure 5-21 shows the dryers in a large yard surrounded by a natural fence of trees and bushes with a barbed wire fence to help prevent people or animals from damaging the dryers.

Figure 5-21: Allison Muehe loading fish into the triangular dryers at Amber Court.

Experiment 3, 4, and 5 took place on February 22-24, March 17-19, and March 31-April 2, 2008, respectively, and similar to the first 2 experiments day 1 consisted of obtaining, chopping, washing, and brining the MW with the last two days dedicated to drying. The fish carcasses were still purchased at Marine and Agro, transported in rice sacks by motorcycle to Masese for the workers to chop and wash the MW. The cleaned pieces of MW were transferred via motorcycle to Amber Court.

For experiments 3, 4, and 5 a few changes were made with the brining and drying process compared to experiments 1 and 2. After recalculating the brining salt concentration each 20 L gerican was mixed with over 16 cups of salt (see Determining Brining Solution in Section 4). In addition to being flipped during the drying days, the MW will also be placed primarily on the edges of the bottom shelf of the triangular dryer, as illustrated in Figure 5-22, to make sure all the fish in the dryer have adequate direct sunlight. The bottom shelf of the triangular dryer also was loaded with only MW bodies because they tend to be thinner and dry quicker with the largest MW

Figure 5-22: Inside view of the triangular dryer with optimal MW shelf placement.

heads placed on the top shelf. Like the triangular dryer, the rectangular dryer had only MW heads and the bottom shelf only had MW bodies. Another change was at the end of day 1 the MW was stored overnight in the rinsed soaking barrels because the home owner was fearful of wild dogs coming into the compound. With these changes all of the MW dried successfully within 2 days and had no more reports of maggots.

Data and Analysis

Similar to experiments 1 and 2, I took readings of three thermometers, noted weather conditions, and insect number each half hour and the data for experiments 3, 4, and 5 can be found in Appendices E and F.

There were many changes to the process of brining and drying between the first two experiments and the last 3experiments. The locations are effect the data because the first two experiments were on the shore of the Nile with no large trees or plants nearby, had stronger winds, and more flies due to more visible waste. Charts 5-4, 5-5, and 5-6 show data recorded from experiments 3, 4 and 5, respectively, displaying a

Chart 5-4: Temperature readings for both dryers and outside during the third experiment.

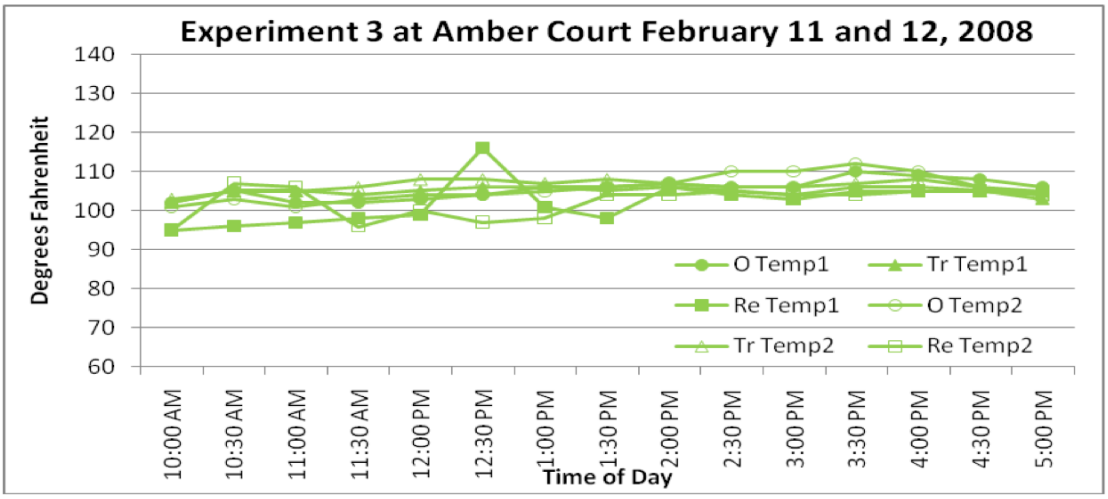


Chart 5-5: Temperature readings for both dryers and outside during the fourth experiment.

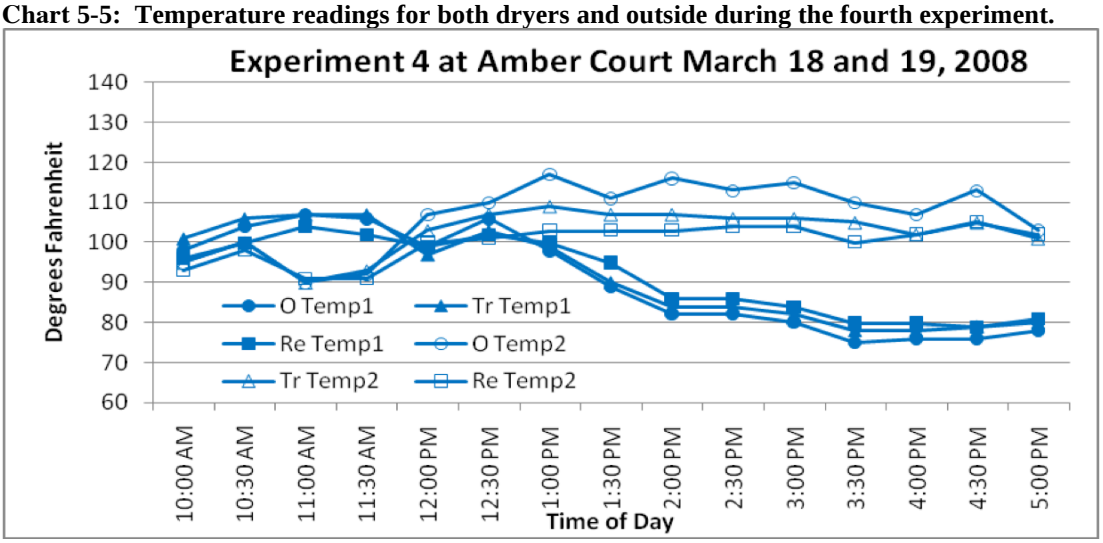
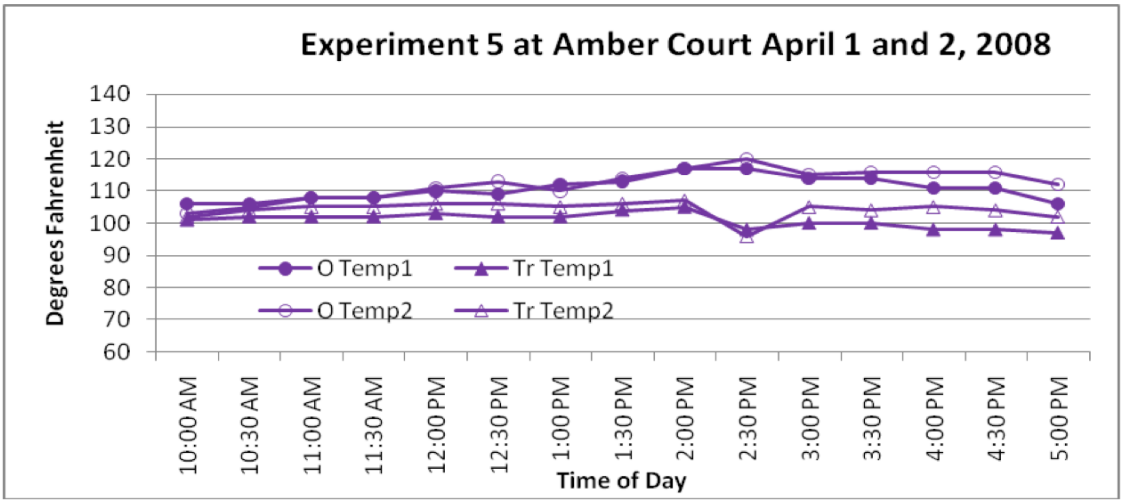


Chart 5-6: Temperature readings for the triangular dryer and outside for the fifth experiment.



couple patterns. To begin with, the rectangular dryer is nearly the same temperature in experiment 3, Chart 5-4, or lower temperature than the triangular dryer in experiment 4, Chart 5-5. After the times of flipping there are noticeable changes in the temperature, like at 2-2:30pm in Chart 5-6. The peak at 12:30pm in Chart 5-4 was because the thermometer was in the direct sunlight and had to be moved within the dryer. There are some similarities to the first two experiments, however, like the outside temperature is higher than the dryer temperatures by the afternoon and when the clouds appear all three temperature readings drop.

As for flies, there were much less at Amber Court than at the processing sites on the first day but after the flies had a chance to notice the fish the number increased dramatically on the second day. Similar to the sites, there seemed to be more flies in the rectangular dryer than in the triangular dryer.

The new system of placing the MW heads on the top shelves and the bodies on the bottom shelves worked wonderfully and even with lower temperatures all the MW were able to dry completely.

Challenges and Improvement

Purchasing Fish: For experiments 3, 4, and 5 obtaining fish became a challenge. According to the general manager of Marine and Agro the daily catches were at a low point for the year due to weather, fish migration or water conditions, see Appendix A so there were not enough fish carcasses for every group processing MW. Also, with a change in the administration at Marine and Agro it became more difficult for me to buy fish at the factory because my verbal agreement for temporary purchases was not held, so difficult that experiment 5 was conducted with only the triangular dryer.

Plastic: Due to the nature of plastic when it gets hot enough the chemical properties of the plastic changes, like the black plastic did after a month in the sun. After over

half a year covering the top of the dryer the clear plastic slowly became brittle and split, seen in Figure 5-23. The very top of the dryer has proven to receive too much

Figure 5-23: Top view of the triangular dryer with deterioration of the clear plastic due to sun.

intense sun rays for the chosen plastic sheet and will need to be replaced by a thicker plastic with a higher heat tolerance or by having the plastic sheet not extend over the top and connect the plastic to the sides of the timber.

Sanitation and Water: Since the chopping and washing of the fish carcasses is completed at Masese the MW is not clean and has waste material still attached when brought to Amber Court for brining and drying. Figure 5-24 illustrates the poor work

Figure 5-24: Workers at Masese chopping the fish carcasses

conditions the MW workers have to operate in and the foul environment the MW lays in before sent for washing. Although the brining solution was made with treated water from the City of Jinja's tap water, during the cleaning process at Masese the MW are still washed with impure wetland water which hinders the ability for the MW to

Figure 5-25: Allison Muehe assists workers at Masese to clean the chopped fish.

absorb salt and to generate a hygienic product. As seen in Figure 5-25, the water that is meant to clean the carcass can be contributing to the impurities contaminating the piece.

CHAPTER 6

EVALUATION

Solar Dryers Design Evaluation

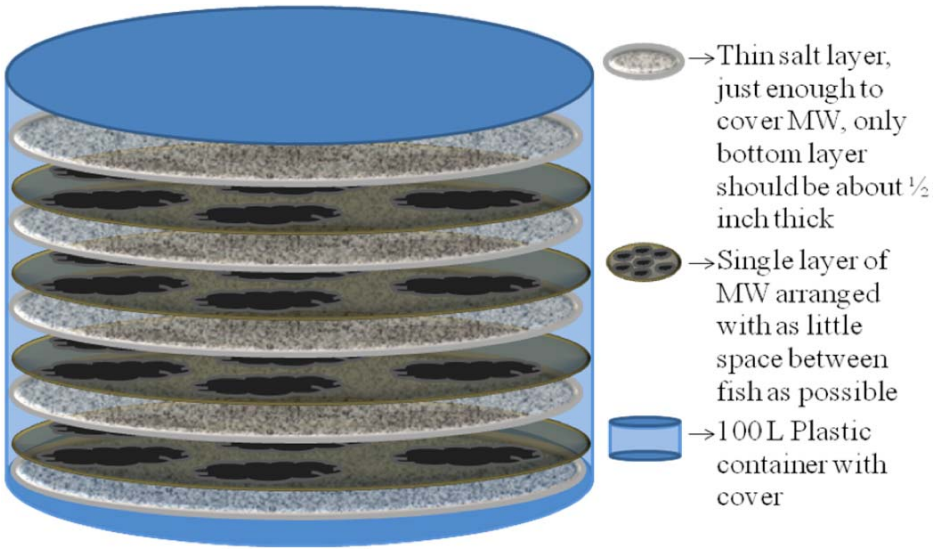
Observation

After the fifth and final experiment was completed it was clear that the salting process and solar dryers both work well but need some improvements. Many of the challenges described in a following section are non technical and are specific to the situation in Uganda. There are, however, a few technical changes to the MW processing procedure that would make an efficient and cost effective drying process that has less environmental impacts.

Salting: Currently, the workers use a salting method called kenching which involves rubbing salt on the MW and allowing the salt solution to drip away from the covered pile of salted MW for a day before drying. The kenching method is inefficient and harmful to the environment because the salt grains are not confined and the salt solution draining from the pile of MW all flow into the nearby wetland and Nile River. The reasons to use kenching includes the lack of storage requirements, just an inexpensive tarp, and that with such a high salt content the fish are preserved for at least a few weeks. My experiment with brining the MW involved making a salt solution before adding it to a covered barrel of cleaned MW and then allowing the fish to sit in the solution overnight before drying. Although the brining method also involves disposing of salt water, all the salt is contained so for long term and high volume usage a small treatment process can be implemented so that the effluent draining into the Nile River is minimally damaging. Unfortunately the brined MW that look and taste more appealing do not have as high a salt content so they stay preserved for only around 2 weeks as opposed to a month with the traditional method

and do not earn as much money because they are lighter than the kenched MW. A salting method that will incorporate both kenching and brining is pickle curing. The diagram in Figure 6-1 depicts the pickle curing method by showing the various layers

Figure 6-1: Diagram of Pickling method: 100 L plastic container with layers of salt between MW.

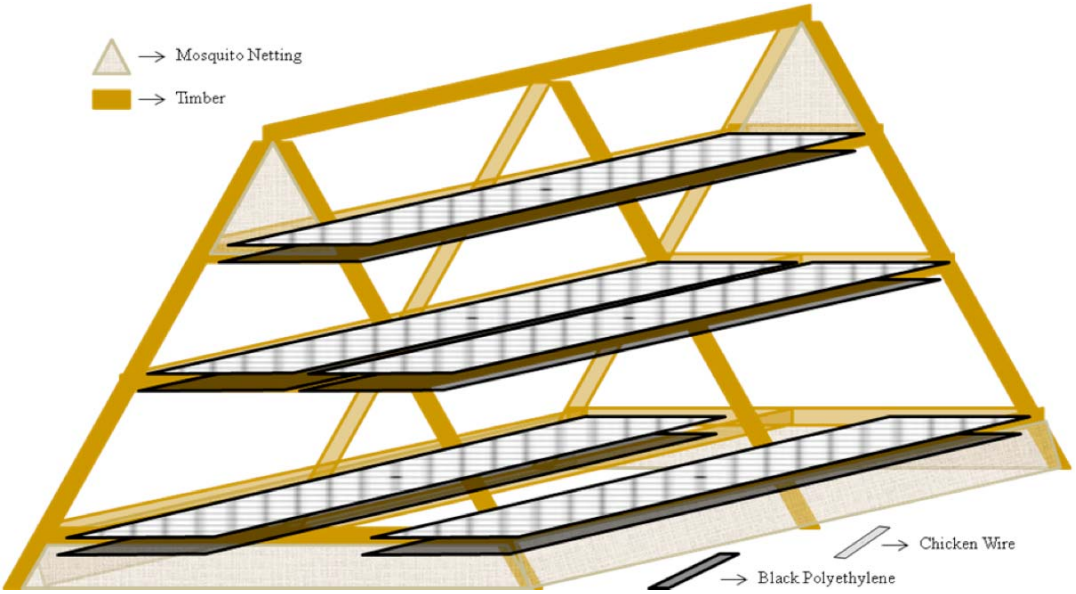


stacked within a 100 L water-tight container. Salt must be between each single layer of MW and as the salt stays in the container overnight the MW's surface moisture will dissolve the salt and form a pickle liquid. The pickle solution is similar to brine and allows the MW to absorb the salt (R15). Ideally pickling will increase the amount of salt on the MW for a longer preservation period than with brining but will still contain all the salt used for treatment before draining into the local environment. Pickling will only require a water-tight container similar to brining, so the cost increase from kenching is minimal.

