



# Impact of Fermentation Duration on the Quality of Malaysian Cocoa Beans Using Shallow Box

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## Abstract

Standard fermentation of cocoa in Malaysia is five days using shallow box fermentation. This duration is considered long to farmers as they have to allow the beans to dry for another three to seven days before they can sell it. This study was conducted to evaluate the impact of the fermentation duration using shallow box on the quality of the Malaysian cocoa beans. Fermentation was done at the Cocoa Research Centre, Hilir Perak with capacity of 150 kg. During fermentation, the mass temperature and pH of the wet beans was taken for every 24 hours. Three subsamples of about 30 kg of the fermented beans were taken randomly at the end of the Day-3, Day-4 and Day-5 of fermentation and sun-dried at one bean thickness layer. The quality of dried beans produced was assessed using cut test, fermentation index and pH of cotyledon analysis. Cut test analysis indicated the percentage of fully brown beans increased from 62% to 82%. Similar increasing trend was observed for the fermentation index (FI). Cocoa fermented for five days had FI value of 1.41, 1.27 for four days and 1.21 for three days, respectively but there was no significant difference in acidity of dried beans samples. Thus, this might suggest fermentation of Malaysian cocoa beans in shallow box fermentation could be shortened to three days. Organoleptic analysis will be carried out to assess if the flavour attribute of beans produced in three days fermentation is significantly different.

**Keywords:** Fermentation, duration, shallow box, cocoa beans, physical quality.

## 1. Introduction

Fermentation is an important process in cocoa beans for the development of cocoa flavour precursor (1), whereas drying determines the final colour of dried cocoa beans (2). The process starts with the activity of microorganisms in mucilaginous pulp producing ethanol and organic acids, predominantly acetic acid with release of heat (3, 4). As a result, temperature of cocoa beans mass

increases and the ethanol and organic acids diffused into the cocoa beans. Following the diffusion of ethanol and acetic acid into beans, stimulates the onset of complex biochemical reactions such as induction of the proteolysis by aspartic endoprotease and carboxypeptidase, and hydrolysis of phenolic component (5-6).

The production of the best quality dried cocoa beans has proven as a result from the complete fermentation process. Fermentation process should be terminated

by drying the cocoa beans to avoid producing over-fermented beans. Over-fermented beans are manifested by off-flavour because the cocoa flavour precursors are destroyed by excessive proteolysis and hydrolysis activities. Incomplete fermentation will produce under-fermented beans that had weak chocolate flavour because the cocoa flavour precursors were not fully formed. It also caused the high acidity levels in cocoa beans (7-9).

Generally, the fermentation takes up to six days depending on the type of fermentation practiced and the quantity of cocoa beans used. In Malaysia, there are various fermentation practices used such as rattan basket, shallow box, plastic bucket, sack, tray and heap. However, only the shallow box fermentation is recommended by Malaysian Cocoa Board as standard practice for Malaysian cocoa growers. The shallow box fermentation required five days fermentation with single turning on the third day. The high level of acidity in cocoa beans can be reduced by pod storage or beans spreading (10-13).

Although the standard fermentation practice is required only five days fermentation, the farmers still considered it too long. While, pod storage or beans spreading are troublesome because they have to wait for another three to seven days for drying before they could sell their beans to market. Therefore, this study was conducted to evaluate the impact of the fermentation duration using a shallow box on the quality of the Malaysian cocoa beans.

## 2. Materials and Methods

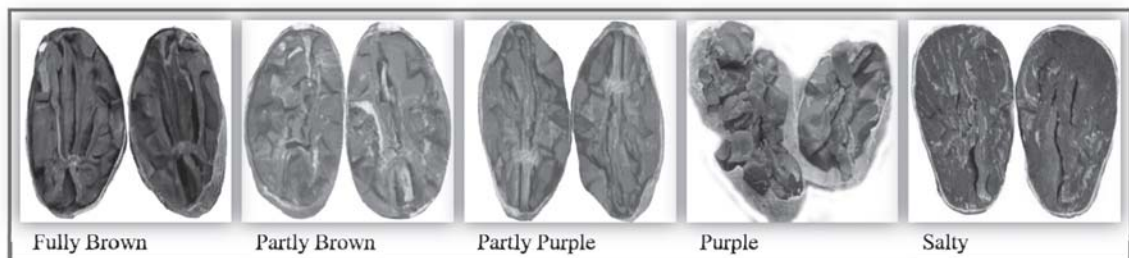
Ripe and healthy pods of mixed clones were used in the experiment and harvested from Cocoa Research and Development Centre, Hilir Perak, Malaysia.

