Solar Cooking for Disaster Relief

Lars Bjorndal [1] and Ann C. Wilkie [2]

[1] Electrical Engineering Major

[2] Faculty Adviser, Soil and Water Sciences Department, University of Florida-IFAS, Gainesville, Florida

Abstract

Solar energy is arguably the most abundant resource in the world and enabling people to use the sun can be a powerful tool in elevating the standards of living in developing countries and disaster-struck areas. Solar cookers are relatively simple to construct and can be cheaply produced and distributed. They have great potential in disaster and humanitarian relief situations, like what occurred in Puerto Rico and other Caribbean islands after the recent hurricane Irma. A solar cooker is easy to use and relies only on sunlight to work. In areas with limited electricity, it could provide a sanitary and effective way of preparing food, thus helping prevent diseases and malnutrition. Further, the use of a solar cooker could potentially reduce air pollution and respiratory illnesses from traditional cooking fires that burn wood or charcoal. A solar cooker uses sunlight to directly generate heat and therefore has a very high energy efficiency. In a preliminary test, 1.5 liters of water were heated to a temperature of over 60℃ within an hour. While this result can be further improved with optimization of the cooker, it is a promising result, as it is approaching the temperature needed to prepare a safe meal.

Introduction

The harmful bacteria typically found in food are neutralized at temperatures between 63℃ and 74℃ (**1**). This experiment has therefore focused on using solar cookers to reach temperatures exceeding this range. Water has a greater heat capacity than common food items (**2**) and was therefore used to assess the solar cookers. To evaluate optimal cooking methods for solar cookers, the experiment also assessed their ability to heat up different cookware.

In an effort to develop an affordable solar cooker that can be easily transported and constructed on site in disaster-struck areas, this experiment compares the effectiveness of a prototype solar cooker – constructed from a cardboard-box frame, 3 tinfoil reflector flaps, and polystyrene insulation – to that of a commercial solar cooker with a metal and wood frame, aluminum reflectors, and black plastic insulation.

Objectives

- Evaluate a solar cooker's effectiveness in producing heat and transferring it to water.
- Investigate the optimal use of a solar cooker in terms of time of operation and ideal cooking methods.
- Test and compare a prototype of a self-constructed solar cooker to a commercial model.

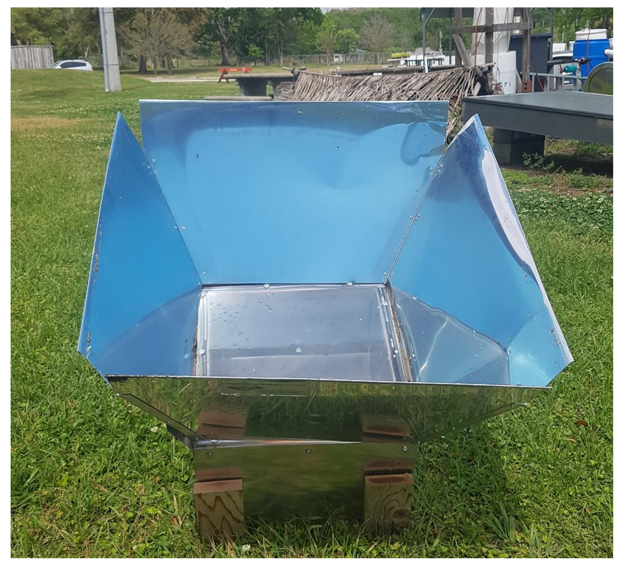

Figure 1. Commercial Solar Cooker

Figure 2. Prototype Solar Cooker

Methods

- Literature research of requirements for sanitary food preparation.
- Testing and evaluation of a commercial solar cooker and a prototype.
  - Both solar cookers were set to heat a pot filled with 1.5L water. The water temperature was measured with a mercury thermometer every 15 minutes.
  - The prototype was used to heat empty cookware (a frying pan and a pot) to a maximum temperature which was measured by an infrared thermometer.
- Evaluation of food and cooking methods suitable for solar cooking.

