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Performance and Energy Saving Analysis of Improved Cooking Vessel

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Abstract
This work investigates the development and optimization of cooking and heating systems. An experimental protocol for achieving energy-efficient cooking systems with a combined cooker and stove assembly is being developed. In conventional cooking practice, a pot or pan is put directly on a flame, and the thermal efficiency of these systems ranges between 20 and 25%. It was desired to boost efficiency to 70% or greater. This work studies the increase in fuel utilization efficiency and time reduction of the cooking vessel with different stacking arrangements of the cooking vessel. This study captured cooking vessels made of stainless steel with different central annulus geometries to improve the steam distribution. Items such as rice and dal have been cooked efficiently and uniformly through the steaming and boiling process. This device has saved fuel up to 30 % and time by up to 40 % of energy compared to conventional cooking practices. These works can be implemented in rural as well as urban areas and an expected to result in more social and economic benefits.

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Keywords
Multichannel Cooking Vessel
Thermal efficiency
Steaming, Energy Saving,
Heat transfer

Introduction
Energy is a necessity for economic development on a fundamental level. Greater energy usage corresponds to a greater economy in every sector, including the energy required in the cooking sector. Several factors affecting the efficiency of cooking, like the method of heat generation, heat utilization, heat transmission, and heat rejection or loss during combustion and cooking, have been evaluated. Energy loss and net thermal efficiency of present cooking techniques and other adverse effects of present cooking techniques have been addressed in this work. Many cooking devices are available to conserve energy during the cooking process, but proper and optimum energy utilization during the cooking system is required, which improves cooking efficiency. Cooking is a daily process of making food to improve taste, maintain nutritional value, and enhance appearance and digestibility. It is essential to improve all energy consumption processes and energy and time efficiency. Energy efficiency is a feature of the eco-sufficiency concept. Energy efficiency decreases the need for more energy, reducing the environmental impact and national security for a sustainable future. According to thermodynamic principles, energy waste affects environmental damage because of increased greenhouse emissions. It may be avoided by improving the efficiency of energy use procedures. Different types of cooking devices are used for cooking, and because of new fabrication or modifications

available in cookware, providing cooking food items efficiently is possible. Changing the cookware design may give faster and more efficient cooking reducing fuel wastage. Hence, this work provides a multi-stacked arrangement of cooking vessels with different stacking arrangements for reducing fuel consumption and cooking time resulting in complete and uniform cooking.

The conventional way of cooking is to boil the meal in an open pot. In other circumstances, the pot is covered with a lid. Food is cooked inside the vessel with sufficient water, and the vessel bottom is placed directly over the flame. The cooking life cycle extends far beyond the kitchen. According to the literature, kinetics studies of cooking milled rice has been investigated. In this paper, the difference in cooking rates with amylose content and gelatinization temperature of cooked and presoaked rice has been studied (Juliano & Perez, 1986).

Most of the cooking devices available in the market use gas or electricity as a fuel, generated using coal, gas, nuclear, hydro, or other renewable energy sources. In this, the effect of using fins in the cooking vessel for the box-type solar cooker has been studied and better thermal performance has been observed in the finned vessel than unfinned vessel (Vengadesan & Senthil, 2021).

In this paper, a cooking pot with a thermal shield is used for energy consumption analysis. The effect of boiling by using a thermal shield on energy absorption has been investigated and the author reported that the thermal shield's effect was influenced by the pot's characteristic height (the ratio of liquid volume to pot diameter) and was not affected by container shape (Zamani et al., 2019). In this regard,(Shashidhar, 2020) evaluated the effect of using fins in cooking vessel to improve heat transfer rate. Cooking vessel of hemispherical and rectangular shapes with fins improves effective heat transfer and reduces energy consumption. Also, it has been noted that the shape of fins has been considered as the key factor for increasing heat transfer and energy consumption and increased weight of vessel with fins due to its additional material compared to the unfinned vessel.