### 2.1 Fermentation experiments

Fermentation was carried out for five days by loading 150 kg wet beans into Shallow box (90 X 60 X 31 cm<sup>3</sup>). During fermentation, the beans mass was covered with gunny sack. The beans mass was turned by transferring from one box to another at the 48<sup>th</sup> hours. Three subsamples of about 30 kg of fermented beans were taken randomly at the end of Day-3, Day-4 and Day-5, respectively. Temperature and pH of wet beans were recorded for every 24 hours. The beans were sun dried at one bean thickness on drying yard until the moisture content reduced to less than 7.5 per cent.

### 2.2 Cut test analysis

Cut test analysis was performed as described by SIRIM (14). A total of 100 dried fermented beans were taken randomly from 250 gram samples derived by quartering technique. The dried beans were cut lengthwise into halves for maximum surface exposed. Both halves of each surface were inspected under artificial light and divided into five groups (fully brown, partly brown, partly purple, fully purple and salty) as showed in Figure 1.



**Figure 1.** The colour of cocoa beans.

The total of dried beans in each group were counted and expressed in percentage. The percentage of the beans was converted into Equivalent Percent Fully Brown (EB) score to compare the degree of fermentation. The formula for EB is as follows, Eq. 1, (15).

$$EB = 1x\% \text{ fully brown} + (0.7 \times (\% \text{ purple-brown})) + (0.5 \times \% \text{ fully purple}) + (0.3 \times \% \text{ slaty}) \quad (1)$$

### 2.3 Fermentation Index

Fermentation index (FI) was determined according to Gourieva and Tserevitinov (16). Dried cocoa beans shells were removed to obtain nibs. The nibs were grinded using analytical grinder. About 0.5 grams of the grinded nibs were homogenized in 50 ml methanol: HCl (97:3) solution. The homogenate was incubated at 4°C overnight, filtered and read in triplicate at 460 nm and 530 nm wavelength, respectively. Ratio of absorbance at 460 nm and 530 nm were calculated.

### 2.4 pH nibs of dried beans

The pH was determined according to the Meyer et al. (17) with slight modification. Five grams of the grinded nibs were dissolved in 45 ml of distilled water. The

mixtures were filtered and pH was read in triplicate using a pH meter.

### 2.5 Statistical analysis

ANOVA was conducted using Microsoft Office Excel 2007 to evaluate the impact of fermentation duration on the fermentation degree and acidity of cocoa beans.

## 3. Results

### 3.1 Cut test, Equivalent Percent Fully Brown (EB) score and Fermentation index (FI).

Distribution of all the dried beans samples were categorized according to colour are shown in table 1. The highest percentage of fully brown beans (82%) was observed for the samples on Day 5 fermentation. Whereas, both samples taken at Day 3 and 4 had 62% of fully brown, respectively. There were no slaty beans observed in all samples. The percentage of purple beans was reduced from 6% for Day 3, 2% for Day 4 and none for Day 5 samples.

**Table 1.** Cut test for all cocoa beans from the three different fermentation duration.

Duration (days)	Percentage of beans color			
	Fully Brown	Partly Brown	Partly Purple	Purple
3	62	22	10	6
4	62	26	10	2
5	82	10	8	0

The EB scores and the average fermentation index (FI) of all samples were showed in Table 2. The EB scores increased from 87.4 in Day 3 to 88.2 in Day 4 and 94.6 in Day 5, respectively. Although the percentages of fully brown beans from fermentation duration for Day 3 and Day 4 were equal at 62%, their EB scores were different. Similar trend was observed for average FI. The average FI increased from 1.21 in Day 3 to 1.27 in Day 4 and 1.41 in Day 5, respectively.

**Table 2.** Fermentation index of dried beans from the three different fermentation duration.

Duration (days)	EB Score	Fermentation Index (Ave)
3	87.4	1.210±0.01
4	88.2	1.271±0.05
5	94.6	1.409±0.05

### 3.2 pH nibs of dried beans

The pH values of all dried beans samples were showed in Table 3. Slight increased in pH values were observed; 4.72 for Day 3, 4.77 for Day 4 and 4.79 for Day 5, respectively.

