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COMPARATIVE EVALUATION OF NSPRI SOLAR DRYERS USING FERMENTED CASSAVA (*Lafun*) AND CASSAVA CHIPS

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ABSTRACT

This study investigated the comparative evaluation of two Nigerian Stored Products Research Institute (NSPRI) solar dryers, namely Parabolic Shaped Solar dryer (PSSD) and Solar Tent Dryer (STD) by using fermented cassava mash and chips. The study was conducted at NSPRI headquarters, Ilorin, Kwara State. Fresh cassava roots curtivar (oko iyawo) was acquired at a farm in Ilorin. The roots were peeled, soaked and fermented for 4 days to form mash and later bagged and pressed with NSPRI hydraulic press overnight while the other roots were converted into chips using NSPRI mechanical chipping machine. Both products (mashed and chips) were weighed and loaded on trays and placed on layers of the NSPRI solar dryers. Drying temperature, drying rate, moisture content and microbial analysis were used to evaluate the performance of the dryers. The average drying temperature results of cassava mash within the drying media were 43.68 °C, 37.53 °C and 30.65 °C for PSSD, STD and Ambient respectively, while the average drying temperature of cassava chip were 31.4 ^{o}C, 27.2 ^{o}C, and 29.3 ^{o}C for PSSD, STD and Ambient respectively. The average drying rate of cassava mash were 361.1 g/day, 329.4 g/day and 324.5 g/day for PSSD, STD and Ambient respectively while the average drying rate of cassava chip were 318.8 g/day, 242.5 g/day and 310.8 g/day for PSSD, STD and Ambient respectively. The result showed that PSSD gave the highest temperature variation and drying rate for both drying of cassava mash and chips. As regard moisture content, both dryers were able to dry the cassava mash from initial moisture content of 49.74 % w.b to safe moisture content (w.b) of 10.45 and 11.4 % for PSSD and STD in four days respectively, and cassava chip from initial moisture content of 51.9% w.b. to safe moisture content (w.b) of 11.0 and 13.8% for PSSD and STD in five days respectively. The Total Viable count (TVC) were observed to be within the permissible limit of 300 cfu/g for both products in the dryers. The study showed that NSPRI solar dryers are potentially viable to achieve not only faster drying but also safer and more hygienic dried fermented cassava and cassava chips.

Keywords: Cassava chips, cassava mash, drying rate, moisture content, solar dryer.

INTRODUCTION

Cassava (Manihot esculenta Crantz), a major root crop grown in many tropical parts of the world supplies about 70% of the daily calorie requirement for over 50 million people in Nigeria (Oluwole et al., 2004). Cassava is ranked fourth and ninth in term of dietary energy supply in the Tropics and world respectively (FAO, 1999). The crop is tolerant to draught and can withstand low soil fertility, pest, and diseases (Clifton and Keogh, 2016). It is also not seasonal, and its availability all year round makes it a preferred alternative to other energy-rich seasonal crops (Alonge et al., 2007; FAO, 1999). These attributes have made cassava a crop of primary importance for food security as well as improved farmers' income especially in fragile and socially unstable environments.

Cassava root is prone to postharvest losses due to its perishability, hence the need for preservation or processing usually in the form of heat treatment into more stable cassava products (Aderinlewo *et al*., 2013). Cassava is usually processed immediately after harvest. Cassava roots are highly perishable, and a lot of postharvest losses occur to this commodity during storage due to high physiological and microorganisms' activities that penetrate bruises received during harvesting as well as the inherent high moisture content of fresh roots. These promote both microbial deterioration and unfavourable biochemical changes in the commodity (FAO, 1999; Wenham, 1995). Estimate of cassava use in Nigeria shows that about 84% of annual production is processed into various foods for local consumption (Sanni *et al*., 2015). Notable among products of cassava that are most widely consumed in Nigeria and require drying or other form of heat treatment are cassava flour, cassava chips, gari (fermented and gelatinized cassava meal) and fermented cassava flour (Oluwole *et al*., 2004).

