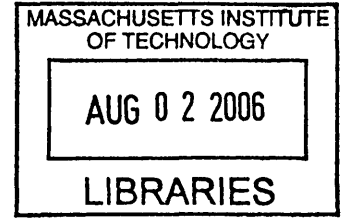**Peanut Oil Press for Developing Countries**

by

Neera Jain and Somin Lee

Submitted to the Department of Mechanical Engineering
In Partial Fulfillment of the Requirements for the Degree of

Bachelor of Science
at the
Massachusetts Institute of Technology

June 2006

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PEANUT OIL PRESS FOR DEVELOPING COUNTRIES

by

NEERA JAIN and SOMIN LEE

ABSTRACT

Despite the problems with obesity that the United States is facing today, malnutrition, caused in part by severely low dietary fat consumption, remains a problem among many people living in Sub-Saharan Africa. According to the World Health Organization, one third of people in developing countries are malnourished as well as vitamin or mineral deficient. While villagers do not have access to commercially produced vegetable oil (a common source of dietary fat), nor are industrial scale oil extraction methods appropriate for small scale production.

As a result, they turn to traditional methods, such as a mortar and pestle, to extract oil from peanuts, sunflower seeds, and other oil bearing seeds and nuts. This process is both time and labor intensive, and still does not yield sufficient amounts of oil to satisfy the need for it. The need for a small scale press is clear.

This thesis introduces a simple design which achieves a yield of 46.9 mL per cup (U.S.) which matches the yield produced using industrial technologies. This corresponds to 153% increase in yield and 38.5% increase in rate over using traditional methods such as a mortar and pestle. The design consists of two fixed plates connected by four rods, with a third plate which slides along the four guide rods. A standard scissor jack is the mechanism by which the necessary pressure of 800-1000 psi is generated to extract the oil. A peanut container with a removable bottom holds the peanuts as they are pressed, and holes drilled into its cylindrical face allow the oil to spill out into a collection dish underneath the container.

The entire design is compact, with a footprint of one square foot and a height of 22 inches. This is 12 times smaller than the Beilenberg ram press, the standard for small scale presses currently used in developing countries. Experimental results of the loading profile as function of time show that the jack does not need to be turned continuously once the oil begins to appear. This requires significantly less strength than current methods of oil extraction. Although future work is recommended to further develop and improve the press, it shows promise of alleviating the need for such a device in many impoverished parts of the world.

Thesis Supervisor: Dr. David Wallace
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Acknowledgements

We would like to express sincere thanks to everyone who has given us their help and support during the last semester as we have worked towards completing our thesis.

First and foremost, we would like thank our advisor, Professor David Wallace, who has shown continual support and guidance throughout the design process. His work as a designer and engineer has been inspirational since this project came to us during 2.009, "Product Engineering Processes" and it has been a privilege to be his advisees this last semester.

We would also like to thank Amy Smith, an instructor at the Edgerton Center. Amy has played an integral role in creating learning opportunities at MIT for students interested in engineering and design for developing countries. We are indebted to her for introducing us to this project and for inspiring us through the example she sets of excellence in engineering and its application to those in need.

We would like to thank Dr. Barbara Hughey, the technical instructor for 2.671 Measurement and Instrumentation, who helped us to design and execute experiments in order to evaluate and optimize our oil press.

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1 Introduction

This project was introduced to us by Amy Smith, the coordinator of D-Lab: Introduction to Development at MIT [5]. After a trip in 2005 to Mwape, a small village in the African country Zambia, she discovered the need for a fast and simple way to extract oil from oilseeds and nuts. For those who live in remote villages, it is difficult to purchase or acquire edible oil of any kind, whether it be peanut oil, soybean oil, etc. These people rely on extracting oil from oilseeds themselves which is both labor and time intensive. Women are often given this tedious and uncomfortable task which requires significant upper body strength to extract small amounts of oil (see Figure 1) [12].
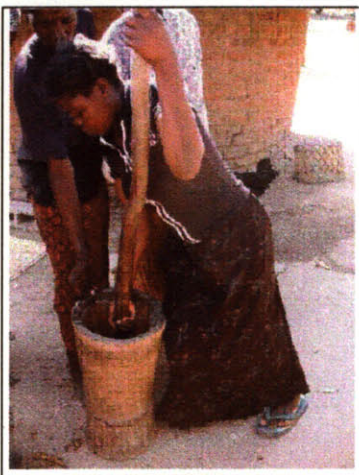
Figure 1: A woman from Mwape crushing peanuts in a mortar[12].

More often than not, villagers are unable to produce an adequate amount of edible oil and as a result, suffer malnourishment. It is recommended that a person consume 9.6 liters of dietary fat each year, yet in many parts of Sub-Saharan Africa, consumption can be as low as 1.5 liters per year [7]. According to the World Health Organization, one third of people in developing countries are malnourished and vitamin or mineral deficient [15].

Amy found that the village owned a small-scale oil press, closely resembling the Bielenberg press, that had been installed by ADRA (Adventist Development and Relief Agency International) to be used for extracting oil from sunflower seeds [12].

It was not being used at the time as the sunflower harvest had failed. Amy's group offered to help them adapt the press to be used with groundnuts (peanuts). Currently, the women in Mwape are able to produce 140 mL of oil from 7.15 cups of peanuts in 20 minutes by using a mortar and pestle. The results when using the current press are similar[12].

Our goal, then, was to design an oil press with improved yield and throughput, that was both less strenuous to use and that could process a variety of nuts and oilseeds. The final design is shown below in Figure 3.

The press can extract 41mL of oil from 120g of peanuts in under four minutes. This is an improvement of 153% and 38.5% in yield and rate, respectively, over to traditional methods of oil extraction. Moreover, this press is compact, with a footprint twelve times smaller than that of the Bielenberg press, and utilizes a car jack which gives the user more mechanical advantage than the long lever characteristic of the Bielenberg press or a long pestle.

In this document, current methods of oil extraction, both on the industrial and small scales, will be discussed, along with design criteria for the press. The final design will
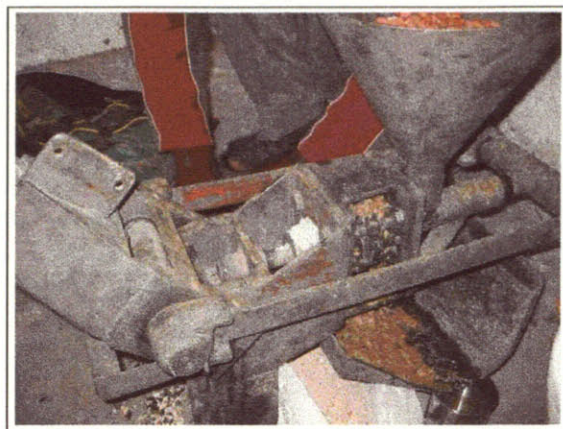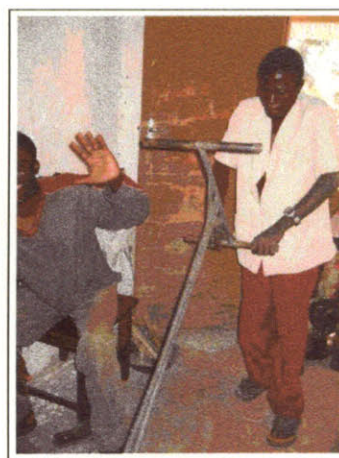
(a)   (b)

Figure 2: (a)Piston of the Ram Press (b) Villagers in Mwape, Zambia demonstrating their Kela Oil Press [12].

Figure 3: Final Design of Oil Press

Method of Extraction	Yield	Rate (mL/hr)	Price	Ease of Use	Pressure
Commercial (Expeller)	46.68		~$2,000	Requires Electric Power	14,000 psi
Hexane	54.92		~$12,000	Requires Chemicals	Solvent
Car Jack	35.18	527.7	$50	Rotational Motion	1,000 psi
Mortar and Pestle	19.58	381.0	—	Upper Body Strength	—
Kela Press	16.80	480.0	$200	Uncomfortable Bending Motion	—

Table 1: Comparison of Yield, Rate, and Throughput Between Small Scale Technologies [3]

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be presented in more detail along with a discussion of its benefits with respect to current technologies.

2   Oil Production and Current Technologies

A total of 87.2 metric tons of vegetable oil was consumed worldwide in the year 2000. Soybean oil accounts for 29% of the world oil consumption and 56% of oilseed production, while peanut oil contributes to 5% of overall consumption and 10% of oilseed production worldwide [16]. While soybeans have become the "main oilseed for the production of oil and meal", peanut production has grown steadily over the last three decades, with four of ten major producer countries in Africa. "Only a small proportion of the world production [of peanuts] is devoted to exports and imports, and most of the production is domestically utilized" [6]. Thus, in countries where peanut production is not large, peanut oil and meal will be largely unavailable to the public.

2.1   Industrial Scale

In countries where vegetable oil is produced on an industrial scale, three methods are commonly used. Two of these methods are mechanical, utilizing either a hydraulic ram press or an expeller press. The third method is a chemical process called solvent extraction.

