FIELD PERFORMANCE OF EFFICIENCY OF A SOLAR CARBINET DRYER ON AGRICULTURAL CROP

Okpala, P. K.
Achu, C.T.
Nsolibe, U. W.

Abstract

Open air solar drying is one of the oldest methods of food preservation but research has shown that during this process, crops due get contaminated and due to uncontrolled amount of sun light crops due loss their quality. In other to improve the process of drying agricultural crops, solar cabinet dryer was discovered. This research investigates the field performance of efficiency of a solar cabinet dryer on agricultural crops. Two samples of Okro (Abelmoschus Esculentus) and pepper (pipper congum) were bought from Eke Awka market in Anambra state. The samples were prepared in readiness for the drying using solar dryer. Three sets of thermometer and a veto letter dual weighing balance and a solar cabinet were used for the experiment. Each sample was weighed in two places to a 300g of mass and placed in chambers 1 and 2 of the solar cabinet dryer. This was done for experiments 1 and 2. Experiment 1 lasted for four days while experiment 2 lasted for three days. The result of the experiment showed that in the first experiment the highest temperature attained was 60^0c in chamber 1 and 59^0c in chamber 2 while in the second experiment it was 62^0c in chamber 1 and 58^0c in chamber 2. The result of the changes in the masses of Okro and Pepper in the experiment 1 showed that mass of Okro reduced from 300g to 65g in chamber 1 and 90g in chamber 2, while pepper reduced from 300g to 105g both in chambers 1 and 2. In the second experiment the masses of Okro reduced from 300g to 65g both in chambers 1 and 2, while Pepper reduced from 300g to 80g both in chambers 1 and 2.The results of the drying of Okro and Pepper has shown that solar cabinet dryer can be used as effective and safe instrument in the drying and preservation of agricultural produce, and that large quantities of the two products can always be dried and stored.

Keywords: Solar Cabinet Dryer, Drying, Agricultural Crops

Introduction

Many agricultural produce like cereals, vegetables and cash crops are produced in Nigeria at a very large extent from local farmers but greater percentage of them do get damaged or are wasted before they reach their final consumers. One of the major problems facing local production of these agricultural produce is the lack of adequate storage and processing facilities. Food and Agricultural Organization (F.A.O.), (2002) statistics shows that such products as cereal, oil seeds and tuber, up to 50% of the produce are lost after harvest before reaching the consumers. With the decline in the prize of crude oil which is the major source of our national income, Nigerian government is now trying to pay serious attention to agriculture. For our country to improve its agricultural produce there is serious need to improve in our storage and processing facilities in our rural areas to assist farmers in the reduction of damage of their agricultural produce and when this is done our agricultural produce will increase.

One of the major ways of processing agricultural produce is through drying. Drying is the process of removing water/moisture from a material. Ganda, Garba, Danshehu, Momoh & Rabiu, (2012), state that the objective in drying agricultural product is to reduce its moisture content to that level which prevents deterioration within a period of time regarded as safe storage period. One of the major ways of drying is the use of solar energy. The sun which is made up of extremely hot gaseous matter is the only source of heat and light for the entire universe, (Gulma, 1996). Solar energy is the world most abundant source of energy known and used by mankind (Danshehu, 2010). Solar drying is the process of removing moisture from a material with the help of heat from the sun. This type of drying is general used by local farmers in the processing of their agricultural produce. According to Okonkwo and Nwoke (2008) solar drying encourages high product quality and reduces period of drying. Solar drying of food has remained an excellent system of food drying, (Nwokoye, 2006). One of the ways of achieving solar crop drying is the use of solar cabinet dryer. The dryer consists of two roof level. The first roof level and the body of the dryer are made of stainless steel. The drying Chambers is approximately 24cm in height with the same length and width as the dryer and houses four drying trays. The drying chamber is provided with two doors which allow loading and unloading of materials. According to Okonkwo and Nwoke (2008), the solar crop dryer could be helpful in drying other agricultural products such as maize, beans and root crops-cassava, plantain, and cocoa yam as well as perishable items as vegetable, tomato, fruits, meat and fish. By systematic application of heat, drying can effectively be achieved (Charm, 1978, Carl & Hall, 1980).

