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Ecosystem Based Adaptation for Food Security Assembly

DRYING RATES OF CASSAVA CHIPS IN THE SOLAR DRYER AND TRADITION OPEN SUN DRYING

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CONTENTS

ABSTRACT

Solar drying technology of agri-produce enhance reduction of post-harvest losses in most developing countries. Therefore, solar dryers reduce moisture contents to a level that prevents deterioration within a period of time regarded as the safe storage period. The main aim of this study is to review the efficiency of solar dryer compared to open sun drying. It is found that the efficiency of the solar dryer and drying rate mainly depend upon temperature and size of the solar dryer with blower., geographical location and season when the agri produce is dried, type of product, initial moisture content, total mass of the product loaded on the trays.

Key words: Solar dryer; Open sun drying; Post harvest handling

INTRODUCTION

Solar food drying is one of the oldest farming methods linked to food preservation, but every year, millions of dollars' worth of gross national product is lost through spoilage. Poor preservation methods, ignorance, limited fiancés to obtain post-harvest handling technologies, inaccessible transporting system during harvesting and this affects market accessibility (Alonge & Adeboye, 2012) . The Food and Agriculture Organization of the United Nations (FAO) estimates that food losses in sub-Saharan Africa add up to 4$ billion annually. Furthermore, about 38 percent of total energy consumption in the global food system is utilized to produce food that is either lost or wasted[1] However Post-harvest losses (PHL) have been identified as a crucial challenge to achieving food and nutrition security in sub-Saharan Africa and leading to financial losses to farmers. A solar dryer dehydrating technology of utilizing solar energy to heat solar dryer installed for farming community, this leads to reduction of food wastage of cassava and other agriculture produce and prolong shelf life of those commodities when dried, limits exposure to dust, foreign matters, flies and rodents (Tesfay et al., 2017).

CONTEXT

The solar dryer and open sun drying methods were used for drying cassava to compare which technique is efficient. The dryer proved to be efficient and adapted by farmers compared to other method. The solar dryer managed to record 8.5% moisture content in period of one and half hours. This is better than the 12% moisture content threshold needed to prevent growth of mold, aflatoxins, and yeast.

A digital grain moisture meter enabled to take measures during the process, and data picked was recorded on the data collection sheets to enable recording of data sets. This work was conducted with women supported by UNEP-EBAFOSA their group known as Sugu Agalyawamu Village saving and loan association, it is a female led group which co-operate around the solution of climate action enterprises of communal solar dryers. For decades the group has been engaged in subsistence agriculture and family farming crop mostly grown include cassava, vegetables, where

1 FAO and Uganda join the world to observe the first-ever day against food loss and waste: http://www.fao.org/uganda/news/detail-events/en/c/1310997/

group members have suffered from post-harvest losses where by their cassava is left to rot in the garden due to lack of markets and technology to add value on it. In addition, Africa egg plants ripen and decay on stems because of price fluctuation this forced most of the members to plant less plantations for home consumption. Case in point before this village savings and loans association received communal solar dryer they have been losing as follows a full bag of 100 kilograms of Africa Egg plants has been ranging from 2.85 USD 5.72 USD during a bumper season and this normally happens during March, April to May rainy season which normally is Uganda's main rainfall season and since over 95% of farmers in Uganda depend on rainfed a group also the farmers in the area wait the rains to conduct agriculture. And cassava they have selling a full bag of 100kiligrams selling it 17.14 USD and also leaving some cassava in the garden. Most times middle men (traders) don't buy small and damaged cassava roots this affects the farmers and they end up feed the remains to animals or other leave it decays in the garden.

It was against this backdrop that UNEP-EBAFOSA Uganda came out to support the group with communal solar dryer to reduce those post-harvest losses and provide PHL training to enable increase of shelf life of cassava and vegetables. In addition, Drying allows safe storage of cassava chips over a long period by reducing the biological degradation rate of raw cassava chips. It also results in a considerable reduction in weight and volume, which helps minimize packaging, storage and transportation costs (Pornpraipech et al., 2017).

Study area: The study was conducted in Buikwe district, Sugu village under Sugu Agalyaawamu Women Group in central Uganda, Buganda Kingdom. Agriculture is the major economic activity in Buikwe district. According to the District website the females provide most labor and yet the men take most of the biggest share of farm proceeds. The annual crops are mostly grown for home consumption. The village is on Latitude 0° 9′ 42″ North and Longitude; 32° 56′ 16″ East. The mean annual rainfall is 11,000mm distributed over 106 rain days[2], with peaks in March – May and September – November. Temperatures range between 16oC and 28oc throughout the year[3]. However, 80% of Buikwe is agriculturally based characterized as subsistence production[4]. The products grown in the areas are transported to Kampala city, Mukono town as their big markets.

