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Agriculture

FERMENTATION PROFILE OF THAI COCOA BEANS

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Abstract

Cocoa beans (*Theobroma Cacao* L.) are increasingly cultivated in Thailand and they are considered as the main ingredients for chocolate production. The most important processing step of chocolate is fermentation regarding to the development of cocoa flavor precursor. The fermentation profile of the completed fermentation process is, therefore, essential to study in order to create fine dried cocoa beans. The purposes of this study were to study on fermentation profile of Thai cocoa beans, to study the effect of fermentation time on fermentation parameters, and to study the grading of Thai cocoa pods on fermentation profiles. Thai cocoa beans were separated into three groups (A, B, and C). Furthermore, pH, total soluble solid (TSS), temperature, and moisture content were measured during fermentation step besides the cut-test examining of each day of fermented cocoa beans. The results of the fermentation profile of Thai cocoa beans showed that the value of pH and temperature were significantly increasing at the beginning (Day 0-2). However, the value of the total soluble solid (TSS) and the moisture content were significantly decreasing at the beginning (Day 0-1). The fermentation time, therefore, significantly affected on the four fermentation parameters in order to develop the cocoa flavor precursor. At the beginning of the fermentation process, all parameters were drastically changed. Regarding to the grading of Thai fresh cocoa pods, there were no significant differences of the yield measuring the weights of dried cocoa bean per the weight of cocoa pods, which were 35.69%, 35.80%, and 34.32% respectively.

Keywords: Fermentation profile, Thai cocoa beans, Thai cocoa pods

Introduction

The global market size of cocoa and products was priced at USD 44.35 billion in 2019 and is projected by 2027, exhibiting a Compound Annual Growth Rate (CAGR) of 4.4% during the forecast period (Fortune Business Insight, 2019). Cocoa beans are manufactured typically in Ivory Coast, Ghana, Indonesia, and Ecuador (Kresnowati et al., 2018). Cocoa pods are harvested. The beans are separated from the pods, fermented, dried and roasted. There are various techniques of cocoa bean fermentations, for example the box fermentation, or fermentation on a drying platform (Wood and Lass, 1986), and double fermentation (VALRHONA, 2020).

In Thailand, cocoa has actually been growing for over a century. Over the last few years, this fruit has been producing in southern and northern part of Thailand as a potentially income for small-holder farmers. Several hundred tons of cocoa are produced per year. For Thai cocoa varieties, the Chumphon#1 variety was originally developed by crossing the PA7 and the NA32 varieties in Trinidad. But it wasn't actually originally developed for Thailand. The researchers of the Chumphon Horticultural Research Center in southern Thailand found that it provided a higher yield and had a

signature yellow color. Eventually, Chumphon#1 became the main varietal of Thailand cocoa (Damecacao, 2020).

For cocoa beans fermentation, the mucilagous pulp (mucilage) covering the cocoa beans were digested by various species of microorganisms originally found in the cocoa beans, such as yeast, lactic acid bacteria (LAB), and acetic acid bacteria (AAB) (Schwan and Wheals, 2004). There were several of microorganism species involved in the cocoa bean fermentation process vary with the plantation location (Ardhana and Fleet, 2003; Camu, 2007; Papalexandratou, 2001). The sugar compound of the mucilage was fermented. During fermentation, heat and metabolic products such as ethanol, lactic acid, and acetic acid were released. Various precursors for the cocoa flavor formation were development. The color of the fermented cocoa beans turns to brown-black. The bitterness was reduced resulting in improvement of cocoa and nutty flavor, and hardens the cocoa bean shell. However, the mechanisms of the fermentation process need further studied to optimize the fermentation conditions to improve cocoa bean quality. Thus, in this article, the fermentation profiles of Thai cocoa bean were studied.