Drying kinetics of food crops are generally affected by factors which include drying temperature, pretreatment, airflow rate, relative humidity, exposure time, types, variety and size of the produce, initial moisture content and drying thickness (Chakraverty and Singh, 2014). Drying curve represents a typical case when a wet solid loses moisture initially by evaporation from a saturated surface on a solid, followed by a period of evaporation from a saturated surface on a solid (constant rate period), followed by a period of evaporation from a saturated surface of gradually decreasing area and finally when the latter evaporated in the interior of the solid (falling rate period) (Hii, 2012). In the constant rate period, drying takes place by surface evaporation and moisture moves by vapor pressure difference. The falling rate period enters after the constant drying rate period and controlled largely by the product and is dependent upon the movement of moisture within the material from the center to the surface by liquid diffusion and removal of moisture from the surface of the product (Chakraverty and Singh, 2014). Thus, research has been carried out on the drying characteristics and kinetics of various food crops (Argo *et al*., 2018; Ajala *et al*., 2012; Tunde-Akintunde and Afon, 2010; Goyal, *et al*., 2008; Vengaiah and Pandey, 2007; Sacilik *et al*., 2006).

In the rural areas, sun drying is the most widely practiced technique of drying cassava products because it is simple, readily available, accessible, and cheap. The disadvantages of this method include extended drying time, contamination from exposure to environmental conditions, and undesirable colour changes which significantly lowers the quality of the dried products (Aderinlewo *et al*., 2013). Simple solar dryers in which heated air rises by natural convection through the product has been proposed for rural areas (Basunia and Abe, 2001). The dryers are constructed from low cost, locally available material consequently eliminating dependence on electricity and fossil fuels which are scarce commodities in these rural areas. They also provide an enclosure which shields product from contaminants and adverse environmental conditions. Cost effectiveness and hygienic ways of preserving foods are of great importance given the prevailing insecurity in food supplies throughout the world (Sobukola *et al*., 2007). Various forms of natural–circulation greenhouse dryers have been modified by various researchers over the years (Rathore and Panwar, 2010; Fleming *et al*., 1986; Sachithananthan *et al*., 1983; Doe *et al*., 1977). Passive solar greenhouse dryers are designed with vents of appropriate size and position to have a controlled air flow. They are characterized by extensive glazing by the transparent cover of polyethylene sheet, polycarbonate or acrylic material (Hii, 2012). Other improved methods of drying cassava products include solar drying and artificial drying using mechanical dryers (Alonge *et al*., 2007).

Access to efficient and affordable solar dryers which can be used for community drying has been an issue especially among farmers in Nigeria. In view of this, Nigerian Stored Products Research Institute (NSPRI) has developed a number of solar dryers in order to proffer solutions to threat to food safety as well as farmers and processors quest for drying with minimal energy and cost without quality compromise. Therefore, this work sought to compare the drying effectiveness of two NSPRI solar dryers; parabolic shaped solar dryer (PSSD) and solar tent dryer (STD) for drying of fermented cassava mash and cassava chips with respect to drying parameters and microbial quality.

MATERIALS AND METHODS

Dryers Description

Parabolic Shaped Solar Dryer (PSSD)

The PSSD (Figure 1) has a structural dimension of 6.46 m x 4.12 m x 2.2 m. It has a black floor painted with food grade paint for heat collection and an underlying polyurethane insulator that prevents heat sink. It has a parabolic shaped structural frame of 2.2 m height made of 25 mm diameter galvanized steel pipes. The cover is made of a transparent acrylic material. The drying chamber has two drying racks with four layers each made of mild steel angle iron, and fifty-six trays of 0.55 m x 0.55 m made of 25 x 25 mm square pipe and galvanized wire mesh. The dryer has an effective drying area of 16.94 m^2. There are two inlet vents with installed solar powered blowers. The top is fitted with two pneumatic aspirators for extraction of moisture from drying chamber. An access door is also provided at one end of the structure.

