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Research Article

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Physicochemical characteristics of fermentation cocoa bean preparing by farmer and researcher in West Sulawesi Province, Indonesia

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ABSTRACT

A lot of cocoa cultivated in West Sulawesi, and their physicochemical characteristics meet the Indonesian National Standard (abbreviated SNI) which influences the cocoa beans quality. The purpose of this research was to find out the profile of fat, polyphenols and fatty acid (oleic) in fermented cocoa beans produced by farmers and researchers in Mamuju and Central Mamuju Regency. The water content of the best cocoa beans came from fermented cocoa beans prepared by researchers and farmers from Kaluku subdistrict (6.07-6.30 %), and it meets the Indonesian National Standard (SNI). Fat content of fermented cocoa beans prepared by farmers from Kaluku and Karossa subdistrict was higher than fermented cocoa beans prepared by researchers (50,80-52,87%). The highest level of fatty acids (oleic) came from fermented cocoa beans prepared by farmers from West Tapalang subdistrict (1.66 %). On the other hand, the lowest fatty acid level came from fermented cocoa beans prepared by researchers from Tapalang subdistrict (0.86 %). The pH level of fermented cocoa beans prepared by farmers and researchers from the four subdistricts was 5.52-6.71. The highest polyphenol level came from fermented cocoa beans by researchers from West Tapalang subdistrict which was 38.89/g.

Key words: Physicochemical characteristics, cocoa bean, West Sulawesi, Fermentation

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INTRODUCTION

Cocoa is one of the plantation commodities that can generate income to support community life. Cocoa used as a commodity that can increase foreign exchange for being able to compete in the market with a high price. This causes the cocoa cultivated more intensively in every area including West Sulawesi.

West Sulawesi is one of the cocoa-producing regions beside South Sulawesi. Because it brings regional income to West Sulawesi, hence the productivity of cocoa in this area begins to be expanded. Cocoa production in West Sulawesi from year to year has increased and is now capable of producing up to 101.011 tons which is cultivated on an area of 181.516 hectares, yet by those large areas it needs to get more serious attention to increase production [1]. The result of this cocoa is a form of the National Movement of Cacao Production and Quality Improvement Program which has run since 2009 by the government, so the increasing production of cocoa which has good physical and chemical properties can be processed into various food products.

Cocoa bean is one part of cocoa that is usually processed and used in the food industry such as the manufacture of cocoa powder (chocolate). Cocoa powder is an ingredient for the manufacture of cakes, ice cream, snacks, and milk. Each cocoa bean has different physicochemical properties so it needs to be analyzed.

Physical and chemical properties of cocoa beans can be seen from the appearance of the physical and chemical constituents contained in cocoa. The factor that determines the quality of cocoa beans are the physical characteristics

(such as number of seeds per 100 grams, beans fermented and moldy grain content), chemical characteristics (such as total fat content and moisture content) and organoleptic [2].

This research was conducted to see the physicochemical properties of the cocoa beans produced by West Sulawesi people in Mamuju and Central Mamuju Regency. It was performed because of less optimal results of the analysis of the physical properties and chemical properties of cocoa beans in Mamuju and Central Mamuju Regency in West Sulawesi

EXPERIMENTAL SECTION

This research consisted of fermentation of cocoa beans and then analyzing the level of water content, free fatty acid, and fat content as well as fermented cocoa beans by farmers and researchers.

Fermentation of Cocoa Beans by Researchers
Cocoa bean was split, and then the seeds were taken. Sorting was performed before the cocoa beans fermented. Wet cocoa beans fermented in a box (size 30x30 cm and 40 cm high) and sealed with banana leaves. Cocoa beans were fermented for 5 days. On day 3, 4, and 5, the cocoa beans were stirred to obtain uniformity of fermented results. After being fermented, cocoa beans soaked in water for 3 hours, and then they were drained. Then they were dried for 3 days.

Fermentation of Cocoa Beans by Farmers
Cocoa bean was split, and then the seeds were taken. Wet cocoa beans fermented in a sack as their fermented container, and then it was sealed. Cocoa beans were fermented for 5 days. After 5 days of fermentation, cocoa beans were cleared from the fibers to produce a clean fermentation of cocoa beans. Then they were dried for 3 days.

