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Research Article

Postharvest Handling Practices and Quality of Cocoa Beans from Major Cocoa Growing Regions in Ghana

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Abstract
A study was conducted to assess the various handling practices of cocoa beans in some selected districts across cocoa growing regions in Ghana. The study adopted the cross-sectional design which employed varying respondents from seven cocoa growing regions for the data collection. The survey was carried out from January to February, 2021. A semi-structured questionnaire was used to collect the needed information from the cocoa farmers. Four hundred (400) cocoa farmers were sampled from a population of 1,691,676. Simple proportion was used to determine percentage of farmers to be randomly selected as respondents for each region. The data was analysed using SPSS at 95% confidence level. The study revealed that 46% of the cocoa farmers were within the ages of 41-61, 34% were 20-40 years old with 20% being above 62 years. Majority (67%) of the farmers harvested at full ripe stage, whereas the remaining 33% harvested at half ripe. After harvest, majority (80%) of the farmers broke their cocoa pods after 4 days of harvest, whereas 15% and 5% broke the pods within 2 days and 3-4 days after harvest respectively. In addition, majority (90%) of the farmers used heap method of fermentation. Moreover, 72% of the farmers fermented their cocoa beans between 6-7 days, 20% 4-5 days and 4% between 2-3 days. All the farmers interviewed indicated that they sun-dried their cocoa beans. This practice was done by all farmers interviewed. Farmers who are non-compliant to the use of recommended handling practices should be encouraged to conform to ensure the production of quality cocoa beans. These findings have provided a justification for an intensified education of farmers and increased monitoring of the activities of all stakeholders in the cocoa industry.
Keywords: Cocoa, Postharvest Practices, Farm Management, Agricultural Extension Services, Fermentation.

1. Introduction

Cocoa is Ghana's main export crop and the country is known for the quality of its cocoa beans leading to a price premium on the international market. The crop plays a major role in the national economy in terms of employment, incomes and foreign exchange earnings. The socioeconomic development of Ghana has been projected to continue to depend on revenue from cocoa exports (Breisinger *et al.,* 2008).

It is estimated that there are currently about 720,000 cocoa farmers in the country (Barrientos *et al.,* 2008). But this figure is likely to be an underestimation of the actual number of people benefiting directly or indirectly from the cocoa industry in the country. Farmers, input suppliers, Licensed Buying Companies (LBCs), Ghana Cocoa Board (COCOBOD) with its subsidiaries like the Cocoa Health and Extension Division, Quality Control Company (QCC), and Cocoa processors are all involved in the cocoa value chain making cocoa a major economic crop. The cocoa sector has received the most attention from successive governments in an attempt to increase the country's output levels and foreign exchange earnings. Achieving these goals calls for measures to maintain and possibly increase product quality since quality determines the value of a product (Osei, 2007).

The nation has set the target of producing one million metric tonnes of cocoa again by 2020. Reasons for the good performance of Ghana's cocoa sector over the past two decades include prudent policy reforms in the cocoa sector, including the partial liberalization of cocoa marketing but with a strong government

involvement in export marketing and quality control. Government involvement in quality control has meant that licensed buying companies cannot adulterate produce sold to COCOBOD for shipment.

The stringent quality checks at village-level buying centers and takeover points for onward shipment of cocoa beans for export has helped to maintain product quality. Notwithstanding the good reputation of Ghana's cocoa and the efforts to maintain quality, there are indications that quality can be compromised in the face of market liberalization. According to Poulton (2018), the liberalization of markets has brought in its wake new challenges, including how to supply inputs on credit to smallholder farmers and how to maintain produce quality in a competitive market environment. They indicated declines in crop quality as one of the major challenges brought about by export crop liberalization. Experts believe that one of the dangers of liberalization is the lowering of product quality due to competition from buyers to consolidate or increase their market share. For example, in 1997 it was found that pressure from the LBCs in Ghana to obtain cocoa from farmers gave rise to the sale of some cocoa beans with high moisture content. This encouraged the development of mould which is one of the most important quality defects of cocoa, and one for which buyers discounted heavily on the international market (Bank of Ghana, 2003).

According to Osei (2007), market-determined premiums in commodity markets are based among other factors on quality perceptions. The author noted that while the quality of Ghana's cocoa has been used as a benchmark for assessing cocoa from other countries, there are always new challenges as the demands of the market keep changing. The buyer, the cocoa processor and the chocolate manufacturer must be satisfied with the quality of the produce that is delivered on the international market.

According to Folayan (2010), poor quality cocoa may lead to arbitration cases, loss of market share and revenue as well as tarnish the reputation of the exporting country. The critical quality issues in cocoa and cocoa by-products market include mould, slaty, bean count, insect damaged beans and other defects in the cocoa beans (Folayan, 1993). Quality is adjudged through flavour, purity, consistency, yield, bean size, percentage shell and fat content all of which influence the choice of cocoa beans (Folayan, 2010).

