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Survey of Ghanaian cocoa farmer fermentation practices and their influence on cocoa flavour

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A survey of 56 cocoa farms in Ghana was carried out during the 1986 main crop to assess the influence of fermentation practices (post-harvest pod storage, cultivar, weight of ferments, number of turns and timing, drying) on quality. Variations in the frequency of turning of the ferments was noted with cocoa-producing region and cultivar. Sensory evaluation of chocolate samples made from the cocoa beans indicated that a short pod-storage and fermentation with a single turn after three days produced the most acceptable cocoa. The acceptability varied by region with the Eastern region producing the most acceptable cocoa. As with acceptability, chocolate flavour significantly improved with a short pod-storage time. A composite sample was average in terms of its sensory characteristics, supporting the concept that blending facilitates the balanced flavour characteristic of Ghana cocoa.

INTRODUCTION

Ghana cocoa is generally recognised by chocolate manufacturers as the standard for bulk cocoa with respect to chocolate flavour. The cocoa is farmed by a large number of smallholders with between 2 and 20 hectares. Most trees planted initially comprised the Amelonado cultivar. However, since the 1960s crosses of Upper Amazon selections and hybrid cocoa (crosses between Upper Amazon selections, Amelonado and local Trinitarios) resistant to black pod (*Phytophthora palmivora*) have been planted (Adomako, 1983).

Cocoa in Ghana is typically fermented by the heap method where the beans are heaped onto leaves (plantain) on the ground and subsequently covered with more leaves (Adomako, 1983).

The first recorded method of cocoa fermentation in Ghana (Knapp, 1934) recommended a fermentation of six to seven days during which the beans should be turned twice. This was to ensure an even fermentation with good aeration and absence of defective beans. Researchers into cocoa fermentation had adopted this regime as standard. However, experimental fermentations in Ghana using this method (Carr *et al.*, 1979; Dougan, 1979; Anon, 1980, 1981; Duncan, 1984) failed to produce cocoa of equivalent quality to standard commercial Ghana cocoa.

A survey of 89 Ghanaian cocoa farmers during the 1983–84 main crop has been carried out in five cocoa producing regions; Ashanti, Brong Ahafo, Western, Eastern and Central (Duncan, 1984). This survey revealed that Ghanaian farmers follow a different fermentation method to that recommended by Knapp (1934) or the cocoa extension services. Usually, most farmers stored the pods for 10 days or less prior to splitting but some stored their pods for up to 18 days. The weight of the beans in each fermentation was typically between 200 and 500 kg while considerably larger fermentations of up to 5 tonnes or small ones of 20 kg occur. The beans were fermented for between three and five days with only one farmer fermenting for the recommended six days. They either did not turn the beans or turned only once. All farmers sun-dried the fermented beans to a moisture content below 7·5%. It is believed that blending of the beans after processing is important in maintaining the high and consistent flavour and hence quality of Ghana cocoa.

The aim of this study was to determine how the variation in cocoa fermentation practices influences cocoa flavour as assessed by a sensory panel. In addition, new information was gathered concerning the cocoa cultivars used, the age of the trees and drying times.

MATERIALS AND METHODS

During the 1986 main crop, 56 farmers from throughout six cocoa producing regions (Ashanti, Brong Ahafo, Central, Eastern, Volta, Western) in Ghana were interviewed and asked to complete a questionnaire concerning their fermentation practices.

Sampling of cocoa farms

In order that the sampling be representative of cocoa production throughout Ghana, the number of samples collected from each region reflected the previous year's output. The approximate output (per cent) of cocoa from each region in 1985 was; Western (27%), Ashanti (27%), Brong Ahafo (17%), Eastern (14%), Central (12%) and Volta (3%). Thus, a composite sample from the farms should be representative of that obtained commercially.