Description Of the Dryer in Question.

The direct passive solar dryers (natural convection) such as cabinet and greenhouse dryers have a simple and cheap construction (Udomkun, 2020). Development of appropriate climate action solution technologies of convention solar dryer which enable conversion of solar radiation to energy which hits onto the sides of the dryers to dehydrates water from cassava and other crops to less than 12 percent moisture content in cassava recommended by Uganda National Bureau of Standard which is a standard body of Uganda. A solar dryer comprising of a blower which enables fast drying of samples in the dryers. The design of the dryer enabled

2 Buikwe district Relief and Climate, p9, http://npa.go.ug/wp-content/uploads/2017/05/FINAL-DDP-II-BUIKWE-DLG-2015-2020.pdf

3 Buikwe district Hazard, Risk and Vulnerability Profile page-12; https://www.necoc-opm.go.ug/HzCentral/Buikwe%20%20District%20HRV%20Profile.pdf

4 Buikwe district local government; https://buikwe.go.ug/activities/tea-production

Solar dryer on the left & right raised platform

Cassava samples loaded into the solar dryer

Materials and methods of preparation

The performance of the dryer was evaluated by drying fresh gartered cassava chips which are half a centimetre. During the dehydration process sample tests of gartered cassava of 20kgs was placed on 4 solar dryer trays each tray carried 5 kilograms of sample and on the raised ground of one tray having also 20 kilograms which were dried to make the sample not biased. weather conditions were observed on the two days of sample drying.

The digital grain moisture meter was used to take measurement/ readings of the samples.

Material preparation

The materials and equipment used for the investigation are solar dryer and the raised drying surface used for the all drying, clean basins and materials were used fresh cassava roots of NAROCAS1 variety sourced from one of the member's garden. This work followed East Africa Standard EAS 739:2010, when sourcing materials to use for the samples. However attributes put into consideration include; Fresh sweet cassava roots, Mature; free from diseases and pests, not be woody; and not be spongy (UNBS, 2010). All the experiments were conducted in the field at the communal solar dryer center in Sugu village.

Sample preparation

Fresh cassava roots of NAROCAS1 variety were harvested, peeled with knives, washed using clean saucepans, backets and basin with clean water. The cassava was sliced using knives and grated using generic stainless steel flat graters in order to provide the same shape of the sample. 1 and half centimeter of cassava chips size were obtained after grating the cassava sample. Was weighted using weighing scale and 40kilgrams were divided for both methods. The samples were packed on metallic trays to be transferred to the dryer and also on the raised ground, 20 Kgs were spread in the solar dryer on four trays, on the first row and second row respectively. Also, on the raised platform we also managed to dryer 20 kgs of gartered cassava chips. This was to enable both drying methods of the solar dryer and traditional open sun drying have equal kilograms and no bias when conducting the tests. The cassava chips where well spread into the solar dryer trays and outside in open sun drying in order to allow all the samples receive equal sunrays.

Methods Applied in Undertaking the Drying Test

The Cassava samples put in the direct passive solar dryer and traditional open-sun drying on raised platform were monitored by the UNEP-EBAFOSA team to come up with best findings. A grain digital moisture meter was used to measure the moisture content of cassava and temperature of samples inside the solar dryer and outside samples. Sample reading were taken every after two hours interval as you see in table below. Weather conditions were also recorded.

A table was formulated and used by the data collectors to full in the data collected in real time this enabled to have the right data recordings of the samples.

How the solar dryer works

Drying needs moisture to be removed from the product being dehydrated. In thermal drying, this is achieved by utilising heat to the product. When heat is applied, the vapour pressure of the moisture within the product is raised above that of the air surrounding it. Pressure and thermal gradients stimulate the moisture (liquid and vapor) to move towards the surface of the product. Evaporation takes place and water vapor is convected to the surrounding air. This air may become dump however the process of drying continues if this moist air is replaced by less saturated air(Harrison & Andress, 2000).

Solar drying also uses the sun as the heat source. A black sheet surface inside the solar dryer at the bottom fasten dehydration of moisture from food put on the trays, the black iron sheet at bottom absorbs heats which is reflected by the solar UV-treated polythene which is covered on the solar dryer attracts sunrays which are reflected to the black sheet below and helps to increase temperature. Ventilation speeds up the drying time shorter drying times, reduce the risks of food spoilage and mold growth. Polyethylene (P) is the most used material for covering solar dryers in Africa (Rodríguez-Ramírez et al., 2021).

