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Research Article

EVALUATION OF THE QUALITY CHARACTERISTICS OF COCOA BEAN DRIED USING DIFFERENT DRYING TECHNIQUES

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ABSTRACT

Processing techniques, particularly drying because cocoa beans are extremely sensitive to moisture, have a significant impact on the quality of the final product. Fermented cocoa beans were dried using the NSPRI parabolic solar tent dryer (PSTD), wooden solar dryer (WSD), and open-air drying (OAD). The dried cocoa beans' respective moisture contents (MCs) for PSTD, WSD, and OAD were 5.94%, 6.01%, and 6.82%, respectively. The corresponding MCs for the dried cocoa beans from PSTD, WSD, and OAD were 5.94%, 6.01%, and 6.82, respectively. It was found that the cut test scores for PSTD, WSD, and OAD were 1000, 985, and 965, respectively. This showed that, in contrast to those from WSD and OAD, the dried cocoa beans obtained from PSTD were fully brown. For WSD, OAD, and PSTD, respectively, the obtained pH values were 5.60, 5.65, and 5.80, and the total titratable acidity was 11.70 meq NaOH 100–1 g, 14.10 meq NaOH 100–1 g, and 18.30 meq NaOH 100–1 g for PSTD, WSD, and OAD, respectively. Food products' shelf life may be indicated by the titratable acidity value. Due to its enclosed design, the NSPRI PSTD has an advantage over other drying methods because it completely eliminates the possibility of external and microbial contamination of the cocoa beans.

Keywords: Drying, Cocoa, Quality, Dryer.

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INTRODUCTION

Theobroma cacao L., a perennial cash crop, is native to the humid tropics (Ndukwu, 2009). Cocoa beans are regarded as a high-value product. They are primarily consumed as chocolate and are widely used in beverages, cosmetics, medications, and toiletry products. They also have a number of positive health benefits (Porter, 2006; Taubert *et al*., 2007). In many nations around the world, the final products made from cocoa beans, particularly chocolate and drinks, are regarded as staple foods. However, how these final products are processed and will determine their quality (Ndukwu *et al*., 2010). Cocoa farmers and traders take care to maintain the highest quality because the quality of cocoa beans is highly dependent on processing techniques and storage conditions for preventing the defective quality, which can directly affect the quality of chocolates. As a result, commercial grade cocoa beans must meet a number of requirements, including those related to moisture content (MC), acidity, slatiness, polyphenol content, moldiness, and mycotoxin production (Aroyeun *et al*., 2009). Fermentation and drying are the two main steps in the processing of cocoa. The pulp that surrounds the bean is removed during fermentation, and the pulp's sugar is changed into acetic acid. Box, basket, heap, and tray fermentation are the various fermentation techniques. Depending on the method of fermentation used, the fermentation process can take anywhere between 4 and 7 days. The first step in developing various flavor precursors in the beans is fermentation (Hii *et al*., 2009). Despite the fact that fermentation and drying have complementary effects on bean quality, poorly dried cocoa beans can still have very poor quality because different heat treatments have different effects on the parameters that determine bean quality (Mbonomo *et al*., 2016). Food can be preserved very well by drying, and solar dryers are an appropriate food preservation technology for sustainable growth. It entails drying out agricultural products to produce a product that can be stored safely for a longer period of time (Puello-Mendez *et al*., 2017).

The most traditional, affordable, widely used, and unrestricted method of drying is by sun exposure, especially in the tropics and subtropics where solar radiation is abundant. It can be used in a variety of ways, from the most simple to the most complex and scientific (Bala and Debnath, 2012). Due to the low setup costs, environmental friendliness, and widespread availability of this method, cocoa farmers primarily use it in Nigeria. However, prolonged direct sun exposure causes the quality of the cocoa beans to decline. In addition, drying helps to lessen the acidity of cocoa beans; it should be done in a way that results in a MC of about 7%. While excessive moisture encourages the growth of fungi, excessive drying can make the shell brittle (Deus *et al*., 2018). A wooden solar dryer (WSD) is one that is constructed of wood. The floor is covered with a black perforated galvanized sheet, and the inner floor is lined with mesh to allow air to flow through while also keeping rodents out. To accelerate heat absorption, the floor sheet was painted black. A transparent film lines the inside of the dryer cover. The parabolic solar tent dryer (PSTD) is a product of the Nigerian Stored Products Research Institute (NSPRI). It consists of a steel drying platform, top frames, and interior surfaces that have been painted black to absorb heat more quickly. A pneumatic extractor fan on the top of the PSTD pulls moisture from the goods being dried.

