PRESERVATION OF INDIGENOUS VEGETABLES BY SOLAR DRYING

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ABSTRACT

The abundance of indigenous vegetables during the rainy seasons and poor transport and storage systems leads to their high post-harvest losses but scarcity in the dry seasons. Effective preservation and storage of theses vegetables would not only reduce their post-harvest losses but make them available throughout the year. A study therefore, was conducted on the effects of solar drying on the nutritional content of selected indigenous leafy vegetable using locally constructed solar drying panels at the Department of Agriculture Engineering and Mechanization of the College of Agriculture Education, Mampong Campus. The study was done in June, 2011 and four (4) designed solar dryers were used. The panels were constructed using hard wood, nail, chicken mesh nylon net and black and white polythene sheets. The samples which include cocoyam leaves: *Xanthosoma sagittifolia*, "Ayoyo", Moringa, *Moringa Oleifera*, waterleaf, *Talinum trangulare* and bitter leaf, *Vernonia* were weighed cleaned and those with broader leaves (cocoyam leaf) were chopped. Half of cocoyam leaves and Bitter leaves were blanched at a temperature of 65°C. The samples both the blanched and unblanched were evenly spread in each of the panels to dry. Panel B which had black polythene sheet covering its exterior and opposite ends recorded the highest mean temperature of (30.13°C to 47.32°C) while the control panel E (open air) recorded the lowest mean temperature (26.25°C to 32.80°C). Drying period ranged between 3 and 5 days for all samples in various panels with waterleaf, *Talinum triangular* showing the longest drying period of 5 days in all the panels due to its high moisture content. Drying was more effective in the panels than the control (higher percentage dried weight loss). Proximate analysis showed that apart from the protein levels of the cocoyam and Ayoyo" leaves that had lower values those of the other nutrients had higher concentration except the moisture and fat contents which showed drastic decrease. The high nutrient levels of the dried vegetable make it a good source of food for malnourish children and patients of heart diseases. It is therefore recommended that similar investigation should be carried out on other indigenous vegetables especially fruits and root vegetable using the solar drying panels technology.

Keywords: solar dryer, indigenous vegetables, preservation, temperature, drying period, nutrient value.

INTRODUCTION

Sub-Saharan Africa regions are reported to have the world's lower intake of micronutrient - rich fruits and vegetables with the mean consumption being less than half the World Health Organization (WHO) recommendations on daily intake of 400g per capita per day in most countries (WHO, 2005). Low consumption of fruits and vegetables is the main contribution to micronutrients deficiencies, especially in populations with a low intake of nutrient-dense animal sources and dietary products. Nutritional deficiencies, particularly, deficiencies of iron, iodine, and Vitamin A are documented to be the major problems for school-age children in low income countries. Yet deficiencies of iron, vitamin A, iodine, and zinc have far-reaching consequences on growth, development and health, contributing to impaired immunity and cognitive function, growth failure, increased morbidity and mortality (Gibson, 2000). Ideally, the prevalence of micro nutrient related disorders can be addressed by fortification and supplementation but this has to be subsidized because it can be expensive and hence financially inaccessible to the rural population who form the majority of the micronutrient deficiency victims.

In Ghana dietary supplements are periodically given to children under five (5) years of age by the government through the Health Ministry and Ghana health services due to micronutrient deficiencies, specially vitamin A, iron and iodine. This prevalence of micronutrient related disorders among Ghanaians, especially the rural poor, can be addressed by fortification, supplementation, dietary diversification and public health awareness. Dietary diversification can provide the nutrient largely from careful selection of fruits and vegetables by communities along side proper nutrition awareness and social marketing. The fruits and vegetables could be sourced domestically or gathered from the wild areas where they have not been domesticated.

Although Ghana is endowed with many varieties of indigenous leafy vegetables, their consumption is seasonal among the poor rural areas leading to severe relish shortage, especially in the dry season and hence contributes to household food insecurity.

One major problem inhibiting the production and consumption of indigenous leafy vegetable in Ghana is the high post- harvest losses due to inadequate storage practices. Losses are exacerbated by loads of mixed leaves ripening, inefficient packaging system, and inefficient transport systems due to poor road network which subject leaves to static and dynamic stress.