Drying temperature, moisture content, weather of the areas, time interval, kilograms of samples were recorded and measured during the process[5] both sample of solar dryer[6] and open sun drying[7], where observed and recorded using a digital grain moisture meter [8]

Women of Sugu VSLA placing a tray of cassava in the solar dryer

Cassava samples loaded into the soalr dryer

Digital Moisture meter used to measure moisture content and temperature rates of cassava chips

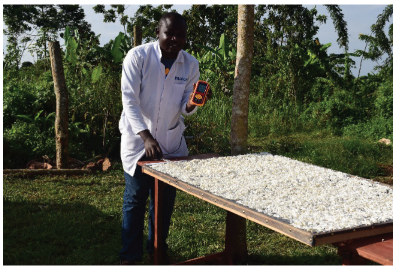
5 Sugu VSLA women group; preparing cassava chips; https://drive.google.com/drive/folders/1zQZGWKQOtS-NjU7OnQZ48PCUANw9M4Lg?usp=sharing

6 Cassava loaded in solar dryer; https://drive.google.com/file/d/1R6lu5rweh2kyGHpSUfUch2tpKFJ_8tdd/view?usp=sharing

7 Open sun drying of cassava chips; https://drive.google.com/drive/folders/1s_hDXLVzeTfpPRlxHPdImAaXORh2cenq?usp=sharing

8 Loading of solar dryers with cassava; https://drive.google.com/file/d/1kv3mpwje8bE5Ifsw7JBOwp0ceg2upHkD/view?usp=sharing

Sugu women group organisng samples of cassava on the raised ground / open sun drying sample.



UNEP-EBAFOSA Officer hold a digital moisture meter. taking readings of samples on the raised platform / open sun drying sample

UNEP-EBAFOSA outreach officer training Sugu women group members how to use a digital moisture meter to pick data.

RESULTS / DATA

Cassava drying rates

Solar dryer drying rates day 1: Table 1 shows the moisture content readings of cassava chips of the solar dryer and samples raised platform. The cassava samples both from the solar dryer and raised platform started with the same moisture content of 31.5% this was because handling of peeling, washing and slicing of cassava. This when the first reading was conducted.

After hour of observation and monitoring of the process, solar dryer cassava samples moisture content reduced from 31.5% to 23.0% this was attributed to high temperatures ranging from 38.5 to 42.0 degrees centigrade although the weather condition was cloudy and associated with windy conditions. tightening of solar dryers' doors, size of the cassava chips ranging from 1 to 2 centimeters. All those factors enabled the solar dryer perform the drying rates.

However, the readings were conducted between a 2 hours interval in day using a digital grain moisture meter and taking readings on samples was give 2 meters of placing the digital moisture meter on the sample to enable capture the best figures.

Table showing Moisture content and temperature rates of cassava inside the dryer Vs traditional open sun drying for day one

Crop dried	Drying rates intervals / Recordings	Weather condition of the area	Time interval of reading samples in the solar dryer	Time interval of reading samples on the open sun shine / ground	Diameters of the samples dried in both	Kilograms dried in solar dryer	Kilograms dried in open sun	Solar dryer drying rates (Moisture levels/ content) (%ages)	Solar dryer Temp readings in degrees Centigrade	Open sun drying rates (Moisture levels)	Open sun drying Temp In degrees Centigrade
Cassava chips	1st reading	Cloudy	10:00 am	10:05am	Grated cassava	20kgs	20kg	31.5%	32.1	31.5%	28.2
	2nd reading	Cloudy	12:00 noon	12:05	Grated cassava			26.0%	38.3	29.0%	31.2
	3rd reading	Sunny	3:00pm	3:05pm	Grated cassava			28.5%	42.0	29.5%	31.6
	4th reading	Sunny	4:00pm	4:05	Grated cassava			27.5%	40.3	26.5%	28.1
	5th reading	Sunny	5:00pm	5:05pm	Grated cassava			23.0%	29.0	23.5%	27.8

Figure 1 Shows the moisture content and temperature rates of cassava inside the dryer Vs traditional open sun drying for day .one