Over the years, a lot of research has been done on how to make cooking devices more efficient (in terms of fuel use and time). It has been studied the efficiency performance of conventional cooking pots, and a water boiling test has been done to determine thermal efficiency(Naphon, 2014; Rather et al., 2016) They have evaluated the physical, cooking, pasting, and milling characteristics of three rice varieties grown in the Kashmir valley. In this paper, it has been investigated the thermal properties of numerous saucepans on different cooktops, such as electric coil, natural gas, and induction cooktops, and found the best pan for each cooktop. Cooking efficiency vary owing to variances in heating techniques and cooktop power, pan shape and size, cooking vessel material composition, cooking vessel bottom thicknesses, and quantity of foods to be prepared (Karunanithy & Shafer, 2016; Matsuki et al., 2019) It has been reported that one pot has been designed and developed for optimization of new rice-gel preparation by modification process with consideration of factor i.e. rice-cooking temperature, the rotation speed of the paddle, and water loss. (Agarwal et al., 2015; Phukasmas, 2019) attempted to develop an LPG burner and carried out cooking efficiency studies utilizing LPG as a fuel. The level of carbon emissions during the cooking process has also been measured at different power levels. The effect of rice cooking methods on the quality of jasmine instant rice dried by industrial microwave oven has been evaluated. (Dardashti & Sedighi, 2014)“The spatial temperature distribution was evaluated using two alternative cooking utensil geometries, and the covered and semi-cook equipment was evaluated”. They have attempted the experimental analysis using nuclear magnetic resonance, and the change in moisture distribution in a grain of rice during boiling was observed (Takeuchi et al., 1997; Kraemer, 2009). A study compared the heat transfer efficiency of cooking pots using plane bottom surfaces and those with curved sides. The heat transfer efficiency of the rounded bottom cooking pot was found to be significantly higher than that of the plane bottom cooking pot. (Sharma, & Joshi, 1978; Joshi et al., 2012b, 2012a; Amogha et al., 2017; Shinde et al., 2017) has reported the development of efficient cooking system designs to optimize energy utilization for cooking foods. However, the above research concluded that even though they had modified the design of cooking devices, they failed to achieve a significant reduction in the cooking time and improved fuel efficiency. Thus this study has been undertaken to improve energy efficiency with complete and spatially uniform cooking by incorporating an annulus portion to provide passage to steam and its distribution in the steaming-based cooking process. The transfer of heat from steam results in natural convection in the pool of water inside the pot. When the water has added rice/lentils these immersed bodies provide resistance to natural convection.

The primary purpose of this research is to apply various processes to achieve good performance by upgrading cooking vessels, which can result in significant energy (fuel) and time savings over conventional technologies used in residential and commercial community level cooking.

Materials and methods

Setup for the experiment:

Fig. (1) shows a description of the Eco-cooker(40L) setup, which consists of weighing balance (W); Eco-cooker base, stand (S) B, burner (B), LPG cylinder (C); temperature sensor, and indicator (T.I), outer cover for Eco-cooker (O.C.), handle (H), vessel 1 (V1), vessel 2 (V2), vessel (V3).

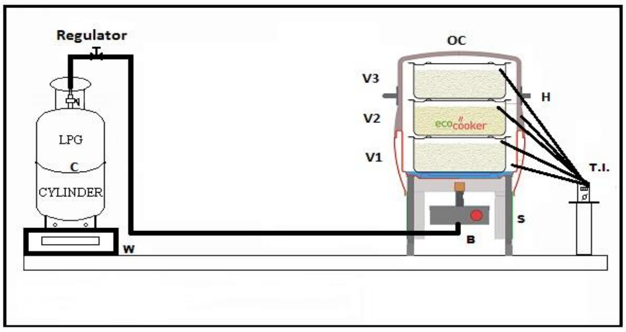

Fig. 1. Schematic of Experimental Set up of Eco-Cooker

Fig. 2. Photograph of Eco-cooker (40 L) and mounting vessel arrangement

Fig. (2) shows the 40L Eco-cooker model. This cooker consists of a vessel, base plate, cover, stand, and pull tray. In the first photograph of the eco cooker, an inner and outer cover creates an air gap that acts as an insulator. The base and covers are made of aluminum, and the three vessels are of stainless steel. The vessels used are of a 13.5-liter working capacity. Each 3 kg rice or 2.5 kg dal can be cooked in a single vessel. A total cooking capacity of 9 kg dry rice or 7.5 kg dal can be achieved. The cooked food can be served to around 75 to 100 people in cooked rice and dal. As a recommended practice, dal is placed in the bottom vessel, followed by rice and vegetables in the upper vessels due to the sequence in the time of heating of the different vessels reported earlier (Joshi et al., 2012a).

Unlike other models of Eco-cooker, this model is designed and standardized for working with domestic LPG and solid biomass as a fuel. To use this model of Eco-cooker with solid biomass fuel, one needs to replace the pull burner tray with a specially designed biomass cookstove

Standard Operational Procedure (SOP) for cooking in 40 L Eco-Cooker: (Joshi et al., 2012a).

(1). Insert the burner tray into the stand
(2). Place the base vessel on top of the stand
(3). Take a measured amount (4 kg) of water in the base vessel of the Eco-cooker.
(4). Keep the base bubble plate in the base vessel
(5). Charge the vessels by adding rice or lentils and the appropriate amount of water.
(6). Arrange the vessels in the form of a stack and cover it using the double-walled insulating cover
(7). Switch on the LPG supply at a pre-decided LPG flow rate and ignite the burner
(8). Confirming the food temperature reaches 75 ^{o}C for rice and 94 ^{o}C for Dal by using a thermocouple and then switching off the LPG supply. For complete cooking of rice and lentils, one has to maintain the cooking temperature of rice and dal for an additional 30-45 minutes. Wait for 30 to 45 minutes until the entire cooking process is completed before opening the top cover.
(9). After that, hot food is ready for serving

