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Designing Fireless Cooker of Indigenous Insulation Material for Better Heat Retention

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ABSTRACT The Indian farm women face the crunch of time and energy twenty four hours all the seven days of the week. She is triply burdened with household work, agriculture work and care of animals in addition to all time financial crisis. In order to relieve some load of farm women a low cost fireless cooker of strawboard was designed and tested for its efficacy in cooking and later on for keeping the food hot within safe temperatures. Rice as standard food was used for conducting all the experiments .The results indicated that the fireless cooker of strawboard could both cook as well as keep the food hot with in safe temperatures well above six hours.

INTRODUCTION

A farm woman is present wherever she is needed most. Although, management of the home remains the major responsibility, she also has to actively participate in farming activities, caring for animals, collecting fuel etc., thus contributing substantially to the national economy and in uplifting the family's standard of living. The woman has to combine activities both outside and inside the home. Strong linkages between women's work and health have been observed. The heavy work load related to energy expenditure and the intake of food naturally affect their health (Singh et al. 2005). She must manage her time and energy, and discharge her duties satisfactorily without much strain on self. On the other hand, the pleasure of hot food is also often beyond the imagination of family members when the homemaker is highly busy

Looking into the demands of Indian rural women, a study was conducted with the objective of designing a low cost 'Fireless Cooker' (An insulated box that can do the cooking with the initial heat of the food.), for cooking as well as storing the food within safe temperature. the Fireless Cooking is a simple process in which food is brought to a boil, simmered for a few minutes depending on the particle size and then put into the box to continue cooking. Because the cooker prevents heat from escaping into the environment, no additional energy is needed to complete the cooking process. The fireless Cooker normally cooks within one to two times the normal stovetop cooking time. The food can be left in the Cooker until it is ready to serve and will stay hot for hours (Cleovoulou 1997; Roth 2003; Still 2001). The Fireless Cooker in the present study was designed keeping in mind the Indian dietary pattern. It could be used suitably for cooking rice, dals, vegetables and other boiling purposes. The cooker with heat retention qualities has also an additional advantage of keeping the food within 'safe limits'', Longre'e (1980) suggests that the temperatures between 7° and 60° C are most favourable for microbial growth) and avoiding preheating of food at the time of serving. The fireless cooker also fulfilled the three basic selection criteria of any equipment *viz.* low in cost, ease in understanding the use and operation and ease in maintaining and storing the equipment.

Although, hey, cotton and polyurethane foam have been used for the purpose, but strawboard, as heat insulation material, was not so far used for fireless cooking. The strawboards are one of the soft varieties of reconstructed boards made from partially cooked straw, bagasse or grass or a mixture of these which are used for both thermal and acoustical insulation The strawboard has helped reducing the size of fireless cooker box from 50cmX50cmX50cm (Devdas et al.1975) to 20cmX20cmX20cm and had all the qualities under laid for good equipment. However, for cooking

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more quantities of food, a larger box of 35cmX35cm X35cm was also tried. Efficacy of the cooker was tested by its cooking and heat retention efficiency.

METHODS AND MATERIALS

Single and double walled insulation box of 20cmX20cmX20cm inner volume made up of strawboard of 10 mm thickness was designed and used for the purpose of the present study. The insulation box – fireless cooker (Fig. 1) was tested for its heat retention qualities with four different shapes of aluminum utensils *viz.*-flat cylindrical, tall cylindrical, round bottom and flat bottom containers. The containers had tight fitting lids (Fig. 2).

Rice as a food was chosen as rice is probably the world's single most important foodstuff, being the 'staple food for over two billion people' (Atukorale 2004) to be cooked and stored in the cooker whereas the other supporting equipment that were used for experimental work were gas stove for preheating rice water mixture, stop watch to note the timings and potentiometer to measure the time and temperature of the food in graphical form.

After trying various dimensions and designs of the boxes, the size 20cmX20cmX20cm (inner dimension) was found to be most effective, economic and convenient. A recipe of 300 grams of rice from single lot with 990 ml of water was standardized after conducting experiments on quality of rice, rice water proportion. For conducting experimental work, measured quantity of water was boiled to boiling temperature and washed, unsoaked rice were added to it. The stove was put off and lid with sensing probe to measure temperature was placed on the container. The container was placed in the insulation box and the box was covered immediately. In fact, whole process was carried with minimum possible time loss. The food was kept in the cooker until it reached 60^{O}C or more temperature. After removing rice from cooker, it was given to panel of judges for testing.

