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EFFECT OF SOLAR AND SUN DRYING ON MOISTURE REDUCTION IN GINGER (*ZINGIBER OFFICINALE*) UNDER DIFFERENT SIZE-REDUCTION TREATMENTS

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ABSTRACT

Solar drying is not only a method for substituting fossil fuels using solar energy, but a technology for producing dried materials of required quality. Solar energy utilization is needed to a greater extent because of its advantageous characteristics, as an environment friendly, sustainable alternative and naturally abundant energy source which satisfies the global requirements of a sustainable development. A solar cabinet dryer was developed to compare the effect of solar drying (D_1) and open-sun drying (D_2) on the percentage moisture reduction from ginger under different size-reduction treatments (W, S and P). The temperature and relative humidity of the heated drying air in the solar dryer varied from 37-70^{0}c and 58-36%, with the ambient conditions at 28-39.5^{0}c and 65-46%, respectively. Under the two drying techniques, WD samples (WD_1 and WD_2) were not effectively dried throughout the drying experiments. The drying periods for SD_2, PD_1 and PD_2 conform with the standard drying time range of 7 – 14 days. SD_1 samples effectively dried after only 4days of drying, showing an improvement over the existing standard drying time range of 7-14 days. Comparative analysis of the solar cabinet dryer and the conventional open- sun drying showed that solar drying takes less time to dry, with superior products of clean and attractive appearance and without contamination of any sort. The developed solar cabinet dryer is recommended for ginger farmers in the ginger producing zones of the country.

Keywords: Ginger, size-reduction, dehydration, sun-drying, solar-drying, renewable energy

INTRODUCTION

Food problem in Nigeria and most developing countries world-wide is not merely as a result of low production, but is due largely to the inability to preserve food surpluses. Food crops are usually for immediate consumption needs, resulting in wastage of food surpluses during glut periods. Drying being the most efficient preservation technique for most tropical crops is one of the methods used to preserve food products for longer shelf life. Sun-drying as the known oldest method of food preservation, involves simply laying food products in the sun on mats, roofs or drying floors. Some of its disadvantages include contamination of products by dust, insects, and animals; some percentage is usually lost or damaged. It is labour intensive, nutrients such as vitamin 'A' is lost and the method totally depends on good weather conditions. Because the energy requirements (sun and wind) are readily available in the ambient environment, there is little or no capital required. Hence sun drying is frequently the only commercially used and viable method for drying agricultural products in developing countries.

A solar dryer is an enclosed unit to keep food products safe from contamination by dust, insects, birds, animals and unexpected rainfall. The food is dried using solar heat energy in a cleaner and healthier condition. The process of drying consists of moisture removal from the food by heat, usually in the presence of a controlled flow of air. Initially the food is washed, peeled or sliced , prepared and placed on flat bottomed trays that are placed inside the dryer (Tatedo, 2010). The Solar rays enter the cabinet through the cover material. The rays are converted into heat energy, which raises the temperature inside and heats the food product being dried. The heated food gives out water vapour and dries up. Gradually the heated moist air goes up and leaves the drying chamber through the air outlet at the high end of the dryer. There are basically four types of solar dryers, Viz: direct solar dryer, indirect solar dryer, mixed mode dryers and hybrid solar dryers (Ajisegiri, 2001). Solar drying is not only a method for substituting fossil fuels by solar energy, but a technology for producing dried materials of required quality (Udroiu et al, 2008). Humanity needs the use of solar energy in the future to a greater extent due to its advantageous characteristics as a sustainable environment friendly alternative energy resource that cannot be monopolized and which satisfies the global requirements of a sustainable development. Various solar dryers have been developed for drying food and agricultural products but most of existing solar dryers are for grain, vegetables, fruits, meat and fish (Udroiu *et al*., 2008; Ampratwum *et al*., 2007; Gunasekar *et al*., 2006; Abe, 2001; Eke, 1996). There has been very little or no attention on the drying of ginger.