Effect of Improved Cooking Vessel on thermal efficiency

Vessels have a diameter of 360 mm and 150 mm in height. These vessels with an annulus portion cylinder opening of 100 mm) were stacked in a base supported by a ring to maintain a preselected gap for efficient steam movement between vessels. For analyzing its performance, a 12 L of vessel volume of rice/dal and water was placed in each vessel, thus making the total volume of 36 L. A quantity of 4 L of water was placed in the base. Thus, making the total volume of 40 L. One or more annular channels are there in the centre of the vessel with a dimension of 100 mm in diameter and 152 mm in height. The heat transfer surface area thus is increased up to 628 cm2 by the newly designed multichannel vessel than the standard cooking vessel without the central steam passage shaft. Overall the heat transfer coefficient of our modified vessel is 391.59 (W/m2k), as mentioned in Table (1) The heat transfer rate of the newly designed multichannel vessel is increased up to 8101.93 W, which is mentioned in Table (1) due to increased heat transfer surface area compared to the standard vessel.

Table 1. Performance of improved cooking vessel

Parameter	Values	Unit
Vessel height	15	cm
Vessel length	36	cm
Vessel 2 length	10	cm
Area Standard Vessel	3730.3	cm^2
Area Annular vessel	4358.3	cm^2
The heat transfer surface area increased	628	cm^2

Temperature 1	300	k
Temperature 2 Standard Vessel	352	k
Temperature 3 annular vessel	361	k
Heat flux	20254	kCal/hr.m2
heat transfer coefficient	391.59	w/m^2k
q1=hA (thf-tcf)	21862.75	w/m^2k
q2=hA (thf-tcf)	29964.68	w/m^2k
Rate of heat transfer Q=q2-q1	8101.93	w

Experimental procedure

The experiment of cooking rice was carried out in a 40 L Eco-cooker model

The First 9 kg of rice was taken into the vessel and washed with water, and then a sufficient quantity of water (2.5-3 times) was added and distributed equally in three vessels. (Shinde et al., 2017)

Rice and water ratio was 1:2.5, and the temperature sensor was placed at various locations inside the bed of rice. Four Liters of water were added to the base of the cooker.

Inner and outer covers were put to close the cooker. Now the initial weight of the LPG cylinder was noted. Then the burner was started (flux was maintained at 40000±1500 (kCal/h.m^2) corresponding to 16 (gm/min) of LPG flow rate having calorific valve 10600 kCal/kg and covered vessel flame area (120mm) to vessel base area (400mm) of the ratio of approx. 30%. This was continued till the temperature reached at least 75 °C in the New Modified vessel (as the rice bed gets stratified due to partial cooking and swelling bottom-most location shows the lowest temperature). This is due to the absence of natural convective current.

Then Eco-cooker was allowed to cool for 25-30 min. After that, the cooker was opened, and the weight of cooked rice in Fig. (3) water remaining in the base, water remaining inside the annular portion of the vessel, and weight of the LPG cylinder were measured.

The weight readings are noted, and calculations are done and neatly tabulated to confirm the thermal efficiency of cooking.

Fig. 3. Photograph of cooked rice and dal in new modified vessel

Results and discussion

The experiments were carried out as per SOP in different vessels to find out temperature profiles with respect to time.

Three experiments with different geometries of open pan/without channel, standard &annular vessel with the same gas flow rate (only water)

Heating of water was done for 30 minutes by using the same LPG flow rate of 16 gm/min, same water charge is 10 lit, and temperature is noted. Fig. (4) shows that a temperature of 100 °C was obtained in annular vessels (bottom) in Eco-cooker and for standard vessel (bottom) in the Eco-cooker temperature was 85 °C. Temperature increases slowly up to 50 °C initially, reaching it in standard & annular vessel in about 14 min. After which, the rate of heating in the annular vessel shows significant enhancement, reaching 70 °C in 18 min, while it takes 22 min in the standard vessel. The figure below means the temperature measured in annular & standard Vessels of eco-cooker. The temperature sensor was located on the left side of the vessel by keeping a distance of 10 mm from the base of the vessel. It is observed that the temperature of water in the annular vessel increases at a much higher rate in the same time period when compared with standard & open pan cooking vessels. An annular vessel has more surface area, and hence heat transfer rate increases than a standard Vessel. Also, when water vapour pressure becomes significant above 70 °C, the steam generated effectively uses this additional heat transfer area.

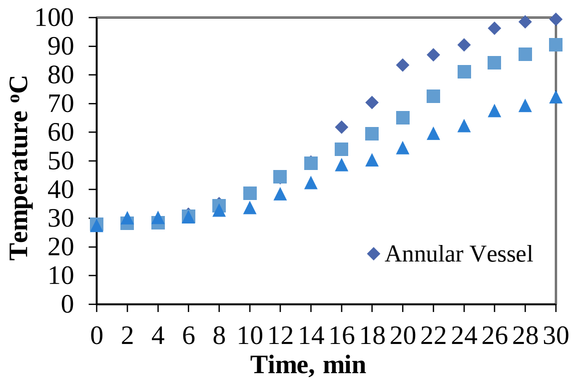

Fig. 4. Temperature profiles of an annular vessel (1), standard vessel (2), and open pan(3).

