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EXPERIMENTAL ASSESSMENT AND COMPARISON OF LOW-COST SOLAR COOKERS FOR THE SUSTAINABILITY OF TROPICAL RURAL COMMUNITIES

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Abstract

Energy crises took place due to the war in the Middle East in 2026 caused a chaos in the energy availability, as well as the dramatic raise in the cost of the fossil fuels. The current energy crises due to the Middle East war strengthened the direction of energy transformation from hydrocarbons to renewables. In particular, the isolation and high-cost transportation of fossil fuels and geographical restrictions to connect rural communities to gas and electricity networks encouraged the utilization of solar energy for cooking. The objective of the current work is to fabricate, experimentally assess, and compare the performance of the most usable types of solar cookers in rural communities, the parabolic and the box types. The locally made solar cookers using potential materials is high techno-economically feasible. However, the low efficiency of 11% and 18.8% of the parabolic and box types, respectively is to be compromised. The in-house made solar cookers have been tested for water heating as standard procedure. Results reviled that the box type performs better than the parabolic type. Cooking by the box type allows the water to reach the boiling temperature, 100 ºC, while the maximum temperature reached by the parabolic is only 71.2 ºC. After one hour, water temperature reached 53.2 ºC and the box type.

Keywords: Box solar cooker, Parabolic solar cooker, Rural communities, Solar cooker, Sustainability.

1. Introduction

Despite the modern electric, gas, and fossil liquid fuel networks, a large population of rural communities are still facing problem to afford above sources for cooking. Local and free of charge resources are a highly appreciated by the rural poor communities. For cooking, large number of populations in rural areas are using agricultural products and biomass as fuel for the cooking by firewood and charcoal. However, one of the ways to allow the poor families in rural regions to be able to enjoy cooked food is by utilizing one of the greatest energy sources, the sun.

For communities and families living below the poverty line, it is perfect for using solar cookers. Not only solar cooker is efficient and cheap, but it will also address one of the most important challenges of our time, which is using sustainability of clean energy to limit the effect of climate change. The challenges with solar cookers, however, are their unreliable efficiency. The low efficiency of the traditional solar cooker is the reason why electric-powered or gas-powered food cooker is still the choice of many people.

The use of solar cookers reduces household energy expenditures, and avoids the complexity of fuel transport, electric network connection, and gas piping networking. Odoi-Yorke et al. [1] performed a bibliometric review and extensively examined related experimental research on the solar cookers' utilization, and the technological advancements from 1994 to 2024 by analysing 581 related published articles. Their analysis revealed a 7.46 % annual expansion in solar cookers experimental research with a focus on the thermal performance, energy efficiency, and technological design. After India been the first, Africa and Latin America show considerable research growth on the solar cooker technologies.

Solar cookers are available in many types ranging from custom manmade using the local materials to the efficient industrial scale solar cookers supported by Fresnel and parabolic sun radiation concentration techniques. The solar cooking technology could be classified as direct types and indirect types as main, and each has subtypes, as summarized in Fig. 1.

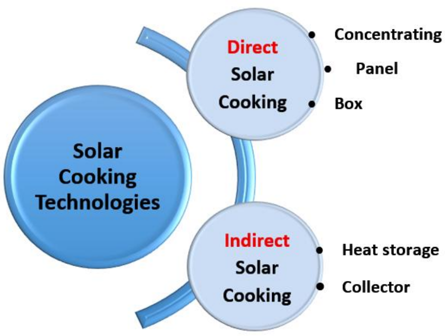

Fig. 1. Classifications of solar cooker technologies.

Direct-type solar cookers utilize the solar radiation directly. They might be concentrating, so-called parabolic solar cooker, panel, and box types [1-3].

In the **concentrating solar cooker**, sunlight is concentrated from above and below the cooking vessel. The common type is the parabolic concentrating solar cookers, which uses a curved, bowl-shaped reflector [3]. The reflected solar radiation is concentrated in the cooking vessel. Parabolic solar cookers could easily construct, and they could provide temperature around the water boiling temperature. With use of well-designed and fabricated reflector, and high-quality reflection materials, it may achieve more than 200 °C in the cooking vessel [4-6] if subjected to frequent adjustment to track the sun. They pose a risk of burns or fire. However, the local made concentrating solar cooker cannot achieve as high as water boiling temperature due to poor design and materials.