Cocoa is graded on the basis of the count of defective beans in the "cut test." The cut test reveals the presence of certain defects which may cause off-flavors and indicates the degree of fermentation of the beans which has a bearing on the flavor and quality of the beans. According to the International Standards Organization cut test procedure, beans must be opened or cut lengthwise through the middle, exposing the maximum cut surface of cotyledons, for a thorough evaluation of bean quality (Prasanna *et al*., 2017). Cocoa beans can maintain their quality during the drying process if they are dried at the proper rate. The beans can develop an off-flavor if they are dried too quickly because they become too acidic. If too slow, mold and fungal growth will damage the cocoa beans. However, when dried properly, cocoa beans will retain their rich flavor without being contaminated by fungi. Hence, the need to carry out a study on the effect of three different drying techniques (Parabolic solar tent drying, wood solar drying and open-air drying) on the quality parameters of dried cocoa beans.

MATERIALS AND METHODS

Fermentation of the cocoa beans

Fresh cocoa pods were obtained from Cocoa Research Institute of Nigeria, Ibadan. The cocoa pods were cracked to separate the beans from the pods. The cocoa beans were weighed. For the fermentation process, banana leaves were spread beneath and across two baskets and the cocoa beans were poured into them and covered with banana leaves and tray. One basket was placed on top of the other and they were placed on an elevated surface. They were placed under a tree for low and moderate sun radiation. The cocoa beans were left to ferment for 5 days but they were turned on the 3rd day to allow even fermentation of the cocoa beans. After fermentation, the cocoa beans (Fig. 1) were weighed and distributed for drying using three different drying methods (PSTD, WSD, and open-air drying [OAD]).

Drying of the cocoa beans

After fermentation, the drying of the beans was conducted using NSPRI fabricated PSTD, WSD, and OAD method. The fermented cocoa beans were removed from the perforated baskets and weighed. They were mixed thoroughly and divided into three parts for each drying method. In the OAD, 8 kg of the fermented cocoa beans were spread on a net on the concrete floor (farmers' method) for direct sun heating. For PSTD, 14 kg of fermented cocoa beans were distributed into four trays of the dryer evenly (Fig. 2). For the WSD, 4 kg of fermented cocoa beans were spread in the dryer for drying. Representative samples were made in each of the drying condition to evaluate the drying rate of the cocoa beans under each drying conditions. The drying took place for 5 days.

Drying rate (R)

Drying rate is defined as the ratio of moisture removed per kg of dry weight of material in unit time.

$$R = \frac{\text{Amount of moisture removed (kg)}}{\text{Initial weight of the sample (kg)} \times \text{Time taken (h)}} \quad (1)$$

MC (W.B), %

The MCs of the fresh and dried cocoa beans were determined by weighing 2 g of cocoa beans in a can of a known weight and dried in oven at 103±2°C for 4 h. The final weight of the dried beans was determined. The MC of the beans was then determined with reference to wet weight of the beans using equation: (Hii *et al*., 2009)

$$\text{M.C. (wet basis)} = \frac{wi - wd}{wi} \times 100\% \quad (2)$$

Where, wi and wd refer to initial weight before drying and final weight of dried beans, respectively.

Cut test

This was carried out according to the Malaysian Standard MS 293. Three hundred pieces of dried cocoa beans were cut lengthwise through the middle using a penknife. Both halves of each bean were examined visually in full daylight by an experienced cocoa grader according to the cross-sectional color of the beans, namely, fully brown, partly purple-brown, fully purple, and slaty, based on a standard color chart. The percentage count of each color note was calculated for the cut test score (CTS) as shown below:

CTS = (10 × % fully brown) + (5 ×% partly purple-brown) + (0 ×% fully purple and slaty)

Determination of pH

The nib pH was determined according to the AOAC (1990). Ground nibs (5 g) were homogenized in 45 mL boiled distilled water. The homogenate was filtered with Whatman No. 4 filter paper and cooled to 20–25°C. pH was determined using a pH meter.