Solar Drying: Both the rectangular and triangular dryers proved to have features to help maximize drying efficiency, but the triangular dryer is a better structure to start from. A dryer on the equator, like in Uganda, needs all sides admitting light, like the rectangular dryer, because there is basically a singular incoming sun ray angle due to sun's East to West daily path. The triangular dryer used for experiments 3, 4, and 5 at

Amber Court has a few improvements, including replacing the black sheeted side for all sides admitting light, that would make the dryer more efficient and a more optimal choice than the rectangular dryer. Figure 6-2 illustrates the modified triangular dryer

Figure 6-2: Diagram of modified triangular dryer to increase drying efficiency and sanitation.



that includes the modification of the ventilation process and shelf structure. Ventilation is required but since flies are such a nuisance there can't be open sections other than the floor of the dryer. From the bottom of the lowest shelf on every side of the dryer will be the ventilation area for cold air to enter the dryer and after absorbing moisture and heat will exit through the top ventilation areas on both of the triangular ends. The triple shelves structure allows for an increased MW content per land area but the current bottom and middle shelves are too wide and the initial idea of using spaced papyrus reeds as an easily attainable, inexpensive, biodegradable material that would allow light to pass through to the lower shelf did not work. Each side of the bottom shelf should be 2 feet deep instead of the current 2.75 feet deep and instead of spending more effort and materials to separate the middle shelf the middle half foot of shelf should not be used. The shelves should consist of black polyethylene sheets below chicken wire because the absorbing black color at the very bottom was not

utilized, chicken wire will hold more weight than needed but will pacify the workers, and even with MW on the papyrus reeds the light could not get through anyways. This dryer design uses chicken wire, mosquito netting, and more polyethylene so is slightly more expensive and less biodegradable but both materials are very accessible and worth the small cost increase.

Local Worker Input

For many operations the best improvement input comes from the people who work the process every day, especially when assessor is from a different culture and society. Many of the people that process MW are very intelligent and have good ideas on how to make the dryers more efficient. Madina and Masitula encouraged me to add more salt when I was a power of ten off in the volume calculations and Madina proposed flipping the MW in the dryers to maximize drying efficiency. After all 5 experiments were completed I returned to Masese to ask for the worker's imput via the survey found in Appendix G. Many workers have 8 years experience and have worked with multiple mugongo waazi processing groups. According to all workers surveyed the brining method is not effective because the long wait times between drying and selling require a product with a high preservation rate. The other reason to use the traditional salting method is because the excess salt provides weight and that increases profit when selling by the kilo. Although the workers did not approve of the brining method they were satisfied with the solar dryers, especially the triangular dryer. The only improvement the workers had for the dryers was to make the shelves sturdier by using chicken wire or thin piece of wood like a fence because they believe the papyrus isn't strong enough to hold a tonne of fish. This is an easy alteration of the dryers and can be done to ease the mind of the workers; however it's not really needed since the papyrus proved more than strong enough to hold the wet MW as long as the fish don't overlap. When asked if the workers would use a solar dryer in the future all said yes if

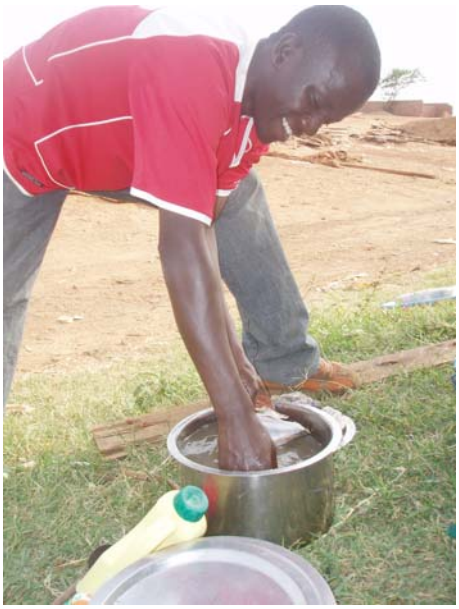
they have the initial capital to build the dryers and if they use the traditional salting method. Madina commented that the solar dried MW look nice and the other workers noted the MW protection the dryers provide from the birds, illustrated in Figure 6-3.

Figure 6-3: The constant showdown between the large marabou storks and the workers.

Taste Testing Analysis

There were 2 attempts for large scale taste testing of traditionally process MW and solar dried MW. The first tasting was conducted at Masese on February 25, 2008 with 16 people and the second tasting was conducted at Kangulumira on April 12, 2008 with 72 people, so 88 participants total. The cooking process begins with a 45 minute soaking and, shown in Figure 6-4, washing the MW twice. Figure 6-5 displays the

Figure 6-4: Tenywa Rogers manually cleaning the MW; Figure 6-5: Ingredients for fish stew.



soaking fish and the spices used in making the fish stew. Figure 6-6 shows me preparing the vegetables and spices for the stew while Rogers cleans the MW with the products of our hard work ready for stewing shown in Figure 6-7. In Uganda

Figure 6-6: A. Muehe and Tenywa Rogers preparing the stew; Figure 6-7: Stew ready to cook.


vegetables are used more for flavor in stews than for their nutritional value. After boiling and stirring the fish stews, shown in Figure 6-8, it was time to begin the survey. Figure 6-9 exhibits a participant feeling both types of MW to choose which

Figure 6-8: Allison Muehe stirring the fish stew; Figure 6-9: Participants beginning the testing.

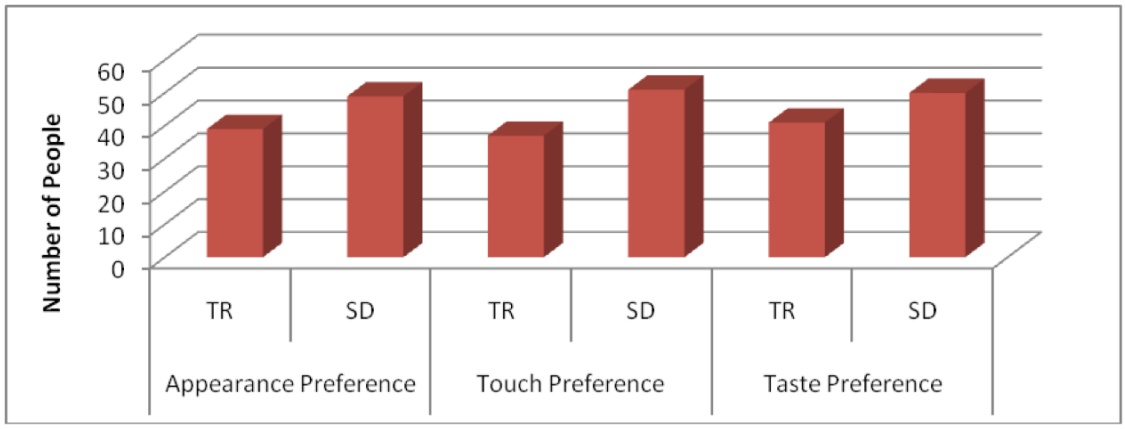

one feels more appealing before having a small taste of each. The first part of the survey is to see which type of MW people prefer based upon the appearance and the feel of the MW, as seen in Figure 6-10. Figure 6-11 reveals that the participants must

Figure 6-10: MW set up for sensory preference tests; Figure 6-11: Participants enjoying the stews.

have liked the stew because some asked to finish a bowl after everyone's responses had been recorded. The complete list of participants and their responses can be found in Appendix H.

The overall results for the taste testing, shown in Chart 6-1, proves that for 3 of the 5

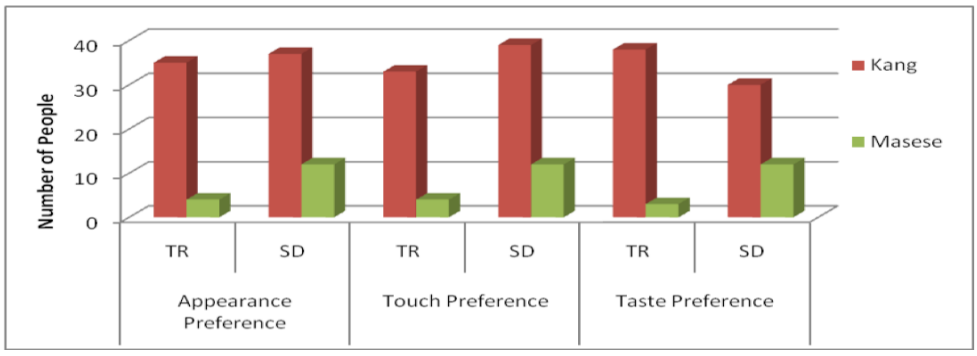
Chart 6-1: Overall taste testing results for traditionally prepared (TR) vs solar dried (SD) MW.



human senses people prefer the solar dried MW to the traditionally prepared MW. Although significant, the differences in each sensory category are not large so breaking down the data into different categories like location, age and gender are appropriate.

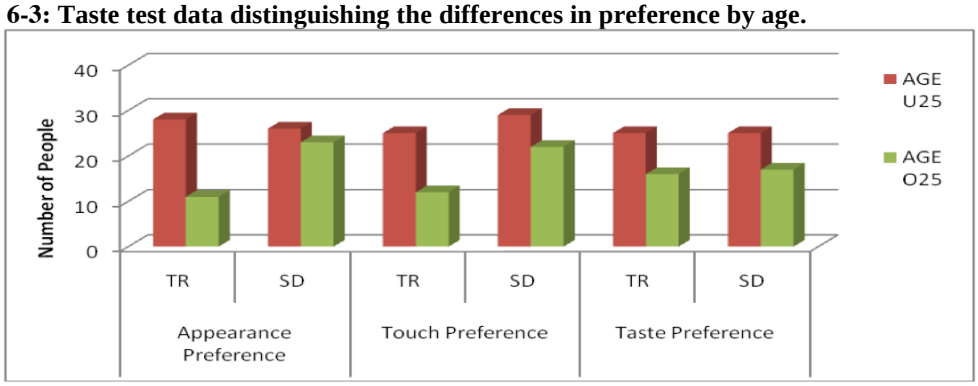
In Masese many people refused to take part in the testing because in the Masese area Mugongo Waazi has a reputation for being dirty, vile, and for poor people in Congo who do not have access to fresh fish. Therefore, it is not surprising to see that looking at Chart 6-2 the people of Masese can identify and convincingly prefer the solar dried

Chart 6-2: Taste test data distinguishing the differences in preference at various locations.



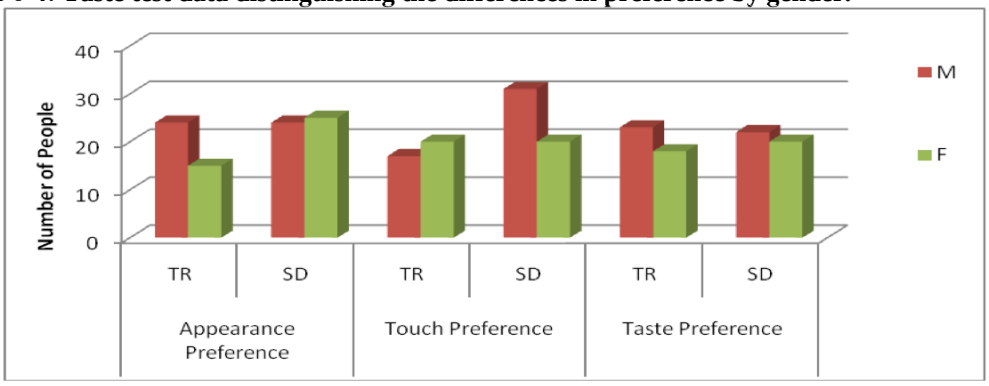
version of MW. The participants in Kangulumira don't show a significant favor to either version except in tasting there is a slight preference to the traditionally processed MW. One reason for this preference is because the Ugandan diet is high in salt and in a rural area like Kangulumira people are more likely used to and liking stews with a large salt content. Another reason could be because of people's availability the MW had to stay for 9 days after drying in a rice bag before being cooked and it could indicate that the solar dried MW does not preserve as well over longer periods of time. Another factor to look at with the taste testing is age of participants. In Uganda, similar to the United States, usually adults buy fish for the family because they don't trust children to pick quality pieces. Looking at Chart 6-3

Chart 6-3: Taste test data distinguishing the differences in preference by age.



we can see that in appearance and touch people over the age of 25 strongly prefer the solar dried MW and for selling purposes that is what matters. Since the workers care most about marketability, the data pertaining to specific ages and gender of buyers must be addressed. Most of the time women will be the one to purchase the fish for the family because she is the one to cook it and it is her job to gather food for the family. Chart 6-4 displays the difference between the men and women who took part

Chart 6-4: Taste test data distinguishing the differences in preference by gender.



in the survey. The data makes it clear that the appearance of the solar dried MW is favored over the appearance of the traditionally prepared MW and at the market sight can be the only tool a woman can use to choose her food.

Overall Challenges

With any projects there are challenges, and completing one in a foreign country invites challenges of the technical and cultural nature.

Weather

As discussed in Chapter 1, in the past decade the weather pattern in Uganda has been changing dramatically. During a normally cold and rainy season, experiment 1 experienced the highest temperatures and during the normally hot and dry season, experiment 2 encountered some of the lowest recorded temperatures. Although the study would have seemed most successful if testing occurred only on sunny and dry days it would not have been realistic. The humid and cloudy days of the second experiment, displayed in Figure 6-12, produced fish with maggots and made the dryers

Figure 6-12: View of the sky at Masese on February 11, 2008.

seem ineffective. The failure of the fish did result in a few process changes that produced improvements in dryer design so testing during uncooperative weather was discouraging but overall productive.

Flies and Birds

For sanitation and quality reasons, flies are one of the most damaging vectors effecting the MW processing. Flies not only carry harmful diseases but the egg larvae and maggots produced by the flies decrease the marketability and hygiene of the MW. As shown in Figure 6-13 the flies come in large numbers to the dryers and although they

Figure 6-13: View of flies on the upper portion of the triangular dryer's side near entry points.

don't always stay on the MW for the duration of their stay, they are a nuisance and have potential to compromise the final product. In the proposed design of the improved solar dryers the mosquito netting used in place of open vents will dramatically decrease the amount of flies entering the dryers due to lack of entry way. One of the only things shown to be effective in warding off flies is when a bird also feeding on the MW scare them away. Unless the workers are chopping and cleaning fish, like in Figure 6-14, the birds usually wander around the drying fish on the tarps until workers are able to frighten them away by waving their arms or whistling at them. Figure 6-15 shows the Marabou stork, a scavenger bird that is mostly found in Uganda around large trash heaps and potentially carrying many diseases who is one of the most frequent thieves of MW. During the night the workers have to cover the piled fish with tarps secured with heavy rocks to keep away the strong Marabou stork and wild dogs. In addition to sanitation reasons, the birds are not welcome because they steal the unsalted and salted MW during all steps of the whole process. With the MW drying in solar dryers the birds did not attempt to take any MW but that could be because there was other more available MW in the vicinity.

Figure 6-14: Birds waiting for scraps during the cleaning process; Figure 6-15: Marabou Stork.

Mugongo Waazi Market

The finished MW is packed and shipped on lorries or large trucks to Mpondwe, Uganda, on the border to the DR Congo. I was not able to travel to this market

because of Peace Corps regulations, but from Madina's verbal description, it sounds like a typical open air market where people bring their product to a wooden booth or if they don't have money for a booth present their product on a tarp laying on the ground. According to Madina, MW sellers from all over Uganda and Tanzania come to the Mpondwe market to sell to buyers from the DR Congo. With fierce competition to sell their MW, sellers have a weekly price per kilo and are forced to reduce it if the MW has maggots, has a strong odor, or shows signs of rotting. Even without the reduction, the profit per unit is so small that the vendor has to sell tonnes of fish in order to account for the operational expenses. The buyers pay per kilo so the sellers want to maximize the weight of each fish while keeping a minimum of quality. According to the Producer Survey found in Appendix G, the brined and solar dried fish did not earn as much money as the traditionally processed MW because without the access salt and smaller moisture content the MW weighed less. Although more appealing in appearance and touch, the buyers are mostly middle men who only trade the MW so the higher quality of brined and solar dried MW does not fetch a better price per kilo. Similar to the middle men buyers at the market, the MW workers in Jinja also do not eat the MW so in order to convince the workers to use this alternative way of MW processing, they have to earn more for the product which will never happen because there are no health regulations for MW.

Resources

Resources including equipment and capital are scarce in Uganda, especially for the MW workers at their economic level. Although you can order almost anything off the internet, buying local goods benefit the Ugandan economy and are relatively readily available. Making an effective and durable solar dryer made out of local and inexpensive materials was a challenge. Some initial ideas, like using a PCV piping frame, glass walls, or metal shelves had to be discarded because of the unrealistic

probability that the MW would have the financial and physical ability to reproduce the dryers. The final dryer design would be feasible for the MW groups to purchase and build themselves but it would require all the various small MW processing groups to work together and invest with a large amount of initial capital.

