

Potential for solar dryer application for food processing in Botswana

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Abstract—Solar drying is a process of utilizing energy from the sun to remove moisture from products, especially food. It is a process that prolongs the shelf life of the harvested products, reduces post-harvest losses and lowers transportation costs since the products become portable and can be easily packaged subsequent to drying. Additionally, solar drying improves the quality and quantity of food. Food preservation by use of solar dryers holds immense potential in the food processing industry in Botswana due to abundant solar irradiance. Solar drying methods that can be applied in Botswana include direct, indirect and the mixed type. The traditional open to sun drying or the direct method is the primary technique currently being applied. Of note is that traditional open sun drying has some disadvantages. More efficient and effective drying techniques such as indirect and mixed type are necessary to guarantee high quality and a constant supply of foods. This paper reviews the traditional drying technologies used in Botswana and explores potential modern solar drying technologies that can be used to substitute and/or complement them.

Keywords—*Solar dryer; solar irradiance; open sun drying; food preservation*

I. INTRODUCTION

Economies of most developing countries are largely depended on agriculture [1]. The agricultural sector produces food so as to meet one of the most basic needs of citizens. People grow crops and rear animals for subsistence and commercial reasons hence contributing to the economic status of their countries. Most developing countries are not self-sufficient when it comes to food provisions to their entire populations because of unprecedented increases in the number of people within their respective borders [2]. A lack of knowledge and use of inappropriate preservation techniques and a shortage of storage amenities causes deterioration of the quality and quantity of produce. Most crops are seasonal as are other sources of food e.g. mopani worms and fruits, as such appropriate preservation during and immediate post-harvesting time is vital in maintaining the relevant balance between food supply and population growth. In the case of mopane worms, the preservation process involves use of firewood which is

suspected to cause deterioration in final product quality as well as contributing to deforestation. Not only will some of the worms get burnt to beyond consumption state but the method results with a soil grains contaminated product.

Drying food in the open using energy from the sun in order to preserve it is one of the main processing techniques used in sunny areas. Botswana is endowed with relatively high solar insolation levels of 21 MJ/m²/day, and on average records 280-330 clear sunny days per year [3]. It is therefore not surprising that in Botswana, open sun drying is the most widely method for food preservation taking advantage of the abundant solar irradiance. Consequently, it is logical that efforts be directed at utilizing the sun for food drying but using improved techniques. The traditional open sun drying method involves scattering the products to be dried in thin layers on flat and open surfaces therefore exposing them to the sun and wind. In the case of mopane worms, after cooking them, they are laid for drying on a swept piece of ground [4]. Drying meat and other related products involve cutting them into thin strips and suspending on a wire for the sun to dry. Drying generally prolongs the shelf life of the harvested products, improves the quality and quantity of products, reduces post-harvest losses and lowers transportation costs since the products are portable and easily packaged after the drying process [5].

There are a number of disadvantages associated with traditional open sun drying. It requires a large open space area, is highly depended on the presence of insolation, is prone to contamination by dust and food being processed is vulnerable to attack by insects, birds, rodents and infections from micro-organisms [4]. Furthermore, open sun drying happens to be labour and time intensive. This is because the food under processing needs to be covered, not only at night but also during harsh weather conditions, and must be protected from animals [1]. Additionally, non-uniform and insufficient drying leads to deterioration of the food grain quality during storage [1]. In order for countries to meet the basic requirement of high quality and constant supply of food for their growing populations, efficient and effective solar dryers are a necessary requirement. Solar dryer designs that use cheap and locally

available materials are the best alternative to improving the quality and quantity of the food and minimizing of post-harvest losses.

II. CLASSIFICATION OF SOLAR DRYING SYSTEMS

Various kinds of solar dryers have been developed for agricultural products and work is continuously being done to improve on these dryers in other countries. Literature shows that basically, there are four types of solar dryers [8]. These are namely direct, indirect, mixed mode and hybrid solar dryers.