Determination of the titratable acidity (TA)

The nib TA was determined according to the AOAC (1990). About 25 mL of the aliquot collected for pH determination was titrated drop by drop with 0.1 M NaOH to pH 8.1, determined using a pH meter.

RESULTS AND DISCUSSION

Moisture loss (%)

Weights of replicate samples were taken at time interval to determine the amount of moisture loss per time. The result is shown in Table 1. In OAD method, the rate of moisture loss was higher followed by PSTD and WSD.

Fig. 1. Fermented cocoa beans

Fig. 2. Parabolic solar tent dryer

Table 1: Variation of moisture loss against drying time in all drying methods

	Drying techniques			
	Time (h)	**W.S.D**	**P.S.T.D**	**O.A.D**
Moisture loss per time during drying (%)	3	12.58	11.63	14.04
	6	19.50	23.26	22.81
	23	23.90	27.91	32.75
	26	32.70	38.37	39.77
	29	38.36	42.44	45.03
	47	41.51	44.19	48.54
	50	45.28	47.67	50.29
	53	47.80	49.42	52.05
	71	48.43	50.00	52.63
	74	50.94	51.74	53.80
	77	51.57	52.33	53.80
	95	50.31	51.16	53.80
	98	51.57	52.91	54.39
	101	52.50	53.49	54.97

W.S.D: Wooden solar dryer, P.S.T.D: Parabolic solar tent dryer, O.A.D: Open-air dryer

Table 2: Temperature and relative humidity over the period of drying

Drying method	Day 1		Day 2		Day 3		Day 4		Day 5	
	Temp. (°C)	R.H (%)	Temp. (°C)	R.H (%)	Temp. (°C)	R.H (%)	Temp. (°C)	R.H (%)	Temp. (°C)	R.H (%)
WSD	40.37±9.78	55.28±16.24	44.57±13.70	46.75±23.01	44.55±14.19	41.82±26.97	45.48±14.48	39.19±25.82	43.95±13.87	40.51±25.94
PSTD	44.47±11.66	45.89±20.10	46.44±13.03	44.30±20.95	46.4±13.40	39.76±25.37	47.58±12.49	35.68±21.86	46.58±12.98	36.9±22.64
OAD	39.00±9.61	50.13±21.51	43.18±10.71	40.45±18.71	40.12±8.45	43.86±19.11	44.25±11.28	40.46±20.22	41.62±9.05	45.26±16.90

W.S.D: Wooden solar dryer, P.S.T.D: Parabolic solar tent dryer, O.A.D: Open-air dryer

Table 3: Determination of quality of cocoa beans using cut test score

Drying method	No. of beans	Fully brown	Partly purple-brown	Fully purple and slaty	Cut test score
WSD	100	97	3	0	985
PSTD	100	100	0	0	1000
OAD	100	95	3	2	965

W.S.D: Wooden solar dryer, P.S.T.D: Parabolic solar tent dryer, O.A.D: Open-air dryer

This might be due to the period that the research was done (December) which was the harmattan season (low [R.H] and high temperature).

Drying rate (kg/kg-hr)

Moisture loss in each replicate sample under each drying method was determined thrice daily at an interval of 3 h (9 am, 12 pm, and 3 pm). The relative weight loss or moisture loss was used in computing the drying rate per time. The results obtained are presented in Fig. 3. The drying rate was higher in OAD method followed by PSTD and WSD. This might also be due to the weather condition (harmattan season).

Temperature and R.H

Table 2 shows the result of temperature and R.H. Temperature and R.H data logger were used to measure the temperature and R.H in all drying methods for the period of drying. The highest temperature build up was observed in OAD followed by PSTD and wooden solar drying. This could be responsible for the rate of moisture loss.

Cut test

The cut test scores of cocoa beans for the drying methods used for this research work are shown in Table 3. The test scores of PSTD, WSD, and open-air sun drying were found to be 1000, 985, and 965, respectively. It showed that the dried cocoa beans obtained from PSTD were fully brown compared to that of WSD and open-air dryer. This implied that the best quality of dried cocoa beans was from PSTD followed by WSD and open-air dryer.

