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Physical Quality Responses of Cocoa Beans to Inclusion and Exclusion of Placenta and Varied Fermentation Periods

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Ghana's premium quality cocoa could be sustained by purging off foreign matter introduced somewhat by placenta mixed with extracted cocoa beans. This study thus examined the effect of placenta and varied fermentation periods on physical quality characteristics of cocoa beans. A field and laboratory studies were done at the Department of Horticulture and Pharmacy, KNUST Kumasi. Experimental design for laboratory work was 2×5 factorial of placenta inclusion or exclusion and varied fermentation days in CRD and replicated three times. Cut test revealed that cocoa beans without placenta were totally clean. Also, the longer the fermentation days with placenta the more chaff content. Longer drying time resulted in the formation of more purple beans while those beans fermented for over six days produced the highest germinated beans. It was concluded that for premium quality cocoa beans, fermentation should be done for, at least, six days without placenta since that improved the physical attributes of the cocoa beans.

Keywords: Slaty; purple; anthocyanin; defects; flavouring and tannins.

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1. INTRODUCTION

As the world's second largest producer and major contributor to the growth of the country, cocoa is highly valued by Ghana. Currently, Ghana exports to 80% of its raw cocoa beans [1]. According to the Global Trade Atlas, as of March 2009, the Netherlands imported cocoa beans to the tune of USD 352,505,018. The United States imported USD 40,785,667, worth of cocoa powder and France imported USD 288,328,480 worth of retail chocolate. These three countries are the highest Importers in the respective categories of cocoa product [2]. Cocoa pulp is reported to be rich in fermentable sugars, such as glucose, fructose and sucrose, and has a low pH of 3.0–3.5, mainly because of the presence of citric acid [3] making it a rich medium for microbial growth [4]. Proteins, free amino acids, vitamins, and minerals are also present in the pulp. Work done by [4] showed that the ratio of sucrose, glucose, and fructose present in the pulp varies with the age of the pod. The pulp is also reported to contain high amount of pectin and other polysaccharides which make the pulp viscous, limiting diffusion of air through the beans during fermentation [5]. Cocoa beans are mostly processed into chocolate and cocoa products using a wide range of intermediate products such as cocoa liquor, cocoa butter, cocoa cake and raw cocoa powder. Cocoa powder is essentially used in flavouring biscuits, ice cream and other dairy products, drinks and cakes and in the manufacture of coatings for confections and frozen desserts [6-8]. Currently, the pod husks and shells are used for the preparation of animal feed and fertilizer in Ghana [9].

Ghana's premium cocoa is facing a quality decline due to issues like suspected adulteration, mouldy beans, and presence of inert matter which may possibly be due to presence of placenta mixed with extracted cocoa beans during the process of fermentation and drying). Ntiamoah and Afrane [10] explained that, the root cause of quality anomalies in cocoa could be traced to poor postharvest handling techniques which included addition of placenta during the bean extraction from the pod stage, bad fermentation including overly fermenting the beans coupled with inadequate drying. Many research works have mentioned the benefits of certain postharvest activities on the quality of cocoa beans. For instance, [11] indicated that the fermentation processes breaks in the mucilaginous pulp surrounding the beans and causes cotyledon death leading quality beans. Afoakwa et al. [12] also opined that fermentation triggers biochemical transformation inside the beans, leading to reduction in bitterness and astringency, development of flavour precursors such as, free amino acids, peptides and sugars. Furthermore, Rodriguez-Campos et al. [13] reported that pod storage and fermentation influenced to varied levels the chemical composition and physical characteristics of Ghanaian cocoa beans. However, little is known about the effect of placenta inclusion or exclusion on the physical characteristics of cocoa beans. The objective of this study was to determine the effect of placenta (with or without) and fermentation duration on physical quality of dried cocoa beans.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted in the Bekwai Municipality of Ashanti Region which lies between 6.4482° N and 1.4821° W. Bekwai municipal is one of the 30 administrative districts in the Ashanti Region. The municipal shares boundaries with Amansie West District to the west, Bosomtwe District to the north, Adansi south and North Districts to the south and the Asante Akim south District to the east. With a population of 208,987, and an intercensal growth rate of 3.2 percent malesin the municipal constitute 52% while females constituting 48%. The rural population of the municipal is 8.4% while the urban population is 11.6%. Farmingis the dominant occupation of the peoplein the municipal with cocoa farming being the main crop produced.