2.1.1   Hydraulic Ram Press
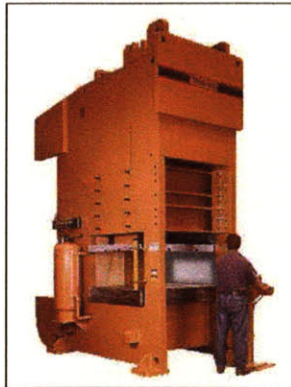
Figure 4: Industrial Hydraulic Press[14]

Hydraulic presses use a hydraulic component to create about 20 tons of force. This large force is used to drive a piston which in turn presses oilseeds and nuts.

An industrial hydraulic press is shown in Figure 4. Although these presses are effective, they are expensive, with prices beginning at $2,000 [8]. Hydraulics are used for a variety of applications. A wide range of hydraulic components exist and are used for a variety of applications. As a result, yield and throughput of hydraulic oil presses varies.

2.1.2   Expeller Press

The example of the expeller shown in Figure 5 has the capacity to produce 1 ton of oil in a 24 hour period. These machines have the ability to extract oil from peanuts, rapeseeds, and

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soybeans, just to name a few. When peanut are fed into the expeller press, the peanuts are first heated using with steam and then pressed [11].

Figure 5: Expeller press used in industry[11].

The major disadvantage of the expeller presses is that although its yield is about 80-90% of the maximum potential yield of oil from peanuts, it is less than what can be achieved through solvent extraction, another industrial oil extraction technique. On the other hand, this process is much safer and purer than using a solvent [8].

2.1.3 Solvent Extraction

In peanuts and other oil seeds, thick cell walls make it difficult for oil to be separated from the meal of the nut or seed. Fortunately, industry has found that using a chemical additive breaks down these barriers, allowing for the extraction of more oil (see Figure 6) [2].
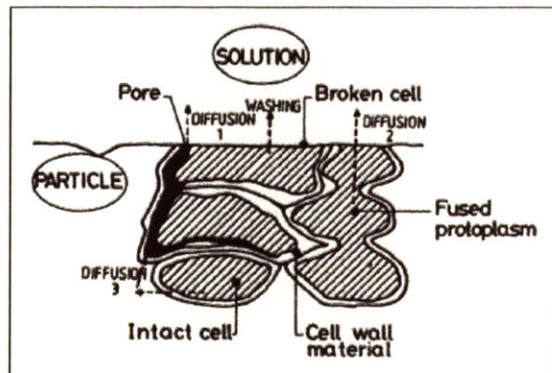
Figure 6: Cells walls of peanuts can be broken by solvents such as hexane [2].

In the 1920s, Europe began using hexane as a chemical compound solvent to expedite the oil extraction process. After the process has been completed, the hexane must be evaporated at a temperature of 90-100 degrees Celsius to ensure that it is completely gone. The process is not only expensive but can also be toxic to the body and affect the quality of the final product. Nevertheless, using hexane as a solvent is the most popular method used today in mass production [2].

2.2 Small Scale

It is difficult for villagers to access commercially produced vegetable oil which is only sold in large cities. Instead, they rely on extracting oil themselves from oil-bearing nuts and seeds. However, the use of industrial technologies requires a capital investment that most villagers cannot afford, nor is there a need for production on such a large scale. Maintenance on these large machines is also be difficult due to the large number of parts. Moreover, solvent extraction demands the continual purchase of Hexane which will not pay for itself if the process is used on a small scale. Finally, these machines are run inside buildings with regulated temperatures. In African towns and villages, machines must be robust to high temperatures and humidity.

Figure 7: The Bielenberg Press developed by Center Songhai
[4]

Figure 7 shows a ram press that has been developed by an organization called Center Songhai. This device is operated by lowering a long lever which then drives a piston to press against the peanuts (or other oil seeds). The throughput of the machine is 10-15 kg of peanuts per hour; a quantification of the yield was not available. One disadvantage of this device is that it is very large, with a footprint of 230 x 50 square centimeters and a height of 90 centimeters. It is also strenuous to use, requiring the user to bend down and stay in that position to maintain enough pressure to extract oil. This press costs $200 and is manufactured with materials readily available in rural areas [4].

Figure 2 shows the piston and the lever arm driving the piston. The length of the lever arm is 1.71m, the crank 0.08m, and the connecting rod 0.653m. The angle of the lever arm changes from approximately 70 degrees to 0 degrees to reach a mechanical advantage of 140 to 1 [9].

3 Design for the Developing World

Regardless of what one is designing, it is important to consider cost, manufacturability, quality, materials, etc. However, when designing for the developing world, where not only money but also resources, infrastructure, and energy are scarce, the constraints associated with these criteria are more stringent.

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3.1 Manufacturability

It is important to use materials that are readily available in these countries so that the product can be manufactured and serviced locally. Some of the materials available are cement, mild steel, galvanized steel, rebar, and wood. need citations! In addition to a limited source of materials, manufacturability in rural villages is limited by the types of technology available. Although it varies by location, villagers often have access to basic tools for cutting and drilling, and many are also skilled at welding, bending, and forging. However, precision machining is not available and therefore designs should be robust and have large tolerances [13].

From a business perspective, if the press were only manufacturable in the U.S., there would be added shipping costs which could easily exceed budget constraints and defeat the purpose of making an affordable oil press. Most importantly, though, local manufacturing can create more job opportunities and stimulate economic growth, as well as facilitate dissemination of the technology throughout neighboring villages.

3.2 Robustness

Rural areas are often characterized as dusty for lack of paved roads; for this reason and general sanitation concerns, the machine should be easy to clean and store. The design and its dimensions should be robust to thermal expansion as as African countries experience a warm climate for most of the year.

3.3 Cost

Since the average annual income of an African family is about $500 U.S. dollars, any machine is expensive from their perspective. Instead, one machine could be shared between a group of people in a village comprised of 100-1000 people [13]. Although this may seem like a large range of people, village size is inherently highly variable. This type of machine cooperative is currently being utilized in Mwape for a machine that grinds peanuts. With such a cooperative, the oil press could potentially be marketable at approximately $100-$500 with the help of NGOs such as OECD Organization for Economic Cooperation and Development, and WTO World Trade Organization [13].

4 Design Requirements

Bench level experiments were conducted to determine the requirements of the peanut oil extraction process. First and foremost, this implies identifying the order of magnitude of pressure needed to extract oil, without which the press would be useless. Beyond that, however, are other considerations, such as the need for a device to separate the dry peanut meal from the oil, a method of oil collection that minimizes losses, etc.

4.1 Pressure

During 2.009 Product Engineering Processes (a design course in the MIT Department of Mechanical Engineering), the Yellow team conducted bench level experiments to determine the pressure required to extract oil from the peanuts [1]. We did this by machining a simple solid delron piston and PVC (polyvinyl chloride) pipe cylinder container and putting it between an arbor press. We can estimate the pressure on the peanuts by calculating the mechanical advantage.

We can use equations

$$M.A. = Arbor\,press\,lever \div piston's\,Arm. \tag{1}$$

and

$$\Gamma = Force * Lever\,Arm \tag{2}$$

to estimate the mechanical advantage. The ratio of the length of the lever arm is proportional to the force applied at the endpoints.

The lever arm on the arbor press was 3 feet, while the piston's lever arm was only 2 inches. Therefore, a mechanical advantage of 18 to 1 was achieved. Assuming that an average person weights 140lbs, we can calculate the pressure by dividing the Force by the area of the piston.

4.2   Separation of Oil and Meal

One of the largest challenges encountered through conducting preliminary experiments was separating the oil from the meal. It is not enough to press the peanuts momentarily with high pressure; instead, there must be continuous pressure on the peanuts in order to successfully extract oil. If the peanuts are pressed and then the pressure is quickly removed, there is a risk of the oil being reabsorbed by the meal.

As previously mentioned, the 2.009 Yellow team conducted an experiment with the PVC and delron apparatus to determine required extraction pressure [1].

(a)   (b)
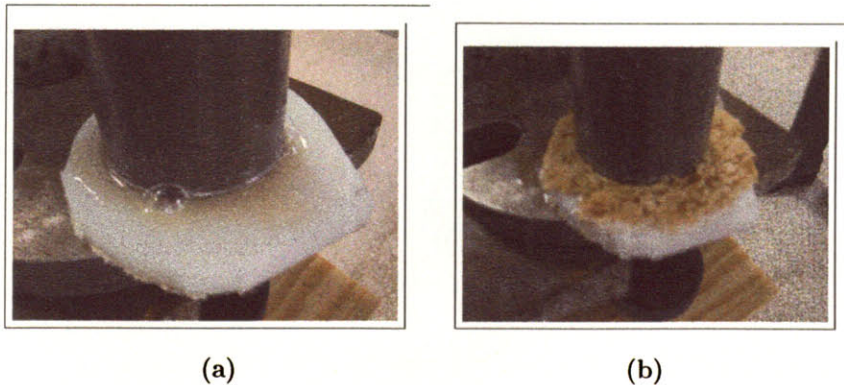
Figure 8: Calculating Oil and Meal Separation Pressure: A PVC pipe was press fit into a HDPE plate to examine the minimum pressure to extract oil out of peanuts. (a) before meal is extruded through the sides (b) after meal is extruded through the sides.

