TESTING THE EFFICIENCY OF MINI-FERMENTATION BOX TO FERMENT SMALL QUANTITIES OF COCOA BEANS.

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ABSTRACT

A mini- fermentation box was developed that successfully fermented small quantities of wet beans as low as 200 kg. The minibox fermented beans produce bean quality and flavor characteristics similar to beans fermented in conventional fermentation box. The minibox was released by the Cocoa Board of Papua New Guinea and now enables majority of the smallholder farmers to ferment and sell dried beans, and receive maximum benefits, unlike selling wet beans in the past for a lower price.

***Keywords**: Minibox fermentation, bean quality attributes.*

INTRODUCTION

Cocoa scientifically known as *Theobroma Cocoa* L is a major cash crop for the majority of the population living in the lowlands of Papua New Guinea (PNG). Cocoa is grown in 14 provinces of PNG. Out of these provinces, East New Britain (ENB) and Bouganville are the major producers. A survey on wet bean marketing in PNG revealed that 92 % of the farmers relied on cocoa as their main source of income (Gimbol 1989). Another similar study by Yabro and Nobel (1989) indicated that between 80 -100 percent of the smallholders in ENB, East Sepik and Oro province depended on cocoa as their main crop for cash income. Cocoa production trend show that smallholders are the major producer, unlike in the early 1970's when cocoa production was dominated by the plantation sector. From the mid 1980s to the current period, smallholders' production has increased to well over 20,000 tonnes of cocoa, which represents two thirds of the total PNG's cocoa production.

The principal aim of farmers is to maximize net returns for their crop. However, under the current arrangement, most of the farmers are selling wet beans because PNG Cocoa Board regulation restricts the smallholder farmers from fermenting their wet beans to sell them as dry beans. The board issues fermentry licenses only to farmers who can produce in excess of 2 tonnes of cocoa per annum. This restriction is imposed to ensure that beans are properly fermented to maintain consistent in quality especially flavour. Under fermented or unfermented beans do not produce flavor precursor required for flavour development. Similarly, over fermented bean resulting mainly from fermenting small quantities of beans, produce purifying odour that leads to producing off flavours detrimental to bean quality. Unfortunately, most of the smallholder farmers can not produce the required quantities of cocoa to meet the cocoa board requirements and therefore are not eligible for the fermentry licenses.

Analysis of economic factors reveal that farmers are getting half the price when selling wet beans as compared to fermented dried beans. A post devaluation analysis using 1996 average price, shows that a smallholder farmer selling wet bean would have generated K1,011 per tonne dry bean equivalent, while the average price of a tonne dry bean was K1,441.00. A farmer selling dried beans would have earned K430.00 (42.5 %) more than wet beans (Omuru 1997). This implies that although the smallholders are major producers, most of them have not actually received the maximum benefit. This is one of the major problems encountered by the cocoa growers in Papua New Guinea that has not been addressed. With the introduction of the mini-fermentation box, farmers are now able to ferment and sell their beans as dried beans thus receiving the maximum benefits.

The problem was addressed through the Australian International Development Assistance Bureau (AIDAB) funded Cocoa Quality Improvement Project (CQIP) undertaken by the Papua New Guinea Cocoa and Coconut Research Institute (PNGCCRI) from 1990-1996. In this project, one of the studies conducted was designing of a mini fermentation box that can ferment small quantities of beans. Different size mini-fermentation boxes were designed and tested to select a model that could successfully ferment small quantities of beans equivalent to what most of the

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small holder farmers can produce. The smallholder farmers can use the mini fermentation box to ferment their wet beans and sell them as dry beans for a better price subject to the Cocoa Boards approval and granting of licenses.

Post harvest process

In a conventional fermentation box (120 x 90 x 90 cm), the temperature range attained is between 24-30 ^{0}C at the start of the fermentation and this rises to 50-51 ^{0}C by the third and forth day, and remains around this temperature until the end of the fermentation. The increase in temperature is the result of microbial activities and can be affected by the batch size of the fermentation. Lower maximum temperatures between 40-41 ^{0}C can be attained in small scale fermentation. Maximum temperature of 48-50^{0}C is required to cause the death of the beans resulting in the disintegration of the beans internal structure allowing endogenous enzymes to come into contact with their substrates. This causes the loss of cell membrane and integrity of cellular compartments. The loss of hydrophilic compartment results in the intra and intercellular mixing of water-soluble components (Lehrian and Patterson 1983), which allows series of biochemical reactions to take place to produce the chocolate flavour precursor, which later develops into chocolate and other ancillary flavours during roasting. A minibox fermentation would require a temperature regime similar to commercial fermentation to successfully ferment the beans. Incorrect processing conditions would lead to development of off-flavours. Quantities of bean less than 200 kg when fermented become over fermented, producing purifying odours. Chemical testing of these beans produce high pH values and strong off flavor indicated by low titratable acidity (TA) values (Kuman 1977).

The degree of fermentation is assessed by the cut test (Wood and Lass 1975). The higher percentage of brown bean indicated that the beans are properly fermented. Flavour test can also be used to assess the difference in flavour produced by different processing methods. Similar flavours can be produced when beans are fermented under similar processing conditions.

OBJECTIVE

To test whether the mini fermentation box can successfully ferment small quantities of wet cocoa beans

MATERIAL & METHOD

Experimental Design

Different sizes of mini fermentation box of different dimensions were constructed and tested to ferment small quantities of cocoa beans. The efficiency of each of the mini fermentation boxes was judged by measuring the degree of fermented beans. Thirty five replicates of fermentation were conducted testing the efficiency of 8 different box sizes before an ideal mini fermentation box (60 x 60 x 60 cm) length, width, and height was selected that can successfully ferment small quantities of cocoa beans between 200-250 kg . Same treatments were applied to all fermentations conducted except the quantities of bean used in each of the fermentation boxes (Kuman 1997).