2.2 Experimental Design

A 2 x 5 factorial Completely Randomized Design with two experimental factors (Extracted cocoa beans with and without placenta) and five different fermentations periods (4, 5, 6, 7 and 8 days) which were replicated three times was used for the field experiment.

3. SAMPLE COLLECTION PROCEDURE

3.1 Harvesting, Sorting and Pod Storage

Six hundred (600) cocoa pods of mixed hybrid variety whichis translated to be equivalent to one bag of cocoa beans (62.5 kg) were harvested from a selected cocoa farm over a period of five

days with 120 pods per day for the experiment at Ashanti Bekwai. The riped pods on the cocoa tree stem were harvested using a well sharpened machete whiles fruits high up the tree were harvested using pruning hook or go-to-hell [14]. Debris, diseased infested and blemished pods were sorted out from the harvested stock in order to prevent them from being added to the experimental samples. Each daily harvested batch of pods (120 pods) were stored or rested for three days period as recommended by Afoakwa et al. [14] before pod breaking process commenced.

3.2 Pod Breaking and Bean Extraction

The one hundred and twenty harvested cocoa pods for the first batch treatment were divided into two equal groups, sixty (60) pods each and were opened for the beans to be extracted. Breaking of the pods was done using a blunt cutlass to expose the beans. This facilitated ease of bean-scooping from the pods. The mucilaginous beans from first 60 pods were extracted with placenta and replicated into three groups and the other remaining 60 pods were extracted without placenta and also replicated into three and were put on a plantain leaves for the fermentation process. This procedure was repeated for the subsequent harvested batches.

3.3 Fermentation Method and Procedure

The traditional heap fermentation method was used with varied fermentation periods (4, 5, 6, 7 and 8 days). In this method, cocoa beans were heaped on a bed of banana leaves with or without placenta. This was replicated into three groups and located at three different locations in the cocoa farm for the fermentation process. The heap fermentation method was used because it is cheap, produces well fermented cocoa beans and its good for small production volumes. This was followed up by the turning of the cocoa beans every two days to ensure even fermentation within every two days [14], until the end of the four to eight days.

3.4 Drying of Fermented Beans

Drying was done on a raffia mat at a cocoa depot in Bekwai. The drying raffia mat was raised one meter above ground and supported below with sawn bamboo sticks which facilitated movement of air around the platforms. Drying started from 8:00 am to 5:00 pm each day. Beans were periodically stirred every three hours to ensure uniform drying. Drying continued until 7.5 to 6% moisture content was achieved. Polyethylene sheet was used to cover the beans on occasion of raining and sunset.

4. PHYSICAL PARAMETERS MEASURED

1. Bean Count of the Dried Cocoa Samples: The bean count per 100 g [15] was taken in triplicate and measured on an electronic scale. The amount attained after the count aided to determine the category of the beans being counted.
2. Chaff (%) in the Dried Cocoa Bean Sample: The chaff content (bean equivalent i.e. 1 g chaff ≡ 1 whole bean) among the treated samples were picked and expressed as percentage to the total bean count and its equivalent whole bean was determined using 1 g whole bean equivalent.
   % Chaff content in beans (C) = (Total chaff by weight)/(100 g of beans weighed) ×100
3. Average Slaty Beans (%) of the Dried Cocoa Samples: Slaty bean, as a defect, were observed from 100 beans cut for each treatment and expressed as a percentage using the formula below [16].
4. % Slaty beans (S) = (Number of slaty beans)/(Total number of beans cut)×100
   % Purple Beans Count (%) of the Dried Cocoa Bean Samples: Purple as a defect, was determined from 100 beans cut from each tray and the number of beans found to exhibit the features of purpleness counted. This was expressed as a percentage using the formula below [15]
   % Purple beans (P) = (Number of purple beans)/(Total number of beans cut) ×100
5. Average Germinated Beans (%) of the Dried Cocoa Samples: Germinated beans as a defect were observed from 100 beans cut from each treatment and the number of beans found to exhibit the features of germination was counted. This was expressed as a percentage for each treatment by the formula below [15]:
   % Germinated beans (G) = (Number of Germinated beans)/(Total number of beans cut) ×100
6. Other Defects (%) of the Dried Cocoa Samples: Other defective beans such as weevily, flat, foreign matter among others were observed from 100 beans cut from each treatment and the number of beans found to exhibit the features of other defects was counted. This were expressed

as a percentage for each treatment by the formula below [17]:

