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Development and Performance Evaluation of a locally fabricated Solar Oven for drying of Moringa leaves

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ABSTRACT: *Energy utilization in Nigeria has increased progressively over the last decades as a result of increase in population and technological advancement. In view of the aforementioned, there is a pressing need to find an alternative source of energy that is renewable and environmentally friendly. With the enormous energy coming from the Sun, scientists have over the years been looking into the effective application of solar energy for the benefit of mankind and in preserving our environment. A solar oven was fabricated using cheap and locally available materials,which do not require photoelectric cells or fossil fuels to operate, but utilizes direct energy from the sun as its source of heat. The performance of the solar oven was evaluated through the drying of Moringa leaves and the results were compared with those obtained from a conventional oven. Temperature within the solar oven varied from 42 ^{o}C to 75 ^{o}C at different times of the day whereas the conventional oven was regulated at a temperature of 60^{o}C for a duration of three hours. The results proved satisfactory and indicated that the solar oven can be used to complement the conventional electric oven. A cost evaluation shows that the solar oven is more economical to fabricate and use than the conventional oven.*

(KEY WORDS:*solar, energy, oven, renewable, performance)*

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I. INTRODUCTION

Energy consumption in Nigeria has been increasing on a relatively high rate. According to Iwayemi (2008), on a global scale, the Nigerian energy industry is one of the most inefficient in meeting the needs of its customers. This is most evident in the persistentuncertainty in the markets for electricity and petroleum products. Domestic baking, cooking and heating account for more than 70% of the energy needs of most households in Nigeria (Bala et al. 2002, Garba and Bashir, 2002). The overall dependence on limited fossil fuels for daily energy demands has caused adverse consequences on the environment such as climate change, global warming and other eco+logical dilapidations. Solar energy is one of the foremost alternative renewable sources of energy, it could serve as a replacement for domestic fuel especially in drying and heating (Yusuf et al, 2014).

Moringa Oleifera is one of the vegetables of the Brassica order and belongs to the family Moringaceae (Nicholas, 2011). The leaves can be dried over a screen and then ground into fine powder and can be added to any food as a nutrient supplement (Makkar and Becker, 1996). The plant moringa have been extensively employed for treating a large number of illnesses such as diabetes, hypertension, stomach pain, malaria, leprosy, epilepsy, diarrhea, asthma, colds, and wound healing. It was also found out that moringa dry leaf powder is a valuable nutrient for the poor communities because it boosts the immune system to fight infections and thereby enhancing the well-being of malnourished and HIV persons (Zaku et al., 2015).

Busani et al. (2011) found out that the dried leaves had crude protein level of 30% and contain the following mineral contents: calcium (3.65 %), zinc (13.03 mg/kg), phosphorus (0.3 %), magnesium (0.5 %), iron (490 mg/kg), potassium (1.5 %), sodium (0.164 %), sulphur (0.63 %), copper (8.25 %), manganese (86.8 mg/kg) and selenium (363 mg/kg).The aim of this project is to develop and carry out the performance evaluation of a locally fabricated solar oven.

II. METHODOLOGY

Description of fabricated solar oven

A box-type solar device was used for the study. The dimensions of the box is 450mm x 450mm measured out-to-out while the side dimensions are: height at the back 500mm, height at the front is 230mm. The wall of the solar oven of was fabricated using 3 mm thick hardboard. The two slanting sides were inclined at

$45^0$to the front wall and measured 540mm as shown in Figure 1. The thicknesses was carefully selected in order to ensure easy carriage. Each sides of the box was firmly tight to prevent heat loss due to convection and well insulated to ensure higher efficiency. The transparent glass was properly fixed on the top openings of the box for the provision of greenhouse effect and also to serve as a reflector.

The inner base of the box was carefully handled and was produced by the mixture of bitumen with epoxy to produce a glass like surface. In addition, the inner base was painted black to enhance the absorbing property of the base in producing efficient heat needed because a black surface is a good emitter and absorber of radiation. It absorbs all the radiation that falls on it, but reflects, and transmits none. The radiation that was refracted by the glass is absorbed by the black base and converted to heat. For efficient result, the vessel inside the container was painted black.

The side walls were covered with a foam to serve as an insulating material and then covered with aluminum sheet and thoroughly spray with silver coloured paint in order to have a perfect and smooth surface. When radiation from the sun is incident on the aluminum sheet, it is reflected in the opposite direction in such a way that it is absorbed by the glass on top of the box which serves as the lid. In this study, a glass with thickness of 4mm was used and the dimension was 22cm x 22 cm. Glass provides about 10% better performance than plastic. Under windy conditions, glass is preferred since it doesn't flap in the wind.

Preparation of Moringa Leaf for Proximate Analysis

The leafy vegetables were obtained from a residential home within the vicinity of the Federal University of Technology Akure (FUTA). The leaves of the vegetable as shown in plate 2 were plucked and the stems were trimmed. An efficient drying process at a regulated temperature for a specific period of time is required in order to maintain the nutrient value of the leaf. Mostly employed method is open air dry under a shade and this has been found not suitable because of the poor results obtained during analysis and longer duration taken in drying.

In order to fully obtain the nutritional benefit of the leaf, it requires a careful process of drying because it contains some elements which must not be exposed to high intensity of heat whether from the sun or the oven used during the drying process. Applications of a conventional oven system for the drying process involves oven drying at a regulated temperature of 60^0C for a duration of three hours before going through every other preparation processes for its analysis. Same process was employed with the fabricated solar oven and the leaves were oven dried for some duration of three and half hours to accommodate for the variations in the chamber temperature as result of the solar radiation. About 200g of the leaves were oven-dried using both the fabricated solar oven and conventional oven. As the solar drying was going on, the leaves were simultaneously oven-dried with a conventional hot-air oven in the laboratory. After drying, 100g of the sample was extracted from each oven and the dried sample was then taken to Prof. Julius Okojie Central Research Laboratory of the Federal University of Technology Akure (FUTA) for analysis. Proximate analysis was carried out on both samples to determine the percentage content of the following parameters: Moisture content, Ash, Crude Protein, Fat, Fibre and Carbohydrates.