As show in Figure 15 it was observed that the meal squeezed between the cylinder and bottom plate. Since the cylindrical pipe holding the peanuts had no bottom, when pressed by the piston, the oil was able to escape through the bottom and create an upward force on the rim of the pipe. This then allowed peanut meal to spill out as well. cylinder.

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5 Initial Design Concepts

Two major aspects of the overall design are a pressure generating mechanism and a peanut oil/meal separation technique. The following concepts explore these different requirements.

5.1 Pressure Generating Concepts

Although there are many aspects of this machine that need to be considered, first and foremost it must be able to create pressures on the order of 800 to 1200psi. Consequently, the initial design concepts focused on exploring force generating mechanisms that could then be further developed and incorporated into an entire machine.

5.1.1 Treadle-Powered Press

During 2.009 [1], the Green team explored the possibility of a treadle-powered press. The motivation behind such a design was to utilize leg muscles as opposed to arm muscles; women, who are usually tasked with extracting oil, have considerably more lower than upper body strength. In order to transfer the power from the treadles to a piston pressing against the peanuts, gears would be used. The initial intent was to have one step of the treadle correspond to one stroke of the piston, but to convert the force of the user into a torque (through gear ratios) which would then create a linear force on the piston great enough to crush the peanuts was impractical. Incorporating a ratchet into the design was considered which would harness the force of multiple steps on the treadle. However, the design was already demanding precision parts which would be difficult to manufacture in a rural village.

5.2 Ratchet System

Another design concept that was explored was a ratchet system (see Figure 9). A hand lever
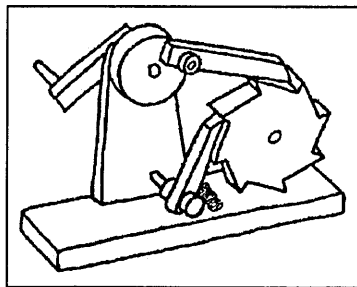
Figure 9: Simple mechanics of a ratchet system

can be used to crank a ratchet which then drives a piston downward to press the peanuts (see Figure 10). A system of gears would have been necessary to achieve the large mechanical advantage needed to create large pressures. Obtaining the resources to manufacture these large gears would also have been costly and impractical.

5.2.1 Extrusion

Another design under consideration was a derivation of the expeller press used in industry. This concept would be a less expensive alternative to the expeller press with a modified screw mechanism that would be easier to manufacture. Rather than using an actual screw
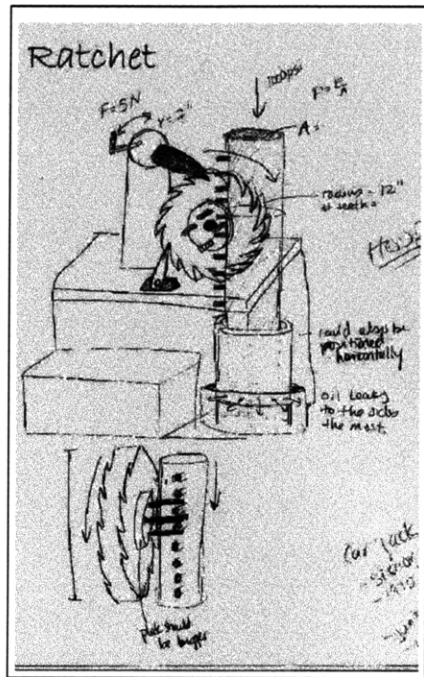
Figure 10: Sketch of a ratchet incorporated into the oil press design

(similar to those used in injection molding machines), a long cylindrical shaft, with solid rod wound around the outside of the shaft, would be used in the design. However, even with the simplified screw, this design would use parts which require precision machining and that would increase the overall cost and difficulty of manufacturing it (see Figure 11).
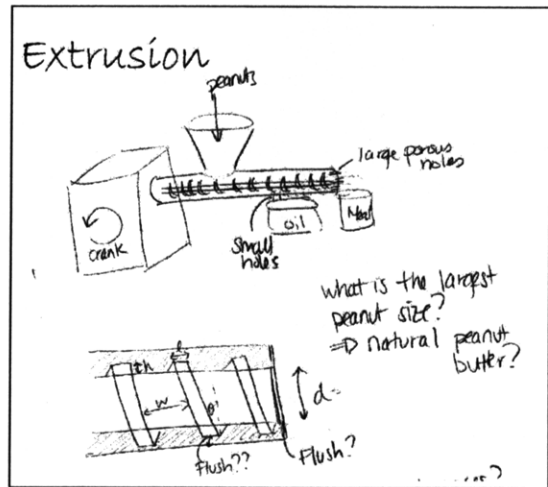
Figure 11: Extrusion

This could solve the oil separation method since the smaller holes would allow the oil to pass but the large meal pieces must push through at the end of the tube.

5.2.2 Cone

Another concept that was explored resembled a mortar and pestle but instead used a metal cone as the mortar and a solid metal ball, welded to a long rod, as the pestle (see Figure 12).
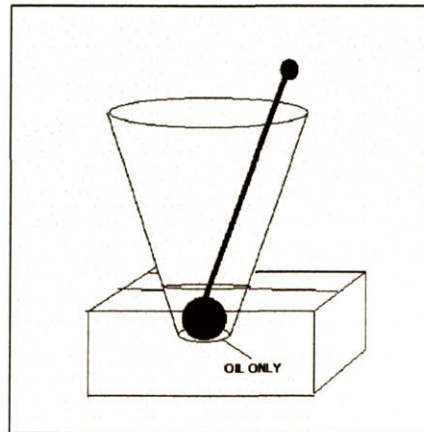
Figure 12: Cone Shaped Method

The metal ball at the end of the rod was sized to fit within a tolerance of one peanut of the bottom circumference of the cone. Peanuts were fed through the wide opening at the top and pressed between the ball and the bottom edge of the cone as the handle was turned through the circular opening (see Figure 13).

Figure 13: Demonstration of cone concept in use.

Ideally, the oil would leak through the gap between the metal ball and the bottom edge of the cone, easily separating it from the dry peanut meal. Theoretically, the pressure and forces are much greater at the bottom of the cone. Unfortunately, the necessary pressure (800-1000 psi) was not generated with this concept. While the peanuts were crushed, very little to almost no oil was extracted (see Figure 14).

Other design concerns which arose were how to easily remove the dry peanut meal from the bottom of the cone. Moreover, even if oil had successfully been extracted, the rate at which it would occur would most likely be low. Finally, it was unclear whether this design would be an improvement in terms of ease of use over a traditional mortar and pestle.
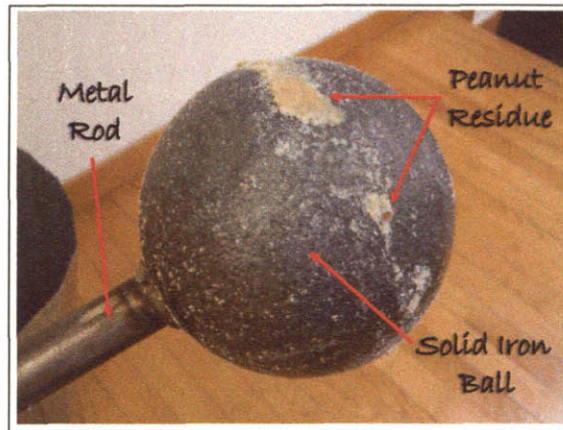
Figure 14: Peanut Residue

5.2.3 Roller

While the cone concept did not create the necessary pressure to extract oil, the idea of creating a force between two moving surfaces was attractive. A bench level experiment was conducted using a sheet metal roller (see Figure ??).

(a)   **(b)**
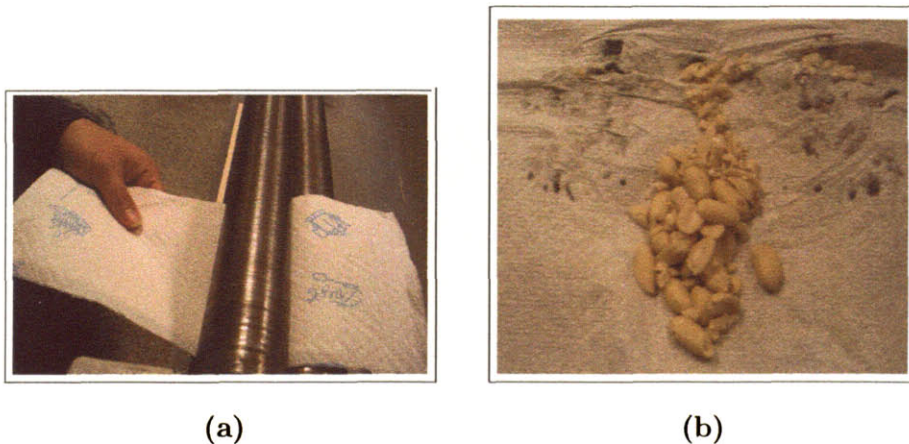
Figure 15: (a)Sheet Metal Roller (b)Peanuts run through a sheet metal roller.