% Other defective beans (OD) = (Number of defective beans)/(Total number of beans cut) ×100

7. All Other Defects (%) of the Dried Cocoa Samples: All other defects were observed from 100 beans cut from each treatment and the number of beans found to exhibit the features of all other defects was counted. This were expressed as a percentage for each treatment by the formula below [17]:

   % All other Defects (AOD) = (Number of All other defects)/(Total number of bean cut) ×100
8. Purity (%) of the Dried Cocoa Samples: Purity as a measure of the overall effect of the observed defects on the quality of cocoa, was expressed as a percentage by the formula [17].% Purity= 100 – [M + S + AOD+PP]

Where,

M = Mouldy Beans
S = Slaty Beans
AOD = AllOther Defects and
PP = Purple Beans

4.1 Data Analysis

The cut test and laboratory results were subjected to ANOVA (Analysis of Variance) using the Statistix software version 9. Where significant differences existed, treatment means were separated with Tukey's Honest Significant Differences at 1% probability level (P≤ 0.01).

5. RESULTS

Total bean count of dried cocoa beans were significantly (p≤0.05) affected by fermentation days and placentainteraction (Table 1). Highest Total bean count (254.00 beans) was produced by cocoa beans with placenta fermented for eight days. The least (225.00 beans) Total bean count was recorded by beans without placenta fermented for eight which was similar to those fermented for four days without placenta (216.67 beans). Across the fermentation days, there were no significant differences (p≤0.05)in the Total bean count. Across the Placenta, there were no significant differences (p≤0.05) in the Total bean count.

5.1 Average Bean Count on Cocoa Beans Fermented for Various Days with or Without Placenta

Average bean count of dried cocoa beans were significantly (p≤0.05) affected by fermentation days and placenta interaction (Table 2). The highest average bean count (84.67 beans) was produced by cocoa beans with placenta fermented for eight days and the least (72.33 beans) average bean count was recorded by beans without placenta and fermented for four which was similar to those without placenta fermented for eight days (75.00 beans). Across the fermentation days, there were no significant differences for average bean count. Across the Placenta, there were no significant differences for average bean count.

5.2 Percentage Chaff of Cocoa Beans Fermented on Various DAYS with or without Placenta

Percentage chaff content of the dried cocoa beans was significantly (p≤0.05) affected by fermentation days and placenta interaction (Table 3). The highest percentage chaff (18.50%) was produced by cocoa beans with placenta fermented for eight days. The least (0.00) percentage chaff was recorded by beans without placenta fermented for four, five, six, seven and eight days. Across the fermentation days, highest percentage chaff (9.25%) was recorded by beans fermented for eight days and the least (3.82%) was those fermented for four days. Across the Placenta, highest percentage chaff was recorded by beans with placenta (13.69%) and the least (0.00%) was those without placenta.

5.3 Percentage Bean Equivalent of the Chaff of the Cocoa Fermented on Various Days with or Without Placenta

Equivalent cocoa beans were significantly (p≤0.05) affected by fermentation days and placentainteraction (Table 4). The highest bean equivalent (15.33) was produced by cocoa beans with placenta fermented for eight days. The least (0.00) bean equivalent was recorded by beans without placenta fermented for four, five, six, seven and eight days. Across the fermentation days, highest bean equivalent was recorded by beans fermented for eight days and the least was those fermented for four and five days. Across the Placenta, highest bean equivalent was recorded by beans with placenta and the least was those without placenta.

