Journal of Food Science and Engineering 7 (2017) 453-457
doi: 10.17265/2159-5828/2017.09.005

Evaluating Low Cost and Sustainable High Quality Cassava Drying Technologies among Small and Medium Processors in Uganda

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Abstract: Cassava regarded as a white gold of Africa is driving the agricultural commercialization and industrialization with small to medium technologies in Uganda. There is an over-whelming demand for high quality cassava flour (HQCF) by Bakeries, beverage industry, paper board and composite end markets. The end market for HQCF dictates on its quality attributes and rewards for its quality in terms of price offered within their minimum standards. However, obtaining sustainable amounts of HQCF for these markets calls for devoted efforts. Limited types of HQCF processing technologies exist and if they exist, their efficiency, costs and sustainability are not well understood. We evaluated high quality cassava drying technologies in Northern and Eastern Uganda in two years using naturally ventilated wooden screen solar drying structures and open air sun drying structures. Naturally ventilated wooden screen solar dryers produced clean dry high quality cassava chips free off insect and bird contamination and caused faster drying to less than 14.3% MC in 1.5 hours than open outside drying conditions. We recommend naturally ventilated wooden screen solar dryers for small and medium cassava processors during dry and rainy season. Half tone to one tone cassava chips dryers per day drying unit can cost one 2,258-4,338 USD to make it functional. Also open outside raised metallic racks with black surface can give good results on a good sunny day especially for starters on small scale basis. A small durable unit of 150 kilograms per day can be made with 500 USD.

Key words: High quality cassava chips, cassava grits, naturally ventilated wooden screen solar dryers, HQCF, open air sun drying structures, raised metallic drying racks.

1. Introduction

Cassava is a most important energy source in the diet of many people living in the tropics where it is a staple food for over 800 million people [4]. The promotion for farmer's use of high yielding varieties in Uganda like NASE 14, NASE 19 and NAROCASS I with good tolerance to cassava viral loads has gained momentum in the cassava growing and processing areas in Uganda to meet the challenging local demands for fresh cassava roots and high quality cassava flour (HQCF). Cassava processing in Uganda is done by small and medium entrepreneurs (SMEs) and community processing groups (CPGs) under cassava adding value for Africa project (CAVA II) using low cost, small to medium technologies [2]. Cassava tubers are very bulky (with high moisture content) and highly perishable with a very short fresh shelf life [8]. However, the moisture content of properly dried food is over twelve percent. Drying can be achieved with presence of enough solar radiation to draw out moisture without gelatinizing the cassava, with dry air to absorb the released hot moisture and adequate air circulation to carry off the hot moisture [7, 8].

Achievement of a quick and perfect moisture removal at a temperature which does not affect the flavor and texture but maintains the natural white/cream color is adequate. Several cassava

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processors in Uganda use open air or sun drying screen solar dryers but these have not been evaluated and documented for their efficiency in Uganda. The need for cassava drying structures with locally available material is a necessity. This main objective of this work was to contribute to improvement of cassava flour quality using low cost drying technologies and specifically to assess the drying rate of locally constructed solar dryers and the open sun dryers in Uganda.

2. Materials and Methods

The experiment was conducted in Apac Processing site, Alelopek village in Middle North of Uganda with temperature range of (Max 30-35 °C and Min 18-20 °C) and rainfall of 1,100-1,500 mm per annum for natural wooden and ventilated screen solar dryers and open sun drying of high quality cassava chips. The open sun drying of grits was done in Kadama, Budaka district Eastern Uganda with average rainfall of 900-1,500 mm and temperatures maximum of 32.520 °C.

2.1 Naturally Ventilated Wooden Screen Solar Drying Technology

The naturally ventilated screen solar dryers of 8 by 15 m were made of UV paper clear (top cover) of 200 microns with a thermicity of 85% to allow in solar radiation through while shielding the drying chips/grits from the rain, besides providing anti drip properties. The roof was made up of eucalyptus tree materials with nails, hoop iron to make a gable roof with an overlap on the windward side. The walls were made of king poles from eucalyptus trees and covered with an insect net to allow in cool air which replaces the hot air out through a special vent on top. The king poles with the back surface removed were first covered with a black polysene two feet above and fixed in 1.5 feet concreted holes to shield off wood feeding insects. The concreted coating was raised by one foot above with a smooth screed. On top of the dryer an open insect netted vent was left with an overhang to block off flying insects. Inside the dryer one meter raised metallic racks with a mesh bed were fixed as drying surface following the designs, in Refs. [3] and [11].

2.2 Open Raised Metallic's Racks Drying Technology

The raised metallic racks for drying were locally fabricated from galvanized angle bars to form a 4 by 8 feet rectangular housing to hold the welded wire mesh (gauge 8) for perforation and joined to form a drying bed, hollow section pipe of 20 by 20 mm cut to support and reinforce the welded wire mesh and fixed on the ground by 1.2 m height rounded pipes (50 by 50 mm) as stands fixed down the ground with a concrete mix. The raised metallic racks were painted white with a food grade material. And on the raised metallic rack we put a black surface made of black polysene material following the design of Ref. [3].

