Experiences of solar cooking in south of Portugal (Algarve)

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Abstract. Algarve and Andalusia, in south of the Iberian Peninsula, are regions with a large potential for solar applications in general. Although this potential, the potentialities for solar cooking are not yet well known and implemented. The intensive use of solar cookers by the author began after his participation in the Solar Cookers Conference in Granada-Spain, July 2006, becoming "well contaminated with the virus of solar cooking" and an important advocate for solar cooking. The author learned to solar cook using the cardboard solar CooKit. He has since made and used several solar cookers, most of them low cost apparatus using recycled materials. The activity of dissemination and the intensive solar food processing during the last four years became useful for the right development and optimization of different types of solar cookers. A new type of funnel solar cooker is being developed and tested since 2010. It is made of concrete and common mirrors. Some of the main advantages of this solar cooker are: easily low cost reproduction in every part of the world using local available common materials, intuitive and practical use, water rain resistant and wind resistant and no risk for fire ignition.

Keywords: clean energy, solar cooking, experiences, dissemination.

1. Introduction to solar cooking.

The south of the Iberian Peninsula has a great solar potential that have been explored in some thermal applications, namely the sanitary water heating systems, but not for domestic or industrial cooking scale applications. With this great source of energy a significant number of families could cook their meals during more than 300 days per year. Taking into account some real examples of other regions of the world, namely in Chile and in India, the integration of a solar cooking process in canteens of schools and companies as well as in restaurants seems to be an attractive strategic measure towards the rational use of the energy. Solar cooking is an interesting alternative to the conventional cooking process. The solar cookers can cook a large variety of meals slowly or quickly as in a gas burner. There are several institutions actuating in several parts of the world, namely non-governmental organizations, with the main goal of the dissemination of solar cooking in large scale.

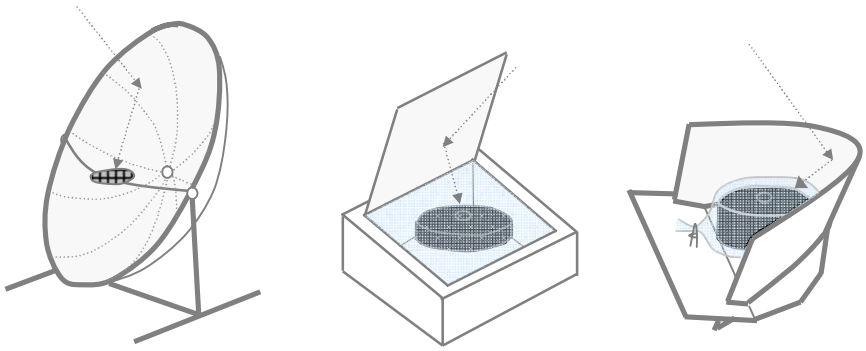
In 1987, the international organization Solar Cookers International (SCI) was created to promote the dissemination of the solar cooking process, focusing the economical, social and environmental benefits of its use (www.solarcooking.org). More recently, as sequence of the international conference realized on July 2006 in Granada-Spain was created the Solar Cookers International Association (SCIA).

In spite of the investigation research about the use of the solar energy is applications such as water distillation, drying and cooking of food, the available equipments are known and used only by a small number of people. Most of these solar devices are manufactured and distributed mainly by cooperation projects to communities of non-developed countries with low economical level or in communities where the available wood for cooking is reduced and is decreasing. The solar devices are also being used in small communities or by individuals preoccupied with the use of more ecological solution.

The sun emits solar radiation in all directions, being only a very small fraction intercepted by the planet earth, but it is important to remark that 1% of this small fraction was well recovered it would be possible to guarantee the energetic needs for the human activity in nowadays.

At the surface of the earth the intensity value of the solar energy varies according to the local, hour, month and composition of the atmosphere. The maximum value is approximately 1000 Wm^{-2}. The conventional cooking devices are rated with heating capacities about 1800 W. This value corresponds to the solar energy that reaches a normal surface to sun rays with 2 m^2. For domestic cooking purposes, it is not strictly necessary a value so high.