Research Objectives

1. To study on fermentation profile of Thai cocoa beans
2. To study the effect of fermentation time on fermentation parameters
3. To study the grading of Thai cocoa pod on fermentation profiles

Literature Review

Cocoa is a high-yielding economic crop and well cultivated in the tropical climate of Thailand. Theobroma cacao tree, or cocoa, has recently garnered increasing attention and become the subject of research due to its antioxidant properties, which are related to potential anti-cancer effects. In the past few years, identifying and developing active compounds or extracts from the cocoa bean such as polyphenol and flavonoid have become an important area of health and biomedicine-related research. Phytochemicals (Phytonutrients) are biological substances found only in plants. One of them is Polyphenols: Flavonoids. Cocoa is an important source of Polyphenol, which is a healthy antioxidant. It can be seen that cocoa has many beneficial nutrients. Therefore, this research was done with the Department of Food Science, National Pingtung University of Science and Technology, Taiwan and Thai coffee-cocoa company. Cooperated with the Faculty of Innovative Agricultural Management, Panyapiwat Institute of Management, Thailand. The objective of this research was to determine volume of antioxidant (Flavonoid) from Thai cocoa (Chumphon#1 Pa7xNa32) bean. The samples of cocoa bean were analysis by ISO17025 laboratory and using High Performance Liquid Chromatography (HPLC). The result showed that total flavonoid content of cocoa formula B is higher than formula A. For future study can be adds value to farmers who are interested in this business including food and non-food products and for commercial products (Chaisu and Chiu, 2019).

Cocoa, a fruit product of *Theobroma cacao L.*, is the third most important agricultural crop in the world. Cocoa is the main ingredient in chocolate manufacture. The consumption of cocoa is increasing due to the demand in international market and chocolate industries. The aim of this research paper studied and compared on food nutrition of cocoa bean some private company in Thai and Taiwan. The results found that total calories, calories from fat, crude fat, saturated fatty acids, dietary fiber, cholesterol, cholecalciferol (Vitamin D3), and total flavonoids content of cocoa bean from Thailand were higher than Taiwan. On the other hand, carbohydrate, ash, calcium, iron, potassium, and ergocalciferol (Vitamin D2) of cocoa bean from Taiwan. Therefore, this research paper is the first report database on food nutrition from private company in Thailand and Taiwan. For

the future can be applies to advance cocoa research, sharing to smart farmer for cocoa industries. Thai cocoa bean sample Chumphon#1 from Thai coffee-cocoa company after processing at 120 ˚C within 20 minutes, formula A (cocoa bean from Thailand) and formula B (cocoa bean from Taiwan) from Taiwan company as same condition (Chaisu, 2019).

Globally, cocoa bean is the sole source of chocolate. The benefit of cocoa bean is increasingly studied because of high volume of nutrition. According to the results of International Chocolate Awards (ICA) 2018, Taiwan chocolate was awarded 9 gold, 30 silver and 29 bronze medals ranking as the top in Asia. Besides, Thailand chocolate was awarded 1 gold, 2 silver, and 2 bronze medals. Most of the world's cocoa is grown well in a narrow equatorial belt. Therefore, cocoa cultivation in Thailand is better growing than in Taiwan. The researchers analyzed and compared both roasted cocoa bean in the laboratory. Significantly, the physicochemical property of the roasted cocoa bean was instrumentally evaluated by the Moisture Analyzer, the pH meter, the titration with 1.1404 g of sodium hydroxide, and the Colorimeter. Under the International Cocoa Standards, the comparison between Taiwan and Thailand roasted cocoa beans indicated that the moisture contents were 2.2% and 3.2%, the pH measurements were 4.68% and 5.03%, the acidity of acetic acid were 1.91% and 1.32%, and the acidity of lactic acid were 2.86% and 1.97%, the color measurement in CIE L*a*b* system were 32.54 and 30.87 of L*, 17.89 and 21.60 of a*, and 10.24 and 14.58 of b*. In summary, Thailand roasted cocoa bean was potentially processed as high quality as Taiwan for better quality of Thailand chocolate products. (Piankarn *et al.*, 2019)

Methodology

1. Fresh Cocoa Pods and Sorting Preparation

All fresh cocoa pods (2 years harvesting) used were taken from Uthai Thani Province, Thailand. Cleaning process using clean water and distilled water was applied to cocoa pods before entering to fermentation process.

2. Cocoa Grading

Cocoa grading was sorted into 3 groups by consideration of the color and ripeness quality of cocoa pods including; A = Ripe cocoa (Yellow skin), B = Half ripe cocoa (Green skin), C = Off specification cocoa (Mix skin color), respectively. After cleaning and grading, the cocoa beans were taken out from the pods for the fermentation process.