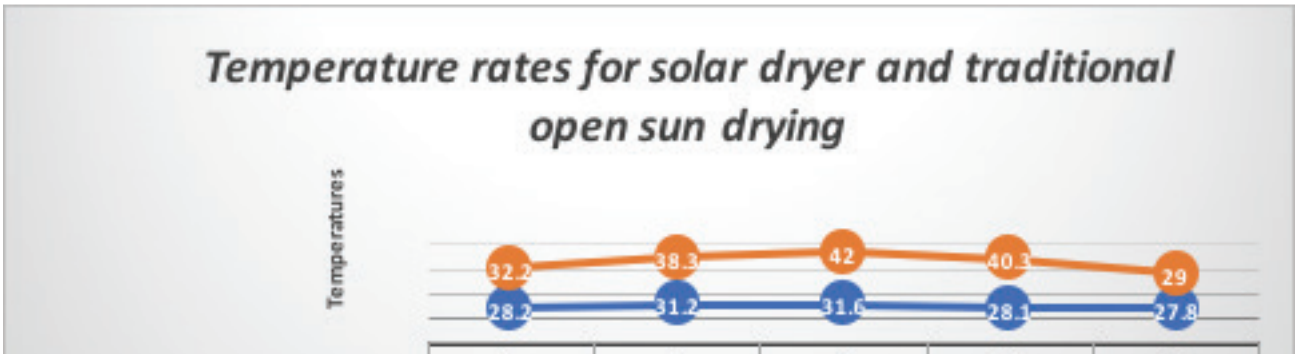
Sample Screenshots of the moisture content and temperature reading of cassava chips using a digital grain moisture meter day 1

Raised platform.

Table 1 also shows the moisture content readings of cassava chips dried on raised platform. 20Kgs of cassava chips were dried on raised ground. This involved spreading out fresh cassava on raised platform. Open sun drying rates moisture content reading at the first reading was 31.5% at temperature rate of 28.2 ^{0}C at the first hours at 10:05am.

The reading was taken after every after 2 hours and moisture content of 23.5% at temperature rate of 27.8 ^{0}C. Moisture content ranging taken from 5 readings interval on the first day include was attributed to the available air circulation, windy conditions which speed up the drying rates. The discrepancy could be attributed to the difference in locality, weather conditions of the area.

Temperature is one of the factors which enhance drying of samples both in solar dryer and open sun drying. Observations were seen that solar dryer temperature rates where high and continued increasing compared to open sun drying rates. The maximum temperature obtained in solar dryer and opening dying were 42 °C and 31.6 °C respectively see in (**Figure 2)** below



	1	2	3	4	5
solar dryer readings in degres centigrade	32.2	38.3	42	40.3	29
Open sun drying Temp In degrees Centigrade	28.2	31.2	31.6	28.1	27.8

Figure 2 Temperature rates for solar dryer and traditional open sun drying day one

The temperatures where too low on day one because it was cloudy from 10:00 am to noon although it was cloudy the solar dryer recorded high temperatures than outside with the highest 42^{0}c . Observation show that the solar dryer when used by farmers it fasten drying of agricultural produce.

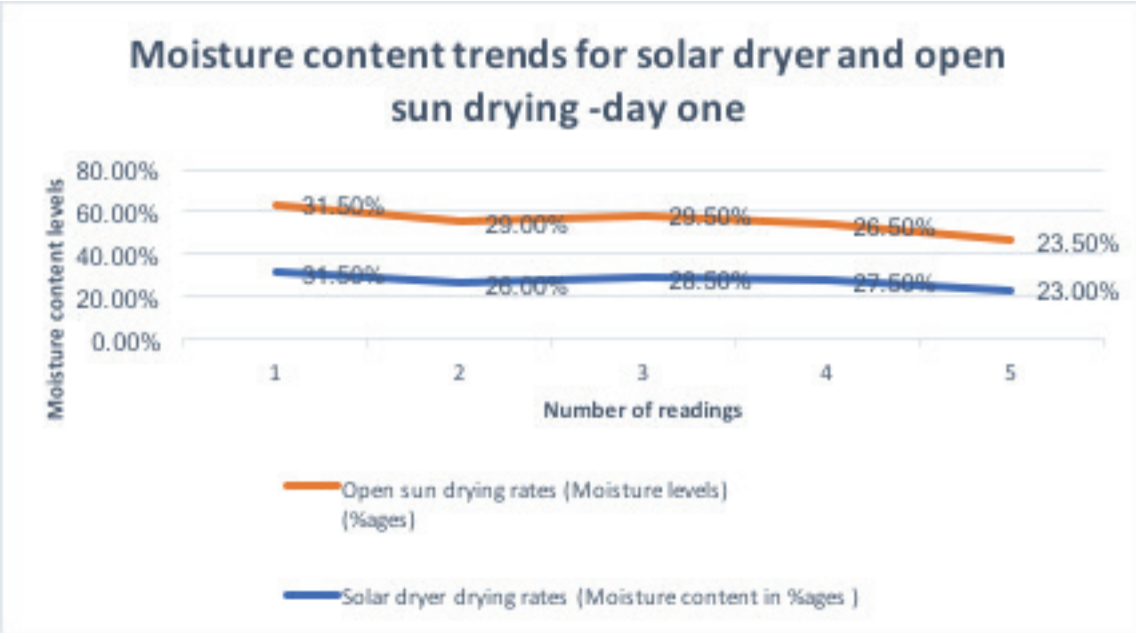


Figure 3 moisture content rate trends for solar dryer and open sun drying for day one

The moisture content on the first day was average because this when cassava contained a lot of water. Both the samples stared with 31.5% moisture content. As we continue at the end of the day solar dryer moisture content of samples reduced faster than open sun drying.