Box solar cooker types came in two variations: with reflectors and without reflectors. Reflectors enhance solar energy collection efficiency by directing additional sunlight into the cooking chamber. Vishwakarma and Sinha [7], and Misra et al. [8], provided a comprehensive overview of the box-type solar cookers including the technology fundamentals, development, environmental and economic benefits. They found that integration of the box-type solar cooker with thermal energy storage could enhance off sunshine cooking. At the same time, the recent experimental and theoretical analysis of Goyal and Eswaramoorthy [9] confirmed that the box-type solar cooker with sensible heat storage could be effectively improved. They concluded that the proposed solar cooker integrated with TES has a payback period of 1.24 years, with annually reduced CO_2 emission of 148.3 kg. It is concluded that installing a single solar cooker for two members of a family reduces a total of 148.3 kg of carbon dioxide annually considering use of the cooker for two persons. Good design and proper selective of materials allow the temperature of the vessel surface to reach around 120 ^{o}C.

Panel solar cooker types. These use multiple flat reflective panels to direct sunlight onto a cooking pot, often placed inside a heat-resistant bag. They are the most cost-effective and easiest to build type. Tomassetti et al. [10] designed, fabricated and experimentally tested a panel solar cooker with solar tracking system. With the tracking system, 1 kg of water was heated from 40 to 90 °C in about an hour using metallic cooking vessel, and around two hours using plastic cooking vessel. Aquilanti et al. [11] fabricated and simultaneously tested four different types of panel solar cookers including Kimono, Funnel, Dual Setting Panel Cooker, and Cook it. The four prototypes of the solar cookers were tested outdoor in three different periods of the year, in Ancona, Italy using 1 kg of water in cake pan as the cooking vessel placed inside a glass bowl. They concluded that the Kimono and Funnel cookers have the best performance with low-medium and medium-high sun elevations. The time for water to reach the boiling point was 1.74 h by Kimono cooker type and 1.66 h for the Funnel cooker type. The Dual Setting Panel Cooker was could not reach water boiling point.

Indirect-type solar cookers, on the other hand, operate through intermediary systems and are divided into categories of heat storage and solar collectors [12]. The heat storage system could be either "with" or "without" storage capabilities, utilizing either sensible or latent heat storage methods. Sensible heat storage involves materials that store heat by increasing their temperature, while latent heat storage uses phase change materials to store energy [13]. Solar collectors, another subset of indirect-type cookers, incorporate various technologies, including flat plate collectors, evacuated tube collectors, and concentrators. Flat plate collectors are simple flat panels that absorb solar energy [14], ETCs use vacuum-sealed glass tubes for better heat retention and efficiency [15], and concentrators employ curved surfaces to focus sunlight onto a smaller area for increased heating power [16].

In spite that the solar cooking technology have been advanced over the years, the research and development is still on the go to manage their low efficiency and operational limitations [17-19]. The literature demonstrates that almost of the development in the solar cooker technology is achieved via experimental studies. The literature highlights the importance of continued experimental investigations and the need to expand the knowledge of solar cooking outside India, Africa, and Latin America. Further advancement and experimental studies in Asia, particularly in Malaysia, Bangladesh, and Nepal are encouraged for advancing sustainable carbon free cooking, reduction biomass based cooking, and sustainable urban communities in Asian countries.

Hashim and Ho [20] discussed the Malaysian policies, such as National Green Technology policy in 2009, National Renewable Energy Policy 2010 and Small Renewable Energy Power (SREP) Programme in 2011 showing that Malaysia government is serious in adopting renewable energies. However, they did not give any information on the efficiency and potential challenges that may arise in achieving the target of those policies. In comparison to the work done by Ahmad et al. [21] stated that the failure of some of the government initiatives on renewable energy is because of some barriers in the dissemination of renewable energy technology. Both study shows there are many concerted efforts on the part of the government, but they fail to criticize the government enough on their effort to promote small-scale usage of renewable energy such as solar cooker which can have a huge impact on energy savings and economic savings especially for poor Malaysians. Their work also did not include suggestions to improve the usage of clean energy and how to overcome the barriers that exist.

Solar cookers are a great alternative to electric cookers because it is cheap and does not cause any pollution. For a developing country like Malaysia, where money is an issue for many people, Solar cooker usage can dramatically reduce the cost of their electricity bills without compromising their nutritional needs. Besides that, solar cookers will also help in reducing carbon emissions thus, helping Malaysia in achieving the global carbon emission target recently signed in Paris.