Research Treatment
The treatments used in this study were fermented cocoa beans, which are as follows:

Table 1. Treatment Matrix Used by Researchers

Subdistricts	Treatment	Analysis
A1 (Tapalang)	B1	A1B1
	B2	A1B2
A2 (West Tapalang	B1	A2B1
	B2	A2B2
A3 (Kaluku)	B1	A3B1
	B2	A3B2
A4 (Karossa)	B1	A4B1
	B2	A4B2

Specification:
A1: cocoa beans from Tapalang subdistrict.
A2: cocoa beans from West Tapalang subdistrict.
A3: cocoa beans from Kaluku subdistrict.
A4: cocoa beans from Karossa subdistrict.
B1: fermented cocoa beans from farmers.
B2: fermented cocoa beans from researchers.

Procedure Analysis
Parameters observed in this research were the water content, ash content, and fat content.

Analysis of Water Content [3]
The empty cup and its lid were dried in the oven for 15 minutes. The fermented cocoa bean was quickly weighted for approximately 5g homogenized samples in a cup. Pour it into the cup and then put it in the oven for 3 hours. The cup was refrigerated for 3-5 minutes. After the material cold, it was weighted again. The material was dried again, and then it was put into the oven for ± 30 minutes until the fixed weight was obtained. The material was refrigerated again, and then it was weighted again until the fixed weight was obtained. The water content was calculated with the following formula:

$$\text{Water content} : \frac{\text{The initial weight} - \text{final weight}}{\text{The weight of the final sample}} \text{ X } 100\%$$

Analysis of Fat Content [4]
Weighted as much as 1 gram of material in the form of flour and wrapped it in filter paper, then placed it in the soxhlet extractor. Diethyl ether solvent was poured into the flask sufficiently. The repluk was performed for at least 5 hours until the solvent was dropped back into a clear colored flask. The solvent in the flask was distillated and was retained, and then the extracted fat was heated in an oven at 105^0C. After it was dried to its constant weight and was refrigerated in desiccators, and then it was reweighted again. The following formula was used to calculate the fat content:

$$\% \text{ Fat } = \frac{\text{fat weight}}{\text{weight of sample (gr)}} \text{ x } 100 \%$$

Determining the Free Fatty Acid [5]
Weighted sample of 5 grams, the sample was inserted into the Erlenmeyer flask and 50 ml neutral alcohol was added. The sample was heated until it was boiling. After the sample was cold, 2 ml of pp indicator were added. Then it was titrated with 0.1 N NaOH solution which has been standardized until a pink color was achieved and did not lost.

$$\% \text{ FFA} = = \frac{\text{ml NaOh x N NaOH x BM Acid fat}}{\text{weight of sample } (gr) x 1000} \text{ x } 100 \%$$

pH
pH was determined by using a pH meter. First the cacao beans were pulverized, it was weighed for 2 grams then it was diluted with aquadest until 10 ml volume, stir to mix it. Filtrate was taken to measure its pH.

Total Acid
The sample was weighted to 5 g and it was poured into 100 ml flask and dissolved with aquadest till the *tera* mark. Then by using a straw it was taken for 10 ml and placed in Erlenmeyer then titrated with 0.1 N NaOH using the indicator drops by 3 pp until it turned into pink. The percentage of total acid calculated using this formula:

$$\% \text{ Acid total } = \frac{ml\ NaOH\ x\ N.NaOH\ x\ Grek\ x\ FP}{\text{weight of sample } x\ 1000} \text{x } 100 \%$$

Where:
Fp = dilution factor = 10
Grek = equivalent gram = 64

Data Processing
Data processing was done by a method 2 factorial completely randomized design (CRD) with three times replications. If there is a difference extended to the Duncan Honestly Significant Difference Test (HSD test).

RESULTS AND DISCUSSION

This research was conducted to determine the mapping profile of fats, polyphenols, and fatty acids (oleic) from fermented cocoa beans which were formulated by farmers and researchers from Tapalang and West Tapalang subdistrict in Mamuju Regency and from Kaluku and Karossa subdistrict in Central Mamuju Regency, West Sulawesi. This research was performed to determine the chemical content of cocoa beans formulated by farmers and researchers, and the results included water content, fat content, and fatty acid (oleic). The supporting data from this research were pH and total acid.

