SOLAR OVEN / COOKER MANUFACTURED FROM A DRUM FOR WASTE DISPOSAL

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Abstract. *It presents a solar oven / cooker for the baking and cooking foods manufactured from a scrap of polyethylene drum of 200 liters for waste disposal or storage of water. It will examine the processes of manufacture and assembly of the solar oven / cooker proposed, whose main characteristic is its low cost and is intended for low-income population, to minimize the use of firewood as damaging to the environment. One innovation is the design and construction of a new system profile reflector to direct sunlight into the oven / stove. This system presents a profile that approximates a parabola, increasing the capitation area of radiation and reflection of rays into the oven / stove. Such a parabolic profile was obtained through a floor segment of the drum is used. Are presented results of tests that diagnose the viability of using the solar oven / cooker for several types of food. Are compared the times of cooking and baking food with those obtained for other types of solar ovens / cookers presented by solar literature.*

Keywords*: solar energy, solar oven / cooker, low cost.*

1. INTRODUCTION

The firewood is the oldest energy used by man and still has great importance in the Brazilian energy matrix, participating with about 10% of primary energy production (National Energy Balance, 2008 - www.mme.gov.br).

About 40% of wood produced in Brazil is transformed into charcoal. The residential sector is the most expensive wood (29%). Usually it is for cooking food in rural areas. A family of eight requires approximately 2.0 m^3 of wood per month to prepare their meals. The industrial sector comes next with about 23% of consumption. The main industries that consume fuel in the country are food and beverages, ceramics and pulp and paper.

These data show that the massive use of wood, putting at risk the health of the planet, point to the need for a policy of mass use of solar cooker for cooking food as a way to preserve nature and also to lessen the ecological imbalance the indiscriminate use of firewood, while minimizing the emission of polluting gases into the atmosphere.

The use of solar energy for cooking and baking food is one of the oldest, spread this energy source and its main characteristic its social function. It's wonderful to see that people in Africa use solar ovens and massively contributing to a policy of non-use of wood, which contributes to the environmental imbalance of our planet.

In the northeastern hinterland plagued by droughts, the hinterland suffers from hunger and thirst due to inclement sunshine on their barren lands. The use of stoves / ovens in the solar caatinga promises to reverse or at least mitigate this situation by allowing backcountry better living conditions.

This paper presents a model of an solar oven / cooker for the baking sun and cook food, built from a scrap of polyethylene drums used for water or garbage dump. By presenting the parabolic cylinder-profile focus of the reflecting surface is linear, allowing the use of up to three pots inside.

The solar oven / cooker proposed is a prototype of solar for the average household in rural and urban, from 9:00 to 14:00 hours, mainly for the operation of cooking foods such as breads, cakes, pizza , lasagna, among others.

The main innovation of the work is the use of the drum, providing an oven to obtain greater internal volume that usually constructed, widely available, low cost and with a structure already defined and built, avoiding the production of cast to obtain cash. It should be noted that the material of the drum is an insulator.

Another innovation is the design and construction of a new reflector system profile from a segment of the drum to direct sunlight into the solar oven / cooker. This system presents a profile that approximates a parabola, increasing the catchment area of radiation and reflection of rays into the solar oven / cooker.

2. REVIEW BIBLIOGRAPHIC

Since ancient times people use the sun's energy to heat water, dry fruits and cooked vegetables. The first solar cooking with modern technology is attributed to Franco-Swiss Suassure of Horace, who built a small box solar energy, among other inventions related to this energy source. The solar kitchen Horace consisted of two boxes of pine wood, one inside the other, insulated with wool and had three cover glasses.

The British astronomer John Herschel used a solar kitchen of his invention during his trip to South Africa in 1830.

Also in the nineteenth century, Adams experimented with solar artifacts in India very successfully. By the year 1860, Mouchot, Algeria, cooked with a curved reflector, concentrating the sun's rays over a small saucepan.

In 1881 Samuel P. Langley used a solar cooking during the ascent to Mount Whitney in the United States.

Charles Abbot drew a mirror concentrator and achieved the same temperature around 200 ° C. Heated oil, retaining some of the heat for several hours after sunset, getting some food to cook at night.

With the arrival of the twentieth century the massive use of fossil fuels, but also the possibility of obtaining relatively cheap and abundant energy in almost all sections of the population, the industrialized world has forgotten the old and simple and natural techniques only in the last third of this century began to emerge when the problems resulting from the distribution of petroleum products and the increasing contamination of their products, solar energy was again being used albeit in incipient form.