The physical characteristics of the beans and the flavour of the cocoa are major determinants of cocoa quality. Ghana is able to maintain a high export quality of cocoa because of the established practices of the farmers, who are very quality-conscious (Bank of Ghana, 2003). Cocoa farmers in Ghana are noted to follow stringent management practices that ensure good quality cocoa, a feat in which they take pride in. In preparing cocoa for sale, the Ghanaian farmer will take great care to sort out the good and bad beans, often discarding most of the bad beans.

The attainment of high quality cocoa beans depends on several factors. It has been argued that 80 percent of the quality of cocoa beans is dependent on the correct growing, drying and fermentation methods adopted by farmers. "Problems militating against the achievement of international quality standards in cocoa are broadly classified into natural factors and structural/financial factors. The natural factors include the effects of weather, sunshine and drying of cocoa beans. The structural/financial factors include: absence of direct extension services; funding of research activities; high levels of chemical residues; presence of heavy metals; use of jute sacks for the export of cocoa; and, mode of shipment" (Folayan,1993).

According to Folayan (2010), the root cause of quality anomalies in cocoa could be traced to poor farm management, infestation and other diseases, poor handling, bad fermentation, inadequate drying leading to high moisture content which makes the produce vulnerable to mould and bacterial growth. Other causes of low-quality cocoa are poor and long storage time which result in fat degradation, and pest infestation in the absence of fumigation and other forms of quality maintaining measures. As noted by Osei (2007), the biggest challenge in maintaining the confidence and trust of buyers of Ghana's cocoa is to ensure consistency in the quality of cocoa that the country supplies. According to the author, "this implies that cocoa farmers must continue not only to adhere to and adopt good agronomic practices but improve whatever good cultural practices they are currently applying" (Osei, 2007). In this study, a survey was conducted to find out the management practices and postharvest handling of cocoa beans and to discuss how these have impact quality of the cocoa beans.

2. Materials and Methods

2.1. Study Area

The study was conducted in all the seven (7) cocoa growing regions of Ghana including Western North, Western South, Volta, Eastern, Central, Brong Ahafo and the Ashanti region. Farmers were selected randomly

across the sixty-nine (69) districts in the seven (7) cocoa growing regions. The study involved a field survey conducted on selected cocoa farmers.