The purpose of this research is to determine the suitability and potential of solar cookers in Malaysia through experimental modelling and evaluation. The experimental solar cooker is being done in a cost-efficient way and all the materials used to build it comes from material that is only available in Malaysia. The experimental solar cookers model will be evaluated by using the solar energy that is available in Malaysia, and the efficiency will be evaluated to ensure whether the solar cooker is suitable to be implemented in Malaysia.

2. Research Methods

Solar cooker can be made from a variety of materials, usually, the material is readily available and is cheap enough for mass usage. The typical material of choice is wood and cardboard for the casing of the cooker, while aluminium foil, mirrors, mylar and reflective paint as heat reflector. Newspaper, cardboard and cloth are material of choice for insulation of solar cooker. Even waste from humanitarian supplies can be used to build a solar cooker without compromising its efficiency [22].

The current research was performed to determine the suitability of solar cooker in Malaysia by conducting an experimental investigation on two models of the solar cooker, namely, parabolic concentration and box types. The two models have been fabricated using low-cost potential materials. Standard testing procedure was followed by heating 1.0 kg of water in metal vessel and recording the temperature rise in 10 minutes time intervals.

2.1. Fabrication of experimental models

Two models of parabolic and box solar cookers have been designed and fabricated using cheap materials. The low-cost solar cookers were fabricated using a basic principle of design and construction with no professional support thus the quality of labour might be compromised. The design and fabrication steps are described in the coming section to permit replication by any interested body.

2.1.1. Fabrication of low-cost parabolic solar cooker

The base and eight spokes of the cooker was made of plywood and fabricated using manual labour and no automated machines were used. Both the spoke and base were fabricated to the required specification and measurement that was drawn prior to the fabrication process. The aluminium reflector was placed on top spokes. Cardboard was used to support the aluminium reflector to ensure that aluminium reflector is as flat as possible. The result is that the aluminium sheet supported by the cardboard was place on top of the spokes.

The fabrication procedure is detailed as steps as following. Drawing of the spoke and base was done on the papers according to the dimensions outlined in Fig. 1(a).

- Eight pieces of plywood was cut sizes of with 500 × 100 × 18 mm. The eight pieces of plywood have been cut to the spokes size, shown in Fig. 2(a).
- A circular shape was drawn with a radius of 500 mm on a 1 m*1 m square shaped 18 mm thick plywood, then, the circular base was cut to size.
- Eight divider lines were drawn on the wooden base to produce marked base with partitions of 45°.
- The prepared spokes were fixed on the base using nails. The produced skeleton of the assembly is shown in Fig. 2(b).
- Aluminium sheet was cut in accordance with the size and circular shape of the spokes, and it is installed on the spokes along with cardboard below it. Nails were used to install the aluminium and cardboard.
- Double sided tape was used to ensure that aluminium and cardboard are sticking together.
- To hold a cooking pot on top of the parabolic reflector, a stand structure made of steel was fabricated. The completed parabolic solar cooker in its final shape is shown in Fig. 2(c).

The cooking pot will be tied with a plastic string, and the string will be tied to the stand. The stand should be strong enough to be able to hold a cooking pot with 0.5 litres to 1 Liter of water. The aluminium sheet is cleaned to achieve best reflectivity but unfortunately, some parts of the aluminium sheet are not even. This is unavoidable because this is the conditioned of the aluminium sheet arrived from the warehouse supplier. The stand is made from steel, and it was fabricated on a laboratory in UTP by welding some of the steel parts together.

For the pot holding stand, steel with length of 1.2 m height and 0.8 m length was fabricated by welding and the result is a stable stand that can hold the cooking vessel filled with 500 g of water. The total result of this fabrication will be the tools needed to calculate the efficiency of the solar cooker.