Materials and Methods

Two samples of Okro (Abelmoschus Esculentus) and pepper (pipper congum) were bought from Eke Awka market in Anambra State. The samples were prepared in readiness for the drying, using solar dryer. Three sets of thermometer and a veto letter dual weighing balance and a solar cabinet were used for the experiment. Each sample was weighed in two places to a 300g of mass and placed in chambers 1 and 2 of the solar cabinet dryer. During the initial measurement, the initial air temperature was taken using the sets of mercury in glass thermometer. The two chamber solar dryer was used to dry the Okro and pepper. The experiment was carried in the month of June 2016 to investigate the performance of the solar cabinet dryer. During the performance period the ambient temperature, collector inlet temperature of chambers I and II were measured by laboratory version of mercury-in-glass thermometer (accuracy of $+0.5^0$c) at regular interval of one hour between the hours of 0900 and 1800hrs local time. The first experiment lasted for four days while the second experiment lasted three days. The reason for this long duration of drying of the samples is because the days were rainy; this makes the temperature to drop. The experiment in each case was continued until total drying was achieved.

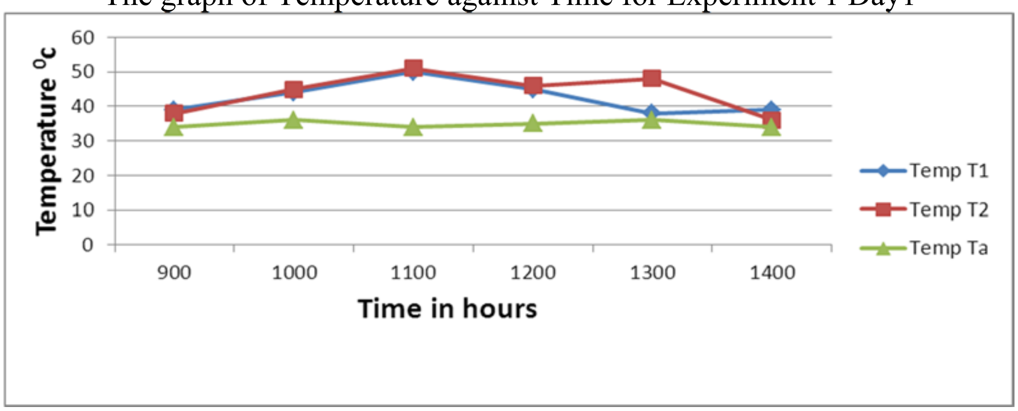
Result and Discussion

The result of the experiment are shown in tables 1-7 .In the first day of the experiment 1, drying started at 0900hrs with the masses of each products weighing 300g in both chambers and initial temperature of 39^0c and 32^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products), but between hours of 1300hrs and 1500hrs there was a drop in temperature due to rainfall and this made the products to absorb moisture and consequently increase in mass of the products, after which there was increase in temperature which dropped in late hours of the day, drying stopped at 1800hrs with the masses of pepper and Okro weighing 220g and 235g in chamber 1 and 253g and 255g in chamber 2

Tables 1, experiments 1, Day 1.10/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in °c	Ambient Temp in °c
	Okro	Pepper					
0900	300	300	39	300	300	38	34
1000	275	295	44	297	285	45	36
1100	265	260	50	295	280	51	34
1200	250	255	45	270	265	46	35
1300	243	245	38	260	255	48	36
1400	250	255	39	275	270	36	34
1500	245	257	49	265	265	46	32
1600	235	240	55	245	253	48	34
1700	225	240	46	255	250	40	32
1800	220	235	36	253	255	36	30