Solar Tent Dryer (STD)

The STD (Figure 2) has a structural dimension of 3.9 m x 3.37 m x 3.16 m. It has a black floor painted with food grade paint for heat collection and an underlying polyurethane insulator that prevents heat sink. It has structural frame of 3.16 m height made of wooden posts erected on a dwarf block wall of 0.8 m height. The dryer is covered with transparent polythene film. The drying chamber has a drying rack with three layers made of wood and twelve trays of 0.70 m x 0.75 m and six trays of 0.55 m x 0.75 m made of wood and galvanized wire mesh. The dryer has an effective drying area of 8.48 m^2. There are three adjustable inlet vents on each side of the dwarf walls. The top is fitted with one pneumatic aspirator for extraction of moisture from drying chamber. An access door is also provided at one end of the structure.

Figure 1. Parabolic Shaped Solar Dryer

Figure 2. Solar Ten dryer

Time and Location of the Experiment

The study of the effectiveness of the dryers using fermented cassava was carried out during the dry season in February 2019 while that of cassava chip was carried out during the wet season in July 2019 at Nigerian Stored Products Research Institute (NSPRI), Ilorin, Kwara State (N 8°27'13.218"; E 4°33'22.349") with an average annual temperature and wind velocity of 26 °C and 3.0 m/s respectively (Weatherspark, 2020).

Experimental Procedure

Wet Fermented Cassava Mash Production

Fresh cassava root (12 months old, local variety *Oko iyawo* (TME 7)) was purchased from a farm in Ilorin. The roots were peeled manually using stainless knife and weighed using electronic weighing balance (Camry ACS-30-JE11; accuracy - ±10g). The peeled cassava was soaked in potable water and left for 4 days to ferment naturally. The fermented cassava mash was bagged and pressed using a 500 kg/batch dewatering hydraulic press (30-ton hydraulic jack) in the cassava processing centre of NSPRI located in Ilorin.

Wet Cassava Chips Production

The cassava roots were sorted, peeled, and washed with potable water. The peeled roots were chipped with mechanical chipping machine (1 ton/hr chipping machine powered with 7.5 hp gasoline engine) in the cassava processing centre of NSPRI located in Ilorin.

Drying of Wet Cassava Mash and Wet Cassava Chips

The pressed cassava mash was weighed and loaded into trays to a thickness of 2.5 cm. The weights of cassava mash on the trays were noted and the trays arranged on the layers of the solar dryers labeled layer 1, 2, 3 and 4 with a vertical spacing of 30 cm for the PSSD and layer 1, 2 and 3 with vertical spacing of 30 cm for the STD. For the PSSD, Layer 1 is the topmost layer on the drying rack while layers 2 and 3 are the middle layers with layer 2 next to the top and layer 4 is the bottom layer on the drying rack. Similarly, for the STD, Layer 1 is the topmost layer on the drying rack while layer 2 is the middle layer next to the top layer and layer 3 is the bottom layer on the drying rack. Four trays were also loaded to the same depth, their weights were noted and placed outside for sun drying which served as the control.

Similarly, for the drying of wet cassava chips, the cassava chips were weighed and loaded on trays and placed on the layers of the solar dryers as applicable to the cassava mash. Three trays were also loaded and placed outside for sun drying which served as the control. The weight of the samples was taken daily until the product was dried to safe moisture content.

Temperature Monitoring

A 4-Channel SDL thermocouple was setup to automatically log temperature readings at 30 minutes interval in each of the dryers to monitor the temperature within the dryers as well as the ambient.

Weight Loss and Drying Rate Determination

Labeled trays from the various layers in both dryers as well as control were weighed daily for weight loss monitoring. The process carried out using electronic weighing balance (Camry ACS-30-JE11; accuracy - ±10g). This was monitored on daily basis. The values obtained were used to determine the drying rate (Equation 1) as well as plot the drying curves.

$$DR = \frac{Mo - Mt}{dt} \quad (1)$$ (Suherman *et al*, 2018)

where;

M_o is the initial weight of the sample (kg)

M_t is the weight of the dried sample at time t (kg)

$Mo - Mt$ is weight loss (kg)

dt is the drying time (day).