3. Fermentation Process

The fermentation process of cocoa beans was carried out for 7 days at room temperature (27±2 ℃), the three groups (A, B, and C) of cocoa beans were brought separately to cleaning plastics box (18 x 12 x 7 cm^3), covered with clean banana leaves (5 g.). Each 100 grams of fresh cocoa bean was respectively separated into A, B, and C grading box. The fermentation parameters including pH, Total Soluble Solid (TSS) (% brix), Temperature (℃), and moisture content (%) were measured every 24 hours during fermentation period. The pH was measured with the pH meter (4 in 1 LCD Moisture Soil Tester). The Total Soluble Solid (TSS) was measured with the refractometer (Refractometer 0-32% brix, sugar level). The temperature was measured with the thermometer (testo 106 Penetration / infrared thermometer). And the moisture content was measured with the moisture tester (Moisture Analyzer Wood Floor Carton Moisture Measurement).

4. Drying Process

After completed fermentation process, all samples were dried by using the hot air oven (Binder FP Series) at 100 ℃ until the moisture content of dried cocoa beans was less than 7%. And the dried cocoa beans were measured the weight to calculate the % yield.

5. Analysis and reporting data

The experimental design used for the study was Ramdomized Complete Block Design (RCBD). The variable factors were cocoa treatments (A, B, and C) and fermentation time (0 to 7 days). The parameters such as pH, Total Soluble Solid (TSS) (% brix), Temperature (℃), and moisture content (%) were recorded during the fermentation process. All statistical analysis was performed using SPSS 13.00 statistical package program (2002). The data were analyzed by analysis of variance (ANOVA). If there is significantly different between treatments, therefore it was followed by Duncan Multiple Range Test (DMRT) using 0.05% significance.

Results

From the Table 1, all fresh cocoa pods from Uthai Thani Province were separated into 3 groups by consideration of the color and ripeness quality of cocoa pods including A = Ripe cocoa (Yellow skin), B = Half ripe cocoa (Green skin), C = Off specification cocoa (Mix skin color), respectively. Since there was no grading of fresh cocoa pods from the cocoa farm, Group A was sorted as the most desirable maturity of cocoa beans (2,230 grams) among three groups. Between Group A and B, the weights of fresh cocoa beans were 688 grams and 946 grams respectively. For the Yeild[1], Group C was calculated as the most (24.5 %) comparing to Group B (16.3%) and Group A (13.5%). However, for the Yeild[2], all three groups were calculated as nearly the same as 35.69%, 35.8%, and 34.32% respectively. And for the Yeild[3], Group C was calculated as the most (8.4 %) comparing to Group B (5.8%) and Group A (4.8%).

Table 1: Variation of cocoa bean yields after fermentation and drying process

Sample		Wight (Pod; g)	Weight (Fresh bean; g)	Weight (Dried bean; g)	Yeild[1] (%)	Yeild[2] (%)	Yeild[3] (%)
A		5,100	688	245.53	13.5	35.69	4.8
B		5,800	946	338.65	16.3	35.80	5.8

Table 1: Variation of cocoa bean yields after fermentation and drying process (cont.)

Sample		Wight (Pod; g)	Weight (Fresh bean; g)	Weight (Dried bean; g)	Yeild[1] (%)	Yeild[2] (%)	Yeild[3] (%)
C		9,100	2,230	765.31	24.5	34.32	8.4

Note: **Yeild[1] (%) =** Fresh cocoa bean weight /Cocoa Pod weight
Yeild[2] (%) = Dried cocoa bean weight / Cocoa Pod weight
Yeild[3] (%) = Dried cocoa bean weight / Fresh cocoa bean weight

From the Figure 1, the data was shown that the pH of cocoa bean during Day 0 – 2 fermentation was significantly ($P < 0.05$) increasing. During Day 3 – 6, the pH of fermented cocoa bean was slightly increasing. And on Day 7, the pH of fermented cocoa bean was presented the significantly highest value among 7 days.