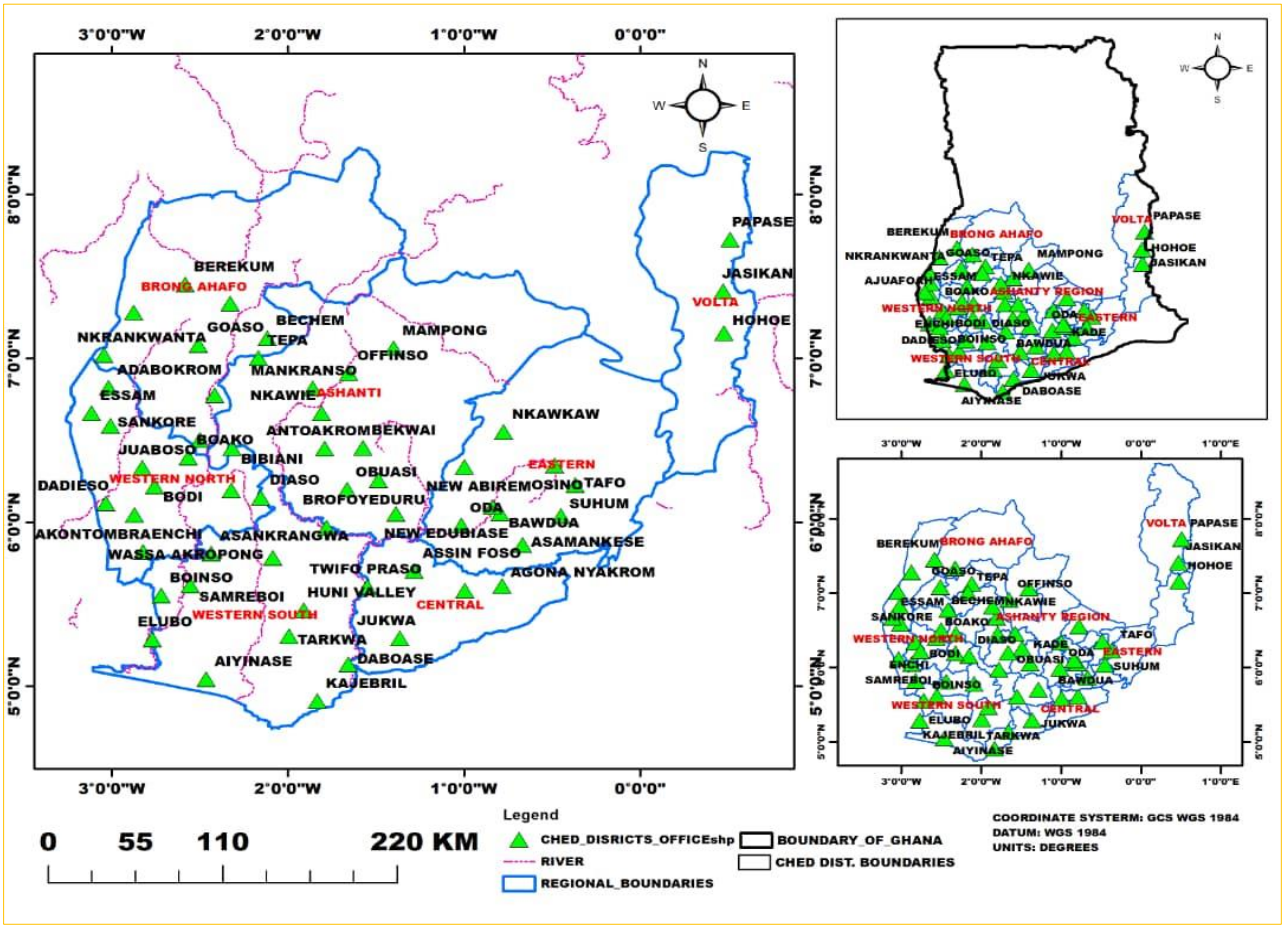

Figure 1. A map showing the study area [Source: Author's construct (2021)].

2.2. Field Survey on Postharvest Practices

Semi-structured questionnaires were designed to collect information from the respondents in the districts. The questionnaires were administered to assess the postharvest handling practices using the snow-ball sampling technique. Farmers were selected randomly across the cocoa districts in the seven (7) cocoa growing regions. Information on the Bio-data, yield, good agricultural practices (GAP) by cocoa farmers, postharvest practices such as harvesting, pod breaking, fermentation, drying and storage were obtained through the survey.

Sample size is the number of observation (respondents) taken from the population under study (cocoa farmers). It is a significant feature of any empirical study which seeks to ultimately make inferences about a population from a sample (Gill and Johnson, 2010). It is not necessary to use the entire population (cocoa farmers) for the study when a sufficiently large representative sample can be used to draw inferences to the entire population (Daly *et al.,* 1991).

Cocoa Health and Extension Division (CHED), subsidiary under Ghana Cocoa Board stipulate that there are 1,691,676 cocoa farmers across the cocoa districts in Ghana. With a 95% confidence level, 400 cocoa farmers were sampled from the population. The sampled size is in reference to the Yamane (1967) formula for determining sample size for a finite population with known population size, $n = N/1+N(e)^2$.

Where;
n = sample size,
e = desired level of precision,
N = study population.

With a desired 95% confidence level and a 5% margin of error $n = 1691676/1 + 1691676(0.05)^2 = 399.90 \approx 400$

In all, 400 respondents from the entire cocoa farmers' population of 1,691,676 were selected. Using cocoa farmer population per district, data obtained from the Cocoa Health and Extension Division, a subsidiary of Ghana Cocoa Board, simple proportion was used to share the sample size among the cocoa districts. This was to ensure efficiency and even distribution of respondents across the cocoa growing areas in Ghana.

Using simple random sampling, structured questionnaires were administered to the 400 cocoa farmers across all the cocoa districts in Ghana. Simple random sampling gives every cocoa farmer the opportunity to be included in the sample.

3. Data Analysis

Data obtained from the field survey was subjected to descriptive statistics using SPSS Version 20 and the results presented in tables. The difference in means was separated using Least Significant Difference (LSD) at 5% level ($p<0.05$).

4. Results

4.1. Background of Respondents

From the field survey conducted, about 24.8% of the cocoa farmers were located in the Ashanti Region followed by Western South (23%), Western North (19.3%), Eastern Region (13%), Brong Ahafo (8.8%), Central Region (6.8%), and Volta Region (4.3%) (Refer to Table 1). This means majority of cocoa farmers in Ghana are located in the Ashanti Region followed by Western South, Western North, Eastern Region, Brong Ahafo, Central Region with the minority located in the Volta Region as deduced from the data collected.

Table 1. Background of respondents.