Trust

Developing countries by definition are economically unstable with a large portion of people living in poverty and living day by day. Since people are in this position in Uganda, I found many people in a variety of businesses using any method possible to increase profits. What would often happen when buying supplies for the experiments or for building the dryers would be an automatic price increase because it was for a foreigner, so every initial price I received I did not believe it was the correct cost. To reduce the bargaining time and false estimates, I would either send a local to buy it for me, find out the price through a third party, or bring along a Ugandan I was close to, like Tenywa Rogers or Nabihamba Ernest to bargain for me. Even with these measures, purchasing any item became a stressful and dreadful experience.

In order to conduct the experiments a large amount of fish carcasses would have to be purchased before being sold at the MW market. Since the MW workers were not confident in the ability of the dryers, it was agreed upon with the group leaders that I would buy the fish carcasses, and pay for the laborers to cut and clean the MW. I brined and dried the MW myself and the group leader would sell the fish at the market. The group leader would pay me back no more than I invested, would keep the profits, and if the money earned for my fish was not enough to cover expenses (because the solar dried fish weighed less) than I would pay the difference. This arrangement worked with one group leader, but another group leader gave me half the amount of money spent after a worker tried to steal part of the funds. There was no way to ask for the funds up front because the MW did not have that much money but

thankfully the majority of the time the group leader I worked with reported the figures from the market to the best of her ability. In my opinion, foreigners doing any project that involves funds will be taken advantage of unless a local business or group of people also invest with you and have an incentive to work with you for accountability to use funds most efficiently.

Situational

While conducting my study, my official position in Uganda as a Peace Corps Volunteer required me to live almost an hour away from Jinja and spend a lot of time on Peace Corps obligations. As a young, American, female Caucasian Peace Corps volunteer I faced many obstacles based on who I am. Although being a 'muzungu' I was assumed to be educated, being female and looking young required me to demand respect from and prove my intelligence to men of all ages and social levels. Another assumption was that as a 'muzungu' I am inherently rich, even though as a Peace Corps volunteer I earned as much as a mid level civil servant did. As discussed in the above Trust section, I was automatically given the 'muzungu' (foreigner) price for any item even if I spoke to them in the local language or if the seller knew of me because I worked or lived near their business. Also, as Peace Corps Volunteer I had a few restrictions that hindered the efficiency of completing the study, like traveling to the MW market or work with the primary schools. All these obstacles only made me more determined to complete my study successfully and, with the help of some wonderful people that I worked, my hope and faith in the Ugandan worker and citizen was restored.

CHAPTER 7

CONCLUSION

Based upon planning and conducting 5 experiments with brining and solar drying MW, I concluded that technically this procedure can work in Uganda but realistically it will be a challenge.

As described in Chapter 6, brining with an apparent saturated salt solution was able to work satisfactorily for a short period of time. In further studies, pickle curing of the MW should be investigated as a salting method instead of brining or kenching.

Throughout the study, both dryers had alterations to improve MW drying, but overall the triangular shaped dryer proved to work better, as detailed in Chapter 6. The triangular dryer has a larger capacity, attracted less flies, and resulted in MW with a smaller moisture content than the rectangular dryer, even though the inside temperature was slightly lower. With a few additional revisions, the triangular dryer design has the potential to allow few flies, absorb more light, and produce more heat to decrease drying time and MW moisture content. Odor issues are also mitigated when using a solar dryer. For future experiments only the revised triangular dryer design should be investigated.

For the pickling and solar drying technology to be developed in Uganda, some logistical issues need to be solved. First, the various Jinja MW processing groups need to work together to pool resources and operate together in a single location with tapped water. Second, the dryers need constant protection via security guard or chain link fence. Lastly, all parties involved, like the fish factories, MW processing groups, and the municipality of Jinja, will need to form a strategic plan to find a single location to process the MW and budget the continuous production of the solar dryers.

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Appendix

A. Marine and Agro Survey
B. Jinja Secondary Fish Market Survey
C. Mugongo Waazi Questionnaire
D. Proposal for Funding of Mugongo Waazi Experiments with Brining and Drying
E. Mugongo Waazi Experiments Data
F. Mugongo Waazi Experiments Comments
G. Mugongo Waazi Producer Survey
H. Mugongo Waazi Taste Testing Data

Appendix A

Marine & Agro

Position and Name of Interviewee: Nitin, Shingade General Manager

Date: 31/3/08

What are the products of the factory?

Frozen and chilled fillets (by products: skins, mugongo waazi, bladders, heads, fat, rejects, offcuts-trimming, wastes, belly fat

How many factories do you have in Uganda? Locations?

6: Entebbe, Masindi, Jinja, mayayi, Kasenyino (seasonally, migration of fish and weather-rainy or calm)

How long has each factory been in operation?

Since 1994

Which factory (location) has the highest input and output?

For the changing amount of fish available, what months of the year give high yields of fish and low yields? May-Dec good pick; Jan-may lean

Do you notice any increase or decrease in the overall availability of fish in the past 5 or 10 years? Yes, overfishing

Any conclusions why there has been this change? Immature catch

What are the costs for mugongo waazi during each of these low and high yield seasons? Depends on availability of fish (300/= for poor people per kilo)

Do you have records that I can see that gives the mass of fish processed per day or at least per week with the associated cost? (No, not available)

How long have you been selling the mugongo waazi to people for drying? Since start of factory 1994

How many daily customers do you have at this time? 10 (get 4-70 kilo/day so depends on # of fish caught that day)

How does a person get to be a daily customer? Deposit cent or amount to become daily customer so that they can get even in lean season.

Appendix B

Jinja Secondary Fish Market Survey

Names of Questioner: Allison Muehe, Ernest Nabihamba
Names of Respondent: Kibwka john
Date and Time: 31st January 2007, 3-4pm
Site Location: Loco village A
Weather Conditions: cloudy, alternate rains in morning, a bit of wind

Site Physical Observations:	**Response**:
1. Give an estimate of the size of the area the workers occupy:	¾-1/2 a football field
2. Is the land level?	No, half slopes in one direction
3. Where does water flow?	To the shore of lake Victoria
4. Are there standing pools of water, how many and how large?	A couple, but small and shallow from rains today and tire tracks
5. What is and how close is the nearest body of water?	Within sight: Lake Victoria. Maybe 20 yards, Nile river about ½ mile away
6. Any water quality tests previously conducted on nearest body of water?	Yes, somewhere by fisheries
7. What is the vegetation like on and surrounding the working area?	Many swamp vegetation, no trees only a few young and small ones
8. On a scale from 1 (not noticeable) to 5 (overbearing), how strong is the stench from the mugongo waazi?	3.5, finitely not appealing nor pleasant but there is a light breeze so it's not too bad
9. Are there any examples of destruction done on the local environment?	The ground they actually work on has no plant life anymore, only mud and dirt and traditional community garbage is spread around
10. Any wildlife present at the working site?	Some local goats, not many flies, same as other spots, I hear many birds in the bushes
Site Location:	
1. How large is the land occupied by the workers and equipment?	¾ -½ foot ball field
2. Who owns the land?	The railway
3. Any specific reason for choosing this land to work on?	They are not charged to work there
4. How long have the workers been using this land?	About 5 years
5. Why did the workers move away from the previous area?	factory company wanted to build another factory there
6. What resources are available there? (water, electricity, transport, etc.)	Water from Lake Victoria is right there, no electricity, transport not difficult
7. What type and where are the toilet facilities that the workers use?	None, use a house that's about 100 yards away
8. Is the land applicable for composting toilets?	Maybe, but too close to water?
Receiving the fish:	
1. Who or where do you get the mugongo waazi from?	Fish packers, in Jinja but 2 others in Jinja
2. If the mugongo waazi is on a truck longer than half an hour, is the fish spoiled when it arrives at site? If not, how is it kept unspoiled?	It's not
3. After receiving the mugongo waazi, is there any type of quality control?	None, think all good quality
4. What type of container is the mugongo waazi transferred in?	None, from a flatbed truck
5. Is there any type of system to decide who gets each container of mugongo waazi?	No, it comes and people start working on it

6. What is the volume, mass, or number of mugongo waazi per container?	About 1.5 tons fish per truck
7. What days of the week and time of day are the containers of mugongo waazi delivered?	4 days a week anytime of the day, usually mornings If a good season they get fish everyday
8. How many containers of mugongo waazi are received per week and per day?	4 trucks a day
After Delivery and Cleaning:	
1. Are the mugongo waazi removed from the transport containers after reaching the working site to another container or heaped in a pile?	Heaped in a pile
2. What is average time the mugongo waazi spend sitting at the working site before being cleaned?	Up to a day, but try immediately
3. How many gericans (~20 L) of water does it take to clean one container full of fish?	About 30 gericans per ton or truckful
4. After scrubbing, is the mugongo waazi again rinsed?	Yes
5. How many gericans of water is used in a day for the whole cleaning process?	30 gericans
6. After cleaning, where is the mugongo waazi placed?	On a wooden platform
7. Any cover/protection from wind, rain, and dust?	No
8. Where is the water to scrub and rinse the mugongo waazi come from?	Lake Victoria
9. What are the by-products of this process?	Fish innards, dirty water
10. How are the by-products dealt with?	They put it into 'the hole', separate water and solids to different holes The liquid hole is disgusting, must be polluting some body of water
Salting:	
1. What is the type and brand of salt used?	50 kg bag of crushed iodized salt by Habari, a little more course than table salt
2. How much salt is used per container mugongo waazi?	About 3 bags per ton or truckload
3. Has the use of a concentrated salt solution been attempted?	Never
4. How is the salt applied to the mugongo waazi?	Sprinkled on
5. The salted mugongo waazi are placed in what?	Onto the platform
6. Where does the runoff from the salted mugongo waazi travel?	Into the marshes, they travel to the 'liquids hole'
7. How long do the salted mugongo waazi spend in a heap before set out to dry?	None, right to platform
8. What is the purity of salt that is used?	Fairly good but contaminated with yesterday's salt
9. At the end of the day is the salt disposed of?	The leftover salt is reused
Drying:	
1. What is the heat and air source to dry the mugongo waazi?	Wind and sun, dry on tarp on ground
2. What type of platform is the mugongo waazi dried upon?	After salting is dried for 2 days on a wooden platform then put on ground on a tarp
3. On a sunny and dry day, how long	1-2 days

does mugongo waazi take to dry?	
4. On a sunny and humid day, how long does mugongo waazi take to dry?	4 days
5. On a cloudy and dry day, how long does mugongo waazi take to dry?	3 days
6. On a cloudy and humid day, how long does mugongo waazi take to dry?	4 days
7. Is the material that the mugongo waazi dries upon perforated?	No, but dries a little on the platforms first so don't need perforation
8. Does the drying apparatus have more than one level?	No
9. How and when is the drying apparatus cleaned?	About every fortnight
Packing and Shipping:	
1. Are the dried mugongo waazi cleaned before packaging?	No
2. Before being packed is any type of quality control with the mugongo waazi?	No
3. What type of containers transport the mugongo waazi to villages?	They use ricebags to make into a type of square tie
4. What is the volume, mass, or amount of mugongo waazi per packed container?	3-4 bundles per ton
5. What type of vehicles distributes the packed containers to the villages?	A lorry
6. How many containers of mugongo waazi are transported in each type of vehicle per day and per week?	About 7 tons per lorry
Social and Economic Factors:	
1. How many women on average work at this site per day?	Busy day: 15 Not busy day: 10
2. How many men on average work at this site per day?	Same as women
3. Do you know of other groups who also prepare the mugongo waazi?	1 other, when factory was built their group split into two
4. What and who are the different committees who control the organizational aspects of the process?	Each group gets fish for themselves
5. How much does one container of mugongo waazi cost to buy from the factory?	280,000/= per ton
6. What contribute to the operational costs in a day?	Salt, workers, transport
7. For each operational cost, what is the daily amount spent?	Busy day: 20 bags salt at 17,000/=, workers: 15,000/=/ton, 10,000 transport to site, 1.3 million per lorry to transport to market
8. For each container of mugongo waazi, how many women will assist in the processing?	-
9. For each container of mugongo waazi, how many men will assist in the processing?	-
10. How much do you sell one container of mugongo waazi for?	Low price: 7-8,000 /= per kilo high price is 10,000 /= per kilo Each bundle is about 100 kilos
11. On average, how many containers of mugongo waazi do you sell in a week?	Busy season: 1 lorry/wk Not busy season: 1 lorry/2 wks

Appendix C

Mugongo Waazi Questionnaire

Date of Survey	Location	Symbol
19th of May 2007	Loco Village, Kirinya (A)	A
19th of May 2007	Loco Village, Kirinya (B)	B
20th of May 2007	Masese	M

What challenges have you experienced with preparing the mugongo waazi?

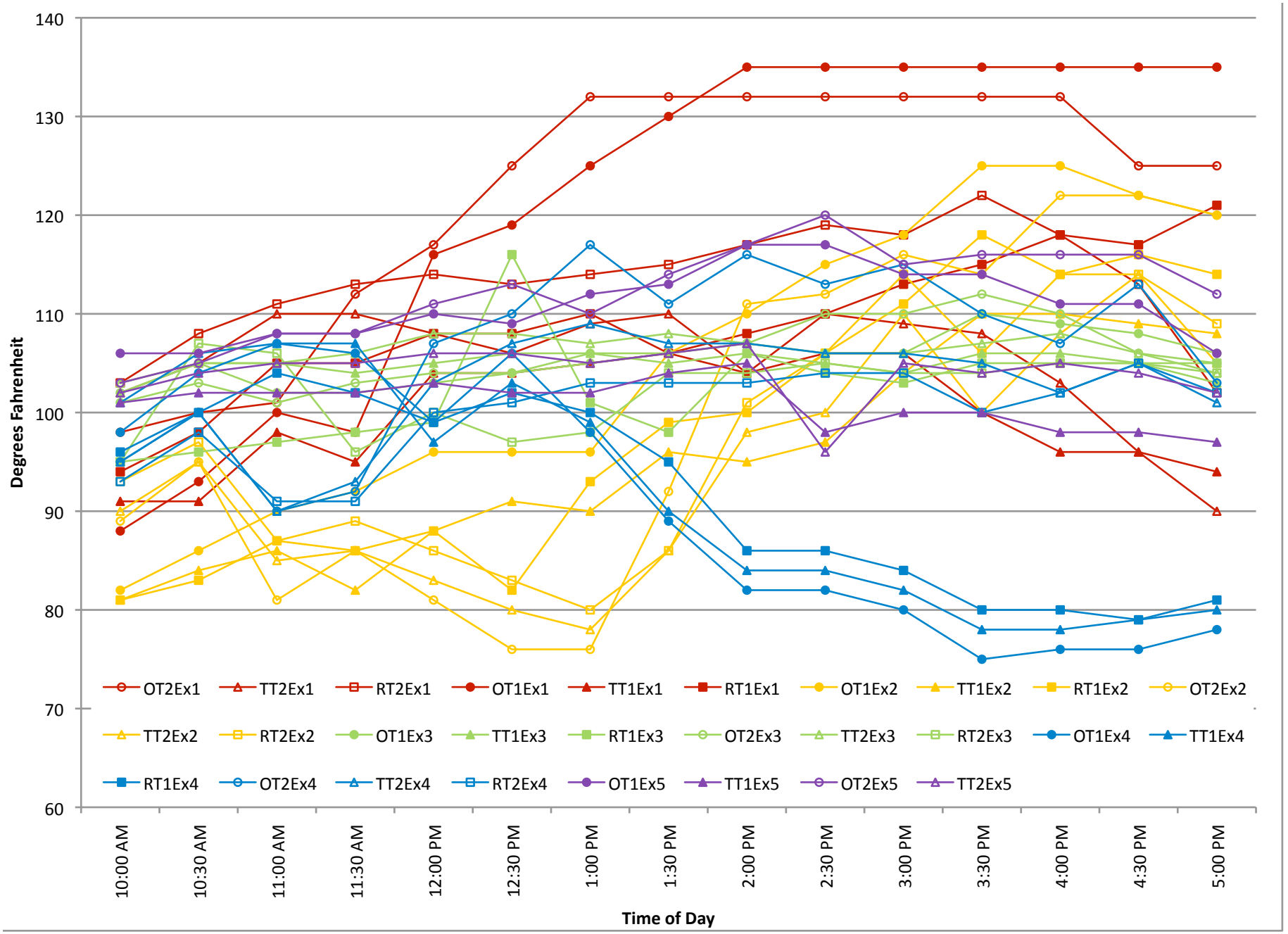
A:	- They work under hot sunshine - They are pierced by bones while cutting and cleaning the carcasses - Rain in the rainy season affects them by: o The fish rots o The rain that causes flu (cold) and malaria o Fish takes long to dry o Fish breaks
B:	- Rainy season causes problems: o Fish rots o Fish breaks
M:	- the bad smell - the rain - when salting, they complain about the salt having bad effects on their skin

For each challenge, please state if and how you have attempted find a solution:

A:	- For the piercing of bones: o Some try to use gloves, but the cutting is not quick and gets sloppy: 'like using bear hands' - For the rain: o They've tried to buy polythene sheets to cover the fish but if rain comes abruptly they are still wet
B:	They try to cover the fish with polythene sheets but since they get fish in large quantities they can't rescue it from the rain very quickly
M:	- for the salt: o tried to buy gloves but workers are not as effective - for the rain: o bought polythene sheets to cover the fish but the fish rots and takes a long time to dry - There is no alternative for the smell because the fish itself smells

Are there any possible solutions to the challenges that have not been attempted?