The graph of Temperature against Time for Experiment 1 Day1



The graph of Mass (kg) against Time for Experiment 1 Day 1

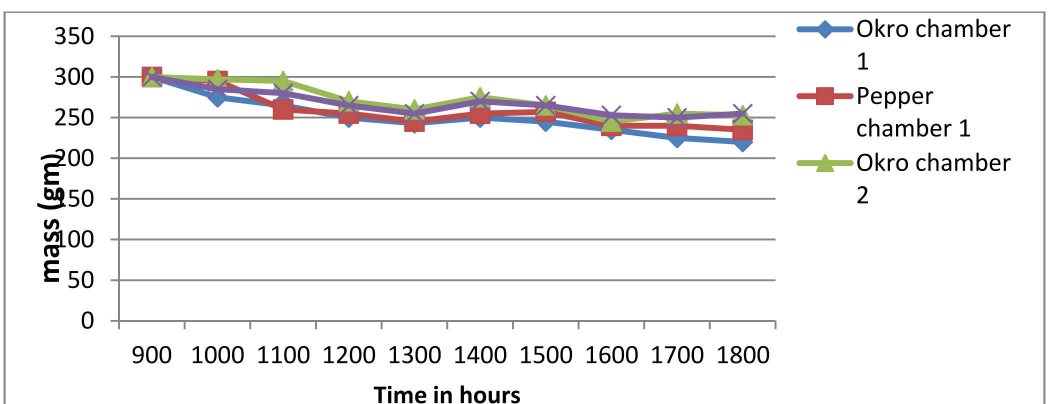


Fig. 1b: Change in Mass Vs. Time for Experiment 1 Day 1

In the second day of the experiment drying started at 1100hrs due to early hour rainfall. The masses of each products weighed 225 for Okro and 230 for pepper in chamber 1 and 245 for Okro and 240 for pepper in chamber `2 with initial temperatures of 28^0c and 27^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products), the highest temperature of 47^0c and 41^0c was recorded between hours of 1500hrs and 1600hrs,which later dropped in late hours of the day, drying stopped at 1800hrs with the mass of pepper and Okro weighing 175g and 195g in chamber 1 and 205g and 205g.

Table 2, experiments 1, Day 2. 11/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in °c	Ambient Temp in °c
	Okro	Pepper		Okro	Pepper		
0900							
1000							
1100	225	230	28	245	240	27	26
1200	210	200	38	225	220	37	30
1300	200	195	36	220	215	35	30
1400	200	195	36	220	215	34	32
1500	180	205	47	215	215	48	32
1600	180	205	41	210	215	38	30
1700	170	195	33	200	200	34	28
1800	175	195	31	205	205	31	26

The graph of Temperature against Time for Experiment 1 Day 2

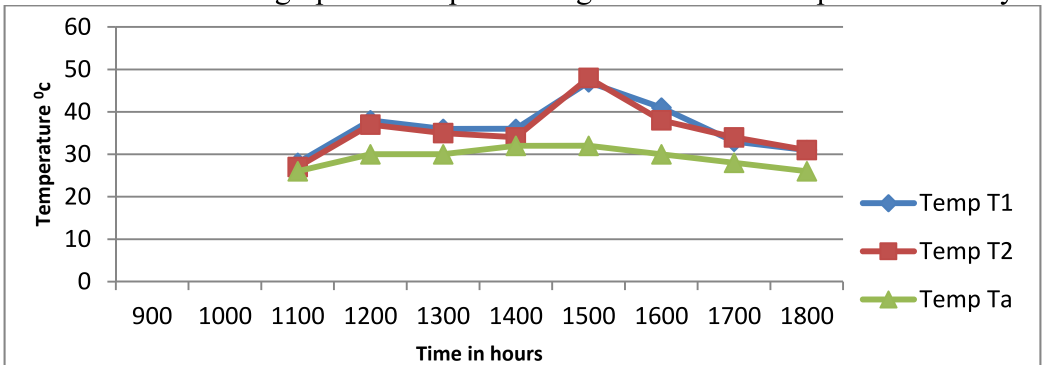


Fig. 2a. Change in Temp. Vs Time for Experiment 1 Day 2

The graph of Mass against Time for experiment 1 Day 2

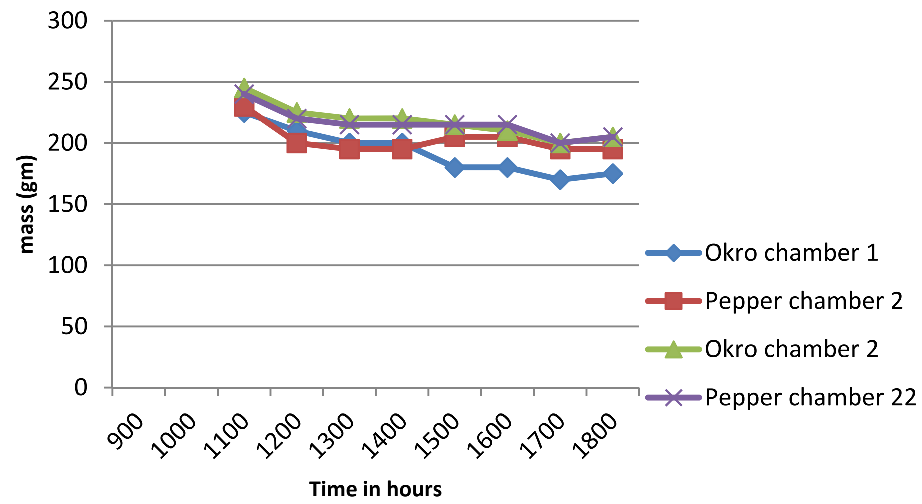


Fig. 2b. Change in Mass. Vs Time for Experiment 1 Day 2

In the third day of the experiment drying started at 0900hrs with the masses of each products weighing 180g for Okro and 200g for Pepper in chamber 1 and 120g for Okro and 205 for Pepper in chamber 2 and initial temperature of 32^0c and 32^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products), the highest temperature was recorded between hours 1300hrs and 1400hrs which dropped in late hours of the day, drying stopped at 1800hrs with the mass of pepper and Okro weighing 115g and 150g in chamber 1 and 140g and 160g in chamber 2