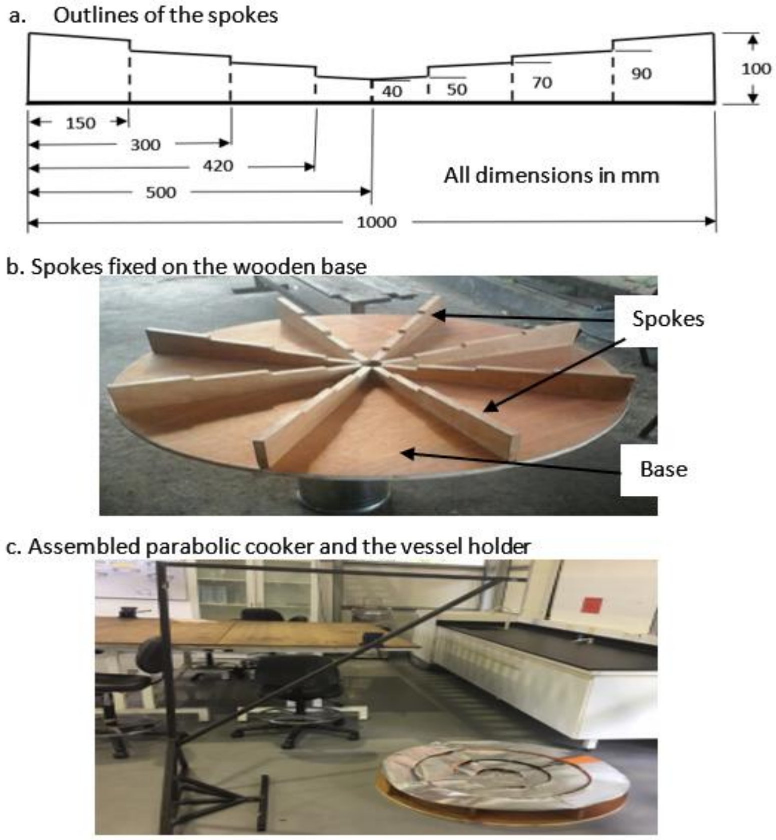

Fig. 2. Fabrication steps of the parabolic solar cooker.
(a) Geometries and diagram of the spokes of the cooker skeleton.
(b) Cut to size of the eight spokes and assemble on a wood base.
(c) The final assembly of the parabolic model with the potholder.

2.1.2. Fabrication of box type solar cooker

The box solar cooker is simple and easy to be fabricated. It is constructed using cardboard box and glass lids that trap the solar radiation and convert it to heat. To ensure thermal insulation of the box, polystyrene sheets were used in each side of the box. The polystyrene is used because it is cheap and it is considered as a very good heat insulator. The polystyrene was wrapped in aluminium foil to make sure that the reflected sun rays that do not hit the cooking pot can be reflected onto the cooking pot. Aluminium sheet was chosen as the material for the main reflector because of its good reflectivity. Procedure for fabricating box type solar cooker:

- A disposed cardboard box was collected from a nearby mini market, cleaned to prepare as the main component of the solar cooker.
- Polystyrene sheet was cut to sheets with size according to the internal box sides and bottom dimensions. The polystyrene sheets have been raped with aluminium foil to secure total usage of the solar radiation penetrate the box.
- The aluminium foiled polystyrene sheets were sticked to the box internal sides and bottoms using a strong glue.
- The cooker was positioned slightly elevated from the bottom of the box to ensure minimal conductive heat loss from the cooker pot to the bottom of the box.
- A glass sheet was used to cover the box to minimize heat loss through convection.
- A reflector was fixed on the side of the box to direct the received solar radiation to the interior of the box, mainly striking the cooking vessel. The total area of the reflector is 175 × 225 mm.

Such design allows solar radiation to directly penetrate the glass cover, and some other radiations are reflected from the reflecting surface and penetrate the glass cover. The final assembly of the box solar cooker is shown in Fig. 3.

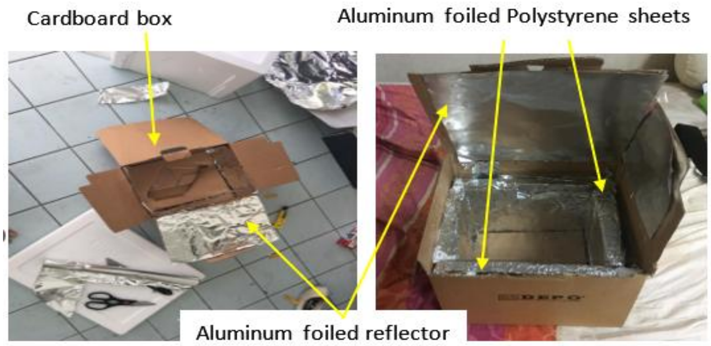

Fig. 3. Model fabrication of the box-type solar cooker.