Cooking of full charge rice

Fig. (5A), (5B) and (5C) shows the results of an experiment with a 40L Eco cooker with new vessels. Cooking is carried out as per the experimental procedure described earlier under the heating cycle of 25 min high flame and 30 min holding time. In this experiment, 3 kg of rice is taken into new Annular vessel 1,2,3 containing 7.5 lit of water in each vessel with a total charge of 31.5 kg. As shown earlier total gas used was 360 gm (15 gm/min) refer to Table (2), and the obtained efficiency was 56.74 %. For complete and uniform cooking of rice vessel required vessel temperature has to reach 75 °C at the earliest. The same experiment was performed using standard Vessels 1,2,3, containing 7.5 lit of water in each vessel. The total gas used was 492 gm (15 gm/min) & thermal efficiency of 42.20 % was obtained.

Fig. (5A) shows that a temperature of 87 °C was obtained in annular vessels (bottom) in Eco-cooker and for standard vessel (bottom) in the Eco-cooker temperature was 85 °C. Temperature increases slowly up to 35 °C initially, reaching it in standard & annular vessel in about 5 min. After which, the heating rate in the annular vessel shows significant enhancement, possibly due to the setting of thermal convective (vessels), reaching 87 °C in 25 min. At the same time, it takes 30 min in the standard vessel.

Fig. (5B) shows that the temperature obtained was 80 °C for the annular vessel (middle) in Eco-cooker, and 77 °C was obtained for the standard vessel (middle) in Eco-cooker within 30 minutes. The time required for the annular vessel was 25 min. It shows that more time was required for the standard vessel (middle) than the annular vessel (middle) to reach the same temperature for cooking food.

Fig. (5C) shows that the temperature obtained for annular vessels (top) in Eco-cooker was 82 °C and for standard vessel (top) in Eco-cooker, the temperature was 79 °C. It shows that there was a slow increase in temperature up to 35 °C for standard & annular vessel in about 5 min. After which, the rate of heating in the annular vessel shows significant enhancement, reaching 82 °C in 25 min, while it takes 30 min in the standard vessel.

This set of experiments clearly indicates and validates the preceding theory that the higher heat transfer area supplied there in the annular vessel and the effective steam circulation enhance the thermal efficiency of this annular vessel.