Fat Levels
The results of the cocoa beans fat level analysis from some treatments in this research were the cocoa bean fermentation carried out by farmers in Tapalang subdistrict was 47.80% whereas in West Tapalang subdistrict was 48.88%. The result of the analysis of fat level fermentation by researchers in the district was 49.71% in Tapalang subdistrict whereas it reached 51.55% in West Tapalang subdistrict. The highest fat level of fermented cocoa beans was the one that carried out by researchers of West Tapalang subdistrict with 51.55% while the lowest fat level in the treatment of fermented cocoa beans was the one that fermented by the farmers of Tapalang subdistrict with 47.80%. Fat level of cocoa beans fermented by the farmers of Kaluku subdistrict was 50.80% and the fat level of Kaluku subdistrict gotten by the researchers was 50.81%. While the fat level of fermented cocoa bean carried out by the farmers and researchers in Karossa subdistrict were 52.87% and 50.81% of researchers. The fat level from the fermented cocoa beans of the researchers was higher than the farmers (Figure 1).

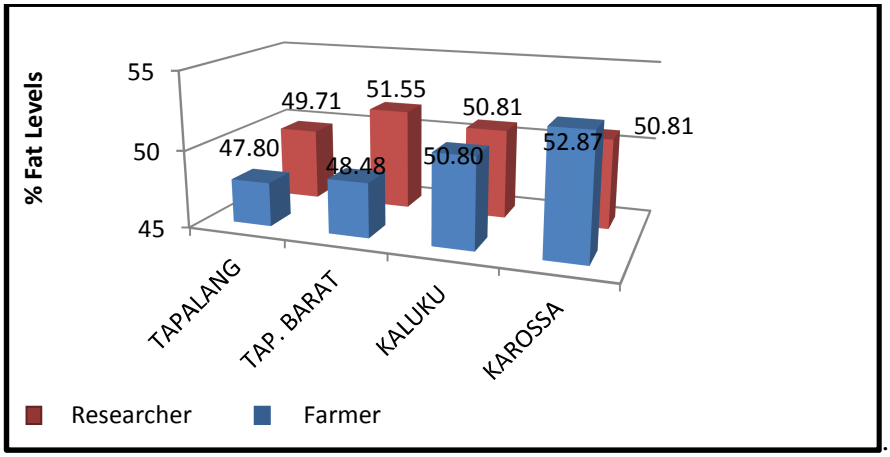

Figure 1. The Interaction Results of Cocoa Beans' Fat Level Fermented by the Farmers and Researchers from Mamuju and Central Mamuju Regency

The results of analysis of variance stated that the fermentation process was significantly different at the level of 5% and 1% of the fermented cocoa beans both by farmers and researchers while subdistricts and interaction in the research treatment were significantly different at the level of 5% and 1%. Further, Duncan test stated that the fermentation process which was carried out by farmers and researchers in Tapalang subdistrict was not significantly different from the West Tapalang, Kaluku and Karossa subdistrict at the level of 5% and 1%. These results affected the fermentation process which was carried out in this research. In addition, the fat level was also influenced by agronomic conditions and treatment during cultivation that produced different sizes of beans and affected the fat levels of cocoa this is in line with [6] that dry beans are very influenced by the type of plant material, rainfall during the fruit growth, agronomic treatment and processing methods. The larger the bean size, the greater the water content and the fat level produce.

Levels of Fatty Acids (Oleic)

The highest fatty acid level in fermented beans treatment in Kaluku subdistrict reached 1% by farmers and 1.3% by researchers while fermented beans by researchers in Karossa subdistrict was 1.4%. The fatty acid fermented beans in the Tapalang subdistrict was 1,3% by farmers and 0,8% by researchers while the result of fatty acid level at West Tapalang subdistrict reached 1.46% fermented by researchers and 1.6% fermented by farmers (Figure 2).