MC (%)

Table 4 shows the result obtained from the determination of moisture content of dried cocoa beans. In this study, the MC ranged from 5.94% to 6.82%. The lowest MC (5.94%) was observed in cocoa beans dried using PSTD while open-air dried samples exhibited the highest MC value of 6.82%. It was observed that there was no significant difference ($p<0.05$) in the MC value of cocoa beans dried using WSD and PSTD. The difference in the MC may be due to temperature differences experienced by the cocoa beans from the different drying methods. It was observed that all samples had MC value that was considered safe and acceptable for dry cocoa beans. This could be as a result of the climatic condition as at the time of drying (dry season in December) However, using NSPRI PSTD is advantageous because its enclosed nature will eliminate the risk of mold and external bean contamination by rain and vermin.

PH and titratable acid determination

The pH of the dried samples ranged from 5.60 to 5.80. pH was significantly higher (5.80) in parabolic solar tent dried cocoa beans. However, there was no significant difference ($p<0.05$) between cocoa beans dried using WSD and open air. Franke *et al.* (2008) indicated that the differences in the pH may be due to several factors such as exposure times to drying air, drying air temperature, relative humidity in the drying site, nature of drying air flow, and the speed with which moisture migrated from the inner cocoa beans structures to their surface. In general, these pH values (WSD 5.60, OAD 5.65, and PSTD 5.80) obtained falls within the values reported to be accepted and desirable for dried cocoa beans in West Africa (Deus *et al.*, 2018).

Table 4: Determination of moisture content (%) of dried cocoa beans

Sample	Moisture content (%)
Wooden solar dryer	6.01±0.18[b]
Open air	6.82±0.26[a]
Parabolic solar tent dryer	5.94±0.09[b]

[a,b] Significant ($p <0.05$)

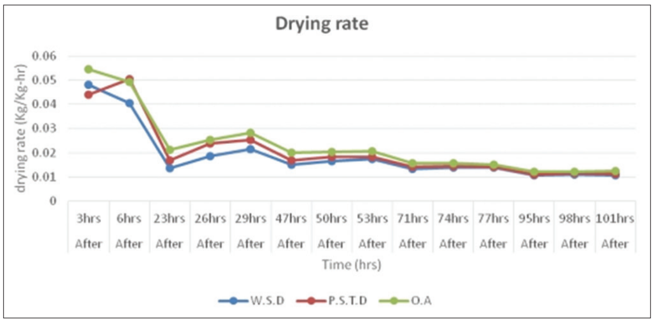

Fig. 3. Variation of drying rate against drying time in all drying methods. W.S.D: Wooden solar dryer, P.S.T.D: Parabolic solar tent dryer, O.A.D: Open-air dryer

The total titratable acidity was 11.70 meq NaOH $100^{-1\ g}$, 14.10 meq NaOH $100^{-1\ g}$, and 18.30 meq NaOH $100^{-1\ g}$. Among the three methods, that is, WSD, PSTD, and OAD method, the OAD cocoa beans had the highest content of titratable acidity (18.30 meq NaOH $100^{-1\ g}$) while PSTD had the lowest value of 11.70 meq NaOH $100^{-1\ g}$ and the WSD cocoa beans was in between (14.10 meq NaOH $100^{-1\ g}$). This result showed distinct significant differences ($p<0.05$) in titratable acidity across the different drying medium used. Titratable acidity value can signify the shelf life of food products (Helen and Henrietta, 2015). The higher the titratable acid value, the lower the shelf life and vice versa. Then, it can be said that drying cocoa beans using the NSPRI PSTD can give longer shelf life when compared to WSD and OAD.

CONCLUSION

NSPRI PSTD is advantageous because of its enclosed nature which eliminates the risk of microbial and external contamination of cocoa beans during drying. The moisture loss observed was 54.97, 53.49, and 52.20 in OAD, PSTD, and WSD, respectively. The drying rate was higher in OAD method followed by PSTD and WSD. Temperature and relative humidity showed that the highest temperature build up was observed in OAD, followed by PSTD and wooden solar drying, which could be responsible for the rate of moisture loss.

The results above showed that drying with NSPRI parabolic solar dryer is very efficient in drying cocoa beans with the lowest MC and in turn produced dried cocoa beans of good quality, compared with WSD and conventional open drying. The visual rating of dried cocoa beans is highly employed in the cocoa trade. The cut test method revealed that the best quality of dried cocoa beans was from a PSTD followed by a WSD and open-air dryer.

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