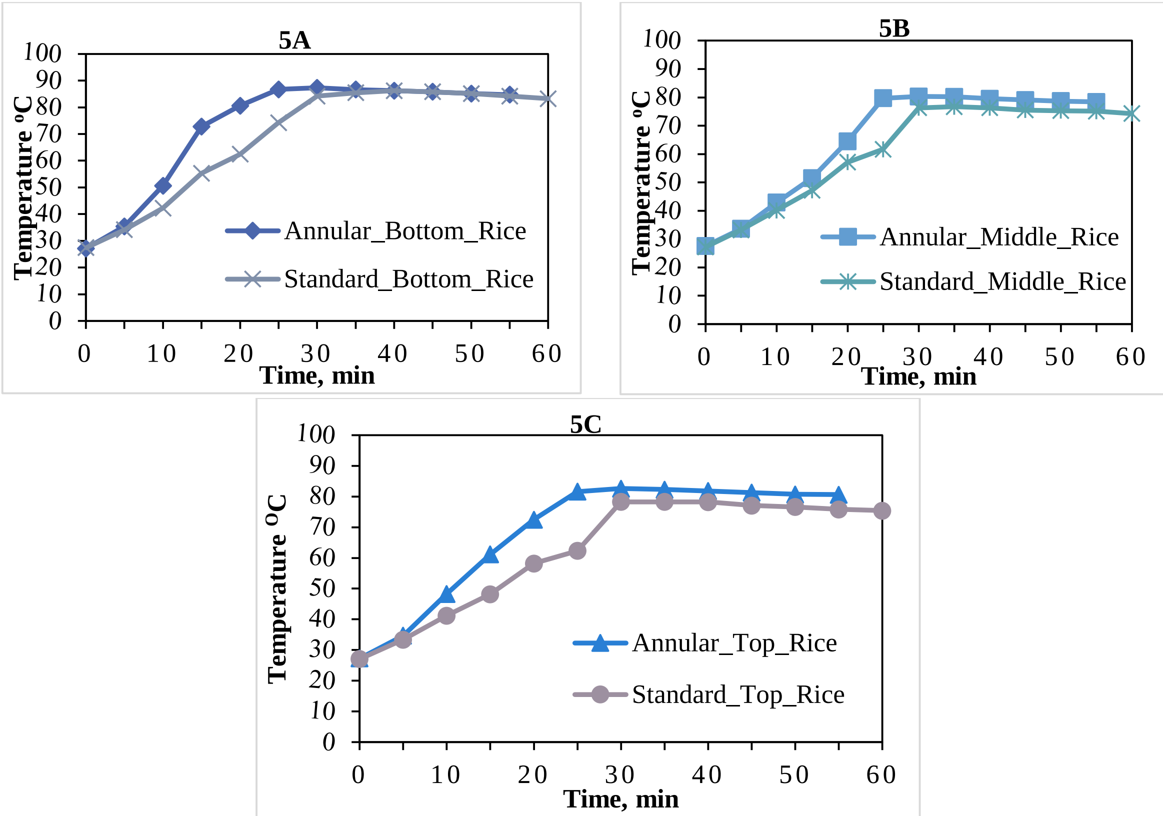

Fig. 5. Temperature profile of annular vessel and standard vessel using a full charge of rice in a 40L eco-cooker

Cooking of dal in one vessel & rice in two vessels

In the traditional Indian meal, consisting of dal and rice, it was desirable to experiment with simultaneously working both. Since the earlier observations have indicated that the bottom vessel reaches the required cooking temperature earlier, dal should be accumulated in the lowermost vessel. The upper two vessels should be used for rice cooking.

Fig. (6A), (6B) and (6C) show the results of these experiments with a 40L Eco cooker with new vessels. Cooking is carried out as specified earlier, and only the holding time was increased to 45 min. In this experiment, 3kg of rice in the top & middle vessel and 2.5kg dal in the bottom vessel is taken into new vessels 1,2,3 containing 7.5 lit of water in each with a total charge of 31 kg in the cooker. The total gas used was 486 gm (16 gm/min) to reach the required temperature with net thermal efficiency is 48.91 %.

Similarly, when standard Vessels were used for a similar charge, 35 min of high flame heating time was needed to reach cooking temperature with 45 min of holding. The total gas used was 570 gm (16 gm/min), and thermal efficiency of 41.70 % was obtained. For complete and uniform cooking of Dal, both types, annular and standard Vessel, LPG gas was stopped after reaching the temperature of 95 °C in the bottom-most vessel.

Fig. (6A) shows that the temperature in the annular vessels (bottom) of the Eco-cooker was 96 °C, whereas the temperature in the regular vessels (bottom) of the Eco-cooker was 94 °C. At first, the temperature gradually rises to 36 °C, reaching it in standard and annular vessels in around 5 minutes. Following that, the heating rate in the annular vessel significantly improves, reaching 96 °C in 30 minutes against 35 minutes in the standard vessel.

Fig. (6B) shows that the temperature obtained was 84 °C for the annular vessel (middle) in Eco-cooker, and 83 °C. was obtained for the standard vessel (middle) in Eco-cooker within 35 minutes. The time required for the annular vessel was 30 min. It shows that more time was required for the standard vessel (middle) than the annular vessel (middle) to reach the temperature required for cooking food.

Fig. (6C) shows that the temperature reached for annular vessels (top) in the Eco-cooker was 87 ^{0}C, whereas the temperature obtained for standard vessels (top) in the Eco-cooker was 84 ^{o}C. It demonstrates that the temperature gradually increased up to 34 ^{o}C for standard and annular vessels in around 5 minutes. Following that, the heating rate in the annular vessel significantly improves, reaching 87 ^{o}C in 30 minutes vs. 35 minutes in the standard vessel.

