The Decision of Farmers do Fermentation to Increase the Quality of Cocoa Beans: A Case Study in Central Sulawesi Indonesia

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Abstract **- The fermentation of cocoa beans is an important part of cocoa processing. Fermentation of cocoa beans increases the quality and price of the beans and the resultant cocoa. Although the fermentation of cocoa beans can increase the quality and income of cocoa farming, few farmers in Indonesia implement this fermentation process. This research therefore, focuses on the way Indonesian farmers assess whether or not to ferment their cocoa beans. A total of 284 cocoa farmers were sampled in Central Sulawesi Indonesia. The results showed that out of the more than 50% of farmers who did not ferment their cocoa beans, a majority were simply not interested in increasing the quality of the resultant cocoa. The quality of cocoa beans produced from smallholder plantations, therefore, was continually poor. The decision of cocoa farmers to ferment their cocoa beans, meanwhile, was significantly affected by the gender, age and education level of the head of the household, the number of productive family members, the quantity of cocoa bean production, and the resultant price of the fermented cocoa beans in the market. The resultant price of the fermented cocoa was the most dominant factor.**

Keywords: *fermentation, price of fermented cocoa beans, fermentation process time, logistic regression model*

1. Introduction

The development of cocoa and cocoa beans in Indonesia cannot be separated from various problems encountered from the downstream sector. Problems in the downstream sector owe largely to a lot of unfermented cocoa beans produced in the country [1,2]. A lot of unfermented beans coming out of Indonesia caused heavy discounts on the eventual price of Indonesia cocoa beans across American markets. In 2005, the magnitude of price discounts due to the problem reached 250 USD ton^{-1} [3]. In the European market, Indonesian cocoa beans were discounted by around 15% of the world cocoa price average [4]. The crux of the issue was the low quality of Indonesian cocoa beans in comparison with those from the rest of the international market, owing largely to the non-fermentation of the cocoa beans, the high levels of dirt and other contaminants present, such as insects, fungi, and mycotoxins, and the weak taste [5]. [6,7] stated that cocoa bean fermentation is crucial to good-tasting cocoa. Fermentation aims to create a distinctive chocolate flavor and to reduce the bitterness in the taste of the cocoa bean [8,9,10].

Although research has revealed that cocoa bean fermentation could increase the quality and price of cocoa beans, and therefore increase the income of farmers, there are still many Indonesia cocoa bean farmers who have not implemented fermentation in their production process. A natural question follows: what factors affect the decision of farmers to ferment their cocoa beans? Awareness of the factors affecting farmers' decisions to ferment their beans would enable stakeholders (such as the Indonesian cocoa association (Askindo) and the Ministry of Food and Agriculture) to identify specific issues (such as socio-economic characteristics) in Indonesian cocoa bean production. Thus the government would be able to propose policies (such as the Gernas program from the Cocoa Association of Asia) that would increase the quality of Indonesian cocoa beans. The necessity of this research, then, is obvious.

There has already been some research done into cocoa bean fermentation and the quality of cocoa bean production in Indonesia [1,5,11], but the focus of existing studies is narrow, and not necessarily useful for developing social or economic policy in the real world. Most pieces focus only on the impacts of developments in fermentation technology on cocoa bean processing, while others look at the precise facilities required by farmers to overcome cocoa bean quality problems. The issues that these studies address, while valid concerns, are not the primary barriers to the implementation of fermentation in Indonesian cocoa bean production; in one of the main cocoa producing areas in Indonesia, the Central Sulawesi Region, many cocoa farmers received agricultural extension training in bean fermentation, yet the majority of farmers did not choose to ferment their beans later. Given this fact, it's clear that an absence of training is not actually the reason behind the continuation of unfermented bean production. This research, then, aims to establish and analyze the real factors that affect whether

or not Indonesian cocoa farmers choose to ferment their beans.

2. Materials and Methods

2.1 Research areas and sampling methods

Central Sulawesi is located between 2^0 22' North Latitude and 3^0 48' South Latitude, and between 119^0 22'−124^0 22' East Longitude. Three districts were selected for this research; many farmers in the three districts have received agricultural extension training in cocoa bean fermentation. From each district, two villages were randomly selected to be surveyed (Table 1).

Table 1. Research areas

District	Villages	Sample size (HH)
Poso	Lape Kilo	91
Sigi	Ranteleda Bakubakulu	99
Parigi Moutong	Siniu Nambaru	94
Total		284

Note: HH = household head

The sample size in this research was 284 HH. The sample was chosen randomly from a set of cocoa farmers who received training in cocoa bean fermentation. Research data were collected during January - April 2017.