Cocoa farmers' questionnaire

The questionnaire asked for information on the following:

- —Cocoa cultivar(s) on their farm
- —Age of the trees (y)
- —Fermentation method
- —Pod storage time (days)
- —Weight of the fermentations (kg)
- —Duration of the fermentations (days)
- —The number of times the fermenting beans were turned
- —Timing of the turns (days)
- —The method used to dry the fermented beans
- —The duration of drying (days)
- —Whether it rained during the drying period

A 1-kg sample of dried cocoa beans was obtained from each farmer for sensory evaluation in the UK.

Sensory evaluation of the cocoa samples

Sub-samples from each of the cocoa farms were combined and mixed to form a blended or composite sample. The composite sample along with the samples from the Ghanaian farms and one from the Dominican Republic were roasted and made into chocolate bars by Nestlé-Rowntree, York, UK. In addition, three different makes of commercially available chocolate were purchased in the UK and included in the sample set.

The Ghana and Dominican Republic chocolate bars together with three commercially available chocolate bar samples, were profiled using published methods (Powers, 1988) by 23 panellists made up of staff at the Natural Resources Institute (NRI). Six of the chocolate samples were repeated at random intervals during the panel sessions. The samples were coded with random numbers at the time of tasting so that their identity was not known to the panellists.

At each visit to the sensory laboratory, the panellists received three chocolate samples presented in random order and coded with random numbers. The panellists scored the chocolate samples on a continuous 100-mm scale for nine attributes; chocolate flavour, astringency, bitterness, winey, acidity, raisin, molasses, liquorice and acceptability.

Statistical analysis

Statistical analysis (regression, multivariate) was carried out using either Statgraphics (STSC Inc, Maryland, USA) or Genstat (Numerical Algorithms Group Ltd, Oxford, UK).

RESULTS AND DISCUSSION

Farmers' cocoa fermentation practices

In order to ensure, as far as possible, the accuracy of the answers to the questionnaire, only the farmers themselves were interviewed either at the buying centres, or on their farms. Samples or information were not accepted from representatives of the farmers or from other family members. It should be noted that the survey data collected were obtained verbally from cocoa farmers and was therefore imprecise. Statistical analysis of the data has been carried out only to highlight differences and trends in the results.

Cocoa cultivar

Three cocoa cultivars are widely grown in Ghana; Amazon, Amelonado and Hybrid. Whereas Amelonado was initially the most widespread, Hybrid has been increasingly planted as this is thought to be more resistant to black pod (*Phytophthora palmivora*) (Adomako, 1983). Experimental studies have been carried out to determine the effect of cocoa cultivar on quality and chemical composition (Dougan, 1979; Anon, 1981; Adomako, 1986; Tomlins *et al.*, 1993). Differences were reported in the concentration of pulp sugars and lactic acid and the pulp-to-cotyledon ratio although it was not clear how cocoa quality might be affected.

As there have been reported differences in the chemical and physical composition of the cocoa cultivars, this survey collected information about the relative proportions of these cultivars and their occurrence. Of the 56 farms surveyed, the most prevalent cultivar was Hybrid (49%) followed by Amazon (28%) and lastly Amelonado (23%). A number of farms (31%) reported a mixture of cultivars. There was no significant difference with respect to region.

Age of cocoa trees

The average age of the trees was 23 years, varying between four and 55 years. Whereas there was no significant difference between the regions surveyed, the ages of the cultivars did significantly differ and this reflects the changes in planting. Hybrid constituted the youngest trees with an average age of 14 years, Amazon were older at 22 years and the oldest trees were Amelonado with an average age of 39 years. The average age of trees on the mixed farms was 24 years. Table 1 implies that Amelonado has not been planted in the last 20 years while planting of the other cultivars is more recent.

