

# Solar cookware setups- A comprehensive review

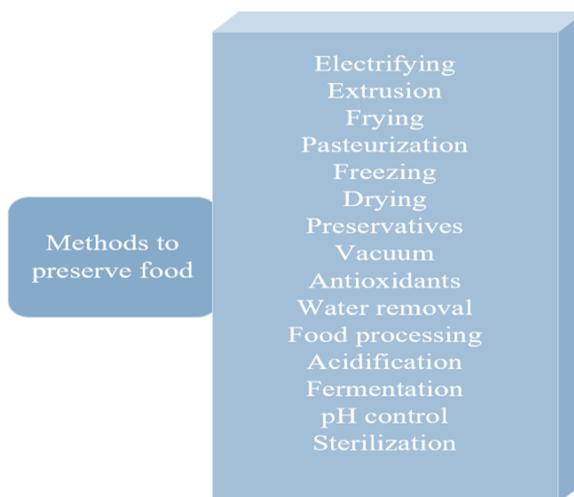
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**Abstract**— In developing countries, cooking accounts for a significant amount of the energy used. Emerging as a potential solution to sustainable processing of food, solar food processors provide eco-friendly substitutes for traditional processes. Therefore, solar cookers are widely used in homes in these countries. There would be a decrease in the quantity of CO<sub>2</sub> released into the atmosphere if solar cookers were used. Despite the fact that a large number of solar cookers have been studied and developed by scientists and researchers worldwide, there is still not enough application for them. A number of reasons, such as their size, weight, lack of open space, sluggish cooking, predetermined cooking durations, and lack of expertise, contribute to the restricted use of solar cookers. A design prototype of solar cookers, such as parabolic cookers, box-type solar cookers, panel-type solar cookers is provided by the presented work. This paper offers a thorough analysis of solar food processors, including their applications, benefits, operating mechanisms, design concepts, and drawbacks. The paper clarifies the possible benefits of solar food processors in improving food security, lowering carbon footprint, and supporting environmentally friendly growth by a comprehensive analysis of the body of published research and examples.

**Keywords**— Solar energy, Food processing, Sustainability,



Renewableenergy, Solar cookers, Solardryers.

## I. INTRODUCTION

A vital component of contemporary food systems is food processing, which makes it easier to preserve, prepare, and turn agricultural products from raw materials into consumables. However, traditional food processing techniques frequently use fossil fuels, which exacerbates climate change and deterioration of the environment. In this case, using solar energy to power food processing processes offers an ecological and renewable option. Solar food processors use solar radiation to produce heat for food preservation methods such as drying and cooking, providing clean and easily available energy to communities across the globe.

A key advantage of solar cookers is frequently mentioned as their decreased dependency on fuel sources. Providing energy that can meet our demands in the future is essential [1]. Solar power is superior to the other options because it doesn't is cost effective to use the energy from the sun. Solar energy was probably used for cooking far earlier than that. Individuals and the natural world both stand to gain from the widespread use of solar cookers. The kitchen is one potential application field for solar thermal systems [13]. Concentrating solar power is one technique that accomplishes this transformation from solar radiation to thermal energy. Conventional solar energy conversion systems made use of reflector materials to focus the sun's rays and turn them into usable heat [12]. The focal point is a small area where all the heat is concentrated. At last, those underprivileged populations may easily boil water or cook meals using the concentrated heat from that point of focus. Sunlight is converted into thermal energy when it encounters with a receiver material. Black is the only acceptable colour for kitchen cookware. Using a glass lid on the pot is a simple way to insulate the cooker. It helps keep the solar cooker's heat from escaping through convection. Although the exact mechanism by which each solar cooker heats food may vary, most of them operate on the same premise. Cutting food into smaller pieces speeds up the cooking process [2]. Typically, solar ovens are used for cooking very little portions of food. A household may use one or more solar cookers, depending on the size of the family and the amount of food that needs to be cooked. In a solar oven, stirring the food is usually not necessary.

Fig.1. Different available methods for food preservation

## II. OPERATIONAL FEATURES OF SOLAR COOKWARE'S

There is a wide variety of layouts and setups for solar food processors that are suited to different uses and conditions in nature. Solar dryers, ovens, and systems of hybrids that combine solar energy with other sources are examples of common designs. To enable effective food processing, the working mechanics of solar food processors incorporate the concepts of heat transmission, insulation against heat, and capturing radiation from the sun. To maximise energy absorption and utilisation, key components like reflectors, absorbers, insulating materials, and control systems are essential [3]. The configuration of the cooking surface determines how effective a mirror with high reflectance is at concentrating

sunlight on a compact hob. On a bright day, most solar cookers can reach temperatures between 650 and 4000 degrees. Solar cookers focus sunlight directly onto a cooking surface. Sunlight is converted into thermal energy when it encounters with a receiver material. Black is the only acceptable colour for kitchen cookware. Using a glass lid on the pot is a simple way to insulate the cooker. It helps keep the solar cooker's heat from escaping through convection. Although the exact mechanism by which each solar cooker heats food may vary, most of them operate on the same premise. Cutting food into smaller pieces speeds up the cooking process. Typically, solar ovens are used for cooking very little portions of food. A household may use one or more solar cookers, depending on the size of the family and the amount of food that needs to be cooked. In a solar oven, stirring the food is usually not necessary. Not only does the method of cooking matter, but so does the amount of food, the weather, the wind, and the latitude. Fig.1. depicts steps included in the operation of solar cookware setups.