Table 1. Total bean count of cocoa fermented for various days with or without placenta

Fermentation days	Placenta		Means
	With Placenta	Without Placenta	
4	231.67^{ab*}	216.67^{b}	224.17^{a}
5	228.00 ^{ab}	236.00^{ab}	232.00^{a}
6	229.67^{ab}	240.33^{ab}	235.00^{a}
7	227.00^{ab}	235.33^{ab}	231.17^{a}
8	254.00^{a}	225.00^{b}	239.50^{a}
Means	234.07^{a}	230.67^{a}	
CV=4.08			
HSD (0.01) Fermentation days=16.55, Placenta=7.23 Fermentation days X placenta=27.74			

**Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

Table 2. Average bean count (%) of cocoa fermented for various days with or without placenta

Fermentation days	Placenta		Means
	With Placenta	Without Placenta	
4	77.33^{ab*}	72.33^{b}	74.83^{a}
5	76.00^{ab}	79.00^{ab}	77.50^{a}
6	76.33^{ab}	80.33^{ab}	78.33^{a}
7	75.67^{ab}	78.33^{ab}	77.00^{a}
8	84.67^{a}	75.00^{b}	79.83^{a}
Means	78.00^{a}	77.00^{a}	
CV= 4.14			
HSD (0.01) Fermentation days=5.60, Placenta=2.46 Fermentation days X placenta=9.39			

** Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

Table 3. Percentage chaff of cocoa beans fermented on various days with or without placenta

Fermentation Days	Placenta		Mean
	With	Without	
4	7.63^{d*}	0.00^{e}	3.82^{d}
5	11.53^{c}	0.00^{e}	5.77^{c}
6	14.63^{b}	0.00^{e}	7.32^{c}
7	16.17^{ab}	0.00^{e}	8.08^{ab}
8	18.50^{a}	0.00^{e}	9.25^{a}
Means	13.69^{a}	0.0000^{b}	
CV (%) = 14.43			
HSD (0.05) Fermentation days=1.70, Placenta=0.75, Fermentation days X placenta=2.85			

** Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

Table 4. Percentage bean equivalent of the chaff of the cocoa fermented on various days with or without placenta

Fermentation Days	Placenta		Mean
	With	Without	
4	7.00^{c*}	0.00^{d}	3.50^{c}
5	11.00^{b}	0.00^{d}	5.50^{b}
6	11.67^{b}	0.00^{d}	5.83^{b}
7	13.00^{ab}	0.00^{d}	6.50^{ab}
8	15.33^{a}	0.00^{d}	7.67^{a}
Means	11.60^{a}	0.00^{b}	
CV (%) = 16.05			
HSD (0.05) Fermentation days=1.61, Placenta=0.71, Fermentation days X placenta=2.69			

** Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

Table 5. Slatiness (%) of cocoa beans fermented on various days with or without placenta

Fermentation Days	Placenta		Means
	With Placenta	Without Placenta	
4	1.47^{ab*}	1.10^{ab}	1.28^{ab}
5	2.53^{a}	2.47^{a}	2.50^{a}
6	1.10^{ab}	1.10^{ab}	1.10 ^{b}
7	1.23^{ab}	1.00^{ab}	1.12^{ab}
8	1.43^{ab}	0.10^{b}	0.77^{b}
Means	1.55^{a}	1.15^{a}	

CV=58.62

HSD (0.01) Fermentation days=1.39, Placenta=0.61 Fermentation days X placenta=2.32

** Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

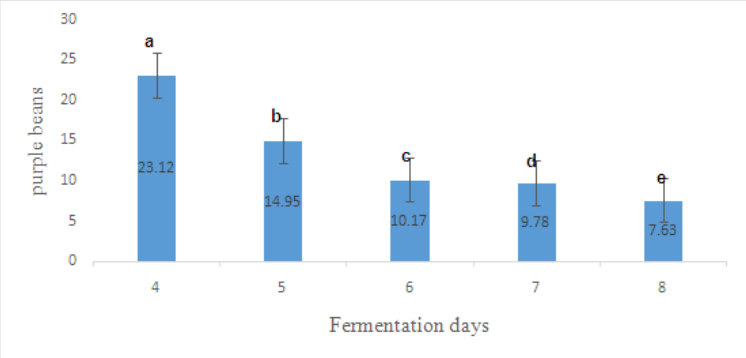

Fig. 1. Purple beans (%) on cocoa fermented variedly with or without placenta

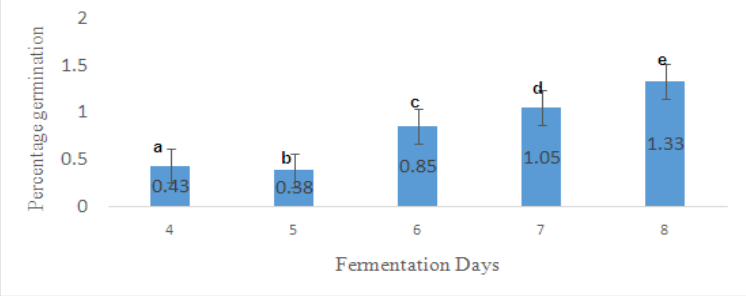

Fig. 2. Germinated beans (%) on cocoa fermented for various days

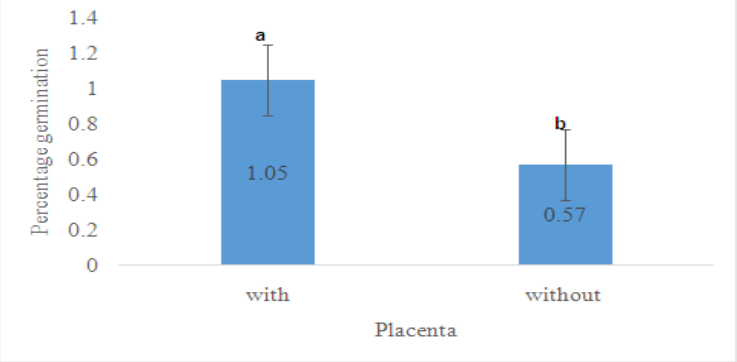

Fig. 3. Germinated beans (%) cocoa with or without placenta

5.4 Slaty Beans (%) of Cocoa Fermented for Various Days with or without Placenta

Slatiness of dried coca beans was significantly (p≤0.05) affected by fermentation days and placentainteraction (Table 5). The highest slatiness (2.53%) was produced by cocoa beans with placenta fermented for five days which was similar to beans fermented for five days without placenta (2.47%). The least slatiness (0.10%) was recorded by beans without placenta and fermented for eight days. Across the fermentation days, highest slatiness (2.50%) was produced by cocoa beans fermented for five days and the least (0.77%) was recorded by beans fermented for eight days which was similar to that of six days (1.10%). Across the Placenta, there were no significant differences (p≤0.05) in the slatiness of the beans.

5.5 Purple Beans (%) on Cocoa Fermented for Various Days With or Without Placenta

Purple bean count (%) was affected significantly (p≤0.05) by fermentation days (Fig. 1). The highest purpleness (23.12%) was recorded by beans fermented for four days and the least (7.63%) was recorded by those fermented for eight days which was similar to those fermented for six and seven days (10.17% and 9.78%).

5.6 Germinated Beans (%) on Cocoa Fermented for Various Days

The average germinated beans was significantly (p≤0.05) affected by fermentation days (Fig. 2). Significantly (p≤0.05) highest (1.33% and 1,05%) germinated beans were recorded by beans fermented for seven and eight days, whiles the least (0.43% and 0.38%) were recorded by beans fermented for four and five days.

5.7 Germination of beans (%) of Cocoa with or without Placenta

Average germinated beans was significantly (p≤0.05) affected by placenta (Fig. 3). Significantly (p≤0.05) highest (1.05%) germinated beans were recorded by beans with placenta whiles the least (0.57%) was recorded by beans fermented without placenta.

5.8 All Other Defects (%) of Cocoa Beans Fermented for Various Days with or without Placenta

All other defects of dried coca beans were significantly (p≤0.05) affected by fermentation days and placentainteraction (Table 6). Significantly (p≤0.05) highest all other defects (8.67%) were produced by cocoa beans with placenta fermented for eight days. The least (0.90%, 0.67%, 0.77%, 2.27% and 0.90%) all other defects were recorded by beans without placenta fermented for four, five, six, seven and eight days which were similar to beans with placenta but fermented for five and six days (2.20% and 2.47%). Across the fermentation days,significantly (p≤0.05) highest all other defects were produced by cocoa beans fermented for eight days (4.78% and the least was recorded by beans fermented for five days (1.43%). Across the Placenta, significantly (p≤0.05) all other defects (4.31%) were produced by beans with placenta and the least (1.18%) was produced by those without placenta.