2.2 Analytical framework

A farmer was assumed to make a choice or adopt a certain technology that maximizes their usefulness. Whether or not a farmer chose to use a certain technology was estimated using a discrete option model. The model used to estimate the farmers' choice was logistic or logit regression. The dependent variable of this model is a dummy variable, equal to 1 if a farmer chose to use a certain technology, and 0 if otherwise. This model has been used in many other studies [12-17] to estimate the adoption of agricultural technology packages.

Based on [18] the logit model could be determined as follows: If P_i is the probability to adopt agricultural technology and X_i is the independent variable that affected adoption:

$$P_i = E(Y = 1 \mid X_i) = \beta_0 + \beta_i X_i \quad (1)$$

Equation (1) can be represented as:

$$P_i = E(Y = 1 \mid X_i) = \frac{1}{1 + e^{-(\beta_0 + \beta_i X_i)}} \quad (2)$$

If $Z_i = \beta_0 + \beta_i Xi$ then equation (2) can be written:

$$P_i = \frac{1}{1 + e^{-Z_i}} \quad (3)$$

If P_i is the probability to adopt agricultural technology then $(1-P_i)$ is the probability agricultural technology is not adopted, where:

$$(1 - P_i) = \frac{P}{e^{Z_i}} \quad (4)$$

Next:

$$\frac{P_i}{1 - P_i} = e^{Z_i} \quad (5)$$

If equation (5) is in natural logarithm, then it becomes:

$$Ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_0 + \beta_i X_i + e \quad (6)$$

Where Z_i is the observed response to cocoa bean fermentation. X_i is the vector of the independent variable, β is parameter vector and e is a randomly distributed error term.

2.3 Empirical model

The logit model is used to analyze the decision of cocoa farmers to ferment their cocoa beans. The logit model in this research can be summarized as follows:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \varepsilon \quad (7)$$

Y = dependent variable (1 = fermentation conducted and 0 = otherwise), β_0 = intercept, $\beta_1 - \beta_8$ = independent variable coefficient, $X_1 - X_8$ = independent variable, ε = error term.

The independent variable is defined as follows:

X_1 = gender of household head
X_2 = age of household head
X_3 = education level of household head
X_4 = access to agricultural extension training
X_5 = experience cocoa farming
X_6 = number of productive family members
X_7 = total cocoa production
X_8 = fermented cocoa price

2.4 Explanation and measurement of independent variables

Bozoğlu and Ceyhan [19] suggested it is very important to include gender in the efficiency analysis in agriculture. The sources of labor in cocoa farming in Indonesia are people of both male and female gender, so gender is included as two dummy variables (1 = male and 0 = female). With regard to age, young farmers are more likely to adopt new technology than older farmers [20,21,22]. Therefore, young farmers were expected to be more enthusiastic to take up the process of cocoa bean fermentation. The age variable was measured from the age of household head expressed in years. Farmers who reached a higher education level tend to adopt new technology because they can analyze and make choices critically [23,24]. The education variable was measured from the last education of household head expressed in the Likert scale (1 = not completed primary school, 2 = primary school graduation, 3 = junior high school graduation, 4 = high school graduation, and 5 = college graduation). Farmers who are highly experienced tend to adopt technology to increase productivity [22,25], so tend to be more enthusiastic in adopting fermentation. The experience variable of cocoa farming was measured from the experience of cocoa farming of household head expressed in years. Farmers who had received more agricultural training would likely find it easier to adopt new agricultural technology [22,26,27]. Therefore, farmers who had received agricultural extension training were more enthusiastic to ferment their cocoa beans. The access variables of the agricultural extension were measured by the number of household heads present who had received agricultural extension training expressed in frequency. The number of productive family members would likely affect the adoption of agricultural technology

[27], therefore, households with more productive family members were expected to be more enthusiastic to conduct fermentation. The variable number of productive family members was measured by the number of people present in the family aged 14 years old or over. Similarly, the increase in total production and price of fermented cocoa beans over unfermented beans would make farmers more enthusiastic to adopt fermentation. The variable of total production was measured by the number of cocoa beans produced during farming expressed in kg, and the variable of cocoa bean price was included as dummy variables (1 = if the difference of fermentation cocoa beans price was more than Rp2,000 and 0 = if others).