Moisture Content Determination and Microbial Load Analysis

Samples from both products were taken for initial moisture content determination. Also, at the completion of the drying process, samples were taken from each layer in PSSD and STD as well as control for final moisture content determination. Moisture content was determined using the standard methods of AOAC (2005). Microbial analysis was also carried out before and after the drying experiment (FAO, 1997).

Statistical Analysis

Data collected were subjected to statistical analysis using Microsoft Excel version 2016 and SPSS version 20. A two-way ANOVA was conducted, and Duncan Multiples Range Test was used to compare the means at 95 % level of confidence.

RESULTS AND DISCUSSION

Moisture Content of Cassava Mash

The initial moisture content of fermented cassava was 49.74 % (wb). The average moisture contents (wb) of dried fermented cassava were 10.45 %, 11.40 % and 12.47 % for PSSD, STD and Control respectively (Table 1). The lowest moisture content of dried product was observed in PSSD, while control has the highest value. The moisture contents in all the drying media after 4 days of drying were below the safe moisture content of 13 % reported by Calverley (1998).

Table 1. Moisture Content of Dried Fermented Cassava

Layer	M.C (%) w.b
PSSD	10.45
STD	11.40
Control	12.47

Moisture Content of Cassava Chip

The moisture content of the fresh cassava root prior to drying was observed to be 51.9% (wb). At the end of the drying experiment (five days), the average moisture content of the cassava chip was found to be 11.0 %, 13.8 % and 13.1 % for PSSD, STD and ambient respectively (Table 2). The lowest average moisture content of the dried cassava chip was observed in the PSSD while the highest was found in STD. This is in conformity with the results recorded in the drying rate of chip in the dryers and ambient. The study revealed that the NSPRI dryers were able to dry cassava chips within five days to the safe moisture content earlier reported (12 - 14 % (wb)) (Alonge and Adeyemi, 2010).

Table 2. Moisture Content of the Dried Cassava Chip

Cassava chip	Moisture content % (w.b)
PSSD	11.0
STD	13.8
Control	13.1

Drying Temperature of Fermented Cassava

The daily temperature variations of fermented cassava in PSSD, STD and ambient are presented in Table 3. The average daily temperature within the dryers were 43.68, 37.53 and 30.65 °C for PSSD, STD and ambient respectively. The highest drying temperature (43.68 °C) was observed in the PSSD while the lowest drying temperature (30.65 °C) was observed in Ambient. The results showed that higher temperature variation was observed in the NSPRI solar dryers as compared to the ambient. PSSD and STD recorded percentage temperature increase of 42.5 and 22.4% respectively. These findings support previous studies conducted on NSPRI solar dryers where higher temperature variation were reported for the PSSD as compared to other solar dryers and the ambient (Ogunsua *et al.*, 2020; Oyewole *et al.*, 2019; Ade *et al*., 2018). The higher temperature recoded in the NSPRI solar dryers could be as a result of the covering materials of the dryers which made them enclosures and easier to trap heat within them as compared to the ambient where wind can easily blow the heat around the drying products away, thereby leading to temperature drop in the vicinity of the products (control). Wider area available for solar radiation reception as well as the parabolic shape of the PSSD which gave way for improved reception could be responsible for the higher temperature recorded in it compared to STD.

Table 3. Daily Drying Temperature of Cassava Mash inside PSSD, STD and Ambient.

