ADVANCE RESEARCH JOURNAL OF MULTIDISCIPLINARY DISCOVERIES
ISSN : 2456-1045
VOL.36 I ISSUE-1 I CHAPTER-5
PUBLISHER : INTERNATIONAL JOURNAL FOUNDATION (IJF)

Comparative evaluation of Fermentation Methods on the quality of Cocoa Beans

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ABSTRACT

Fermentation as an important operation in the processing of cocoa beans is now affected by the recent climate change across the globe. The major requirement for effective fermentation is the ability of the material used to retain sufficient heat for the required microbial activities. Apart from the effects of climate on the rate of heat retention, the materials used for fermentation plays an important role. Most Farmers still restrict fermentation activities to the use of a traditional method. Improving on cocoa fermentation in this era of climate change makes it necessary to work on other materials that can be suitable for cocoa fermentation. Therefore, the objective of this study was to comparatively determine the effects of fermentation methods on the quality of cocoa beans. The materials used in this fermentation research were heap-leaves (traditional), stainless steel, plastic tin, plastic basket and wooden box. The period of fermentation varies from 0 to 10 days. Physical and chemical tests were carried out for variables in the quality determination in the samples. The weight per bean varied from 1.0 to 1.2g after drying across the samples and the major colour of the dry beans observed was brown except with the samples from stainless steel. The moisture content varied from 5.5 to 7%. The mineral content and the heavy metals decreased with increase in fermentation period. Wooden box can conclusively be used as an alternative to heap-leaves as there was no significant difference in the physical features of the samples fermented with the two methods. The use of wooden box as an alternative for cocoa fermentation is therefore recommended for cocoa farmers

Keywords : Comparative evaluation, fermentation, fermentation materials, period, quality

ORIGINAL RESEARCH ARTICLE

ISSN : 2456-1045 (Online)
(ICV-AGS/Impact Value): 72.30
(GIF) Impact Factor: 5.188
Publishing Copyright @ International Journal Foundation
Journal Code: ARJMD/AGS/V-36.0/I-1/C-5/APRIL-2019
Category : AGRICULTURAL SCIENCE
Volume : 36.0/**Chapter**- 5/**Issue** -1 (APRIL-2019)
Journal Website: www.journalresearchijf.com
Paper Received: 16.04.2019
Paper Accepted: 26.04.2019
Date of Publication: 10-05-2019
Page: 27-31

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CITATION OF THE ARTICLE

Ale, M. O., Obolo, A. A., Orungbemi, O. O; (2019); Comparative evaluation of Fermentation Methods on the quality of Cocoa Beans; *Advance Research Journal of Multidisciplinary Discoveries;* 36(5) pp. 27-31

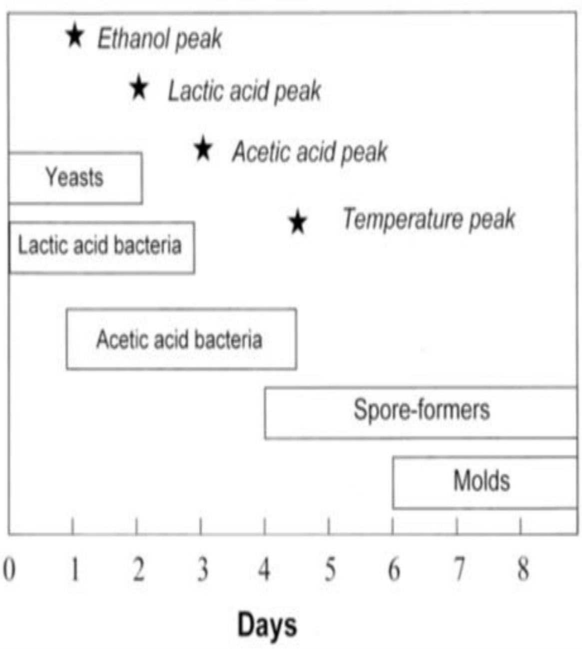
I. INTRODUCTION

Cocoa (*Theobroma cacao L*) which literally means food of the gods (WCF,2015) belongs to the Malvaceae family and is a tropical plant cultivated for its beans from which cocoa powder and butter are extracted. The cacao tree is indigenous to the tropical forests of Latin America. According to Wood and Lass, 2001, Cocoa originated in the foothills of the Andes in the Amazon and Orinoco basins of South America (now Colombia and Venezuela and its bean was a common currency throughout Mesoamerica before the Spanish conquest.