A solar cooker is a device that allows the cooking of food by using the solar energy direct or indirectly. There exist several models with different constitution, typology, performance and field of application. The most common devices use directly the solar energy, the cooking process being possible only when the solar radiation is available. These models have been used more in domestic context and are usually classified as panel, box or parabolic solar cookers (Fig.1).



a) b) c)

Fig. 1 Three types of solar cookers: a) parabolic, b) box and c) panel

The main working principle of a solar cooker is the concentration of the solar radiation, by using materials with high reflectivity as example mirrors, polished aluminium or some special reflective foils. The rate of energy concentrated in the cooking zone depends on the reflectivity of surface and of the open area for solar caption of the device. The outside colour of the pot should be black to promote a better absorption of the concentrated solar radiation. The knowledge of the optical fundaments is crucial to design an efficient device. The most common reflective curve surface is of parabolic type, enabling a very high level of concentration in the focus point, cooking zone, when it is well orientated towards the sun. The plane reflective surfaces change the direction of the radiation to the cooking zone, but with much lower concentration effect than in parabolic devices. The reflected solar radiation is continuously concentrated in the cooking zone, if the reflected surface is re-oriented after a certain time step. The most effective devices are those that integrate a device to perform the automatic sun tracking. The solar cooking process consists basically to put the pot in the cooking zone and control the period of cooking process. The pot should be a good absorber of the concentrated solar radiation

and a transmitter of the heat to the food to be cooked. The cooking process is more efficient in locals without wind and with high values of temperature of the air and of the surroundings.

A parabolic solar cocker with a diameter of 1.4 m has a heating capacity similar to a conventional gas burner, but it requires tracking every 15 minutes. The parabolic solar cooker must be used properly and a special care should be taken into account because a fire can occurs in the surroundings or a part of the human body of the user can be burned, namely the eyes.

The box solar cooker is basically a box having a clear glass surface in the top to promote the green house effect inside the box and reflective surfaces to promote the concentration of the solar radiation inside the box. The walls and the floor of the box must be insulated in order to minimize the heat losses. The useful heating capacity is in generally lower than the capacity a parabolic cooker, but in spite of that a large amount of food can be cooked slowly and homogenously without tracking the sun during 2 or 3 hours. A good result can be achieved if an efficient box solar cooker with massive elements inside to avoid that the inside temperature decreases a lot when the clouds are between the sun and the cooker. The massive elements can be for example a layer of small stones. For food safety reasons, it is crucial that the cooking of the foods do not stop and continues with a temperature higher than a safety value avoiding a bacteria development and an acceptable cooked food at the end of the process.

The panel solar cooker is an apparatus that everyone can do, due to the easy and quick construction. No special tools and knowledge are required. The most common panel cookers have more than one reflective surfaces to guarantee the concentration of the solar radiation in the cooking zone during a period of 2 or 3 hours without tracking the sun. The pot must be inside a clear and transparent enclosure, a heat resistant plastic bag or two pieces of glass, where the green house effect occurs. This effect is crucial to have a final good result in the cooking process.

The time period required for cooking a certain amount of food by using directly the solar radiation depend on several parameters. The clouds actuate as a filter of solar radiation and difficult a lot the solar cooking process. The heat losses from the cooking zone to the surrounding air are influenced a lot by the heat convection losses. These losses become important when the air velocity of wind is high and the air temperature is low. In those severe conditions a good cooking result can be achieved only if used solar cooker is very efficient.

The parabolic solar cookers are very powerful, being possible to cook very fast, but the risk of burning the food is higher. When the weather conditions are good for cooking it is not strictly necessary to use a black pot. When the clouds filter a significant part of the direct radiation, the air velocity of wind is high and the air temperature is low it would be possible to cook a reduce amount of food if the pot is black and if a device promoting the green house effect is used.