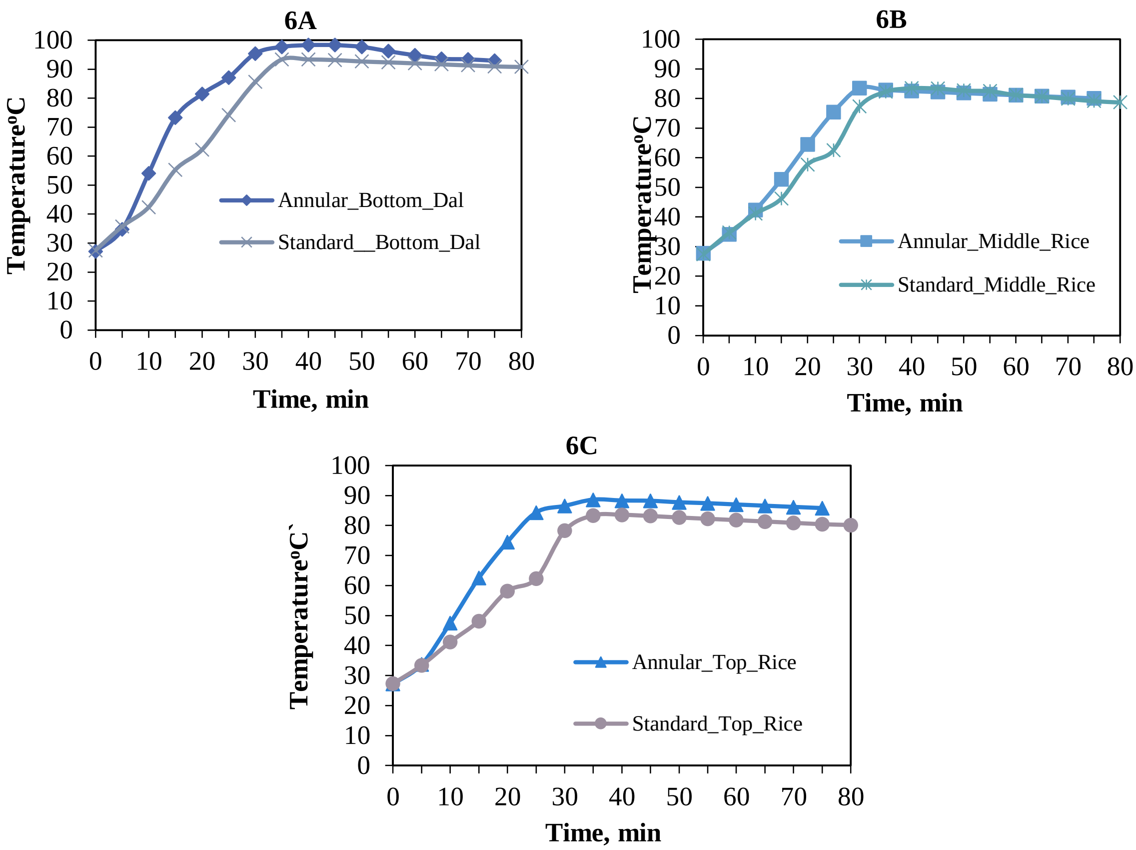

Fig. 6. Temperature profile of annular vessel and standard vessel using dal in bottom vessel and rice in middle and top vessel in 40L eco-cooker.

Cooking of full cooker charge with dal

The last set experiment was carried out with a total charge of Dal in the cooker. Fig. (7A), (7B) and (7C) show the result of an experiment with a 40L Eco cooker with new vessels. The heating time of 33min with high flame was needed to reach 95 ^{o}C. temperature to ensure cooking 60 min holding time was provided. In this experiment, 2.5 kg of dal is taken in each of the new vessels with 7.5 lit of water in each of the vessel with a total charge of dal and water is 30 kg. The total gas used was 528 gm (16 gm/min), giving thermal efficiency of 45.02 %.

Similarly, when standard Vessel-based cooking was carried out, a heating time of 40 min with high flame was needed to reach a cooking temperature of 95 ^{o}C. In this experiment, 2.5 kg of dal is taken into standard Vessel 1,2,3 with 7.5 lit of water in each vessel with a total charge of 30 kg. The total gas used was 644 gm (16 gm/min), giving thermal efficiency of only 36.91%. For complete and uniform cooking of Dal in an annular and standard vessel, LPG gas is stopped after reaching a temperature of 95 ^{o}C, as stated before.

Fig. (7A) shows that a temperature of 94 ^{o}C was obtained in annular vessels (bottom) in Eco-cooker and for standard vessel (bottom) in Eco-cooker temperature was 95 °C. Temperature increases slowly up to 34 °C initially, reaching it in standard & annular vessel in about 5 min in both. After which, the rate of heating in the annular vessel shows a significant enhancement, reaching 94 °C in 33 min, while it takes 40 min in the standard vessel.

Fig. (7B) shows that the temperature obtained for the annular vessel (middle) in Eco-cooker was 95 °C, while the temperature obtained for the standard vessel (middle) in Eco-cooker was 94 °C within 40 minutes, whereas the time necessary for the annular vessel was 33 minutes. It shows that the standard vessel (middle) took much longer than the annular vessel to reach the temperature of cooking food.

Fig. (7C) shows that the temperature attained in the Eco-cooker for annular vessels (top) was 96 °C, whereas the temperature obtained for standard vessels (top) was 95 °C. It shows a gradual increase in temperature up to 34 °C in around 5 minutes for both the standard and annular vessels. Following that, the heating rate in the annular vessel improves significantly, reaching 94/95 °C in 33 minutes against 40 minutes in the standard vessel.