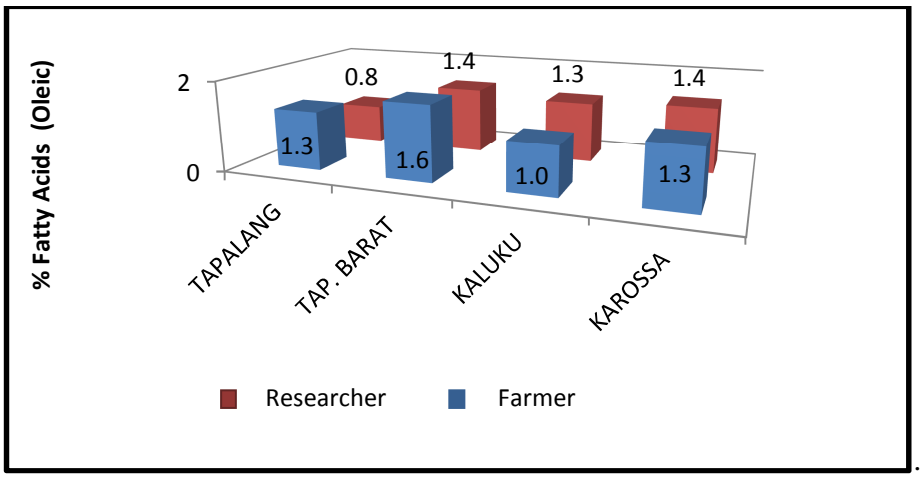

Figure 2. The Interaction Results of Cocoa Beans' Fatty Acids (Oleic) Level Fermented by The Farmers and Researchers From Mamuju and Central Mamuju Regency

The results of variance analysis stated that the sampling districts were significantly different at the level of 5% and 1%. After doing Duncan test, it was found that the results from Tapalang subdistrict were not significantly different with the four subdistricts where the research was conducted. They were at the level of 5% and 1%, but the results from West Tapalang subdistrict were significantly different with Kaluku subdistrict. While the interaction process differed significantly between the districts and the fermentation process which were carried out by researchers and farmers, it was at 5% level. Duncan test stated that the interaction between Tapalang subdistrict, West Tapalang, and

Kaluku treatments were significantly different both the fermentation by farmers and researchers, but they were not significantly different in the fermentation carried out by farmers and researchers in Kaluku and Karossa subdistrict.

The fermentation by farmers and researchers were not significantly different at the level of 5% and 1%. There was difference in free fatty acid levels which indicated that the level of fat damage in cocoa beans caused by processing and storage process which are inappropriate, and it is in accordance to [7] who was stated that the presence of free fatty acids in cocoa fat should be avoided because it is one of the indicators of quality defects. Free fatty acids generally occur if dried beans are stored in warehouses that are less clean and moist. The level of free fatty acid levels should be less than 1%. Cocoa beans are already considered to have malfunctioned if the free fatty acid levels are above 1.3%. Therefore Codex Alimentarius defines tolerance for the free fatty acid level in cocoa beans with a maximum limit of 1.75%.

Polyphenols

The levels of polyphenols of cocoa beans in Tapalang subdistrict fermented by farmers were 33.06/g and fermented by researcher 31.49/g while in West Tapalang the result of cocoa beans fermentation were 36.15/g by the farmers and 38.89/g by the researchers. The levels of polyphenols from the cocoa beans fermentation in Kaluku subdistrict were 34.36/g by farmers and 35.14/g by researchers whereas in Karossa subdistrict the levels of polyphenols from cocoa beans fermentation were 39.97/g by farmers and 30.08/g by researchers (Figure 3).

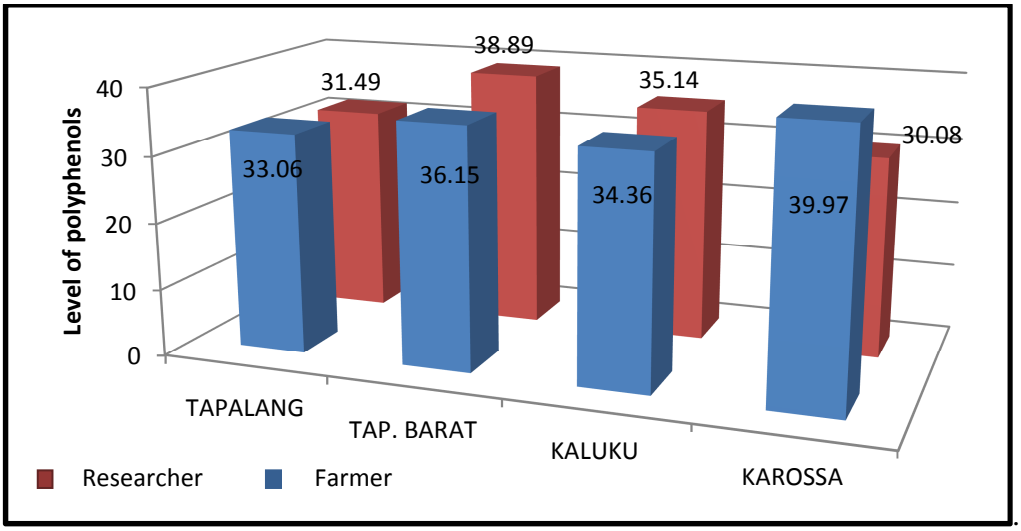

Figure 3. The Interaction Results of Cocoa Beans' Polyphenols Level Fermented by Farmers and Researchers From Mamuju and Central Mamuju Regency