Table 3, Experiment 1, Day 3 12/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in °c	Ambient Temp in °c
	Okro	Pepper	T_1	Okro	Pepper	T_2	T_a
0900	180	200	32	210	205	32	25
1000	170	185	37	200	195	35	28
1100	165	185	43	200	190	44	30
1200	150	175	55	180	180	52	36
1300	135	160	59	175	175	57	38
1400	120	155	60	155	160	59	38
1500	103	145	46	140	145	46	32
1600	100	130	38	140	145	37	30
1700	115	145	32	145	155	30	28
1800	115	150	30	140	160	28	26

The graph of Temperature against Time for Experiment 1 Day 3

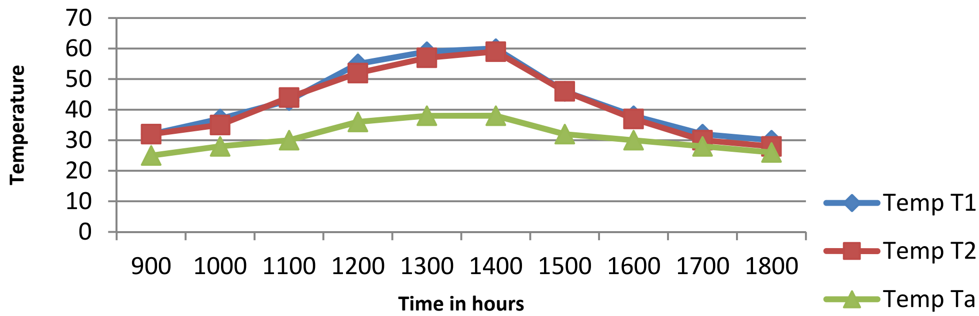


Fig. 3a: Change in temp. VsTime for Experiment 1 Day 3

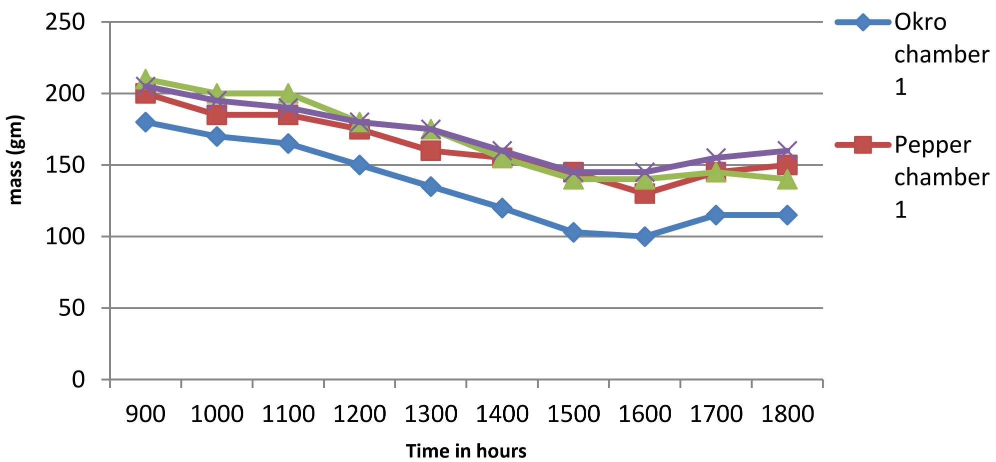


Fig. 3b: Change in Mass. Vs Time for Experiment 1 Day 3

In the fourth day of the experiment drying started at 0900hrs with the masses of each products weighing 110g for Okro and 140g for pepper in chamber 1 and 140g for Okro and 145g for Pepper in chamber 2 with initial temperature of 29^0c and 29^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products). The highest temperature of 57^0c and 59^0c was recorded at 1400hrs in chambers 1 and 2 respectively. The temperature dropped in late hours of the day, drying stopped at 1800hrs with the mass of pepper and Okro weighing 65g and 105g in chamber 1 and 90g and 105g in chamber 2

Table 4, Experiment 1, Day 4 13/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in °c	Ambient Temp in °c
	Okro	Pepper	T_1	Okro	Pepper	T_2	T_a
0900	110	140	29	140	145	29	28
1000	95	135	30	135	145	29	28
1100	95	130	46	130	140	47	26
1200	95	125	47	130	140	52	31
1300	80	120	49	155	125	57	32
1400	80	120	57	155	125	59	34
1500	75	115	49	105	125	46	32
1600	65	110	49	100	120	37	32
1700	65	110	39	95	110	30	30
1800	65	105	39	90	105	28	30