In 1960 a UN study has been published to assess the real possibilities of implementation and development of solar kitchens in underdeveloped countries and developing countries. The conclusion of this publication was that the kitchens were viable and that it needed only a change in customs for an adaptation to their widespread use.

In this quest to make the solar cooker a real option for primetime for the cooking of food can not fail to mention the efforts of engineer Maria Telkes that created numerous designs for solar kitchens, which were characterized by easy construction and low cost, viable therefore, to be used in poor countries.

China and India later this season has made efforts to distribute a large number of solar cooking to the population.

In 1970 Barbara Kerr and Sherry Cole developed in Arizona several models of solar cookers that have received wide acceptance because of their low prices. Meanwhile, Dan Halacy, a pioneer in the field of solar energy, solar cooking fabricated 30-60, so named because its construction was based on angles measured in degrees whose they were.

In the '80s there was the popularization of solar chef, Sam Erwin. It was the most efficient solar oven at home. Sunspot was the simplest of Bud Clevette, along with the Sun Oven, which has greater diffusion.

In 1992 the Solar Cookers International Association promoted the First World Conference on Solar Cooking, a historic event that brought together researchers and enthusiasts from 18 countries. This conference was repeated in 1995, 1997 and recently in 2006 in Spain.

In Brazil the study of solar cookers was a pioneer in Solar Energy Laboratory, Federal University of Paraíba, in the 80's through the Professor. Arnaldo Moura Bezerra, who built several types of stoves to concentration, using various materials for the reflective surface of the paraboloid.

In LMHES/UFRN this line of research has been highlighted as having been the four dissertations, several scientific works and two other master theses in progress. Several versions of solar cook have been built.

Solar cookers are special devices through which sunlight are used for cooking food and other utilities. Classified into three basic types; kitchens of type box, galley kitchens and concentrators heated by flat plate collectors (Gomes, 2008).

The cooker box type can have different numbers of external reflectors, flat or slightly concave. It is characterized by allowing the attainment of temperatures below 150°C. It takes the heat and its operation is very simple. It has the advantage of being able to function with virtually no user intervention, keeping the food warm for a long time. It produces no harmful effects to the user or for contemplation or for reflection. Are stable and pose no risks for the production of flame, not generating, therefore, susceptibility to sunburn (Lion, 2007).

They are built with low cost materials, even if it is unlikely to use it for every day of the year. These models can be built for easy transport and lightweight.

This type of solar cookers finds wide application in the world, mainly in Africa and Asia, especially India and China as countries that have invested more in social programs that make the construction of low-cost solar cookers for a significant use by his people (Souza, 2009, 2007, Melo, 2008). Figure (1) shows several models of solar ovens / cookers in use in the world.

Figure 1. Solar ovens / cookers in use worldwide.

3. MATERIALS AND METHODS

The solar oven / cooker built has the following internal and external dimensions.

- Internal: L(length) = 49cm C(width) = 73cm, H(height) = 24cm; A(area) = 0.36m²; V = 0.066m³ (66 l);
- External: L(length) = 57cm C(width) = 87cm, H(height) = 30cm; A(area)= 0.20; V = 0.105 m³ (105 l);

The internal surface of the solar oven / stove was covered with sheets of mirror, pasted on sheets of EPS (Styrofoam) to the function of thermally insulate the enclosure of cooking, keeping his profile cylinder-parabolic.

We used a parabolic profile; a segment of the drum is made of polyethylene and covered with mirrors with catchment area of 0.46 square meters, in a structure above the furnace to reflect the incident rays inside. The structure of these segments of mirrors has motion to allow the adjustment of them in the light of the sun's apparent motion.

Temperature data were collected at various points inside the oven, to quantify the average temperature of the absorbing surfaces in the manner in which the food is placed and indoor air for several days of testing. There were also measures the temperature of the glass and the internal and external temperature. Was measured also the temperature of the outer surface of the oven on all sides and bottom to quantify and evaluate the thermal losses.

There were certain times of the oven for some food and their results were compared to the times obtained with conventional gas ovens.

The temperature data were measured with thermocouples Cromel-Alumel, coupled to a digital thermometer. The solar radiation was measured with a solarimetric station installed on LMHES/UFRN.

Every surface of the solar oven / cooker was covered with sheets of mirror and stops were placed at the bottom of styrofoam to give the same profile that allows a concentration of rays incident on it in the absorber surface where food was contained.

We used a plate covered with mirrors parabolic profile with catchment area of 0.6 m², in an oven above the structure to reflect the incident rays on his interior. The structure of these segments of mirrors has motion to allow the adjustment of them in the light of the sun's apparent motion.

Figure 2 shows the solar oven/cooker proposed preliminarily tested for baking a pizza 650g. During testing it was noted that the reflecting surface placed outside the oven needed some modifications to optimize the reflection of rays into the oven.

