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Firming up Science and Technology in Mid day Meal Programme Through Introduction of Solar Cooking

Dr.Vijayalakshmi Purushothaman
Dean, Faculty of Community Education and Entrepreneurship Development,
Avinashilingam University for Women, Coimbatore.

Gayathri Duraisamy ,
Shobana Kulanthaisamy &
Ithaya malar
Research Assistant,
Department of Resource Management,
Avinashilingam University for Women, Coimbatore.

Dr. Gnanasakthi Jagadeesan
Professor and HOD, Dept of Resource Management,
Avinashilingam University for Women, Coimbatore.

Dr. A. Thirumani Devi
Associate Professor,
Dept of Food Science and Nutrition,
Avinashilingam University for Women, Coimbatore.

Abstract

Children and their well-being are the basic concern of every nation. child nutrition plays a vital role in positive health, functional efficiency and productivity in later stages of life. The School Meal Programme aims to improve not only the nutritional status of school children but also increase school enrolments, attendance, reduce dropout rates of the school children and enhance scholastic performance. Each day meal provides roughly one third of the daily nutrient requirement and helps to alleviate hunger and malnutrition among school children. One area requiring urgent attention is the cooking of school meals which involves cost and also pollutes the atmosphere. Solar cooker is the simplest technology which has been developed for cooking food without requiring any conventional fuels. Solar cooker can be an appliance for cooking in schools in which there is no smoke and no soot deposition. It saves money and fuel, and preserves the nutritive value of the food.

The present study was undertaken to utilize solar energy for meeting the cooking requirements in the school lunch kitchens. For facilitating the quantity cooking a paraboloid solar cooker which is convenient, cost effective and operationally viable device was used to study the possibility of opting for large scale solar cooking devices for noon meal programmes to conserve fuel and to alleviate the drudgery of women being exposed in the kitchen. The cooking experiment was conducted for a period of four months in Sk23 Paraboloid Solar Cooker using vessel cooking and pressure cooking for noon meal beneficiaries in the selected primary schools. It was inferred from the study that the introduction of Sk23 paraboloid solar cooker could conserve one third of the fuel cost in the Noon Meal Programme.

I. INTRODUCTION

Nutrition is an integral component of health and well being of an individual. Good nutrition enables one to lead a socially and economically active life and it improves the quality of life as evidenced through enhanced nutritional status of the population groups, better work efficiency rate, reduced mortality and morbidity rate by raising the standard of living. Thus, child nutrition plays a vital role in positive health, functional efficiency and productivity in later stages of life.

Early childhood constitutes the most crucial period in life, when the foundation is laid for cognitive, social, emotional, physical, motor development and cumulative life long learning. Rao (2005) points out that in the early stage of life, dietary habits, and feeding pattern alter more than any other stages of life [1]. This phenomenon reflects the physiological development of the child and rapid changes in his / her nutritional requirements. Provision of adequate dietary energy and macro and micronutrients for growth and development should be the principle determinant of the diet of growing children.

The School Meal Programme aims to improve not only the nutritional status of school children but also increase school enrolments, attendance, reduce dropout rates of the school children and enhance scholastic performance. Each day meal provides roughly one third of the daily nutrient requirement and helps to alleviate hunger and malnutrition among school children. One area requiring urgent attention is the cooking of school meals which involves cost and also pollutes the atmosphere [2].

Solar cooker is the simplest technology which has been developed for cooking food without requiring any conventional fuels. Solar cooker can be an appliance for cooking in schools in which there is no smoke and no soot deposition. It saves money and fuel, and preserves the nutritive value of the food. Since the food is cooked at lower temperature, the nutritive value of the food so cooked is better than the food cooked with other fuels [3].

In this context, the present study was undertaken to utilize solar energy for meeting the cooking requirements in the school lunch kitchens. For facilitating the quantity cooking a paraboloid solar cooker which is convenient, cost effective and operationally viable device was used to study the possibility of opting for large scale solar cooking devices for noon meal programmes to conserve fuel and to alleviate the drudgery of women being exposed in the kitchen.