Fermentation process

Cocoa pods of mixed cultivar were harvested from field and transported to the fermentry before the pods were removed. The wet beans collected were thoroughly mixed before they were weighed to collect 200 kg of wet beans and fermented in the mini fermentation box. The remaining batch (5-600 kg) was fermented in the large conventional box. The fermenting beans were covered with hessian bags or alternatively banana leaves to control and maintain the temperature and moisture. The fermenting beans were turned daily for 5 days before the cured beans were dried in a solar dryer. For comparison purpose, dried beans processed by conventional methods were also sampled from the commercial fermentry together with minibox fermented bean for quality assessment. Twenty fermentation replicates were carried out to generate samples for quality assessment.

Flavours assessment

Organoleptic evaluation was conducted by trained taste panel following the procedure described by (BCCA 1996; Sukha 2001). The flavour intensity was estimated using 0-10 scale, with 0 being weak and 10 being strong. Individual flavor attribute scores from the flavor profiling were used to determine mean. Variance components were investigated using analysis of variance (ANOVA) using Minitab Release 14 (Minitab Inc.) to determine the significance of treatments effect and interactions.

Cut test

The cut test procedure, significance of cut test and its use as a tool to measure the fermentation index is discussed by Shamsuddina and Dimick

(1986) and Dand (1993).

RESULTS AND DISCUSSION

The results shown in Tables 1 & 2 are average results of 120 batches of samples collected from each treatment and analysed. As for the flavour result, it represents the average result of 60 samples assessed (Table 3).

and partly brown beans with 20 percent of purple beans. Purple colour indicates unfermented beans, which when present in lower number (percent) is acceptable (Dand 1993). Chemicals assay of the samples (Table 2) indicated a similar range of pH and TA for beans fermented from the two fermentation boxes. This may indicate a similar conditions in both fermentation processes (minibox & conventional) with a succession of microbial activities (Ostovar and Kenney 1973, Carr *et al.* 1979), which are prerequisite for successful fermentation, though the fermentation process can be influence by heterogeneities in aeration, temperature and other fermentation conditions.

Table 1. **Average cut test results for minibox and conventional fermentation box.**

Fermentation Method	Brown	Partly brown	Purple	Insect	Germination	Slaty	Criollo	Mouldy
Minibox	44 ± 21	32 ± 22	20 ± 32	-	-	-	3	1
Conventional	39 ± 25	30 ± 20	27 ± 26	-	-	-	3	1

Commercial fermentation box (range of brown bean = brown + partly brown): 61-77 %
Minibox (range of brown beans): 54-71 %. (NS) P>0.05

No significant variation in the degree of fermentation between the samples generated from the two fermentation boxes

Table 2. **Average chemical assay results of beans generated by minibox and conventional fermentation box.**

Method of fermentation	PH	Titratable Acidity (TA)
Minibox	4.9	0.21
Range	4.4 - 5.3	0.06 - 0.29
Conventional fermentation box	4.6	0.26
Range	4.4 - 4.9	0.21- 0.31

Table 3. **Average flavor assessment results of beans produce from minibox and conventional fermentation box.**

Sample	Choco-late	Acidity	Bitterness	Astringency
Minibox	7.5	5.8	1.6	1.3
Conventional fermentation box	7.5	5.3	1.6	1.4

(NS) P>0,05
No significant variation was shown for samples generated from two fermentation boxes

DISCUSSION

The cut test results (Table 1) indicated that beans produce by the two processes were properly fermented, as indicated by the percentage of brown and partly brown beans. Both fermentation processes produced on average 70 percent of brown

The success of a fermentation process is also measured by the temperature range of the fermentation cycle. The maximum temperature

range for a successful fermentation is between 47-51 °C. The maximum temperature range achieved in minibox fermentation was between 47-51 °C, similar to temperature range attained in conventional fermentation. Other minibox designs failed to successfully ferment small quantities of beans because they can not maintained the fermentation temperature; as a result fermented beans got dried and turned black producing putrefying odour (Kuman 1997).

The organoleptic assessment result (Table 3) indicated that minibox fermented beans produce similar flavour profile as compared to beans produced by conventional fermentation method. Individual flavor attribute scores of the two fermentation process were compared to determine the significance of treatment effects and interactions. The flavor results indicated that there was no significant ($p<0.05$) difference between flavour profiles of beans produced by the two fermentation processes (Kuman 1997).

CONCLUSION

An mini-fermentation box (60x 60 x 60 cm) can successfully ferment small quantities of wet beans between 200-250 kg, which is equivalent to the average quantities of beans produce by most of the smallholder famers who own between 0.5 to 2 hectares of cocoa. Minibox fermented beans produced quality and flavour characteristic similar to those beans produced by the conventional fermentation process. The minibox was approved for use by the PNG Cocoa Board and is now widely used by smallholder cocoa farmers. The farmers are benefiting from this technology by fermenting their beans and selling them as dried beans for a better price.

However, one of the major problems observed in the adaptive trial were farmers producing over fermented and putrefied beans when using minibox. This problem was widespread during the off flush period when farmers were not able to collect sufficient beans to fill up the minibox to the required depth of 60 cm, equivalent to 200 kg of wet beans. To address this problem, new trials were initiated to ferment small quantities of beans between 10 to 100 kg using eskies.

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