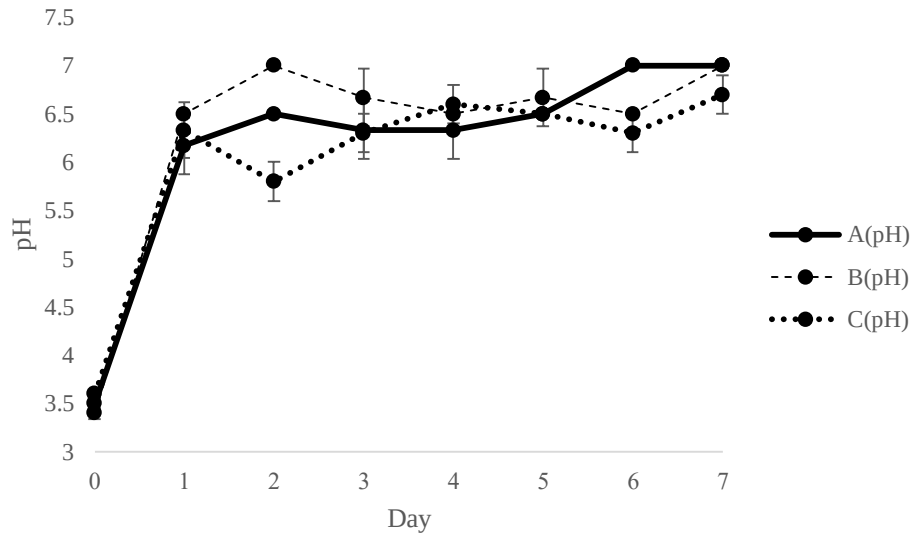


Figure 1: Change in pH of cocoa bean during 7-days fermentation

From the Figure 2, the data was shown that the % Brix of fermented cocoa bean during Day 0 – 3 was dramatically ($P < 0.05$) decreasing. This can be explained as the fermentation process is the anaerobic. Consequently, the microbes (mainly yeast, Latic Acid Bacteria (LAB)) transform the sugar of cocoa pulp to ethanol (Watson *et al.*, 2013; Lima *et al.*, 2011). And during Day 4 – 6, the % Brix of fermented cocoa bean was moderately decreasing. However, on Day 7, the % Brix of fermented cocoa bean was presented the significantly lowest value among 7 days.

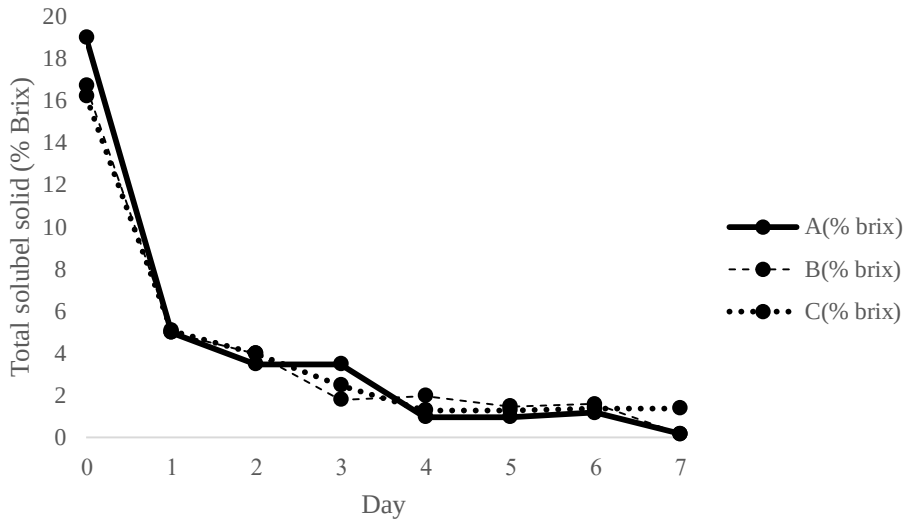


Figure 2: Change in Total Soluble Solid (TSS) of cocoa bean during 7-days fermentation

From the Figure 3, due to the temperature range was important in regulating the enzymatic activity of the yeast, the temperature of cocoa bean significantly changed during the first three days of fermentation (Cruz *et al*., 2013). During Day 0 – 2, the temperature of cocoa bean was significantly ($P< 0.05$) increasing. However, on Day 3, the temperature of cocoa bean was drastically ($P< 0.05$) dropped. And during Day 4 – 7, the temperature of cocoa bean fermentation was slightly increasing.