Shelled peanuts were placed between a paper towel which was then pulled through the gap as the machine was turned. It was found that with this method, the peanuts are not experiencing sufficient pressures for a long enough period of time to efficiently extract oil. Moreover, the little oil that was extracted was completely reabsorbed into the meal and the paper towel.

5.2.4 Lead Screw using Car Jack

The final concept was to use a lead screw, rather than a ratchet or gear system, to mechanically create the necessary pressure of 1000psi. The concept was explored by using a scissors car jack, whose design already incorporated a lead screw, to push against a piston which then pressed against peanuts. Holes 1/64 in diameter were drilled through the bottom of an aluminum tuna-fish can which was filled with peanuts. A piston was machined from Delron

plastic to fit into the can. The entire assembly was placed in an arbor press as a make-shift frame which could constrain the car jack as shown in Figure 16.
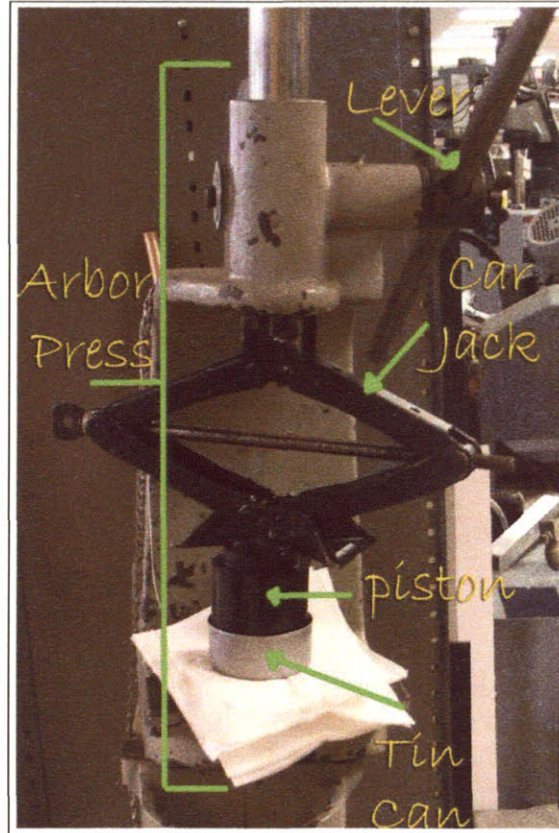
Figure 16: Car jack positioned in an arbor press.

A paper-towel was placed underneath the can to prevent the oil from leaking onto the Arbor press. Since we had not fashioned a collection device, we were not able to quantify the amount of oil extracted. However, it was clear that oil had been extracted as can be seen by the ring of oil absorbed by the paper towel (see Figure 17).

It may seem that requiring the purchase of a car jack for the design is counterproductive if it is to be easily manufactured. However, in developing countries, car batteries are known to be common as they are often salvaged from old cars. It can be assumed that these old cars also contain jacks that could be salvaged before the entire car is scrapped for metal, meaning that they would be readily available in an area where this would likely be used.

5.3 Water Separation

During 2.009, the Yellow team explored the possibility of separating the oil and meal using the difference in density of water and oil. This idea was eliminated due to the availability of clean water and heating constraints. Through experimentation, we also found that water and peanut oil take a long time to separate. This idea would have been a novel way to address the problem of reabsorption of oil in the meal but is not feasible in the developing world.

Figure 17: Ring of oil absorbed into the paper towel

6   Final Design

After evaluating the various pressure generating concepts, it was decided to proceed with the lead screw design would be most promising. The final design of the oil press is shown below in Figure 18. The frame of the press consists of three 0.5 inch thick steel plates, a 6 inch square top plate and 12 inch square base plate, and a third 6 inch plate which slides along 4 steel guide rods. A collection dish, currently machined out of nylon plastic, rests on the steel sliding plate and also slides along the guide rods. The scissors jack is welded between the base plate and sliding plate. Finally, the peanut container sits in the center of the oil collection dish. Currently, the piston is a solid cylinder machined from delron plastic as this was ideal for testing purposes; it is placed between the peanut container and the underside of the top plate and as the jack is turned, the sliding plate moves upward and the piston and peanut container assembly is pressed between the sliding plate and top plate of the frame. The final design would incorporate a steel piston consisting of 2 inch tubing with a round steel plate 2.75 inches in diameter welded on one end. The free end of the tube would then be welded to the underside of the top plate.

The following sections will describe the evolution of the design. This is divided into three main areas: the frame, the container in which the peanuts would be pressed, and the oil collection device.

6.1   Designing the Frame

For the bench-level experiment, an arbor press was used to constrain the entire scissors jack and peanut container system. For the next phase of this concept, then, a frame was designed to serve the purpose of the arbor press. Two metal plates, each 0.25 inches thick and forming the top and bottom base of the frame, were connected via four threaded rods, each 0.25 inches in diameter.

The rods were bolted to each plate using nuts and washers. The scissor jack was inverted and its bottom base was bolted to the top plate. To allow for the jack to be easily turned, it was fixed towards one edge of the plate. Although oil was successfully extracted from the peanuts, we observed severe buckling in the top plate (see Figure 19).

This resulted for a few reasons. First, the points at which the top plate was constrained by the rods were unnecessarily far away from the point at which the load was being applied. This created a moment and allowed for bending to occur. Furthermore, the moment of

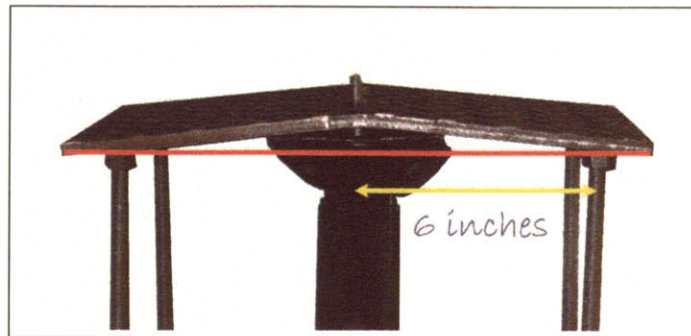Figure 18: Final Frame Design

Figure 19: Buckling in Initial Design

inertia of the top plate was limited by its thickness. The moment of inertia of a rectangular beam is given by

$$I = frac112)bh^3 \tag{3}$$

where b is the length of the beam and h is the thickness. By increasing the thickness of the top and bottom plate, our frame could significantly increase its resistance to bending or local buckling.

Also, by creating an overall symmetric system with a vertical line of action, the entire force of the car jack would be applied directly to the piston and the peanuts.

Using the finite element analysis (FEA) software package ADINA (Automatic Dynamic Incremental Nonlinear Analysis), a stress-strain analysis was conducted on our newly designed top plate to determine if it would indeed withstand the pressure exerted on it by the jack (see Figure 20).

Figure 20: Stress-strain analysis in ADINA (Finite Element Analysis)

The maximum stress at the center of the plate which is the point of loading; its magnitude is 15,000psi. Given that the yield strength of low-carbon (A36) steel is 54,000psi, the frame has a safety factor of 3.6. After running multiple trials, no local buckling or bending was detected in the plates, thus supporting the FEA analysis in ADINA.

6.1.1 Jack Placement With Respect to Frame

In the originally frame design, the jack was inverted and bolted to the top plate with the peanut container resting on the bottom plate. After redesigning the frame it was important to consider how the oil would actually be collected by a larger, external collection device. It was apparent that this would be difficult with the peanut container sitting on the bottom. However, if the peanut container was placed on the sliding plate and the jack were welded in its standard orientation to the base plate, a larger container could rest on the table (or floor depending on where the entire press is seated) and collect oil as it drips from the smaller collection device underneath the peanut container.

6.1.2 Plate Attachment

When designing for developing regions, it is often preferred that welding be used to join metal rather than screws and bolts. The top and base plate of the frame are connected by four steel rods which are threaded at each end. Welding is more readily available and faster than threading screws to attach the plates. A double set of nuts and washers are used on each plate to ensure that the plates and rods stay fixed.

Although welding is certainly easier, it is not the best means of attaching the rods and plates, primarily for safety reasons. Considerably large forces are being applied to the plates. Weld joints are known to be strong, but the strength itself is dependent on many variables, including the length of the weld, weld throat, and the type of weld metal being used. The expertise of the welder himself must also be considered; variability in skill level could compromise the integrity of the welds.

Furthermore, welded joints are not optimal because they inhibit maintenance. Welds are difficult and often impossible to remove, making it harder to clean the press and/or replace individual plates. The mobility of the press would also benefit from the ability to be disassembled.