2.2. Performance parameters of the solar cooker

Common variables and performance parameters have been adopted for evaluation and comparison of the solar cookers. The main comparison parameter is the water heating curve which is representing the tracking and recording of the water temperature. Other parameter is mainly the cooker efficiency, which predicted as in Eq. 1 for the parabolic type, and Eq. 2 for the box type.

$$\eta = \frac{[Mw \times Cw + Ma \times Cp] \times [T_{w2} - T_{w1}]}{I \times A_r \times (t_2 - t_1)} \tag{1}$$

$$\eta = \left(\frac{Mw\ Cw}{I \times A_r}\right) \times \left(\frac{T_{w2} - T_{w1}}{t_2 - t_1}\right) \tag{2}$$

where, M_w=mass of water (= 0.5 kg), M_p= mass of pot (= 0.42 kg), C_w= specific heat capacity of water (= 4180 J/kg·K), C_p = specific heat capacity of pot (= 226 J/kg·K), A_r = area of reflector (= 1 m^2 for the parabolic type and 0.036 m^2 for the box type), I = Solar irradiance (W/m^2), T_{w1} = water temperature at time t_1 and T_{w2} = water temperature at time t_2. Time difference is in sec.

However, a new parameter has been proposed and utilized to compare the performance of the cookers representing the ratio of the water temperature rise to the mean measured solar irradiation over a period, which is 10 minutes in this investigation work. The parameter is named the Mean Heating Capacity, M.H.C. that could be predicted by Eq. (3), with units of ^{o}C.s.m^{2}/W.

$$\mathrm{M.H.C.} = \frac{T_{w2}-T_{w1}}{0.5\,(I_1+I_2)} \times (t_2 - t_1) \tag{3}$$

2.3. Experimental procedures

Both cooker's testing and data gathering were conducted at Universiti Teknologi PETRONAS's solar site (4°23'14.0"N 100°58'24.1"E). Each cooker was positioned in a clear area where there is no interference to the solar beams to the cooker's reflector. The cooking bots are identical, and they are made of Aluminum. Three parameters were recorded during the testing which are the solar irradiance, and temperature of water and ambient. Each of these parameters was taken every 10 minutes until the water reaches its maximum stabilized temperature. For the parabolic solar cooker, the position of the reflector base is adjusted every 10 minutes to ensure that the cooking pot is at the focal point of the reflected sunlight. For box cooker, the cooker is adjusted from time to time to ensure that the reflector is facing directly towards the sun to ensure the reflector is reflecting the maximum amount of sunlight onto the cooking pot.

Weather data for the input solar irradiance, ambient temperature, and rainfall, wind speed for was recorded using the weather station available at the solar research site, the study location. The weather station consisted of a pyranometer, rain gauge, humidity, and temperature sensor as shown in Fig. 4. Data for the weather was recorded in a DataTaker and transferred to the Excel software for calculations and analysis. Type-K thermocouple probes connected to a data logger were used to measure and record the water temperature.

Fig. 4. The used weather station installed in the solar research site to measure the weather parameters.

3. Results and Discussion

The result for both low-cost parabolic solar cooker and box type solar cooker is as follows.

3.1. Heating curve of parabolic solar cooker

The experimental measurements were started at 11:00 am in the solar research site, UTP, Malaysia. Solar irradiance and water temperature was recorded each 10 minutes and the measurement results are shown in Fig. 5. Initial water temperature was 28 °C, and initial solar irradiance was 508 W/m^2. The irradiation increased and reached maximum of 998 W/m^2 around 01:00 PM and started to slightly decline after 02:00 PM, but stayed high, with around 900 W/m^2 till the end of the experiment at 02:00 pm. The increase in water temperature did not follow the solar irradiation trend. Measured water temperature increased noticeably during the first two hours, and then the increase became very slight and stabilized after 130 minutes at 72.5 °C. Very small change occurred after 130 minutes and no more increase until 170 minutes in spite the high solar irradiation, around 900 W/m^2.

The water temperature was raised to 72.5 °C which is a long way away from boiling. However, at that temperature some other activities such as heating food, water and food pasteurization and germ inhibition of food and water. This shows that while this low-cost parabolic cooker may not be good enough to cook food, it is good enough to do several simple heating tasks without using electricity or biomass and fossil fuels.