Specific **objectives** of the research study are-

1. Introduce solar cooking in the selected primary schools, testing their efficiency and improve the technology
2. Estimation of fuel cost and assess the carbon monoxide level in traditional cooking and find out the time involved in using different cooking procedures
3. Determine the optimum temperature for solar cooking in noon meal programme and
4. Analyse the impact of solar cooker in terms of fuel conservation, time involved in cooking and environmental pollution.

II. EXPERIMENTAL DESIGN

This aspect consists of the following phases:

A. Selection of Primary Schools for the Present Study

The two schools selected for the present study were:

1. Sri Avinashilingam Primary School, Coimbatore and
2. Thiru T.A Ramalingam Chettiyar Primary School, Coimbatore

B. Selection of Children for the Present Study

A total number of 60 children were selected and considered as Experimental group I; received school lunch prepared using solar cooker with aluminium cooking vessel. Another 60 children formed the Experimental group II and received school lunch cooked in solar cooker with pressure cooker as cooking vessel. Third group of 60 children formed the Experimental group III and received lunch with improved chulah cooking followed in noon meal and rest of the 60 children served as control group, getting their food from home.

C. Introduction of Sk_{23} Paraboloid Solar Cooker in the Selected Primary Schools

Scheffler model SK_{23} Paraboloid / Dish Solar Cooker was installed in the open area of the selected primary schools. The cooker consisted of reflecting bowl, tracking mechanism and supporting frame for holding the cooking vessel. The reflection bowl was made of multiple reflectors (52) fixed firmly to a rigid frame. It had a dish diameter of 2.3m reflectors with polished, hardened, bright anodized aluminum sheets of 0.4 m thick. Its reflector surface area was 4.79 m^2, focal length of $1/5^{th}$ of dish diameter, and a focal spot of 340mm. The Sk_{23} Paraboloid Solar Cooker was a manual type with tracking arrangement in which adjustment was made once in 15 minutes at the time of cooking. The cost of Sk_{23} paraboloid solar cooker was Rs. 37,440/-. The cooking vessels such as blackened aluminium vessel and blackened pressure cooker with the capacity of 22 litres each were recommended for large scale cooking in Noon Meal Programme. The stand which is used to fix the vessel in the solar cooker was modified inorder to serve its purpose better. Precautionary measures such as use of hand gloves, caps, and sunglasses were adhered to protect from the converged sun rays for safety and security.

D Appraisal of Sk_{23} Paraboloid Solar Cooker for Noon Meal Programme

SK_{23} Paraboloid solar cooker in Noon Meal programme was assessed in terms of quantity of fuel used in conventional method of cooking and estimating the smoke emission from conventional cooking. The impact of using SK_{23} parabolid solar cooker in large scale cooking for noon meal programme was assessed in terms of fuel conservation, time taken for cooking and environmental factors prevailed

III. RESEARCH FINDINGS

A. Menu Pattern Followed in the Noon Meal Scheme

One third of the well balanced nutritious food was provided by the noon meal programme to each child daily. Low cost, locally available, seasonal, two to three vegetables are daily used in the preparation of sambar. In addition to the daily menu of rice with the combination of sambar, boiled egg/ boiled potato and bengal gram/ green gram sundal is given to each child in alternative days to enrich the nutrient content of their daily diet.

B. Solar Energy Measurements during the Study Period

It was observed from the study that the solar intensity was directly proportionate to the ambient temperature of the day. The highest ambient temperature was observed during the month of April and May showing 36°C and 37°C respectively and the lowest temperature of 33°C was recorded during the month of July. The trend was similar in the case of solar intensity and it was found to be maximum of 1075 w/m^2 and 1094 w/m^2 during the months of April and May respectively, whereas a minimum of 942 w/m^2 was recorded in the month of July. This might be due to the seasonal variations and climatic changes. However partial cooking was still possible utilizing the available temperature. The temperature reached at the focal point of the paraboloid solar cooker depended on the solar intensity and ambient temperature. Table 1 gives details regarding ambient temperature and solar intensity during the experimental period.