Vegetables are the succulent edible plant parts that may be eating as supplementary food or side dishes in raw state or in the cooked form, alone, with fish or meat stew or soups and various preparations (Okigbo, 1983). They may be sweet, aromatic, bitter, hot and tasteless and sometimes require salting and considerable seasoning to render them more tasty and acceptable. Products of vegetables play an important role in the diet of West Africans (Sinnadurai, 1992). Some crops grown for one purpose may also be put to dual use, thus cowpea and cassava grown for their protein-rich seeds and carbohydrate-rich respectively also have their leaves harvested for vegetables (okigbo, 1983).

Research has shown that leafy vegetable are related to important nutritional value as a major source of vitamins and minerals to ensure a balanced diet. Vegetables are good source of roughages, which by providing an indigestible matrix stimulates intestinal muscles and keep them in working order and also prevent constipation through their laxative effect. The fiber content of vegetables generally adds to bulk of the food which prevents us from frequent hunger (Norman, 1992; Rubaihayo, 1997).

Some indigenous leafy vegetable such as okra, vegetable jute impart a glutinous constituency to stew and soup and thus facilitate swallowing of food such as ‘Banku’ ‘Fufu’ and ‘Gari’. It has been also discovered that vegetables are rich source of vitamins K, A, and C as well as minerals such as calcium, iron, phosphorus, some appreciable amount of thiamine, Niacin and riboflavin, carbohydrate and crude protein as compared to exotic leafy vegetables (Schippers, 2000)

Regular consumption of fruits and vegetable can provide the required nutrients to all Ghanaians with particular emphasis on our rural children who are prone to malnutrition. However, evening - out seasonality of fruits and vegetables through preservation methods to avail them throughout the year together with systematic promotion of their cultivation and consumption, it is possible to alleviate the above nutrient deficiencies and associated public health problems among the rural poor communities. This will be more effective and attainable using improved drying technique (solar dying) since the old sun drying has many constrains on product quality.

The study, therefore, focused on the effect of solar panel drying of indigenous vegetables on their nutrient content levels.

MATERIALS AND METHODS

Site and time of project

The Experiment was performed in June, 2011 at the Department of Agriculture Mechanization and Engineering of the College of Agriculture Education, Mampong Campus. Mampong lies between latitude 07° 04’ North of the Equator and longitude 01° 24’ West. The area is in the forest-savannah transitional zone of Ghana with altitude of 257m above the sea level. There are two main patterns of rainfall. March to July being the major season intercepted by slight draught in August and then begins the minor season from September to mid November. Mampong has a total annual rainfall of between 1270 mm and 1524mm the mean monthly temperature ranges between 25°C - 32°C (Ghana Meteorological Department, Mampong - Ashanti, 2011). The project was carried out in June, 2011.

Materials

Materials used in carrying out this project include the five most popularly consumed indigenous vegetables namely; Cocoyam leaves (kontomire: local name) “Ayoyo” water leaves (local name:), Moringa leaves and “Bitter leaves”. Five locally constructed solar panels labeled A, B, C, D and E (control) were used for the experiment.

Description of the panels

Panel A

This panel is rectangular with roof of white transparent polythene sheet. All sides of this panel were covered with this same transparent polythene sheet while the drying platform was covered with chicken mesh and nylon net on top. Vents were created to get rid of moisture accumulation in the panels. The panel is raised to a high of 137cm from ground level, 90cm being the height of roof to drying platform. The span of the roof is 198cm by 97cm. and a dimension 198cm and 97cm length and breadth, respectively.

Figure-1. Panel A with all parts covered with white polythene sheet.

Panel B

This panel is having the same shape, roofing material as well as platform material as panel A. unlike panel A, this panel has black polythene sheet covering the entire front and the two opposite sides while the back was covered with the same roofing material. This was to allow more heat to aid drying rate in the panel. The dimensions of this panel are the same as panel A. There were vents on this panel as well.