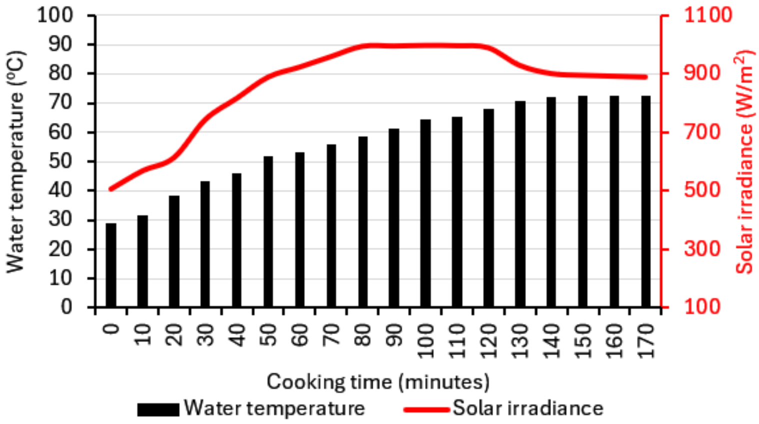

Fig. 5. Cooking curve of the parabolic solar cooker.

3.2. Heating curve of the box type solar cooker

Figure 6 presents the cooking curve of the box type solar cooker. It shows the measurement of the solar irradiance and the vessel water temperature in intervals of 10 minutes. The initial water temperature was 28 °C and the solar irradiance was 508 W/m^2. The water temperature rise was high in early hours, where the water temperature increased to 92 °C at minute 180. Then, the water temperature increment became slight, but kept rising despite of reduction in the solar irradiance. However, the water in the vessel reached the boiling point in around 220 minutes.

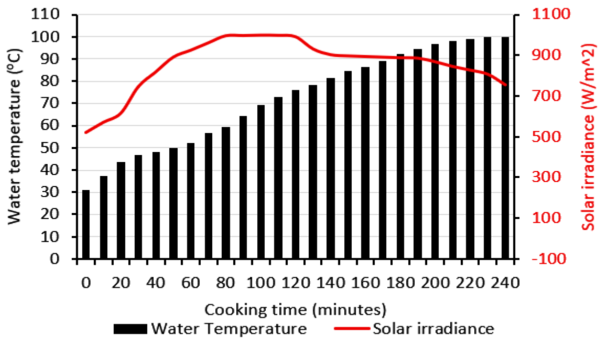

Fig. 6. Heating curve of box-type solar cooker.

3.3. Performance comparison and analysis

Two methods have been used to compare the performance of the fabricated and tested solar cookers. The cooking efficiency, presented in Eqs. (1) and (2), a newly developed parameter representing the Mean of the ratios of the water temperature increase to the mean solar irradiation over the time difference, as presented in Eq. (3).

Efficiency comparison is presented in Fig. 7, including the mean efficiency and the mean solar irradiation. The overall efficiencies are 18.8% with mean irradiation of 748 W/m^2 and 10.1% with mean irradiation of 856 W/m^2 for the box and parabolic types, respectively. The cooking efficiency of the box type is better than the parabolic type. The efficiency of the parabolic type is very low compared to other parabolic solar cookers reported by previous works, which has a range from 20% to 30%. There are a couple of reason for that. First is the reflector quality, which is proposed to be free from any irregularities such as dents or uneven surface. The aluminium used was compromise due to constant rain which causes many moisture spots on the aluminium sheet. Aluminium also has some dents and uneven spot. The aluminium comes with some dents and during fabrication, some uneven surface and dents were introduced.

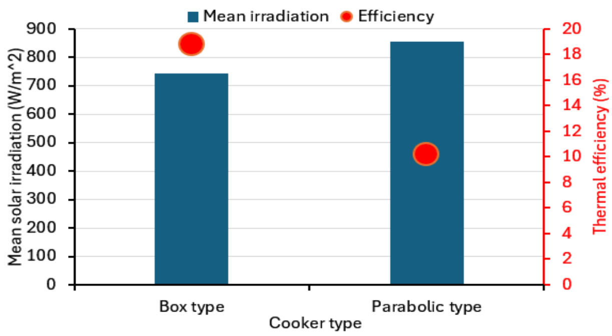

Fig. 7. Comparison between the parabolic and box types of solar cooker models.

The other comparison parameter used for the performance comparison is the M.H.C, as shown in Fig. 8. The results of the predicted M.H.C factor of the box type is 2.17 ^{o}C.s.m^2/W, while it is 2.01 ^{o}C.s.m^2/W for the parabolic type. The results indicate that the box type is performing better than the parabolic type.