Variable	Frequency	Percentage (%)
Regional distribution of cocoa farmers'		
Eastern	53	13
Central	27	6.8
Brong Ahafo	35	8.8
Volta	17	4.3
Western North	77	19.3
Western South	92	23
Ashanti	99	24.8
Gender		
Male	320	80
Female	80	20
Age		
20-40 years	136	34
41-61 years	184	46
62 and above	80	20
Educational background		
No formal education	64	16
Primary	64	16
JHS	184	46
Secondary	72	18
Tertiary	16	4
Number of years in cocoa farming		
1-10 years	88	22
11-20 years	176	44
21-30 years	80	20
31-40 years	52	13
Above 50	4	1
Size of cocoa farm (acres)		
< 1 acre	12	3
1 acre	16	4
2 acre	28	7
> 2 acres	344	86
Source: Field survey, 2021		

It was realized that cocoa farmers in the Ashanti region had a small portion of farm lands thereby given them more cocoa farmers relative to the other cocoa regions. According to Donkor and Owusu (2014), the agricultural land tenure system is largely by inheritance in Ghana. Therefore, most farmlands are divided equally into smaller pieces among family members from generation to another. This reduces the size of farmland under cultivation. This was commonly observed in the Ashanti region.

In terms of the gender of respondents, the survey revealed that about 80% and 20% of the sampled farmers' were males and females respectively. This, therefore, means that cocoa farming is a male dominated activity in Ghana (Table 1). Also, the field survey further revealed that about 46% of the farmers were within the age bracket of 41-61 followed by age group 20-40 years (34%) with minority (20%) being within the age bracket 62 years and above (Table 1). Thus cocoa farmers between the ages of 41-61 constitute the majority followed by age 20-40 years and then age 62 years and above. This means that most of the youth from cocoa production regions in Ghana are not into farming.

In terms of the educational background of respondents, the study revealed that majority (46%) of the cocoa farmers had some form of basic education (JHS) followed by secondary education (18%), no formal educational (16%), primary education (16%) with minority (4%) having some of form of tertiary education (Table 1). It is worth noting that about 16% of the cocoa farmers did not have any form of education. Furthermore, data was collected on the number of years spent in cocoa farming by the respondents. The results showed that majority (44%) of the cocoa farmers had been cultivating cocoa for between 11-20 years followed by 1-10 years (22%), 21-30 years (20%), 31-40 years (13%) with minority (1%) of the cocoa farmers have been cultivating cocoa for more than 50 years and above (Table 1). However, the average number of years the cocoa farmers had engaged in cocoa production in the country was 20 years.

Finally, in terms of the sizes of the cocoa farms of the respondents, the results revealed that majority (86%) of the cocoa farmers owned more than two acres (2 acres), followed by the cultivation of cocoa farms of two acres (7%), cocoa farm of one acre (4%) whereas minority (3%) have a cocoa farm of less than one acre (Table 1).

4.2. Effects of Fermentation on Quality of Cocoa Beans

4.2.1. Sources of Planting Material

According to the survey conducted, the cocoa farmers sampled across the seven major regions noted for cocoa production in the country obtained their planting materials particularly, the cocoa seedlings from two main sources, that is, from their own farm and the Seed Production Division of the Ghana Cocoa Board. Thirty-five percent (35%) and sixty-five percent (65%) of the farmers obtained their seedlings from the Seed Production Division of the Ghana Cocoa Board and their own farms respectively (Table 2). This means that majority of the farmers nurse their own seedlings whereas only a handful depend on the Seed Production Division of the Ghana Cocoa Board for certified seedlings.

Table 2. Sources of planting material.

Sources	Number	Percentage (%)
Ghana Cocoa Board	140	35
Farmers own farm	260	65
Total	400	100
Source: Field survey, 2021		

4.2.2. Sources of Cocoa Cultivation Knowledge

According to the survey conducted, the sources of knowledge on cocoa cultivation include from elderly family members, neighbour/peers and cocoa extension. A percentage of 55, 25 and 20 were for family, neighbour and cocoa extension respectively (Table 3).

Table 3. Sources of cocoa cultivation knowledge.

Sources	Number	Percentage (%)
Ancestral/family	220	55
Neighbour/peers	100	25
Cocoa extension	80	20
Total	400	100
Source: Field survey, 2021		

4.2.3. Sources of Chemical for Spraying Cocoa Farm

The outcome of the survey conducted revealed that the sources of chemical for spraying cocoa farm included, unlicensed agro-chemical shop, purchasing from licenced agro-chemical shop and depending on government mass spraying exercise. A percentage of 20, 26 and 54 of the cocoa farmers sourced their chemicals for spraying their cocoa farms from unlicensed agro-chemical shop, licensed agro-chemical and depending on mass spraying exercise respectively (Table 4). This means that majority (54%) of the cocoa farmers depended on mass spraying exercise to control insect-pests on their farms.

Table 4. Sources of chemicals for spraying cocoa farm.