Fermentation as an essential process in cocoa production differs from one to another, but all methods involve removal of the beans from the pods and piling them together in a confinement to allow the activities of micro-organisms to initiate the fermentation of the pulp surrounding the beans. The piles may be covered with banana leaves for the traditional method; or in a box or any other confined and air-tight environment. In anaerobic conditions, the alcohol converts to lactic acid and later acetic acid during the process of fermentation. The temperature is raised between 40ºC and 45ºC during the first 2 to 3 days. As a result of the increased temperature, cell walls break down and segregate substances to mix. Enzyme activity, oxidation and the breakdown of proteins into amino acids takes place also in the fermentation process (Figure 1). These chemical reactions cause the chocolate flavour and colour to develop (ICO, 2001; Oduwole, 2003)

There have been many cocoa processing industries established in the country and abroad and many more are still springing up due to the increasing market force for cocoa products. The processing of cocoa includes the splitting of the pods; extraction, fermentation, drying, dehulling, and winnowing of the beans (Faborode and Oladokun, 1991). Nicholas et al, 2008 studied the performance of population dynamics, metabolite target, and chocolate production for seven independent spontaneous cocoa bean heaps fermentation in Ghana. Although the same microorganisms were involved in these heaps, carried out at different farms or in different seasons, heap temperature and microbial metabolite concentrations were different. This could be due to heterogeneity and size of the heaps, but was mainly ascribed to microbial variability. Indeed, differences in microbial activity could be linked with the favour of chocolate made from the corresponding dried, fermented cocoa beans. Fermentation is commonly carried out by the local farmer in Nigeria by the traditional way of using banana and cocoa yam leaves but there has been little research to improve on the traditional technique. To find alternative fermentation system in cocoa production and processing that can improve quality of the beans as well as control pollution of agricultural soil and its environment, there is the need to comparatively study the effects of other suitable materials and techniques on the quality of cocoa beans. Therefore, the objective of this study was to comparatively determine the effects of fermentation techniques on the quality of cocoa beans.

Figure 1: Schematic of Microbial succession during Cocoa Bean Fermentation.



Source: Schwan and Wheals, 2004.

Figure 2: Manual Cocoa Pod Splitting

Figure 3: An Aspect of the Fermentation Process

II. MATERIALS AND METHODS

Experiment Site

The experiment was conducted at the research farm of the Department of Agricultural and Bio-Environmental Engineering, Rufus Giwa Polytechnic, Owo, Nigeria (Lat7^0 15΄ N Long.5^0 35 ΄E) and Elevation 210 m. Experimentation Procedure.

Cocoa pods were procured from farms from Aladi farms settlement in Ose Local Government Ondo State. The cocoa pods were broken with the use of cutlass and the beans separated from the broken pods (Figure 2). The wet beans were subjected to fermentation using a wooden box, plastic basket, plastic, Stainless steel and heap leaves (Figure 3) to know the influence of the material on the fermentation rate and quality of the cocoa beans after drying. The temperatures of the samples were taken daily at intervals using a thermometer. The fermentation period was varied from 0, 2, 4, 6, 8 to 10 days to determine the effect of fermentation period on the quality of cocoa beans. The fermented beans were dried by sun-drying and physical evaluation was carried by cut test and weight test after drying to determine the effect of the materials on the quality of cocoa beans. The moisture content, nutritional and chemical analysis of each sample were carried out at Food Science Technology Laboratory.

Physical Evaluation Test

Weight Test: The weight test is to know the various weight of the cocoa beans in the various materials and for different days after fermentation and drying. The weight test was carried at the crop processing laboratory of Agricultural and Bio-Environmental Engineering Technology Department. The weights of the samples were taken using electronic weighing balance.

The cut Test : The cut test was carried at the crop processing laboratory of Agricultural and Bio-Environmental Engineering Technology Department. 50 cocoa beans were selected as samples from each material with different days of fermentation. Each of the beans was laterally cut using a sharp knife for defect observation from its cotyledon. The defects observed varied from slaty, insect damaged, flat bean, over fermented and mouldy beans.

Moisture Content Using Gravimetric Method

Dry samples of the beans were milled to powdery form. The powdery cocoa was measured inside the Petric dish and 2 kg of each of the samples was weighed using the digital weighing balance and then oven dried for
about three hours at 110℃. The dried sample cooled using a desiccator for 1 hour before reweighing to record the final weight after drying. The moisture content was determined using equation 1

$$Moisture\ Content = \frac{M_W}{M_s} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where M_w is the mass of water and M_s for soil

Chemical and Nutritional Analysis

Mineral analysis was carried out using AOAC, 2005 method with slight modification. About 0.5 g of the ground cocoa bean (sample) was weighed into a 250 ml beaker. Twenty-five ml (25ml) of concentrated nitric acid was added and the beaker was covered with a watch glass. Each sample was carefully digested on a hot plate in a fume chamber until the solution turned pale yellow. The solution was cooled and 1ml chloric acid (70% HCL04) added. The digestion continued until the solution turned colourless. After the digestion process, the solution was slightly cooled and 30 ml of distilled water added. The mixture was boiled for about 10 minutes and filtered using a Whatman NO.4 filter paper. The solution was transferred to a 100 ml volumetric flask and mixed with distilled water. The concentrations of Ca, Mg, Zn, Fe, Na, and K were determined using spectral AA 220 FS Spectrophotometer (Varian Co, Musgrave, Australia) with an acetylene flame. 1 ml aliquots of the digest was used to determine the Ca, Mg, Zn, Fe, Cu, Na, and K content of each sample.