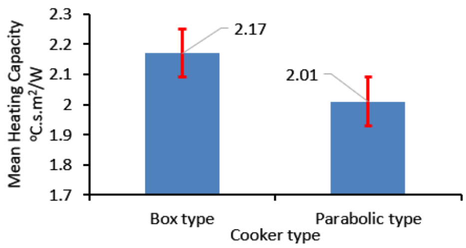

Fig. 8. Mean heating capacity for both tested cookers.

Weather condition during the testing is uneven, which is a normal status in the tropical regions. Sometimes cloud blocks the sun radiation, and this has some effects on the cooker's performance. Parabolic solar cooker is more venerable to weather changes. The wind also affects the performance of the parabolic type of solar cooker. The cooking vessel in parabolic solar cooker is exposed to the surrounding environment thus if there is any dip in solar irradiance or wind, it would start losing heat to the surrounding.

Unlike the parabolic type, the box type solar cooker uses a different fundamental in cooking food. It is more resistant to weather changes because it uses the principle of directing heat onto the pot in which the pot is placed in a heat insulated area. As the sunrays are directed onto the pot, the heat is generated from at the pot and the heat is unlikely to transfer out of the insulated area if it is insulated properly. This allows water temperature to rise and eventually boil water. This means that for a country that can varies in Weather throughout the day such as in Malaysia, the box type solar cooker is an ideal type of solar cooker because it is not greatly affected by it and can store heat for hours. Besides that, the portability of solar cooker is also a huge advantage over the parabolic-type solar cooker. Parabolic type solar cooker is large and is not easily transferred to other places while box type solar cooker can be easily brought along by anyone and it can perform some cooking tasks well without emitting any carbon dioxide.

4. Conclusion

The results presented in this work are the outcomes of evaluation and comparison of two types of low-cost potentially fabricated solar cookers. Box and parabolic types of solar cookers have been fabricated and tested experimentally. The results revealed that the box type is performing better than the parabolic type under the same weather conditions. The predicted efficiencies of the box and parabolic solar cookers are 18.8% and 10.2%, respectively. Water reached boiling point in the box type solar cooker after around 230 minutes, while the parabolic type could not reach more than 72 ºC. The main outcome is that solar cooking is possible to be adopted by the Malaysian communities to support their financial constraint, avoiding complicated transportation to rural areas, as well as it represents more sustainable clean energy.

Acknowledgement

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Nomenclatures

Ar	Area of reflector, m^2
C_w, C_p	Specific heat capacity of water and pot material, J/kg·K
I	Solar irradiance, W/m^2
$M_{w,}$ M_p	Mass of water, mass of pot, kg
T_1, T_2	Initial and final temperatures of water, ^oC
t_1, t_2	Initial and final time

Greek Symbols

η	Efficiency

Abbreviations

M.H.C.	Mean Heating capacity, $^OC.s.m^2/W$

References

1. Odoi-Yorke, F.; Baah, B.; and Opoku, R. (2025). Scientific mapping of experimental research on solar cookers: Global trends, evolution, and future directions. *Solar Energy Advances*, 5, 100093.
2. Sarangi, A.; Sarangi, A.; Sahoo, S.S.; Nayak, J.; and Mallik, R.K. (2024). Advancements and global perspectives in solar cooking technology: A comprehensive review. *Energy Nexus*, 13, 100266.
3. Gorjian, A.; Rahmati, E.; Gorjian, S.; Anand, A.; and Jathar, L.D. (2022). A comprehensive study of research and development in concentrating solar cookers (CSCs): Design considerations, recent advancements, and economics. *Solar Energy*, 245, 80-107.
4. Sagade, A.A.; Apaolaza-Pagoaga, X.; Ruivo, C.R.; and Carrillo-Andrés, A. (2022). Concentrating solar cookers in urban areas: Establishing usefulness through realistic intermediate temperature rating and grading. *Solar Energy*, 241, 257-266.
5. Dev, P.; Roy, V.; and Kesari, J.P. (2024). *Concentrating solar energy for community cooking*. In Raghavendra, G.; Deepak, B.B.V.L.; and Gupta, M. (Eds.), *Recent advances in mechanical engineering, Volume* 1. Springer Nature Singapore, 187-198.
6. Saxena, A.; Sagade, A.A.; Joshi, S.K.; Tyagi, V.V.; Singh, D.B.; Tawfik, M.A.; Kumar, A.; and Gupta, P. (2025). A thermodynamic review on concentrating type solar cookers. *Solar Energy*, 286, 113159.
7. Vishwakarma, A.; and Sinha, S. (2024). Box type solar cooker with thermal storage: An overview. *Energy Systems*, 15, 1289-1315.
8. Misra, N.; Anand, A.; Pandey, S.; Kant, K.; Shukla, A.; and Sharma, A. (2023). Box-type solar cookers: An overview of technological advancement, energy, environmental, and economic benefits. *Energies*, 16(4), 1697.
9. Goyal, R.K.; and Eswaramoorthy, M. (2024). Theoretical and experimental analysis of box-type solar cooker with sensible heat storage. *Solar Energy*, 268, 112273.