The results of variance analysis stated that the four subdistricts (the research sites) interaction levels were significantly different with 5% and 1%. Then Duncan test was performed, and it stated that there was not significantly different of polyphenols between Tapalang, West Tapalang, Kaluku, and Karossa subdistricts. While the fermentation process did not differ significantly between the fermentation carried out by farmers and researchers. Duncan test showed that the interaction between the farmer fermentation in Tapalang subdistrict and the researcher fermentation in West Tapalang subdistrict were significantly different. The differences that occurred in the total polyphenols in each treatment were due to the treatment process. Fermentation can cause the total polyphenols decreased but has a good taste, it is in line with [8], which state that good taste can be obtained if the cocoa beans are fermented well, but the process of fermentation causes the level of polyphenols in cocoa beans decreased

Water Content

The result of cocoa beans' water content analysis fermented by farmers was 8.90% from Tapalang subdistrict while the result from West Tapalang subdistrict was 7.05%. The result of cocoa beans' water content analysis fermented by researchers taken from Tapalang subdistrict was 8% while fermented cocoa beans of researchers from West Tapalang subdistrict reached 6.69%. The water content of fermented cocoa beans from the farmers of Kaluku subdistrict was 6.07% while the water content got by researchers was 6.31%. The water content of Karossa subdistrict from the farmers' fermentation was 7.16%, and the researchers' fermentation was 6.30%. The result of water content analysis influenced the drying process which was performed by the help of sunshine, the percentage of water content in this research with multiple treatments (Figure 4).

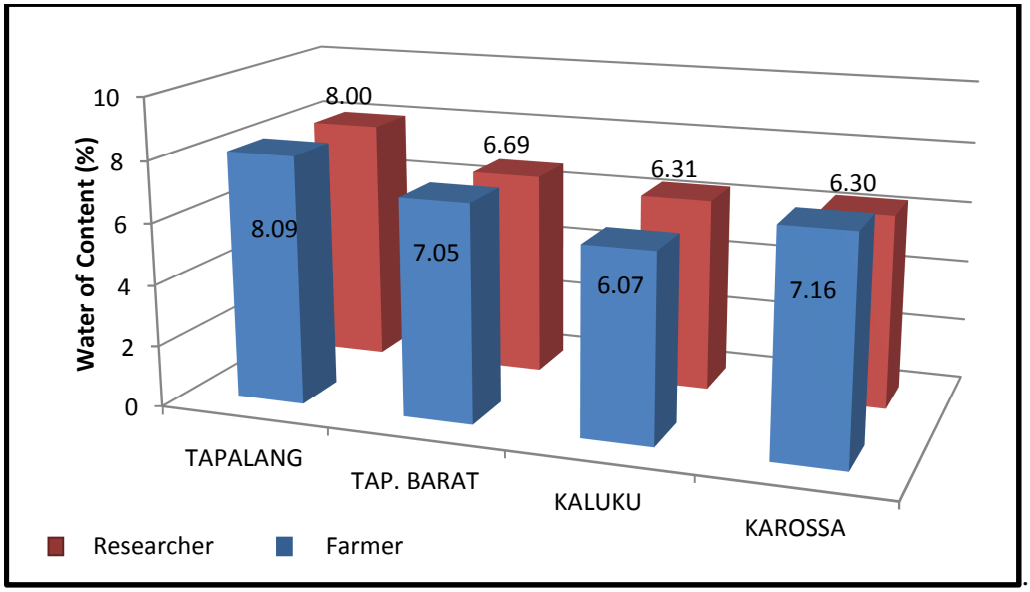

Figure 4 The Interaction Results of Cocoa Beans' Water Content Fermented by Farmers and Researchers From Mamuju and Central Mamuju Regency