Table 1. Age of Ghana cocoa cultivars

Cultivar	Proportion of trees (%) at age (years)					
	0–10	11–20	21–30	31–40	41–50	51–60
Amelonado			7	7	6	3
Amazon	7	10	6	5		
Hybrid	16	27	6			

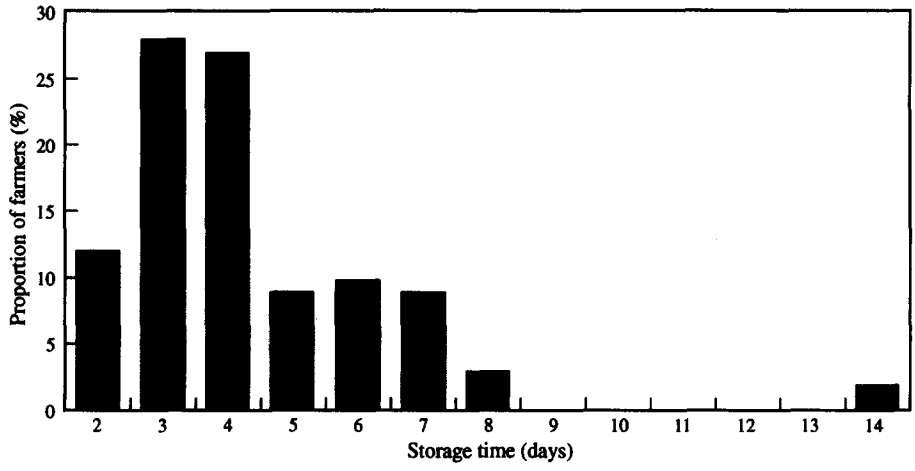

Fig. 1. Variation in the pod storage time used by Ghanaian cocoa farmers.

Fermentation method

All the farmers used the heap method of fermentation. The fermentations varied according to the pod storage time, weight of beans used, the duration of the fermentation, the number turns and the timing of these turns.

Pod storage time

The pod storage time is the time that the pods were stored after harvesting but before splitting. A survey of the 1983–84 main crop (Duncan, 1984) indicated that the farmers stored their pods for an average period of approximately eight days varying between 0 and 18 days. However, information about the influence of cocoa cultivar and region had not been reported.

In this survey, the pod storage time did not significantly differ according to the producing region or cultivar. The average time that the pods were stored was four days; the majority of the farmers stored the pods for between three and four days whereas one farmer stored for 14 days (Fig. 1). The pod storage time in this study is less than that previously reported. Possible reasons for a difference may be because of variations between surveys and differences in practice from year to year depending on the weather conditions and labour availability.

Weight of beans

A previous survey (Duncan, 1984) has reported that, in Ghana, the size of ferments varied between 20 and 5000 kg of wet beans with between 200 and 500 kg being most common.

This study revealed that the wet bean weight did not differ between the regions or cultivars used. The average weight of the ferments was 186 kg; 53% were of 100 kg or less with the minimum size being 5 kg and the largest 1000 kg (Fig. 2). While the weight is less than in previous studies, experimental fermentations of 100 kg or less have been reported to yield beans of acceptable quality and grade (Rohan, 1958; Adomako, 1981).

Fermentation time

The first recorded method of cocoa fermentation in Ghana (Knapp, 1934) recommended an optimum fermentation of six or seven days during which the beans should be turned twice. A recent survey (Duncan, 1984) reported that the average duration of cocoa fermentations in Ghana was shorter being between three and five days.

In this current survey, the average duration of the fermentation was five days with a minimum of three days and a maximum of six days (Fig. 3). This was irrespective of the region or the cocoa cultivar used.