Sources	Frequency	Percentage (%)
Licensed agro-chemical shop	104	26
Unlicensed agro-chemical shop	80	20
Mass spraying exercise	216	54
Total	400	100
Source: Field survey, 2021		

4.3. Fermentation Process of Cocoa Beans

From the field survey conducted, the types of fermentation methods used include fermentation in basket, fermentation in heap (banana leaves), box method and tray method. That is, majority (90%) of the farmers used the heap method of fermentation, followed by the use of basket (6%), whereas (2%) used boxes and (2%) tray methods (Table 5). In terms of the turning period during fermentation, in Ghana, the cocoa farmers often turned the cocoa beans, every 24 hours, every 48 hours with some farmers no turning. In the field survey conducted, 57% of the farmers' usually turned the cocoa beans every 48 hours followed by every 24 hours (23%) and 20% do not turn the beans (Table 5).

Table 5. Types of fermentation methods and turning during fermentation.

Method of fermentation	Frequency	Percentage (%)	Turning period during fermentation	Frequency	Percentage (%)
Basket	24	6	No turning	80	20
Heap in banana leaves	360	90	Every 24 hours	92	23
Box method	8	2	Every 48 hours	228	57
Tray method	8	2	-	-	-
Total	400	100	Total	400	100
Source: Field survey, 2021					

4.3.1. Duration of Fermentation and Materials Used in Drying Cocoa Beans

According to the survey conducted, 72% of the cocoa farmers fermented their cocoa beans for a period of 6-7 days followed by 4-5 days (20%) and 2-3 days (4%) (Table 6). Accordingly, cocoa farmers use sun drying for their cocoa beans by spreading it on raised mats, spreading it on polythene sheet, and spreading it on tarpaulin. Majority (95%) of the cocoa farmers sun dry their cocoa beans by spreading it on raised mats followed by spreading it on tarpaulin (3%) whereas minority (2%) on polythene sheet (Table 6).

Table 6. Duration of fermentation and materials used in drying cocoa beans.

Duration	Frequency	Percentage (%)	Material used in drying cocoa beans	Frequency	Percentage (%)
2-3 days	16	4	Spread on raised mat	380	95
4-5 days	80	20	Spread on polythene sheet	8	2
6-7 days	304	76	Spread on tarpaulin	12	3
Total	400	100	Total	400	100
Source: Field survey, 2021					

4.4. Ripening Stage to Harvest Cocoa Pod and Harvesting Interval

According to the survey conducted, there are two ripening stages for the harvesting of cocoa pods that is, fully ripe with yellow colour and partially ripe cocoa pods. Majority (67%) of the cocoa farmers harvested their cocoa pods when they were fully ripe whereas minority (33%) harvested at partially ripe/yellow colour (Table 7). The survey further revealed that the harvesting of cocoa pods time interval ranges between

1-2 weeks and 3-4 weeks. Majority (77%) of the farmers takes between 3-4 weeks to harvest their ripe pod whereas minority (23%) takes between 1-2 weeks to harvest their cocoa pods.

Table 7. Ripening stage to harvest cocoa pod.

Repining stage of cocoa pod	Frequency	Percentage (%)
Fully ripe or yellow colour	268	67
Partially ripe	132	33
Total	400	100
Source: Field survey, 2021		

4.5. Resting Period after Harvesting Before Pod Breaking

The survey conducted revealed that the resting time after harvesting before pod breaking were 1-2 days, 3-4 days and more 4 days. Majority (80%) of the farmers break the pod of the harvested cocoa pods above 4 days, followed by 1-2 days (15%) with minority (5%) breaking the pods 3-4 days after harvesting (Table 8).

Table 8. Resting period after harvesting before pod breaking.

Resting period after harvesting before pod breaking	Frequency	Percentage (%)
1-2 days	60	15
3-4 days	20	5
Above 4 days	320	80
Total	400	100
Source: Field survey, 2021		

4.6. Tools Used in Breaking Cocoa Pod

From the survey conducted, the tools used for the breaking of the cocoa pods include the use of blunt cutlass, the use of wooden clubs and by hitting against the floor. Majority (91) of the cocoa farmers used blunt cutlass followed by the use of wooden club (8%) whereas minority (1%) used hitting against the floor (Table 9).

Table 9. Tools used in breaking cocoa pod.