The geometry of the outer surface of this subject has totally changed as can be seen in Figure 3 where the furnace after the modification process of the external reflecting surface.

Figure 2. Solar oven / cooker in his first design.

Figure 3. Solar oven/cooker in its design modified.

4. RESULTS AND DISCUSSION

The solar oven/cooker was preliminarily tested to evaluate their ability to baking of a pizza (650g). The solar oven/cooker was exposed to the sun for 15 minutes before baking. When the pizza was placed in the solar oven/cooker at room temperature corresponded to 32.5 ° C, wind chill, 35.5 ° C and humidity 61%. Figure 4 shows the solar oven/ cooker in test.

Figure 4. Solar oven / cooker in test for baking a pizza.

The solar oven / coker was viable for the proposed end, producing baking in about 35 minutes, but the energy contribution from the external surface was small. He left to a process of modification of that surface. The test was then repeated and the results are shown in Table 1. The solar oven was exposed to the sun for 15 minutes before baking. When the pizza oven was placed in the internal temperature corresponded to 92°C, the absorber 101°C, room temperature 30.5°C, wind chill, 34.5°C and humidity 61%.

Table 1. Temperatures inside the oven and solar radiation during the test of baking a pizza (450g).

Time (hours)	**T_{int} (°C)**	**$T_{absorber}$ (°C)**	**I_d (W/m²)**
11:05	70	85	753,6
11:10	60	93	765,2
11:15	60	89	742,1
11:20	72	89	736,5
11:25	78	80	728,1
11:30	78	86	741,6

Despite the internal temperature of the absorber and reach levels below those obtained with a conventional oven gas viability thermal solar oven / cooker was demonstrated by the proposed acquisition of pizza baked in 25 minutes. Compared to other solar ovens / cookers shown in the literature alternative solar time obtained proved to be competitive and less about the best result. Figure 5 shows the behavior assumed by the oven internal and absorber temperature of the solar oven / cooker in test of a pizza backing.

Regarding the conventional oven, the time was obtained twice, but it is worth mentioning the cost-benefit ratio for the solar oven/cooker and want to study in such a prototype solar would be used primarily by people with low incomes. Figure 6 shows the solar oven / cooker modified producing a pizza baking and pizza after baking.