A:	The sunshine has no solution because ' we need it and we can't use shade because we need the sun in every process.'
B:	Nothing ** other complaints from B: From the factories: they pay for more fish and are supplied with less kgs. They are not allowed to move near the weighing scale and some factories have no weighing scale so they only have containers to go by, therefore the estimating is incorrect.
M:	Not Yet


140
130
120
110
100
90
80
70
60
Degrees Fahrenheit
10:00 AM
10:30 AM
11:00 AM
11:30 AM
12:00 PM
12:30 PM
1:00 PM
1:30 PM
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RT2Ex4
OT1Ex5
TT1Ex5
OT2Ex5
TT2Ex5

Mugongo Waazi Experiments

Experiment: 1 Date: 8th nov 2008, Thursday Site: Loco Village

Time	O Temp1	Tr Temp1	Re Temp1	Weather	Insects	Wetness test
9:30 AM	84	87	91	light wind, sunny, spotty clouds	Many, mostly bottom shelf	All Wet
10:00 AM	88	91	94	light wind, sunny, 1/4 sky clouds	Many, mostly bottom shelf	
10:30 AM	93	91	98	light wind, sunny, 1/4 sky clouds	Many, mostly bottom shelf	
11:00 AM	100	98	105	light wind, sunny, 1/3 sky clouds	very few ones on top by many on lower	
11:30 AM	98	95	105	light wind, sunny, more clouds	still many	
12:00 PM	116	104	108	light wind, sunny, more clouds	still many	
12:30 PM	119	104	108	bright and sunny	still many	
1:00 PM	125	105	110	bright and sunny	still many	Tops almost dry
1:30 PM	130	106	106	bright and sunny	still many	Bottoms wet
2:00 PM	135	104	108	bright and sunny	still many	
2:30 PM	135	106	110	bright and sunny	so many! Flies seem to want to get in and not know how to get out	
3:00 PM	135	106	113	bright and sunny	TONS	
3:30 PM	135	100	115	bright and sunny	TONS	
4:00 PM	135	96	118	bright and sunny	TONS	
4:30 PM	135	96	117	bright and sunny	TONS	
5:00 PM	135	94	121	clear sky	TONS	
5:30 PM	120	88	108	sun at ~45 degree angle	many in Tdryer not as many in Rdryer	
6:00 PM	112	82	100	sun at ~30 degree angle	many in Tdryer not as many in Rdryer	Tops dry, middles mec
	OT1Ex1	TT1Ex1	RT1Ex1			

Experiment: 1 Date: 9th nov 2008, Friday Site: Loco Village

Time	O Temp2	Tr Temp2	Re Temp2	Weather	Insects	Wetness test
8:30 AM	83	88	88	Sunny, almost no wind, wispy clouds	Very few in both	same as last night
9:00 AM	87	92	92	Sunny, almost no wind, wispy clouds	a few in both	
9:30 AM	92	95	97	1/3 cloud coverage	couple in Tdryer few bunch in Rdryer	
10:00 AM	98	102	103	wispy clouds	couple in Tdryer few bunch in Rdryer	
10:30 AM	100	105	108	1/3 cloud coverage	in Rdryer number is growing	
11:00 AM	101	110	111	1/2 cloud coverage	bunch in both	
11:30 AM	112	110	113	1/2 cloud coverage	bunch in both	
12:00 PM	117	108	114	2/3 clouds	bunch in both	
12:30 PM	125	106	113	increased wind	bunch in both	
1:00 PM	132	109	114	small wind, 1/3 cloud coverage	few in each	only bottom shelf on
1:30 PM	132	110	115	small wind, 1/3 cloud coverage	near top of Tdryer and Rdryer but not flying	
2:00 PM	132	104	117	small wind, 1/3 cloud coverage	near top of Tdryer and Rdryer but not flying	
2:30 PM	132	110	119	1/4 cloud coverage, slight wind	only hanging out at tops of dryers	
3:00 PM	132	109	118	1/4 cloud coverage, slight wind	few in each	
3:30 PM	132	108	122	1/4 cloud coverage, slight wind	few in each	
4:00 PM	132	103	118	1/4 cloud coverage, slight wind	not many	
4:30 PM	125	96	113	Clear skies, little wind	few in each	
5:00 PM	125	90	102	Clear skies, little wind	not many	Everything dry
	OT2Ex1	TT2Ex1	RT2Ex1			

little to no wind/almost no wind
little wind
slight wind
small wind

Comments
Tdryer needs to more sunlight for bottom
too much wind, adjust Tdryer front nail
A lot of wind circulation in both dryers
flies exited when I opened Tdryer a little
O Therm now in sunshine
moved thermo to 2nd shelf but moved back
flipped fish from 1:30-1:50

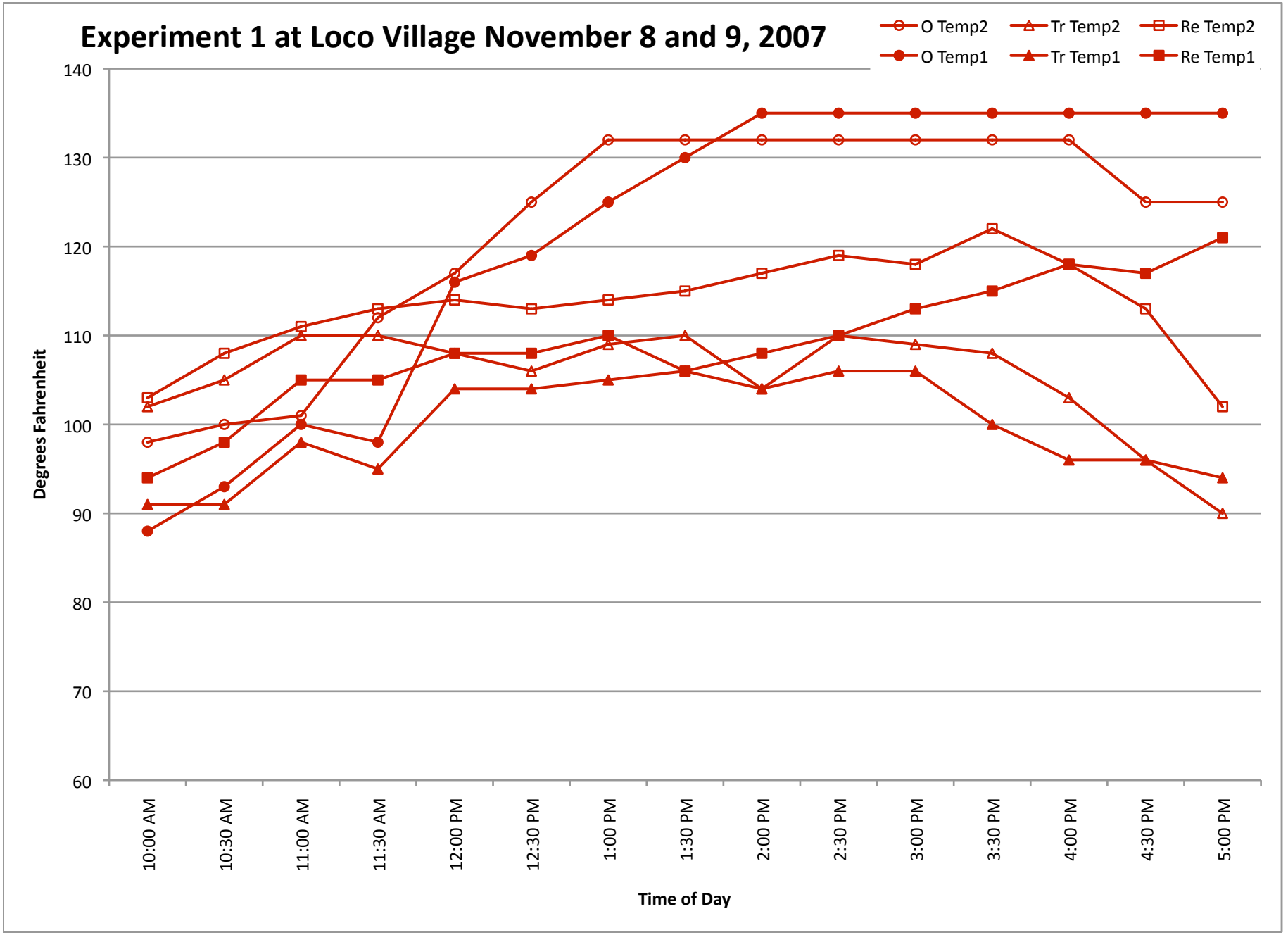
Maybe eggs killed but flies aren't
angle of Rdryer wrong

dium wet and bottom still wet

Comments
fish a bit dryer than last night but not finished
O Therm now in sunshine

Rdryer and a towards back on bottom of

Tdryer not completely dry, others are


Experiment 1 at Loco Village November 8 and 9, 2007
O Temp2
Tr Temp2
Re Temp2
O Temp1
Tr Temp1
Re Temp1
140
130
120
110
100
90
80
70
60
Degrees Fahrenheit
10:00 AM
10:30 AM
11:00 AM
11:30 AM
12:00 PM
12:30 PM
1:00 PM
1:30 PM
2:00 PM
2:30 PM
3:00 PM
3:30 PM
4:00 PM
4:30 PM
5:00 PM
Time of Day

Mugongo Waazi Experiments

Experiment: 2 Date: Feb 11 2008 Site: Masese

Time	O Temp1	Tr Temp1	Re Temp1	Weather	Insects	Wetness test
10:00 AM	82	81	81	Fairly overcast	increasing in number	
10:30 AM	86	84	83	fairly overcast with light wind	not usually stay on fish, flying around	-Wet!Soaked through napkin
11:00 AM	90	86	87	sun starting to come through clouds, small breeze	in TDryer like the wood, many of them!	completely
11:30 AM	92	82	86	can see shadow, more sun, still cloudy, breezy	like to stay in middle of shelves on fish and wood	
12:00 PM	96	88	88	sun shining but no intensity, still cloud cover w breeze	like to stay in middle of shelves on fish and wood	
12:30 PM	96	91	82	sun shining amongst clouds, small breeze	huge number especially on top and on wood frame	**
1:00 PM	96	90	93	overcast for a while but sun peeks through clouds	huge number especially on top and on wood frame	
1:30 PM	106	96	99	sunnier with breeze	still many flies on both	
2:00 PM	110	95	100	sunnier with breeze	still many flies on both	TD: Mid, bot spotty head in sun spotty
2:30 PM	115	97	106	sunnier with breeze	mostly on plastic not on fish	not in sun big wet spots upper shelf all
3:00 PM	118	104	111	sunnier with breeze	mostly on plastic not on fish	spotty; RD: top spotty bodies big spots
3:30 PM	125	110	118	sunnier with breeze	ridiculous amount but also some dead	w heads, lower shelf has big spots w
4:00 PM	125	110	114	sunnier with breeze	ridiculous amount but also some dead	bodies wet heads; Tarp: spotty heads
4:30 PM	122	109	116	sunnier with breeze	ridiculous amount but also some dead	but bodies upper side done and
5:00 PM	120	108	114	sunnier with breeze	opened Rdryer and tens of flies came out	flipped bodies
5:30 PM	117	104	104	sun going down slowly ~35-40 degrees up little breeze	still tons	
6:00 PM	100	92	92	same but 30 degrees up	still tons	TD: top lil spots on sun fish mid/bot
6:30 PM	89	85	87	same but 20 degrees up	still tons	shelf barely spotty, non sun fish
	OT1Ex2	TT1Ex2	RT1Ex2			spotty; RD: top barely spotty, bot very
						spotty; Tarp; bodies done, sm-med
						heads lil spotty, big heads spotty

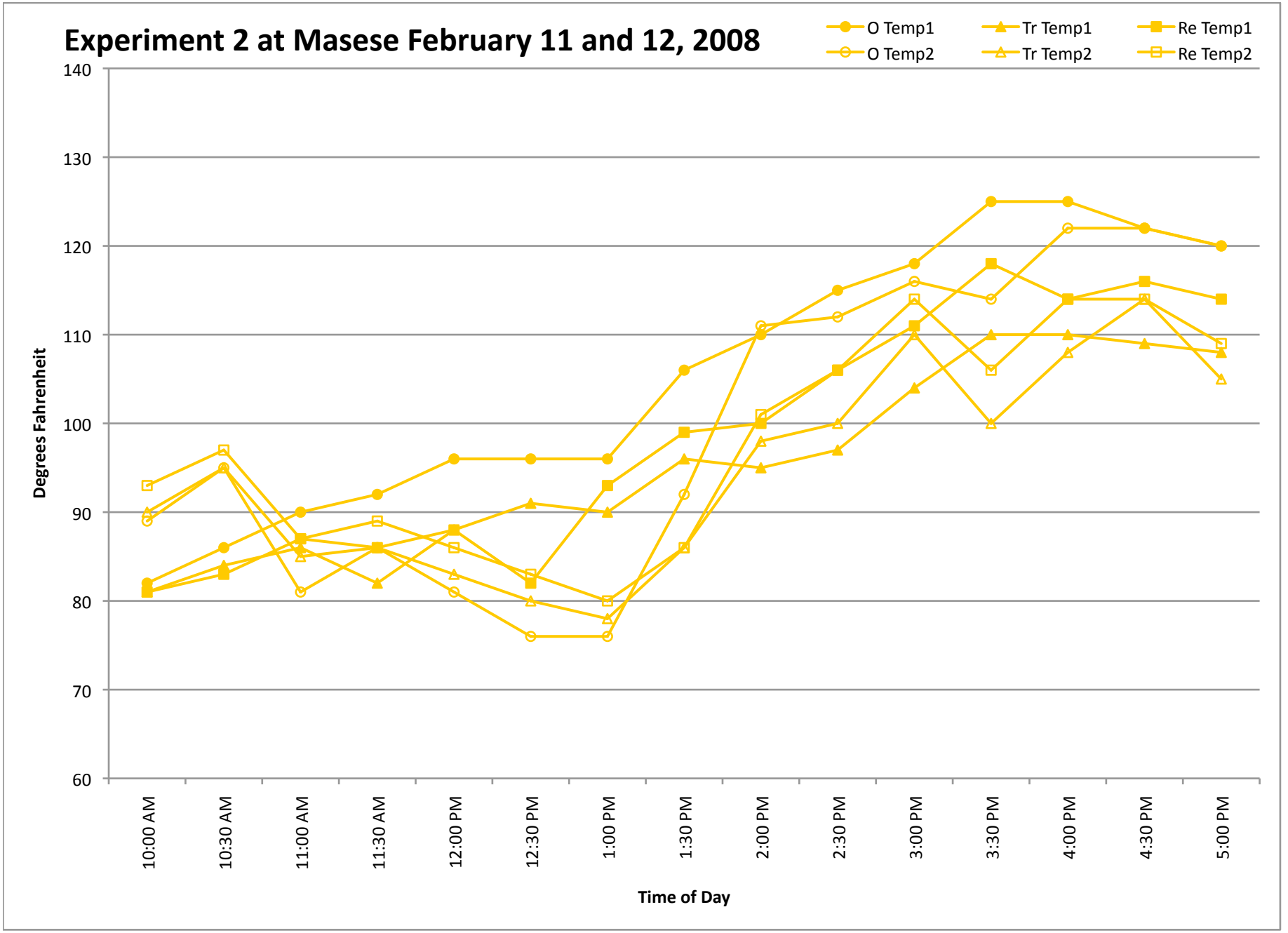
** finished putting up nails to close Rdryer door and thermometer dropped to ground