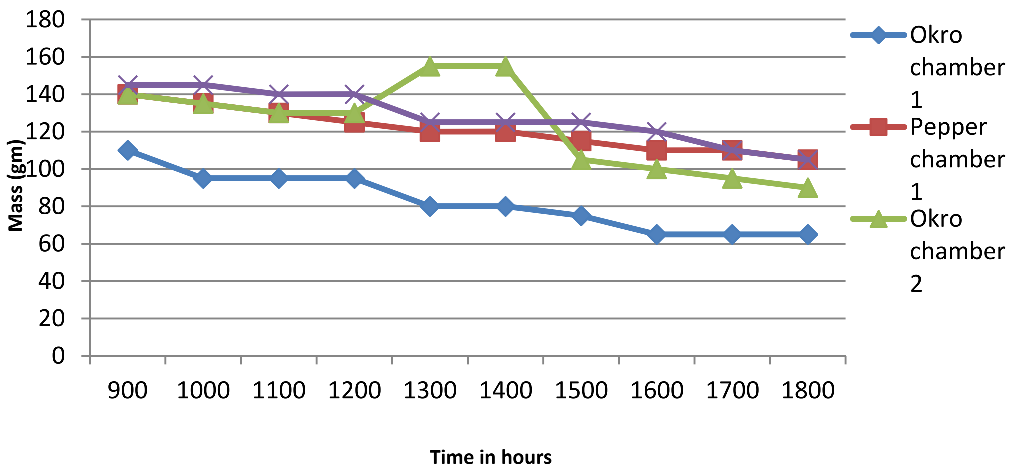


Fig.4a: Change in Mass. Vs Time for Experiment 1 Day 4

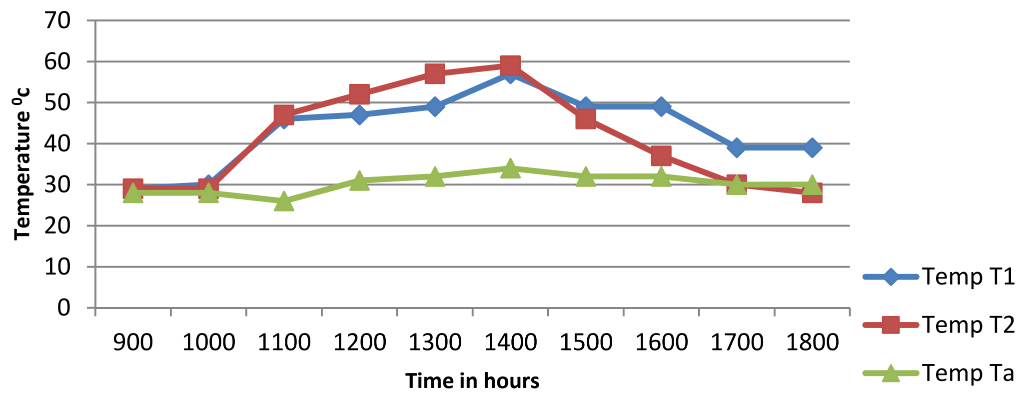


Fig. 4b: Change in Temp. Vs Time for Experiment 1 Day 4

In the first day of the experiment 2 drying started at 1100hrs due to early rainfall. The masses of each products weighing 300g in both chambers and initial temperature of 29^0c and 29^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products), the highest temperature of 49^0c and 50^0c for chambers 1 and 2 at 1300hrs respectively which dropped in late hours of the day, drying stopped at 1800hrs with the mass of pepper and Okro weighing 275g and 275g in chamber 1 and 275g and 275g in chamber 2

Table 5, Experiment 2, Day 1.15/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in oc	Ambient Temp in °c
	Okro	Pepper	T_1	Okro	Pepper	T_2	T_a
0900							
1000							
1100	300	300	29	300	300	29	28
1200	290	295	32	295	295	32	28
1300	290	295	49	295	295	50	32
1400	290	295	28	295	295	28	28
1500	275	290	25	280	285	25	26
1600	285	295	25	290	295	25	26
1700	280	285	30	280	285	32	28
1800	275	275	32	275	275	32	28