6.2 Designing the Peanut Container

6.2.1 Hole Placement

The tin tuna-fish can that was used for the bench level experiment to explore the lead screw concept was a start, but its size would severely limit the output rate of the machine. A larger can (those typically containing canned vegetables and canned soup) was used. Since the can needed to be constrained on the bottom to withstand the force of the piston, holes were drilled radially through the sides of the can rather than through the bottom to allow oil to be collected in a dish surrounding the can (see Figure 21).
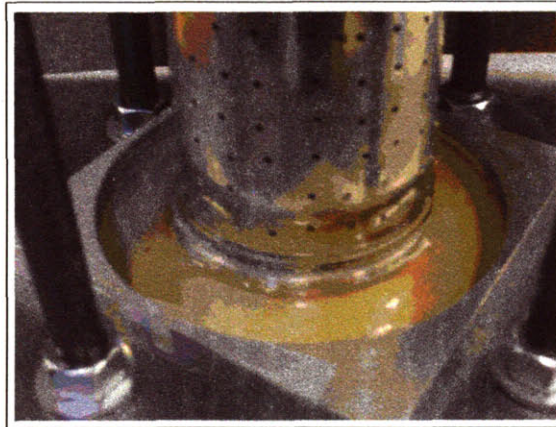
Figure 21: Collection Device

The hole size used was again 1/64. Thin metal plates of a diameter just smaller than that of the inner diameter of the can were used to separate layers of peanuts under the assumption that this would facilitate oil flow out of the can. The radial holes were a success - the oil easily escaped through the sides of the can and dripped down into the collection device.

6.2.2 Structural Integrity of Container

After running multiple trials, it was observed that the tin can had actually buckled underneath the force of the piston (see Figure 22).

The buckling resembled crinkles in the can that did not look like they could have been formed by a mass of peanuts pushing against the sides of the can. Circular plates of galvanized steel (see Figure 23) were placed between the peanuts within the container.

Figure 22: Tin Can Buckling

Figure 23: Plates

These metal separators in the can, however, could have caused the buckling, and after reducing the diameter of the plates to allow a clearance of 1/8 between the edge of the plate and the inside of the can, the buckling issue was resolved. That being said, tin cans are not readily available in rural villages nor would they be so robust as to last for weeks, let alone months or y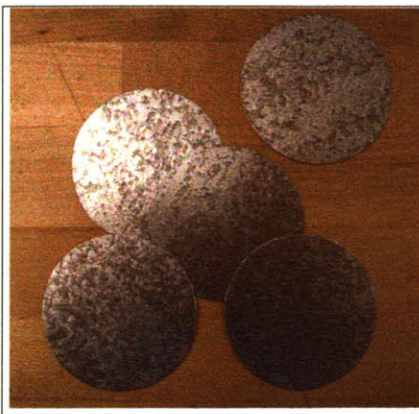ears, without replacement. The decision was made to use 1/8 thick cylindrical steel tubing in place of the tin can (see Figure 24).
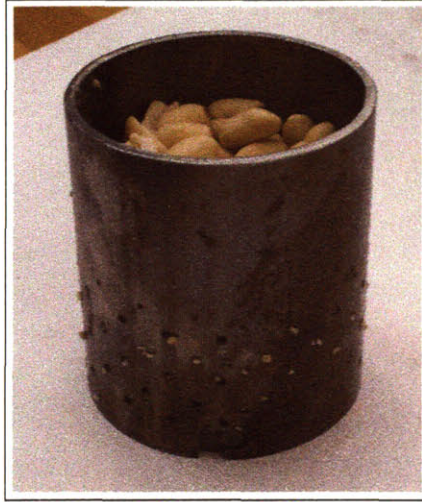

Figure 24: New Steel Container)

This type of steel tubing is available in developing nations and would allow for experimentation with different heights and diameters as tin cans are manufactured in a limited number of sizes.

6.2.3 Designing for Easy Clean-up

The move to cylindrical tubing meant that some sort of base for the container would need to be designed. A removable base seemed ideal to allow the peanut meal to easily be removed and any excess oil to be collected. Originally, we had considered simply slipping the cylinder over the center island in the collection device so that the bottom edge of the cylinder was flush with the surface of the moat. However, as discussed earlier, the piston exerts a large force downward on the peanuts which in turn exert pressure against the wall of the cylinder. While this force is radial throughout most of the cylinder height, towards the bottom of the cylinder there is a downward component to this force. As a result, oil at the bottom of the can is pushed into the space between the cylinder and the island. If the cylinder is not locked down, oil will actually slip underneath the bottom of the edge of the cylinder and exert an upward force on its cross sectional area, displacing the cylinder from the island.

Many locking mechanisms were considered, including screwing the cylinder onto the island similar to the way a lid screws onto a glass jar, and inserting removable pins through the cylinder and island to hold the two in place together. The screw idea would be difficult to machine and removable pins introduce extra pieces into the design which is not ideal. Instead, we designed an external base with fixed pins over which the cylinder could slide and then twist and lock (see Figure 25).
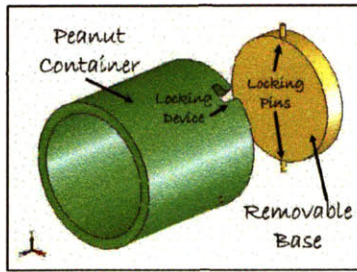
Figure 25: Peanut Container and Removable Base

6.3 The Collection Device

Although extracting the oil is the most important feature of the device, if the oil cannot be efficiently collected, the machine serves no purpose. The first concept was to create a dish resembling a circular island surrounded by a moat. The circular island had a diameter equal to that of the outer diameter of the peanut container, and the volumetric capacity of the moat was initially arbitrary. The oil which escaped radially through the sides of the can collected in the moat. A small escape hole had been milled on one edge of the moat to allow the oil to be poured from the moat into a larger container. This concept was chosen before the design of the frame was finalized, and consequently we encountered problems interfacing the two.

One problem was that the escape hole was not flush with the edge of the sliding plate, so we could not allow for oil to continuously leave the moat and drip into a larger container (e.g. a graduated cylinder for experimental purposes). Secondly, the collection device was not centered on the sliding plate, and given that the peanut container had to sit exactly on the island, the peanut container and piston assembly was then also off center. In one unfortunate experiment, the misalignment led to the jamming of the sliding plate and the failure of the car jack.

The new design proposed was to machine the island and moat from a plate with the same dimensions as the sliding plate. Four holes were also drilled through the plate to accommodate the guide rods. The island and moat were machined in the center of the plate which corresponded to the center of the sliding plate and the loading point of the jack. The user could simply align the peanut container with the island and could be assured that the entire line of action was vertical. Finally, a peninsula was left to protrude from one edge of the plate with a channel milled through it (see Figure 26). This allowed the oil to escape from the moat, move through the channel, and then drip down into a container sitting underneath the edge of the peninsula.

7 Experimental Testing

Throughout the development of the peanut oil press, experimental testing was conducted in order to optimize the machine.

7.1 Quantifying Yield

As mentioned previously, small, round plates cut from a thin sheet of galvanized steel were used to create layers of peanuts within the peanut container under the assumption that
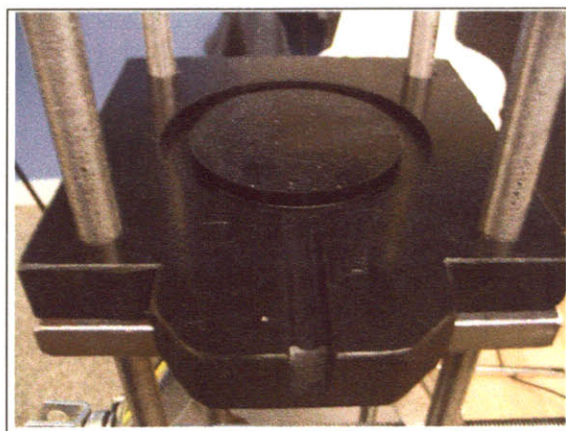
Figure 26: New design of collection device

this would improve yield. However, this assumption was based on no real data, and an experiment was created to determine the effect, if any, of using these plates.

A fixed mass of peanuts, 120 g, was heated at 300 degrees Fahrenheit for 3 minutes. Four trials were run to determine the yield of the press: two trials using plate separators and two trials with the same mass of peanuts but no plates. During each trial, the peanuts were pressed for 3 minutes after the first appearance of oil; during those three minutes the jack was not continuously turned but instead, it was cranked every 20-30 seconds. At the end of 3 minutes, the jack was released and the volume of oil extracted was measured using a graduated cylinder. The results are summarized below.

Condition	Yield (mL/g)	% of Peanut Mass of Oil Extracted
with plats – Trial 1	38	29.7
with plats – Trial 2	42	33.3
without plates – Trial 1	40	31.6
without plates – Trial 2	41	31.0

Table 2: Comparison of oil yield with and without plates.