To study the effect of the naturally ventilated wooden screen solar dryer we used three drying conditions inside the dryer that is one meter raised metallic racks with a black surface on top as a drying surface, black surface on the floor as drying surface and a double black surface drying racks (black surface on top and under the drying racks). The black surface was made up of black polysene paper with a thick material. We compared these with open sun drying outside. The open sun drying conditions outside were also modified to have two conditions; one meter raised metallic racks with a black surface and a black surface on the ground as the farmers' way following the procedures of Refs. [4, 5, 7].

The fresh cassava roots were peeled using stainless knives, washed thoroughly 3-times with clean water and chipped into 2 to 3 cm length and 1-3 mm thickness using a motorized chipper machine of 5.5 HP (petrol engine). Also the grits were made to 1-2 mm thickens using a motorized grater machine of 5.5 HP (petrol engine). Weigh 3.5 kg of chips/grits using a salter scale into polysene bags following the procedures of Ref. [5].

The initial percentage moisture contents were taken, room temperature and relative humidity for both inside the dryer and outside drying conditions recorded. The percentage moisture content and temperature of the drying sample was taken using a cup moisture meter. The room temperature was taken using an ordinary thermometer and humidity of the surrounding air using a sensor meter (model-MC 7825G). The samples were spread to one single layer (10 mm) for drying based on the five treatments after taking the initial moisture content and temperature following Ref. [5].

The samples were dried using the naturally ventilated wooden screen solar dryer and open sun drying conditions outside. Subsequently the chips/grits were turned after every 30 minutes with temperature and moisture content reading taken following the procedures of Ref. [8]. The samples were observed for color and still retained the variety color of white/cream and pH of the dry chips was taken using a pH meter HI 98128 and averaged at chips (pH = 6.11) and dry grits (pH = 6.12).

2.3 Data Collection and Data Analysis

Data were collected three times in a day considering two seasons in each year for two years and analyzed. The drying technologies (naturally ventilated wooden screen solar dryer and open air outside drying conditions) were designated as raised inside top black surfaced racks, black surfaced floor, raised inside double black surfaced racks, open outside raised black surfaced racks and open outside black surfaced ground as fixed factors in the analysis model to generate means. The microclimate (relative humidity and temperature) inside the dryer and open air outside was recorded and averaged as before noon and afternoon. The analysis was done in SPSS PASW Statistics for Windows, Version 18.0. [10].

3. Results and Discussion

The drying of high quality cassava chips inside the naturally ventilated wooden screen solar dryer was steadily faster throughout the drying process attaining 12.6% MC by 1.5 hours on the inside double black surfaced compared to the outside open drying conditions. The open outside raised black surfaced racks were faster than the outside black surfaced ground. Overall the conditions inside the naturally ventilated wooden screen solar dryer were faster than the condition outside the dryer (Table 1).

The drying of HQCG was faster on open outside raised black surfaced racks than open outside black surfaced ground attaining the percentage moisture content of 12.1% compared to 14% in two hours (Fig. 1).

The naturally ventilated wooden screen solar dryer had higher average temperatures in the afternoon (46.7 °C) compared to the open air outside the dryer. The average relative humidity in the open air did not differ with relative humidity inside the naturally ventilated wooden screen solar dryer throughout the study period (Fig. 2).

Table 1 Loss of moisture by drying time in the naturally wooden screen solar dryer.

Time (hrs)	% mc SBSRI	% mc RDBSRI	% mc BFI	% mc ORBSRO	% mc OBGO
Initial	40.25	40.25	40.25	40.5	40.5
0.5	38.8	35.1	38.9	39	39
1	20.9	19.85	21.55	20.9	20.8
1.5	14.3	12.6	14.8	14.9	14.8
2	10.2	7.2	12	11	11
2.5	10.4	7.1	10.3	10.8	10.7
3	8.1	6.9	9.2	9	9
3.5	6.9	6.4	8.1	7.5	7.5

Single black surfaced racks inside (SBSRI); Raised double black surfaced racks inside (RDBSRI); Black floor inside (BFI); Open raised black surfaced racks outside (ORBSRO); Open black ground outside (OBGO).