3. Results and Discussion

3.1 Descriptive of research variables

Description of research variables is given in Table 2.

Table 2. Descriptive of research variables

Variable	Units	Mean	Std. deviation
Y	dummy	0.36	0.48
X_1	dummy	0.61	0.49
X_2	year	42.35	8.97
X_3	Likert scale	2.86	1.13
X_4	number	11.64	5.74
X_5	number	4.88	2.00
X_6	number	2.75	1.23
X_7	kg farm^{-1}	1,556.94	701.79
X_8	dummy	0.36	0.48

Fewer than 50% of farmers chose to ferment their beans, indicating that farmers did not want to increase the quality of their cocoa beans, such that the quality of cocoa beans produced from smallholder plantations was still poor. This finding is compatible with research from [5,11]. Farmers who did not ferment their cocoa beans in the research area comprised 64% of the sample size. The interview results showed that farmers did not choose to ferment because of the cocoa beans' eventual price, and the time required for the fermentation process. The difference between the price of fermented and non-fermented cocoa beans ranged from Rp2,000. The process of cocoa bean fermentation takes 3-6 days [28]; farmers in the research area found this an unacceptably long time.

The gender of respondents was predominantly by the male (more than 50%). This suggests that males have greater access to cocoa farming, and accords with the findings of [29]. The average age of respondent farmers was 42 years; this is a fairly young average age, so would likely have a positive impact on productivity, since young farmers are more energetic and tend to adopt new technology more readily [20,21,22]. Most of the respondent farmers were primary educated; this would likely affect the readiness with which farmers adopted the technology [23,24]. Cocoa farmers' access to extension training in this particular research field averaged at 5 sessions per year. This number was significantly lower than the overall opportunities available to the farmers; more than 24 total government and non-government extension activities were fielded for farmers in the sample area. This would have an impact on the adoption of agricultural technology by farmers [22,26,27]. Cocoa farming experience in the research area averaged 12 years; this suggests that people involved in the cocoa production were experienced in their field. The number of productive family members in the research area was 3 people, on average. This would have an impact on the adoption of agricultural technology by farmers [27]. The number of cocoa production in the research area was 1,556.94 kg farm^{-1} and the difference of fermented cocoa beans price received by farmers in the research area was less than Rp2,000 kg^{-1}.

3.2 The goodness of Fit of the Logistic Distribution Model

Whether a logit model fits well or not can be evaluated from the log value of likelihood in block 0 (beginning block) and in block 1 (method), as well as by reference to the Hosmer and Lemeshow test value of SPSS, the results of which are processed in Table 3.

Table 3. The goodness of fit of the logit model

Description	Value	Critical value
block 0 (beginning block)	369.69	
block 1 (method)	69.36	369.69 > 69.36
Hosmer and Lemeshow Test (Chi-square)	3.84	0.872>0.05
Overall Percentage	95.10	

The SPSS result shows a log value of likelihood in block-0 as 369.69, while the log value of likelihood in block-1 is 69.36. The log value of likelihood in block-0 is greater than the log value of likelihood in block-1 (that is, 369.69 > 69.36); this decrease indicates the regression model is a good fit. Note the goodness of fit test value, measured by the value of a chi-square count, was 3.836 (this is the Hosmer and Lemeshow Test), with the probability value of 0.872 > 0.05. It can hence be concluded that hypothesis H_0 is accepted. It means that the logit model was feasible for conducting further analysis, since there was no significant difference between the predicted classification and the observed classification, with a model accuracy of 95.1% and an error rate of 5%.

3.3 Testing of Regression Coefficients

Factors affecting the decision of cocoa farmers to ferment their cocoa beans were modeled by logistic distribution and were analyzed with SPSS version 17.00. The results of this analysis are reported in Table 4.

Table 4. Estimation of logit model parameters

Variable	β	S.E.	Wald	df	Sig.	Exp(β)
X_1	-1.712	0.976	3.078	1	0.079**	0.180
X_2	-.328	0.070	21.703	1	0.000***	0.721
X_3	.670	0.417	2.583	1	0.108*	1.954
X_4	.430	0.092	21.861	1	0.000***	1.537
X_5	.067	0.212	.099	1	0.753	1.069

X_6	1.020	0.307	11.077	1	0.001****	2.774
X_7	.001	0.001	6.184	1	0.013***	1.001
X_8	4.466	0.879	25.785	1	0.000****	86.980
Constant	-1.563	2.340	.446	1	0.504	0.209

Note: **** significant at 1% level (p < 0,01).
*** significant at 5% level (p < 0,05).
** significant at 10% level (p < 0,10).
* significant at 15% level (p < 0,15).

