A Comparative Study of Effects of Drying Methods on Quality of Cocoa Beans

D. Lasisi
Department of Agricultural and Bio-Environmental Engineering
Oyo State College of Agriculture, Igboora

Abstract

The study was conducted in order to determine and compare the effects of drying methods on quality of fermented cocoa beans. Drying was carried out using two different methods namely oven drying and sun drying methods. Samples were dried at five different oven temperatures of 35^{o}C, 40^{o}C, 45^{o}C, 50^{o}C and 55^{o}C while the other samples were sun dried until the moisture content of the samples were reduced to 6 – 8 %. Each sample was replicated twice. Some quality assessments were carried out for each forced-air drying temperatures and sun drying to compare the quality of sun dried samples with the oven dried ones. The quality assessments were acetic acid level, pH, colour, free fatty acid, acid value and grading. The values obtained were used to determine better method of drying cocoa beans. It was found that the samples sun dried were better than the samples oven dried. Free fatty acid (FFA) and acetic acid levels significantly increased (P < 0.05) with increase in drying temperature while the pH level decreases significantly (P < 0.05) with increase in drying temperature.

Key words: effects, drying methods, cocoa beans, quality.

1.0 Introduction

Cocoa (Theobroma cacao) is one of the economic tree crops grown in Nigeria. It is one of some twenty species that constitute the genius theobroma, a member of the family sterculiaecae (Are and Gwyne-Jones, 1974). It originated from Amazonian region of Brazil and grown in tropical countries like Nigeria, Ghana, Ivory Coast, Brazil, Malaysia,Venezuela and Indonesia (Beckett, 1994). The cocoa pod which is botanically a berry, attains a height of 129 to 159 mm and diameter of 72 to 83 mm when fully ripe (Maduako, 1989). It normally contains 20 to 40 seeds surrounded by a mucilagenous pulp when the pod is ripe. By weight, cocoa pod is composed of about 74.4% husk, 22.5% wet beans and 3.1% placenta. Cocoa is a perennial cash crop with three important varieties viz. criollio, foresterio and trinitario. Cocoa beans is mainly consumed as chocolate and widely used in beverages, cosmetics, pharmaceuticals and health benefits such as anti-carcinogenic, anti-ulcer, anti-inflammatory, anti-microbial and analgesic (Porter, 2006; Taubert et al., 2007). Processing of cocoa beans involves the harvesting of cocoa pods, breaking of the harvested pods, fermentation of wet mass of cocoa beans obtained from broken pods, drying of fermented cocoa beans to moisture content of about 6 to 8% and storage of the dried beans till the time of use. Figure 1 shows a flow chart of the preparation processes. Out of these steps of processing cocoa pods into beans, the two major steps are fermentation and drying. Fermentation of cocoa beans involves keeping a mass of cocoa beans well insulated while at the same time air is allowed to pass through. This process is carried out to develop the chocolate flavour and aroma in the beans. During fermentation, the pulp surrounding the bean is removed and the sugar in the pulp is converted into acetic acid. The different methods of fermentation are box, basket and heap and tray fermentation. The duration of fermentation varies from 4 to 7 days depending on the method of