Figure-2. Panel B with three of its sides covered with black polythene sheet.

Panel C

This panel is also having the same roofing materials, platform material and dimensions as the previous panels (A and B). Unlike panels A and B, this panel has the black polythene sheet covering the exterior area of the drying platform. Vents were also provided to facilitate exchange of moisture within the interior and the exterior of the panel.

Figure-3. Panel C with black polythene sheet lining the exterior of the drying platform.

Panel D

This panel is having all its characteristics as Panel A, this panel has a black polythene sheet covering the two opposite side to distinguish it from panel A.

Figure-4. Panel D with the black polythene sheet covering the two opposite sides

Panel E (Control)

This panel is the control with dimensions 315cm and 1800cm as its length and breadth, respectively. The platform of this panel is covered with chicken mesh and nylon net on top. This panel is open to direct sunlight and ambient temperature during the drying process.

Figure-5. Panel E, open air (Control).

Preparation of vegetables

Cocoyam leaves (Kontomire: local name) “Ayoyo” water leaves (local name:), Moringa leaves and “Bitter leaves” were procured from the local market at Ejura and Mampong, They were cleaned by removing all adhering dirt, fibrous or aged leaves and damaged parts. The young and succulent leaves were than separated from their branches and finally washed under a standing pipe. Each vegetable sample was divided into two equal parts. The cocoyam leaves, having much broader leaves were chopped using the AIWA KITHEN MATE machine. One part each of the cocoyam leaves and bitter leaves were blanched at 65^{o}C while the other half was not blanched as

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well as those of the "Ayoyo", water leaf and the moringa leaves.

Drying procedure

1.5kg each of both blanch and unblanched cocoyam leaves and the bitter leaves, 1.1kg of 'Ayoyo' leaves, 1.0kg of water leaf and 0.8kg of the Moringa leaves using a 100kg Salter weighing scale were randomly spread evenly to dried in each of the four solar dryers including the open air (control). Samples were periodically turned after each hourly reading of the temperatures inside the dryers to ensure uniform drying and to avoid moulding of the product.

Temperature reading

With the aid of thermometers placed in each panel temperatures were taken hourly from 8. 00 hrs (GMT) to 17. 00 hrs (GMT) each day until drying of all the vegetables were completed.

Preservation and storage of dried sample

Dried samples of all the vegetables were removed and weighed again separately. The samples were then stored in tight polythene sacks and further seated in brown envelopes and stored under room temperature for six months.

Nutritional analysis of samples

Proximate analysis of sampled fresh and the dried vegetable was done to determine their nutrient levels.

RESULTS

Temperature evaluation

The graph represents the mean hourly temperatures in the various panels during the drying of the samples.

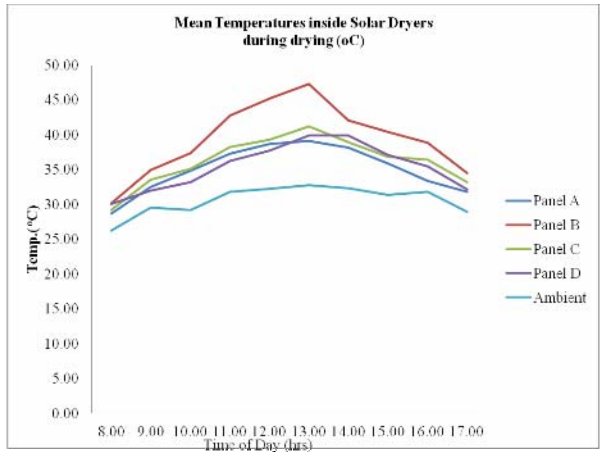

Figure-6. Temperatures recorded inside panels during drying.

Length of drying periods of vegetables inside solar dryers (days)

Table-1 is the descriptive summary of the average days; it took the vegetables to dry in the various solar dryers.

Table-1. Days of drying of vegetables in the various solar dryers (Days).