The panel solar cookers are devices that cook food slowly, usually, without any risk of burning the food. The heat losses from the cooking zone to the surroundings are higher than a well insulated box solar cooker, becoming difficult to cook in a panel cooker when clouds appear intermittently. The device promoting the greenhouse effect is a crucial element. If the transmissivity to the solar radiation is low and if there is gaps enabling infiltration of the outside air, the food can be not cooked well. The cooking required time period depends on: the open area for the caption of solar radiation, the shape of the reflective surfaces, the properties of the device promoting the green house effect, type of the pot, and amount and kind of the food.

Another important factor to achieve a good result in the box a panel solar cooker is the user experience, namely the right tracking of the solar cooker and the required adjustment of the reflective surfaces, available in some models of cookers, according the hour of the day.

The slow cooking process leads to the conservation of the energetic and nutritional properties of the foods. Moreover, a thermodynamic cycle with continuous vaporization and condensation of water occurs, being the water losses during the process small. The odours of the cooking process exiting to the surrounding are also usually small. There is no risk of burning the foods. There is no flame, no danger of explosion and no danger of ignition of a fire.

2. Some examples of experiences with solar cooking

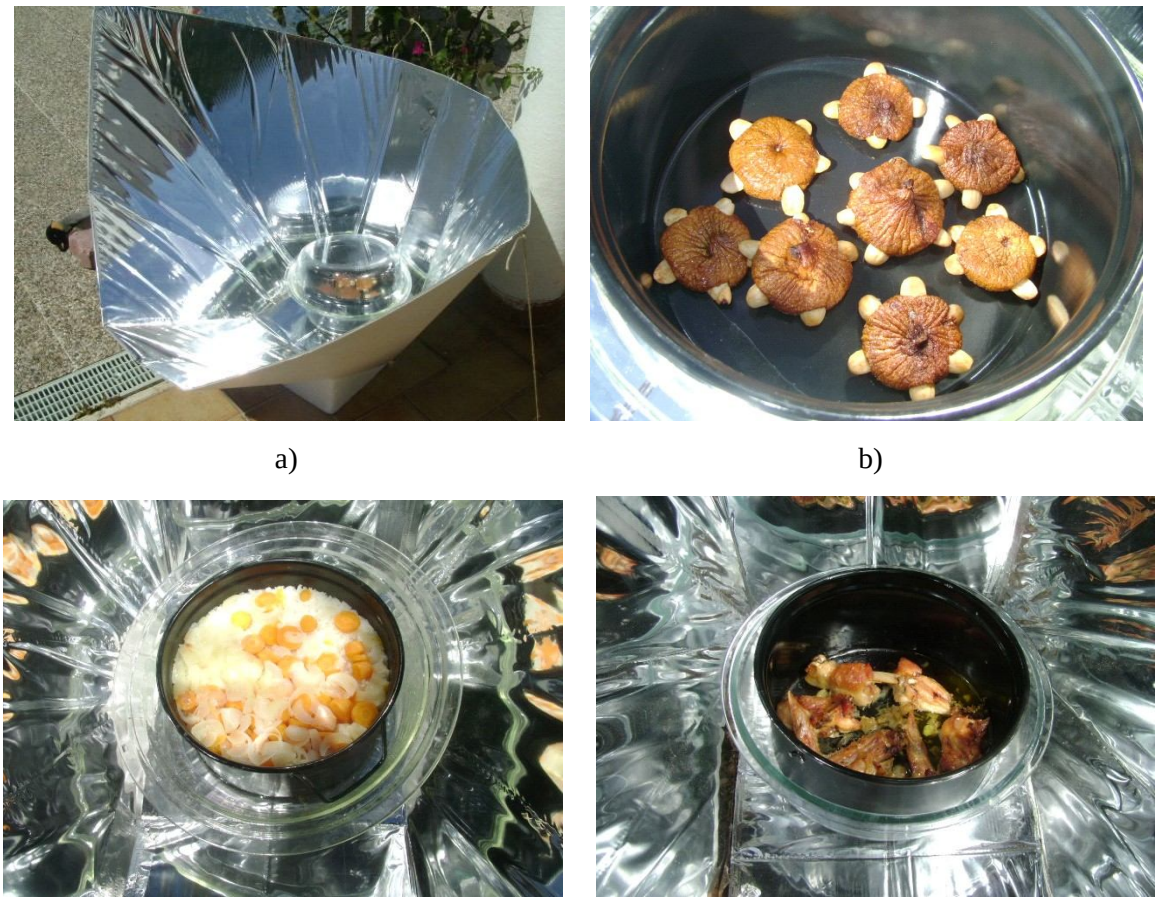
The intensive use of solar cookers by the author began after his participation in the Solar Cookers Conference in Granada-Spain, July 2006, becoming "well contaminated with the virus of solar cooking" and an important advocate for solar cooking. The author learned to solar cook using the cardboard solar CooKit. In the first summer, August and September 2006, several meals have been cooked in panel cookers made of cardboard with an adhesive reflective foil, a black pot and common plastic bag. In these first experiences, the main critical problem detected was the fusion of the plastic bag. The experiences have been continued during autumn and winter time but with difficulty due the low efficiency of the apparatus. Another critical observed point was the deterioration of cardboard when it becomes wetted with rain or just with dew. Fig 2 illustrates a set of nine solar panels cooking, in a central garden of the city of Faro-Portugal, several meals in the context of a birthday party, namely the main cake. More than 40 participants, children and adults have participated and have eaten for the first time a solar lunch. Four of the used solar cookers were manufactured in the proper day as an activity of the party. It was in fact, a very interesting and amazing moment for the children and also for the adults.