Day	PSSD (°C)	STD (°C)	Ambient (°C)
1	38.13	33.69	29.52
2	41.72	38.31	31.01
3	49.53	41.29	32.45
4	45.34	36.83	29.63
Average	**43.68**	**37.53**	**30.65**
STD	**4.89**	**3.16**	**1.38**
SE	**2.44**	**1.58**	**0.69**

Drying Temperature of Cassava Chips

The daily drying temperature of cassava chips inside the PSSD, STD and Ambient during the drying period is presented in Table 4. The average daily temperature was 31.4 ^{o}C for PSSD and 27.2 ^{o}C for STD while the average daily drying temperature of the ambient was 29.3 ^{o}C. The result showed that the highest average temperature (31.4 °C) was observed in PSSD while the lowest was observed in the STD (27.17 °C). The higher temperature variation observed in the PSSD agrees with earlier observations in the drying of cassava mash which showed higher temperature variation in the PSSD as compared with STD and ambient. The drop in temperature recorded during the drying trial was as a result of the period in which the evaluation was carried out. July 2019 was characterized with cloudy weather and low temperature which contributed to the performance of the dryer since they are weather dependent (Oyewole *et al.*, 2019).

Table 4. Daily Drying Temperature of Cassava Chips inside PSSD, STD and Ambient.

Day	PSSD (°C)	STD (°C)	Ambient (°C)
1	31.3	27.7	28.7
2	29.6	26.0	28.0
3	31.5	27.2	29.9
4	32.4	28.0	30.5
5	31.9	27.0	29.4
Average	**31.37**	**27.17**	**29.28**
STD	**0.97**	**0.67**	**0.89**
SE	**0.43**	**0.30**	**0.40**

Drying Assessment of Fermented Cassava

The effect of drying layers on the drying rate of fermented cassava in PSSD and STD is presented in Tables 5 and 6. Results showed that there was no significant difference in the drying rates between the layers of the PSSD. The highest drying rate (366.3 g/day) was observed in the first layer while the least drying rate (350.5 g/day) was observed in the third layer. However, there was a significant difference ($P \leq 0.05$) in the drying rates between the layers of STD. The highest drying rate was observed in the first layer while the drying rate was significantly lower in the second layer. This variation in drying rates could be attributed to the direct heat received through the transparent cover by Layer 1 and the radiation from the stored heat in the black floor for Layers 4 and 3 in PSSD and STD respectively.

Table 5. The Effect of Drying Layers on the Drying Rate of Fermented Cassava in PSSD

Layers	**Drying Rate (g/day)**
1	366.3[a]
2	365.9[a]
3	350.5[a]
4	361.6[a]

Note: Means with different superscripts are significantly different at $P \leq 0.05$

Table 6**.** The Effect of Drying Layers on the Drying Rate of Fermented Cassava in STD

Layers	**Drying Rate (Kg/day)**
1	342.2[b]
2	308.8[a]
3	337.1[ab]

Note: Means with different superscripts are significantly different at $P \leq 0.05$

The drying curves for fermented cassava are shown in Figures 3 to 5. The curves showed that the initial drying process in the PSSD and STD was preceded by a warming-up period, indicated by an increase in the drying rate, and followed by a falling rate period, while the drying process in the STD was observed to be in the falling rate period. Drying of agricultural products in the falling rate period has been reported by several authors (Argo *et al.*, 2018; Dairo *et al.*, 2015; Ajala *et al.*, 2012; Tunde-Akintunde and Afon, 2010; Velic *et al.*, 2007). The falling rate period of drying is controlled largely by the product and is dependent upon the movement of moisture within the material from the center to the surface by liquid diffusion and removal of moisture from the surface of the product (Chakraverty and Singh, 2014). Figure 3 also showed that the warming-up period was within the first day of the drying period. The recorded drying rate on the first day of drying showed that the Control had the highest value (754.5 g/day). The moisture in the loaded product increased the relative humidity in the dryers, thereby limiting the rate at which moisture was leaving the product in the two dryers. Thereafter, the drying rates in the two dryers were higher than what was obtained in the control (Ambient) in the rest of the falling rate period.