Tools used in breaking cocoa pod	Frequency	Percentage (%)
Blunt cutlass	364	91
Wooden club	32	8
Hitting against the floor	4	1
Total	400	100
Source: Field survey, 2021		

5. Discussions

5.1. Background of Respondents

The field survey conducted revealed that majority (24.8%) of the cocoa farmers in Ghana were in the Ashanti Region followed by Western South (23%), Eastern Region (13%), with the minority being located in the Volta Region (4.3%). It was observed during the survey that, individual farmers held smaller portions of cocoa land area in Ashanti region as compared to the other cocoa regions. This might be why the Ashanti region is having the largest number of cocoa farmers in the country. According to Donkor and Owusu (2014), the agricultural land tenure system is largely by inheritance in Ghana. Therefore, most farmlands are divided equally into smaller pieces among family members from generation to another. This reduces the size of farmland under cultivation. In terms of the gender of respondents, the survey conducted revealed that about 80% and 20% of the sampled farmers are males and females respectively. Cocoa farming in Ghana is a male dominated activity. The activities involved in cocoa cultivation are highly laborious and this could be reason for majority of farmers being men (Kongor *et al.,* 2018). The land tenure systems in the country also often favour the male population. Furthermore, the males are often endowed with resources such as land and other assets by virtue of the inheritance system (Baffoe-Asare *et al.,* 2013). Culturally in Ghana, where females own land, they are held in trust by their husbands.

The study further revealed that most (46%) of the farmers were within 41-61 years, 34% between 20-40 years with minority (20%) at 62 years and above. This suggests that most of youth from cocoa producing regions in Ghana are not into farming. It can be deduced that cocoa farming is seen as a long term investment which is not attractive to the youth who prefer to migrate to urban areas in search of better life

opportunities. This observation is not unique to cocoa producing areas as it is a general issue in the country where the youth are not interested in venturing into the agricultural sector. This can be attributed to the fact that the youth often perceive the agriculture sector to be a low paying sector coupled with the fact that cocoa cultivation takes a longer time to mature. For a prospective cocoa sector, majority of the youth should be engaged in cocoa production, however, the survey revealed that majority of the cocoa farmers in Ghana were within the ages of 41-61 years.

In terms of the educational background of respondents, the outcome of the field survey revealed that majority (46%) of the cocoa farmers had some form of basic education (JHS) with minority (4%) having some form of tertiary education. This finding has dispelled the notion that farming undertaken by people with no educational background requires no special skills. The reason is that cocoa farmers need to be able to read to enable them apply fertilizers and other chemicals accurately. Also, cocoa farmers require formal education to enable them keep proper records on their farms. Cocoa farmers also require formal education to enable them observe all the requirement necessary to produce cocoa of high quality to meet the quality standards of the world market. The high number of educated farmers as revealed erases the general perception that most cocoa farmers are illiterate and have no formal education (Baah, 2006). Generally, education enhances farmers understanding of technologies and helps to better appreciate, accept and implement innovations (Asamoah, 2015). In terms of the number of years in cocoa farming by the respondents, majority (44%) of the cocoa farmers have been cultivating cocoa for 11-20 years with minority above 50 years (1%). As revealed by the data collected, cocoa is a perennial cash crop which can be harvested yearly.

5.2. Sources of Planting Material

The sources of planting materials were from the farmers own farm and the Seed Production Division of Ghana Cocoa Board. According to the survey conducted, 65% of the farmers used seeds from their farms in planting whereas 35% received their seeds from Seed Production Division (SPD). According to the farmers hybrid pods and seedlings are insufficient for seasonal new establishment, resorting to the use of pods harvested from their own farms. Some farmers also mentioned delay in the supply of hybrid cocoa seedlings thereby forcing them to used pods from their farms. Again, some farmers complained of over grown seedlings at SPD nursery sites which normally do not establish after transplanting. Other farmers also indicated that the old variety, Amelonado, is hardy and bears more fruits than the hybrid and therefore prefer it to the hybrid, though the hybrid is early maturing (Opoku-Ameyaw *et al.,* 2010). Currently, Cocoa Health and Extension Division (CHED), a subsidiary of Ghana Cocoa Board is supporting farmer groups and farmer cooperatives to raise additional seedlings to augment that of SPD.

5.3. Sources of Cocoa Cultivation Knowledge

Most of the farmers were born into farming, others acquire it through their peers in the communities and some learnt through the cocoa extension services provided by government. The results of the field survey showed that majority (55%) of the farmers learnt farming through their parents. According to them, farming was their main source of livelihood and therefore inherited it. It also showed that 25% learnt farming from their peers. They also learnt from the majority of farmers who have acquired experience through their families to also make progress. Few (20%) of the farmers learnt from directive and trainings provided by the cocoa extension directorate. This was through mass education on radio, television, information centres and personal contacts with cocoa extension agents. According to Oladosu and Okunade (2006), information and knowledge are essential for farmers to respond successfully to the opportunities and challenges of the physical, social and policy environments in which they operate. This finding is consistent with the finding of Nana *et al.,* (2013) who established that at the village level, farmers' source of information and knowledge on cocoa farming was mostly from their colleague farmers, family members (personal sources) as well as from the media outlets including radios and television.