Panel	Vegetables						
	Cocoyam leaves *Xanthosoma sagittifolia*		Bitter leaf *Vernonia amygdalina*		Ayoyo leaf	Moringa *Moringa aleofera*	"Bg" Leaf *Talinum triangulane*
	Blanched	Unblanched	Blanched	Unblanched			
A	3	3	4	4	3	3	5
B	4	3	5	4	3	3	5
C	4	3	5	4	3	3	5
D	3	3	4	4	3	3	5
Open air	3	3	4	4	3	3	5

Percentage dried weight loss of products

Tables 2, 3, 4, 5 and 6 show the various dried weight and percentage weight loss of the individual dried vegetables.

Table-2. Percentage dried weight loss of cocoyam leaf (*Xanthosoma Sagittifolia)*.

Panel		**Initial weight** (kg)	**Final weight** (kg)	**Loss wt.** (kg)	**Percentage weight loss** (%)
A	Blanched	1.5	0.1315	1.3682	91.21
	Unblanched	1.5	0.1408	1.3592	90.61
B	Blanched	1.5	0.1215	1.3790	91.93
	Unblanched	1.5	0.1450	1.3550	90.33
C	Blanched	1.5	0.1260	1.3740	91.60
	Unblanched	0.4	0.0675	0.3325	83.13
Open air	Blanched	1.5	0.1176	1.3824	92.16
	Unblanched	1.0	0.0737	0.9263	92.63

Table-3. Percentage dried weight loss of Ayoyo.

Panel	**Initial weight** (kg)	**Final weight** (kg)	**Loss of weight** (kg)	**Percentage weight loss** (%)
A	1.1	0.1979	0.9021	82.01
B	1.1	0.2257	0.8743	79.48
C	1.1	0.2073	0.8927	81.15
Open air	1.1	0.1737	0.9263	84.21

Table-4. Percentage dried weight loss of *Moringa oleifera*.

Panel	**Initial Weight** (kg)	**Final weight** (kg)	**Loss of weight** (kg)	**Percentage weight loss** (%)
A	0.8	0.1764	0.6236	77.95
B	0.8	0.1735	0.6265	78.31
C	0.8	0.1970	0.6030	75.13
Open air	0.8	0.1819	0.6181	77.26

Table-5. Percentage dried weight loss of bitter Leaf: *Vernonia amygdalina*.

Panel	**Initial weight** (kg)	**Final weight** (kg)	**Loss of weight** (kg)	**Percentage weight loss** (%)
D (Blanched)	1.5	0.1809	1.3191	87.94
D (Unblanched)	1.5	0.1985	1.3015	86.77
Open air (blanched)	1.5	0.1618	1.3382	89.21
Open air (unblanched)	1.5	0.1821	1.3179	87.86

Table-6. Percentage dried weight loss of “Bgbg” *Talinum triangulare*.

Panel	**Initial weight** (kg)	**Final weight** (kg)	**Loss of weight** (kg)	**Percentage weight loss** (%)
A	1	0.1928	0.8072	80.70
B	1	0.2114	0.7886	78.86
C	1	0.2010	0.7990	79.90
Open air	1	0.1802	0.8188	81.88

Proximate analysis of dried vegetables

Tables 7 to 13 give the proximate analysis of the blanched and unblanched dried vegetables of the various panels and the open air drying, respectively.

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Table-7. Proximate analysis of 'Kontomire' *Xanthosoma sagittifolia* (Unblanched)
ND = Not Determined.

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbo-hydrate (%)
Fresh	85.76	4.65	ND	3.19	10.00	**6.80**
PA	12.48	4.00	1.13	0.94	6.52	74.93
PB	10.95	3.52	1.40	0.80	6.51	76.72
PC	12.11	3.72	1.33	0.80	6.50	75.54
Open air	10.28	3.96	1.21	0.80	6.53	77.22

Table-8. Proximate analysis of 'Kontomire' *Xanthosoma sagittifolia* (blanched).