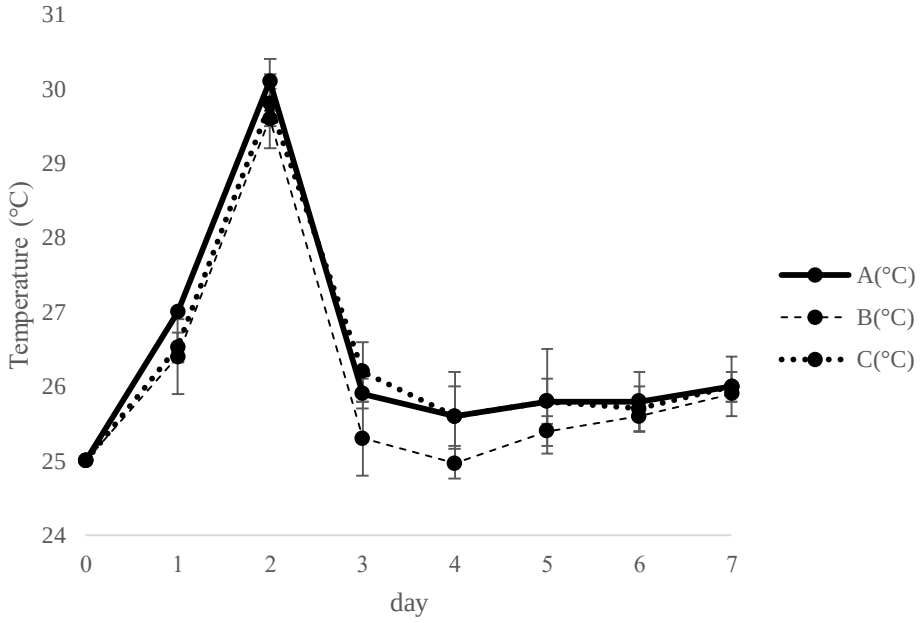


Figure 3: Change in temperature of cocoa bean during 7-days fermentation

From the Figure 4, the data was shown that the moisture content of cocoa bean during Day 0 – 1 fermentation was significantly ($P< 0.05$) decreasing. However, on Day 2, the moisture content of

fermented cocoa bean was gradually increasing. During Day 2 – 7, the moisture content of fermented cocoa bean was steadily fluctuating (P> 0.05).

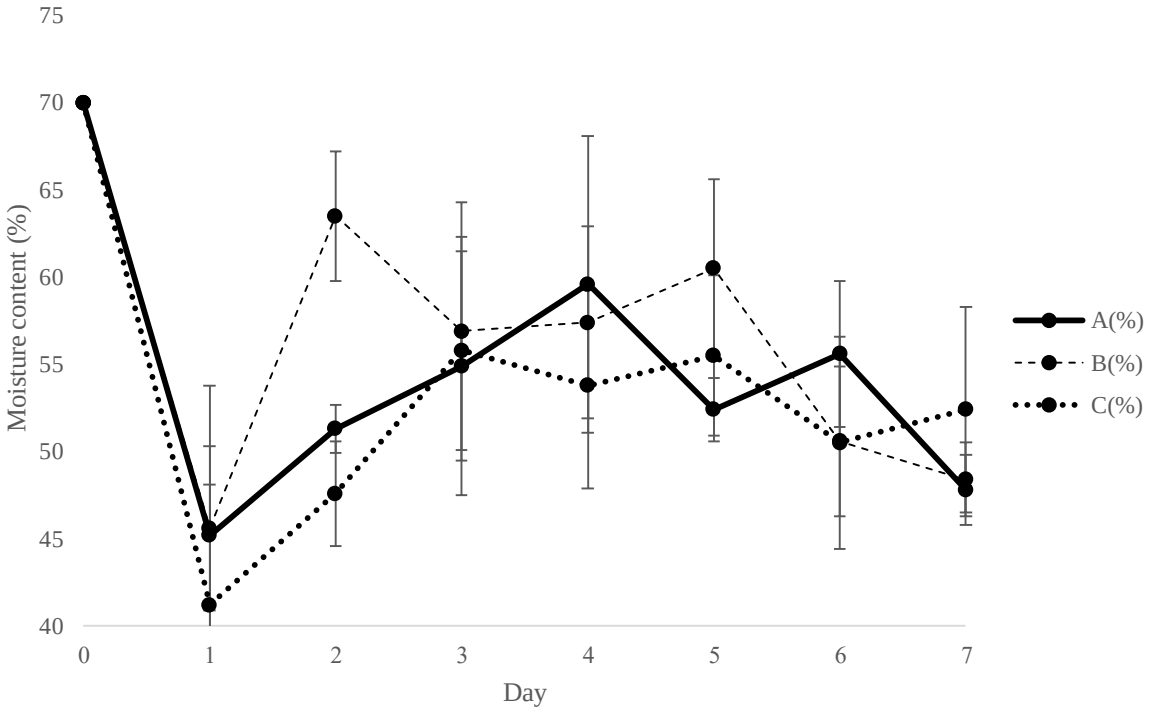
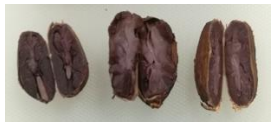