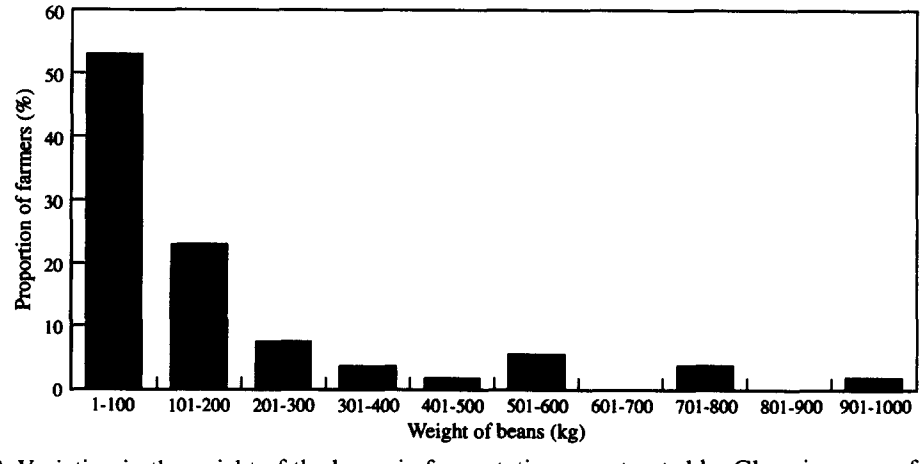

Fig. 2. Variation in the weight of the beans in fermentations constructed by Ghanaian cocoa farmers.

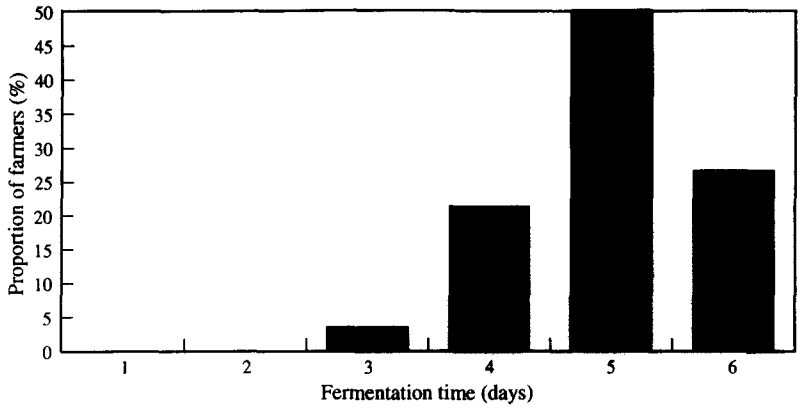

Fig. 3. Variation in the fermentation time of Ghanaian cocoa.

Turning of the heap

Recommended methods (Knapp, 1934) suggest turning the ferment twice on the second and fourth days. A previous study (Duncan, 1984) of the Ghana 1983/84 main crop reported that 50% of farmers did not usually turn the ferments and, of those who did, the turn was normally after two or three days.

In this survey, most farmers (57%) did not turn the beans at all, some (39%) turned the beans once and only two farmers (4%) turned the beans twice. Of those who turned the beans only once, 87% did so on day 3 of the fermentation whereas the remaining 13% turned the beans on day 4. Of the two farmers who turned the beans twice, one turned on the second and fourth days and the other on the third and fifth days.

There were significant differences in the number of times the fermentations were turned between the regions and the cocoa cultivar (Table 2). Considering the region, the farmers from the Eastern, Volta and Ashanti regions were the most likely to turn their ferments. For cultivars, those who reported only Amelonado on their farms were the least prone to turn their ferments.

Drying

All the cocoa was sun-dried. Most dried for seven days with a minimum of five and maximum of 15 days (Fig. 4). There were no significant differences between the regions, cultivars used or if it rained during the fermentation. However, although the influence of rain during drying was not significant (P = 0·098) when rain had been reported, the beans were on average dried for longer (8·8 days) than when it had not rained (7·4 days).

Table 2. Percentage of farmers who turned cocoa ferments by cultivar and region

Cultivar	Number of turns		
	0	1	2
Amazon	35	59	6
Amelonado	57	43	0
Hybrid	50	44	6
Region			
Ashanti	40	53	7
Brong Ahafo	70	30	0
Central	71	29	0
Eastern	12	88	0
Volta	0	33	67
Western	93	7	0

Sensory assessment of the chocolate samples

Given the wide variations possible in the practices of Ghanaian cocoa farmers it is thought that no two fermentations yield the same flavour. Therefore the balanced and characteristic flavour of commercial Ghana cocoa may result from 'bulking' or blending of the cocoa from a large range of fermentations. In this study, samples of cocoa were collected from each farm and portions of each were combined to form a composite or blended sample to simulate the mixing that occurs in commercial cocoa. The composite and individual farmers' samples were assessed by a sensory panel in order to test the blending concept.