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbo-hydrate (%)
Fresh	85.56	4.65	ND	3.19	10.00	**6.80**
PA	7.75	2.69	1.92	0.66	6.72	80.26
PB	7.23	2.66	1.87	0,.61	6.74	80.89
PC	9.42	2.23	2.17	0.51	6.72	78.95
Open Air	8.39	2.24	2.07	0.47	6.74	80.09

Table-9. Proximate analysis of "Bgbg" *Talinum triangulare.*

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbo-hydrate (%)
Fresh	91.83	5.10	ND	1.33	8.00	**1.05**
PA	15.87	8.90	1.21	1.51	8.59	63.92
PB	13.00	9.25	1.28	1.99	8.88	65.60
PC	16.96	8.35	1.23	1.82	8.77	62.87
Open air	14.14	8.83	1.28	1.52	8.46	65.77

Table-10. Proximate analysis of *Moringa oleifera.*

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbo-hydrate (%)
Fresh	75.00	6.60	ND	1.50	1.00	**13.50**
PA	12.30	28.09	1.04	1.59	7.27	49.71
PB	13.61	27.84	1.06	1.59	7.26	48.64
PC	11.3	28.36	1.03	1.53	7.32	50.27
Open air	13.45	28.99	1.08	1.54	7.38	47.56

Table-11. Proximate analysis of ayoyo.

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbo-hydrate (%)
A	9.61	2.69	2.31	2.00	8.19	75.22
B	9.86	2.53	2.65	1.78	8.09	75.09
C	11.56	2.48	2.35	1.92	8.10	73.65
Open air	12.04	2.24	2.62	1.90	8.04	73.16

Table-12. Proximate analysis of bitter leaf: *Vernonia amydalina* (unblanched).

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
D	13.59	6.41	1.13	2.07	9.30	67.50
Open air	14.01	6.81	1.12	2.04	9.10	66.92

Table-13. Bitter leaf: *Vernonia amydalina* (blanched).

Panel	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbo-hydrate (%)
D	8.27	5.17	1.20	1.89	9.73	73.74
Open air	8.08	5.58	1.20	1.97	9.65	73.52

DISCUSSIONS

Mean temperatures recorded during drying of vegetables in solar dryers (^oC)

From Figure-1, the temperatures in the various panels varied from (26.23^{o}C to 47.32^{o}C) during drying depending on the weather conditions, time of day and constructional material (Wagner, 2005).

Panel B recorded the highest mean temperature of (47.32^{o}C), followed by Panel C recording (41.23^{o}C). This high temperature occurred due to the black polythene sheet covering their exterior parts (Figures 2 and 3).

Panel A and D recorded almost the same mean temperature less of B and C because they have most of their parts covered with the same white polythene sheets. The control panel which is the open air dryer recorded the least mean temperature of (26.23^{o}C). In all the intermittent cloudy weather and at times rains had some effect on the temperature recordings. Also the results revealed that temperatures recorded at 13.00GMT were high in all panels during the drying period.

Length of drying period of vegetables in solar dryers (days)

From the table, the drying periods of products in all the panels ranged between 3 to 5 days. The results showed that samples in panels B and C especially the blanched samples took 4 and 5 days to dry respectively, whilst the unblanched dried within 4 days. This means drying of unblanched samples was faster than the blanched. Samples other than blanched samples in other panels had constant drying period as shown on the Table (3 days, 4 days and 5 days). However, due to high moisture content in the "B g b g " water leaf, it took five days to be well dried in all the panels including the open air. *Moringa oleigera*, 'Ayoyo' and the unblanched cocoyam leaves took 3 days to dry in all panels (http://www.hgic.clemson.edu.com, Seidu *et al.*, 2008).

Percentage dried weight loss

Table-2 revealed that kontomire (*xanthosoma sagittifolia*) had its percentage weight loss ranging from 83.12% and 92.65% depending on the panel's make up. The control panel D recorded the highest percentage weight loss. This indicated that proper drying took place in panel D. Panel C recorded the least percentage weight loss for the blanch products. This means blanched products still maintained some level of moisture when dried in Panel C.

In Table-3 the results revealed that the percentage weight loss in all panels ranged from (79.48% to 84.20%). Panel D recorded the highest weight loss. This means that drying was effective in the panel than the other. Panel B recorded the lowest percentage weight loss indicating drying was not perfectly done or there was moisture re-absorption in the dried products.