Drying rates day 2: Table 2 below shows the moisture content readings of cassava chips of the solar dryer and samples dried in the open in the day 2.

Crop dried	Drying rates intervals / Recordings	Weather condition of the area	Time interval of reading samples in the solar dryer	Time interval of reading samples on the open sunshine / ground	Diameters of the samples dried in both	Kilograms dried in solar dryer	Kilograms dried in open sun	Solar dryer drying rates (Moisture content) (%ages)	Solar dryer Temp readings in degrees Centigrade	Open sun drying rates (Moisture content) %age	Open sun drying Temp In degrees Centigrade
Cassava chips	1st reading	Cloudy	10:00 am	10:05am	Grated cassava	20kg	20kg	24.0%	36.2	18.5%	30.7
	2nd reading	Sunny	12:00 noon	12:05	Grated cassava			14.0%	47.1	18.0%	38.8
	3rd reading	Sunny	2:00pm	2:00pm	Grated cassava			13.0%	52.3	10.5%	40.5
	4th reading	Sunny	4:30pm	4:32	Grated cassava			8.5%	34.1	9.0%	32.5

Figure 4 of the sample recording show the performance of cassava chips in the solar dryer which on the second day

Sample Screenshots of the moisture content and temperature reading of cassava chips using a digital grain moisture meter day 2

Figure 4 of the sample recording show the performance of cassava chips in the solar dryer which on the second day started reading at 10:00am with moisture content of 24.0% to 8.5 % for samples in the solar dryer.

The moisture content rates were attributed to the high temperatures in side the solar dryer and solar dryer was tightened, not opened widely when taking samples. Though observation at night the solar dryer also releases some heat which made the sample dry very first. This will be more explained in the analysis section on graphs and bar graphs.

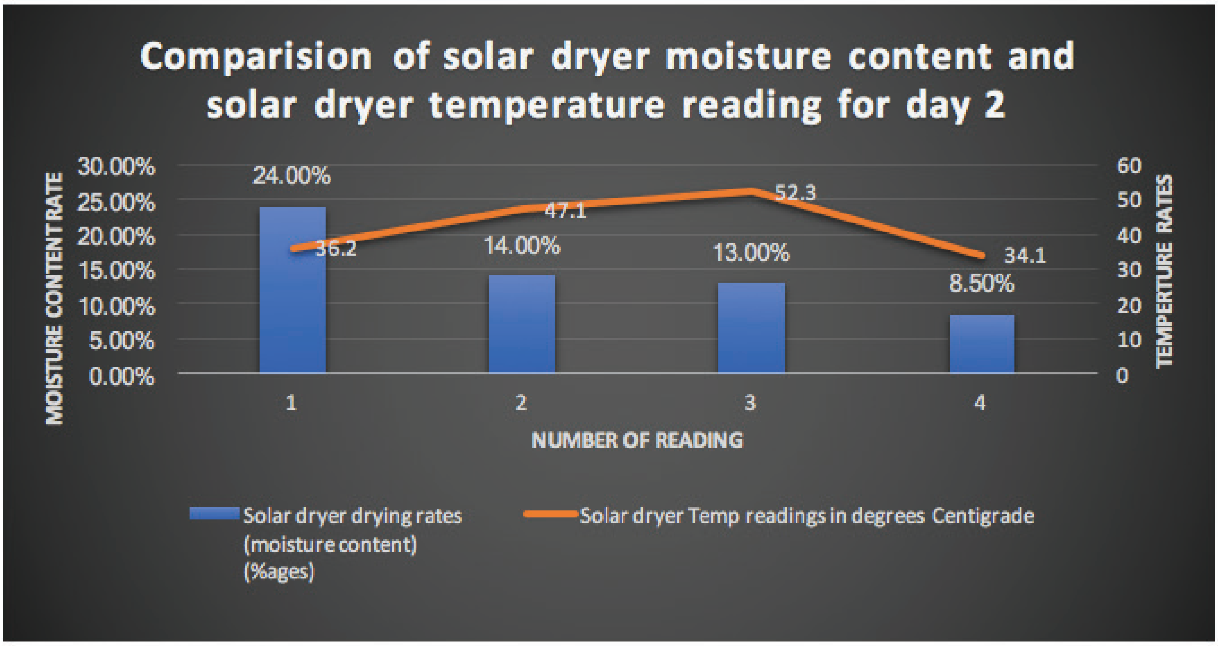
Due to the sunny conditions which increased the temperature in the solar dryer to 47.1 we measured and got 14% moisture content levels, this was attributed to the high temperatures in the solar dryer, giving use evidence that the higher the temperature the lower the moisture content in the samples.