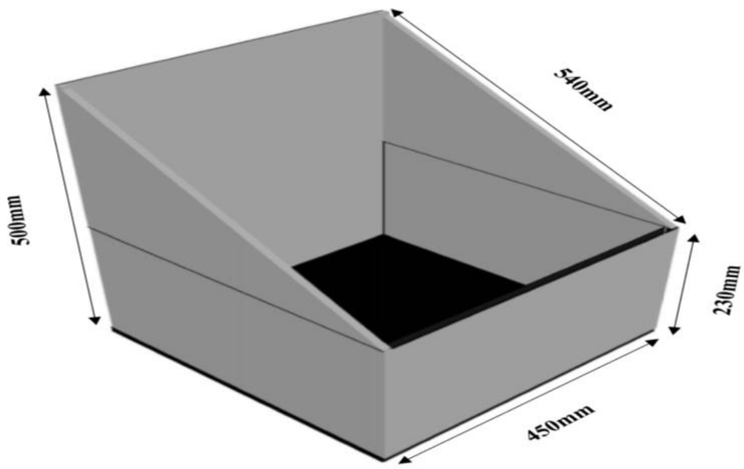

Figure 1: Schematic representation of solar oven

Plate 1: Oven Drying of the Moringa Leaves in Progress

Plate 2: Moringa Leaves

III. RESULTS AND DISCUSSION

The experiment started at 9:00 am on 21-02-2017 being day one and 22-02-2017 being day two The temperature variations at different time intervals for each are plotted in figure 2.

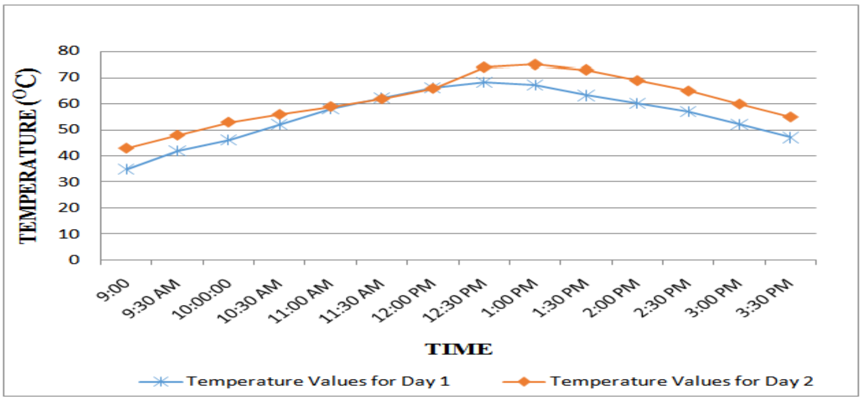

Figure 2: Oven Temperature against Time for the two days

Table 1: Proximate Composition of Moringa Oleifera (Solar Oven)

Test No	Moisture(%)	Ash(%)	Crude Fate(%)	Crude Fibre(%)	Crude Protein(%)	Carbohydrate(%)
A	9.21	6.12	2.84	10.00	21.48	50.35
B	9.30	6.11	2.81	9.81	22.01	49.96
Average (%)	9.26	6.12	2.83	9.91	21.75	50.16

Table 2: Proximate Composition of Moringa Oleifera (Conventional Oven)

Test No	Moisture(%)	Ash(%)	Crude Fate(%)	Crude Fibre(%)	Crude Protein(%)	Carbohydrate(%)
A	9.00 ±2.30	6.00 ±0.63	2.43 ±0.47	5.43 ±0.23	39.13 ±0.16	38.21 ±0.31
*						

The results of the proximate analysis carried out on the Moringa leavesdried using the locally fabricated solar oven is shown in Table 1while Table 2 shows the results of the proximate analysis carried out on the leaves dried using a conventional oven system. From the results obtained, there is an appreciable closeness in the values obtained for the Moringa leaves dried with the fabricated and the conventional oven.

The average cost of conventional or industrial oven system in Nigeria ranges between N50,000 to N80,000. The cost evaluation of the solar oven is shown in Table 3. The total amount expended in fabricating the 450mm x 450mm solar oven is N23,680.

Table 3: Cost Evaluation of the fabricated oven.

Component	Material	Cost
Wooden box	Hardwood	N3,000
Glazing	4mm glass	N1,000
Reflectors	Aluminium sheet	N1,650
Coating	Paint and thinner	N3,300
Thermometer	Glass thermometer	N2,000
Fabrication cost, Transportation and Miscellaneous	Lump sum	N12,730
Total		N23, 680

IV. CONCLUSION AND RECOMMENDATION

A solar oven was designed and fabricated at the Federal University of Technology, Akure (FUTA) using locally available materials. The oven does not require solar panels or electric circuit to operate but depends solely on direct energy from the sun. The performance of the oven was evaluated by drying Moringa leaves and compared with a conventional oven. The results proved satisfactory and indicate that the solar oven can be used to complement the conventional oven in cases of power outage and high solar intensity thereby saving electrical costs. The overall cost of the solar oven was compared against the conventional oven which also proved economical. It is recommended that heat storage and retention principles should be incorporated into the solar oven in order to improve its thermal stability.

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