fermentation employed. Fermentation is the initial step needed in the development of various flavour precursors in the beans (Hii *et al.*, 2009). After fermentation, the moisture content of the beans is about 55% and this must be reduced to 6 to 8% for safe storage (Opeke, 1987). The drying process apart from reducing moisture content of the beans, aids in the completion of the chemical reactions that were started during the fermentation process and in the development of the chocolate brown colour of well fermented beans (Wood and Lass, 1986). Drying of cocoa beans on most farms is carried out naturally by making use of the sun rays while few large farms use artificial dryers to achieve the drying operations. Sun drying is carried out by spreading the beans on mats raised off the ground or on concrete floors during the period of sunshine. Beans dried on ground level are easily contaminated by insects or domestic animals and they tend to become dusty. Sun drying is effective where the rainfall is not excessive and the hours of sunshine is sufficiently high. The length of time it takes to dry in the sun depends on weather conditions. During rainy or wet conditions, drying period of up to 22 days may be needed and during dry season, drying may last for 7 days. The long duration of drying using this method may cause possible damage of beans due to mould development. Off-flavour odour is obtained from products manufactured from mouldy beans. Oven drying involves the use of heat other than radiant heat to reduce the moisture content of cocoa beans. Heated air is commonly used to dry cocoa beans artificially. Oven drying is also necessary where fermented beans are produced in the wet season. Artificial drying also saves time due to the fact that drying time for the beans to reach safe storage moisture content is reduced when compared to sun drying. Most past studies on the oven drying of cocoa beans have concentrated on the removal of moisture from the beans at the shortest possible time. This results in high drying rate, and this does not allow for the completion of the needed oxidative reaction and acid diffusion process. Hence, the high acid level and off-flavour odour of beans oven dried. This research work, therefore, aims at investigating the comparative effects of forced-air artificial continuous thin layer drying and sun drying at various levels of temperature, moisture contents, relative humidity and time of drying on the quality of cocoa beans and determining the method of drying that would give the best quality of the cocoa beans.

2.0 Materials and Methods

2.1 Sample Preparation

Fresh cocoa pods were obtained from Obafemi Awolowo University Teaching and Research Farm, Ile-Ife. The harvested cocoa pods were broken and the cocoa beans were processed for fermentation for five days using heap-basket fermentation method.

2.2 Initial Moisture Content

100 g of cocoa beans was placed in the sample container and placed inside an air-ventilated oven (Gallen Kamp Oven Model 300 Series) and the oven was set at a temperature of 103^{o}C for 16 hours as recommended by International Standard Organization (ISO) Table of Standard 2291 – 1972 (E) and AOAC (1984). The moisture content (MC) of the beans was then determined with reference to wet weight of the beans using equation:

$$M.C.(wet\ basis) = \frac{wi - wd}{wi} \times 100\% \quad \text{(Hii } et\ al.\text{, 2009)} \ldots\ldots\ldots\ldots (1)$$

Where w_i and w_d refers to initial and dry weight of the beans respectively.

2.3 Oven Drying

Triplicate samples of fermented cocoa beans, each weighing 100 g were placed in the sample container and then placed in the oven with the oven temperature set at 35^{o}C with known initial moisture content. Hygrometer was used to measure the wet and dry bulb temperatures of the surrounding. Using psychometric chart, the relative humidity of the surrounding and oven were known. At every 3 hours, each sample weight was known and recorded and the corresponding moisture content determined. This experiment was continued until the moisture contents of the samples were reduced to 6 - 8 %. The experiment was repeated with oven temperatures set at 40^{o}C, 45^{o}C, 50^{o}C and 55^{o}C each time. The equilibrium moisture content (E.M.C.) for each drying temperature was determined by drying until no further change in weight of the beans was observed.

2.4 Sun Drying

A sample of cocoa beans was spread on a concrete floor in the sun. Thermometer was used to measure the peak temperature of drying every day. The sample was sun dried between 9.00 a.m. and 6.00 p.m. every day. At the end of the drying period every day, some quantities of the sample were taken and placed in the oven for 16 hours with the oven temperature set at 103 ^{0}C to determine the moisture content in the sample until the moisture content was reduced to 6 – 8 %.