RESULTS AND DISCUSSIONS

The advantage of the fireless cooker are economy of fuel time and energy . Foods which require long cooking can usually be prepared to advantage in the cooker. Fire-less Cooker could save fuel to the extent of one third of the total consumption by avoiding the need for reheating (Shrestha and Munankami 1999). The efficacy of self-designed Fireless Cooker thus was tested by two means for making it suitable for cooking as well as storing cooked food:

1. The cooking efficiency and
2. The heat retention efficiency.

1. Cooking Efficiency: The cooking efficiency of the cooker was tested by observing cooking time with variations in shapes of containers and thickness of insulation.

The study indicated that the cooking time in the four different shapes of containers (Fig. 2) in single walled box ranged between30 minutes to 45 minutes, while in double walled box it was in the range of 25 to 40 minutes, that is, the increase in insulation could reduce the cooking time by five minutes, it was substantially low as compared to hay box that takes 60-90 minutes (http://thermalcooker.wordpress.com). The effect of shapes of containers was also observed on cooking time, both the traditional shapes *viz.* the round bottom and flat bottom containers were more efficient in cooking in both the type of boxes in comparison to the other two nonconventional shapes i.e. tall cylindrical and flat cylindrical both of which took 10-15 minutes extra cooking time in both the boxes (Table 1). Thus, it can be inferred that either of the traditional shapes *viz.* the round bottom or the flat bottom containers in double walled box can conserve on cooking time in the fireless cooker. The acceptability scores also indicate higher acceptance value for the food cooked in these two containers.

The ANOVA also indicate that there was significant difference between cooking time in different shapes (38(3, 3) p>.01), the flat bottom and round bottom containers took significantly less cooking time than cylindrical containers (tcal=5.806>ttab at .05) .Secondly, it was also inferred that the cooking time could further be reduced by increase in insulation .The double walled box helped reducing additional 5-10 minutes in comparison to single walled box. Although, the ANOVA showed that there was no significant difference between the cooking time in single and double walled boxes (8(1, 1) p> 0.5) .And the inference on quality of cooked rice, when drawn from the acceptability scores, also did not indicate much difference between the two types of insulation boxes, although in three out of four cases the acceptability scores were higher in case

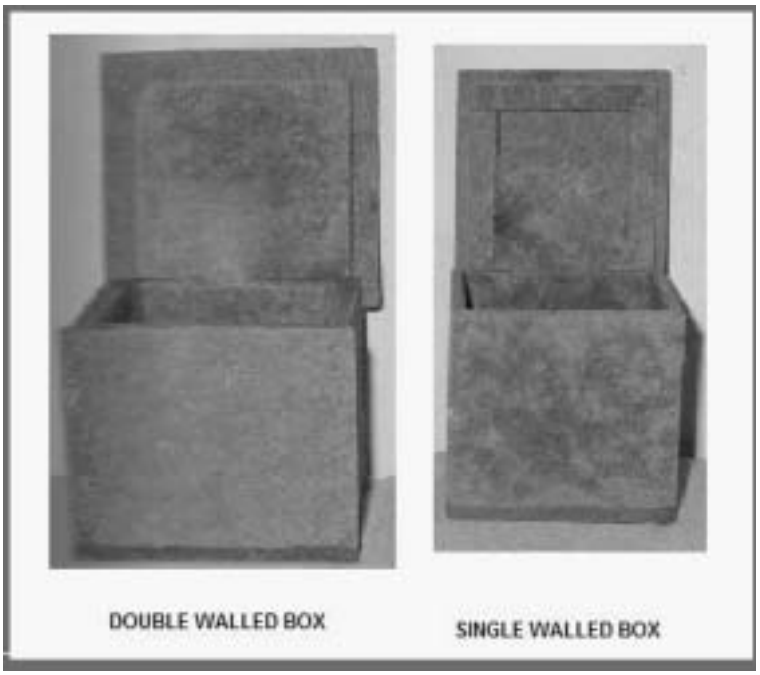

Fig. 1. Insulation box – fireless cooker

Fig. 2. Four different shapes of aluminum utensils viz.–flat cylindrical, tall cylindrical, round bottom and flat bottom containers.

of double walled box in comparison to single walled box.

The study also revealed that as far as cooking time estimations are concerned the round bottom and flat bottom containers gave better performance than cylindrical and flat cylindrical containers .Secondly; the double walled fireless cooker took considerably less cooking time.

2. Heat Retention Efficiency: The heat retention efficiency of the cooker was also tested by observing heat retention time with variations in shapes of containers, thickness of insulation and quantity of food.

The data in table 2 indicates the highest heat retention time by the food, within safe limits, was in the cylindrical container followed by flat cylindrical and round bottom containers, whereas the lowest heat retention time was by the food in flat bottom container. But the acceptability scores of the food did not differ among the containers. The data in table 2 therefore indicates that as opposed to the results for cooking time, where flat bottom and round bottom containers had performed better, for heat retention within safe temperatures, the cylindrical and flat cylindrical containers showed better performance.