Table 4 shows that seven variables of eight variables were estimated to be significant. Significant variables were gender, age, education level, access to extension services, number of productive family members, the quantity of bean production, and the price of fermented versus unfermented cocoa beans. Gender was found to be negatively correlative and significant at 10% level. Exp (β) shows a value of 0.180, which means that the likelihood fermentation was chosen over non-fermentation was significantly affected by gender variables, being 0.180 times more likely to have occurred if the farmer was female than if the farmer was male. This indicates that female farmers were more likely to ferment their cocoa beans. This means that female farmers are absolutely vital to the process of increasing the quality of Indonesian cocoa beans, and can thus ensure greater food security and increased income. This concurs with the findings of [30], who also found that female managers were more efficient than male ones.

Age was found to be negatively correlative and significant at 1% level. Exp (β) shows a value of 0.721, meaning that as the age of the farmer increased, they were 0.721 times less likely to have adopted fermentation. It indicates that young farmers were more likely to have adopted the fermentation of cocoa beans in the production process. The results were compatible with the findings of [20,21,22]. All found that young farmers were more likely to adopt newer agricultural technology than old farmers.

Education was found to be positively correlative and significant at 1% level. Exp (β) shows a value of 1.954, meaning that as the education level of the farmer increased, they were 1.954 times more likely to have adopted fermentation. This indicates that higher educated farmers would tend to ferment their cocoa beans. The results fitted with the findings of [23,24], who noted that education would affect the likelihood with which farmers adopted the technology.

Access to extension service was found to be positive and significant at 1% level. Exp (β) shows a value of 1.537, which means that the likelihood that the farmer had adopted fermentation was 1.537 times greater when they had had more access to extension training. This suggests that access to extension services increases the likelihood of farmers fermenting their cocoa beans. The results were suitable with the findings of [22,26,27] which stated that access to extension services had an impact on agricultural technology adoption by farmers.

The experience level of the farmers was found to be positively correlative and not significant at 15% level. The result could perhaps be explained by reference to the price difference between fermented and unfermented cocoa beans; since the difference was so small in the region, even experienced farmers did not choose to ferment their cocoa beans. It was expected that the experience level of farmers would have a significant effect on their decision to ferment or not; previous studies have suggested that more years of experience gives farmers improved skills and better access to new information about technology [25].

The number of productive family members was found to be positively correlative and significant at 1% level. Exp (β) shows a value of 2.774, which suggests that a larger quantity of productive family members increased the likelihood that fermentation had been adopted by 2.774. It indicates that a larger number of productive family members would increase the probability that farmers had adopted fermentation of their cocoa beans.

The quantity of cocoa bean production was found to be positively correlative with the presence of fermentation and significant at 5% level. Exp (β) shows a value of 1.001, which means that farmers producing more cocoa beans were 1.001 times more likely to have adopted fermentation. It indicates that the quantity of cocoa bean production increases the probability that the farmer had adopted fermentation.

The fermented cocoa bean market price was found to be positively correlative and significant at 1% level. Exp (β) shows the value of 86.980, which means that the higher the price of fermented cocoa beans, farmers were 86.980 times more likely to have adopted the fermentation process. This indicates that a higher fermented cocoa bean price would increase the probability farmers fermented their cocoa beans.

4. Conclusions

Less than 50% of farmers fermented their cocoa. This indicates that farmers were not interested in increasing the quality of their cocoa beans so that the quality of cocoa beans produced from smallholder plantations was still poor overall. The decision of cocoa farmers to ferment their cocoa beans was affected by the gender, age and education level of the head of the household, the number of productive family members, the quantity of cocoa bean production, and the resultant price of the fermented cocoa beans in the market. The resultant price of the fermented cocoa beans was the most dominant issue. The higher the difference in the price of fermented cocoa beans with non-fermented cocoa beans, the greater the possibility the farmers chose to ferment their beans. To increase the quality and value of Indonesian cocoa beans, the resultant price of fermented cocoa beans should be higher and reflective of the extra time and labor required for the fermentation process; the government needs to increase the quantity and quality of extension.

Acknowledgments

The author would like to thank the Kemenristekdikti for providing fund support for this research

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