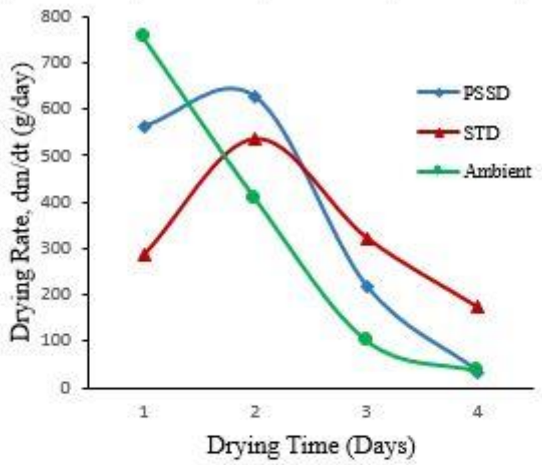

Figure 3: Drying rate versus drying time time curve of fermented cassava

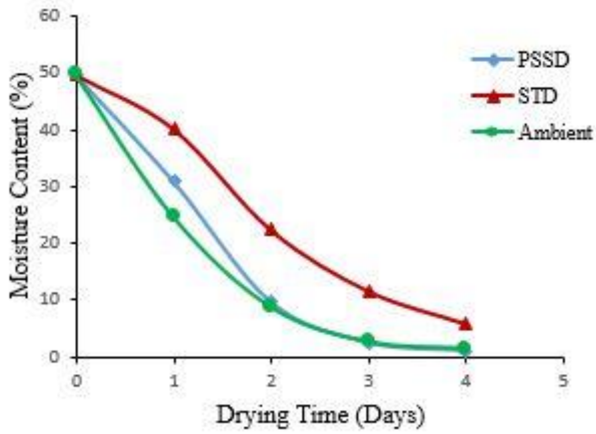

Figure 4: Moisture content versus drying curve of fermented cassava

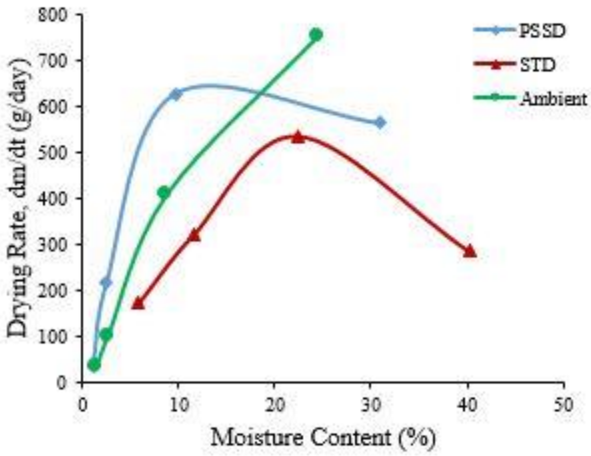

Figure 5: Drying rate versus moisture content curve of fermented cassava

Drying Assessment of Cassava Chips

The highest average drying rate was observed in the PSSD with a value of 361.1 g/day while the least drying rate was observed in the ambient drying condition with a value of 324.5 g/day. STD had a value of 329.4 g/day. The result also showed that drying rate in PSSD was significantly higher ($p \leq 0.05$) as compared to the drying rates in STD and ambient which could be attributed to the higher temperature variation recorded in the PSSD (Table 7). This agrees with the observations of Olayemi *et al.* (2017) in the drying of Whitings fish and Ojutiku *et al.* (2009) in the drying of *Hyperopisus bebe occidentalis*. The falling rate period was characterized by the increasing temperatures both at the surface and within the solid (Hii, 2012). Increase in the temperature of drying air increased its ability to hold moisture. The drying air heated the product thus increased its vapour pressure which drove the moisture to the surface faster hence increased the drying rate (Leon *et al.*, 2002; Tokar, 1997). Temperature variations in the drying media could be said to be responsible for the different drying curves for fermented cassava mash as depicted in Figure 4, which illustrates the variation of moisture content with drying time. The drying process was characterized by a progressive decrease in moisture content with time in all the drying media which is the general trend reported for other food products including sweet sorghum stalk (Shen *et al.*, 2011), tomato (Doymaz, 2007), eggplant (Ertekin and Yaldiz, 2004) and red pepper (Akpinar *et al.*, 2003).

