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DRYING OF SWEET POTATO (*Ipomoea batatas*) (CHIPPED AND GRATED) FOR QUALITY FLOUR USING LOCALLY CONSTRUCTED SOLAR DRYERS

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ABSTRACT

A study was conducted on the suitability of processing sweet potato tubers into chips using locally constructed solar panels within the semi forest and the transitional climatic zone of Ghana. The study was done during the months of November, 2010 and January, 2011 and seven designed solar panels were used. The panels were constructed using hard wood, binding materials (nails), chicken mesh, nylon net and black and white polythene sheets. The cassava tuber was first thoroughly washed, peeled and chopped into 20mm by 10mm as T1 and the grated tubers as T2. Sixty kilogram of each type was dried in each panel. Data variations in the panels resulted from the type of polythene sheet used (black lining, white or a combination of the black and white). Drying was observed to be faster in the panels with their drying platforms covered with the chicken mesh and nylon net (5 and 6 days) than those with their drying platform lined with the black polythene sheets (2 and 3 days) for October, 2010 and January, 2011 respectively. The chips dried on the chicken mesh and nylon drying platforms looked whiter and more appealing to the eye than those dried on the black polythene sheet platform due to moisture condensation that encouraged mould growth before drying. The open air dried cassava appeared darker since the sweet potato got mouldy before drying. The dried products stored for 12 months in poly sacks lined with plastic sheet still retained their original appearance (white or grey). The least significant difference (LSD) was used to separate the means when the data was subjected to statistical analysis. It is therefore recommended that Panels A, C, E, F and G should be used to dry the grated and chipped sweet potato during both the rainy and dry seasons since it took 6 days and 2 days respectively to dry the product of better quality (whiter) and without any mould infestation during the two sessions (November, 2010 and January,2011).With the result obtained processing cassava into quality chips will not only reduce postharvest losses but will also enable the rural farmers produce quality chips to earn more income and improve upon their standard of living.

Keywords: solar dryer, sweet potato, temperature, nutrient value, storage quality.

INTRODUCTION

Sweet potato is one of the top five crops that feed the world, the others being wheat, corn, sorghum and rice. In 1998, sweet potato was ranked as the fourth most important food crop in the USA, Simmonds (1995). About 35% of the production was processed into frozen products (primarily fries) Davies (2002). Agbo and Ene (1994) cited in Twere (1992) reported that consumption pattern of sweet potatoes indicated that most people consume boiled sweet potato roots as food, as well as fried slice or chips and roasted tubers. Sometimes the tubers are eaten in the form of pounded foofoo. Sweet potatoes flour may be prepared from dried chips and the flour may be reconstituted into foofoo. Agbo and Ene (1994) also indicated that bakeries in Nigeria now blend 15 to 33 percent sweet potatoes flour with wheat flour for baking bread. 20 to 30 percent sweet potatoes flour for pastries. Baby food has also been formulated using sweet potato flour. The roots are also utilized in brewing local alcoholic beverages while the leaves are eaten as vegetables.

Sweet potato (Ipomoea batatas) is only a minor root crop on tropical Africa despite its potentials as indicated by its growth in terms of production, Mendoza (1989).

The crop is widely cultivated in the Northern, Central and Volta Region of Ghana by peasant farmers. Those farmers encounter post harvest losses greatly which adversely affect their income and standard of living as well.

Generally sweet potatoes are red, white, yellow or orange in color. The texture of the tuber, the sweetness, size and shape of tubers, vary with different varieties. Sweet potato tubers are eaten boiled or fried in oil in Ghana. Its leaves are also used as spinach in soups. The tuber, especially the yellow one is a rich source of vitamin A and calcium. A local alcoholic drink is also brewed using the tuber. Sweet potato has the following components: starch, sugar, amylase, amylopectin, vitamin A, vitamin C, tannins, phytin, oxalate, crude protein, either extract and crude fibre. According to Tewe (1993), sweet potato leaves were accepted as soup ingredient in Nigeria after boiling for three minutes in water. The fibre content of the leaves was between 3.3 and 6.0 percent while the protein content was 18.4 percent.

Sweet potato production in Ghana brings to farmers substantial amount of income when harvested and sold but other uses and value of sweet potato is limited to most them. Inadequate knowledge of how the tuber could

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be processed and stored for further use was lacking. This in turn resulted in great post harvest losses of the crop after harvest and in storage. Most farmers did not have any knowledge of sweet potato drying which could add more value to the produce to have much market alteration to users or consumers.