Further classification of dryers is based on their operating temperature range hence high temperature and low temperature dryers. They may also be categorized broadly into fossil fuel dryers (conventional dryers) and solar energy dryers depending on their heating sources. High temperature dryers are powered by fossil fuels, while low temperature dryers are either fossil. The heating modes and the manner the solar heat is utilized by solar dryers can also be used for dryer classification [9]. Other factors that may be used in categorizing solar dryers include: mode of air movement, exposure of insulation, direction of air flow, architecture of the dryer and the status of solar contribution. This leads to classification into two broad groups which are, active solar-energy drying systems (hybrid solar dryers) and passive solar energy drying systems (natural-circulation solar drying systems).

Fig. 1, is an illustration of the main features of different designs of various classes of solar dryers.

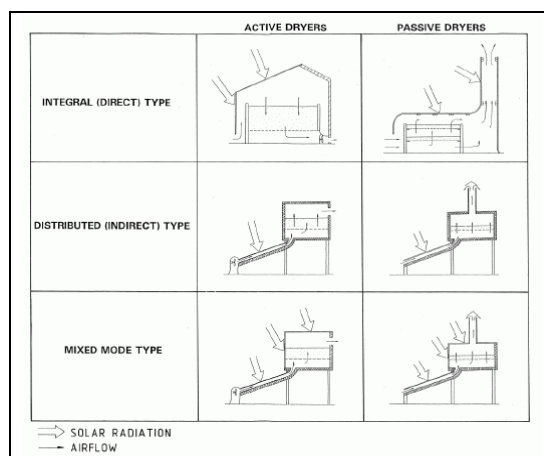


Fig. 1. Different designs of various classes of solar dryers [1].

III. COMPARING OPEN SUN DRYING AND THE SOLAR DRYER

The sun has been used for drying for as long as humans have inhabited the planet [10]. The application of a solar dryer (also known as solar drying) for dehydration process is a possible alternative to open sun drying [1]. Solar drying is the process of using an enclosed unit to remove moisture from the products (foods) using energy from the sun in a cleaner and healthier way [11]. On the other hand, open sun drying involves simply laying or hanging the products in the sun on mats, roofs or drying floors. Both methods utilize thermal energy from the sun; however the modes of operation are different. The advantages and disadvantages of solar dryers are summarized in *table I* while *table II* lists the disadvantages and disadvantages associated with open sun drying.

TABLE II. ADVANTAGES AND DISADVANTAGES OF SOLAR DRYERS.

Advantages	Disadvantages
Food is of better quality and quantity. It reduces post-harvest losses. Reduces the risk of contamination from micro-organisms. Low labor requirements. Higher drying rate hence reduced drying time. Protects food from dust, rains, insects, birds and animals as solar dryers are enclosed.	Solar dryers are expensive; they have high initial investment capital. Solar dryers have often been too complicated to local farmers due to inadequate training. A backup system such as a heater is necessary for products that require continuous drying. Can only be used during day time when it is sunny.

TABLE III. ADVANTAGES AND DISADVANTAGES OF OPEN SUN DRYING.

Advantages	Disadvantages
Prevent the usage of fossil fuels that lead to environmental pollution. It is very cheap, no cost are incurred in buying materials.	Food is exposed to insects, dusts, rain, birds and animals. Food contaminations, as the idle time in between drying sessions allow the growth of unwanted microorganisms. Sudden rains and strong winds may totally ruin the all food being dried. Deterioration of food quality due to direct exposure to the sun. Non-uniform and insufficient drying. Labor and time intensive, as products need to be covered at night and during harsh weather conditions, and also must be protected from domestic animals.

IV. FOOD DRYING IN BOTSWANA

A. Common practices of drying food products.

Traditional open to sun drying is the main method of preserving food that has been used in Botswana since far back in time. In rural areas agricultural products such as ground nuts, jugo beans, bean leaf stew (morogo wa dinawa), seeds, meat (segwapa) and wild spinach are seasonal and are normally produced in high quantities hence cannot all be consumed in-season. As a way of preserving these produces for future usage during drought times or out of season, Batswana resort to drying using the sun [6]. Some produce must be pre-processed prior to exposure to the sun. Examples are the mopane worms which go through a fire-based treatment and salting before drying and meat which is usually salted before drying (see Fig. 2). Other products such as maize are normally dried without undergoing any pre-processing.