Table 7. Effect of Drying Media on the Drying Rate of Fermented Cassava

Media	Drying Rate (Kg/day)
PSSD	361.1^{b}
STD	329.4^{a}
Ambient	324.5^{a}

Note: Means with different superscripts are significantly different at $P \leq 0.05$

The effect of drying layers on the drying rate of cassava chip in PSSD and STD is presented in Tables 8 and 9. The highest drying rate (320.2 g/day) in the PSSD was observed in layer 4 while the lowest drying rate (316.9 g/day) was observed in layer 2. Similarly, for the STD, higher drying rate was observed in top and lower layers while the lowest drying rate was recorded in the middle layer which is in accordance with what was observed in the drying of cassava mash in STD.

Table 8. The Effect of Drying Layers on the Drying Rate of Cassava Chip in PSSD

Layers	**Drying Rate (g/day)**
1	318.4[a,b]
2	316.9[a]
3	319.6[a,b]
4	320.2[b]

Means with different superscripts are significantly different at P ≤ 0.05

Table 9. The Effect of Drying Layers on the Drying Rate of Cassava Chip in STD

Layers	**Drying Rate (g/day)**
1	276.0[b]
2	224.9[a]
3	226.7[a]

Means with different superscripts are significantly different at P ≤ 0.05

The drying curves for cassava chips are presented in Figures 6 to 8. The curves exhibited a warming-up period and a falling rate period for all the drying media (Figure 6). Similar drying pattern was observed by Bamband *et* al, (2018) in the thin layer drying of cassava chips in a multipurpose convective-type tray dyer. The warming period was observed to be within the first two days in the NSPRI dryers while the warming-up period was only observed on the first day in the ambient. However, the drying rates were higher during the falling rate period in the later days of the drying period (Figure 6 and 8). Diffusion has been described by several researchers as the most likely mechanism for moisture movement during this period, where moisture movement is from the interior to the surface of the product (Sobukola *et al.*, 2007).