Experiment: 2 Date: Feb 12 2008 Site: Masese

Time	O Temp2	Tr Temp2	Re Temp2	Weather	Insects	Wetness test
7:30 AM	76	69	71	Sun hazy, popping out over low lying clouds, light breeze	Some in Tdryer, many already in Rdryer	
8:00 AM	70	72	73	Sun hazy, popping out over low lying clouds, light breeze	Some in Tdryer, many already in Rdryer	
8:30 AM	74	76	77	little to no shadow because overcast and breezy	starting to increase in number	TD: all excpet bottom bodies are
9:00 AM	82	84	85	sun coming out, light breeze	they love the wood frame	spotty, bottom bodies have flies on
9:30 AM	89	89	90	small shadows, bazy sun, light breeze	in Tdryer not flying as much in Rdryer flying	them; RD: top barely spotty bottom all
10:00 AM	89	90	93	small shadows, bazy sun, light breeze	in Tdryer not flying as much in Rdryer flying	very spotty; Tarp: barely spotty heads,
10:30 AM	95	95	97	sun out, with breeze	flies still increasing in # they love the small holes	bodies done
11:00 AM	81	85	87	overcast, breezy	flies still increasing in # they love the small holes	
11:30 AM	86	86	89	dark slouds coming in distance	flies still increasing in # they love the small holes	
12:00 PM	81	83	86	overcast, light breeze, dark clouds in distance	flies still increasing in # they love the small holes	
12:30 PM	76	80	83	overcast, breezy, dark clouds in distance	still in the dryers	
1:00 PM	76	78	80	overcast and fairly windy	reduced in number bc light wind, temp like evening	
1:30 PM	92	86	86	sun start coming out and breezy	getting more active again	TD: middle/bottom bodies still have
2:00 PM	111	98	101	sun shining with clouds and light breeze	less than yesterday but still many	film but bottom ends ok, all others
2:30 PM	112	100	106	sun shining with clouds and light breeze	less than yesterday but still many	spotty some heads on middle shelf w
3:00 PM	116	110	114	sun shine with little amount of clouds and breezy	not as active mostly sit on wood frame	small sun look wetter; RD: top shelf
3:30 PM	114	100	106	sunshine with clouds, breezy	not as active mostly sit on wood frame	done, bottom shelf spotty heads and
4:00 PM	122	108	114	sunshine with few clouds, light breeze	not as active mostly sit on wood frame	bodies; Tarp: bodies done, small
4:30 PM	122	114	114	sunshine with few clouds, light breeze	not as active mostly sit on wood frame	heads have almost not spot but large
5:00 PM	120	105	109	sunshine with few clouds, light breeze	not as active mostly sit on wood frame	heads have sections still wet
5:30 PM	96	92	98	sun less intense b/c clouds, setting slowly, light breeze	not as active mostly sit on wood frame	
6:00 PM	80	83	98	sun decreasing and wind increasing	not as active mostly sit on wood frame	
	OT2Ex2	TT2Ex2	RT2Ex2			

Tarp Comments
huge, constant fly and bird problem
huge, constant fly and bird problem
huge, constant fly and bird problem
hundred of flies, at least 5/fish, fish starting to dry
less flies than before but still many, fish seem to be drying
few flies because birds, seem to be drying
birds not around, flies increase
seem to be drying faster than dryers
drying well, some parts but when turn bodies they are dirty
tons of flies
I think almost done, Madina and other lady say no
I think almost done, Madina and other lady say no
I think almost done, Madina and other lady say no
I think almost done, Madina and other lady say no
Madina took most bodies but said heads not done
almost done but not yet
almost done but not yet
fewer flies and almost dry so pack up

Tarp Comments
fish look fine
flies starting to gather, ~50 now
more than 50 now
more than 50 now
I see the fly eggs but no maggots, yet
I see the fly eggs but no maggots, yet
Madina covered bodies says heads not done
still no maggots
not as many flies as before, around 50
all fish in a pile under tarp
all fish in a pile under tarp
all fish in a pile under tarp
Now o thermo in sun; only heads put out
Now o thermo in sun; only heads put out
Now o thermo in sun; only heads put out
not many flies maggots not there yet
not many flies maggots not there yet
not many flies maggots not there yet
heads look a bit dark
heads look a bit dark
heads look a bit dark
heads look a bit dark


Experiment 2 at Masese February 11 and 12, 2008
O Temp1
Tr Temp1
Re Temp1
O Temp2
Tr Temp2
Re Temp2
140
130
120
110
100
90
80
70
60
Degrees Fahrenheit
10:00 AM
10:30 AM
11:00 AM
11:30 AM
12:00 PM
12:30 PM
1:00 PM
1:30 PM
2:00 PM
2:30 PM
3:00 PM
3:30 PM
4:00 PM
4:30 PM
5:00 PM
Time of Day

Mugongo Waazi Experiments

Experiment: 3 Date: 23rd Feb 08 Site:

Time	O Temp1	Tr Temp1	Re Temp1	Weather	Insects
10:00 AM	102	102	95	little breeze, sunny with few clouds	not many ~10 per dryer
10:30 AM	105	105	96	little breeze, sunny with partial clouds	not many ~10 per dryer
11:00 AM	102	105	97	small breeze, sunny with partial clouds	increased but ~15 per dryer
11:30 AM	102	104	98	small breeze, sunny with partial clouds	more flies in Sdryer not so many in Tdryer
12:00 PM	103	105	99	small breeze, sunny with few clouds	in Tdryer ~15, in Sdryer ~30-35
12:30 PM	104	106	116	small breeze, sunny with few clouds	in Tdryer ~25, in Sdryer ~45-50
1:00 PM	106	106	101	small breeze, sunny with few clouds	in Tdryer ~25, in Sdryer ~45-50
1:30 PM	106	105	98	small breeze, sunny with few clouds	in Tdryer ~20, in Sdryer ~40
2:00 PM	107	106	106	small breeze, sunny with few clouds	So many less than at other sites
2:30 PM	106	105	104	more breeze, less clouds	very few in Tdryer, more in Sdryer but ~40
3:00 PM	106	104	103	small breeze, few to no clouds	very few in Tdryer, more in Sdryer but ~40
3:30 PM	110	106	105	small breeze, few to no clouds	very few in Tdryer, more in Sdryer but ~60-80
4:00 PM	109	106	105	small breeze, few to no clouds	very few in Tdryer, more in Sdryer but ~70-90
4:30 PM	108	105	105	small breeze, few to no clouds	very few in Tdryer, more in Sdryer but ~80-100
5:00 PM	106	103	105	sun starting to set	very few in Tdryer, more in Sdryer but ~80-100
5:30 PM	102	100	104	sun starting to set	flies in Sdryer not Tdryer
6:00 PM	95	93	98	sun at 30 degree angle	flies in Sdryer not Tdryer
6:30 PM	81	80	88	sun at less than 30 degree angle	flies a little less
	OT1Ex3	TT1Ex3	RT1Ex3		

Experiment: 3 Date: 24thFeb 08 Site:

Time	O Temp2	Tr Temp2	Re Temp2	Weather	Insects
9:30 AM	98	99	83	Breezy, hazy sun	not many in TD: 30-50, many in SD: 80-100
10:00 AM	101	103	95	light breeze, hazy sun	not many in TD: 30-50, many in SD: 120-140
10:30 AM	103	105	107	light breeze, hazy sun	so many in SD! 150-180
11:00 AM	101	105	106	light breeze, sunny, few to no clouds	so many in SD! 150-180
11:30 AM	103	106	96	light breeze, sunny, few to no clouds	so many in SD! 150-180
12:00 PM	104	108	100	light breeze, sunny, few to no clouds	TD: 50-70, SD: over 200
12:30 PM	104	108	97	light breeze, sunny, few to no clouds	TD: 50-70, SD: over 200
1:00 PM	105	107	98	light breeze, sunny, few to no clouds	TD: 50-70, SD: over 250
1:30 PM	106	108	104	light breeze, sunny, few to no clouds	TD: 50-70, SD: over 250
2:00 PM	107	107	104	light breeze, sunny, few to no clouds	TD: 50-70, SD: over 250
2:30 PM	110	106	105	light breeze, sunny, few to no clouds	SD: not many because when flipped swatted out flies wit
3:00 PM	110	106	104	light breeze, sunny, few to no clouds	SD: 50-70
3:30 PM	112	107	104	light breeze, sunny, few to no clouds	very few in TD, SD: 60-80
4:00 PM	110	108	105	light breeze, sunny, few to no clouds	over 100 in Sdryer
4:30 PM	106	106	105	light breeze, sunny, few to no clouds	over 150 in Sdryer
5:00 PM	105	104	104	sun at angle, small breeze	over 150 in Sdryer
5:30 PM	100	99	101	sun at angle, small breeze	over 150 in Sdryer
6:00 PM	94	92	98	sun setting at 40 degree, small breeze	over 150 in Sdryer
	OT2Ex3	TT2Ex3	RT2Ex3		

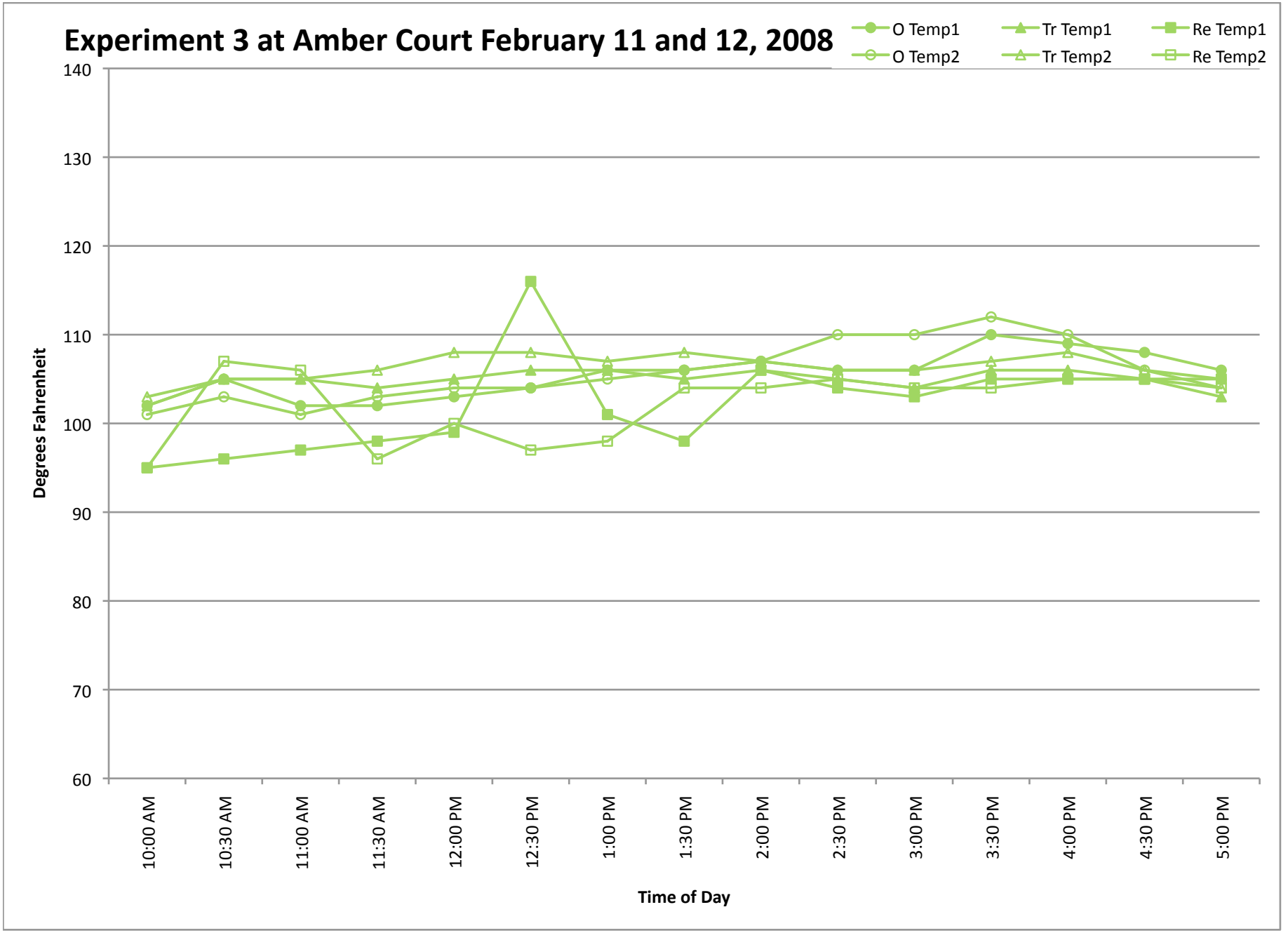
Amber Court

Comments
Thermo in sun so switched sides
Rotated Sdryer
Sdryer Thermo in sun, put on another part
Sdryer Thermo in sun, switch spot
TD: top and middle shelves spotty bottom pretty spotty; SD: top shelf pretty spotty and bottom shelf very spotty

Amber Court

Comments
why flies back?
SD thermo in sun, moved it again
SD thermo in sun, moved it again

h branch


Experiment 3 at Amber Court February 11 and 12, 2008
O Temp1
Tr Temp1
Re Temp1
O Temp2
Tr Temp2
Re Temp2
Degrees Fahrenheit
140
130
120
110
100
90
80
70
60
10:00 AM
10:30 AM
11:00 AM
11:30 AM
12:00 PM
12:30 PM
1:00 PM
1:30 PM
2:00 PM
2:30 PM
3:00 PM
3:30 PM
4:00 PM
4:30 PM
5:00 PM
Time of Day

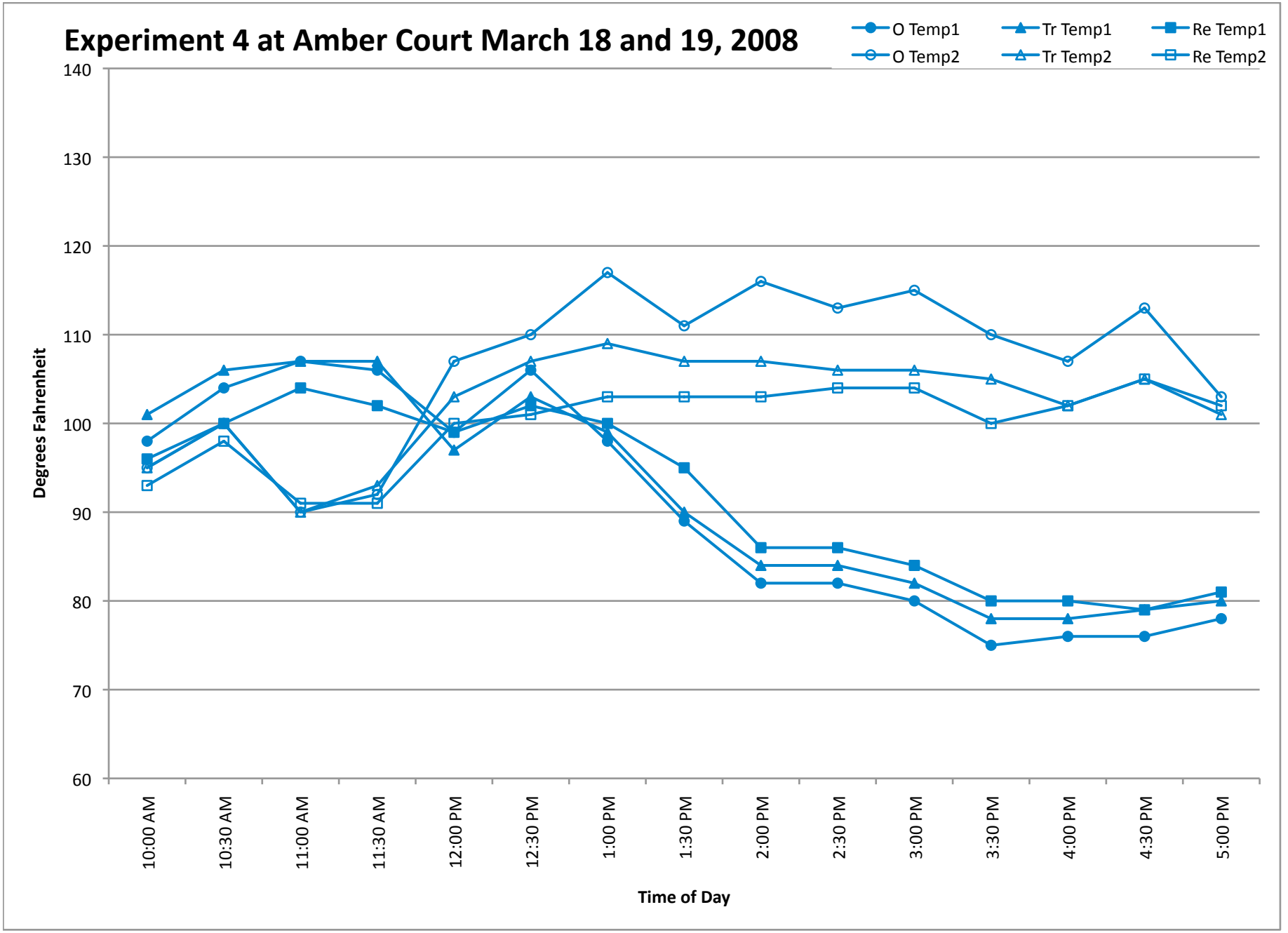
Mugongo Waazi Experiments

Experiment: 4 Date: 18-Mar-08 Site: Amber Court

Time	O Temp1	Tr Temp1	Re Temp1	Weather	Insects	Comments
9:00 AM	94	96	91	hazy sun, small to no breeze	TD: 10-15, SD: over 35	
9:30 AM	95	100	94	sunny, few clouds or breeze	TD: over 15, SD: over 50	
10:00 AM	98	101	96	sunny, few clouds or breeze	TD: over 20, SD: over 70	
10:30 AM	104	106	100	sunny, more clouds or breeze	TD: over 20, SD: over 90	
11:00 AM	107	107	104	Cloudy	TD: over 20, SD: over 90	
11:30 AM	106	107	102	partially cloudy	TD: over 20, SD: over 90	
12:00 PM	99	97	99	Cloudy	TD: over 20, SD: over 90	
12:30 PM	106	103	102	cloudy, small breezy	TD: over 20, SD: over 90	
1:00 PM	98	99	100	overcast	TD: over 20, SD: over 90	
1:30 PM	89	90	95	overcast and breezy	TD: over 20, SD: over 90	
2:00 PM	82	84	86	overcast and small breeze	TD: ~15, SD: over 70	
2:30 PM	82	84	86	overcast and small breeze	TD: ~15, SD: over 70	
3:00 PM	80	82	84	overcast and small breeze	TD: ~15, SD: over 70	SD: top bit
3:30 PM	75	78	80	overcast and small breeze	TD: less than 15, SD: around 50	spotty, bottom
4:00 PM	76	78	80	overcast and small breeze	TD: less than 15, SD: around 50	very spotty
4:30 PM	76	79	79	overcast and small breeze	TD: less than 15, SD: around 50	almost wet; TD:
5:00 PM	78	80	81	sun in the distance, still cloudy	flies in SD laying eggs	top fairly spotty,
5:30 PM	79	80	81	sun in the distance, still cloudy	flies in SD laying eggs	middle spotty,
6:00 PM	76	78	79	sun setting	flies in SD laying eggs	bottom very
6:30 PM	71	74	76	sun setting	very few in TD, SD: 20-30	spotty
	OT1Ex4	TT1Ex4	RT1Ex4			