From Table-4 percentage weight loss ranged from (75.13% to 77.95%) in all panels for *Moringa oleifera*. The results revealed that Panel A recorded the highest percentage weight loss showing that drying was better in the panel. Panel C recorded the lowest percentage weight loss. This means moisture could not be adequately removed from products.

In Table-5, percentage weight loss of Bitter leaf (*Vernonia amygbalina*) ranged from (86.77% to 89.21%) in all panels. Panel C recorded the highest percentage weight loss, drying occurred perfectly in panel. Panel B recorded the least percentage weight loss this means that effective drying of products did not take place in panel. Again in this panel, blanched products weight losses comparing to their unblanched samples.

Table-6 showed percentage weight loss of "Bgbg" Water leaf ranging from (78.86% to 81.88%) in panels. The table revealed that panel D recorded the highest percentage weight loss indicating drying was better in panel. Panel B showed the lowest percentage weight loss signifying that moisture could not be properly removed from products.

Proximate analysis of dried vegetables

From Table-7, moisture content of dried samples ranges from (10.28% to 12.48) in unblanched kontomire (*Xanthosoma sagittifolia*) in the panels. This signifying a better drying to enhance longer shelf life. Protein also ranges from (3.52% to 4.00%) in the dried product showing a minimal reduction in nutrition comparing it to the fresh state. On Ash they ranged from (1.21 to 1.40), Fat ranges from (0.80 to 0.94), Fibre ranged from 6.52% to 6.57%) and Carbohydrate ranging from (74.93% to 77.22%). From the above results, it is only carbohydrate which saw an increase in nutritional composition in the dried state.

Table-8 showed the nutrient composition of blanched “Kontomire”. From the results, it is revealed that all nutrient composition had a decrease except in carbohydrate which saw an increase ranging from (80.29% to 78.95%). Moisture had a drastic decrease in composition in the dried state ranging from (7.23% to 9.42%).

“Bgbg” *Talinum tringulare* nutrient composition is illustrated in Table-10. From the results there was a reduction in nutrient composition in moisture ranging from (13.00% to 16.96%), other nutritional composition saw increases; protein (8.35% to 9.25%), Ash (1.21 to 1.28%), Fat (1.51% to 1.99), Fibre (8.46% to 8.88%) with Carbohydrate recording the highest increase ranging from (62.87% to 65.77%) in their dried state as shown in the table.

Table-10 illustrates the nutrient changes in *Moringa oleifera*. From the results, it is shown that nutrient composition in protein; ash, fat, fibre as well as carbohydrate undergo increases. With protein ranging from (27.84% to 28.99), Fat (1.53% to 1.59%), Fibre (7.26% to 7.38%) and Carbohydrate (47.56% to 50.27%). This indicate that protein and carbohydrate recorded the highest increase in nutrient composition in dried Moringa . Table-11 shows the nutritional composition of ‘Ayoyo’ with moisture ranging from (9.6% to 12.04%) Protein (2.24% to 2.69), Ash (2.3% to 2.65%), (1.90% to 2.00%), Fibre (8.04% to 8.19%) and Carbohydrate from (73.16% to 75.22%). This result showed that the open air dryer recorded the least nutritional values on dried ‘Ayoyo’ of all nutrients except in moisture content.

Nutritional composition of dried bitter leaf *Vernonia amygbalina* (unblanched) is shown in Table-12. From the results, Carbohydrate recorded the highest ranging from (66.92% to 67.50%). Other nutrients recordings were as follows; Fibre (9.10% to 9.50%), Fat (2.04% to 2.07%), Ash (1.12% to 1.13%), Protein (6.41% to 6.81%) while moisture ranges from (13.59 to 14.01). This shows that Ash recorded the least.

The blanched sample of bitter leaf is also shown in Table-13. The results revealed carbohydrate recording the highest of (73.52% to 73.74%, and Ash the least of (1.20), a constant value in all the panels.

CONCLUSIONS

From the study it was observed that:

Panels B and C recorded the highest mean temperature because their exterior and opposite ends were covered with black polythene sheets while the control panel (E) recorded the lowest mean temperature. Intermittent cloudy weather and rains affected temperature during the drying periods.