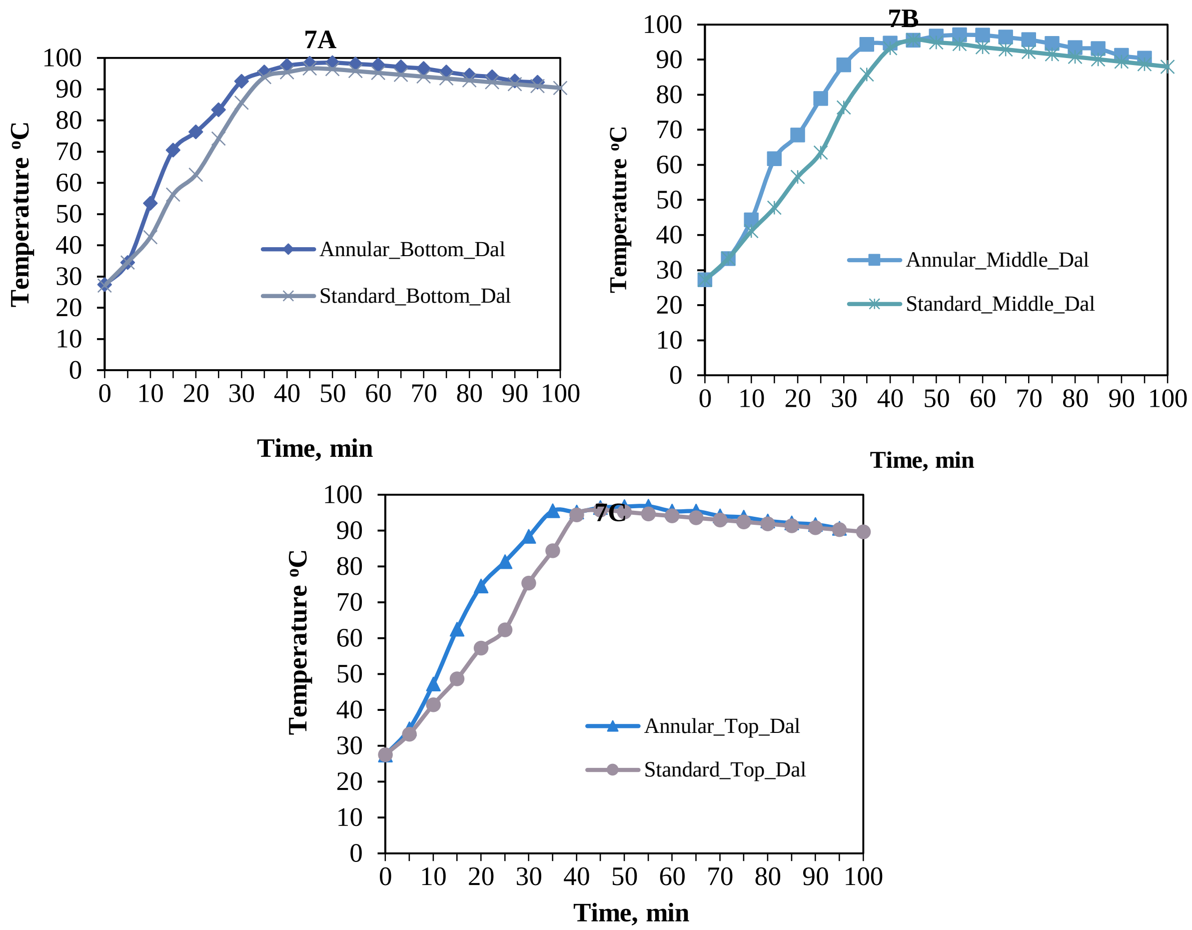

Fig. 7. Temperature profile of annular vessel and standard vessel using a full charge of dal in 40L eco-cooker.

The graph is in Fig. (5), Fig. (6), and Fig. (7) represent various cooking rice, dal trials, and their combinations. Experimentally, cooking time can be reduced by 5-10 min (equivalent fuel saving ~15%) using a modified vessel with internals for complete and uniform cooking. Also, it is observed that the minimum temperature required for cooking rice is 75 °C and that for dal is 95 °C.

Thermal efficiency estimation; sample calculations

Three standard cooking vessels were used for cooking the rice in a steaming chamber (Eco-Cooker), and each of them contained 3 kg of rice and 7.5 kg of water in the cooking vessel and 4 Liters of water in the base of the eco cooker Therefore, the total quantity of food with water taken in all three vessels was (M) 35.5 kg. The average maximum temperature rise achieved during the cooking procedure in vessels was (T2) 88± º C. The total fuel (LPG) used was (m)360 gm having the calorific value of (CV) 10600 kCal/kg.

Thermal efficiency (based on food alone) can thus be calculated by using the following equation:

$$\text{Efficiency} = \frac{M * Cp * (T2-T1)}{m * CV} = \frac{35.5 * 1 * (88-27)}{0.360 * 10600} = 56.74\ \% \quad (1)$$

Net thermal efficiency of cooking operation using eco cooker is found to be 56.74 % An average temp of 88 ºC was achieved in 25 minutes of heating only. Therefore, the total quantity of fuel-saving is nearly 30 % as compared to open pan/ without channel vessel and in addition, nearly 40 % of the time is saved in the annular vessel as compared to open pan/ without channel vessel as mentioned in Table 2) Cooking took significantly less time and probably improved the surface of energy transfer, resulting in significant fuel savings. Cooking was performed significantly less time, saving a significant quantity of fuel.