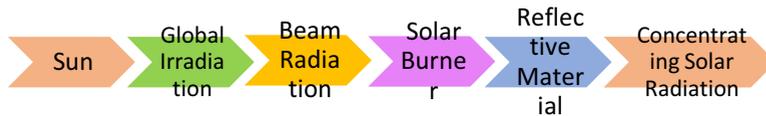


Fig.2. Steps included in operation of solar cookware [2]

### III. METHODS FOR STORING COLLECTED SOLAR HEAT

Practical heat storage involves capturing the temperature change that occurs during the heating or cooling of either a liquid or a solid thermal storage medium to store thermal energy. With regard to their exceptional thermal conductivity, low specific heat, good thermal stability at elevated temperatures, and lack of combustibility and adverse effects, molten salts are considered a suitable material for usage in solar energy facilities. When certain chemical bonds are broken or formed in endothermic or exothermic reactions, particular substances may soak up or release a great deal of thermal energy. The chemical heat storage technology was developed due to these factors. Chemical heat storage can be accomplished using either organic or inorganic materials, provided that their reversible chemical reactions absorb/release a significant quantity of heat [4].

As the phases of their geometries are transformed by melting/solidification, gasification/liquefaction, and other processes, phase change materials (PCMs) can hold/release an immense amount of heat. It is substantially more efficient to store heat as latent heat than actual heat since the phase-transition enthalpy of PCMs is often much higher than practical heat. The latent heat of these materials varies from 124 to 560 kJ/kg, and their phase change temperatures go from 100 to 897 degrees Celsius. Latent heat retention can function in an almost isothermal manner due to the phase change procedure, in contrast to practical heat storage, in which solids have a considerable temperature surge/drop when

capturing/releasing thermal energy. This makes latent heat storage a good option for uses that have very specific temperature requirements. However, low thermal conductivities are latent heat storage's biggest drawback. The basic objective of the cooker was to focus on sun radiation and use various reflective materials to transform it into heat. The reflector's surface needs to be glossy and smooth, and both controllable (by loading, tracking, and temperature monitoring) and unrestrained (by wind, etc.) aspects were taken into attention.

#### **IV. SOLAR COOKERS**

The most popular and affordable solar ovens. A black coated metallic trapezoidal tray (cooking tray) and a pair of glass pane are the primary components of these low-priced and straightforward box cookers. It is protected by a metal or fibre - glass exterior and insulated with glass wool to prevent heat transfer between the cooking tray and the exterior [5]. The pots and tray, which have become blackened from exposure to the sun, are hit directly by the rays as they pass through the double glass lid. While short-wavelength radiation from the sun can pass through the glass covers, low-temperature radiation from the box is almost completely blocked. This causes the internal temperature of the box to increase until the heat gained from the glass and the heat lost from the exterior surfaces cancel each other out (greenhouse effect). In addition, the aperture area is supplemented with solar radiation using a plane reflecting mirror (booster mirror) of almost the same size [6]. Insulation lines the underside and sides of the cooking tray. The food within the pots is cooked more quickly because the blackened top absorbs more heat.

When compared to panel or box cookers, solar parabolic cookers don't require a particular cooking container and may reach very high temperatures in a short amount of time. Nevertheless, because of the focused power, food cooked in a parabolic cooker runs a possibility of being burned if left unchecked for too long. A solar parabolic cooker is no more complicated than a parabolic reflector, a base, and a pot to cook in placed at the cooker's focal point. The main benefits of this steel are its ability to resist corrosion and its quality as a reflector. It also has a low electrical conductivity [7]. Stainless steel can be divided into five categories. Austenitic, Ferritic, Martensitic, Duplex, and Precipitation Hardening are the other four. Molybdenum, Nickel, Manganese, and Chromium Alloy are the Main Components. In addition to being easily formed, it also welds well. Stress corrosion cracking is a common failure mode in these steels. Steel with no magnetic properties. The focal point is the point where a ray reflected from the surface meets the axis of symmetry. Parabolic dish collectors concentrate sunlight onto the receiving device at the collector's focal point with the help of a row of mirrors in the configuration of a parabolic dish. For the generation of electricity, a tiny engine is connected to the receiver and heated to working temperatures and pressures using heat transfer fluid contained in the receiver [8]. Diverse reflecting materials, including stainless steel, aluminium foil, and mylar tape, were devised for use in a number of parabolic solar cookers.