The yield differed only slightly between the two conditions, leading to the conclusion that the plates do not play a role in improving this quantity. Moreover, not using separation plates reduces the amount of time needed to load the peanut container as well as decreases the number of external parts of the press.

If future experiments are run to investigate the possibility of a taller peanut container, it is recommended that this particular experiment be conducted again since the effectiveness of the plates could change as a function of cylinder height.

7.2 Examining Loading Profile

The objective of this test was to determine the loading profile on the peanuts as a function of time.

Multiple trials were conducted during which a fixed mass of peanuts was pressed at a pressure of 800 psi. Once the pressure was reached, the user waited 20 seconds before turning

Figure 27: Experimental Setup
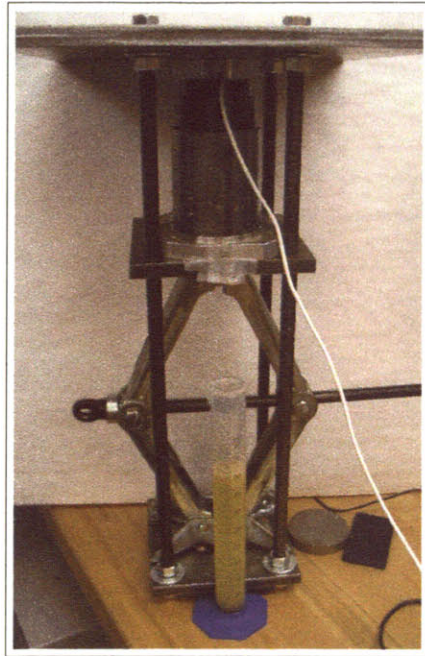

Figure 28: Experimental Setup
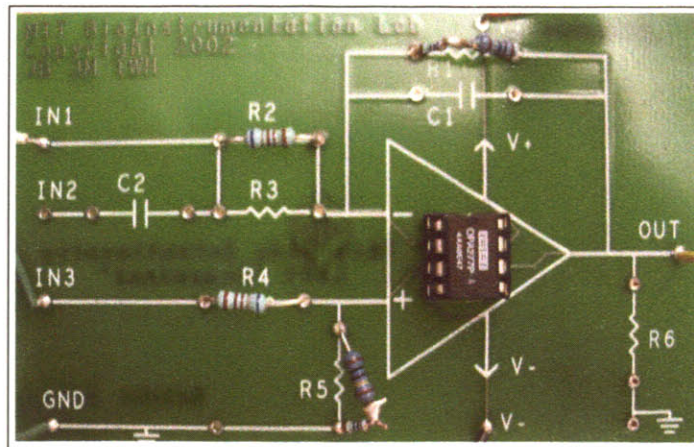
Figure 29: Experimental Setup

Figure 30: Amplifier

the jack to again reach 800 psi. This continued for three minutes. A representative loading profile is shown in Figure 31.
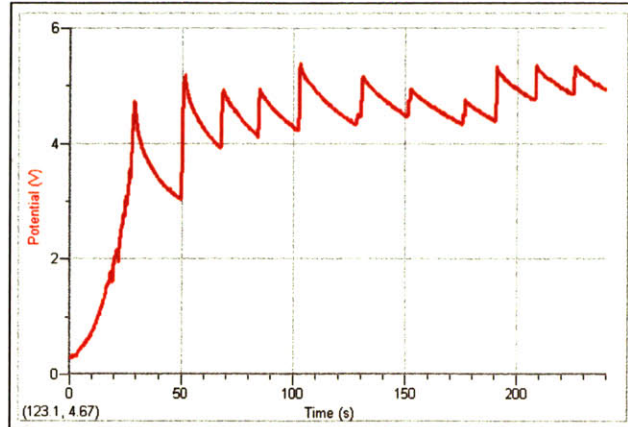

Figure 31: Trial 4

It is clear that during the initial ramp up to the desired pressure, the force reduces quickly if the jack is not continuously turned. Also, even after the maximum pressure is reached, there is still a relatively quick decay profile. However, with successive turns, the force decays more slowly. This indicates that the user does not need to continuously turn the jack to maintain a strong enough pressure to extract oil.

7.3 Varying Peanut Container Diameter

After obtaining the maximum pressure, different sizes of the peanut container were evaluated. Two containers with inner diameters of 2.76 inches and 3.76 inches, respectively, were used. The cross sectional areas of these containers were 5.98 square inches and 11.1 square inches, respectively. From the area, we calculated the force required to obtain a pressure of 800psi in each container. The height of peanuts in each container was kept constant; yield would be calculated in volume of oil per mass of peanuts to accurately compare the two. See Appendix D for a detailed explanation of the experimental procedure.

While conducting this experiment with the larger container, we experienced failure in the scissor jack. The jack that was used for this oil press was rated at 1000kg which is equivalent to approximately 2200lbs. Given an area of 11.1 square inches on the bigger cylinder, a minimum of 8880 pounds of force was needed over that area to generate 800 psi. Since scissor jacks are engineered with a large safety factor, we decided to run the experiment and operate beyond of the safety rating of the jack. Unfortunately, during the experimental testing of the 3.76" tube container of peanuts, the scissor jack failed.

It is important to note that not only was the jack not rated to create the forces necessary to generate 800psi over an area of 11.1 square inches, but during the experiment, the loading was not uniaxial. The peanut container was placed offcenter on the sliding plate, and as the jack was turned, the sliding plate actually began to tilt and eventually jammed against the guide rods.

This type of loading created a moment on the jack which was the primary cause of its failure. Consequently, reliable data is not available to compare the yield of peanut containers of different diameters. Future work should incorporate the use of a significantly higher rated jack.
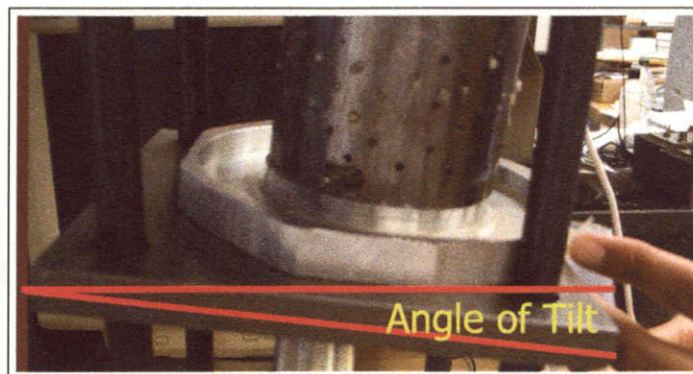
Figure 32: Jamming and Tilting

7.4 Substituting Sunflower Seeds for Peanuts

Another important design aspect of the press is its ability to process a variety of oilseeds and nuts. Most varieties of sunflower seeds contain anywhere from 39 to 49% oil [10], similar to peanuts.

Under the same conditions that were used when determining yield with peanuts, 60g of sunflower seeds were heated and then pressed in the oil press. The yield results were comparable to those of tests run with peanuts - 20mL of oil were extracted, which was equivalent to 33.4% of the sunflower seed mass that was pressed.

Figure 33: Oil Extraction from Sunflower Seeds

It is important to note that the sunflower seeds used were already shelled, albeit it would be more common for unshelled sunflower seeds to be pressed in a rural village. Future work should include testing with unshelled sunflower seeds as well as conducting multiple trials to develop statistical reliability.

8 Discussion

The results of our experiments showed a significant increase in the yield of the press over traditional extraction methods. The press produced 46.9mL of oil per cup (U.S.) of peanuts, as compared to the 19.6mL of oil per cup (U.S.) extracted using a mortar and pestle. The

yield of the Kela oil press was comparable to that of the mortar and pestle, so it can be deduced that the new press design is a significant improvement over the Kela press as well.

The results of the loading profile on the peanut container is an indicator of the improved ease and use of this press. The user can turn the jack and then wait as oil drips from the container, and continue to turn the jack a partial revolution every 20-30 seconds (roughly 3 to 5 more times) before removing the peanut meal from the machine. Traditional ram presses such as the Bielenberg press require the user to continuously press downward on the long lever to maintain enough pressure on the peanuts to extract oil. Not only does this require sustained strain on arm muscles but also on the lower back.

Finally, the failure of the scissor jack when testing a larger diameter container highlighted the need for a mechanism to correct align the peanut container with the jack. This was done by designing the oil collection dish to be the same size as the sliding plate and also ride along the guide rods. An island is machined in the center of the dish (with the moat for oil surrounding it), allowing the user to quickly place the container and be assured that it is directly above the loading point of the jack.

9   Conclusion

Through this thesis we have aimed to design a simple oil press for use in remote villages in Africa where vegetable oil is not readily available. The need for such a device is evident given the persistent malnutrition and lack of sources of dietary fat among many people living in Sub-Saharan Africa.