Experiment: 4 Date: 19-Mar-08 Site: Amber Court

Time	O Temp2	Tr Temp2	Re Temp2	Weather	Insects	Comments
9:00 AM	91	91	87	hazy sun, partial clouds, little to no breeze	TD: over 20, SD: over 50	
9:30 AM	93	92	91	pretty cloudy, little to no breeze	TD: over 70, SD: over 90	
10:00 AM	95	95	93	sunny but cloudy	TD: over 90, SD: over 130	
10:30 AM	100	100	98	cloudy, small breeze	TD: over 90, SD: over 130	
11:00 AM	90	90	91	overcast, felt a couple rain drops, small breeze	TD: over 90, SD: over 130	
11:30 AM	92	93	91	cloudy, breezy	TD: over 90, SD: over 130	
12:00 PM	107	103	100	sunny, partial cloudy, small breeze	TD: over 90, SD: over 130	
12:30 PM	110	107	101	sunny, some clouds, small breeze	TD: over 90, SD: over 130	
1:00 PM	117	109	103	sunny, some clouds, small breeze	TD: over 90, SD: over 130	
1:30 PM	111	107	103	sunny, partial clouds	TD: over 50, SD: over 100	
2:00 PM	116	107	103	sunny, partial clouds	TD: over 30, SD: over 50	
2:30 PM	113	106	104	sunny, partial clouds	TD: over 20, SD: over 30	
3:00 PM	115	106	104	sunny, partial clouds	TD: over 20, SD: over 30	
3:30 PM	110	105	100	partially cloudy, breezy	TD: over 20, SD: over 30	
4:00 PM	107	102	102	partially cloudy, breezy	TD: over 20, SD: over 30	
4:30 PM	113	105	105	some clouds, small breeze	TD: over 20, SD: over 30	
5:00 PM	103	101	102	wispy, covering clouds, small breeze	TD: over 20, SD: over 30	
5:30 PM	93	92	93	hazy sun at 45 degrees, little breeze	TD: over 20, SD: over 30	
	OT2Ex4	TT2Ex4	RT2Ex4			


Experiment 4 at Amber Court March 18 and 19, 2008
O Temp1
Tr Temp1
Re Temp1
O Temp2
Tr Temp2
Re Temp2
Degrees Fahrenheit
140
130
120
110
100
90
80
70
60
10:00 AM
10:30 AM
11:00 AM
11:30 AM
12:00 PM
12:30 PM
1:00 PM
1:30 PM
2:00 PM
2:30 PM
3:00 PM
3:30 PM
4:00 PM
4:30 PM
5:00 PM
Time of Day

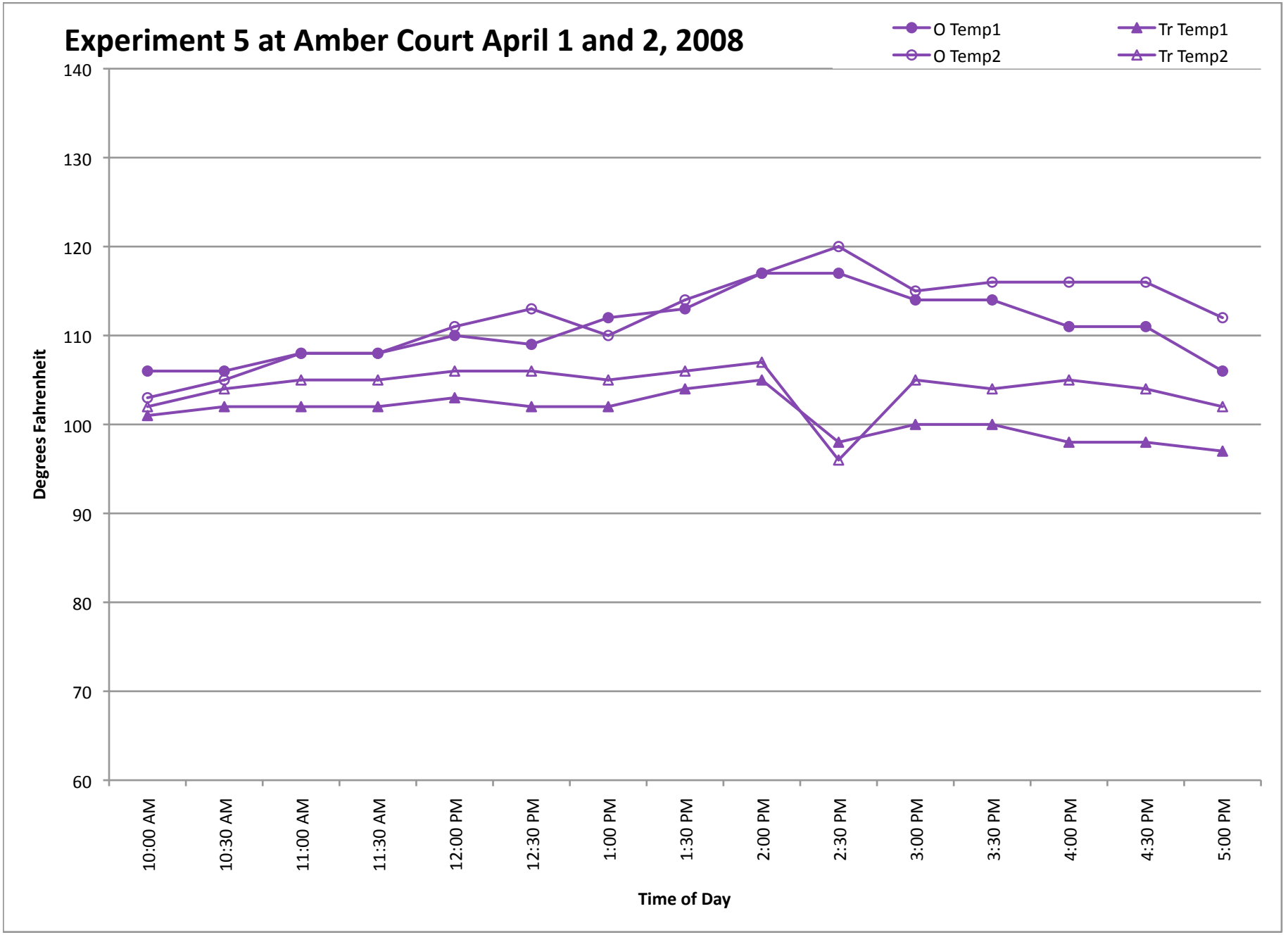
Mugongo Waazi Experiments

Experiment: 5 Date: 1st Apr 08 Site: Amber Court

Time	O Temp1	Tr Temp1	Re Temp1	Weather	Insects	Comments
10:15 AM	106	101		Cloudy, sunny, little breeze	70-100 many!	
10:30 AM	106	102		Cloudy, sunny, little breeze	70-100 many!	
11:00 AM	108	102		Cloudy, sunny, but breezy	~70	
11:30 AM	108	102		Cloudy, sunny, but breezy	~70	
12:00 PM	110	103		puffy clouds with small breeze	~70	
12:30 PM	109	102		puffy clouds with small breeze	~70	
1:00 PM	112	102		puffy clouds with small breeze	~70	
1:30 PM	113	104		puffy clouds with small breeze	many flies on tarp outside flying around	
2:00 PM	117	105		puffy clouds with small breeze	50-70	
2:30 PM	117	98		puffy clouds with small breeze	50-70	flipped fish from 2-2:30pm
3:00 PM	114	100		puffy clouds with small breeze	inside but on outside again, ~70	
3:30 PM	114	100		not many clouds	~70	
4:00 PM	111	98		not many clouds	50-70	
4:30 PM	111	98		no clouds, breezy	50-70	
5:00 PM	106	97		sun starting to droop, 45 degrees	50	
5:30 PM	103	94		sun starting to droop, 35 degrees	50	
6:00 PM	98	92		sun starting to droop, 30 degrees	50	
	OT1Ex5	TT1Ex5				

Experiment: 5 Date: 2nd Apr 08 Site: Amber Court

Time	O Temp2	Tr Temp2	Re Temp2	Weather	Insects	Comments
9:30 AM	102	86		hazy sun, light breeze	many! Over 130	
10:00 AM	103	102		many wispy clouds, light breeze	many! Over 150	
10:30 AM	105	104		many wispy clouds, light breeze	many! Over 151	
11:00 AM	108	105		wispy clouds, slight breeze	many! Over 152	
11:30 AM	108	105		wispy clouds, slight breeze	many! Over 153	
12:00 PM	111	106		wispy clouds, slight breeze	many! Over 154	
12:30 PM	113	106		wispy clouds, slight breeze	many! Over 155	
1:00 PM	110	105		wispy clouds, slight breeze	many! Over 156	
1:30 PM	114	106		wispy clouds, slight breeze	getting less, 100-130	
2:00 PM	117	107		wispy clouds, slight breeze	getting less, 100	
2:30 PM	120	96		wispy clouds, slight breeze	getting less, 100	flipped fish from 2-2:30pm
3:00 PM	115	105		wispy clouds, slight breeze	getting less, 70	
3:30 PM	116	104		wispy clouds, slight breeze	getting less, 70	
4:00 PM	116	105		wispy clouds, slight breeze	getting less, 70	
4:30 PM	116	104		wispy clouds, slight breeze	getting less, 70	
5:00 PM	112	102		sun at almost 45 degree angle	getting less, 50	
5:30 PM	104	98		sun at almost 45 degree angle	getting less, 50	
6:00 PM	89	92		sun at almost 30 degree angle	getting less, less than 50	
	OT2Ex5	TT2Ex5				


Experiment 5 at Amber Court April 1 and 2, 2008
O Temp1
O Temp2
Tr Temp1
Tr Temp2
140
130
120
110
100
90
80
70
60
Degrees Fahrenheit
10:00 AM
10:30 AM
11:00 AM
11:30 AM
12:00 PM
12:30 PM
1:00 PM
1:30 PM
2:00 PM
2:30 PM
3:00 PM
3:30 PM
4:00 PM
4:30 PM
5:00 PM
Time of Day

Appendix F

Mugongo Waazi Experiments Comments

Experiment 1-Site: Loco Village

Date: 6th November, 2007-Tuesday

Problems occurred to date:

- Building of Dryers:
  - Want as many organic and local materials as possible
  - Want poles and rope but timber available for low price so use with nails and use papyrus mats instead of mesh chicken wire
  - Chicken wire not optimal because of inorganic nature, ability to rust and cost
- Maximum heat and efficiency with clear and black plastic
  - In past experiments sun at angle but very little angle here because on equator and earth's tilt not angled enough
  - In triangle dryer put black on one side and over top to maximize heat containment
  - In rectangle put black on short sides to allow max sunlight in
- Size of dryers and number of shelves
  - Triangle dryer too wide
- After dryers sitting in semi shade for over a month:
  - Dirt on clear plastic-wiped off
  - Black plastic became brittle and shreds soon on triangle dryer
    - Top of plastic use clear
    - Side of dryer replace with thick plastic
- At Loco:
  - Angle of dryers verses sun
  - Payment of fish-try bargaining but locals overcharge, to go factory and pay local to clean- 400/= per kilo, at 350 kilos, 140,000/= per day
  - Around 350 kg per load

Date: 7th November, 2007-Wednesday

- Around 4:30pm fish delivered from factory fresh from being cut, immediately people start cutting and washing MW
- Issues:
  - water comes from swamps-very dirty!! What is in it?
  - Salt water not uniform because gericans not 20 L exactly and make 'level' scoop for 600 ml salt but not exact and everytime different and salt there before?
  - Soaking time not exact because 1 gerican and needed ~10 trips to get them
  - Ended late, pretty dark-people wash well? Water buckets for washing very dirty with blood, guts and dirt

- Around 6pm start putting fish heads into buckets and saltwater from 6:10pm – 6:35pm (those in lower shelf of triangle dryer)
- Then put bodies into buckets and saltwater (triangle dryer) then other heads (some in rectangle dryer) then other bodies (extra) in bucket ending at 7:15pm
- Issues: Pour dirty fish water (separate guts and brains) on ground or into marsh, within 10-15 yards of where retrieve 'clean' water

Date: 8th November 2007, Thursday

- Arrived at site at 7am and started filling dryers, finished at 7:3am with help of 1 man with the triangle dryer
- Finished square dryer by 8am and starting laying out extra fish and cleaning buckets, done by 9am
- Hammered nails for thermometer at 9:15 and made data sheet
- Issues:
    - Size of fish aren't uniform, place on scales or meat side up? I place scales side up
    - Soaking time and drying time not uniform because placement of fish takes time, try to take out 1st fish soaking in barrels to be placed in dryer first
    - Bought almost 2x as much fish as needed, but good to test difference between air dried, only need 150-200 kg
    - Thermometers not correct-banged up in shipping? No way to test them. Placement important, try to place outside thermometer with minimal sunshine hitting it.
- At 1pm toilet paper test-fish need to be flipped and possibly rotated
- Improvements for next time:
    - Take out middle 2 racks in rectangle dryer
    - Make both sides clear plastic on triangle dryer and on rectangle dryer
    - Seal air vents on bottom and top

Experiment 2-Site: Masese

Date: 6th February 2008-Wednesday

- At 11am called Madina: "Have fish, no fish, come tomorrow"?-language barrier
- Wait til afternoon for Rogers or Ernest to help me to call Madina
- ~4:30pm Roger calls Madina: "she doesn't have enough money for fish- expensive and scarce." Since I got fish previously at Gomba before, Rogers got 'contact name' for Gomba and we agree to meet tomorrow at Gomba at 10am.
- No one else I know has English skills, project understanding, and my well being in mind enough to help except Rogers, Ernest and maybe Beatrice

Date: 7th February 2008-Thursday

- Meet Madina at Gomba ~ noon-she has no money.
- See lady manager at Gomba-tell me "they sell mugongo waazi everyday at 9am except some Sundays no. If not there by 9 or 10 the fish are gone."