5.9 Percentage Purity (%) of Cocoa Beans Fermented on Various Days with or without Placenta

Percentage purity of dried cocoa beans was significantly (p≤0.05) affected by fermentation days and placenta interaction (Table 7).

Table 6. All other defects (%) on cocoa beans fermented for various days with or without placenta

Fermentation days	Placenta		Means
	With Placenta	Without Placenta	
4	4.10^{ab*}	0.90 ^{b}	2.50^{ab}
5	2.20^{b}	0.67^{b}	1.43^{b}
6	2.47^{b}	0.77^{b}	1.62^{ab}
7	4.10^{ab}	2.67^{b}	3.38^{ab}
8	8.67^{a}	0.90^{b}	4.78^{a}
Means	4.31^{a}	1.18^{b}	
CV (%) = 69.57			
HSD (0.01) Fermentation days=3.33, Placenta=1.46 Fermentation days X placenta=5.59			

** Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

Table 7. Percentage purity (%) of cocoa beans fermented for various days with or without placenta

Fermentation days	Placenta		Means
	With Placenta	Without Placenta	
4	94.77[ab*]	97.77 [a]	96.27[a]
5	95.47[ab]	95.23[ab]	95.35[a]
6	96.43[ab]	98.37[a]	97.40[a]
7	94.00[ab]	96.13[ab]	95.07[a]
8	89.90[b]	98.53[a]	94.22[a]
Means	94.11[b]	97.21[a]	
CV=2.54			
HSD (0.01) Fermentation days=4.24, Placenta=1.87 Fermentation days X placenta=7.11			

** Means followed by the same alphabets are not significantly different (p≤0.05) from each other*

Maximum (98.53%) percentage purity was produced by cocoa beans without placenta fermented for eight days which was similar to beans without placenta fermented four and six days (97.77% and 98.37%) respectively whiles the minimum (89.90%) purity was recorded by beans with placenta fermented for eight days. Across the fermentation days, there were no significant differences (p≤0.05) in the percentage purity. Across the Placenta, the highest purity (98.21%) was recorded by beans without placenta and the least (94.11%) was recorded by beans with placenta.

6. DISCUSSION

Total and Average Bean Count of Dried Cocoa Beans Fermented on Varied Periods with or Without Placenta.

The total bean count for all the cocoa samples ranged from 224 beans to 240 beans with their corresponding average beans ranging between 75 beans and 80 beans, (Table 2) According to QCC [15] all the cocoa treated samples fall within category 'S' indicating super main crop beans. A Bean Count test tells the size of beans. There are seven categories of bean size: Super main crop, Main crop, Super light, Light crop, Small beans and remnant category. It is a part of the chocolate manufacturing requirements that cocoa beans are of reasonable same size. This will ensure even roasting of all beans and prevent small beans in being charred.

Chaff Content (%) And Bean Equivalent in the Dried Cocoa Samples.

The most useful and valuable part of the cocoa crop is the bean. Meaning that any substance other than cocoa beans for instance; cocoa related matter, flat beans, sievings, husk as well as traces of placenta are considered as foreign matter [18]. The result of the current study reveals cocoa sample fermented for eight days with placenta as having the highest percentage (18.5%)of chaff content representing 15.33 bean equivalent. This means that, the longer the fermentation days and the quicker the drying time for those cocoa bean samples with placenta the more the chaff production. This may be due to cells of placenta not degraded or high production of placenta debris or the rapid release of placenta attached to the cocoa beans during the drying process. This indicates higher levels of cocoa bean adulteration and foreign matter existence in the cocoa sample with placenta. Consequently this high foreign matter content level may affect the premium quality of the cocoa beans leading to it being graded as a sub-standard [15]. Conferring to [19] such high levels of chaff content in a sampled cocoa sample triggers rejection and subsequent confiscation. This has been affirmed by [20] asserted that such too high levels of foreign matters are not allowed or permitted by the international buyers. According toInternational Cocoa Standards requirements, cocoa of tradable quality should be well fermented, thoroughly dried, free from smoky beans, abnormal or foreign odor, foreign matter and free from any evidence of adulteration [21]. [10] explained that the root cause of quality anomalies in cocoa could be traced to poor postharvest handling techniques which included addition of placenta during the bean extraction from the pod stage, bad fermentation including overly fermenting the beans coupled with inadequate drying makes the produce vulnerable to mould and bacterial growth. Foreign matter not only affects the wholesomeness of the product but may also affect the flavour, cause damage to plant and machinery and reduce the yield of edible material [18]. The presence of foreign matter will also affect the yield of edible material