Our design yields 46.9 mL per cup (U.S.) of peanuts, a significant improvement over current methods which yield roughly 19.6mL per cup (U.S.) of oil. Although industrial presses can process oil at a much faster rate, the yield per mass of peanuts is identical to that of our press. The rate at which our press extracts oil does show improvement compared to other small scale methods: 527.7 mL/hour as compared to 381 mL/hour and 480 mL/hour for the Kela press and mortar and pestle, respectively. Moreover, the use of a scissor jack in the design gives the user an increased mechanical advantage which translates to less strain on muscles.

This machine is much smaller than the Bielenberg press and other ram presses which have derived from that design. Not only does it occupy less space, but it requires less material to be manufactured, resulting in a significant reduction in cost. The utilization of a scissor jack in the design takes advantage of resource that can become cheap and readily available if the demand is there; with car batteries so ubiquitous in developing countries, jacks can just as easily be salvaged from old cars prior to scrapping.

This design resulted in improvements in yield, rate, ease of use, and cost. Although future work is recommended to further develop and improve the press, it shows promise of alleviating the need for such a device in many impoverished parts of the world.

10   Future Recommendations

As is the case with most research, there is still work to be done. Below are some specific areas which warrant a closer look if the development of this press continues.

10.1   Plastic to Metal

Both the piston and collection dish are currently made from plastic (delron and nylon, respectively) as this material was readily available to us and lended itself well for testing

33

purposes. However, plastic is expensive and not recommended for manufacturing the press in Africa. Both of these parts can be designed with steel which is readily available in developing countries. For the piston, it is recommended that a hollow steel tube with an outer diameter of 2 inches be welded to a round steel plate with a diameter of 2.75 inches.

The collection device should also be manufactured from steel or another available metal. Moreover, rather than designing an extra plate for the collection device, the island/moat can be machined into the top surface of a thicker plate which slides along the guide rods. The bottom surface of this plate would still be welded to the top of the jack.

Milling may be difficult to do in some African countries, so it is recommended that alternative designs, which are more easily machined, be explored.

10.2 Frame Stability

The current design incorporates a large base plate to provide stability to the press. However, the base is attached to the metal rods with nuts and washers on both sides of the base plate. This results in the base resting on four points: the four washers. To increase its stability, there are two alternatives. First, the machine can be clamped to a table. Alternatively, the holes in the base plate could be tapped and not drilled completely through the plate so that the guide rods could screw in to the base plate without protruding from the other end.

10.3 Further Experimentation

A number of experiments were designed to test optimal pressure as well as optimal hole size but time did not allow for all the experiments to be tested (see Appendices B, C, D). It is recommended that these experiments be conducted to further optimize the design and yield of the press.

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Appendix

A Preparation for West Africa

We are currently looking for funding to implement this design in Mwape, Africa. In January of 2007, we plan to go to the local people and replicate or adapt this design with the locally available materials and technology. Strong effort was put into using material and technology similar to Africa with the help of Amy Smith. The list of materials is shown in figure 0837402 which is comprised of mostly steel.

Cost of materials (steel) List of Materials

- Car Jack Rated at 700kg

- Steel Plate 12 x 12 x 12

- 2 Steel Plate 6 x 6 x 6

- Square Tube (Piston)

- Tubing 4 Outer Diameter with 1

- 4 Steel Rods 0.5 Diameter, 21 long

- 1 Round Steel Plate 3 Diameter with .25 pins

- 1 Collection Cup Attachable

- 16 Nuts and Washers

B   Experimental Procedure 1 - Analyzing Hole Size

Throughout the design process we have been informally experimenting with different sized holes in our can. Thus far, we have tried holes of the following sizes: 1/64, 1/16, 3/16, 7/64. Our goal is to find the largest sized hole that is most optimal; it is simple to drill through an aluminum can but difficult to do so through a 1/8" thick walled steel. We need to know if we are compromising yield or output (and if so, by how much) by either increasing or decreasing the hole size.

Hypothesis We do not think hole size affects yield. It may affect rate.

Materials/Apparatus

- 4 Tin cans

- Raw Peanuts - 1cup/can

- Peanut Pres

- Graduated Cylinder (100 mL)

- Measuring Cup

- Water

- Load Cell

- Computer/Software Program to interpret load cell readings

Experimental Procedure

1. Drill holes into each can. one can each with holes of diameter 1/64, 1/16, 3/16, 1/8) 18 holes even spaced around 360 degrees; 6 rows high 1/2cm apart; each row staggered

2. Measure 1 cup of peanuts (pour 1 cup of water into graduated cylinder; pour peanuts in until water displaces by one cup); Dry peanuts on paper towels.

3. Place peanuts into tin can, creating 5 layers with 4 metal spacers.

4. Place can into peanut press. Begin turning car jack until piston begins pressing against peanuts. Monitor the pressure via the computer, and cease cranking the jack when the pressure reaches 800psi. (Calculate corresponding force since that is what load cell measures)

5. Wait while oil seeps out for one minute after reaching 800 psi. Make sure that the force/pressure remains constant during this minute (i.e. do not just turn the screw every 10 seconds as in the force/pressure experiment).

6. Record the amount of oil collected in the graduated cylinder every 5 seconds. After 2 minutes, record the total amount of oil collected.

7. Make observations of immeasurable phenomena such as clogging.

Observations   Calculations
Calculations of force and pressure on load
cell Results Graph total yield (in mL) as a function of hole size
Graph average flow rate (in mL/sec) as a function of hole size Conclusions and Recommendations

C Experimental Procedure 2 - Determining Optimal Force and Pressure

Background Throughout the design process we have been informally experimenting with different sized holes in our can. Thus far, we have tried holes of the following sizes: 1/64, 1/16, 3/16, 7/64. Our goal is to find the largest sized hole that is most optimal; it is simple to drill through an aluminum can but difficult to do so through a 1/8" thick walled steel. We need to know if we are compromising yield or output (and if so, by how much) by either increasing or decreasing the hole size.

Hypothesis We do not think hole size affects yield. It may affect rate.

Materials/Apparatus

- Tin Cans

- Raw Peanuts

- Peanut Press

- Graduates Cylinder

- Measuring Cup

- Water

- Load Cell

- Computer/Software Program to interpret Load Cell

Experimental Procedure

1. Drill holes into each can. one can each with holes of diameter 1/64, 1/16, 3/16, 1/8) 18 holes even spaced around 360 degrees; 6 rows high 1/2cm apart; each row staggered

2. Measure 1 cup of peanuts (pour 1 cup of water into graduated cylinder; pour peanuts in until water displaces by one cup); Dry peanuts on paper towels.

3. Place peanuts into tin can, creating 5 layers with 4 metal spacers.

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5. Wait while oil seeps out for one minute after reaching 800 psi. Make sure that the force/pressure remains constant during this minute (i.e. do not just turn the screw every 10 seconds as in the force/pressure experiment).

6. Record the amount of oil collected in the graduated cylinder every 5 seconds. After 2 minutes, record the total amount of oil collected.

7. Make observations of immeasurable phenomena such as clogging.

Observations

Calculations Calculations of force and pressure on load cell **Results** Graph total yield (in mL) as a function of hole size Graph average flow rate (in mL/sec) as a function of hole size Conclusions and Recommendations

D Determining Optimal Diameter and Height

Purpose Determining the optimal diameter and height.

Background Based on our current design, the yield is limited in part by the volume of uncrushed peanuts that can fit in our can (soon to be cylinder). We would like to increase the height of the cylinder and create more layers using more spacers to see and determine if yield increases significantly. One concern is that the oil extracted from peanut layers towards the top of the cylinder will have to slide down a longer length of the cylinder and therefore a smaller percentage will actually be collected. We have to make sure that the oil lost on the sides of the cylinder does not outweigh the oil gained through having a taller cylinder.

Hypothesis We think increasing the height and diameter will increase the yield but we are unsure if we can maintain the pressure and oil yield.

Materials/Apparatus 1.) 3 and 4 OD tubing (3.25, 4.75, 6.5) Will we have time? What is more important? We will experiment with diameter first and based on those results, we will proceed with the height. 2.) Raw Peanuts different amounts of peanuts for each can 3.) Peanut Press 4.) Graduated cylinder (100 mL), (larger) 5.) Measuring cup 6.) Water 7.) Load Cell 8.) Computer/Software program to interpret load cell readings

Experimental Procedure

1.) Measure peanuts (pour 1 cup of water into graduated cylinder; pour peanuts in until water displaces);

Tube Specifications Number of Spacers Peanut Volume (cups) 3 Diameter 3.25 Height 5 1.5 3 Diameter 5.75 Height 7 2.25 3 Diameter 6.5 Height 10 3 4 Diameter 3.25 Height 5 1.5 4 Diameter 5.75 Height 7 2.25 4 Diameter 6.5 Height 10 3

3.) Place peanuts into tin can, creating layers with metal spacers.

4.) Place can into peanut press. Begin turning car jack until piston begins pressing against peanuts. Monitor the pressure via the computer, and cease cranking the jack when the pressure reaches 800psi. (Calculate corresponding force since that is what load cell measures)

5.) Wait while oil seeps out for one minute after reaching 800 psi. Make sure that the force/pressure remains constant during this minute (i.e. do not just turn the screw every 10 seconds as in the force/pressure experiment).