2.5 Procedures for quality assessment of dried cocoa beans

The quality of the dried cocoa beans was assessed based on the acetic acid value, pH, and free fatty acid (FFA) level and grading. The acetic acid content was determined according to Association of Official Analytical Chemists (AOAC, 1984). A forty gramme of ground sample of cocoa beans was mixed with de-ionized water in a conical flask. The mixture was distilled and allowed to cool. Phenolphthalein of two drops was used as indicator. The solution was then titrated against 0.5 M potassium hydroxide (KOH) until the colour changed. The concentration of acetic acid in the solution was then determined. The pH of the beans was determined according to Duncan et al. (1989).10 g of ground sample of cocoa beans was homogenized with 200 ml of distilled water. The mixture was filtered and pH of the solution was measured using a digital pH meter. The free fatty acid content was determined according to AOAC (1984). One gramme of ground cocoa beans was poured into a conical flask (250 ml). 50 ml of 0.5 M ethanoic potassium hydroxide was added to each of the samples. Heat was applied to dissolve the solution and allowed to cool. Two drops of phenolphthalein indicator was added and the solution was treated with 0.5 M HCl until the colour changed. The percentage FFA was determined as the percentage molar equivalent of the KOH titre to the mass of cocoa beans sample. Samples of dried cocoa beans were taken to cocoa graders in Ile-Ife for grading. Three hundred cocoa beans were randomly selected and cut with a knife. Fully fermented (FF) beans, total mould (TM), Slatee, damp and other defects (OD) were separated. Specifications for grading cocoa beans were given below. For grade I , total mould (TM) should not be more than 1 to $1\frac{2}{3}$; Slatee(s) – 1 to 3%; other defects (OD) – 1 to 3%. For grade II - total mould (TM) - 2 to 3% Slatee(S) – $3\frac{1}{4}$ to 4%; other defects (OD) – $3\frac{1}{3}$ to 4% while no grade falls below grade II in quality.

3.0 Results and Discussion

3.1 Initial Moisture Content

The initial moisture content of the fermented cocoa beans at the point of commencement of the experiment was 53.7 % for all the samples.

3.2 Oven Drying

The sample with 55^{o}C drying temperature dried appreciably fastest taking 18 hours while the sample with 35^{o}C drying temperature was the slowest taking 39 hours to dry to moisture content of about 8 %. This shows that the higher the oven temperature the less the drying time. The relative humidity of the oven temperatures of 35^{o}C, 40^{o}C, 45^{o}C, 50^{o}C and 55^{o}C are 42 %, 36 %, 27 %, 19 % and 16 % respectively. This also indicates that the relative humidity decreases with increase in drying temperature. The equilibrium moisture content (EMC) for the samples were 6.97, 6.85, 6.75, 6.70 6.62 for 35^{o}C, 40^{o}C, 45^{o}C, 50^{o}C and 55^{o}C respectively.

3.3 Quality assessment of dried cocoa beans

The physico-chemical characteristics of the dried beans using forced-air artificial continuous drying system are shown in Table 1. Test results showed that the cocoa beans dried under 55^{o}C oven temperature had the highest free fatty acid and acetic acid of 1.69 and 6.70 while the samples dried at 35^{o}C oven temperature had the lowest free fatty acid and acetic acid of 1.38 and 3.70 mg/g respectively. This showed that free fatty acid and acetic acid level increase with increase in drying temperature. The pH level of dried cocoa beans (6.7) was lowest at 35^{o}C drying temperature while it was highest (4.5) at 55^{o}C drying temperature (Table 1). This showed that pH also increases with increase in drying temperature. All the samples fall under grade I. Cracks were recorded in the testa of the samples of cocoa beans under 50 and 55^{o}C drying temperature. This may be attributed to high drying rate which did not allow for the completion of the needed oxidative reaction and acid diffusion process. There was no flavour difference in all the samples of dried beans. In terms of ratings, sun drying samples attained first position (Table 2) in three out of the five physico-chemical characteristics of cocoa beans used in quality assessment which shows that 45^{o}C is the oven drying temperature that is best for drying cocoa beans artificially within 33 hours (1 – 2 days)

4.0 Conclusion

It can be established from this research work that cocoa beans could be best dried by sun drying and at the same time be of high quality. It can also be concluded that 45^{o}C drying temperature is also good for drying cocoa beans artificially to safe storage moisture content of 8% wet basis, especially during wet season.