Additionally, previous research into the flavour of Ghana cocoa has tended to adopt experimental cocoa fermentations based on a six-day ferment with two turns (Carr *et al.*, 1979; Dougan, 1979; Anon, 1980; Anon, 1981; Duncan, 1984) but had failed to produce cocoa of equivalent quality to standard commercial Ghana cocoa. In this study, statistical analysis of the sensory results along with the farmers' practices was used to derive a model for optimum quality.

Consistency of use of the attributes by the sensory panel

Pairwise correlation of the panellists scores were used to assess the consistency of the 23 panellists in their use of each attribute. An assessment of the number of positive or negative coefficients suggested that the attributes, chocolate flavour, acidity and acceptability were most consistently used by the panel, followed by raisin and bitterness. For the remaining attributes, the proportions of positive and negative attributes were similar.

Standardised principal components analysis (PCA) was used to determine how the sensory attributes related to each other for the panel as a whole. The first two principal components accounted for 67% of the variation in the results (Fig. 5). The most dominant variables were chocolate flavour and molasses, which are inversely related. The latter attribute explains the variation of

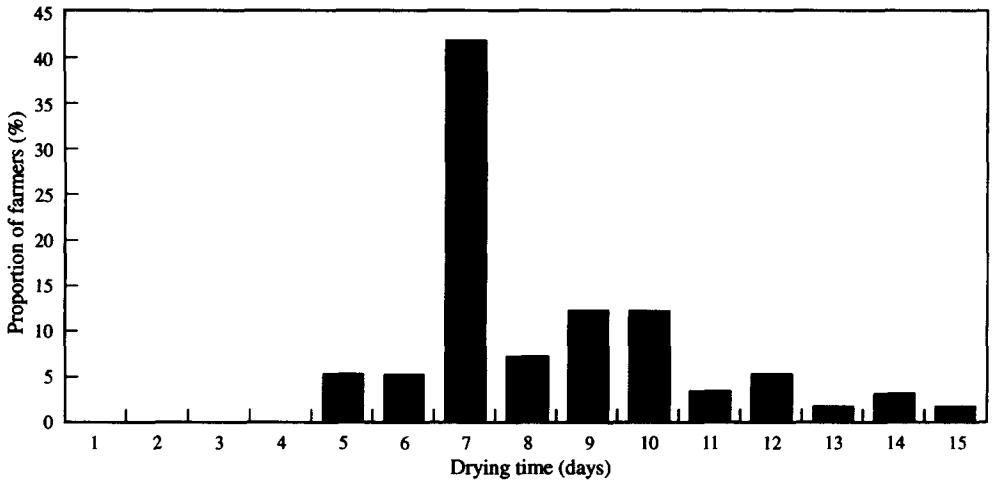

Fig. 4. Variation in the drying time of fermented cocoa beans in Ghana.

samples 21 (Ghana) and 61 (commercial chocolate) from the other samples. The Ghana sample (21) was fermented normally but the ferment size was larger than average at 600 kg. Three sensory attributes, winey, astringency and acidity were used in a similar way by the panel.

Correlation of chocolate samples with respect to their sensory attributes

Figure 6 shows a PCA scatter plot (accounting for 67% of the variation) of the chocolate samples with respect to their sensory attributes. Numbers 1 to 58 refer to the Ghanaian chocolate samples and 59, 60, 61 and 62 to the three commercial and Dominican Republic samples. The plot demonstrates the outlying nature of the three commercial chocolate and Dominican Republic samples. It is noteworthy that the Ghana composite sample (No. 58) lies in the centre of the cluster of Ghana samples and is 'average' with respect to the sensory attributes used. This tends to support the concept of a balanced flavour for commercial Ghana cocoa.

