 J Hum Ecol, 30(3): 197-199 (2010)

# Efficacy of Stainless Steel as Cooking Utensil Material for Solar Cooking

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**KEYWORDS** Rice. Aluminum. Consumers. Shopkeepers

**ABSTRACT** The study was undertaken with an objective to test the suitability of stainless steel utensil. Market survey of shopkeepers and consumers indicated a very high acceptance of stainless steel over aluminum. Experimental research design was used to test the efficacy of stainless steel. The data for testing the efficacy of stainless steel was collected after pre-testing and standardizing certain parameters *viz.* rice water proportion for cooking, thermal performance test under stagnant temperature condition and procedure to be followed for experimental work. Experiments on cooking time tested efficacy of stainless steel and compared stainless steel with traditionally used aluminum container in solar cooking. Further the efficacy of stainless steel containers was enhanced by comparing them with traditional black finish – black board paint. The results of the study indicate that solar cooking can be done in stainless steel container with some extra time. Stainless steel took merely 4-17 minutes extra in comparison to aluminum.

## INTRODUCTION

Alternative energy sources are far less polluting than traditional fuel (Sperber 2002). Among various alternative energy devices, cooker is gaining high appreciation, solar box cooker may save millions of women many hours. Food cooked in solar cooker is more nutritious. Usually aluminum black painted pot is used in solar cooker because of good heat conductivity, lightweight and low price. It is losing popularity due to its disadvantages like being highly reactive material. The rate of reaction specially increases if the food is acidic. Relationship between alumi-num and prevalence of Alzheimer disease has been established through researches (Jorm 1996). A market survey of sellers and consumers con-ducted by researcher has indicated that the preference for aluminum utensils has reduced by ninety percent and the material has been substituted by stainless steel. The steel utensils have been found more user friendly, corrosion resistant, easy to clean, and non-reactive. Steel can be more efficient in solar cooking with finishes. Efforts were made to test the efficacy of stainless steel in solar cooking, in order to search a possible alternative to aluminum cooking utensil. The present study was taken up with the objec-tives to test the suitability of stainless steel uten-sils for solar cooking. So that aluminum container can be willfully substituted by stainless steel container in solar cooking.

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## MATERIAL AND METHODS

The study on testing the efficacy of stainless steel was conducted using solar cooker, unobstructed open space for solar radiation, temperature recorder and other desired equipment for conducting experiments. Rice was the standard food grain used for testing the efficacy of stainless steel for solar cooking. Rice was selected for three reasons. Firstly, it is a staple food for two-third population world over (Ismail 2001), secondly, it is non-perishable and thirdly, it can be cooked simply without adding any additives. Experi-mental research design was used to test the efficacy of stainless steel for solar cooking. The data for testing the efficacy of stainless steel in solar cooker was collected in two phases.

*Phase I-Pre testing and Standardization:* Efficacy of stainless steel for solar cooking was test-zed by cooking 100 g rice with 300 ml of water each time for all experimental purposes. Before starting the experimentation the following were determined.

- Rice-water proportion for cooking
- Thermal performance test under stagnant temperature condition

· Procedure to be followed for experimental work

*Phase II*-Testing the Efficacy of Stainless Steel as Cooking Utensil Material

## RESULTS AND DISCUSSION

To test the efficacy of stainless steel as cooking utensil material for solar cooking, a number of experiments were conducted. Before conducting actual experiments certain parameters were standardized.

### 1. Pretesting and Standardization

***1.1 Standardization of Rice Water Ratio:*** After conducting various experiments the researcher reached to the conclusion that to cook 100g of rice, 300 ml of water is required. To reach this conclusion rice cooked in various ratios were given to a panel of selected judges for evaluation. The ratio of 100g of rice and 300 ml of water was rated as best with 4.21 scores on a 5 point scale.

***1.2 Thermal Performance of Solar Cooker:*** Based on the experiments conducted for testing the thermal performance of solar cooker, the ratio of optical efficacy to heat loss coefficient of solar cooker was calculated to be 0.153.Since the ratio was greater than 0.12 (Negi and Purohit 2004) the selected cooker could be rated as thermally efficient and was selected for conducting experiments for testing the efficacy of stainless steel for solar cooking.

***1.3 Market Survey:*** To know the consumer preference for the type of utensil material, 30 shopkeepers and 30 consumers were interviewed while 80 percent shopkeeper said that steel is more popular than any other material, 90 percent consumer said they preferred stainless steel over aluminum as cooking utensils material.

### 2. Experimentation for Testing the Efficacy of Stainless Steel

The actual experiments were conducted after the above standardizations. The experiments were conducted to test the efficacy of stainless steel in solar cooker once by comparing it with aluminum. The three replicates were taken for all the variations, thus the observations reported, are the averages of time, radiation and acceptability scores etc. For all the experiments the comparisons were made by

- Ø Solar cooking in high and low temperature.
- Ø Solar cooking with different loads (1, 2, 3 and 4 containers).