The result of analysis of variant showed highly significant difference among the sampling sites Tapalang, West Tapalang, Kaluku and Karossa subdistrict at the level of 1% and 5%. The test result of Duncan test analysis was on the level of 5% and 1% which was not significantly different among Tapalang, West Tapalang, Kaluku, and Karossa subdistrict. It was influenced by the processing of cocoa through the drying cocoa beans under the sunshine which aimed to reduce the water content of cocoa beans in a considerable period. This is in accordance with [9] who states that the drying process aims to reduce water content in beans from 50 to 55% to 7%, so the beans are not grown by microbes and safely stored. Drying can be done in three ways, namely drying, using a dryer, and a combination of both. Although the levels of water uniformity results analysis of fermented cocoa beans by farmers and researchers from Tapalang and West Tapalang subdistrict were quite high and has met the SNI (Indonesian National Standard). It was 6-7% for the moisture content.

pH

The results of the pH measurements of cocoa beans in this research was that the fermented cocoa beans by farmers from the Tapalang subdistrict was 5.52 while the fermentation of cocoa beans by farmers from West Tapalang subdistrict was 5.67. While the cocoa beans fermented by researchers from Tapalang subdistrict reached 6.22 and from West Tapalang subdistrict reached 6.71. The treatment with 5.52 pH value of fermented cocoa beans was done by farmers from Tapalang subdistrict. PH values of 6.16 and 5.26 were the results of fermentation by farmers and researchers from Kaluku subdistrict. In Karossa subdistrict the fermentation of farmers and researchers reached of 6.46 and 5.16 of pH value. The high pH in this research was due to the acetic acid content that will be formed after the fermentation process. It is in accordance with [10] who state that the pH level is more than 4 it means that the condition is suitable for the growth of acetic acid bacteria in the substrate alcohol. After 2 days the acetic acid bacteria suppresses the growth of lactic acid. Meanwhile the beans' pH increases because of acetic acid and lactic acid (Figure 5).

The result of analysis of variance stated that the fermentation process from the two subdistricts were very different. It was significantly different to the resulted pH at the level of 5% and 1%, and the average result of interactions was also significantly different at the level of 5% and 1%. Further Duncan test results stated that the pH of cocoa beans from Tapalang subdistrict was significantly different from cocoa beans from West Tapalang subdistrict at the level of 5% and 1%. While the interaction results of cocoa beans showed that there were some results which were significantly different and were not significantly different from the level of 5% and 1%. In the fermentation process the farmers' fermentations were not significantly different with the fermentation process conducted by the researcher at the level of 5% and 1%. The apparent discrepancy is due to the formation of acetic acid during the fermentation process. Acetic acid is formed after fermentation lasting for 37 hours. The reducing concentration of acetic acid in the seeds causes acidification process slow so that the cocoa beans' pH increases [11].

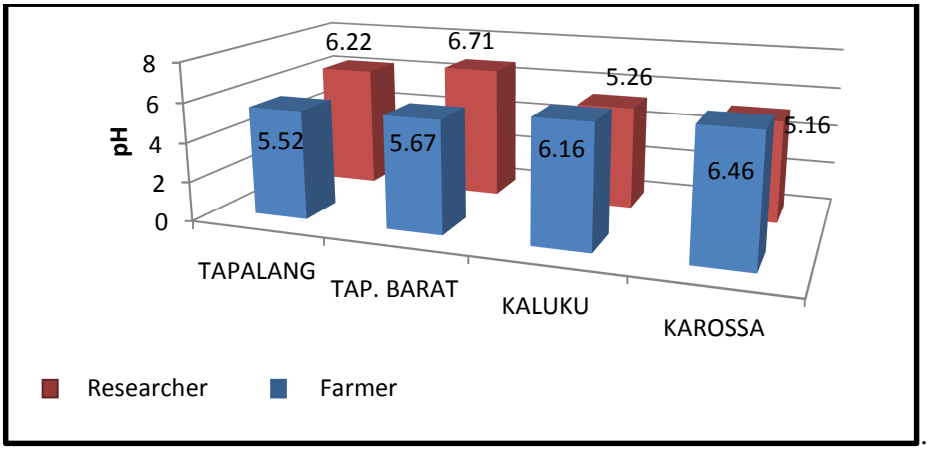

Figure 5. The Interaction Results of Cocoa Beans' pH Fermented by Farmers and Researchers From Mamuju and Central Mamuju Regency