Fig. 2 Cooking with the Cookit panel solar cooker

During the second year of experiences, year 2007, the results were much better. More efficient solar panel cookers were developed using sheets of polypropylene and using recycled windows of cloth washing machines to make the green house effect around the pot. Fig. 3 a) illustrates the complete set.

Fig. 3 b) to c) illustrates some examples of cooked food. This solar cooker is portable and evidences an acceptable performance during cold months.

On November 2007, Prof. Pedro Serrano from Chile, an expert of solar cooking since the years 80, came to Faro to transfer technology related to the its parabolic model, named ARTESOL. The main advantage of this kind of parabolic model against other parabolic models is it stability and practical way of use. Moreover the reflective surface is done by using common mirrors, a common material in every part of the world. A constructed model following the design instruction of Pedro Serrano is illustrated in Fig. 4.



a) b)

c) d)

Fig. 3 Solar cooking experiences: a) funnel solar cooker b) traditional toasted “star” of figs and almonds c) rice with carrots and d) chicken

a) b)

Fig. 4 Parabolic solar cooker ARTESOL: a) step of construction b) final step of the construction

More recently, a new type of funnel solar cooker have been developed and tested since 2009. Two devices in a residential cooking operation in Algarve are illustrated in Fig 5. They are made of concrete and common mirrors. Some of the main advantages of this solar cooker are: low cost reproduction in every part of the world using local available common materials (sand, cement powder, mirrors, etc), intuitive and practical use, water rain resistant and wind resistant and no risk for fire ignition. The main disadvantage relatively to the parabolic cookers is that common frying processes are difficult. The useful heating capacity of this model was estimated around a value of 100 W, after a conducted specific experimental test basically measuring the temperature evolution of a certain mass of water duration a certain period of time. The estimated value referred to an autumn sunny day with an environmental air temperature of 20ºC and moderate wind velocity.

a)

c) c)

Fig. 5 Funnel solar cooker.

The dissemination activities promoted by the author began also after his participation in the Solar Cookers Conference in Granada-Spain, July 2006. The lived experiences during the years 2006 and 2007 were very intensive and very interesting. Several specific events about solar cooking such as seminars and workshops were organized in Portugal, Spain and Brazil.

3. Conclusions.

According to the intensive experiences of the author during the last five years it is possible to use the potential of the sun to cook more than 300 days per year in South of Iberian Peninsula, but to that in an effective way a change of human mentality is required. Some barriers still exist, namely the fact that

most of the actual residential buildings do not have the required conditions for the practical installation and use of solar cooking devices. The integration of solar cooking process in canteens and restaurants has also an interesting potential towards a better use of the energy. The schools have also the responsibility to form solar cooking chefs as well as technicians for companies of installation and maintenance of solar cooking industrial devices.

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