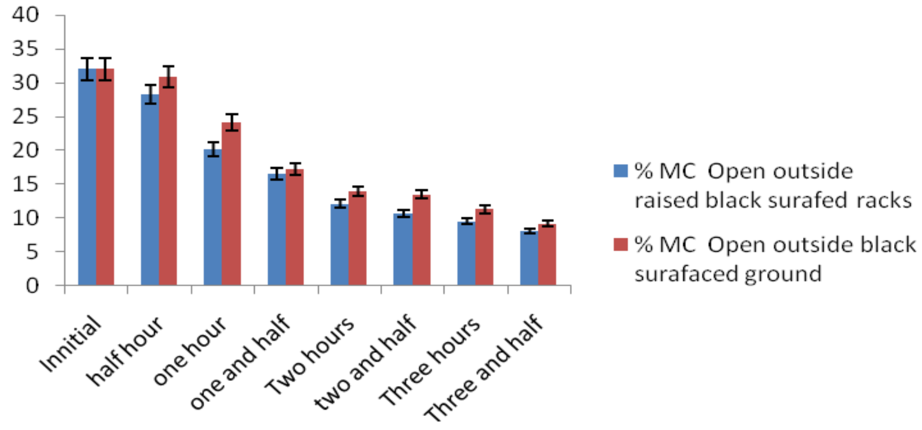

Fig. 1 Loss of moisture content from high quality cassava grits by drying time and drying technology.

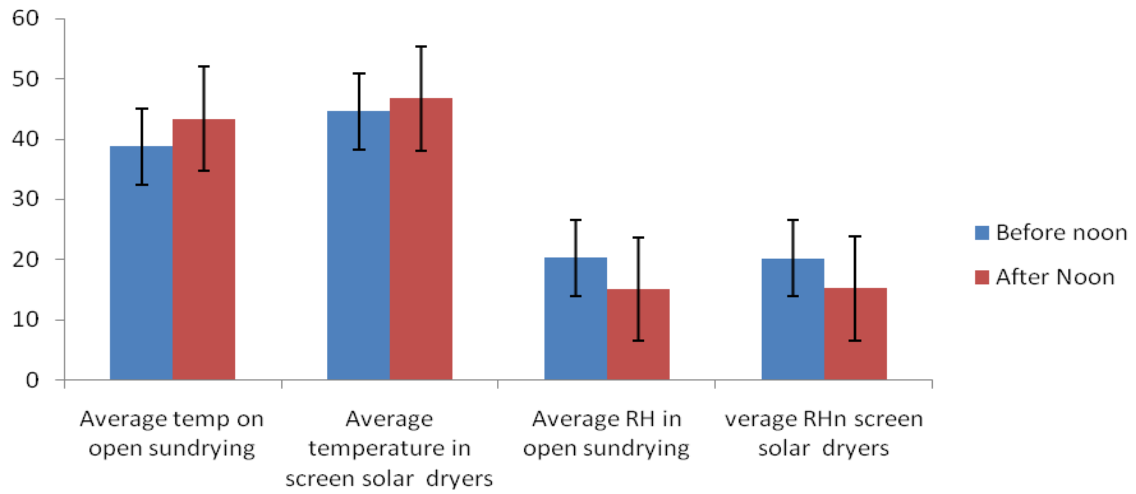

Fig. 2 Microclimatic conditions in the naturally ventilated wooden screen solar dryer and open air outside the dryer with time of the day.

The drying conditions inside the naturally ventilated wooden screen dryer were attributed to higher temperatures build up inside the dryer due to the higher thermicity of the top cover allowing solar radiation which warmed up the air inside the dryer. The insect netting at the walls allowed in cool air which replaced the heated up air inside the dryer forcing it out through the top insect netted vent. This is in line with the work of Ref. [9] reporting the performance of drying surfaces. Also the work done by Refs. [1], [6], [13] and [14] reported a reduction of drying time with use of conventional dryers.

The blacked surface absorbed heat and heated up the drying cassava causing the loss of moisture on the top drying surface and creating the drying process. This is in line heat absorption by black colors ENC.com [12].

The raised metallic racks allows in faster air circulation on top and below causing faster removal of heated up moisture by steadily repulsing with cool air from outside. The ground outside takes time to heat up and allows only on the top air circulation hence causing a delay in the drying which was also the case with floor inside the naturally ventilated wooden screen solar dryer without racks. This is synonymous to the work of Ref. [9] reporting better performance on perforated surfaces.

4. Conclusion

Naturally ventilated wooden screen solar dryers produce clean white/cream HQCF free off insect and bird contamination. It shields off rain losses and reduces the drying time much faster than open sun drying. This ensures that the processors could make two-three drying rounds/day and be active all year around with a constant supply of HQCF for the existing markets. Half to one tone dryers/day can cost one 2,258-4,338 USD to make it functional and meet the daily market demand needs.

Also open outside raised metallic racks with black surface can give good drying results especially for starters on a sunny clear day for small scale basis. Small durable unit of 150 kilograms/day can be made with 500 USD.

5. Recommendations

We therefore recommend naturally ventilated wooden screen solar dryers for small and medium processors and open raised metallic racks for beginners with small startup capital.

Acknowledgement

We acknowledge support from Federal University of Agriculture Abeoukuta, Nigeria through the Cassava Adding Value for Africa Project, Natural resources Institute of Greenwich through the Cassava Gmarkets Project.

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