Team #1

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October 4, 2013

THE SOLAR BLANKET

Solar Dryer Tray Project Final Report

Prototype 1

Specifications:

12”x18” wood with a .75” thickness nailed together at each corner

2 Paper clip hinges on each 18” side. 1 paper clip hinge on each 12” side

Cotton weave fabric covering the wooden frame held together by hinges 4 needles at the corners

Drying capabilities: How much water is lost in bananas for a drying time of 6 hours

Mass of Bananas Before Drying (g)	**8.5**
Mass of Bananas after Drying (g)	**2.0**
Water lost from bananas (g)	**6.5**

Tests:

Three tests were conducted on the solar dryer tray for three separate variables.

1. Cleaning Test
2. Weight Test
3. Durability Test

The cleaning test (results in Table 1) was conducted to see how easy the cotton weave fabric is to clean. This test was separated into two separate cleaning tests: with and without soap. Cotton weave fabric is easy to stain, so we defined the state of being clean as having the same texture and properties as before being used. Discoloration of the cotton weave was expected and does not affect its cleanliness.

The weight test (results in Table 2) was conducted to see how much weight the solar tray could hold. The point of this experiment was to see if the tray can hold a large amount of fruit. To test this, we put several hammers on the solar dryer tray and lifted the tray to see how it would bend / break. 1 hammer was equal to two pounds for this test.

The durability test (results in Table 3) was conducted to test how well the solar dryer tray maintains its form with stress applied to it. The first part of this test was conducted alongside the weight test to see if the tray changes form with weight applied on the cotton weave. The second part of this test was conducted to see how much force the tray can take before its form is completely lost. This was done by applying forces to the corners to see if the tray changes shape. We were to look for nails coming out of place, the cotton being ripped, the wood breaking, and the needles dislocating.

Table 1

Cleaning Capabilities	
Without Soap	With Soap
Banana residue still on cloth	No banana pieces or banana residue on cloth

Table 2

Weight Test	
2 pounds	Does not bend cloth
4 pounds	Does not bend cloth
6 pounds	Bends cloth slightly
8 pounds	Bends cloth and wood slightly

Table 3

Durability Test	
Hammer Test	Bent the wood on all corners inwards
Forces on corners	Can pull apart tray with minimal force

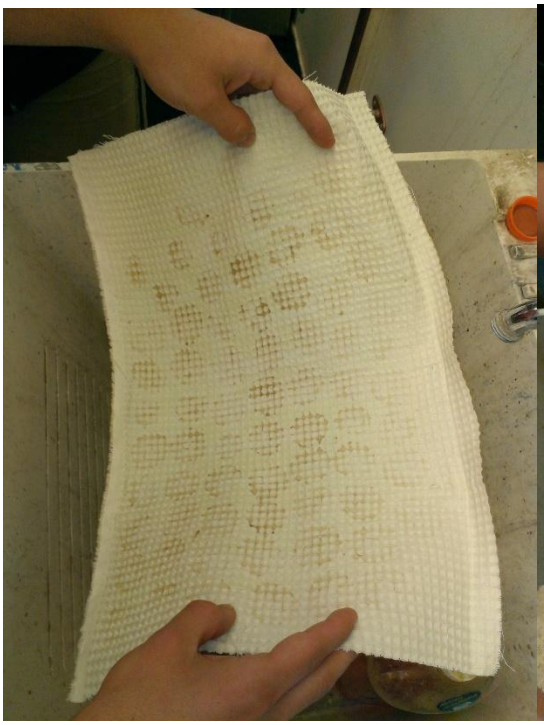
The solar dryer tray performed exceptionally well in terms of drying capabilities, but the tray still had several design flaws. The cleaning test showed that the cotton fabric does not become fully clean with water alone. Once soap was used to clean the fabric, the cotton weave was clean and only had discoloration from the banana. The fabric returned to its original state after being cleaned with soap. Pictures before cleaning, after cleaning, and after cleaning with soap (Figure 1, 2, 3 respectively) are at the end of the report.

The weight test was very successful. The tray was able to withstand more than enough force than fruit will be able to apply to the tray (est. 6 pounds absolute maximum). While 6-8 pounds worth of hammers bent the cloth, it did not affect its function. The amount of curvature is small, and would not get in the way of other trays in a solar dryer.

The durability test contained the most flaws in the tray's design. The tray bent very easily due to the weak wood used in the project and the inefficient nails used to hold it together. We only had one nail on each corner holding the tray together, and it was very easy for the tray to come undone after bending with a moderate amount of force. If this were being used daily, the tray would not last very long.

Cotton Weave Cloth

Before washing (Figure 1)



Cotton Weave Cloth

After washing with water (Figure 2)

After washing the cotton weave cloth with soap (Figure 3)

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Prototype 2

12”x18” wood frame with a 0.75” thickness and industrial staples in each corner.

4 unfold paper clips hooks on each 18” side. 2 unfold paper clip hook on each 12” side

Cotton weave fabric covering the wooden frame held together by 4 pins in the corners.

The cleaning capabilities are the same as prototype 1 because the cloth is the same.