Table 1

Month	Maximum ambient temperature (°C)	Maximum Solar intensity (w/m^2)
March	35	1018
April	36	1075
May	37	1094
June	35	1023
July	33	942
August	35	1036
September	35	1054

Ambient Temperature and Solar Intensity during the Experimental Period

C. Time Taken to Cook Rice in Sk$_{23}$ Paraboloid Solar Cooker during the Experimental Period

The cooking experiment was conducted for a period of four months in Sk$_{23}$ Paraboloid Solar Cooker using vessel cooking and pressure cooking for noon meal beneficiaries in the selected primary schools shown in Figure 1. Table 2 depicts the details relating to cooking rice in SK $_{23}$ paraboloid solar cooker.

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Table 2

Details Relating to Cooking Rice in SK $_{14}$ Paraboloid Solar Cooker

Month	* Ambient Temperature (°C)		** Solar Intensity (w/m²)		Temperature at Focal Point (°C)		Aluminium vessel		Pressure cooker		No. of days cooking	No. of days		No. of Holidays
	Initial	Final	Initial	Final	Initial	Final	Quantity of rice cooked (kg)	Average time taken (hr.min)	Quantity of rice cooked (kg)	Average time taken (hr.min)		Partial Cooking	Rainy	
April	28-31	32-36	763-856	906-1075	52-75	109-142	6	2.00	-	-	17	2	-	11
June	28-31	32-35	758-849	892-1023	50-79	96-124	6	2.20	3	1.19	18	2	-	10
July	28-30	31-33	786-833	860-942	50-69	78-104	-	-	3	2.20	16	3	1	11
August	28-31	32-35	795-843	887-1036	53-78	97-129	3	1.40	3	1.24	19	-	2	10
September	29-31	32-35	808-845	892-1054	55-76	102-138	3	1.38	3	1.22	19	-	2	9

* **Ambient temperature** - the temperature of the surrounding air or outside temperature at any given altitude.

** **Solar intensity** - the amount of radiant energy emitted by the sun over all wavelengths that fall each second on Earth's atmosphere

The solar intensity was recorded as maximum of 1075 w/m^2 in the month of April during the summer season showing the highest ambient temperature of 36°C and focal point temperature 142°C. The ambient temperature, solar intensity and temperature at focal point were found to be minimum of 33°C, 942 w/m^2 and 104°C respectively during the monsoon month of June.

The time taken to cook 6 kg of rice in black coated aluminium vessel was found to be minimum of 2 hours in the month of April whereas 2 hours 20 min was required to cook during the month of June, showing the focal point temperature of 124°C. When the solar intensity, ambient temperature, temperature at focal point were recorded as minimum in the monsoon month of July, the time taken to cook 3 kg of rice in pressure cooker was recorded as maximum of 2 hours 02 min in SK $_{23}$ paraboloid solar cooker.

There was not much time difference (16 min) observed in cooking 3 kg of rice between vessel cooking and pressure cooking in Sk$_{23}$ Paraboloid Solar Cooker during the month of August and September indicating an average time taken of 1 hour 39 min and one hour 23 min respectively. It was inferred from the study that vessel cooking may be propagated to cook the maximum quantity of 6 kg of rice in Paraboloid solar cooker whereas it was not possible to cook more than 3 kg of rice in pressure cooker.

It was inferred from the study that solar cooking was possible for the noon meal programme only at optimum ambient temperature of 31-36 °C, solar intensity of 860-1075 w/m^2 and focal point temperature of 96-142 °C in a day. It was observed from the study that partial cooking was done only for seven days due to intermittent solar energy, whereas the cooking experiment was not carried out for four days due to rain and climatic changes, during the experimental period of four months. Egg/ Sundal/ Potato could be boiled in solar cooker. In addition drinking water was also boiled in paraboloid solar cooker for noon meal beneficiaries. The solar cooked food was distributed to noon meal beneficiaries shown in Figure 2.