- I decide I can't wait for Madina to get fish. Make agreement with her that if I supply funding for operation, she gives me back what I put in and she keeps profit-drew up budget.
- All agree to meet Sunday morning to get fish

Date: 10th February 2008-Sunday

- Met Madina at Gomba Marine about 11am
- With some fillet vs head problems we got rest of full carcusses and heads (~850 kilos) by about noon start loading at 11:11am, finish at 12:15pm-manager at Marine is a deceptively nice man
- Bought salt on way to Masese site, with car trouble arrived ~1:30pm
- I was very angry because when arrived fish dryers had clothes inside and on top of it, plastic bags and basins on shelves; plastic cut vertically and other punctures and some sheets not attached to the side anymore. Workers claimed it was wind-obviously not, maybe some if the whole sheet ripped off, otherwise it was children. Determined not to have a loco village experience twice, I wanted to change locations and/or people. Madina told me they don't understand well, but I'm angry because I have to spend time and money to fix the dryers. I try to call Ernest around 2:30pm, it rains and I have no airtime. I eventually called, he said he'd be there at 4. We went to get my tools and something to eat at Rogers. On way back to Masese, market closed, can't get more clear plastic sheets. Arrive to Masese around 4:30pm and try to call Ernest again. Give up on Ernest and start patching holes with duct tape and try reattaching plastic sheets. Have little sheet left over from last time and use it for door of triangular dryer and fix poorly attached rectangular dryer sheets. Started to organize fish around 6pm-I figured whether it's at Masese or town hall I need to fix the dryers and I need to start the experiment. Ernest came around 6:15pm or so. He said a few words to Madina, he told me they are going to talk to the workers about the dryers. I told Ernest that I don't trust them and don't want to spend time and money <u>again</u> (3 times already) to fix dryers. I said I'll pay for transport of the fish to and from Masese but I want to conduct the experiments somewhere else. Experiment 2 can be done at Masese but Experiment 3, etc done at Town hall. Ernest said since TH is so public I should bring to Rogers house. We agreed upon that. Since Madina seems ok I'll continue to get fish from her to use. Rogers and I continued past dark to fix dryers , 7:35 or so. Almost finished…

Date: 11th February 2008

- I arrived by bike at 7am. Didn't have time to fix door of rectangular dryer so do while monitoring temperature-see a difference! Before loading fish I had to change orientation of dryers by myself and it took over 20 minutes. Transferring fish from barrels to tops to arranging in dryers takes a long time about an hour and a half.
- Want to study other fish as well. Some leftover fish I'm drying on a tarp and observing at same time as dryers. I wanted to observe Madina's fish because received, cut and cleaned same time as mine because same batch. She has hers under a tarp after finishing salting last night, she wants to dry tomorrow.

Notes:

- Arrive at Masese: 7:01am
- Action: Positioned dryers to maximize sun by myself
- Sun: at 7 am the sun rising behind clouds, fairly windy
- Load Fish into big, triangle dryer from 7:24am til 9:02 am by myself with outside temperature of 70F
- Load fish into small, rectangular dryer from 9:02am til 9:20am with the sun starting to come out, see random shadows
- Spread remaining fish onto a tarp on the ground from 9:20am til 9:50 am with weather pretty cloudy (overcast) with a small breeze
- Madina says there are many flies because not enough salt-salt acts like acid covering
- Madina decide to start drying tomorrow, let coat of salt soak in a bit more
- Seems wind is keeping dryers cools, but need some airflow and non-taunt plastic so night wind doesn't tear plastic
- Flies huge problem, inside and outside dryers, for tarp fish birds help to lower number but they eat the fish
- The flies know how to get in but they are trapped, when did wet test many flies few out
- By ~2 or 3 pm birds decreased: too hot, given up, not hungry?
- Noticed at 2:30pm that both outside and small in sun not big and condensation but only that side
- I don't think dryers are getting hot enough to kill the fly larvae
- Women at site said something about fish oil and a lot of salt dries it… language barrier and probable misunderstanding. But my fish do have a lot of fish oil, looks wet but just oily.
- Ladies at site keep telling me the fish will get maggots but theirs don't because of the high level of salt.
- I want to research the life cycle of the common fly
- About 5:15pm Madina looks at fish drying on tarp. The large fish heads have fly larvae that will turn into maggots. The small and medium sized heads do not seem to have. Checking 2 random ones in the dryers, one fish had eggs, another didn't- both medium sized.
- Although I was never shown fly larvae before, at loco I don't remember seeing maggots on the fish.
- Loco vs Masese:

Loco	Masese
Many flies	Disgusting number of flies
Dry season	Wet season
Excruciatingly hot (constant sweat)	Tolerably hot (little sweat)
Small breeze	Moderate breeze with chance of high wind
Many trees and bushes around	No tall foliage for coverage near by
Few animals	MANY birds-small white & marabou stork
Workers get water there at inlet of lake or in wetland area 15-10 feet away	Hire a man to get water from lake about 100 meters away

Date: 12th February 2008, Tuesday

- Arrived at 7:05am then arranged fish on tarp and put thermometers on dryers
- Both dryers still had ~50 flies already there
- Both dryers smelled bad from ~5 ft away like rotten fish, not a good sign and tarp ones smelled but not as bad
- At 11:50am felt few drops rain, with drops and heard thunder, blouds and breeze Madina and others started to pile up fish to put under tarps so I also put my few tarp fish in a pile and then under the tarp, by 12:10pm better out, I don't think we'll get rain but I'm not going to argue with locals about weather
- Birds not a problem today because people are here cutting and cleaning new fish and so they hang out there to get the guts and brains
- At 1:20pm workers felt we are not getting rain so started putting out fish-so did I
- Many fish look dirty even though not on ground, lake water very dirty
- Around 3pm I took pictures of Madina's fish that sat for a day in the salt. It seems they have over saturated completely the fish so they dry fast but I can't imagine they taste good-they don't look appetizing-salt costs a lot too
- Madina says she tried brining but by time fish got to market they were black, I think that means rotten. I have asked her to record the fish's condition when she sells them at the market.

Possible Reasons for Failure (fish turning black or dark red (rotting?) and not drying within 2 days)

- Salt:
    - Water used contaminated-large bacterial infection
    - Added salt water after fish in barrels so salt not reach fish uniformly-noticed salt left over in bottom of gericans
    - Salt water not mixed well enough so not all fish absorbed enough salt
- Flies:
    - Too many, over abundance
    - Dryers and sun not hot enough to kill bacteria and fly eggs
- Convective heat transfer vs heating fish with direct sun
- To dry, sunlight is a must, some fish still in shade
- Heaters have higher temp if more air tight, less wind current
- Looser plastic sheets provide more air current and ventilation for CHT

Madina's Comments on Tarp Heads:

- The small and medium heads are ok, enough salt
- The big heads require more salt
- Since not use as much salt they are not as clean and become black
- Can sell but at lower price-customers think look bad
- Also get less money because salt weighs more and since way less weight

Madina's Comments on Triangular and Rectangular Dryers' Heads and Bodies:

- Would have dried and not get maggots if more salt
- If flip, would by dry now
- Middle and top ok but bottom not get enough sun

Therefore, when Madina goes to the market on Sunday, sells on Tuesday and Friday will try to fill out form I give her. Also keep each batch separated and marked so that any weight and price difference from hers I will reimburse her for. When at Rogers' house will have the same arrangement but will pay for cleaning and cutting.

Experiment 3-Site: Rogers' House

Date: 22nd February 2008, Tuesday

In lieu of salt dissolvability tables, took a 1.5 L bottle full of 1 L of tap water and by adding T by T of salt and shaking the bottle until the salt dissolves and once the salt will no longer dissolve after 30 seconds or so of shaking I know I have approached the saturation point to as close as I can get in that environment. Using this method, it took 13 T to reach the saturation point.

Therefore for a 20 L gerican needs around 16 C salt:

$$=13 \quad 1 \quad \times 2 \quad 32 \quad \times 20 \quad 1$$
$$=16.25$$

- Getting supplies took a long time and 11-11:30pm I got saltwater to barrels of fish and let soak for 10 hours until 9 am.

Date: 23rd February 2008, Wednesday

- Started placing fish in dryers at 9am done at 9:45am, outside temp 100 but thermometer is partially in sun
- Not many flies around
- In TDryer, not put fish in bottom shelf middle of shelf
- In TDryer, interplaced fillets with heads in middle and bottom shelves
- Thermometer outside is partially in sun in morning
- Switched thermometer in TDryer to otherside so not in sun
- At 9am a lot of dew and condensation on inside of dryer but most gone by 10 am
- There is a lot of condensation on front part of dryer, that means it's too humid and moisture can't escape, but on the top there are large openings. Maybe there needs to be ventilation holes near the middle shelf?
- I switched the SDryer ninety degrees because the sun
- Since last time it was recommended we flip, if ~2:30pm fish dry will flip them
- Most condensation in TDryer gone at 1pm
- At 2:30pm, after wetness test, decided to flip fish til 2:55pm
- Many flies in SDryer not TDryer, and most came in late afternoon/evening
- At 6:30pm had to put back in barrels because owner of land afraid of wild dogs. So each dryer have a barrel for each level alternate face down and face up and finish at 7pm

Date: 24th February 2008, Thursday

- At 7am too cold, too much dew, at 8 started putting fish out, done by 9am, temp 86
- At 8 almost no flies in or around dryers, after putting out fish for 10 minutes they swarmed, mostly to bottom racks, more so in SDryer, at 9am almost 30-50 in TDryer, 70-80 in SDryer
- Positive about taking out of barrel: miss night dew, flies not have to time or opportunity to breed, less night or morning cold
  Negative about taking out of barrel: fish not in same place as before (tried as much as possible), extra work
- Because so many flies in SDryer, I untapped top tarp to encourage them to leave
- At 2pm flipped the fish, all seem dry in TDryer, the top shelf of SDryer almost dry but on bottom shelf not dry. No maggot eggs seen, but may be because only small-medium sized heads
- Start to pack fish up at 6pm to bring to Madina at Masese and all fish in TDryer seem to be done, top shelf of SDryer is done and bottom fish seem to be almost done

Date: 25th February 2008, Friday

Taste Testing at Masese Village Site

Need: 2 esigiri (coal stove), Amanda (coal), obutungulu (onion), ennyannya (tomato), ekambe, toothpicks, essofiiya (bowls), egiiko (spoon), essowani (), amabutto (oil), omunyo (salt), ebidomola w'amazzi, mubuzi mix, get pots and utensils and gericans at Rogers

- At 4:25pm broke 2 larger pieces of Madina's and 3 smaller pieces of mine into pots to soak until 5pm
- Brought 2 pieces each for appearance and feeling test
- For testing:
  - Appearance: 1-traditional, 2-Solar
  - Touch: A-Solar, B-traditional (dirtier, duller black plastic bag)
  - Taste: I-traditional, II-solar (smaller pot)
- As MW trad and MW solar sitting in grass, awaiting tests, flies LOVE MWsolar, left MW trad alone mostly
- From 5-5:25 Rogers cleaned MW each 2x, took pix of water after first washing then sautéed veggies in oil 5:25-5:40pm (spice: 1 heaping t mchuzi mix, ½ t black pepper; veggies: 3 med/small tom, 3 med/small onions, 1 garlic clove, ½ small green pepper)
- At 5:40pm added water, stirred and put on top at 5:45pm til stir at 5:52pm and 6:00pm and 6:12pm
- At 6:15pm started by myself doing survey to show how to do it

Experiment 4-Site: Rogers' House

Date: 17th March 2008, Monday

- Went to Gomba 2nd March to 5th March, no fish, see calendar
- 17th march got fish from Gomba at 11am
- Done washing by 1pm
- Loaded in barrels and at Rogers' house by 2pm
- Sad outside, partial sun til 6:30pm
- Barrels inside and salt water added from 6:45-730pm
- Next morning a faint odor-it's from barrels in sun?
- Same amount of salt as last time, 20L water for 16 C salt, ~12-15 kilos salt

Date: 18th March 2008, Tuesday

- Found dryers with dust and condensation on plastic
- From 7:45-8:30am put fish out on dryers
    - TD: top-have large heads; middle-small/med heads try to put medium heads on outside; bottom: have fillets, try to put large ones on outside, few in middle
    - SD: top have med/lg heads with large fillets; bottom have smaller fillets on the sides
- At 8:30am temps were all 80 degrees
- A lot of dust from road construction around house-after washing buckets, at 9;30am wipe off plastic
- About 12:15pm hear thunder and dark clouds in distance
- Began to rain when I flipped the fish from 1:45-2:15pm
- When flipped fish, noticed ants in some areas, more in Sdryer but some in TD, bottoms and middle
- From 6:30-7pm put fish back in barrels, looked for fly larvae in a couple (3) heads on top shelf of SDryer, didn't see any

Date: 19th March 2008, Wednesday

- Again, from 7:45-8:30am brought fish from barrel to dryer
- At 8:30 am the temperature outside was 82 degrees
- A lot of dew in morning with flies and ants already there, when putting in fish, many flies
- At 10am noticed top of dryer has plastic flaking off
- At 2:30pm flipped fish til 2:50pm with Rogers. Noticed a large decrease in flies and did not notice as many ants

Obtaining Fish Issues:

Date: 19th March 2008, Thursday

- Since now have to deal with new managers at Gomba to get 6 tonnes fish, they give 300 kilos every other day

Got fish for Madina on Sat 22nd and Tues 25th

Experiment 5-Site: Rogers' House

Date: 31st March 2008, Monday

- Went to Marine about 10:15am-person hit my bike
- Only got 100 kilos fish-not want to give me any
- Keep charging me extra-380/=per kilo instead of 300/= per kilo
- Have 'interview' with general manager: not good, very rude, blunt, short answers; when asked, 300 for poor people because I'm not
- Put 100 kilos in 1 barrel
- About 12:30pm people cut and cleaned fish
- By 2pm at Rogers' house but inside room
- At 7pm put 1.5 gericans (~30L) water to barrel with rest of salt; therefore for 250 kilos fish used 20 kilos salt or ~4.5 gericans

Date: 1st April 2008, Tuesday

- 8:30am start, 9:45am at 104 degrees outside
- Started putting fish in dryer at 8:30am
- Finish at 9:45am, outside temp at 104
- Flies come as I'm putting fish in the dryers
- I only put fish in the triangular dryer because availability of fish and rectangular dryer not work very well, but prove 100 kilo fish fits in triangular dryer
- Only fillets in bottom shelf, but not in middle
- Took photo of fish at 11am, took up tarp, flies came out with heat
- Flipped fish from 2-2:30pm and no ants noticed this time
- At 6pm-6:30pm put fish away in barrel
- When putting fish away, looked at 3 of them on top, 4 in middle and 4 on bottom, no fly larvae! Almost all on top are dry, most on edges mostly dry, in middle need more time and bottoms are almost completely dry

Date: 2nd April 2008, Wednesday

- From 8:15-9:30am put out fish, at 8:15 a lot of dew on outside of dryer and by 9:30am SO many flies kept coming as I put out the fish, more because only using 1
- Each time I go to check temps, I try to get the flies out by hitting side on tarp and lifting flap on top

- From 2-2:30pm I flipped fish in dryer, all seemed to be done
- From 6-6:30pm put fish in barrels then brought to Masese

Date: 12th April 2008, Saturday

Taste Testing at Kangulumira R/C Primary School

- From April 3-12th MW in rice bags in my goat house
- Got out fish, cleaned with toothbrush then soaked for an hour (9:20-10:20am)
- Cleaned again and soaked for 45 minutes (10:30-11:15am)
- Cut up fish and added to veggies at 11:30am-noon
- Boiled noon-12:45pm
- Serve and do taste testing at noon
- This morning, after a big rainstorm fish are not mouldy but damp, even inside plastic bag or rice sack
- After 10 days, both fish don't smell horribly but my fish has some dark spots but Madina's doesn't-even close up fish both smell normal
- Very difficult to cut fish heads into parts
- Testing:
    - Appearance: 1-Madina's, 2-Allie's
    - Touch: A-Madina's, B-Allie's
    - Taste: I-Allie's, II-Madina's
- By 12:30 green sigiri not make stew boil so switch pots

Appendix G

Mugongo Waazi Producer Survey

Names:	*Nakayiza Madina (used interpreter Tenywa Rogers)*	*Birabwa Sarah, Natukunda Immaculate, and Namukasa Rose (Sells in Congo) All 3 women are workers of all bosses (Mama Sandra, Madina) as washers, salters, packers, dryers, etc. (interviewed by interpreter Tenwya Rogers)*
Date:	*30th April 2008*	*8th of May 2008*
Location:	*Masese (met in Jinja town)*	*Masese*

Work History

1. How long have you been drying mugongo waazi?

8 years	*8 years*

2. Have you always worked at this site?

No, first worked for 6 years next to fish factory on Masese town, like 1/2-1 km away from current site	*No, I first worked at Masese fish factory in Masese town then we went away to the current site. (all moved together)*

Brining

1. What is the method of salting you currently use?

After washing, take handfuls of salt and manually spread on fish then pile and wait for 2 days.	*Direct spreading after washing the fish and then wait for 2 days in heaps under tarps*

2. Have you ever tried salting by brining? When?

Never	*No*

3. Why not or why did you stop?

Did not know the method	*Brining takes a long process and the fish does not look nice after drying it (because fish can look darker than with salting)*

4. After seeing the results of mugongo waazi that were brined will you use that method? Why or why not?

No because her salthing method keeps the fish longer, almost a month but with brining not as long (when took my fish last time had to wait for a week in Congo and my fish went bad. The fish in tarp when waiting gets hot and humid and absorbes water, put in sun again and are decent to sell) Also because when fish gets so dry and not as much salt they get less money for fish because sell by the kilo. Therefore, no, would not sure brining method.	*No because brined Mugongo Waazi does not last long reason being that there is not enough salt on the fish there by attracting flies which contaminate the fish.*

Solar Dryers

1. Of the two dryer designs (rectangular or triangular), which design works best to dry the fish in the most sanitary and efficient way?