References

AOAC (1984). Official Methods of Analysis. Association of Analytical Chemists, 4th Edition, Washington D.C., USA.

Are L.A. and Gwyne-Jones D.R.G. (1974). Cocoa in West Africa. Oxford University Press Ltd, Ibadan, pp. 101 – 114.

Beckett S.I. (1994). Industrial Chocolate Manufacture and Use. (2nd Ed.). Blackley Academic and Professional, Glasglow, UK.

\Duncan R.J., Godfrey E.G., Yap T.N., Pettipher G.L., Tharu-marajah T. (1989). Improvement of Malaysian cocoa bean flavour by modification of harvesting,

fermentation and drying method. The Planter (Malaysia), pp.57 – 65.
Hii C.L., Law C.L., Cloke M., Suzannah M. (2009). Thin layer drying kinematics of cocoa and dried product quality. J. Bio-sys. Eng., Elsevier Ltd, pp. 153 – 161.
Maduako J.N. (1984). Thin-layer drying of yellow dent corn. Trans. of the ASAE, Michigan, 27(2): 581- 585.
Opeke L.K. (1987). Tropical tree crops. John Wiley and Sons, Chihester, pp. 67 – 213.
Porter L.L. (2006). Benefits of cocoa polyphenols. Manufacturing Confectioner, 86(6): 49 – 53.
Taubert D., Roesen R., Schomig E. (2007). Effect of cocoa and tea intake on blood pressure: a meta- analysis. Arch Intern. Med., 167(7): 626 – 634.
Wood G.A.R. and Lass R.A. (1986). Cocoa. Tropical Agricultural Series. Longman's Scientific and Technical. Co-published with John Wiley and Sons, Inc. New York, pp. 445 – 503, 544.

Table 1 Quality assessment of dried cocoa beans

Oven Temp. (^oC)	pH	Acetic Acid (mg/g)	FFA (mg/g)	Colour	Grade
35	6.7	3.70	1.38	Dark brown	1
40	6.1	4.10	1.46	Light brown	1
45	5.8	5.20	1.52	Light brown	1
50	4.9	5.90	1.61	Dark brown	1
55	4.5	6.70	1.69	Dark brown	1
Sun drying	6.9	3.75	1.40	Light brown	1

Table 2 Ratings of dried cocoa beans

Quality assessment	1st	2nd	3rd	4th	5th	6th
pH	Sun drying	35°C	40°C	45°C	50°C	55°C
Acetic acid	Sun drying	45°C	40°C	50°C	55°C	35°C
Free fatty acid	35°C	40°C	Sun drying	45°C	50°C	55°C
Colour	Sun drying	40°C	40°C	50°C	55°C	35°C
Grade	Sun drying	40°C	45°C	40°C	50°c	55°C

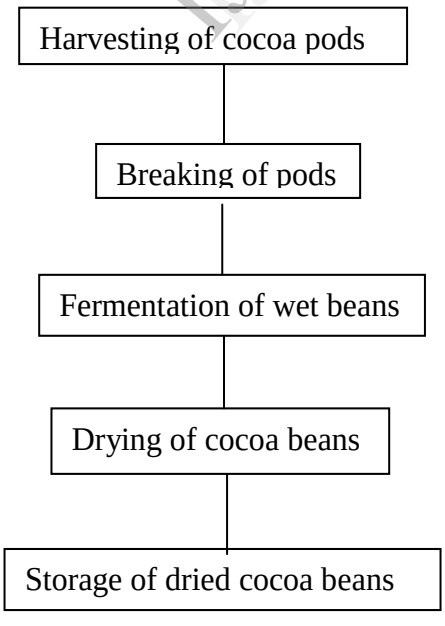

Fig. 1 Flow chart for processing cocoa beans from cocoa pods