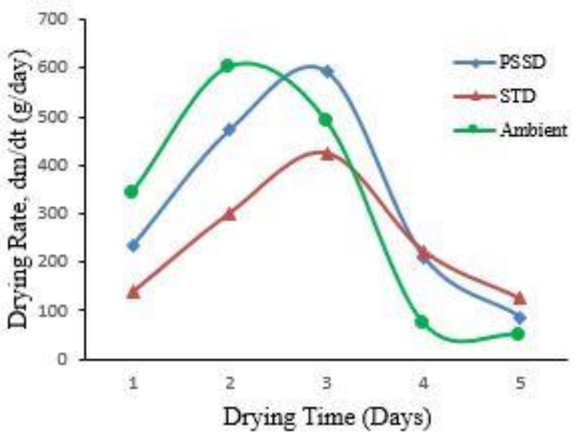

Figure 6: Drying rate versus drying time curve of cassava chips

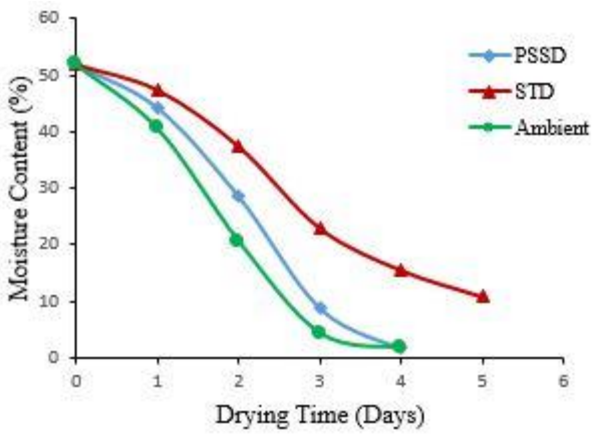

Figure 7: Moisture content versus drying time of cassava chips

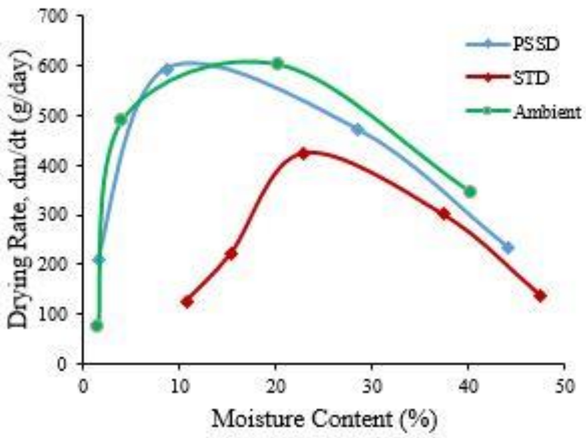

Figure 8: Drying rate versus moisture content of cassava chip

The highest drying rate was recorded in PSSD with a value of 318.8 g/day while the lowest drying rate was observed in the STD with a value of 242.5 g/day (Table 10). The result also showed that drying rate in STD was significantly lower as compared to the drying rates in PSSD and Ambient ($p \leq 0.05$). The drop in drying temperature and rate in the STD could be attributed to the period of the year in which the cassava chip evaluation was carried out (July 2018). This period was characterized with cloudy weather and high humidity and could be mainly responsible for the performance recorded (Cloud and Morey, 1991). Report of previous studies has shown that solar dryers are less susceptible to weather variation; however, it is possible to experience low performance on bad weather days caused by low sun intensity, increased humidity, low wind speed or combination of any of the three parameters (Oyewole *et al.*, 2019; Assefa *et al.*, 2013).

Table 10. Effect of Drying Media on the Drying Rate of Cassava Chip

Media	**Drying Rate (Kg/day)**
PSSD	318.8^{b}
STD	242.5^{a}
CONTROL	310.8^{b}

Means with different superscripts are significantly different at $P \leq 0.05$

The drying curve (Figure 7) showed that the moisture content reduced with increased drying time, as expected, and observed by several other researchers for cassava chips (Argo *et* al, 2018; Pornpraipech *et al*, 2017; Ajala *et al*, 2012; Tunde-Akintunde and Afon, 2010). An initial high rate of moisture removal was followed by slower moisture removal in the latter stages. This characteristic behaviour is due to the various forms in which water is present in (water and bound water) in cassava roots (Tunde-Akintunde and Afon, 2010).

Microbial Quality of Cassava Mash

The result of the microbial examination showed an average initial Total Viable Count (TVC) of 0.3 x 10^3 cfu/g while dried products had TVC of 0.025 x 10^3 cfu/g, 0.05 x 10^3 cfu/g and 0.1 x 10^3 cfu/g for PSSD, STD and Control respectively. These results show that the two dryers have potential to reduce microbial loads in fermented cassava during drying process. This is in line with the report of Tessem *et al*. (2008). The bacteria and fungi counts for dried fermented cassava were within the acceptable limit of 300 cfu/g.

Microbial Quality of Cassava Chips

The TVC of wet cassava chips prior to drying was 0.1 x 10^3 cfu/g. The TVC of the dried cassava chips was found to be 0.05 x 10^3 cfu/g, 0.03 x 10^3 cfu/g and 0.1 x 10^3 cfu/g for PSSD, STD and control respectively. The viable counts of the dried cassava chip samples inside PSSD, STD and Control were found to be within the acceptable standard of ≤ 300 Cfu/g. This is in agreement with earlier observations on dried cassava mash, which is an indication that the cassava mash and chips were not contaminated by NSPRI solar dryers.

CONCLUSION

The NSPRI solar dryers (PSSD and STD) were able to dry fermented cassava mash and cassava chips from initial moisture content of 49.74 - 51.90% (wb) to safe moisture content of 9.46 - 13.80% (wb) in four days. The average drying temperature in PSSD were 43.68 and 31.37 ^{o}C for fermented cassava and cassava chips respectively while the average drying temperature in the STD were 37.53 and 27.17 ^{o}C for fermented cassava and cassava chips respectively. Generally, the Total Viable count (TVC) obtained for the products were better than control values. This is an indication that the NSPRI solar dryers could be used for production of safer and more hygienic dried fermented cassava and dried cassava chips.

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