6.) Record the amount of oil collected in the graduated cylinder every 5 seconds. After 2 minutes, record the total amount of oil collected. Record observations. Calculations of force and pressure on load cell

Results Graph total yield (in mL) as a function of diameter size Total yield per cup of peanuts vs diameter Total yield per cup of peanuts vs height Graph average flow rate (in mL/sec) as a function of hole size
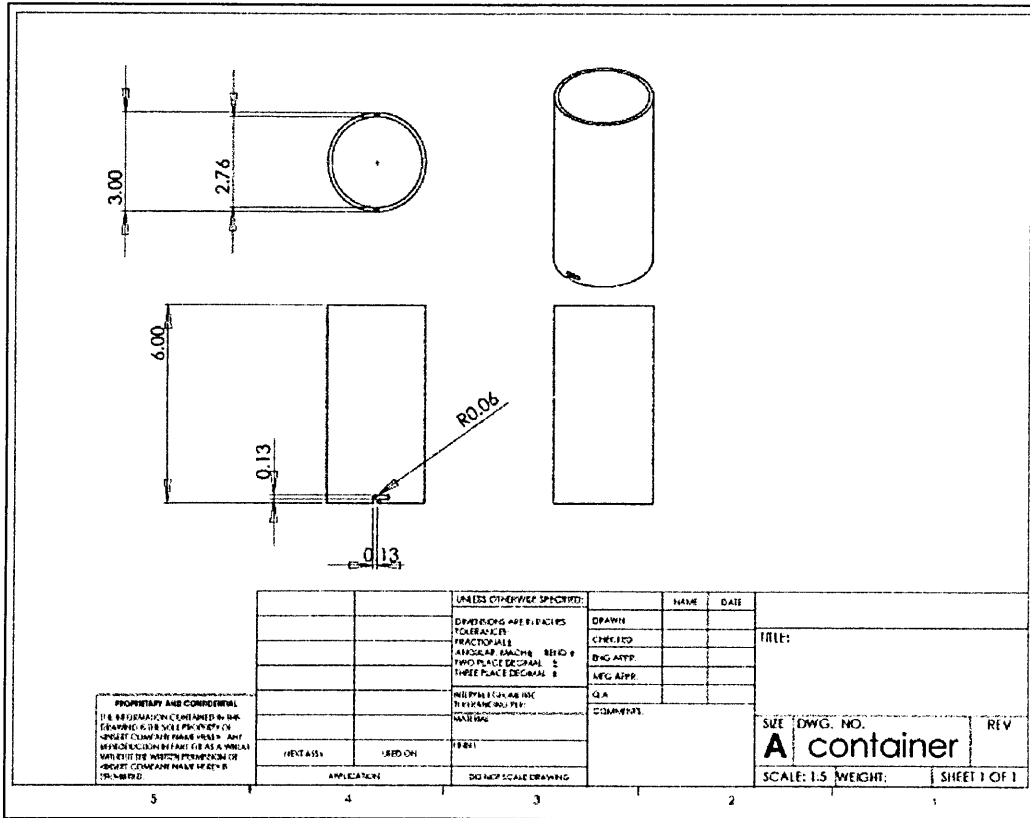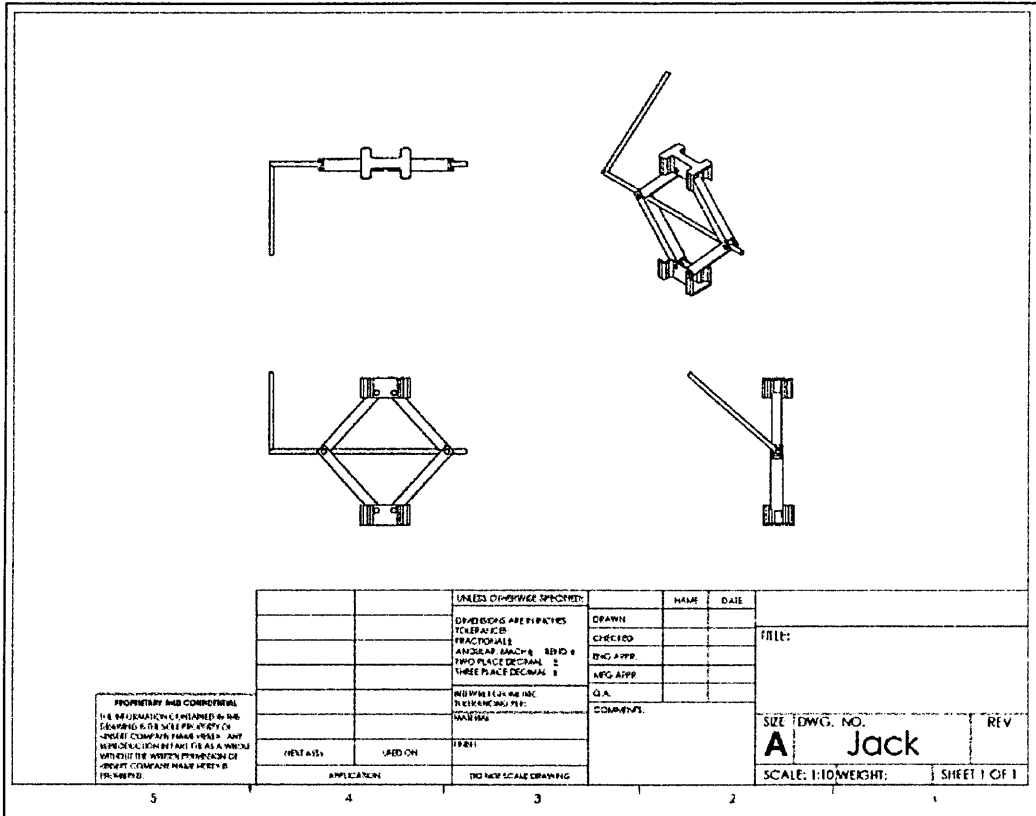
E Parts with Dimensions

Figure 34: Bottom Container

Figure 35: Peanut Container
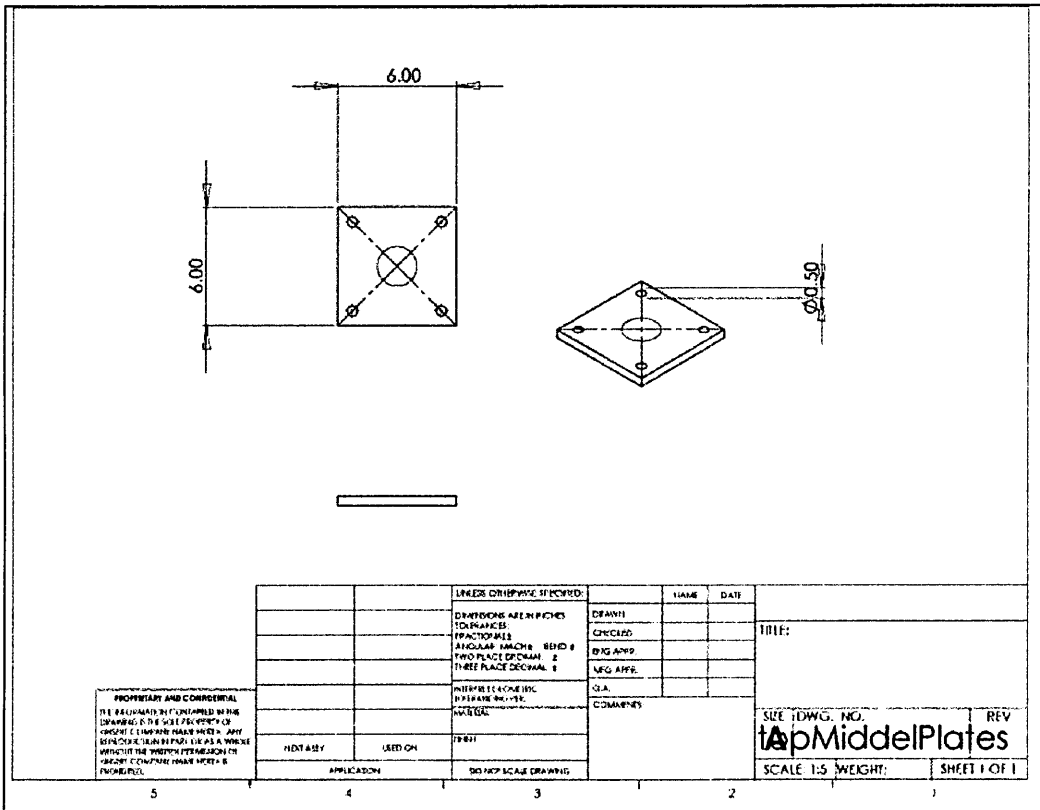
Figure 36: Oil Collection and Filter

Figure 37: Scissor Car Jack

Figure 38: Piston

Figure 39: Threaded Rods

Figure 40: Top Plate