Triangular	*Triangular*

2. Do you have any ideas to lower the cost to build the dryers?

No idea	*No idea*

3. Do you have any ideas to improve the design of the dryers?

- *Chicken wire instead of papyrus as shelves* - *Make shelves timber like thin fence across shelves* *Basically she thinks the papyrus isn't strong enough*	*Using wire mesh instead of papyrus reason being that papyrus are not strong enough to hold a full tone. (but not need ton because fish can't overlap)*

4. In the future, will you use the solar dryer design? Why or why not?

She hopes in future when she has enough money to build them will use because keeps fish clean and it dries well	*Yes as long as we continue using our method of spreading salt on the Mugongo Waazi*

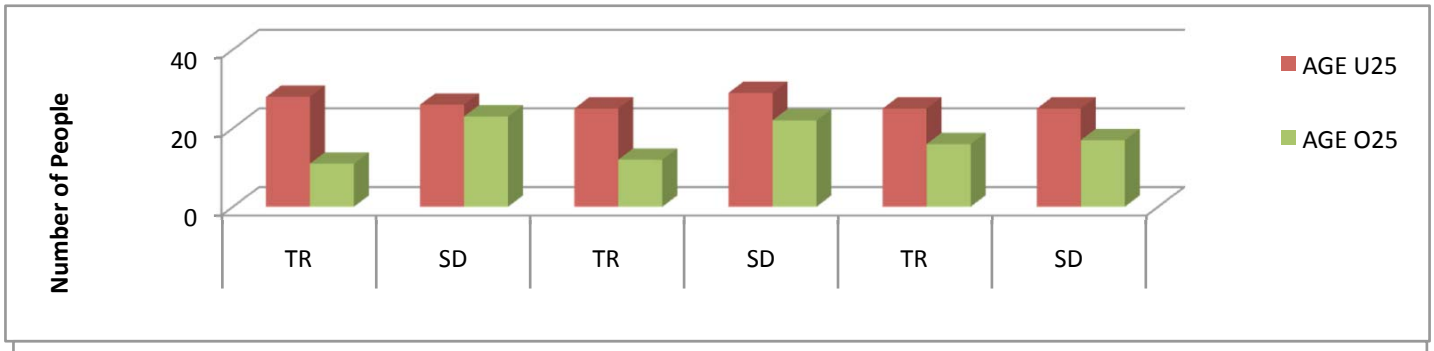
5. Any overall comments?

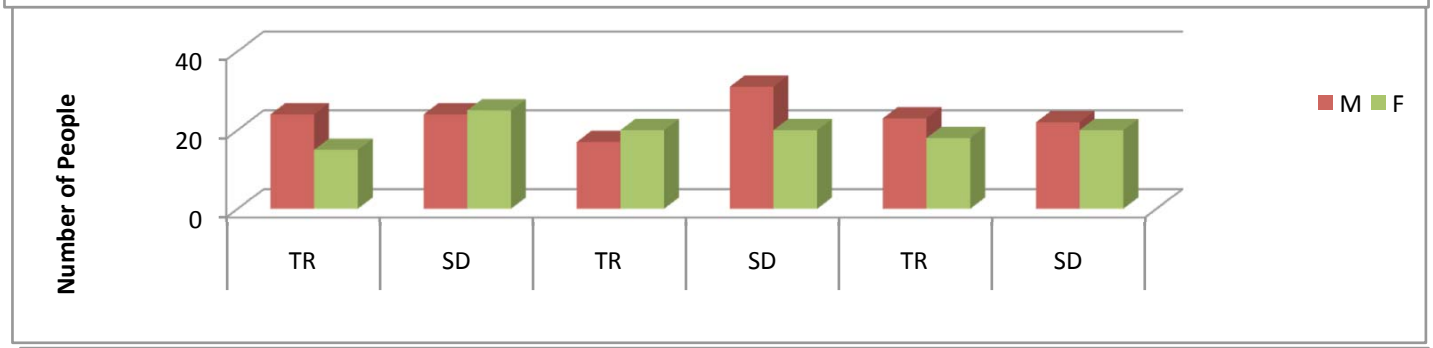
- *My fish looked nice but wouldn't keep long-need more salt. Liked my method better if used more salt therefore she salts the fish her way then uses solar dryer.* *The other women and men at the site won't complete the survey because they think I'm a business women, will bring information to the US, come back and close their business.*	*Brining Method attracts more flies in the area of work* *Dryer method helps keep away birds*

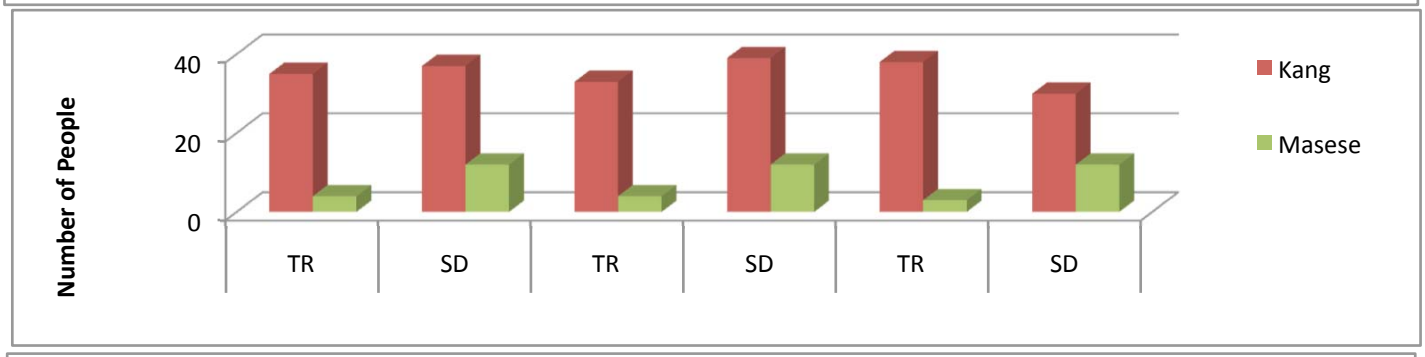
Appendix H

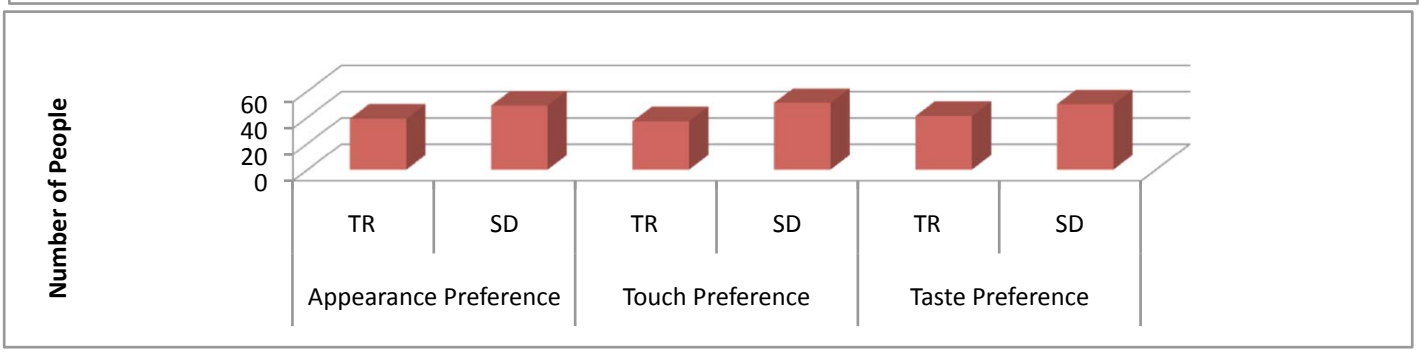
Mugongo Waazi Taste Testing

Factors		Appearance Preference		Touch Preference		Taste Preference	
		TR	SD	TR	SD	TR	SD
Overall	Overall	39	49	37	51	41	50
AGE	U25	28	26	25	29	25	25
	O25	11	23	12	22	16	17
GENDER	M	24	24	17	31	23	22
	F	15	25	20	20	18	20
LOCATION	Kang	35	37	33	39	38	30
	Masese	4	12	4	12	3	12









Mugongo Waazi Taste Testing

Location: Kangulumira R/C P/S Date: 12th April 08

					Appearance Preference		Touch Preference		Taste Preference	
	Name	Nationality	Gender	Age	1	2	A	B	I	II
1	Nakazibwe Kevin	Ugandan	F	23		1		1		1
2	Kigongo Isah	Ugandan	M	23		1		1		1
3	Nansanja Oliver	Ugandan	F	23		1	1			1
4	Kasana Betty	Ugandan	F	22		1		1		1
5	Amojong M. Brendah	Ugandan	F	26		1		1		1
6	Emol Max	Ugandan	M	53	1		1		1	
7	Lugwanirya James	Ugandan	M	25		1		1		1
8	Mutabaali Ahamedi	Ugandan	M	26	1			1	1	
9	Ngobi Godfrey	Ugandan	M	22	1		1			1
10	Mafabi John	Ugandan	M	26	1			1	1	
11	Nyonga Geoffrey	Ugandan	M	29		1		1		1
12	Nabagala Taikia	Ugandan	F	8		1		1		1
13	Sanyu Lydia	Ugandan	F	9		1		1	1	
14	Kabete Zlyna	Ugandan	F	13		1		1		1
15	Nalokuma Monica	Ugandan	F	9		1		1		1
16	Juuko Sharif	Ugandan	M	13		1		1		1
17	Semudu Richard	Ugandan	M	12		1		1		1
18	Mugenyi Edward	Ugandan	M	40	1		1			1
19	Nantale Prossy	Ugandan	M	22		1	1			1
20	Kamlala Daniel	Ugandan	M	17		1		1	1	
21	Abagenyi Robina	Ugandan	F	15		1	1			
22	Abakaba Jaleva	Ugandan	M	15		1		1		1
23	Nafuna Carol	Ugandan	F	32		1		1		1
24	Logose Mercy	Ugandan	F	26		1		1		1
25	Acho Christine	Ugandan	F	14	1		1		1	
26	Nantum Marriam	Ugandan	F	13	1		1			1
27	Mukebezi Hakim	Ugandan	M	14		1		1		1
28	Kiwana Didas	Ugandan	M	15		1		1		1
29	Kiiza Brian	Ugandan	M	14		1		1		1
30	Isabirye Ben	Ugandan	M	13	1		1			1
31	Nambuya Sarah	Ugandan	F	13	1		1			
32	Namusisi Lilian	Ugandan	F	14	1		1			1
33	Wanzagino Enoch	Ugandan	M	13		1		1		1
34	Ombele Ratib	Ugandan	M	13		1		1		1
35	Kimbugwe Ceasar	Ugandan	M	14	1		1			1
36	Okello Francis	Ugandan	M	30	1		1		1	
37	Nabukonde Shamila	Ugandan	F	14	1		1			1
38	Lubega Ivan	Ugandan	M	14	1			1	1	
39	Mbaziira Ronald	Ugandan	M	14	1		1			1
40	Namboze Evelyn	Ugandan	F	14	1		1			1
41	Mutawe Robert	Ugandan	M	12	1		1			1
42	Longino Bulangula	Ugandan	M	14	1			1	1	

43	Sserwanja Jesse	Ugandan	M	13	1			1	1	
44	Nankabirwa Juliet	Ugandan	F	12	1		1		1	
45	Nalumu Grace	Ugandan	F	10	1			1	1	
46	Lumu Mark	Ugandan	M	11		1	1		1	
47	Julibatono Martin	Ugandan	M	12	1		1			1
48	Amoro Carol	Ugandan	F	13		1		1	1	
49	Auma Prossy	Ugandan	F	13	1		1		1	
50	Mugala Viola	Ugandan	F	11	1		1		1	
51	Kukisa Farouk	Ugandan	M	13		1		1	1	
52	Ssekulima Paul	Ugandan	M	12		1		1		
53	Kakooza Juma	Ugandan	M	11	1			1		
54	Namabiro Oliva	Ugandan	F	13	1		1		1	
55	Nassimbwa mary	Ugandan	F	13	1		1			1
56	Naluwembe Justine	Ugandan	F	13	1		1			1
57	Sande Ronald	Ugandan	M	13		1		1		1
58	Musisi Nicholas	Ugandan	M	13		1		1		1
59	Nugalu Gerald	Ugandan	M	9		1		1	1	
60	Bagaya Eddy	Ugandan	M	10	1		1		1	
61	Ssentamu Nirisa	Ugandan	M	13		1		1	1	
62	Bwayo Mutwalibi	Ugandan	M	14		1		1	1	
63	Mukule Clement	Ugandan	M	12	1			1	1	
64	Semakula Lawrence	Ugandan	M	13	1		1			1
65	Bukenya Sylvester	Ugandan	M	14	1			1	1	
66	Nalungo Ritah	Ugandan	F	12		1	1		1	
67	Nambooze Aisha	Ugandan	F	12		1	1		1	
68	Kapele Abby	Ugandan	M	13	1		1		1	
69	Edidu Denise	Ugandan	M	12	1		1		1	
70	Maama Winnie	Ugandan	F	29		1	1			1
71	Kayegi Beatrice	Ugandan	F	44	1		1		1	
72	Nafuna Winnie	Ugandan	F	17		1		1	1	
73										
74			Totals		35	37	33	39	30	38
75										
76					M	A	M	A	A	M
77										
78										
79										
80										
81										
82										
83										
84										
85										
86										
87										
88										
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90										

Mugongo Waazi Taste Testing

Location: Masese Mugongo Waa		Date:	25th Feb 08		Appearance Preference		Touch Preference		Taste Preference	
	Name	Nationality	Gender	Age	1	2	A	B	I	II
1	Namutebi Allie	American	F	25		1	1			1
2	Nswadi Mugrej	Ugandan	F	52		1	1			1
3	Manatov J	Ugandan	F	25		1		1	1	
4	Natongo Aha	Ugandan	F	27		1	1			1
5	Namukose Asha	Ugandan	F	48		1		1		1
6	Twyukye Slirer	Ugandan	M	28	1			1		1
7	Ssebayigga Tibulisio	Ugandan	M	38		1	1			1
8	Halima Mutesi	Ugandan	F	37		1	1			1
9	Mukesa Jarfari	Ugandan	M	28		1	1			1
10	Kila Jarfari	Ugandan	F	52	1		1		1	
11	Maganda Isima	Ugandan	M	23	1			1	1	
12	Kulaba Aloni	Ugandan	M	23		1	1			
13	Madina Nakayiza	Ugandan	F	47		1	1			1
14	Tenywa Rogers	Ugandan	M	29	1		1			1
15	Nabakade Mugnet	Ugandan	F	30		1	1			1
16	Madina Nuloda	Ugandan	F	30		1	1			1
17										
18		Totals			4	12	12	4	3	12
20					M	A	A	M	M	A
22										
1	Namutebi Allie	American	F	25		1	1			1
2	Nswadi Mugrej	Ugandan	F	52		1	1			1
3	Manatov J	Ugandan	F	25		1		1	1	
4	Natongo Aha	Ugandan	F	27		1	1			1
5	Namukose Asha	Ugandan	F	48		1		1		1
8	Halima Mutesi	Ugandan	F	37		1	1			1
10	Kila Jarfari	Ugandan	F	52	1		1		1	
13	Madina Nakayiza	Ugandan	F	47		1	1			1
15	Nabakade Mugnet	Ugandan	F	30		1	1			1
16	Madina Nuloda	Ugandan	F	30		1	1			1
			Total		1	9	8	2	2	8
					M	A	A	M	M	A
6	Twyukye Slirer	Ugandan	M	28	1			1		1
7	Ssebayigga Tibulisio	Ugandan	M	38		1	1			1
9	Mukesa Jarfari	Ugandan	M	28		1	1			1
11	Maganda Isima	Ugandan	M	23	1			1	1	
12	Kulaba Aloni	Ugandan	M	23		1	1			
14	Tenywa Rogers	Ugandan	M	29	1		1			1
17										
18		Totals			3	3	4	2	1	4
20					M	A	A	M	M	A