Drying is one of the oldest methods of processing and preserving food for later use. Food can be dried in the sun, in an oven, or in a food dehydrator by using the right combination of warm temperature, low humidity and air current. The common drying method in Ghana is sun drying which has so many disadvantages. The traditional sun drying methods often yield poor quality, since the produce is not protected against dust, rain, wind or even against birds, insects, rodents and domestic animals while drying. Soiling, contamination with micro organisms, formation of mycotoxins, and infection with disease-causing germs are the result (Markus, Hauser and Omar Ankila, 1994). They further maintain that solar drying facilities combine the advantages of traditional and industrial methods, namely low investment cost and high product quality. According to Scanlin, Dennis (1997), solar drying is the cost effective way of processing and storage of food.

The study's objective was to determine the effectiveness of solar drying of sweet potatoes into chips.

MATERIALS AND METHODOLOGY

Location of the experiment site

The experiment was carried out at the Department of Agricultural Engineering and Mechanization of the College of Agricultural Education of the University of Education, Winneba, Mampong campus in Sekyere West District of Ashanti Region of Ghana during the period of November 2010.

Mampong Ashanti lies 45.7m above sea level and between latitudes 7^o and 8^o north of the equator (Meteorological Service Department, Mampong, 2004).

The area has an annual rainfall of 1,270mm to 1, 524mm with mean monthly rainfall of 105mm to 127mm (Baffour, 1981; SRI, 1989).

The average temperature is about 30.50^oC and the area lies within the transitional zone between the Guinea savannah belt in the north and the rain forest belt of south (SRI, 1989). Farming is the major economic activity of the area and food crops such as cassava, yam, plantain and maize are grown. In addition to these crops, the most predominant crop which fetch the youth with income is carrot. Sweet potato cultivation is done on small scale level due to lack of economic importance of the crop to some farmers, insufficient marketing, and lack of processing and storage technologies by the farmers. The soil of the area is the Bediase series belonging to the savannah ochrosol class formed from voltain sandstone of the Afram plane with pH between 5.5 and 6.0 (Asiama, 1975).

Materials used

Seven constructed solar drying panels of different forms with different roofing and covering materials as well as drying surfaces and the open sun drying as the control were used.

Two improved varieties of sweet potato were obtained from the local market of Northern Ghana for the project. These were the Apomuden-redish, Okumakom-white, (CSIR, 2005).

Description of the panels

Panels A and B

Figure-1. Panels A and B.

Panel A and B were made up of a rectangular wooden structure. They were the gable roof type made up of transparent and translucent polythene sheet, respectively. The sides were all covered with the same sheets. The space between the roof eave and side walls acted as vent for the moist air from the drying product to escape.

The base of these panels and the drying platforms were made up of wire mesh and nylon netting. The wire mesh was first laid and on top of it the nylon net.
The panel has the following dimensions:

Height from the ground level to the drying base = 75cm
Height from the ground level to the roof top = 260cm
Length of the base = 340cm
Width of the base = 170cm

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Panel C

Figure-2. Panel C.

Panel C was made up of a rectangular wooden structure. The roof was a lento type. It was roof with the same transparent polythene sheet at both length sides and one of the sides was covered with nylon netting and the other side was covered with black polythene sheet. The side with the nylon netting provided the whole structure good ventilation to reduce moisture accumulation in the panel.

The following are the various dimension of the panel:

Height from the ground level to the drying base = 75cm
Height from the ground level to the roof top = 240cm
Length of the drying base = 340cm
Width of the drying base = 180cm

Panel D

Figure-3. Panel D.

Panel D was made up of a rectangular wooden structure with a lento roof type covered with a thick transparent polythene sheet. The drying platform consisted of eight (8) removable drawers (four at each side) lined with wire mesh and nylon net.

Its dimensions are as follows:

Height from ground level to the drying platform = 30cm
Height from ground level to the slope roof top = 176cm
Length of the base = 360cm
Width of the base = 180cm

Panel E

Figure-4. Panel E.

Panel E is similar to panel C. it was made up of a rectangular wooden structure. The roof sloped at both sides. It was roofed with transparent polythene sheet but the polythene does not cover up to the ground level. It hanged slightly above the drying platform which permitted much circulation of air throughout the drying period. The drying base was covered with wire mesh and nylon net.

