THE ROLE OF SOLAR ENERGY IN THE PRESERVATION OF AGRICULTURE PRODUCTS IN NIGERIA

BOLAJI, BUKOLA OLALEKAN
Department of Mechanical Engineering
School of Engineering, Federal Polytechnic
P.M.B. 5351, Ado-Ekiti, Ekiti State
Nigeria.

ABSTRACT

The use of energy from renewable sources particularly from the sun is, and always has been, basic to farming. This paper presents the possibilities of tapping from the inexhaustible energy source for the preservation of agricultural products in order to accelerate the pace of industrialization and food production in Nigeria. Various ways in which solar cooling can be utilized in agricultural firms for the preservation of their products are discussed. Types of solar drying equipment and the necessity of using direct solar dryers as a consequence of disadvantages exhibited by the natural sun drying systems are explained.

INTRODUCTION

In many parts of the world there is a growing awareness that renewable energy have an important role to play in preservation of agricultural products. Solar energy is the driving force behind several of the renewable forms of energy. Solar energy is an ideal alternative source of energy because it is abundant and inexhaustible (Bather and Caruthers, 1981).

Solar energy is more evenly distributed over the earth's surface than fossil fuels and the amount of energy available for conversion is several orders of magnitude greater than the present world requirements (Adegoke and Bolaji, 2000). For instance, the earth receives annually energy from the sun amounting to 1×10^{18} kWh. This is equivalent to more than 500000 billion barrels of oil or about 1000 times the present annual consumption of energy of the whole world (Garg, 1982).. Moreover, solar energy is a renewable source of energy which is also free from pollution hazards associated with nuclear energy development (Bolaji, 1997).

The parts of the world lying between 35 ^oN and 35 ^oS which have at least 2000 hours of bright sunshine per year is normally accepted to be suitable for utilization of energy from the sun (Chandra and Oguntuase, 1986). Nigeria satisfies this requirement; hence positive results are expected from solar energy utilization. Even in the UK, where the lack of sunshine, particularly in winter, is notorious, the amount of solar energy received is eight times the present total primary energy requirement (Taylor, 1983).

Due to unexpected high prices of agricultural products, their preservation is becoming more and more important nowadays. Also food preservation becomes more important in a country like Nigeria where agriculture plays crucial role in providing employment for the majority of the population. Food and energy are the essential factors of the human survival, so the efforts for greater food production and smaller energy dissipation can undoubtedly provide more peaceful and secure future for mankind. The farmers in developing countries are confronted with the problem of preserving their harvested crops to prevent spoilage during storage. Farmers suffer heavy losses of food in the post-harvest period during which the harvested crops pass through series of well-defined steps, like threshing (or shelling), drying and final processing.

The technology must extend to help the farmer to preserve their products and to sell it when there is more demand in order to reduce to minimum the wastage of agriculture products. There must be a great interest in any device or process which can contribute to economic and industrial growth of developing nations such as Nigeria. The two major applications employed in preserving agricultural product through the application of solar energy are cooling and drying. These applications have not been able to make noticeable impact in agricultural firms in this country because of the following important reasons:

(i) A large cross-section of people in Nigeria feel that the most important objective is to increase the production of agricultural products, therefore, the importance of solar cooling and solar drying which enhances quality and reduces spoilage is not appreciated.

(ii) The financial resources of farmers in Nigeria are very limited and hence they are usually not capable to invest in solar equipment.
(iii) There is little awareness about the existence of solar cooling and solar drying equipment and about the benefits of using them.

METHODOLOGY

Solar Cooling Application

Improving food production is a basic and one of the most difficult problems of world food policy (Kaminsky, 1986). The problem exists because of the need for faster growth in food resources than population levels, especially in the developing countries where food consumption per capital is very low.