5.4. Sources of Chemical for Spraying Cocoa Farms

Asamoah and Baah (2003) reported that stakeholders such as chemical companies, input distributors and Licensed Buying Companies (LBCs) depend largely on cocoa farmers for markets for their products, employment and income. One of the significant aspects of cocoa farming is proper farm maintenance practices which comprises weeding and insect pests control to increase production. However, the sources of chemicals for spraying a cocoa farm are very important. The survey conducted revealed that the sources of chemical for spraying cocoa farm include purchasing from licensed agro-chemical shop (26%), purchasing from unlicensed agro-chemical shop (20%) and depending on government mass spraying exercise (54%). It can be deduced from the data gathered that it is expensive for the farmers to purchase their own chemicals

to spray their farms and also difficulty approved hence the farmers are beneficiaries of the Government mass cocoa spraying programme. Poor maintenance practices, planting of low-yielding varieties and the incidence of pests and diseases have accounted for the low productivity of cocoa in Ghana (Abekoe *et al.,* 2002).

5.5. Cocoa Bean Fermentation Methods Used

Generally, there are several methods of cocoa fermentation which include fermentation on drying platforms, fermentation in heaps (in banana leaves), fermentation in baskets (cocoa baskets), fermentation in trays and fermentation in boxes (Hamid and Lopez, 2000). From the field survey conducted, the types of fermentation methods used include fermentation in basket, fermentation in heap (banana leaves), box method and tray method. The study showed that majority (90%) of the farmers used the heap method whereas few (2%) used box and tray methods. The main reason given by majority of the farmers who used the heap method was that it was more convenient to just heap the beans for fermentation. Also, the heap method increases the quality of the dried cocoa beans for chocolate flavour as they asserted. According to Ardhana and Fleet (2003), the fermentation methods used determine strongly the quality of cocoa beans produced. In Côte d'Ivoire for instance, cocoa beans were commonly fermented in heaps in small farms or in wooden boxes in big farms without turning (Guehi *et al.*, 2007).

This finding is consistent with the finding of Guehi *et al.,* (2010) who established that fermentation in heaps using banana leaves and wooden boxes is ideal for the production of good-quality cocoa beans. In terms of the turning period during fermentation, Beckett (2000) stated that the beans need to be mixed after 48 hours and 96 hours of fermentation to limit the growth of lactic acid bacteria. In the case of Ghana, most cocoa farmers often turn the cocoa beans, every 24 hours, every 48 hours, and some with no turning. In this study, about 57% of the farmers' usually turn the cocoa beans every 48 hours whereas minority (20%) of the farmers do not turn their cocoa beans. According to the farmers and the purchasing clerks, improper fermentation affects drying and quality of the beans. According to Ardhana and Fleet (2003), well-fermented cocoa beans (6 days) are less acidic than partially fermented cocoa probably because the formation of lactic acid which can be reduced or avoided by turning after 48 hours and 96 hours of fermentation.

5.6. Duration and Materials Used for Cocoa Fermentation

According to Hii *et al.,* (2006), the fermentation period for cocoa beans ranges between 5-7 days depending on the farmer. During this period, the cocoa beans are piled in heaps or stacked in boxes, trays or in baskets, covered with plantain leaves and left to ferment for 5–7 days. According to the current survey, the duration for fermentation period used were 2-3 days, 4-5 days, 6 -7 days (Table 6). Majority (76%) of the cocoa farmers fermented their cocoa beans for 6-7 days, whereas few (4%) farmers fermented theirs for 2-3 days. According to the farmers, a well fermented cocoa beans requires 6-7 days with effective turning to promote drying for improved flavour. Turning aerates the fermenting mass to avoid uneven temperature and oxygen distribution (Opoku-Ameyaw *et al.,* 2010).

Again, Guehi *et al.,* (2010) observed that cocoa beans fermented for 6 days present better commercial value, better chemical quality in terms of acidity than those fermented for less than 5 days. Generally, cocoa beans are sun dried (Guehi *et al.,* 2007) and this is the common practice in Ghana where the farmers spread the cocoa beans on mats, polythene sheets or tarpaulin. It can be said that spreading the cocoa beans on mat to solar dried them prevent the contamination of the cocoa beans. In the Ivory Coast for instance, the cocoa farmers often spread freshly fermented beans under sun on mats, polypropylene sheets or on concrete floors each day to a depth of not <5 cm and mixed constantly to promote uniform drying and to break agglomerates (Guehi *et al.,* 2010).