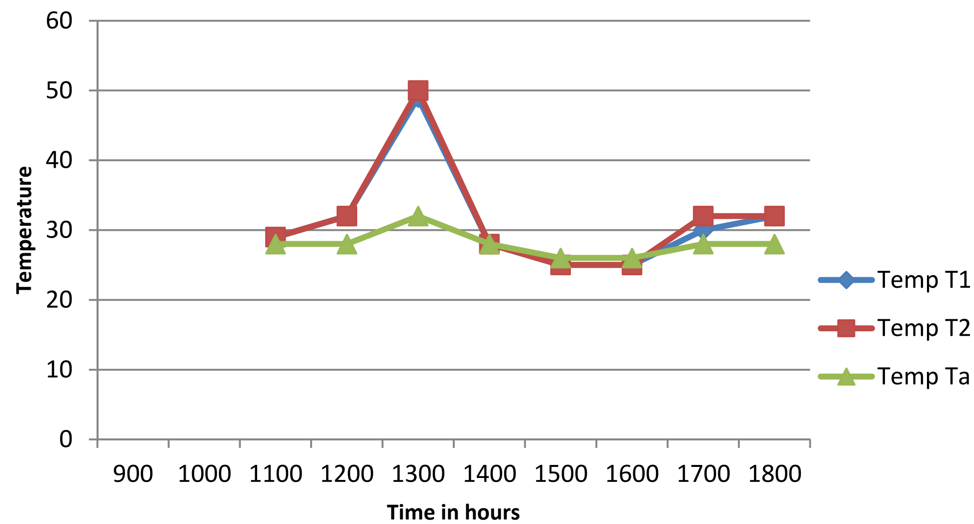


Fig. 5a: Change in Temp. Vs Time for Experiment 2 Day 1

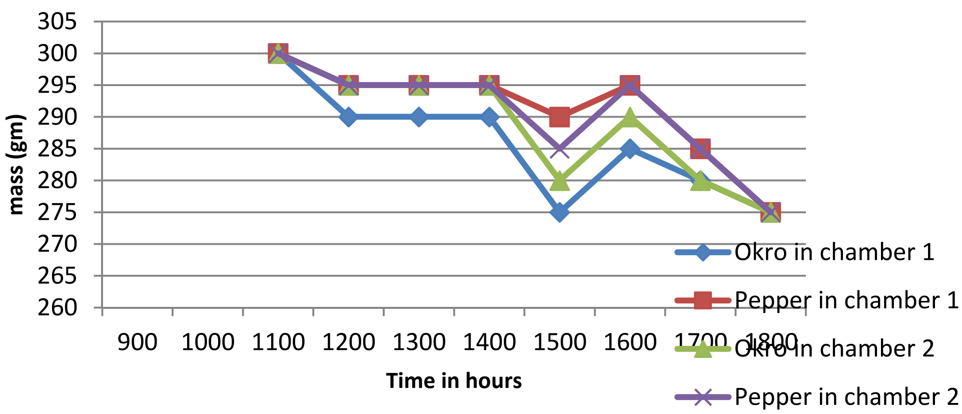


Fig. 5b: Change in Mass. Vs Time for Experiment 2 Day 1

In the second day of the experiment 2 drying started at 0900hrs with the masses of each products weighing 275g in chambers 1 and 275g for Okro and 265g for Pepper in chambers 2 with initial temperature of 30^0c and 31^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products), the highest temperature of 60^0c and 59^0c in chambers 1 and 2 respectively was recorded at 1400hrs, which dropped in late hours of the day, drying stopped at 1800hrs with the mass of Okro and Pepper weighing 150g and 155g in chamber 1 and 160g and 155g in chamber 2 for Okro and Pepper respectively.

Table 6, Experiment 2, Day 2.16/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in °c	Ambient Temp in °c
	Okro	Pepper	T_1	Okro	Pepper	T_2	T_a
0900	275	275	30	275	265	31	30
1000	260	250	40	260	255	44	32
1100	255	215	45	255	250	51	34
1200	240	235	52	235	280	49	38
1300	220	215	58	225	215	56	36
1400	210	210	60	215	210	58	34
1500	195	190	58	200	195	56	36
1600	175	175	52	180	170	48	34
1700	160	165	44	170	165	40	32
1800	150	155	38	160	155	40	28