The panel E has the following dimensions:

Height from ground level to the drying platform = 75cm
Height from ground level to the roof top = 240cm
Length of the drying base = 360cm
Width of the drying base = 180cm

Panel F

Figure-5. Panel F.

Panel F is similar to panel D. The panel is constructed with wood. It has a rectangular shape at the drying base. The roof sloped at one side and the top is roofed with plain polythene sheet. The drying base or the

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drying platform was of a rectangular box which was covered with black polythene throughout. The bottom of the panel about 15cm from the ground is covered with black polythene sheet which absorbed and retained much heat from the sun. The drying surface was covered with wire mesh first and later nylon net was used to cover the top of the wire mesh.

A vent is created at the slope side to allow moisture to escape through that place. The plain polythene attracted the sun rays into the panel.
This panel F has the following dimensions:

Height from the ground level to the black polythene covering the bottom base = 15cm
Height from the ground level to the drying base = 176cm
Length of the base = 360cm
Width of the base = 180cm

Panel G

Figure-6. Panel G.

Panel G is made up of a rectangular wooden structure. The base is of rectangular box covered with black polythene sheet. Inside of the rectangular box is lined with wire mesh. The roof is sloped at only one side and transparent polythene sheet was used as a roofing material to cover it. The drying platform is made up of wire mesh and nylon net and protected with square wire mesh. The panel has the following dimensions:

Height from the ground to the drying platform = 30cm
Height from the ground to the roof top = 175cm
Length of the base = 360cm
Width of the base = 180cm

Open air dryer

It is an opened rectangular platform. The drying platform is made up with wire mesh and nylon net. It has no roof on top of it.
It has the following dimensions:

Height from ground level to the drying platform = 75cm
Length of the drying base = 340cm
Width of the drying base =170cm

Drying procedure

The sweet potato tubers were sorted and washed thoroughly with tap water before peeling in order to ensure that the white flesh was not soiled. After peeling they were chopped into 20mm x 10mm (T_1) and grated (T_2). The Salter weighing scale of 100kg capacity was used to measure 60kg for each panel, as well as the control experiment. The chips (T1) were blanched in hot water at 65^{o}C for 3 minutes before spreading them in the various panels.

All the dried products were weighed to get the dried weight and moisture contents removed. They were packaged in nylon sacks lined with white polythene bags and stored in a cool dry place in the Department of Agriculture Engineering and Mechanization for a period of twelve months.

Positioning and loading the solar panels

To ensure proper drying, the panels were positioned in the east to west direction to receive more sun rays.

The panels were left at their position day and night throughout the drying period. The products on the drying platform were stirred from time to time to enhance uniform drying of product

Treatment

The drying of the chips was replicated three (3) times with seven solar dryers and the open sun drying as the control. The grated sweet potato was also replicated thrice using only two solar dryers and the open air drying as the control

Data collected

The data collected were hourly temperature, humidity and wind speed in the panels as well as the outside ambient starting from 09:00 hrs GMT - 17:00 hrs GMT throughout the drying period. Mercury in glass thermometers were hanged in all the panels to read the temperatures which were recorded hourly. One thermometer was also kept outside to read the outside temperatures. During each period the drying processes were replicated thrice.

Statistical analysis

Analysis of variance of means of temperatures, relative humidity and wind speed of the various panels was done using the analysis of variance (ANOVA). The least significant difference (LSD) was used to separate the means. Results were considered significant at $P \leq 0.05$.

Packaging

The dried chips were collected, weighed and put into polythene sacks and labeled.

Storage

The products were re-dried for one day and were treated with Acetylic super 3.0 E to prevent insects' attack and finally bagged and stored on shelves at room temperature (20^{o}C) at the Mechanization and Engineering Department for twelve (12) months and observed periodically.

RESULTS AND DISCUSSIONS

Temperature inside Solar Dryers during drying (°C), November, 2010

Figures 7(a) and 1(b) are the descriptive summary of the mean hourly temperatures of the various panels during the drying of both the grated and chipped sweet potato.

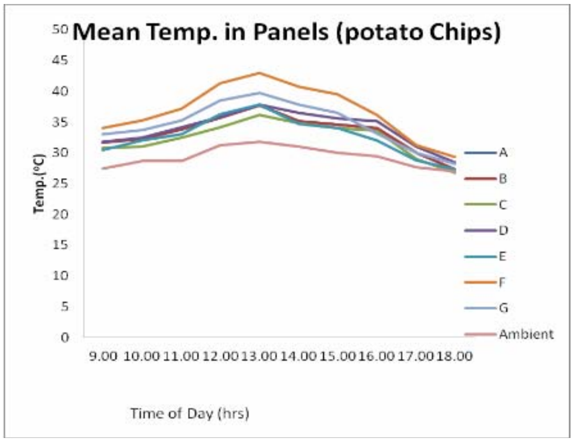

Figure-7(a). Graph of temperature against time during drying of chipped sweet potato.