5.7. Assessing the Effects of Ripening Stages on the Quality of Cocoa Beans

5.7.1. Ripening Stage to Harvest Cocoa Pod

Generally, the cocoa farmers harvested fully ripe cocoa pods five months later following the development of the cocoa pod and when pods change colour. Cocoa colour offers valuable information in estimating the ripeness of the pods since it is one of the most significant criteria associated to pod maturity identification for harvest (Afoakwa *et al.,* 2008). According to the survey conducted, there were two ripening stages for the harvesting of cocoa pods, fully ripe with yellow colour or partially ripe cocoa pods. Majority (67%) of the cocoa farmers often harvest their cocoa when it is fully ripe whereas minority (33%) harvest their cocoa pods with partially yellow colour. This is because fully ripe pods are easily broken and fully ripe pods with wet beans ferment easily when extracted from the pods. Tee YeiKheng *et al.,* (2018) established that cocoa pods which are harvested immature or over-ripe determine the quality of the beans during fermentation; harvesting pods at the right time at optimum maturity is significant because it guarantees that succeeding

procedures to accomplish premium cocoa flavour from beans is successful. However, an overripe pod decreases in weight after drying. The harvesting of cocoa pod time interval ranges between 2-3 weeks. According to Guehi *et al.,* (2007), Ivorian cocoa farmers take between three to four weeks to harvest their cocoa during the peak season with farm labourer whereas they take between one to two weeks to harvest their cocoa during the light season with hired labourers. Reasons given by farmers for overripe cocoa pods during the study were, scarcity of labourers during the peak season, farmers with multiple or large farms and without inadequate drying mats. Interestingly, according to some farmers, it is a prestige to see a lot of ripped pods on the tree and can even be used to secure loans.

5.8. Assessing the Effects of Pod Breaking Time on the Quality of Cocoa Beans

5.8.1. Resting Period after Harvesting Before Pod Breaking

Afoakwa *et al.,* (2007) established that the resting time before pod break after harvesting depends on the extent of ripeness and maturity of the pod. However, according to COCOBOD, pod breaking should be done with 2-3 days after harvest (Opoku-Ameyaw *et al.,* 2010). As revealed by the survey conducted, resting time after harvesting before pod breaking were 1-2 days, 3-4 days and more than 4 days. However, the majority (80%) of the farmers break their pods after more than 4 days after harvest, whiles minority (5%) break their pod at 1-2 days after harvest. According to majority of farmers who break pods in more than 4 days after harvest, time was their main limiting factor because they had multiple engagements and fewer labourers to assist. It is therefore, suggested that extension education be intensified on the effects of longer resting period on bean quality. According to Afoakwa *et al.,* (2007), the pods harvested at a ripe stage of maturity are likely to undergo anaerobic fermentation faster within the pods and become over-fermented when wet beans are extracted from the pods and processed for fermentation. Similarly, Tee YeiKheng (2018) argued that immature pod beans often lack the quality to be presented for a better commercial value and better chemical quality in terms of acidity.

5.9. Tools Used in Breaking Cocoa Pod

The method used for pod breaking after harvesting varies from region-to-region where cocoa is being produced. However, it is determined by the available tool which the farmers can afford as well as being conversant with it in terms of the pod breaking. As revealed by the survey, the tools used for the breaking of the cocoa includes the use of blunt cutlass, the use of wooden clubs and the use of the floor by hitting the pod on the floor. In all, 91% of the cocoa farmers used blunt cutlass whereas few (1%) break the pods by hitting against the floor. Also, it can also be stated that blunt cutlass is the main tool the cocoa farmers are used to as it is easily affordable to the cocoa farmers in Ghana. This finding is consistent with the finding of Hii *et al.,* (2006) who established that cutlass is the main tool used for pod breaking by cocoa farmers in Colombia, pods can be broken using either a wooden club on breaking knife, however, wooden clubs are recommended as cutlass may injure the beans inside the pods (Opoku-Ameyaw *et al.,* 2010).

6. Conclusion

The results of this survey has shown that cocoa production in Ghana is largely a male dominated venture with majority being the elderly in the cocoa growing regions. Moreover, majority of cocoa farmers in Ghana are in the Ashanti region where they mostly own small pieces of cocoa farms due to fragmentations after demise of the parents or uncles. It was found that majority of cocoa farmers in Ghana had some form of formal educations. Sadly, majority of the farmers still produce their own seedlings instead of obtaining certified seedlings from the Seed Production Division. They also rely on information provided by their colleague farmers. For insect pests control, most of the farmers rely on the government's mass spraying exercise or the buy chemicals from certified agro shops to spray. It is worth noting that as much as 20% of the farmers still use pesticides from unlicensed agro-chemical shops. The heap method of fermentation is the most widely used and majority of farmers allow 6-7 days for fermentation. Majority of the farmers allow pods to fully ripe before harvesting and the pods are usually kept for more than four days before breaking with blunt machete. The findings of this study has provided a justification for an intensified education of farmers and increased monitoring of the activities of all stakeholders in the cocoa industry.

Declarations

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