In the past, refrigeration and air-conditioning industry was considered primarily for luxury. Now this illusion has disappeared due to its essentiality in the preservation of agricultural products. If refrigeration process can be constantly adjusted in form to meet the needs of food economy, they can play an important role in the following areas: food reserves, reducing losses in food production and turnover, reducing seasonal variations and frozen food production. There are two different major cooling applications for food preservation in food processing industry, these are chilling and freezing. These can be carried out in the absorption refrigeration system, which is the suitable refrigeration cycle for solar cooling since the thermal energy to operate an absorption refrigerator can be supply by the sun. A schematic diagram of a solar absorption system is shown in Fig. 1.

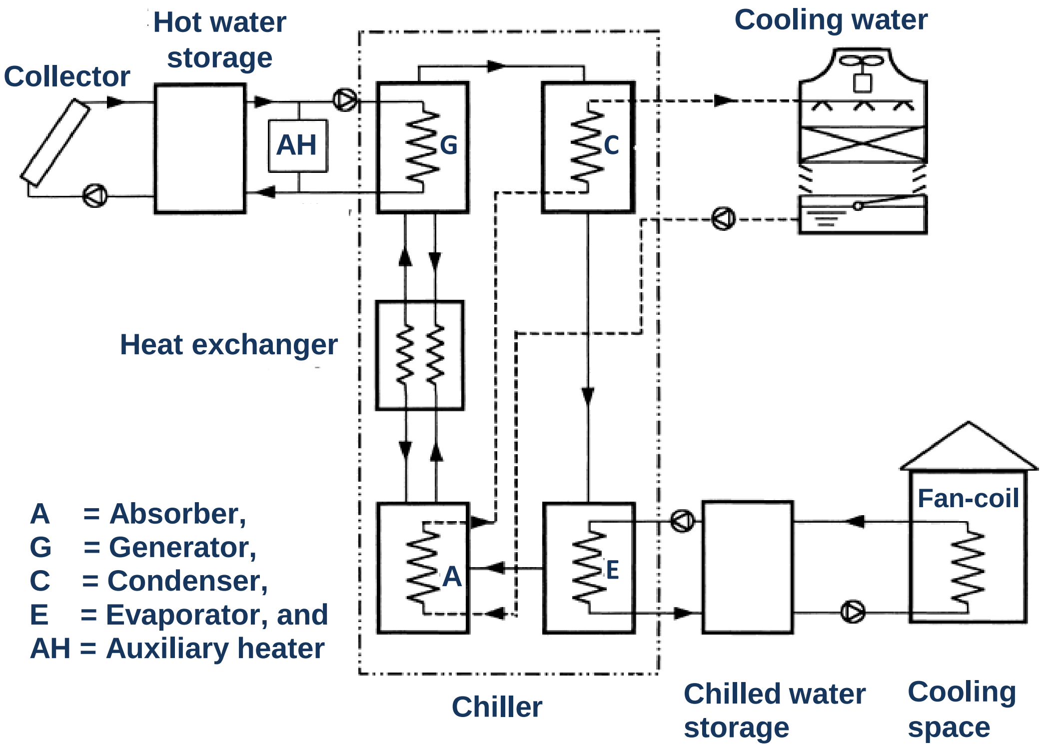

Fig. 1: Schematic diagram of a solar operated absorption system.
(Source: Li and Sumathy, 2000)

Chilling Application

Chilling is the unit operation in which the temperature of foods are reduced to between 1 ^{o}C and 8 ^{o}C. It is used to reduce the rate of biochemical and microbiological changes of fresh and processed foods. It causes minimal changes to sensory characteristics and nutritional properties of foods.

Freezing Application

Freezing is the unit operation in which the temperature of foods is reduced below the freezing point and a proportion of the water undergoes a change in state to form ice crystals. The immobilisation of water to ice will lower the activity of spoilage agents, such as enzymes and microorganism, thereby preserving the food substances in their original fresh state for a longer period. Table 1 shows the water contents and freezing points of some selected foods items.

During freezing, sensible heat is first removed to lower the temperature of a food to the freezing point. In fresh foods heat produced by respiration is also removed. This is termed the "heat load" and is important in determining the correct size of freezing equipment. Latent heat of crystallisation is then removed and ice crystals are formed.