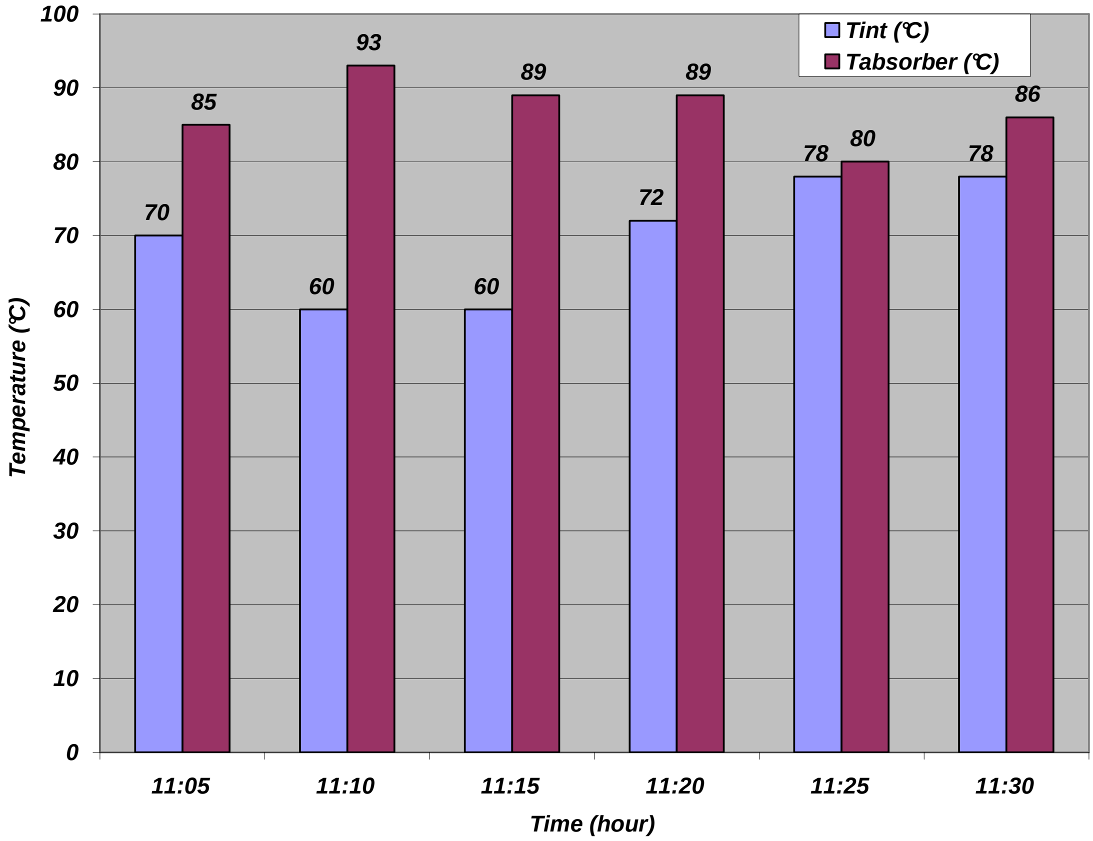

Figure 5. Behavior given by the absorber and internal temperatures during testing of baking a pizza in the solar oven/cooker studied.

Figure 6. Solar oven/cooker modified test for baking a pizza and pizza after baking.

Another test done was baking lasagna. Table 2 shows the measured data for the operation of baking lasagna 650g. The lasagna was posted at 11:38 hours, and at that moment the room temperature was 30.0 ° C, wind chill, 34.0°C and humidity 62%.

Table 2. Thermal results of the test for baking lasagna 650g.

Time (hours)	**T_{int} (°C)**	**$T_{absorber}$ (°C)**	**I_d (W/m²)**
11:43	69	56	741,2
11:48	82	54	738,5
11:53	83	60	742,6
11:58	84	68	744,2
12:03	87	69	745,7
12:08	87	73	735,5
12:13	89	76	732,8
12:18	85	75	725,8
12:23	88	73	732,4

The temperatures inside the furnace and the absorber were well below those achieved with a conventional oven gas. However, considering the time of baking lasagna in a conventional oven gas occurs in about 30 minutes, the solar oven / cooker built was viable to cook that food, especially for its low cost. Its time to cook the food tested was 50.0% higher. Solar radiation levels were in great magnitude. Figure 7 shows the behavior given by the measured temperatures in the solar oven/cooker proposed during the test for lasagna backing and Figure 8 shows the solar oven/cooker modified producing baking lasagna and baked lasagna after

A measure that causes a significant improvement in the efficiency of the baking oven is to place in the sun long before the beginning of the process of placing the food to produce his pre-heating, which also occurs in conventional ovens, where this recommendation is suggested for a uniform temperature.

The average surface temperature of the furnace was around 48.0°C, 13.0 ° C above ambient temperature. It is noteworthy that the entire external surface is black and is exposed to sunlight, which contributes to the increase of temperature. This low level of loss shows a good thermal insulation of the drum, which was made with EPS boards.