and hence reduce the value of the cocoa to the chocolate manufacturer, and may also affect the flavour and be a source of contamination to the product19.It also portrays a false weight to both producers and buyers.

Slaty Bean Content (%) of Cocoa Beans Fermented on Various Days With or Without Placenta.

From the current study, placenta presence or absence was not a contribution factor for slatiness but rather fermentation duration. Lower fermentation days (5 days) resulted in the highest slaty bean count (2.53%), whiles those cocoa beans samples which were fermented for eight days had the least slaty beans count (0.10%). The presence of grey or slaty beansis an indication of poor fermentation. This result from the current study has confirmed that of [22], who stated that improper fermentation of less than six days leads to formation of slaty beans. Though slatiness in cocoa has also been found to be contributed by fermenting inadequate ripened beans from immatured pods which does not allow the beans to undergo effective fermentation, [3,18]. [23] enumerated factors that contribute to slatiness of cocoa beans to include;inadequate fermentation, large heap mass of beans per unit area and also when the temperature outside the fermentation heapis too low particularly during dry seasons. He alsoincluded harvesting ofimmature cocoa pods coupled with inadequate turning of cocoa beans during fermentation as well as diseased pods as contributing factors to slatiness of fermented cocoa beans. Chocolate made from slaty beans is dark grey, extremely bitter, astringent and lacks the typical chocolate flavor [18]. To avoid slatiness, proper fermentation with adequate turning coupled with harvesting of fully ripped pods should be adhered to.

Purple Bean Content (%) of Dried Cocoa Beans Variedly Fermented With or Without Placenta.

From the current study, placenta is not a contribution factor to purpleness but rather fermentation days. The highest purple bean count was recorded by beans fermented for four days (23.12%) whiles the least (7.63%) was recorded by those beans fermented for eight days. From the results obtain, purple colouration decreased drastically with increasing duration of fermentation. That is, less fermentation days' result in increased anthocyanins in beans due to the fact that Glycosides in the beans have not hitherto broken down [24], though according to [25], fermentation of cocoa beans for six or seven days did not guarantee the complete removal of anthocyanins and purpleness from the cocoa beans. Shamsuddin and Dimick [26] reported that, the brown pigments might also be produced from complexation of condensed tannin, a high molecular weight product of flavonoid polymerization, with protein, through hydrogen bonding.

The results of the current study validates the findings of [27] whoindicated that, high percentage of purple beans in cocoa might be due to the short length of fermentation, while increased browning and the reduction of purple coloration in the dried beans indicates increased degree of fermentation. [27], explained that indicators of well-fermented and dried quality cocoa beans are a good brown colour, low astringency and bitterness, and an absence of off-flavours such as smoky beans and excessive acidity. [27], explained that the observance of the traditional fermentation period of at least six days ensured much decrease of the anthocyanins or polyphenols (purple) compound contentin the cocoa beans to as low as between nine to fifteen per cent but the three to four-day fermentation could keep the compound to as high as between forty to eighty percent in the bean. This was later on confirmed by Appiah [28].

According to Dietrich et al. [29], oxidation of polyphenol during the aerobic phase of cocoa fermentation is largely responsible for the characteristic brown colour of fermented cocoa beans. Wood and Lass [30] asserted that, the percentage purple beans decrease with aeration. This is so because purple colouration and loss of the characteristic chocolate brown colour is a function of fermentation. Purple bean occurrence has been of a major worry to the Ghana COCOBOD over the past few years as it poses a great threat to the nations well known premium cocoa beans at theinternational level [28].