- As we continued with the reading at 2:00pm the temperatures increased to 52.3^{0}C centigrade inside the solar dryer was too hot and now living organisms can stay alive in the dryer.
- After two hours we conducted the fourth reading of the samples of the second day the temperature had reduced from 52.3 to 34.1^{0}C. And moisture content of the sample was 8.5%.
- However, in 1 day and 6 hours the solar dryer cassava samples are reading 8.5% moisture content reading. According to Uganda National Bureau of Standard 12% moisture content is recommended for cassava to dry (UNBS, 2010). Table 3 explains this dried cassava chips specification by national standard body

Parameter	Requirement	Method of test
Moisture content, by mass, %, maximum	12	ISO 712
Crude ash on dry matter basis %, maximum	3	ISO 2171
Acid insoluble ash, on dry matter basis, %, maximum	0.15	EAS 82
Crude fibre on dry matter basis %, maximum	2	ISO 5498
Hydrogen cyanide mg/kg, dry matter basis max	10	DEAS 744

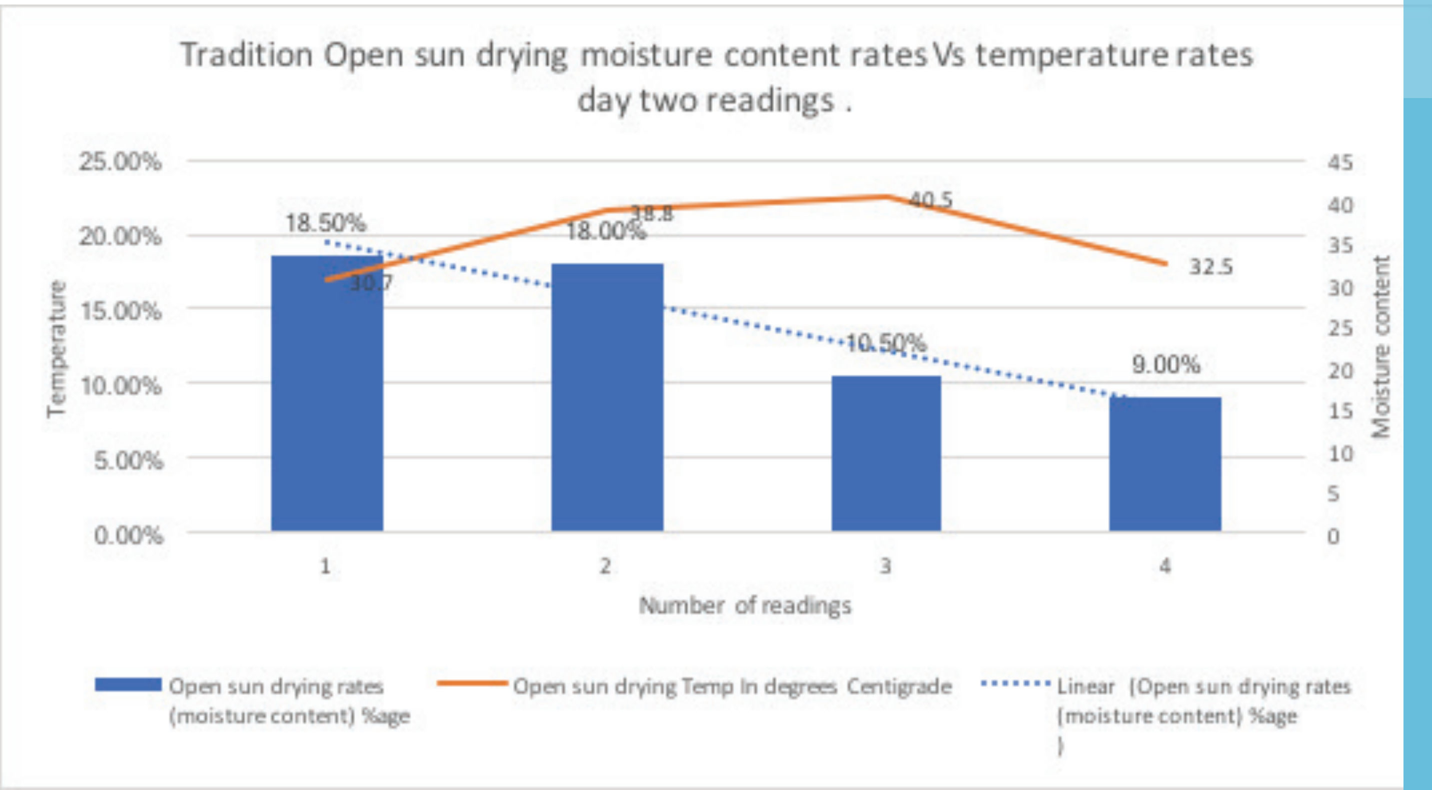
Figure 5 Compositional requirements for dried cassava chips. *Source: Uganda National Bureau of Standards*

In figure 4, we observed that some of the grated cassava dried mainly at the edge of the solar dryer trays because they are well spaced and also isolated. We expect the solar dryer to dry faster than open sun drying because the temperature of the solar dryer is higher than outside.