Table 1: Water contents and freezing points of some selected foods

Food	Water Content (%)	Freezing Point (^oC)
Vegetables	78 - 92	-0.8 to -2.8
Meat	55 – 70	-1.7 to -2.2
Fish	65 – 81	-0.6 to -2.0
Milk	87	-0.5
Egg	74	-0.5

(Source: Fellows, 1990)

EXAMPLES OF SOLAR ENERGY APPLICATIONS IN AGRICULTURAL FIRMS

Application of Solar Cooling in Dairy Farms

The purpose of cooling in dairy farms is to preserve the initial quality of the milk up to the moment it is used or transformed. After milking, milk has a temperature of between 32 ^oC and 33 ^oC, therefore, it is necessary to immediately reduce this temperature to less than 15 ^oC to avoid the development of acidifying bacteria (Pilatowsky *et al*., 1981). Refrigeration must be applied from the moment of milking and it is most efficient when the milk shows low bacteria count after it is obtained. The most important factors in the preservation of milk are the initial bacteriological quality and the preservation temperature.

Solar Drying of Harvested Crops

Many farmers of the world are faced with the problem of reducing the moisture content of their harvested crops to prevent spoilage during storage. Drying is one of the most important steps of post-harvest handling of the crops. The natural sun drying in the open air is a very old practice of drying agricultural products by solar energy. In this method products were spread on the ground or on platforms and were turned regularly until they were sufficiently dried so that they could be stored for later consumption. In these processes there is little control over the drying rate, the dried products are very often under-dried or over-dried. Under-drying results in deterioration of product due to fungi or bacteria, whereas the over-drying may leads to case-hardening, followed by bursting resulting in the spoilage of the product.

The followings are the disadvantages of using various techniques of natural sun drying in the open air:

(i) Drying period is long and is largely dependent upon the meteorological environmental conditions,
(ii) Drying is not safe from intrusion by people and animals,
(iii) Drying is adversely affected by rain and storm,
(iv) Drying is adversely affected by pollution and dust,
(v) The products being dried are subjected to infestation by insects, and
(vi) A standard drying quality cannot be maintained, the quality is often seriously degraded, sometimes beyond edibility.

In an increasingly hungering world, practical ways of cheaply and sanitarily preserving foods are needed. Therefore, the problems stated above, exhibited by the natural sun drying systems can be overcome by the use of solar dryers, in which agricultural products can be dried under controlled conditions of temperature and humidity. This technique will dry the products reasonably rapidly to a safe moisture level, and simultaneously it ensures a superior quality (better nutritional and germination characteristics) of the dried product.

The two principal phases of the process in solar agricultural dryers are the solar heating of the working fluid (air), which extracts moisture from the products and the drying itself. The first phase can either accomplished indirectly by separate solar air-heater collectors using natural of force convection to pre-heat the ambient air and reduce its relative humidity of directly by heating the air which dehydrates the particle products. There are different types of solar-dryers for different purposes, but in this paper, solar wind-ventilated cabinet dryer, glass-roof solar dryer, solar rice dryer and solar timber dryer are discussed.

Solar Wind-Ventilated Cabinet Dryer

A cabinet dryer designed for direct solar drying can be used to dry a wide variety of agricultural products on a small scale. The solar air heater of the dryer (Fig. 2) consist of a back painted hardboard sheet (back-plate) insulated at the bottom and covered by transparent glass. The air-heater faces south and has an optimum angle of tilt. Air enters through the open end of the heater. A black mesh screen midway between the glass cover and the absorber back plate provides effective air heating because solar radiation that passes through the transparent cover is then absorbed by both the mesh and back-plate. The mesh provides an additional heat transfer surface area. The upper end of the air-heating collector is connected to the vertical drying chamber, which holds drying trays in layers.

Additional drying is also achieved from direct solar radiation incoming through the transparent walls. As shown in Figure 2, a rotary wind ventilator is located at the top for effective circulation of heated air through the cabinet dryer. It is a corrugated vane rotor, which sucks air from the ventilator stack as it spins. This cabinet dryer can efficiently dry okra, eggplant, tomato paste and yam slices.