Percentage Germination Content (%) of Cocoa Beans Fermented on Various Days With or Without Placenta.

Cocoa beans are known to be recalcitrantinherently [31]. This suggests that cocoa beans are short-lived, unable to survive desiccation when extracted from the pods, germinate in a few days after harvesting and cannot withstand drying [3]. Germination of beans normally occurs before or during fermentation when optimum conditions are created [32]. From Fig. 2, result shows higher

germinated percentage of 8 days fermentation. Again beans extracted with placenta had highest germination (Fig. 3).These results from the current study reveal that fermenting cocoa beans for more than seven days with placenta enhance germination probably due to the presence of placenta serving as a conducive medium for the bean to germinate. This is because, [33], suggested that seeds germination is induced by both the environmental and inherent seed behaviors. He added that when over riped pods are harvested, the beans may have already germinated or do so during the beginning of fermentation thereby reducing the weight as well as the commercial value of the beans. Afoakwa et al. [34] also reported that the lack of generation of enough acids to kill cotyledon resultsin germination of cocoa beans. According to Wood and Lass [30] germinated beans assist the entrance to mould through the ripped hull of the beans. Since longer fermentation days (8 days) with placenta favoured the emergence of higher percentage of germination, well riped cocoa beans could be fermented for at most seven days without placenta to reduced germination incidence of postharvest processing of cocoa.

Other Defects and All Other Defects of Cocoa Beans Fermented on Various Days With or Without Placenta.

Cocoa beans which were fermented for longer days with placenta gave the highest percentage of all other defects. This is perhaps due to the fact that, the beans over fermented with high moisture content from the placenta leading to the deterioration and defective beans. All other defects entail Germinated beans, weevils and other defects like placental masses, chaff, debris or anything other than cocoa beans in a given cocoa sample to be graded [21].

When cocoa over ferments,it leads toincreasedinherent microbial deterioration processes as asserted by [16]. According to Ardhana and Fleet [35], in cocoa bean fermentation, sugars in the mucilage are converted into alcohol by yeast which proliferate after the sterile mass from the pod is exposed to the surrounding air. The result of the current study collaborates with the above findings. Beans fermented with placenta for eight days having the highest all other defects could be as a result of the presence of high germinated beans, other defects like traces of placental mass, chaff and other materials other than cocoa beans.

Purity Content (%) of Cocoa Beans Fermented on Various Days With or Without Placenta.

Percentage purity which is the overall assessment of the impact of all the defects on the quality of the cocoa under consideration indicated an overall good performance for those cocoa beans fermented for six days without placenta. The results of the current study shows that beans fermented with placenta reduced percentage purity (94.11%) considerably, while those fermented without placenta gave the highest purity (97.21%) undoubtedly due to presence of high counts of placental masses, chaff, flat beans, germinated beans and other defects (Foreign matter) which are mostly associated with presence of placenta inclusion during postharvest handling of cocoa beans. According to Amanquah [36], cocoa mucilage together with its placenta consists of 87% water, 15% sugar, 3% pentosans, 3% citric acid, and 1.5% pectin. Proteins, amino acids, vitamins (mainly vitamin C), and minerals. These compositions makes placental mucilage a rich medium for microbial growth and thereby leading to defective and mouldy beans which are the highest source ofimpure cocoa beans [21].

7. CONCLUSION

For the cut test, study revealed a significant placenta and fermentation days' interaction. Significantly ($p \leq 0.05$),the highest of all other defects, other defects, unusual bean count and average bean count were produced by cocoa beans with placenta fermented for eight days. Cocoa beans fermented for eight days without placenta had the highest total bean count and percentage purity. Beans without placenta gave clean beans. But for those with placenta the longer the fermentation days the more the chaff content produced. Cocoa beans fermented for less than six days with placenta had the highest slatiness whiles beans fermented for less than six days had the highest purple beans and the longer it took the samples to dry the more purple formation. Also those beans fermented for more than seven days had the highest germinated beans.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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