

The Wire Dryer - Final Report

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Tests conducted in 313 Hammond on October 3, 2013, 2:30PM (Prototype #1);

October 10, 2013, 2:30PM (Prototype #2)

(unless otherwise specified)

Table 1: Testing Summary for Prototype #1 and Prototype #2

Test	Description of Test	Results/Notes (Prototype #1)	Results/Notes (Prototype #2)
Capacity	How many whole bananas fit on the tray	2 bananas filled roughly 4 of the 7 wires of the tray. Entire tray estimated to hold 3.5-4 whole bananas	[Not tested]
Durability (Drop Test)	From height of 4 feet: tray dropped once horizontally (rods parallel to floor), once on its smaller side, and once on its corner onto the tile floor of 313 Hammond (total of 3 drops)	No visible damage was evident after the horizontal and smaller side drops. However, after the tray was dropped on its corner, the corner joints began to separate.	-No damage on the horizontal drop. -One dislodged wire after long side drop. -Retaining bar and 3 wires dislodged minimally after corner drop.
Durability (Shake Test)	Tray was shaken vigorously in all directions for roughly 30 seconds.	[Not tested]	The wires did not come out of place (no damage was noticed)
Drying Effectiveness (Prototype #1) - conducted at Ms. Kisenwether's residence	Tray placed in Ms. Kisenwether's home oven for 6 hours with two banana's worth of slices. Slices weighed before and after drying.	Initial weight of bananas: 7oz. Final weight of bananas: 2oz. Our device reduced the water content by roughly 71%	N/A
Drying Effectiveness (Prototype #2) "rapid-drying"	Nine banana slices placed in three rows of three in the center of the tray. Thermocouple placed in center of tray. 1250-watt hair dryer set to "High" aimed at center of tray such that temperature was maintained near 60 degrees Celsius for 15 minutes	N/A	Initial weight of bananas: 23.0g Final weight of bananas: 17.8g Our device reduced the water content by roughly 23% Bananas closer to center of tray (where hair dryer was aimed) were drier, especially around the edges. All slices were wet in the middle.
Ease of Cleaning	A rag was saturated with cold water and then slightly rung out. The rag was then used to scrub the tray for 1 minutes. Before and after visually compared.	While the rag was successful in removing some of the banana residue, discoloration remained on the wires and some residue would not come off (see pictures and observation summary for more detail)	All banana residue was removed.

Observation Summary

The main difference in the testing of Prototype #2 as compared to that of Prototype #1 was in the way the Drying Effectiveness test was carried out (see Table 1). For Prototype #1, the tray was loaded with two banana's worth of slices—we counted 68 (see Figure 7)—and was placed in Ms. Kisenwether's home oven for 6 hours. The weight of the banana slices was determined before and after drying, and the percent reduction in water content (assuming that all loss of mass was water) was calculated to be roughly 71%, as shown in Table 1. In contrast, Prototype #2 was tested with a rapid-drying method, as there was not enough time to complete another full drying cycle in the oven. For the rapid-drying test, nine banana slices were arranged on the tray as shown in Figure 1. A thermocouple was placed near the center of the banana formation so that a temperature reading could be taken. A 1250-watt home hair dryer set to "High" was aimed at the center of the formation, and the distance from the hair dryer to the thermocouple was manipulated by moving the hair dryer. The goal was to keep the thermocouple reading as close to 60 degrees Celsius for the duration of the 15-minute test.

After the 15 minutes was completed, the banana slices appeared as pictured in Figure 2; their edges were beginning to dry, but their centers were still wet. This was a stark contrast to the dried slices from Prototype #1 (Figure 8). The quantitative results confirmed this, as the rapid-drying test only reduced the water content in the banana slices by roughly 23% (see Table 1). For only 15 minutes of drying, the 23% reduction was still a significant reduction. However, it would be unfair to compare the results of the rapid-drying test directly to the results of the oven-dry test done on Prototype #1—they are two very different drying techniques. In the oven, only convection causes movement of air, whereas the hair dryer pushes high-velocity air at the fruit. Thus, the hair dryer will dry the bananas at a higher rate. Using a linear estimation of drying rate, the hair dryer method reduced the water content of the fruit at a rate of about 92% per hour, while the oven drying method managed a rate of about 12% per hour.

The oven-dry test more closely simulates real conditions in Kenya. The use of a hair dryer consumes an enormous amount of electricity, which is neither available in high quantities in Kenya nor an efficient method by which to dry fruit. The hair dryer pushes air in a narrow column, and therefore one hair dryer air cannot cover the entire tray. Thus, the rapid-drying method is only effective for small quantities of fruit. In Kenya the solar dryer will directly use the sun's heating ability to warm the air in the dryer—little to no electricity required—and will be able to dry a much higher quantity of fruit at a time at a slower rate but with increased efficiency.

The same wash test was performed on Prototype #2 as was performed on Prototype #1, and our observations seem to show much better results for Prototype #2. In Figure 3, no banana residue is visible after washing, whereas Figure 11 and Figure 12 depict banana residue spots even after washing. However, the observations may be misleading, as Prototype #2 did not dry the bananas as much. The banana residue did not harden and stick to the tray. After the rapid-drying test the bananas slid off with ease because their centers were still wet. Therefore, not

much weight can be placed on the results of the cleaning test for Prototype #2. Under the oven-dry conditions, we would likely expect Prototype #2 to behave similarly to Prototype #1.