.Figure 6 Comparison of solar dryer moisture content and temperature rates

Tradition open sun drying: Method started with moisture content of 18.50% on the second day with temperature of 30.7 degrees centigrade. this was attributed to air circulation and windy condition of the location we conducted the drying. This was attributed to following factors; The drying rate for cassava chips was observed to increase with increase in temperature as you see in (**figure 7) below.** The high circulation of air outside led to the samples outside to dry fast. And the windy and sunny conditions which were observed on that day.



.Figure 7 Graph showing readings of tradition open sun drying moisture content rates vs temperature rates for day two

Comparison of temperature of solar dryer and open sun drying day two

The results shows that drying rate in the solar dryer was also found to be higher than traditional open sun dryings of cassava, this explains that high temperature enables samples to dry faster. On the second day the solar dryer registered the highest temperature of 52.3 and the same time open sun drying had 40.5 degrees centigrade. The efficiency of the solar dryer is seen on the rate of temperature it produces.

Observations from the (figure 7) shows that temperature during drying of trays of samples increased from reading 1 to 4th reading from 36.2 ^{0}C, 47.1^0 C, 52.3^0 C, 34.1^0 C. Compared to open sun drying which registered 40.5 ^{0}C as highest of the day.

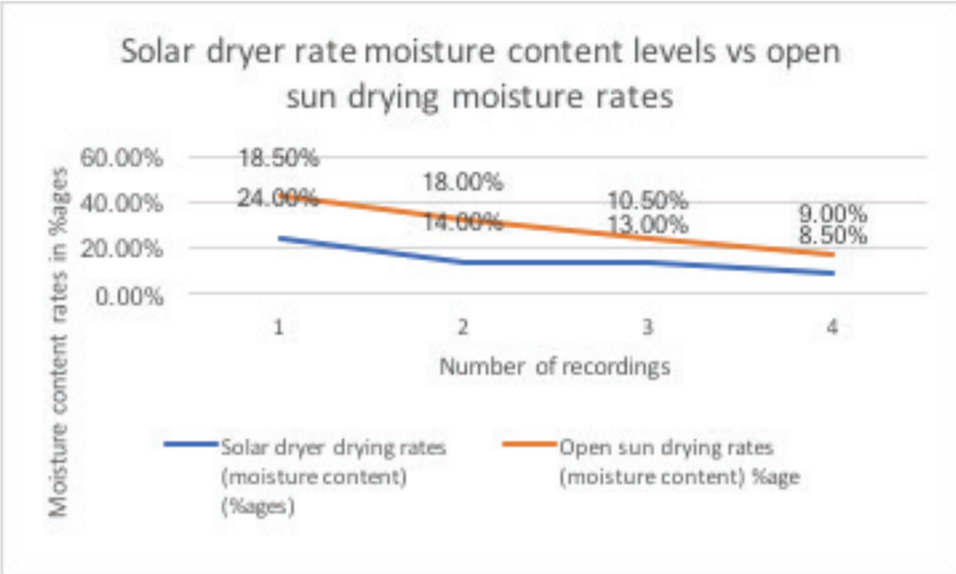
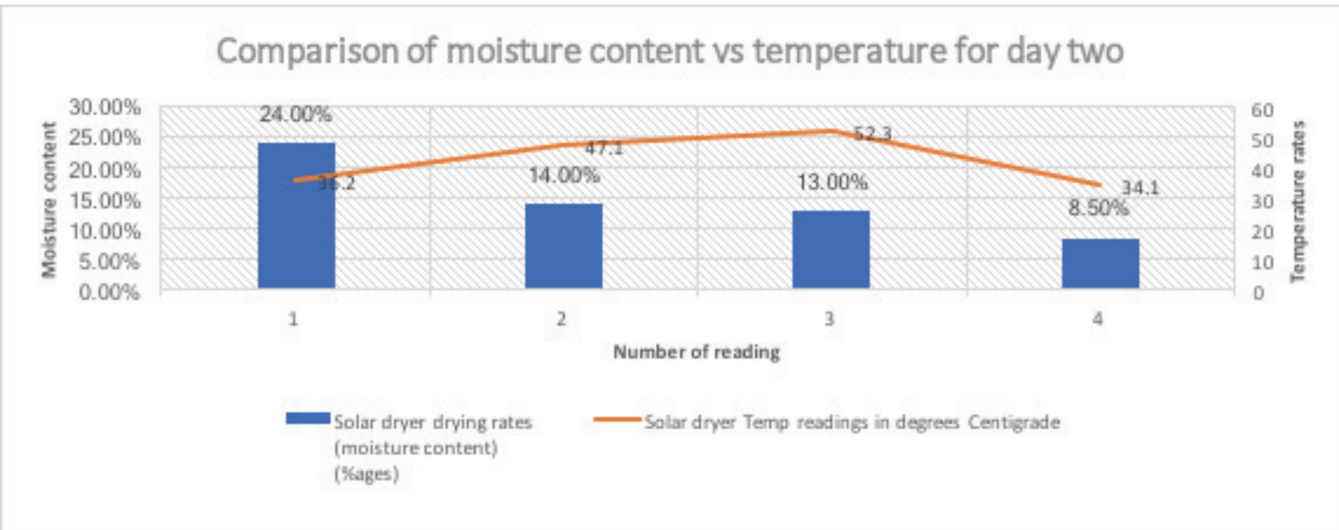