Table 2. Time and fuel saving LPG based cooking vessel

Details	Annular Vessel	Standard Vessel	Open Pan Cooking
Rice cooked (kg/batch)	31.5	31.5	31.5
Time (min)	25	30	42
Water in the Base of the Eco-cooker (L)	4	4	-
Initial Temperature (k)	27	27	28
Final Temperature (k)	88	86	76
The Calorific Value (kCal/kg)	10600	10600	10600
Total gas is used (kg/batch)	0.36	0.492	0.53
Efficiency %	56.74	40.84	28
Time-saving compare to Standard Vessel (%)	16.66	-	-
Fuel-saving compare to Standard Vessel (%)	26.82	-	-
Time-saving compare Open Pan Cooking (%)	**40.47**	-	-
Fuel-saving compare to Open Pan Cooking (%)	**30.76**	-	-

40L capacity of Eco-cooker is designed for community cooking where meals for nearly 75 to 100 people are served at a time. College hostels mess, college canteens, small restaurants, and industrial kitchens are the targeted places for installing this 40L model. Other than rice and Dal, Idali, chicken, meat, veg-pulav, and cholle are some of the additional food dishes cooked at all of the places mentioned above. This Eco-cooker is tested to cook rice and dal in our laboratory. Eco-cooker can be used to cook any of the dishes that involve steaming or steam cooking as the main operation for cooking. Thus, ideally, all the dishes mentioned above can be cooked in Eco-cooker. An attempt has been made to successfully cook all of the above dishes during field trials. All of the dishes listed above can be prepared in Eco-cooker with significantly higher thermal efficiency than the conventional cooking method and significant savings in time.

Reducing the carbon footprint of the cooking process

LPG is the major energy source in India for cooking in urban households (56%), while in rural areas, 85 % of households still use biomass for the same (Legros et al, 2009) The use of LPG has been encouraged as part of the government's Ujjwala scheme in India, which aims to supply subsidized and clean cooking fuel to every home. Only about 8% of rural households use LPG as a cooking fuel, mainly due to the initial cost of the setup. LPG consumption for cooking was 11.1 Mtoe, while biomass consumption was 123.6 (Million tons of oil equivalents, Mtoe) in 2005. The consumption of LPG and biomass is predicted to increase by 4.3 % and 0.5% per year. Thus, in 2022, consumption of LPG and biomass for cooking would have been around 28.5 and 240.63 Mtoe, respectively. Based on this quantity, the following is a sample calculation for the commercial scope for Eco-cooker using only LPG and possible fuel savings.

LPG consumption in India for cooking (2022) = 28.5 Mtoe

Assuming 50% of the cooking practices are replaced by the Eco-cooker systems and fuel saving of 50 %.

LPG saving = 0.5 x 28.5 x 0.5
= 7.125 Mtoe
1 Mtoe = (10000/10500) MT of LPG
Hence,
LPG saving = 6.785 MT
LPG cost = 65 Rs/kg (14 kg LPG cylinder cost = 900 INR)
Cost saving in LPG =4.41025 x 10^{11} Rs/yr.
= 441025 Cr Rs/ yr.

Apart from direct saving in the cost, the saving in CO_2 emissions would also be substantial.
1 kg oil = 3 kg CO_2
CO_2 saved = 11.01 MT.

This is a major contribution as far as global warming is concerned. Eco-cooker coupled with biomass-based stoves has a larger scope since biomass consumption for cooking is much larger than LPG. Further, saving on biomass would help, in addition to the above two factors, reduce deforestation and reduce health problems due to reduced fuel burning and make biomass available for the making of other cellulose derivatives.

Today, our green planet is degrading daily, primarily due to rising air temperatures caused by global warming,

References

and one of the major causes is air pollution. According to studies, the escape of carbon compounds caused by the burning of LPG gas fossil fuel for cooking reasons pollutes roughly 60-70 % of the air, particularly in developing nations (Legros et al, 2009). The best approach to solving this problem is utilizing microwave ovens or an electric induction cooktop. However, while cooking with an LPG gas burner has been utilized since the beginning, most people are apprehensive about utilizing these cooking devices. As a result, the best strategy to decrease LPG gas usage is to use a well-designed cooking pot and reduce its consumption by utilizing more thermally efficient cookers. The results show that this new experimental novel vessel has high thermal efficiency in all testing phases. This shows that using this new vessel in each family for everyday cooking purposes could decrease 2.1 million tonnes of carbon dioxide emissions, reducing the impact of GHG.

Conclusions

In all tests, the new experimental cooking vessel demonstrated high thermal efficiency. The efficiency of cooking operation using conventional vessels was found to be 42.20 %. The efficiency of our newly developed cooking vessel is found as newly 56.74 %. The average temp of 88 ^{0}C is achieved in 25 minutes only. Using this cooking vessel, we can save up to 26.82 % fuel as compared to the standard vessel, and 16.66 % of the time is saved in our newly developed vessel than the standard vessel, which will conserve more energy and help to reduce the global warming.

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