Another major change in Prototype #2 was in its construction. The loading and unloading mechanism was redesigned, and this modification is the primary feature of Prototype #2. It features wires that are fixed at one end (similar to Prototype #1—Figure 9), but the other ends are straight instead of the curled ends pictured in Figure 10. Not having curled ends makes it easier and less time-consuming to load the banana slices; with no wire to uncurl, the user simply rotates the retaining bar (pictured on the right of Figure 4), lifts up a wire, and slides the slice on the wire. When all the wires are loaded, the retaining bar is rotated back to its original position, where it snaps into place. Additional modifications found in Prototype #2 include additional nails in the joints to increase the joint durability during drop tests. In our drop tests, Prototype #2 performed similarly to Prototype #1. Joint separation was still evident (see Figure 6, Figure 13). Additionally, since the wire ends are no longer curled around the side, there was potential for them to be dislodged as a result of an impact. As depicted in Figure 4, some of the wires were dislodged after the long side drop test, but Figure 5 shows that all of the wires remained in place in the horizontal drop test. We are not concerned with the wires becoming dislodged—a shake test was performed (see Table 1 for details), and no wires were dislodged. Even if a wire were to come out of place, the fruit would not likely fall off, and the wires are easy to put back into place.

The Wire Dryer is a cost-effective and easy-to-manufacture design concept, requiring the use of minimal materials: 12-gauge wire, wood, finishing nails, and wood glue. All of these materials are low cost; 12-gauge wire is \$6.79 per 100ft from The Home Depot¹, and the wood used can even be scrap material. The cost of the nails and glue is almost negligible, at roughly 2 cents per nail² (times 10 nails) and pennies more for the small quantity of glue used. Thus, the price of the device depends mainly on the cost of the wood. The full scale model would use about 31.5 ft of wire (at the same spacing as the small-scale version), for a cost of \$2.14. All sides of the device could easily be cut from a 2 x 4 x 8' block of wood (likely with excess wood remaining), which is sold for \$2.82³. All in all, the total cost of the full-sized tray comes out to be just over \$5—well within the \$10 goal.

However, with material selection comes the goal of using food-safe materials. With The Wire Dryer, the only material that comes into contact with the food is the metal in the rods. The wood does not have to be specifically food-safe, although treated lumber would not be recommended nonetheless. In the prototyping lab, it was difficult to determine which materials were food safe and which were not. We used the wire that most suited our design (thick, flexible,

¹ <http://www.homedepot.com/p/Suspend-It-12-Gauge-100-ft-Hanger-Wire-8850/100670613#.UmiS8ZEQhBU>

² <http://www.homedepot.com/p/Grip-Rite-12-1-2-x-2-1-2-in-Galvanized-Steel-Finish-Nails-1-lb-Pack-8HGF1/202308603#specifications>

³ <http://www.homedepot.com/p/Unbranded-2-x-4-x-8-Premium-Kiln-Dried-Whitewood-Stud-161640/202091220#specifications>

and sturdy), but the wire did not have any external markings of its composition that would enable it to be designated food-safe. According to a University of Florida article⁴, food contact surfaces should be smooth, nonporous, nonabsorbent, nonreactive, corrosion resistant, nontoxic, and cleanable (to list a few). Our wire was smooth, nonabsorbent, relatively cleanable, and appeared nonporous. However, without knowledge of its material composition, we couldn't determine its reactivity, corrosion resistance, or toxicity. A good material to use for the wires would be stainless steel, as it is "the preferred general use metal for food contact surfaces," according to the article.

Redesign Ideas

Even though the project has come to a close, there are a few things that our group would have liked to improve upon with our tray if we were to make a prototype three. We think that the material of the rods/skewers can still be improved and we also think that we could improve the quality of the wood and of the materials used to hold the tray together.

While the wire that we were using carried out its role, we still think that there might be better materials to use out there. We still think that the wires are a bit too bendy which sometimes makes loading and unloading difficult and makes washing the tray a pain. We think that the bendiness may have also led some people to think that our tray was not durable, even though the wires worked just fine. Regardless, we think that we could either find a less flexible metal string/rod or we could look for food safe plastic rods.

The other thing we could improve would be the general quality of the frame's materials. Because we were creating a prototype, we created the frame out of scrap wood. For the next prototype or the final product we would have liked to find some better quality wood to increase the durability and workability of the tray. The increased quality of the tray would allow us to make another improvement that we wanted to make, which is using screws to hold together the majority of the tray rather than nails. By using better quality wood, we could use screws and not split the wood, and therefore further increase the durability of the tray.

⁴ <http://edis.ifas.ufl.edu/fs119>

Images (Prototype #2)



Figure 1: Banana slices on tray post-drying



Figure 2: Banana slices removed from tray post-drying

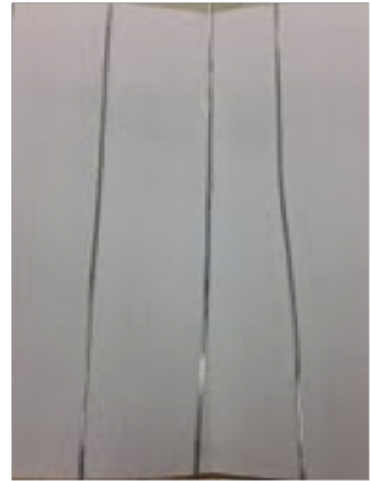


Figure 3: Banana residue after wash test



Figure 4: Top of tray after long side drop test



Figure 5: Bottom of tray after horizontal drop test



Figure 6: Corner of tray after corner drop test (most severe damage shown)

Images (Prototype #1)



Figure 7: Dried banana slices (68 total)



Figure 8: Dried banana slices close-up



Figure 9: Tray side view (fixed wire ends)



Figure 10: Tray side view (curled wire ends)



Figure 11: Tray top view prior to wash test. Black spots on wire are banana residue.



Figure 12: Top view after wash test. Black residue spots still exist, but there are fewer.



Figure 13: Corner of tray after corner drop test.