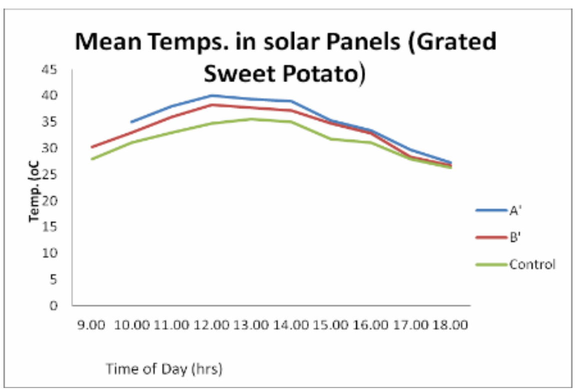

Figure-7(b). Graph of temperature against time during drying of grated sweet potato.

The graph (Figure-7a) clearly shows that temperatures in all the panels were generally low during the early hours of the day but gradually increased from 10.00 GMT until it reached its peak at 13.00 GMT (31.8°C - 43.°C). From the graph, panels A, B, C, D, E, F and G recorded higher temperatures compared to the ambient air, (the control). Panel F recorded the highest temperature at 13.00 GMT (43.0°C); the recorded high temperature in Panel F was due to the presence of the lined black polythene sheet below the drying platform.

Panel G that is similar in shape without the black polythene cover at the base had its temperature also high.

It was also observed from the graph that, panel C had the lowest temperature among the seven panels; this was due to the fact that the opposite sides were of the panel were covered with nylon netting instead of the polythene that allowed more exchange of moisture with the outside air. Temperatures values of panels E and C were slightly closed since their structure and roofing material were the same.

In Figure-7(b), temperatures of the various panels increased steadily from 9.00 to 12.00 noon and decreased from 13.00 GMT to 18.00 GMT. The highest temperature recorded was at 12.00 noon (34.7°C to 40.0°C) for the ambient and panel A^1.

The graph also indicated clearly that the control recorded the lowest temperature. Panel A^1 recorded the highest temperature followed by panel B^1. Panel A^1 and B^1 were of the same structure, but differed in the material used to roof and cover the sides in texture and colour. The material used for panel A^1 was a thick transparent polythene sheet while that of Panel B^1 was a lighter translucent polythene sheet. Clouds cover and intermittent rainfall in the afternoon resulted to temperatures of both panels and ambient air to be almost the same between the hours of 13:00 and 14:00 hours during the drying periods. The least significant difference (LSD) was used to separate the means when the data was subjected to statistical analysis.

Drying weight of the produce

Tables 1(a) and 1(b) indicate the weights of the dried product in the various panels and the open air drying.

Table-1(a). Drying weight of the potato chips (kg).

Panels	Fresh weight (kg)	Dry weight (kg)	Weight loss (kg)	Percentage weight loss (kg)	Days of drying
A	60	27	33	55	6
B	60	28	32	53	6
C	60	30	30	50	6
D	60	25	35	58	5
E	60	29	31	52	6
F	60	24	36	60	5
G	60	26	34	56	5
Ambient	60	33	27	45	7

Table-1(b). Weight of the dried grated sweet potato (kg).

Panels	Fresh weight (kg)	Dried weight	Weight loss	Percentage weight loss	Days of drying
A[1]	60	23	37	62	2
B[1]	60	25	35	58	2
Control	60	28	32	53	3

The results obtained indicated that panel F (Figure-7a) recorded the lowest drying weight 24kg that is the highest weight loss of 60% of the fresh weight after drying.

In the same vein, panel F has the lowest moisture content of 8.61% which is a clear indication that water loss from the product dried in it was greater compared to the rest of the panels.

From Table-1(b), it has been observed that the control had the highest drying weight of 28kg with a weight loss of 32kg while those of the solar panels A and B were 37kg and 35kg, respectively. It took 2 days and 3 days for the grated sweet potato to dry and between 5 days and 7 days for the sweet potato chips in the solar dryers to dry. Absorption of moisture during the night and early hours of the day made the open air panel to take 3 days for the grated sweet potato and 7 days for the chipped sweet potato to be effectively dried.