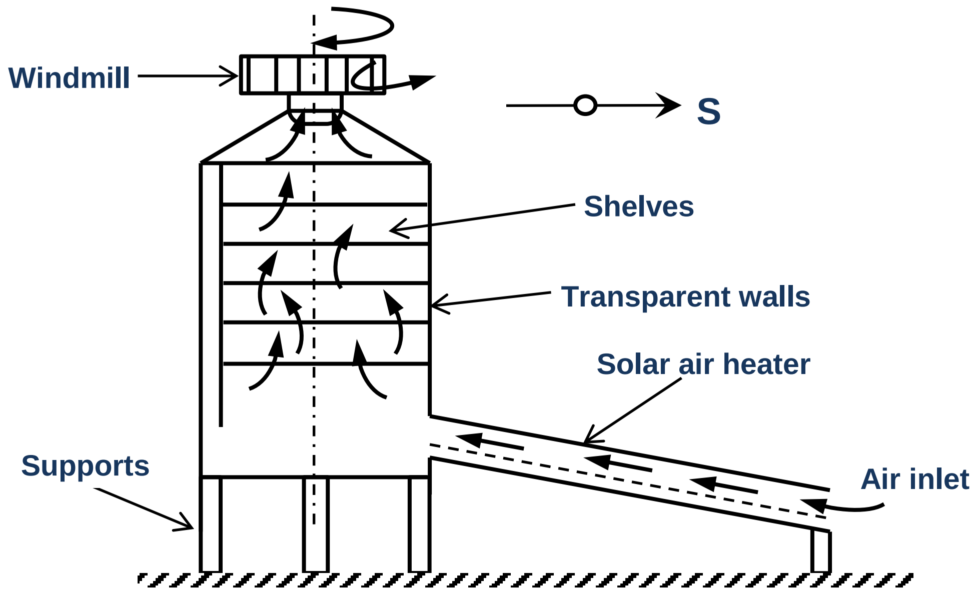

Fig. 2. Solar wind-ventilated cabinet dryer

Glass-Roof Solar Dryer

The dryer (Fig. 3) is identical to a greenhouse structure and its working is based on the same principles. The drying unit essentially consists of two parallel rows of drying platforms with slanted glass roofs aligned length wise a long a north-south axis. The platform is generally made of galvanised iron mesh, laid over wooden beams. The inside surfaces of the dryer are painted black and openings are provided on the eastern and western walls above and below the level of platforms containing the product. Air passes through the wire mesh, gets heated and pick up the moisture from the product spread over it. A roof pick cap, made of folded zinc sheet, allows the heated and moistened air to leave the room thereby creating velocity gradient. It also protects the product from rain as well as other environmental degradation. The fresh air enters the dryer through the shutters which are provided in the structure along the length of the dryer. The provision of opening or closing the shutters independently is readily made in the structure to regulate the air flow inside the dryer. Cocoa is a good example of agricultural product that is suitable for this type of dryer.

Solar Rice Dryer

Fig. 4 shows the set-up details of a low cost solar rice dryer. The rice particles can be dried in two days. It has been found out that the milling quality is higher than that of ordinary sun dried rice and that the dryer can be equivalently used for other crops such as corns and coffee beans (Kilkis, 1981).