III. RESULTS AND DISCUSSION

Results

The results of the comparative evaluation are presented in Figures 4 – 6 and Tables 1 - 5.

Figure 4: Moisture Content Analysis of Cocoa Bean after Drying on Each Material

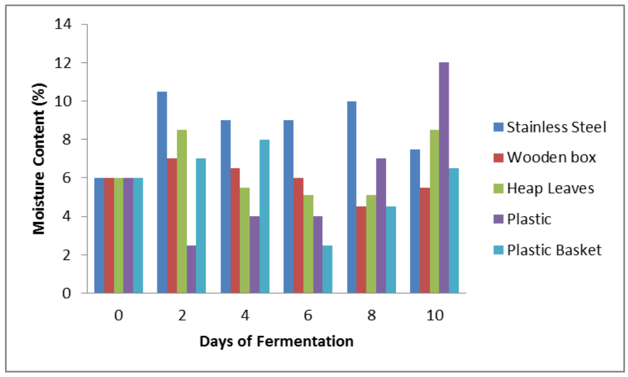


Figure 5: Temperature of Cocoa at Fermentation

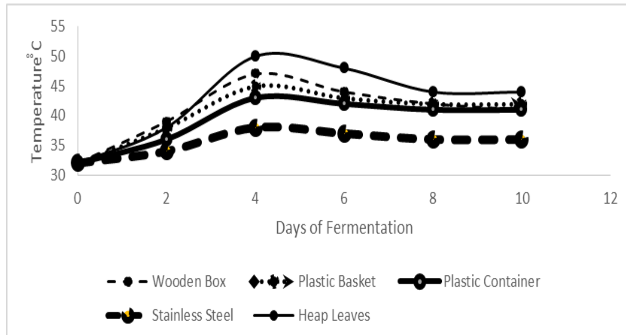


Table 1: Effect of Fermentation on the Colour of Cocoa Beans after Fermentation

Materials	Colour
Wooden Box	Brown
Plastic basket	Brown
Plastic	Brown
Stainless steel	Milk
Heap leaves	Brown

Figure 6: Fermentation Materials versus percentage of Brown Beans in Cut Test

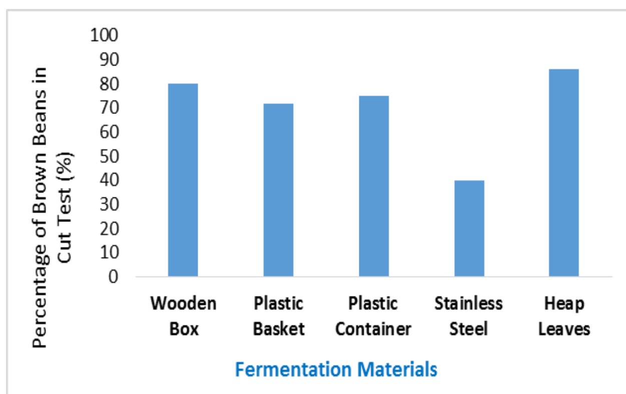


Table 2: Effects Fermentation Techniques on the Weight of Dry Cocoa Beans

Materials Days	0	2	4	6	8	10
Wooden Box	1.3	1.1	1.1	1.1	1	1
Plastic basket	1.3	1.2	1.2	1.2	1.1	1
Plastic	1.3	1.1	1.2	1.1	1.1	1
Stainless steel	1.3	1.1	1	1	1	1.1
Heap leaves	1.3	1.2	1	1.2	1.2	1

Table 3: Effects of Fermentation Material and Period on the Physical Characteristic of Dry Cocoa Bean

No of Days	0	2	4	6	8	10
Wooden Box	Slatey and unfermented	Slatey and unfermented	Partly purple and partly brown	Violet	Well fermented pale	Slaty turning violet
Plastic basket	Slatey and unfermented	Violet turning brown	Slatey turning violet	Violet	Mould	Mould and infested
Plastic	Slatey and unfermented	Slatey and unfermented	Slatey turning violet	Well fermented	Slightly over fermented	Mould and infested
Stainless steel	Slatey and unfermented	Slatey and unfermented	Well fermented (pale)	Partly purple partly brown	Violet turning brown	Slightly over fermented
Heap leaves	Slatey and unfermented	Violet	Well fermented	Well fermented (Pale)	Slightly over fermented	Mould and infested