Ginger is one of the very important root and tuber crops (yam, cassava, ginger, Irish potato, sweet potato and cocoyam) and spice crops (Onion, pepper, ginger, garlic and chilies) grown in Nigeria. It is one of the spices that are grown on commercial scale for export in Nigeria (Fumen and Ajisegiri, 2006; Njoku et al, 1995). Ginger is an important source of foreign exchange to the country, of which Nigeria, among others (India, China, Taiwan, Jamaica, Mauritius and Australia), is a major producer. The introduction and promotion of ginger production in Nigeria began in Southern Kaduna in 1927, with major producing spots located in Kwoi, Kubacha and Walijo areas of the defunct Jaba and Kagarko districts (Fumen and Ajisegiri, 2004, NAERLS, 2004; Simonyan *et al*., 2003; Musa, 1991; Orkwor *et al*., 1988). The spicy aromatic crop enters market in fresh (green), preserved (prickle) and dried forms, but the bulk of Nigerian ginger is marketed internationally in split- dried form.

The mechanization of ginger production and processing has not received adequate attention in Nigeria. Its processing, especially the drying which is the most important processing step involved in ginger processing, needs to be mechanized to increase the quality of processed split dried ginger in Nigeria. Maigida and Kudi (2000) reported that farmers continue to process their ginger into split dried form as it is the form demanded by the local market. After the harvested rhizomes have been washed and split, the traditional method of drying is to lay them on either clean bamboo mats, concrete floor, compacted floor or on roofs and sun dried until the product is completely dried to an acceptable moisture level of 7-12%. The drying may take between 7-14 days depending on the weather conditions, size-reduction treatment and the number of turns(3-4) daily until the product is completely dried (Azam-Ali, 2008; FMARD/UNDP, 2002; Meadows, 1988). Although sun drying does not seem to add any extra cost to the farmer, it has inherent disadvantages such as, dependence on availability of sun light, prolonged drying time which allows mould growth, contamination by insects, bird and animal droppings and severe limitations of seasonal variation (Akomas and Oti, 1988). Much of this contamination in ginger during sun-drying has resulted in processed product with microbiological, organoliptic and chemical properties far below importers' specifications. Consequently, Nigeria's dried ginger receives low rating in international markets thereby losing huge foreign exchange earnings, annually. This paper presents a report on the effect of solar drying and sun drying on moisture reduction in ginger under different size- reduction treatments.

MATERIALS AND METHODS

A bulk sample of freshly harvested ginger rhizomes was used for the study. The sampled spicy rhizomes were prepared in different size- reduction treatment samples (table 1) and the samples were dried separately in a solar dryer (D_1) and open-sun (D_2), after determining their respective initial weights of 200g.

Table 1: Size-reduction treatment and drying method interaction for ginger

Size-reduction treatment	Drying Method (D)	
	Solar drying (D_1)	Sun drying (D_2)
Whole rhizomes (W)	WD_I	WD_2
Split rhizomes (S)	SD_1	SD_2
Peeled rhizomes (P)	PD_1	PD_2

The prepared fresh ginger rhizomes under different size-reduction treatment samples were placed wire mesh trays. Each sample tray was duplicated, one to be dried under open sun drying and the other under solar drying. WD_1, SD_1 and PD_1 sample trays were placed in the solar dyer chamber and the dyer was set up for the drying test. For the sun drying test, WD_2, SD_2 and PD_2 sample trays were placed on a vintage platform and a clear non- shaded area, where the samples were exposed to open sun shine for effective drying. The Solar drying test was carried out in a natural air-draft solar cabinet type dryer (Fig 1). The drying experiments were conducted between the hours of 9.00a.m.- 5: 00 p.m daily, and for a period of 12 days in the month of January, 2009. At 5: 00p.m daily, each sample was weighed, recorded and packaged into a labeled air-tight pack to prevent the sample from gaining or losing moisture during the off-hours. The temperature and relative humidity of the ambient air and the heated air in the drying chamber were recorded at the intervals of two hours (11.00am and 1.00pm; 3.00pm and 5.00pm). During the drying experiments, the ambient air temperature and relative humidity varied from 28 – 39.5^{0}C and 65-46%, respectively, while the heated air in the solar dryer, the temperature and relative humidity varied from 37-70^{o}c and 58-36%, respectively. The drying experiments lasted for 96hours (12 days). The percentage moisture (wet basis) removed from each sample on daily basis was determined through an equation (Ajambe *et al*, 2011; Solomon *et al*., 1999):