Tests:

1. Weight Test
2. Durability test
3. Ease of manufacture
4. Hairdryer Test

We performed the weight and durability test again because we changed the structure of the tray, but the cloth is the same as before so that test was not repeated. The ease of manufacture test was necessary because it is one of the key design factors.

Table 4 (Weight Test for Prototype 2)

Weight Test	
2 pounds	Does not bend cloth
4 pounds	Does not bend cloth
6 pounds	Bends cloth slightly
8 pounds	Bends cloth slightly

In the new prototype we use 4 clips in each 18” side and 2 on each 12” side, this improves the design and makes the tray resist 8 pounds without a problem. Figure 6 shows the tray holding 4 hammers (2 pounds each) flawlessly. While the cloth was still bent, the wood was not bent like in Prototype 1. This is due to the more sturdy design used in Prototype 2.

Table 5 (Durability Test for Prototype 2)

Durability Test	
Hammer Test	Did not bend the wood
Forces on corners	Could not break or pull apart tray

This tray performed exceptionally well with the durability test. The tray did not bend or break and it held its form perfectly in contrast to prototype 1, where it did not perform well at all. Figure 6 shows the tray being suspended with hammers (2 pounds each) on the tray.

Table 6 (Ease of Manufacture Test)

Easy to manufacture Test	
Number of pieces	6
Design time	Less than 1 hour

Our design is very easy to manufacture. To assemble our tray the person needs to cut the wood to the size in our specifications and then use an industrial stapler to staple the pieces of wood together at the corners. They can then use clips to secure the fabric.

Hairdryer test (15 min)	
Mass of bananas and the tray before drying	72g
Mass of bananas and tray after drying	59g
Water loss from bananas	13g

The hairdryer test was very successful. This experiment was set up so that someone was pointing a hair dryer (Figure 4) at the bananas on the tray (Figure 5) for 15 minutes at a temperature of 60 degrees centigrade. The total mass lost in 15 minutes was 18% of the initial mass. However, it should be stated that this does not apply to an actual solar dryer. Hair dryers move air at a much higher speed than the air that will be flowing through the solar dryer. The actual flux of the air through the bananas using a hair dryer is much higher than that of a solar dryer.

Food Grade Eligibility

The cotton used in our prototype is of the same type as that used in cheese cloths for making cheese, so it meets the same standard in that regard. Cotton is listed under approved fibers intended for repeated use, so it is food grade. The qualification for approved fibers is, most importantly, “generally recognized as safe in food” ("Cfr - code," 2013).

Costing

The cost of the solar dryer tray is under the goal of $10/tray. The cost of the cotton weave bought for this project was $10, however, after researching it was possible to find cotton that with a rate of 0.5 dollars per square foot. The price of cheesecloth, which is similar to the cotton weave used, is approximately 0.5 dollars per square foot (2). Because the size of the actual tray is 18” by 36”, or 6 square feet, the cotton component would cost $3. The wood is difficult to price, but due to the small amount of wood being used, a $7 or less projection is not unreasonable. The price of the industrial staples is negligible. A 1000 pack of industrial staples costs $3 (3), or 1 cent per tray. Paper clips also cost $3 (4), or 2 cents per tray.

> Note: Costs were obtained from Amazon.com for an estimate of current market prices (2) refers to the second source in references or the first amazon link, (3) refers to the third source in references or the second amazon link, etc.

Re-design Ideas

This design for the solar tray is remarkably solid with only a few flaws. The flaws of this prototype resided in the unnecessary amount of hooks we used. The tray did not need 4 paper clips on each long side to hold it together, so two would be used in a future design. However, paper clips are not a viable option. In fact, it may be ideal to make drape the whole tray in cotton and remove all hinges. In this design, the cotton would act as a pillow that can be tied at the end of the tray. This would make disassembly and reassembly much easier without removing functionality of the tray. An alternative to the hair dryer test would be ideal. It is not representative of how the tray performs in a solar dryer at all. The air flow is significantly different, which is very important when dealing with drying capabilities. The oven drying test is much more representative of a true solar dryer. The structural design of the tray should be kept, as it passed all the tests flawlessly.

The Hair Dryer (Figure 4)

Tray used for hair dryer test (Figure 5)

← Hammers used during the hammer test (Figure 6)

References

Cfr - code of federal regulations title 21. (2013, 04 01). Retrieved from

http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfCFR/CFRSearch.cfm?

http://www.amazon.com/Regency-Natural-Cotton-Cheesecloth-9sq-ft/dp/B001B14ODG

Used for an estimated price of cotton

http://www.amazon.com/Arrow-215-Genuine-16-Inch-000-Pack/dp/B00004Z2HC/ref=sr_1_4?ie=UTF8&qid=1384399491&sr=8-4&keywords=industrial+staples

Used to estimate the price of industrial staples

http://www.amazon.com/ACCO-Economy-Paper-Non-skid-A7072385/dp/B001B0D5T6/ref=sr_1_1?ie=UTF8&qid=1384399579&sr=8-1&keywords=paper+clips

Used to estimate the price of paper clips