Further, if the heat retention time between the single and double walled boxes (Table 2) are compared it can be observed that while the heat retention time of the food was more in the double walled box in all the containers, the acceptability scores for the food cooked in all the containers were a little less except in the cylindrical container.

The t' values for heat retention time in table 3 indicate that there was significant difference at 1% level of significance in heat retention time between different shapes of containers in both single and double walled boxes, except in case of comparison between tall cylindrical and round bottom container where heat retention time was significantly different at 5% level of significance only in single walled box and non-significant in double walled box. The cylindrical containers were more efficient in retaining heat than round bottom and flat bottom containers.

The efficacy of cooker for heat retention was found very high for different quantities of rice even in single walled box. The trials were done in tall cylindrical container as it had given highest heat retention time. It was found that with the increase in the quantity of rice the heat retention time also increased.

The correlation analysis between amount of food and heat retention time (Table 4) indicated a positive correlation that is 0.913 in smaller (20cm X 20cm X 20cm) and 0 .837 in bigger box (35cmX35cm X35cm), (values significant at 1% level of significance) that helped in concluding that with increase in amount of food the heat retention time will also increase significantly. It

Table 1: Average cooking time and acceptability scores in different shapes of containers in single and double walled boxes

Containers	*Single Walled Box*		*Double Walled Box*	
	Ave. cooking time (in mins.)	*Acceptability scores (max. scores:5)*	*Ave. cooking time (in mins.)*	*Acceptability scores (max. scores:5)*
Flat Cylindrical(A)	40	3.50	40	3.62
Round Bottom(B)	30	3.80	25	3.85
Cylindrical(C)	45	3.40	40	3.32
Flat Bottom(D)	30	3.90	25	3.69

Table 2: Average heat retention time and acceptability scores in different shapes of containers in single and double walled boxes

Containers	*Single Walled Box*		*Double Walled Box*	
	Ave. heat retention time (in mins.)	*Acceptability scores (max. scores:5)*	*Ave. cooking time (in mins.)*	*Acceptability scores (max. scores:5)*
Flat Cylindrical(A)	300	4.22	315	3.90
Round Bottom(B)	290	4.1	310	3.98
Cylindrical(C)	315	4.17	340	4.16
Flat Bottom(D)	254	4.1	284	3.90

Table 3: 't' Values for heat retention time between different shapes of containers in single and double walled containers

Comparison between shapes	*Single walled box*	*Double walled box*
Cylindrical Vs Flat Cylindrical	5.17**	8.06**
Cylindrical)Vs Round Bottom	10.87**	12**
Flat Cylindrical Vs Round Bottom	3.295**	2.17NS
Cylindrical Vs Flat Cylindrical	21.32**	12.25**

*Significant at 5% level, ** Significant at 1% level, NS NonSignificant

Table 4: Relation between heat retention time and amount of rice

Amount of food(gms.)	*Average heat retention Time (mins.)*	
	20cm X 20cm X 20cm	*35cmX35cm X35cm*
150	195	70
200	260	110
250	285	255
300	315	300
450	420	415
900	-	435
1200	-	600
1500	-	765

can also be concluded that the size of the box also had a role in heat retention; smaller quantities in larger box tend to loose heat faster in comparison to same amount in smaller box due to larger quantity of comparatively low temperature air within the box.

CONCLUSIONS

Based on the results it can be concluded that

1. While seeing the difference in cooking time in the different shapes of containers' it was found that round bottom and flat bottom containers took significantly less cooking time than cylindrical containers. But no significant difference in the cooking time was observed between the different types of boxes.
2. The findings on heat retention show that in case of different shapes of containers, the cylindrical container was found more superior in heat retention than all the other containers, the flat container was rated next to it . Further the double walled box retained heat for significantly longer period time than the single walled box. The increase in amount of rice to be cooked affected the heat retention time markedly, while there was no effect of increase in amount of food on cooking time.

The results show that fireless cooker can be used in the way the homemakers need it, whether for cooking or for retaining heat in the food within safe temperatures, larger amounts can also be cooked in the cooker. Strawboard, the indigenous insulation material remains unaffected by rot, insects, vermin, and humidity. The cooker is easy to clean, and handle.

The use of a fireless cooker is not only an environmental bonus but also a convenience in many villages where firewood is used. Woman would need to spend less time huddling over a fire or stove and would-be less exposed to smoke if they have the fireless cooker (Shrestha and Munankami 1999) The fireless cooker is a benefit to the poor for its fuel-saving, and to society at large for the convenience it offers. It is also a way of helping to preserve non-renewable energy sources.

There is a need today of identifying, testing and popularizing such measures that are not only cheap, easily available and energy efficient but are user friendly also. If popularized among masses the cooker will be a very handy asset to the family which can try it more innovatively for other purposes also like cooking vegetables or setting curds.

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