Table 4: Mineral Analysis of Dry Cocoa Beans

No of Days	Na (ppm)	Ca (ppm)	K (ppm)	Fe (ppm)	Mg (ppm)	Zn (ppm)
0	18.400	106.000	30.460	1.080	5.960	1.860
2	16.800	94.000	41.000	0.970	4.080	1.510
4	10.560	71.700	29.500	0.900	4.010	1.300
6	9.450	69.300	23.600	0.850	3.960	1.480
8	6.290	69.100	21.000	0.720	3.520	1.360
10	5.440	66.000	29.100	0.50	2.920	1.220

Table 5: Chemical Analysis of Heavy Metal in Dry cocoa beans

Days	Cd (ppm)	Ni (ppm)	Pb (ppm)	Cr (ppm)
0	0.003	0.010	0.230	0.005
2	0.003	0.006	0.190	0.002
4	0.002	0.002	0.120	0.001
6	0.001	0.001	0.090	0.002
8	0.001	0.001	0.060	0.001
10	0.001	0.001	0.040	0.001

IV. DISCUSSIONS

Effects of Fermentation Material on the Physical Characteristic of Dry Cocoa Bean

As presented in Table 1, the colour of the beans after fermentation was majorly brown in all the fermentation materials except with stainless steel in which milk colour was observed after fermentation. The percentage of brown beans in the cut test as presented in Figure 3 varies from 40 to 86 %; heap leaves having the highest percentage of 86 % and stainless steel with the least percentage of 40 %.

From the results presented in Table 2, it was observed that the weight per dry cocoa bean ranged from 1.0 to 1.2 for the fermented beans in the experiment. While the average weight of bean without fermentation was recorded as 1.3 g. This is in conformity with Opeke, 2005 who reported that average dry and fermented cocoa bean was 1g. It was observed that the weight of dry cocoa bean decrease with increase in the period of fermentation.

On temperature of the beans at fermentation, it ranges from 34 to 50 C as presented in Figure 5. This is in conformity with AusAID, 1995. The temperature of cocoa beans without fermentation was recorded as 32 C. The peak temperature was recorded at fermentation period of 4 days. This is in conformity with Schwan and Wheals, 2004

Table 3 presents the result of the cut test after drying of the fermented cocoa beans. It was observed that the beans fermented with heap leaves gave out the optimum results, the observations range from violet, well fermented slightly over fermented except with period of fermentation period of 10 days which shows that the beans were mouldy and infested. The unfermented beans were slaty after drying. This is in conformity with Schwan and Wheals, 2004 in his review work on microbiology of cocoa fermentation

Effects of Fermentation Period on the Moisture Content of Dry Cocoa Beans

It was observed from Figure 4 that moisture content of dry cocoa beans decreased with increase in fermentation period but later increased with time in all the fermentation materials. It was also observed that the moisture content later decreased with increase in fermentation period at day 6 (Figure 6). Maximum moisture content was 12 % observed with the plastic container with fermentation period of 10 days. This is not suitable as it was more than 7.5 % maximum moisture content recommended by NEPC, 2005. While the minimum moisture content of 2.5 % was observed with the plastic container with fermentation period of 2 days. Optimum moisture contents of 5.5, 6, 6.5 and 7% were observed with heap leaves, the wooden box, the plastic container and the plastic basket with fermentation days varying from 2 to 10 days. The moisture content of dry and unfermented cocoa beans was observed as 6 %.

Effects of Fermentation Period on The Chemical Composition of Dry Cocoa Beans Fermented with Heap Leaves

As presented in table 4 and 5, the mineral content and heavy metal decreased with increase in fermentation period in all the materials. This shows that the more fermentation period the better for the health of cocoa consumers as heavy metals are not good for human health.

V. CONCLUSIONS AND RECOMMENDATIONS

This study was carried to know if there could be alternatives to the traditional way of cocoa beans fermentation in which banana and cocoyam leaves are used. The other materials used for the experiment were wooden, plastic basket, plastic and stainless steel. It was found that the traditional (heap leaves) method produced the best quality in terms of the acceptable standards. But wooden box had a very close range in quality performance with heap leaves.

The best quality of cocoa beans was achieved at fermentation period of 6 days in all the materials used for the fermentation experiments.

There was a correlation between fermentation period and the chemical composition. The more fermentation period, the better for the health of cocoa consumers as heavy metals reduced with an increase in the days of fermentation.

For mechanization, it is recommended that wooden box can be used as an alternative to the traditional (heap leaves) method. This will reduce the destruction of economic crops like plantain, banana, and cocoyam as well as eliminate the pollution of agricultural soil and its environment.

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