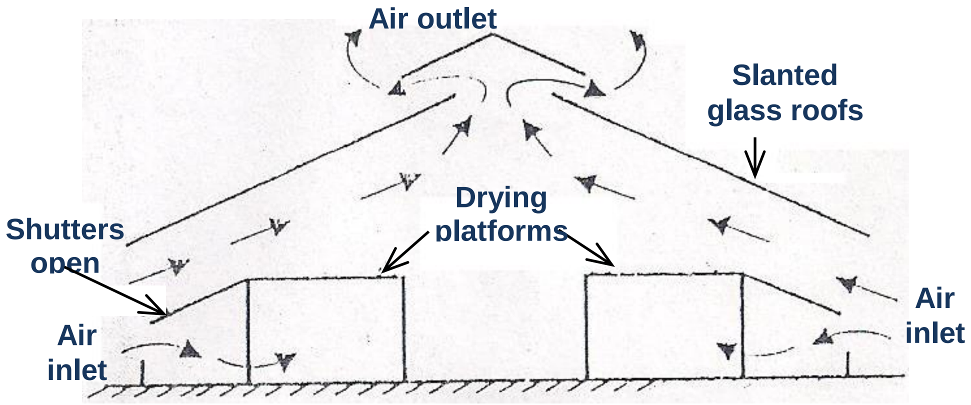

Fig. 3: Glass roof solar dryer

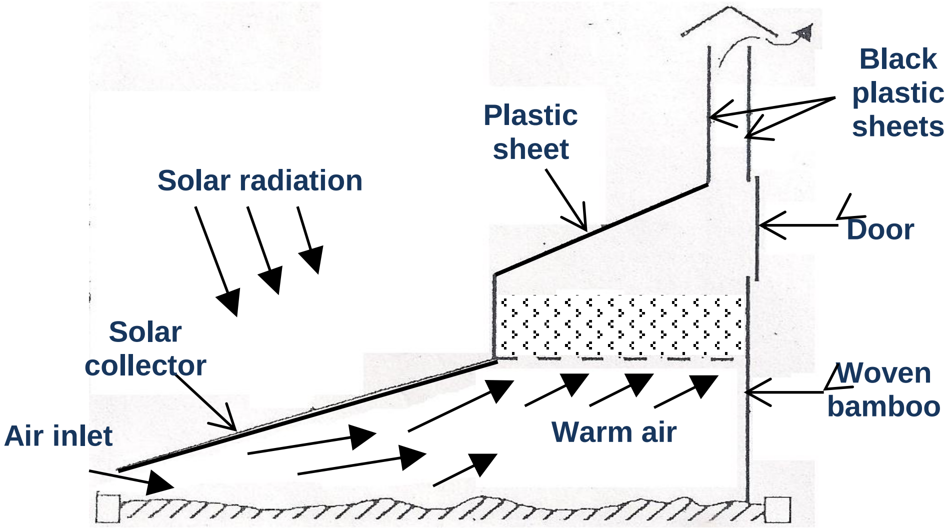

Fig. 4. Solar rice dryer

Solar Timber Dryer (Solar Kiln)

Employing solar kilns for high quality timber is an important application of solar energy. Construction of solar kilns is simple; usually the timber is stacked (Fig. 5) in a fashion so as to allow spaces for air circulation through the stack. An auxiliary circulation fan is generally used, although natural draft with appropriate stacking arrangement may be adequate.

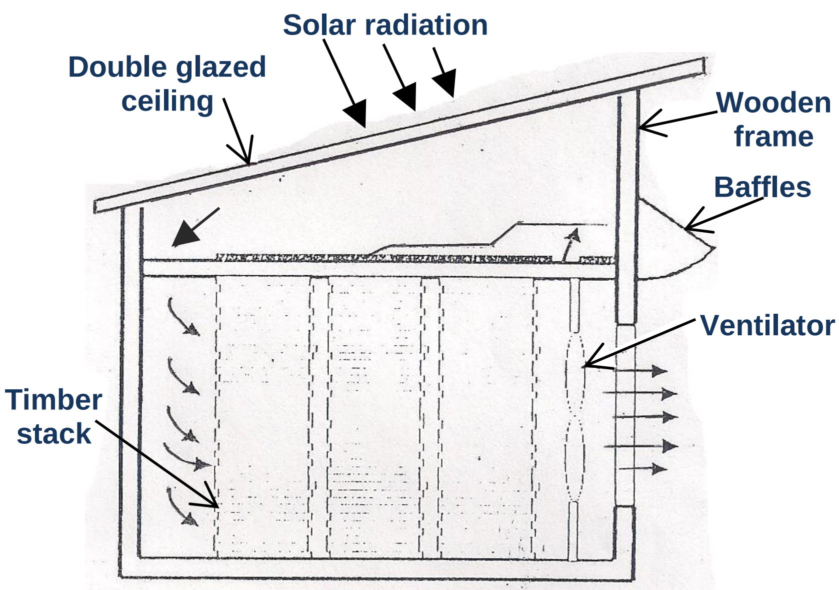

Fig. 5. Solar timber dryer (Solar kiln)