Figure 8 Moisture content level in the graph for day 2 readings

Figure 8: Observation show that Samples in the solar dryer dried very fasted because the solar dryer has a blower which enables letting air which blows/push warm air to the extreme end of the dryer and trays to enable samples dry uniformly.

Traditional open sun drying reduction in moisture content is attributed to the open-air circulation which also enables to fasten the drying. Both samples of cassava chips in the dryer and open sun drying were well spaced and spread to allow each unit receive the same temperature.



.Figure 9 comparison of moisture content and temperature rates of day two readings

Figure 9- moisture content reduced with increase in temperature. On start of recording of reading it was sunny and the all day it was hot. This enables the solar dryer absorb high temperatures which results into 85.5% moisture content.

Why should we use solar drying instead of open sun drying?

According to the study conduct some of the advantages of using a solar dryer compared to open drying were observed in the committee during the gap analysis to cassava farmers. In comparison to the traditional way of drying outside in an open field, solar dryers prevent contamination of produce by dust, insects, etc., thereby ensuring quality. They allow small-scale farmers to transform their harvest into storable and tradable goods, which they can sell off-season at higher prices. Other benefits of the solar drying include;

- No foreign material like sand, stones in the dried samples.
- Reduced wastage of the agricultural product during drying
- Improved product quality, according to the study conducted cassava dried in the dryers was color white with no smile while open sun drying quality of products were compromised due rainfall conditions, attract of sand and animal waste.
- Reduced wastage of the agricultural product during drying
- reduction in the drying time. For example, on the study we have conducted the solar dryer managed to dry cassava to 8.5% moisture content in one and half hours
- Potential product loss during open sun drying this happen when rain comes the product has to be covered or transferred to the house /store, sometimes the product is kept in the same store with animals and poultry

incremental price the solar dried product can fetch in the market as compared to the open sun-dried product because the cassava dried in the drier remain in white color, no odor.

CONCLUSION

On the other hand, traditional open sun drying practiced on a large scale in the rural areas of Uganda. Population suffers from high product losses due to inadequate drying, fungal growth, encroachment of insects, birds and rodents, etc. Properly designed solar dryers may provide a much-needed appropriate alternative for drying of some of the agricultural products in rural agricultural communities.

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APPENDICES

Frist day Google drive photos of the moisture meter reading include the following

https://drive.google.com/drive/folders/11oZwnsemzMl24uLjB7kVwdIoEWAbRA8I?usp=sharing

Second day Google drive photos to show evidence of the reading of samples using moisture meter

https://drive.google.com/drive/folders/1teinrPy_sgnvP8dez1lGoRFbKz1hs2RX?usp=sharing

Sugu Village saving and loans association training photos

https://drive.google.com/drive/folders/1JxdiLyBK-ft02nfVEwUXCf6gXv8Wm9ss?usp=sharing

Video explaining the testing rates on the ground by our operational officer

https://drive.google.com/file/d/1hOPLjmP54VyvwwII70LHNHnhf-RcOkNI/view?usp=sharing

https://drive.google.com/file/d/1iTvSCGGiMUysek6dBnjtXgGbTjYKBnrR/view?usp=sharing

https://drive.google.com/file/d/19yUsrXVq1TuX9eOMetdpP_seImRzt-qw/view?usp=sharing

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