Results

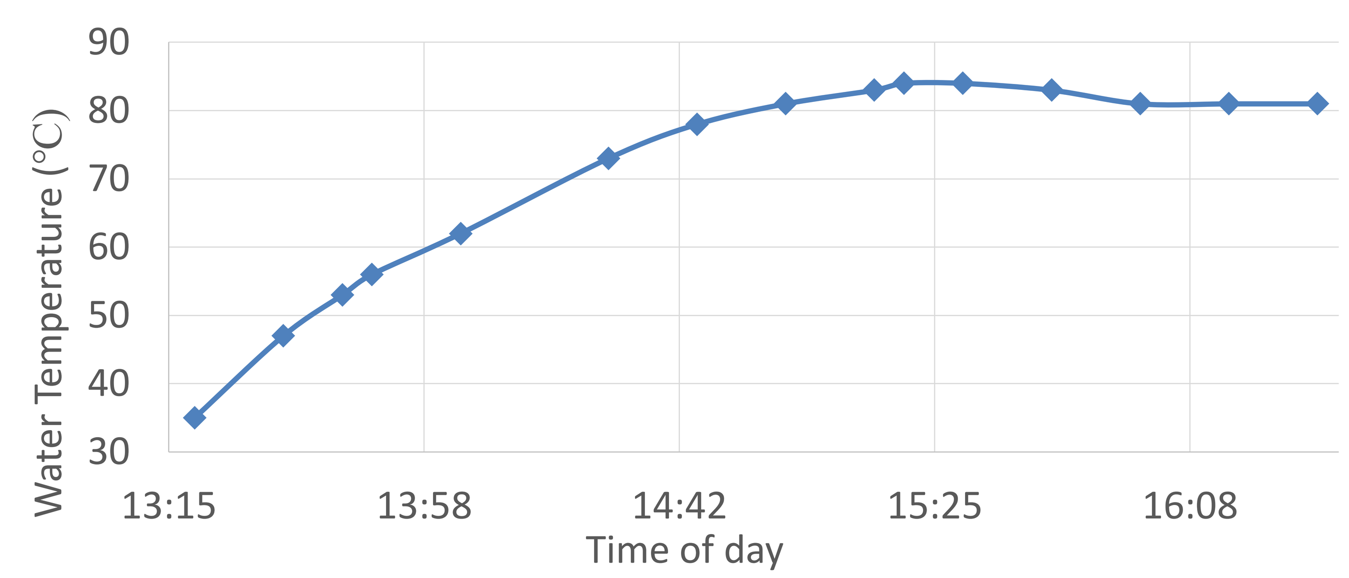

Figure 3. Temperature Data for Commercial Solar Cooker

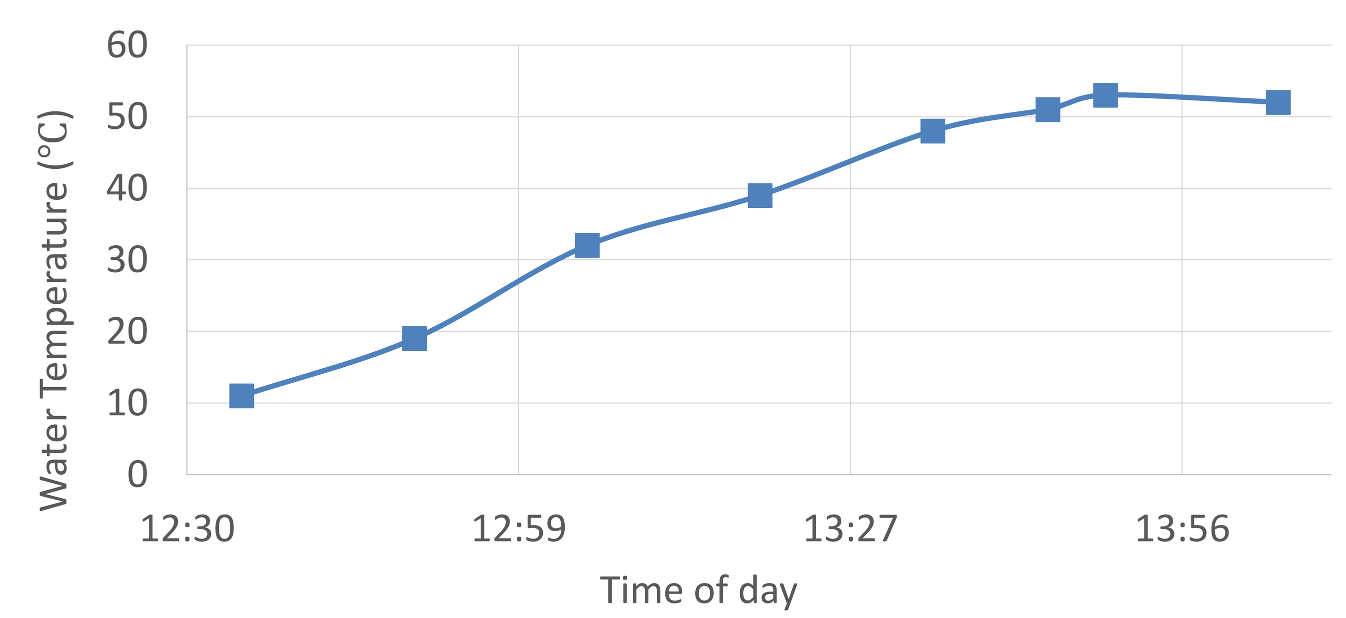

Figure 4. Temperature Data for Prototype Solar Cooker

Both solar cookers initially heated up quickly, but as their temperature increased they lost progressively more heat to the environment and eventually stabilized around a peak temperature.

The commercial solar cooker succeeded in heating the water from 35℃ to a sterilizing temperature of 78℃ between 13:20 and 14:45 (1 hr 25 min) and reached its peak temperature of 84℃ at 15:30. This temperature is lower than what is used in conventional cooking, but high enough to confirm that the cooker has the potential to prepare a safe meal.

The prototype solar cooker peaked at 53℃ and would need further improvements to be viable for this type of cooking.

Results (continued)

While the prototype had difficulty heating water, it succeeded in quickly heating the frying pan and empty pot to much higher temperatures, as seen in Table 1.

	Peak Surface temperature in ℃
Frying pan	105
Pot	100

Table 1. Surface Temperature of Cookware

As the intensity of the sun decreased around 15:30, the temperature in the commercial solar cooker also started decreasing. With the solar trajectory of the day the data was collected (03/17/2018), there was a period of about 4 hours (11:30 to 15:30) during which the cooker could operate at optimal capacity.

Conclusions

- This experiment has proven that a good solar cooker has the potential to heat food to safe temperatures.
- It is possible to bring metallic cookware to higher temperatures. Thus, in solar cooking, the high thermal conductivity of metal should be utilized to transfer heat directly to food.
- Solar cookers are not able to bring water to a conventional cooking temperature, and the cooking method used must therefore be adapted.
- Due to the solar trajectory, a solar cooker has a limited time during a day when it can function optimally. This must be taken into account when considering the use of solar cookers for disaster relief.
- The prototype solar cooker is still lacking in capacity compared to the commercial model, and the design should be reevaluated.

Future Work

- Further research should be done on the preparation of actual food and which cooking method is most effective for solar cookers.
- It will be important to gather information about weather conditions and what food would be available in an area to determine if and how solar cookers could be an effective aid.
- Design improvements for the prototype solar cooker should focus on increasing the sun collection area and improving the insulation.

References

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