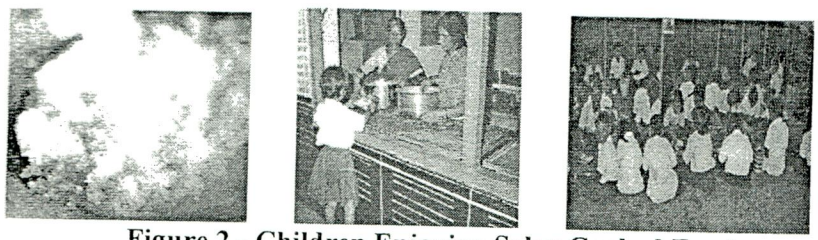

Figure 2 - Children Enjoying Solar Cooked Foods

D. Assessment of Carbon Monoxide in the Noon Meal Kitchen

Carbon monoxide (CO) is an odorless, colorless gas that is very dangerous to human health. Even at low levels of exposure, carbon monoxide can cause serious health problems. It is produced by burning of fuel. It is poisonous and breathing in can cause loss of consciousness [4]. It is measured in parts per million (ppm). The emission of carbon monoxide concentration level was estimated at three stages of cooking viz initial, middle and final in the noon meal kitchen for a period of two months in the selected primary schools.

School I

Table 3 gives the carbon monoxide level in the noon meal kitchen.

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Table – 3: Carbon monoxide Level in the Noon Meal Kitchen in School I

Week	Carbon monoxide level in ppm							
	April				June			
	Initial	Middle	Final	Average	Initial	Middle	Final	Average
I	126.4	121.3	124.4	124.03	117.5	114.6	115.2	115.76
II	125.3	122.7	123.6	123.86	126.4	122.5	125.6	124.83
III	124.2	121.4	122.5	122.70	130.3	125.6	127.7	127.86
IV	122.3	118.6	120.4	120.43	123.2	120.7	121.3	121.73
Average	124.55	121.0	122.72	**122.75**	124.35	120.85	122.45	**122.55**

The National Institute for Occupational Safety and Health (NIOSH) has established a Recommended Exposure Limit (REL) for Carbon Monoxide of 35ppm (40mg / m^3) as an eight hour Time Weighted Average (TWA) and 200ppm (229mg / m^3) as a ceiling [5]. Carbon Monoxide (Co) becomes toxic when it reaches a level higher than 50 ppm with continuous exposure over eight hour period. When the level of Co becomes higher than that a person will suffer from symptoms of exposure. Mild exposure over a few hours (Co level between 70ppm and 100ppm) will exhibit symptoms such as headaches, sore eyes, runny nose and cough. Medium exposure (Co level between 150ppm and 300ppm) will produce dizziness, drowsiness and vomiting. Extreme exposure (Co level of 400ppm and higher) will result in unconsciousness, brain damage and even death [6]. It was observed from the study that the mid - day meal workers were exposed to Carbon monoxide emission 2.30 hours daily. It is a potentially deadly gas that can have devastating effects upon life. It displaces the levels of oxygen within the blood, which results in the death of cells and damage to major organs, which are subsequently starved of oxygen. This lack of oxygen in the blood is known as anoxia. This can lead to a range of symptoms and effects, both short term and long term depending on the levels of gas breathed in and the duration over which one is exposed to carbon monoxide. It can also cause permanent damage to other major organs within the body, such as the heart[7].