The product cooked for each experiment was given to selected panel of judges for rating the acceptability. The results of the various experiments are being reported.

***Comparison of Stainless Steel With Traditional Container Material-Aluminum:*** Comparison of stainless steel with traditionally used container (Aluminum) was done with the container lids painted with black board paint. To

**Table 1: Solar radiation, cooking time and acceptability scores for Al and SS in different loads of solar cooking**

| *Type of container* | *Time* | *Load in (no. of containers)* | *Average solar radiation in watt/m²* | | *Average time taken (minutes)* | *Average acceptability scores* |
|---|---|---|---|---|---|---|
| | | | *Initial* | *Final* | | |
| Aluminum | Before 1.00 PM | 1 | 649 | 833 | 73 | 2.49 |
| | | 2 | 660 | 856 | 82 | 2.39 |
| | | 3 | 667 | 920 | 95 | 2.65 |
| | | 4 | 678 | 954 | 115 | 2.70 |
| Stainless steel | After 1.00 PM | 1 | 680 | 862 | 77 | 2.81 |
| | | 2 | 672 | 910 | 92 | 3.01 |
| | | 3 | 686 | 961 | 102 | 3.12 |
| | | 4 | 694 | 998 | 132 | 2.98 |
| Aluminum | Before 1.00 PM | 1 | 965 | 840 | 67 | 2.86 |
| | | 2 | 957 | 815 | 79 | 2.96 |
| | | 3 | 973 | 764 | 81 | 2.90 |
| | | 4 | 985 | 691 | 105 | 3.01 |
| Stainless steel | After 1.00 PM | 1 | 990 | 825 | 73 | 3.07 |
| | | 2 | 971 | 810 | 85 | 3.21 |
| | | 3 | 960 | 705 | 98 | 3.51 |
| | | 4 | 995 | 684 | 118 | 3.35 |

test the stainless steel as cooking utensil material in solar cooking, the standardized rice water ratio of 1:3 was kept in solar cookers in both stainless steel and aluminum. The results of the experiment are being given in table 1. The table gives observation on type of container material. Time of conducting the experiments, loads in the solar cooker i.e. cooking in 1, 2, 3 and 4 container, average initial and average final radiation during the experiments, average time taken and the acceptability scores. From the table it can be seen that the radiation in the forenoons was comparatively low (initial radiation 649wt/$m^2$-678wt/$m^2$, final radiation 833 wt/$m^2$-954wt/$m^2$) whereas in the afternoons the radiations were high and thus the impact of same can be seen on cooking time. The intensity of radiation saved 6-10 minutes in aluminum container and 6-14 minutes in steel container.

In the forenoons, it can be observed that aluminum saved only 4 minutes in single container load, 10 minutes in double container load, 7 minutes in 3 container load and 17 minutes in full load, inspite of its better conduction qualities in comparison to stainless steel. Similarly in the afternoon also since the solar radiation was higher; the time taken for solar cooking was a little less in both the types of containers. Further, a similar time difference was observed between aluminum and stainless steel during both forenoons and afternoons observation. Thus, it can be concluded that even when the radiation was more or less equal, the stainless steel was only taking an insignificant extra time in cooking. (The higher average final radiation in case of stainless steel was due to some extra cooking time in that container).

When the cooked rice samples were given to panel of judges, they rated the rice cooked in stainless steel comparatively better, with an average score ranging between 2.81-3.12 in the forenoon as against the scores between 2.39-2.70 for rice in aluminum and in the afternoons. Also the acceptability score for rice was higher for stain-less steel (3.07 to 3.5) in comparison to aluminum (2.86 to 3.01).

Thus, the following observations were made on the basis of the experiments:

1. Solar cooking can be done in stainless steel.
2. Stainless steel took merely 4-17minutes extra in the morning and about 6 to 13 minutes extra in the afternoons.
3. The quality of cooked rice was rated better by judges in stainless steel in comparison to aluminum.

## CONCLUSION

The experiments indicated that solar cooking can be done in stainless steel, although the cooking time in stainless steel was a little higher but the acceptability scores were better for the finished product in it. The extra cooking time in steel can be undermined looking in to the advantages of its higher acceptance by the judges and convenience in use, in comparison to aluminum.

The stainless steel is highly convenient to use due to ease in its cleaning and maintenance. Stainless steel being non-reactive metal, it is possible to cook and store both acidic and non-acidic food in it without affecting its quality and acceptability. Stainless steel being non-corrosive material will also have longer life than aluminum. Other decorative flat bottom stainless steel utensils can also be tried in solar cookers, which may increase the possibility of making it ready to serve container.

Fresh measures can be taken to popularize solar cooker with stainless steel containers because while aluminum container as surveyed by the researcher was highly non-popular material and stainless steel was a highly popular material which might enhance the popularity of the solar cookers also.

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