Samples took between 3 and 5 days to dry completely, with blanched samples showing dark brown colours, while the unblanched were slightly yellowish green. The percentage weight loss was highest in the blanched, showing that drying was more effective in the blanched samples than the unblanched.

Products dried better in the solar panels than in the control due to the protective covering of the panels that prevent unfriendly weather conditions during the drying periods.

Proximate analysis showed higher nutrient concentration of the dried samples with carbohydrate recording the highest. However moisture and fat levels were low. The low fat content of the dried vegetables make them suitable for people who suffer from heart related diseases. The low moisture content of the dried vegetables makes them suitable for longer storage period (Thomas, 1997).

RECOMMENDATIONS

- Both the solar panels with black polythene sheets and plain (white) could be used by farmers to dry vegetables in the peak season to even out seasonal imbalances of indigenous vegetables since the drying time were shorter and less exposed to contaminants as compared to the open dryer.
- Samples should be blanched to have high percentage weight loss to enhance longer shelf.
- Farmers should be educated on the use of the solar dryers to dry vegetables before use since their nutritional values are mostly high in the dried state.
- Further studies on the mineral content of vegetable should be done.
- The technology should be used to dry fruits and root vegetables as well as the exotic vegetable.
- Sensory analysis is done to compare the organoloptic qualities of dried and fresh indigenous vegetables.
- The consumption of dried indigenous leafy vegetable in the rural areas should be encouraged since they contain the essential micro and macro nutrients to alleviate nutritional deficiencies and reduce most heart related diseases among the rural folks.

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REFERENCES

Gibson R.S., Hotz C., Temple L., Yeudall F., Mtitimuni B. and Forguson. 2000. Dietary Strategies to combat deficiencies of iron, zinc and vitamin A in developing countries: Development, Implementation, monitoring and Evaluation. Food and Nutrition Bulletin. pp. 219-229.

http://www.dystore.citymax.com. 1999. Salehoo forum Centre, USA.

http://www.hgic.clemson.edu.com, Clemson University, South Carolina, USA. 1999.

Kant A.K, Schatzkin A and R.G Ziegler. 1995. Dietary Diversity and subsequent cause-specific mortality in the NHANES 1 epidemiologic follow-up study. J. Am Coll. Nutr. 14: 233-238.

2011. Meteorological Services Department, Mampong Ashanti, Ghana.

Norman J.C. 1992. Tropical vegetable crops, Arthur H. Stockwell Hd. Great Britain. pp. 10, 11b, 17c, 199d.

Okigo B.N. 1983. Fruits and Vegetables Production and Extension Services in Africa. Acta Hortic. 123: 23-37; pp. 84b.

Rubaihayo E.B 1997. The contribution of Indigenous Vegetables to the Household Food Security in Uganda. African Crop Science Conference Proceedings. pp. 1337-1340.

Seidu J.M, Tevor W.J, Kotei R. and Mahama. 2008. Suitability of Locally Constructed Solar Dryers for Vegetable Drying. Journal of Ghana Science Association. 10(1).

Sinnadurai S. 1992. Vegetable cultivation, Asempa Publishers, Accra. pp. 1-11.

Schippers R.R. 2000. African Indigenous vegetables. An overview of the cultivated species, chathan, UK: Natural Resources Institute (ACP-EU) Technical centre for agricultural and rural cooperation. pp. 22; 172b; 121c; 3d.

Tindal H.D. 1976. Commercial vegetable growing. University press, Oxford, Great Britain. p. 74.

Wagner Mary K, Mannes Mary E. and Clarence Johnson E. 2005. Food processing and preservation in the tropics. Washington state university. Pullman Washington. pp. 115-120, 221-233.

World Health Organization/Food and Agriculture Organization. 2005. Patterns and determinants of fruit and Vegetable consumption in sub-Sahara-Africa: A multi-country comparison. Background paper for the joint FAO/WHO Workshop on fruit and vegetables for Health, Geneva, Switzerland.