It was proved from the study that the carbon monoxide level was found to be higher in the initial stage followed by final stage and middle stage of cooking. On an average carbon monoxide level was estimated as 122.75 ppm and 122.55 ppm for the month of April and June in the primary school I

School II

It was known from the study that the carbon monoxide concentration level was found to be 133.52 ppm and 132.85 ppm at the initial stage of cooking followed by 131.47 ppm and 130.52 ppm in the final stage and 129.45 ppm and 127.87 ppm in the middle stage of cooking during the month of July and August in primary school II. This might be due to the usage of large quantity of coconut fonds as fuel for cooking. On an average carbon monoxide concentration level was estimated as 131.48 ppm and 130.41 ppm. Though the carbon monoxide level in the noon meal kitchen of the selected primary schools were found to be below the medium exposure limit of 150 ppm of carbon monoxide as per WHO recommendation and below the upper limit of 200 ppm (National Institute for Occupational

Safety and Healthy), continuous exposure to smoke is not advisable. Table 4 shows the carbon monoxide level in the noon meal kitchen.

Table - 4
Carbon monoxide Level in the Noon Meal Kitchen in School II

Week	Carbon monoxide level in ppm							
	July				August			
	Initial	Middle	Final	Average	Initial	Middle	Final	Average
I	132.4	130.3	131.2	131.30	131.4	128.9	130.7	130.33
II	135.2	131.4	133.6	133.40	130.5	124.5	129.4	128.13
III	133.7	129.5	131.7	130.86	133.7	128.4	130.6	130.90
IV	132.8	126.6	129.4	129.60	135.8	129.7	131.4	132.30
Average	133.52	129.45	131.47	**131.48**	132.85	127.87	130.52	**130.41**

E. Fuel Conservation through the Implementation of Paraboloid Solar cooker

Table 5 exhibits the fuel conservation through utilization of Sk_{23} Paraboloid Solar Cooker for cooking noon meal in the selected primary schools.

Table5
Fuel Conservation through the Implementation of Sk_{23} Paraboloid Solar cooker

School	Cooking method	No. of. children benefiting	Quantity of food cooked in kg	Fuel consumed (kg)	Cost of fuel used per day	Cost of fuel per month	Percentage of saving fuel
I	Conventional Solar (vessel cooking)	169 60	20 6	17.34 5.02	51.96 17.34	1143.12 381.42	33.37
II	Conventional Solar (pressure cooking)	220 60	25 3	22.14 2.65	66.42 7.95	1461.24 174.9	11.97

It is clear from table that about 17.34 kg of fuel wood of was required for cooking food for 169 children in the primary school I. The cost of fuel per child was 15 paise as per the government norms. Therefore an amount of Rs 23.85/- per day was spent towards fuel wood for cooking for 169 children. An additional amount of Rs 28.11/- was managed by getting fuel free of cost from the locally available resources. After the introduction of paraboloid solar cooker for noon meal preparation, an amount of Rs17.34/- could be conserved daily. Assessing 22 working days in a month, the monthly expenditure on fuel saved will be as Rs 381.42/-. The saving of fuel was worked out to be 33.37% by adopting vessel cooking in Sk_{23} paraboloid solar cooker for noon meal preparation. About 22.14 kg of fuel wood was estimated in the primary school II to cook 25 kg of food for 220 noon meal beneficiaries. The cost of the fuel was worked out to be Rs 66.42/- per day. The monthly expenditure on fuel was calculated to be Rs 1461.24/-. After the introduction of pressure cooking in Sk_{23} paraboloid solar cooker, an amount of Rs 174.90/- could be conserved towards fuel. The saving of fuel was worked out to be 11.97%. Considering 160 days in a

year for solar cooking about 0.4 to 0.9 ton of fuel wood could be conserved per year through the implementation of Sk_{23} paraboloid solar cooker for noon meal preparation.

CONCLUSION

It may be concluded that the introduction of Sk_{23} paraboloid solar cooker could conserve one third of the fuel cost in the Noon Meal Programme. Pressure cooker or aluminium vessel could be used for cooking in large scale cooking, as per the individual convenience. There was an added advantage of zero carbon reduction level in the adoption of paraboloid solar cooker. Therefore Sk23 paraboloid solar cooker is an eco-friendly technology in Noon Meal Programme for reducing the drudgery of cooking and solving the problem of environmental pollution due to use of fuel wood.

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