Traditionally open drying surfaces consist of paved grounds, mats, trays, boards, wires or strings supported by poles. Sun-drying of fish is done on racks made either of chicken wire or woven reed mats mounted on poles erected on the ground [6]. Some configurations of which are shown in Fig. 3. The racks are installed where there is enough shading, such as under trees so as to avoid direct heat from the sun. The fish is exposed to ambient temperature for about 7 days before packaging [6]. The fish being dried should be covered at night, during harsh weather conditions, and must also be protected from domestic animals throughout the drying process. On the other hand, sun drying of mopane worms is done on a swept piece of ground as shown in Fig. 4, a process that apparently allows easy access for insects [4]. The mopane worm is directly exposed to the heat from the sun for 2-4 days depending on weather. A visit to a mopane processing site in the bush has also revealed that sometimes a large fire is made on the ground and mopane worms are then directly spread on that piece of ground after extinguishing the fire upon removal of amber and ash.

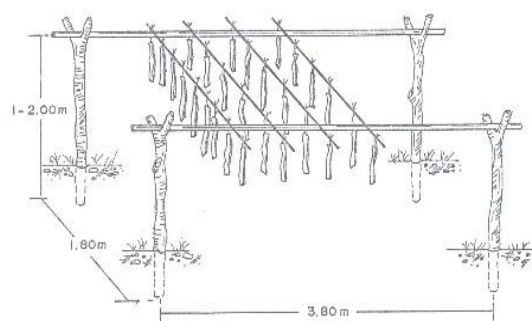


Fig. 2. Set up for meat drying [8].

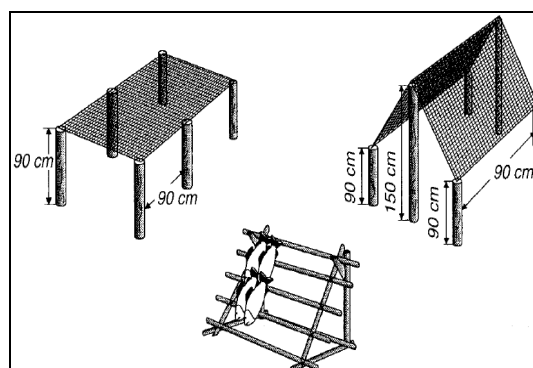


Fig. 3. Fish drying racks [7]



Fig. 4. Drying mopane worm on an open ground [4].

B. Government initiatives on promotion of food drying using solar energy in Botswana.

The Government of Botswana has contributed in food preservation by introducing the dried salted fish technology after the country suffered from severe droughts [6]. Open sun drying technology of salted fish was successfully promoted for long term preservation of seasonal catches in remote areas. The success of dried salted technology was primarily due to a Government programme of buying the salted-dried fish for subsequent distribution to the most disadvantaged [6]. Regardless of the Government contributions towards fish drying using the sun, there are some major problems with the system. The quality of the dried salted fish is poor, due to insufficient and ineffective drying [5]. It is therefore necessary to apply solar dryer technology for food processing in Botswana to eliminate the disadvantages associated with open sun drying. However, in Botswana less or limited research and innovations have been done on solar dryers. It is quite difficult

to come across published work that deals with solar drying technology that is specific to Botswana.

V. CONCLUSION

Traditional open sun drying of agricultural products or food has long been used in Botswana in rural areas due to abundant solar irradiation. However, there are problems associated with open sun drying hence there is a need for adoption of other solar drying technologies. Solar dryer application for food processing as a solar drying technology has a large potential in Botswana but to our knowledge, it is not being widely researched on, utilized or promoted. Raising awareness is crucial in sensitizing the public, institutions, researchers and relevant stakeholders of Botswana on the advantages of adapting environmentally friendly methods of food processing.

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