$$\%M\ (wb) = \frac{100Wm}{Wd+Wm} \quad (1)$$

where,

% M (wb) = Percentage moisture removed during drying

Wm = Weight of moisture removed during drying

Wd = Weight of dry matter in ginger.

RESULTS AND DISCUSSIONS

Table 2 presents percentage of moisture removed during the experiments and drying

Table2: Percentage Moisture Reduction in experimental Samples (%)

Drying Day	Hour (Hr)	WD_1	WD_2	SD_1	SD_2	PD_1	PD_2
1.	8	12.5	7.5	35.0	15.0	26.0	17.5
2.	16	8.6	2.7	38.5	13.5	23.0	18.8
3.	24	9.4	1.1	40.0	18.4	21.9	14.8
4.	32	6.9	1.7	29.2	16.7	18.0	12.3
5.	40	7.4	2.3	0	15.0	22.4	15.0
6.	48	8.0	2.3	0	18.8	7.9	16.5
7.	56	8.7	4.2	0	15.9	0	19.5
8.	64	6.7	2.5	0	22.4	0	15.8
9.	72	8.2	3.2	0	15.6	0	14.6
10.	80	10.0	2.6	0	0	0	12.2
11.	88	7.4	2.7	0	0	0	0
12.	96	6.7	2.0	0	0	0	0

W: Whole coated ginger rhizomes
S: Split ginger rhizomes
P: Peeled ginger rhizomes
D1: Solar drying method
D2: sun drying method
WDI: Solar dried whole coated ginger samples
WD2: Sun dried whole coated ginger sample
SD1: Solar dried split ginger samples
SD2: Sun dried split ginger samples
SD1: Solar dried peeled ginger samples
PD2: Sun dried peeled ginger samples.

WD samples under the two drying techniques did not attain equilibrium. The slow drying rate of these samples could be attributed to the impermeable skin coat of the rhizomes, inadequate temperature rise in the solar dryer (< 100^{o}c) and limited drying time. SD samples were effectively dried under the investigated drying methods. While SD_1 samples attained equilibrium moisture content after 32hours (4days) of drying, SD_2 attained equilibrium after 72hours (9days) of drying. For the PD samples, PD_1 reached equilibrium after 56hours (7days) of drying, while PD_2 attained equilibrium after 80hours (10days) of drying.

On the effect of size-reduction treatment and drying methods for moisture removal, percentage moisture removal from WS_1 and WS_2 samples was insignificantly low, and the samples were not effectively dried throughout the drying period. For SD and PD samples, SD_1 and PD_1 dried within limited times of drying , 4days and 7days, respectively). Irrespective of the difference in the times of attaining equilibrium moisture contents by SD_2, PD_1 and PD_2, their effective drying times conform within the standard range of drying period of 7-14 days (Zam Ali, 2008).

CONCLUSION

From the study the following conclusions were drawn: 1). samples, WD_1 and WD_2 could not attain the equilibrium moisture content due the impermeable skin coat of the rhizomes which prevent flow of moisture from the interior fleshy part of the rhizomes to the outside. 2). Samples SD_1 and SD_2 were effectively dried, with SD_1 samples attaining equilibrium moisture content after 4days (32 hours) of drying and SD_2 attaining the equilibrium moisture content after 9days (72 hours) of drying. 3). Samples PD_1 and PD_2 attained equilibrium moisture content after 7days and 10days of drying, respectively. 4). The drying times for SD_2, PD_1 and PD_2 samples conform to the standard drying period of 7 to 14 days. The SD_1 samples effectively dried after only 4days of drying. This is an improvement over the existing standard drying time range of 7-14 days (Azam Ali, 2008).

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