Models relating the fermentation practices with sensory attributes

Stepwise multiple regression was used to search for a model relating the mean panel attributes with the fermentation practices used by the farmers. The attributes

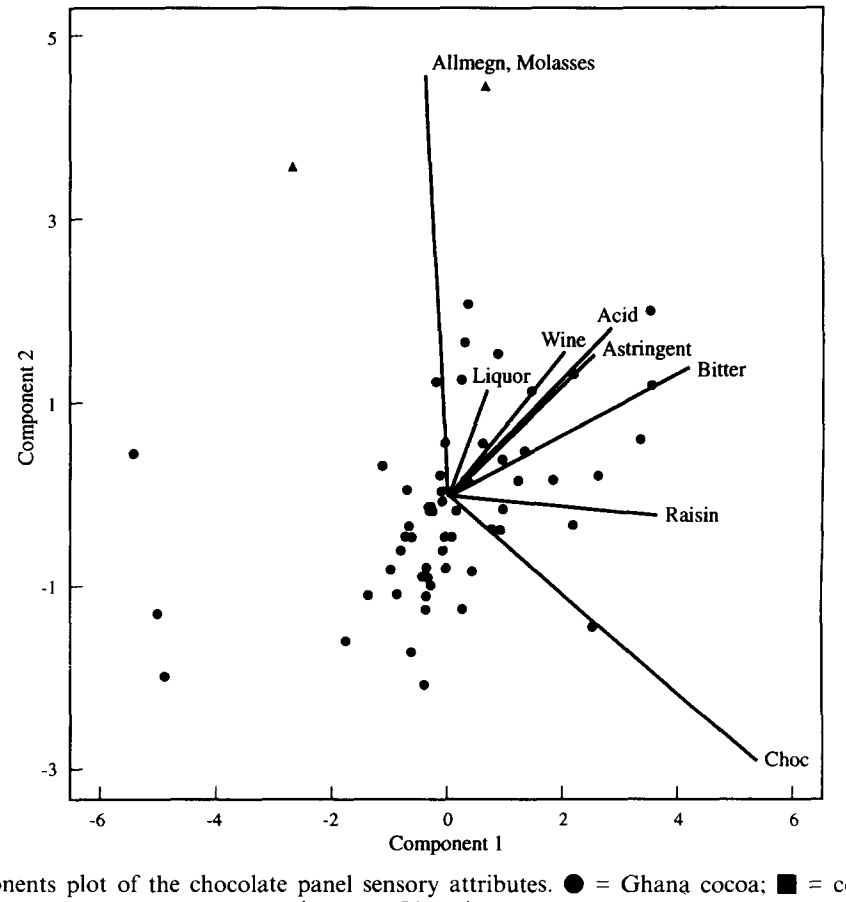

Fig. 5. Principal components plot of the chocolate panel sensory attributes. ● = Ghana cocoa; ■ = composite Ghana cocoa; ▲ = non-Ghanaian cocoa.