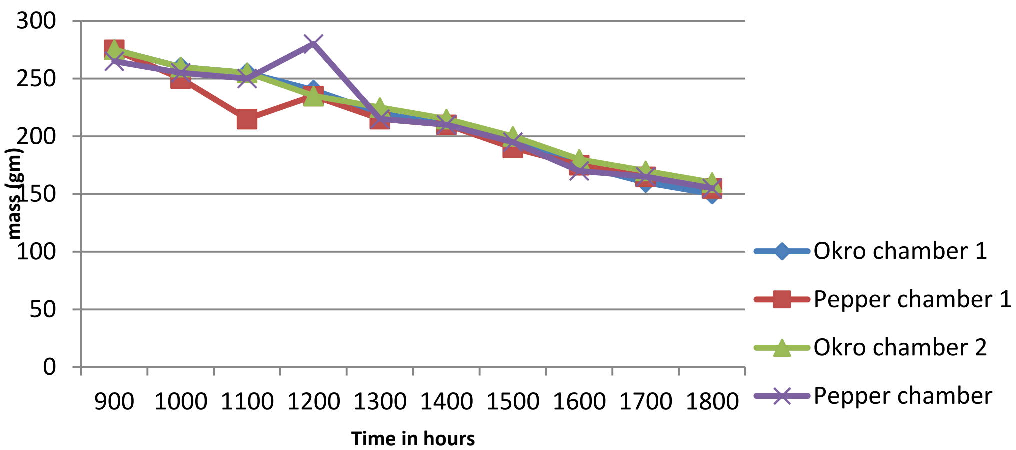


Fig. 6a: Change in Mass Vs Time for Experiment 2 Day 2

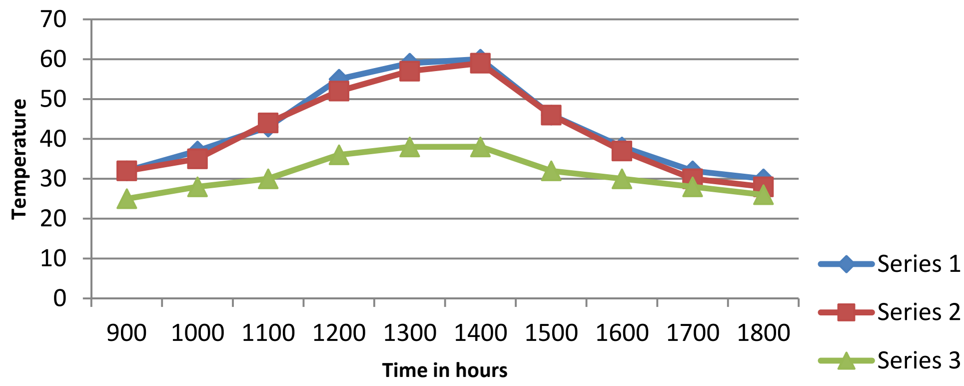


Fig. 6b: Change in Temp. Vs Time for Experiment 2Day 2

In the third day of the experiment 2 drying started at 0900hrs with the masses of each products weighing 150g for pepper and 160g for Pepper in chambers 1 and 165g for Okro and 155g for Pepper in chambers 2 with initial temperature of 30^0c and 31^0c in chambers 1 and 2 respectively, the products showed a noticeable change (i. e. reduction in mass of the products), the highest temperature of 62^0c and 57^0c in chambers 1 and 2 respectively was recorded at 1300hrs, which dropped in late hours of the day, drying stopped at 1800hrs with the mass of Okro and Pepper weighing 65g and 80g in chamber 1 and 65g and 80g for Okro and Pepper in chamber 2 respectively.

Table 7, Experiment 2, Day 3 17/06/2016

Time in Hrs	Chamber I mass in (g)		Temp in °c	Chamber II mass in (g)		Temp. in °c	Ambient Temp in °c
	Okro	Pepper	T_1	Okro	Pepper	T_2	T_a
0900	150	160	30	165	155	31	29
1000	145	155	40	160	145	40	32
1100	140	140	45	145	135	46	36
1200	120	125	52	135	130	50	34
1300	105	110	62	115	120	57	38
1400	90	95	58	95	100	54	37
1500	80	85	55	85	95	53	36
1600	75	80	50	80	90	51	32
1700	65	80	44	65	80	44	32
1800	65	80	36	65	80	35	30