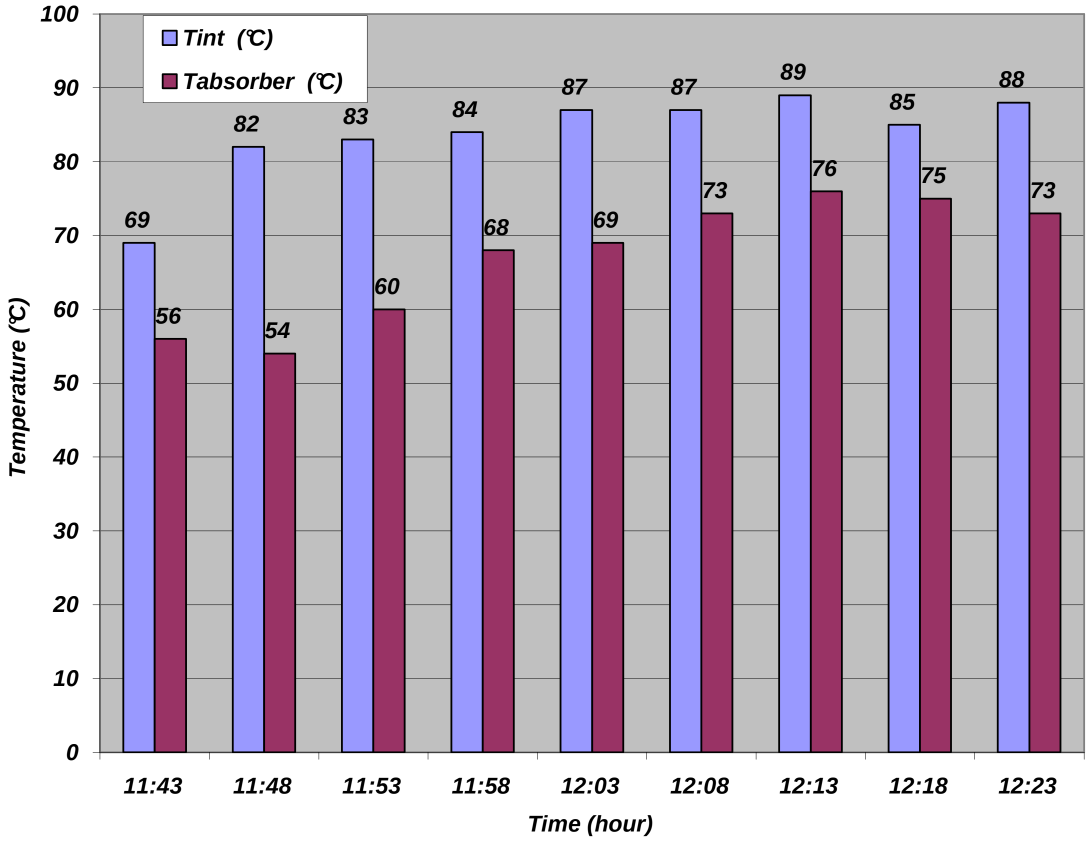

Figure 7. Behavior given by the absorber and internal temperatures during testing of baking lasagna in the solar oven / cooker studied.

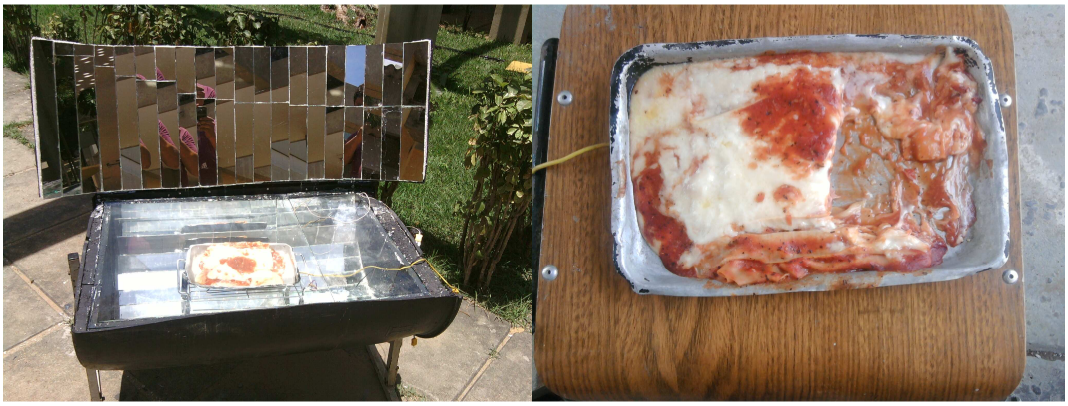

Figure 8. Solar oven/cooker modified test for baking a lasagna and baked lasagna after.

The tests demonstrated the viability of using the solar oven/cooker proposed. Its mass use can be of great significance in social policy to generate employment and income for poor communities, which could produce baked at a low cost and using clean energy, environmentally friendly and promotes sustainable development, contributing to the reduction of use of firewood as an energy source.

A test to be carried out is the two baking foods in oven while proposed. Since it has a parabolic profile, with concentration on one line, this option of the oven for more than a food becomes possible, resulting in a differential to other furnaces already designed. It is intended, for example, produce baking lasagna and pizza at the same time and compare their results with those obtained with other solar ovens shown in the literature for baking food.

5. CONCLUSIONS

1. The solar oven / cooker proposed was viable to cook food from 9:00 to 14:00 hours under good conditions solarimetric;
2. The solar oven / cooker has become more competitive with conventional gas stove for cooking food;
3. The solar oven / cooker has proposed cost-benefit ratio for its low cost manufacturing;
4. The operational and manufacturing processes and assembly of the solar oven / cooker proposed are simple and can easily be transferred to poor communities who might use it;
5. The baking times of foods tested were higher than those obtained with conventional oven gas, due to its lower internal temperature, but did not hamper the operations of roasting and baking foods;
6. The format of the mirrored surface inside the furnace led to a substantial increase in temperature of the base of the pan and a decrease in the time of baking or cooking food;
7. For the segments of mirrors placed on top of the furnace it was noted that the contribution of the same function to direct and concentrate the sun's rays inside the oven is extremely important, producing a better performance in roasting and baking foods by solar oven / cooker constructed;
8. The risks to the user of this type of stove are of low magnitude requiring only a few precautions that can be easily transmitted to its users;
9. It is intended to test the solar oven / cooker in the cooking operation of food and backing of the other foods.

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