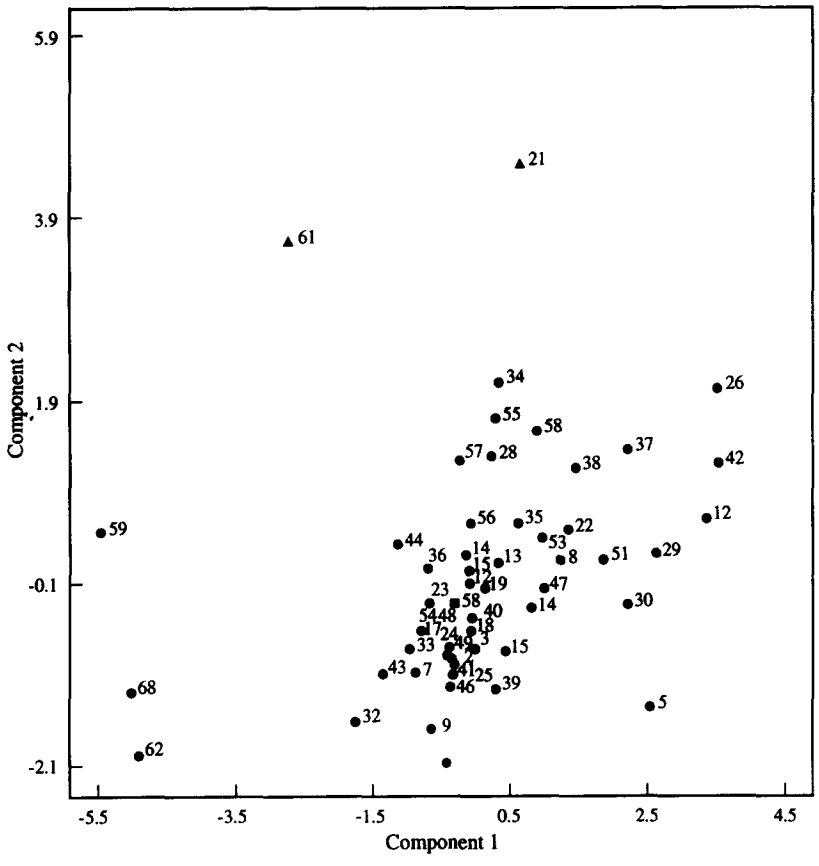

Fig. 6. Principal components scatter plot of chocolate samples in relation to their sensory scores. ● = Ghana cocoa; ■ = composite Ghana cocoa; ▲ = non-Ghanaian cocoa.

that were significantly explained by the practices used by the farmers were acceptability and chocolate flavour.

Acceptability. The most significant relationships were with the regional origin of the cocoa, pod storage, the duration of the fermentation and the number of turns of the cocoa heap. Other factors such as the cocoa cultivar, age of the trees, weight of the fermentation, drying time and rain during drying had no significant effect.

A short pod storage and fermentation, with turning of the heap after three days seemed to be associated with higher average acceptability, and the most consistent practice of this procedure was in the Eastern region, which also had the highest average acceptability of any region. However, the estimated effect of turning after four days, or the inclusion of a second turn, could not be evaluated because there were too few examples in the survey.

Chocolate flavour. The most significant correlation was with the pod storage time; all other factors measured has no significant correlation. As with acceptability, a shorter pod storage time was associated with higher scores for chocolate flavour.

CONCLUSION

Considering the cocoa cultivar, the survey reveals a change from older Amelonado trees (average age 39 years) to younger Hybrid and Amazon (average ages 14 and 22 years, respectively) which are now the most widespread. No new planting of Amelonado had been reported during the last 20 years. One third of the farmers reported a mixture of cultivars suggesting that many fermentations comprise a combination of them.

Regarding the fermentation practices, all farmers used the heap method of fermentation. The average pod storage time was four days, with a heap of 100 kg beans or less (mean of 186 kg) that was fermented for five days. Differences were found in the number of times that the heaps were turned (57% did not turn their ferments), with the farmers in the Eastern region being more likely to turn their ferments, and those having only Amelonado cocoa being the least prone to turn their ferments. Of those who turned the beans, most (87%) turned on the third day of fermentation. The majority of farmers sun-dried the beans for seven days (average of eight days), the farmers' fermentation practices having no significant effect.

Sensory profiling of chocolate samples made from beans collected from each farm indicated differences in acceptability and chocolate flavour with variations in fermentation practice (pod storage time, fermentation time, number of turns) and region. A short pod storage time and fermentation with turning after three days was associated with a higher average acceptability. The

Eastern region produced the most acceptable cocoa and is responsible for approximately 14% of the total Ghana production. As with acceptability, chocolate flavour improved with a short pod storage time. The cocoa cultivar, age of the trees, weight of the fermentation and drying time had no effect. A blended sample was average with respect to the sensory assessment and supports the concept of bulking or blending to yield the balanced cocoa flavour that is characteristic of Ghana.

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