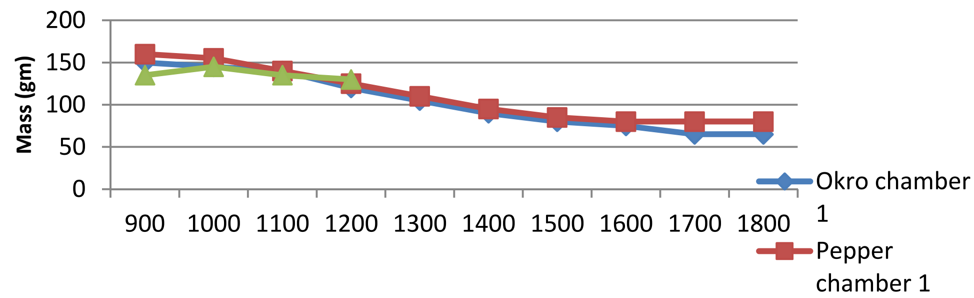


Fig. 7a: Change in mass vs time for experiment 2 Day 3

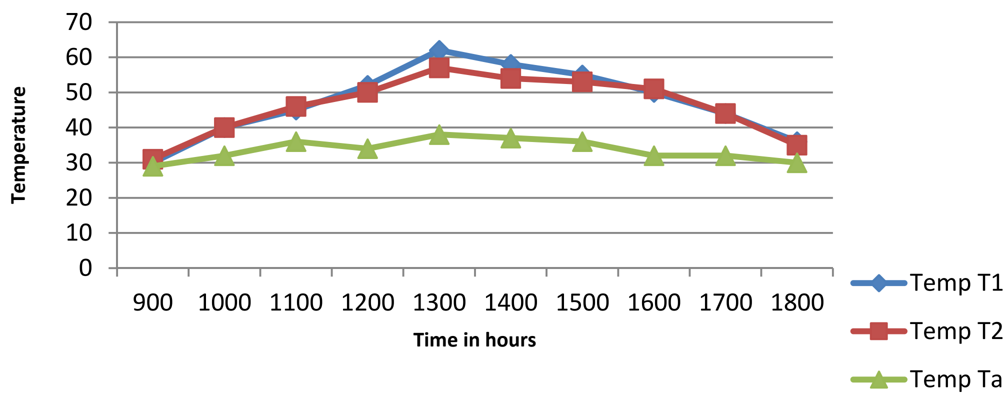


Fig. 7b: Change in Temp. Vs Time for Experiment 2 Day 3

Discussion

In the first experiment, drying lasted for four days with the masses of each product weighing 300g in both chambers initially. The products showed a noticeable change (i. e. reduction in mass of the products), from 300g in day 1 for both chambers to 65g for Okro and 105g for Pepper in chamber1 to 90g for Okro and 105 for Pepper in chamber 2. In the second experiment drying lasted for three days, there was a serious reduction in the mass of each product weighing 300g in both chambers. The mass of the products reduced from 300g in day of second experiment to 65g and 80g for the mass of Okro and Pepper respectively for both in chamber 1 and chamber 2. Total drying was achieved in both experiments. High temperature of value of 62°c at 1400 hours was recorded. The moisture content was reduced between 15-20% in both experiments. This is in line with the works of Nwokoye et al, (2006) who carried out the same experiment using maize, groundnut and pepper. They found that good drying of the products was achieved with moisture content of the products reducing by 20%.

Conclusion

The use of solar cabinet dryer has been proved as a good means of preservation of the agricultural products. It has also been shown that solar can be used in place of fossil fuel for drying of agricultural produce; thus, making room for savings on the parts of the farmers, open new markets and generally improve the quality of life of the farmers

Food preservation here is seen to have controlled the factors adversely affecting the safety, nutritive value, appearance, texture, flavour and keeping the qualities of the raw materials and processed foods. The analysis of the solar drying has shown that they are cost effective solution to some of the problems of food preservation in sunny climate.

The result of the drying of Okro and Pepper has shown that solar cabinet dryer can be used as effective and safe instrument in the drying and preservation of agricultural produce, and that large quantities of the two products can always be dried and stored and could retain the quality over a period of time.

References

Carl & Hall, (1980), Drying of agricultural Crops, Westport Connecticut: Publishing Company Inc.

Charm, (1978), Fundamentals of food engineering (3rd Ed) AV,Westport Connecticut Publishing Company Inc.

Danshehu,B.G,(2010). The role of solar thermal, in drying and preservation of farm produce. National Workshop on Application of Renewable Energy Devices And Climate For Rural Women in Awka From 20th-28th June,2010.

F.A.O., (2002), Food and agricultural organization of the United Nation Http://Apps.Fao.Org

Ganda, Y. M., Garba M.M., Danshehu B.G., Momoh, M., & Rabiu A. M.(2012) Development and performance evaluation of A PV powered indirect solar dryer. Nigerian *Journal of Solar Energy Vol 23, Number 1.*

Gulma, M., A. (1996), Application of solar technology 2nd Edition, Ahmadu Bello University Press Ltd, Zaria Pp 12-65.

Nwokoye, A.O.C.,(2006), Solar energy technology, other alternative energy resources and environmental sciences, Rex Charles & Patrick Ltd. Nimo, Anambra State. Pp 20-270.

Okonkwo W. I., & Nwoke O. O., (2008) Family size green house solar energy crop dryer.*Nigerian Journal of Solar Energy, Vol 19 Number 2*.