RECOMMENDATIONS AND CONCLUSION

Solar energy could be made to play a crucial role in the preservation of agricultural products in Nigeria. Nigeria is the countries in the parts of the world lying between 35 ^{o}N and 35 ^{o}S which normally accepted to be suitable for solar energy utilization. In spite of this fact, many farmers in the country suffer heavy losses of their products in the post-harvest period, which is due to lack of good preservation. Agricultural products can be preserved through the applications of solar cooling and drying. These applications were discussed in this paper. Solar cooling consists of chilling and freezing applications that could be used for preservation of various types of food products both on a small scale as well as for commercial and industrial purposes. The moisture content of the harvested crops can be reduced through the use of various types of solar dryers, in order to reduce post-harvest losses.

The traditional methods of drying usually employed in Nigeria are open air sun drying and natural drying in shade. In these methods drying is adversely affected by rain, storm, dust and various kinds of pollution, so that the quality is often seriously degraded, sometimes beyond edibility. In order to ensure a superior quality of the dried products, the drying must be done under controlled conditions of temperature and humidity, which can easily be attained by the use of solar dryers, For proper implementation of the use of solar energy in agricultural firms, it is recommended that: (i) there should be a well-coordinated research and development programme to provide performance data on the success of the solar equipment. This will build public confidence in these technologies. (ii) Effort should be made to fabricate the equipment with the help of locally available materials and labour. (iii) There should be sponsored demonstration programmes to create awareness about the existence of solar cooling and solar drying equipment, and about the benefits of using them.

REFERENCES

Adegoke, C.O. and Bolaji, B.O. (2000): “Performance evaluation of solar-operated thermosyphon hot water system in Akure”. International Journal of Engineering and Engineering Technology, FUTAJEET, Vol. 2, No.1, pp. 35-40.

Bather, D.M. and Caruthers, S.P. (1981): “Energy from agriculture; catch crops as a potential fuel source in the UK”. Proceedings of the International Seminar on Energy Conservation and the use of Solar and other Renewable Energies in Agriculture; Polytechnic of Central London. Pergamon Press Ltd., England: 9-22.

Bolaji, B.O. (1997): “Performance Evaluation of an Improved Thermosyphon Solar Water Heating System”. M.Eng. Thesis, Federal University of Technology, Akure, Nigeria.

Chandra, M. and Oguntuase, O. (1986): “A natural convention solar water heater for application in Nigeria buildings”. Nigeria Journal of Solar Energy, Vol. 5, No. 1, pp. 151-157.

Fellows, P.J. (1990): “Food Processing Technology”. Ellis Horwood Ltd., West Sussex, England.

Kaminski, W. (1986): “Refrigeration as a world food security factor”. International Journal of Refrigeration, Vol. 9, No. 1, pp. 21-24.

Kilkis, B. (1981): “Solar energy assisted crop and fruit drying systems: theory and applications”. In Energy conservation and use of renewable energies in the bio-industries: proceedings of the International Seminar on Energy Conservation and the Use of Solar and other Renewable Energies in Agriculture, Horticulture, and Fishculture, held at the Polytechnic of Central London, 15-19 September 1980. Oxford, Pergamon Press, 1981.

Li, Z.F. and Sumathy, K. (2000): Technology development in the solar absorption air-conditioning systems. Renewable and Sustainable Energy Reviews, Vol. 4, pp. 267-293.

Pilatowsky, I., Romero, E. and Best, G. (1981): “Cooling and conservation of milk with solar refrigeration”. Proceeding of the International Seminar on Energy Conservation and use of Solar and other Renewable Energies in Agriculture, Polytechnic of Central London, Pergamon Press Ltd., England, pp. 423-429.

Taylor, R.H. (1983): “Alternative energy sources for the centralised generation of electricity” Adam Hilger Ltd., Redcliffe Way, Bristol.