Figure 4: Change in moisture content of cocoa bean during 7-days fermentation

From the Table 2, there were three stages of cocoa beans during this experiment, which were fresh cocoa beans (pre-fermentation period), fermented cocoa beans (during fermentation period), and dried cocoa beans (post-fermentation period). According to three stages, each cocoa bean was cut as a cross section test, and they were compared among three groups of cocoa beans.

Table 2: Three stages of cocoa beans

Types of cocoa beans	A	B	C
1. Fresh cocoa beans			
2. Fermented cocoa beans			
3. Dried cocoa beans			

Discussion

In this study, the cleaning and sorting process of Thai fresh cocoa pods was performed prior to the fermentation process to obtain the good quality of dried cocoa beans. The fresh cocoa pods were sorted by consideration of the skin damage, color, and ripeness quality and classified into 3 groups. As long as the pods are not damaged, the internal part is considered sterile (Ostovar and Keeney, 1973; Watson et al., 2013). This could prevent the contamination during fermentation process. The total soluble solid which revealed the sugar content as well as the ripeness level of cocoa pod was measured in each group and they presented the different sugar contents which reflected to the ripeness levels. However, there were no effect on fermentation process and the yield of dried cocoa bean. The different sugar content of fresh cocoa might influence on the flavor attributes of dried cocoa beans. So, the sensory evaluation of dried cocoa beans from different ripeness level is recommended for further study.

Fermentation is an important process in cocoa beans for the development of cocoa flavor precursor (Lopez, 1986). In this study, it was found that the fermentation time significantly affects the fermentation parameters. This agreed with the work of Res (2014) which illustrated that the fermentation duration has significantly influence to the degree of fermentation of Malaysian cocoa beams. The suggestion was presented that the fermentation time could be shortened five days to three days. However, the flavor attributes of dried cocoa beans should be further evaluated.

The fermentation parameters included pH value, total soluble solid, and the temperature revealed to the degree of fermentation which affected on the quality of dried cocoa beans. The level of acidity in cocoa beans is reflected by the pH value. In this study, the fresh cocoa beans had pH value of 3.5. At the beginning of fermentation period (Day 1 and 2), the increasing in pH value could be explained by the accumulation of ethanol production by yeast naturally found in cotyledons. Similar studies were reported by Watson et al. (2013) and Lima et al. (2011). After that, the pH value slightly decreased. This might be due to acetic acid which is mainly produced through oxidation of ethanol in aerobic condition by acetic acid bacteria from the second day of fermentation period (Hii et al., 2009). However, after the fermentation, the pH values of cocoa beans were higher than previous study (Res, 2014). Highest level of acidity affected the flavor and taste of cocoa nibs (Lopez, 1986; Jinap and Dimic, 1990).

Conclusion

The sorting of Thai fresh cocoa pods by consideration of the color and ripeness quality of cocoa pods, there were no effect on fermentation process and the yield of dried cocoa bean. The study of the fermentation profile of Thai cocoa beans was found that the value of pH and temperature were significantly increasing at the beginning (Day 0-2) of the fermentation period. However, the total soluble solid (TSS) and moisture content were significantly decreasing at the beginning (Day 0-1). The fermentation time, therefore, significantly affects the four fermentation parameters in order to develop the cocoa flavor precursor. Especially at the beginning of the fermentation process, all parameters were drastically changed. The recommendation emphasized is to use these parameters to monitor during fermentation process of cocoa beans to achieve the good quality of dried cocoa beans. According to the result of the research, Thai cocoa bean group A was graded as the recommended group for the purpose of fermentation profile. However, for the yield measuring the weights of dried cocoa bean per the weight of cocoa pods, there were no significant differences. This finding, therefore, would be useful to develop the guideline of Thai cocoa production for small-holder farmers in Thailand.

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