Total Acid

The results of total acid analysis showed that total acid of fermented cocoa beans by farmers from Tapalang subdistrict was 0.38%, and the result of fermented cocoa beans by farmers from West Tapalang subdistrict was 0.40%. Total acid of fermented cocoa beans by researchers from Tapalang subdistrict reached 0.56%, and total acid of fermented cocoa beans by researchers from West Tapalang subdistrict reached 0.49%. Total acids of fermentation by farmers and researchers from Karossa subdistrict were 0.40% and 0.70% while the total acid of fermentation by farmers and researchers from Kaluku subdistrict were 0.73% and 0.56%. The result of total acid obtained is influenced by the process of fermentation which forms acetic acids (Figure 6).

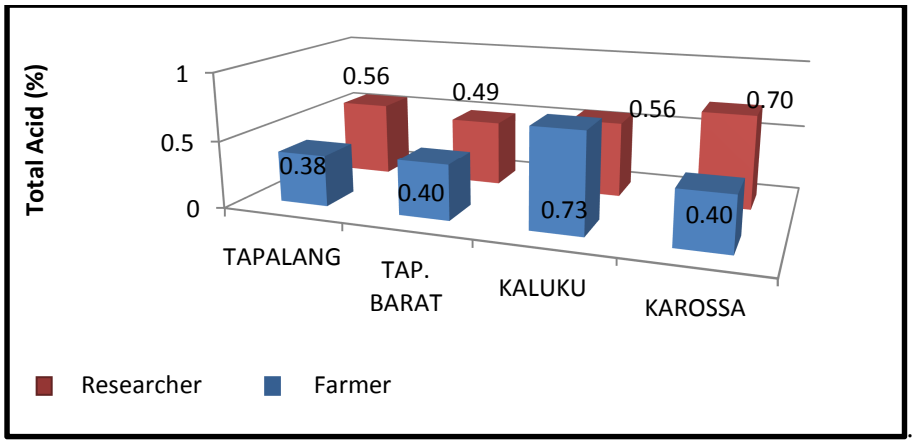

Figure 6. The Interaction Results of Cocoa Beans' Total Acid Fermented by Farmers and Researchers from Mamuju and Central Mamuju Regency

The results of analysis of variance showed that the total acid concentration was significantly different to the fermentation process which was carried out by farmers and researchers, the sampling sites were Tapalang, West Tapalang, Kaluku, and Karossa subdistrict, as well as the interaction between the processes of fermentation and the four subdistricts at the level of 5%. Then Duncan test stated that the fermentation process carried out by the researcher was not significantly different from the fermentation process carried out by farmers. The results from the four subdistricts where the samples were taken were not significantly different at 5% level, but the interaction results of farmers' fermentation between Tapalang and Karossa subdistrict were significantly different. Fermentation is a major factor affecting the total acid levels, and the total acid levels are also affected by cocoa processing in accordance with [12] who state that during the fermentation process sugar is converted into alcohol and then the alcohol is converted into acetic acid by *Acetobacter*. Long fermentation will cause the seed coat damaged and thinned so that the organic acids evaporation process happened which easily evaporate during the drying process that leads to the decreasing of total acid levels.

CONCLUSION

It can be concluded this study such as follows:
1. The levels of total polyphenols from all treatments reached 30.08/g -39.97/g.
2. The highest water content in cocoa beans fermentation treatment performed by researchers from Mamuju and Central Mamuju Regency were 6.30 to 7.16%, and it meets the Indonesian National Standard (SNI).
3. The highest fat level of fermented cocoa beans performed by researchers and farmers from Mamuju and Central Mamuju Regency was 52.87%, and the lowest rate of fat level of fermented cocoa beans by researchers and farmers from Mamuju and Central Mamuju Regency was 47.80%.
4.The highest free fatty acid level found in cocoa beans fermented by farmers and researchers from the two districts was 1.6%, and the lowest free fatty acid level found in cocoa beans fermented by researchers and farmers from the two districts was 0.8%.
5.The highest pH from cocoa beans fermented by researchers from Tapalang subdistrict was 6.22 and the lowest pH from cocoa beans fermented by farmers from Tapalang subdistrict was 5.52. The highest total acid was 0.73%, and the lowest total acid was 0.38%.

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