Panel A had the lowest dried weight, the highest weight loss and the highest percentage weight loss. This observation indicated that panel A'[s] product dried faster due to the higher temperatures recorded in it.

Proximate analysis of the dried sweet potato products

Table-2 indicates the result of the proximate analysis carried out on the dried sweet potato chips.

Table-2. Proximate analysis of the dried sweet potato.

Panels	Parameters				
	% Moisture	% Protein	% Ash	% Fat	% Fibre
A	9.51	3.58	1.82	1.69	1.06
B	9.08	3.81	1.41	1.48	1.02
C	9.40	3.68	1.70	1.28	1.00
D	9.88	3.32	2.01	2.00	0.98
E	9.23	3.78	1.69	1.33	1.05
F	8.50	4.04	1.35	1.91	1.26
G	8.61	3.93	1.21	1.81	1.18
A[1]	8.93	3.97	1.56	1.90	1.22
B[1]	9.62	3.42	1.96	1.16	0.96

The results indicated that panels F, G and H had the lowest moisture content of 8.50%, 8.61% and 8.93%, respectively. These panels also recorded the highest temperatures during the drying period of the sweet potato products; hence drying was more effective and faster.

From the table it is clear that the products with the lowest moisture content had the highest percentage of protein and fibre content and lower ash content.

Products in panel D, I and A recorded the highest percentage Ash content of 2.01%, 1.96% and 1.82% and the product in panel D has the highest percentage moisture content of 9.88%. This means that the higher the percentage moisture content in the product, the greater the percentage Ash content. The same panel D's product has the highest percentage fat content of 2.00%. But the principle does not apply here strictly that the higher the moisture content the higher the percentage fat content because the product in panels F, H and G which had the lowest percentage moisture content had their fat content lower.

In terms of percentage fibre content the principle of low moisture to higher fibre content is applied. The percentage fibre of the product in the panel F, H and G (1.26%, 1.22% and 1.18%) with respect to their percentage moisture (8.50%, 8.61% and 8.93%) indicated that the lower the moisture in the product, the higher the fibre.

Quality of stored products (chips and grated sweet potato)

Table-3 indicates the physical quality of the stored products after the 12 months.

Table-3. Quality of the dried chip and grated sweet potato after storing for 12 months.

Panels	Types of storage container	Form of dried potato	Quality of products
A	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non-mouldy
B	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
C	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
D	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
E	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
F	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
G	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
O	Double polythene sack inside synthetic fibre sack	Sliced and blanched	Dried non mouldy
H	Double polythene sack inside synthetic fibre sack	Granules not blanched	Dried non mouldy
I	Double polythene sack inside synthetic fibre sack	Granules not blanched	Dried non mouldy
O	Double polythene sack inside synthetic fibre sack	Granules not blanched	Dried non mouldy

Table-3 indicated that well dried and well packaged chips and granules of sweet potato can be stored better for a longer time. This is true that all well dried products that are packaged well have a longer shelf life than products which are not well dried. The shelf life of stored product depends on their moisture and the storage containers used (FAO/World Food Programme, 1983).

CONCLUSIONS

Observations from the experiment indicated that solar drying is an effective method of drying products compared to open sun drying. In all, the seven different designed solar panels recorded higher temperatures than the open air (Ambient) with Panels F and G recorded the highest temperature due to the black polythene sheet used to line beneath their drying platforms.

In general the solar dryer took lesser days to completely dry their products; between 2 and 6 days depending on the constructional shape, material used for the roof drying platform and the size of cut or grate of the sweet potato tuber. The weather was also a contributing factor for the delays in drying since there intermittent cloud covers and rainfalls during the drying period (October/September, 2010)

The proximate analysis indicated higher concentration of nutrient and lower moisture content (dry basis) Audrey *et al*, 2004.

Further observations showed that when products are well dried, they can be stored for a longer time. On the whole the solar driers are the best means of drying potato chips because they are effective in drying and void of contamination of products.

The technology of producing high quality chips from sweet potato by solar drying should be encouraged by the Ministry of Food and Agriculture Organization in Ghana.

More vents should be provided on the sides of the panels to facilitate air circulation between the inside and outside of the panels.

The panels should be positioned at a place where maximum sun rays can be achieved till 17:00 daily.

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