**Table 3.** Average pH nibs of dried beans from the three different fermentation duration.

Duration (days)	Average pH nibs
3	4.72
4	4.77
5	4.79

### 3.3 Statistical analysis

Table 4 shows the ANOVA analysis of FI and pH value of three samples. Significant differences was observed between the three samples for FI (P=).05). However, the pH of the samples taken at the three sampling period was insignificant.

**Table 4.** Summary of ANOVA analysis of dried beans from the three different fermentation duration.

Duration (days)	Average FI	Average pH nibs
3	1.210	4.72
4	1.271	4.77
5	1.409	4.79
F ratio (Between group)	16.53	0.176
P value	0.003	0.84
F critical	5.14	3.403

## 4. Discussions

### 4.1 Degree of fermentation

The best quality dried beans is indicated by degree of fermentation, low astringency and bitterness,

and an absence of the off-flavours such as smoky notes and excessive acidity (18). The degree of fermentation can be determined either by cut test or by fermentation index analysis. Cut test analysis is based on visual observation for colour changes of cocoa beans and the degree of fermentation is determined by grouping the beans according to slaty, fully purple, partly purple, partly brown and fully brown. The fermentation index is based on breakdown of purple pigments, anthocyanin to it products such as cyanidin-3-b-D-galactosid and cyanidin-3-a-L-arabinosid during fermentation process. Oxidation of these products is suspected to contribute in the development of brown pigments. Therefore, the value of fermentation index obtained from the ratio of absorbance of 460 nm to absorbance at 530 nm (15, 19).

In this study, both techniques were used because unlike the fermentation index, the cut test does not have any standard for over-fermented cocoa beans. According to SIRIM (14), if cut test results have fully brown beans for more than 60%, the dried cocoa beans (in batch) are considered as good quality. Whereas, 45% - 60% of fully brown beans are moderately good and below 45% are fairly good, respectively. The percentage of slaty beans should always be 3% or less. On the other hand, the cocoa beans is considered as under-fermented if the value of fermentation index is below 1.000, 1.000 - 1.599 is completely fermented and more than 1.600 as over-fermented, respectively (20).

Based on the standards mentioned, all the cocoa beans samples have undergone a complete fermentation process regardless their fermentation duration. Similar finding was reported by Romero-Cortes et al. (21), where they observed that the FI value of all analyzed beans is more than 1.000 at 72 h of fermentation. Furthermore, it was also observed in this study that the FI value of dried cocoa beans fermented for five days FI was 1.409. This may suggest that the cocoa beans are approaching over-fermented; if it was not stopped at Day 5.

#### 4.2 Acidity of dried cocoa beans

The level of acidity in cocoa beans is reflected by the pH value. It is the result of diffusion of organic acids such as acetic, lactic, gluconic, oxalic, malic acid and propionic acid in cocoa beans during the fermentation process. All organic acids are produced by microbial activity in cocoa pulp layer. Succession microbes involved in the fermentation of cocoa beans Malaysia had been established (4, 22). However, the information did not improve the level of acidity of Malaysian beans. The pulp volume of Malaysian cocoa beans especially sugar is higher than West African beans. The organic acids are excessively formed and this content may not completely oxidized during drying which will still remain left as residual acid content and resulted in low pH (23).

During this study, the fresh cocoa beans had pH value of 6.38 at the beginning of the fermentation. As the fermentation proceeds, the pH value dropped to the lowest level to 4.43 on the third day. The pH value increased slightly to 4.66 towards the end of fermentation. Similar trend had been reported by other researchers (12-13, 24). Based on these observations, the final pH value was slightly low. Thus, it is expected that the pH value of dried cocoa beans in this study will also be lower which are 4.72 (Day 3), 4.77 (Day 4) and 4.79 (Day 5), respectively. Based on these pH values, the dried cocoa beans are considered acidic. Highest level of acidity will affect the flavour attributes especially cocoa tastes (25, 26). Pulp preconditioning prior fermentation was not conducted prior to the experiment which might cause high acidity. In addition, the turning of the cocoa beans on the second day may cause mass of the fermented beans become a slightly aerated. These conditions might promote the growth of acetic acid bacteria and also the formation of acetic acids by ethanol oxidation (3, 22). Hence, pulp preconditioning is recommended before fermentation.

## 5. Conclusion

Fermentation duration has significant influence to the degree of fermentation but insignificant for the acidity of cocoa beans. This may suggest that the fermentation duration could be shortened from five days to three days fermentation. However, organoleptic analysis and other parameters will be carried out to confirm the effect of the shortened fermentation duration on the flavour attributes.

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