Because of their inexpensive cost and ease of assembly, solar panel cookers are often considered the easiest option. Solar panel cookers focus sunlight from the sky. Flat panels on panel cookers concentrate and reflect sunlight for use in the

kitchen. This solar approach to cooking is not recommended due to its low efficiency.

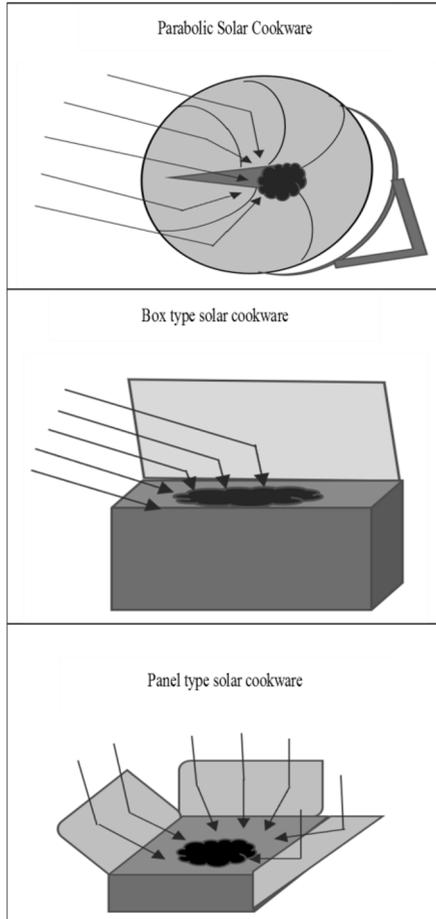


Fig.3. Portable solar cookware setups

## V. ADVANTAGES, LIMITATIONS AND APPLICATIONS OF SOLAR COOKERS

There are several benefits to using solar food processors from a monetary, sociable about, and ecological standpoint. Initially of all, solar energy reduces dependency on finite fossil fuels and helps mitigate climate change because it is plentiful, sustainable, and emission-free. Second, solar food processors encourage persistence and independence from energy suppliers, especially in isolated and underdeveloped areas with little access to traditional energy sources. Lastly, solar cookers improve public health and ecological responsibility by decreasing indoor emissions and conserving forests by taking the place of conventional techniques for cooking and firewood usage.

Notwithstanding its apparent advantages, solar food processors are not widely adopted or scalable due to a number of issues and restrictions. The durability and

efficacy of solar energy capture can be impacted by weather fluctuation, especially the presence of clouds and seasonal variations, which calls for backup plans or hybrid technologies [9]. Adoption may also be hampered by upfront expenses, complicated technology, and social acceptance, particularly in customary cultures and low-income areas. Furthermore, user behaviour, design fit, and location all affect how effective solar food processors are, underscoring the need for tailored to the setting approaches and societal involvement tactics.

Throughout the food manufacturing process, solar processing machines are used for cooking, drying, pasteurisation and sterilization, among other processes. Solar cookers offer a clean, environmentally friendly option for cooking in remote areas and off-grid homes, lowering dependency on conventional fuels made from biomass and enhancing interior air quality. With solar dryers, one can increase the duration of storage of fruits, vegetables, grains, and spices while cutting down on losses following harvesting in a cost-effective manner [10]. In addition, solar-powered pasteurization systems improve food safety by getting rid of dangerous bacteria from dairy and water to be consumed.

In order to fully realise the infinite possibilities of solar food processors and surmount current obstacles, additional investigation, creativity, and cooperation are crucial. Future research should concentrate on improving system robustness, cost, and efficiency by utilising improvements in engineering layout, material understanding, and techniques for manufacturing [11-14]. Furthermore, multidisciplinary strategies that combine solar energy technology with agroecological methods, food supply chain direction, and financial inclusion programmes can promote comprehensive methodologies that deal with social justice, ecological responsibility and nutrition.

## **VI. CONCLUSION**

With their renewable, environmentally friendly and decentralised power sources, solar food processors offer a viable path to sustainability food production for communities all over the world. It is imperative to supply energy that will be able to fulfil our needs going forward. Using renewable energy instead of traditional fuels for cooking is the best substitute option for rural families. In many underdeveloped nations, solar cookers can completely or partially replace the use of firewood for cooking by providing the necessary energy. Solar cooking has frequently been perceived as a technology solution created to consumer demands or as a solution hunting for a problem. This study examines several solar cookers, evaluating each one's viability, functionality, and design. Even though a variety of cooking fuels are readily available, biomass still serves as the primary fuel source for a large number of residences, contributing significantly to pollution and fire accidents. The use of solar cooking is a promising way to address the problem because it has the potential to provide safe cooking while simultaneously conserving fossil fuels. Notwithstanding obstacles and constraints, the increasing acknowledgement of solar energy's capacity to revolutionise food systems emphasises the significance of sustained investigation and funding. A more adaptable, legitimate and ecologically viable food future for later years by utilising the power of solar can be possible.

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