10. Tomassetti, S.; Aquilanti, A.; Muciaccia, P.F.; Muccioli, M.; and Di Nicola, G. (2025). Experimental characterization of a panel solar cooker with adjustable geometry for sun tracking. *Solar Energy*, 287, 113178.
11. Aquilanti, A.; Tomassetti, S.; Coccia, G.; Muccioli, M.; and Di Nicola, D. (2023). Experimental characterization and performance comparison of four prototypes of panel solar cooker for low to high sun elevations. *Journal of Cleaner Production*, 390, 136158.
12. Getnet, M.Y.; Gunjo, D.G.; and Sinha, D.K. (2023). Experimental investigation of thermal storage integrated indirect solar cooker with and without reflectors. *Results in Engineering*, 18, 101022.
13. Mabrouk, R.; Naji, H.; Benim, A.C.; and Dhahri, H. (2022). A state of the art review on sensible and latent heat thermal energy storage processes in porous media: Mesoscopic simulation. *Applied Sciences*, 12(14), 6995.
14. Bamisile, O.; Cai, D.; Adun, H.; Adedeji, M.; Dagbasi, M.; Dika, F.; and Huang, Q. (2022). A brief review and comparative evaluation of nanofluid application in solar parabolic trough and flat plate collectors. *Energy Reports*, 8, 156-166.
15. Chaudhary, R.; Mehla, N.; Kumar, A.; and Yadav, A. (2023). Energy, exergy and exergoeconomic (3E's) analysis of simmering type cooking using evacuated tube collector. *Environmental Progress and Sustainable Energy*, 42(2), e14071.
16. Abreham, R.E.; Getie, M.Z.; and Demissie, Y.A. (2024). *Recent developments on design and thermal performance enhancement of parabolic dish solar concentrators*: *A review*. In Mequanint, K.; Worku, A.K.; Getie, M.Z.; and Workineh, Z.G. (Eds.), *Sustainable Development Research in Materials and Energy*. Springer Nature Switzerland, Cham, 177-188.
17. Khatri, R.; Goyal, R.; and Sharma, R.K. (2021). Advances in the developments of solar cooker for sustainable development: A comprehensive review. *Renewable and Sustainable Energy Reviews*, 145, 111166.
18. Omara, A.A.; Abuelnuor, A.A.; Mohammed, H.A.; Habibi, D.; and Younis, O. (2020). Improving solar cooker performance using phase change materials: A comprehensive review. *Solar Energy*, 207, 539-563.
19. Sagade, A.A.; Sagade, N.A.; Belgasim, B.; Tawfik, M.A.; Kulkarni, S.; and Shukla, S.K. (2023). Building integrated innovative non-imaging concentrating solar collector for clean cooking under low sun elevation. S*ustainable Energy Technologies and Assessments*, 57, 103234.
20. Hashim, H.; and Ho, W.S. (2011). Renewable energy policies and initiatives for a sustainable energy future in Malaysia. *Renewable and Sustainable Energy Reviews*, 15(9), 4780-4787.
21. Ahmad, S.; Kadir, Z.A.; and Shafie, S. (2010). Current perspective of the renewable energy development in Malaysia. *Renewable and Sustainable Energy Reviews*, 15(2), 897-904.
22. Regattieri, A.; Piana, F.; Bortolini, M.; Gamberi, M.; and Ferrari, E. (2016). Innovative portable solar cooker using the packaging waste of humanitarian supplies. *Renewable and Sustainable Energy Reviews*, 57, 319-326.