E-ISSN-2580-7129
Print- ISSN-1978-6107

TECHNO: JURNAL PENELITIAN
Journal homepage: http://ejournal.unkhair.ac.id/index.php/Techno
Volume 11 Number 02 October 2022 DOI: http://dx.doi.org/10.33387/tjp.v11i2.5205

The Effect of Container Type and Fermentation Period Towards Cocoa Beans Quality in Tidore Island

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Received : 15-08-2022
Accepted : 15-09-2022
Available online : 30-10-2022

ABSTRACT

The purpose of this study was to determine the effect of wooden box containers on the quality of fermented cocoa beans. The experimental design used was Completely Randomized Design (CRD) with one factor, namely the length of fermentation consisting of each treatment repeated 3 times so that 9 experiments were obtained. The results obtained are analyzed for variance and if there is a significant difference between treatments, the Dancen test will be carried out. By the results of the treatment and discussion, it can be concluded that after fermenting cocoa beans using wooden boxes, the results obtained were an increase in the fermentation index of dry cocoa beans on the 3rd to 5th days (0.243, 1.147 and 2.027). This number indicates a change in color from purple to brown. Furthermore, the yield of dry cocoa beans, the content of moldy beans, and the skin content were at quality levels B and C and the water content and fat content still met the requirements of SNI-2323-2008. Polyphenols as antioxidants are in the range of 0.06 - 0.08. Based on this research it is also recommended that the fermentation process of beans use wooden boxes because it meets the requirements of the Indonesian National Standard for Cocoa Quality Number 2323-2008.

Keywords: Cocoa beans, Container fermentation, Chemical and physical properties

ABSTRAK

Tujuan dari penelitian ini adalah untuk mengetahui pengaruh wadah kotak kayu terhadap mutu biji kakao fermentasi. Rancangan percobaan yang digunakan adalah Rancangan Acak Lengkap (RAL) dengan satu faktor yaitu lama fermentasi yang terdiri dari masing-masing perlakuan diulang sebanyak 3 kali sehingga diperoleh 9 percobaan. Hasil yang diperoleh dianalisis variansnya dan jika terdapat perbedaan nyata antar perlakuan maka akan dilakukan uji Dancen. Dari hasil perlakuan dan pembahasan dapat disimpulkan bahwa setelah dilakukan fermentasi biji kakao menggunakan kotak kayu diperoleh hasil peningkatan indeks fermentasi biji kakao kering pada hari ke 3 sampai hari ke 5 (0,243, 1,147 dan 2,027). Angka ini menunjukkan adanya perubahan warna dari ungu menjadi coklat. Selanjutnya, rendemen biji kakao kering, kandungan berjamur, dan kadar kulit berada pada taraf mutu B dan C serta kadar air dan kadar lemak masih memenuhi persyaratan SNI-2323-2008. Polifenol sebagai antioksidan berada pada kisaran 0,06 – 0,08. Berdasarkan penelitian ini juga direkomendasikan proses fermentasi biji menggunakan kotak kayu karena memenuhi persyaratan Standar Nasional Mutu Kakao Indonesia Nomor 2323-2008.

Kata kunci: Biji kakao, Kotak fermentasi, Sifat kimia dan fisik

INTRODUCTION

One of the processes that play an important role in the quality of the cocoa beans produced is the fermentation process and the drying process (Wahyudi *et al*., 2008). In the cocoa bean fermentation process, the factors that can affect the quality of cocoa beans are the length or time of fermentation. From these several factors, the fermentation capacity which refers to the dimensions of the fermentation container and the duration of fermentation are very important factors to produce good quality cocoa (Afoakwa *et al*., 2011). The results of research conducted by Arinata (2020) showed that the quality of lindak cocoa beans fermented for 3 days produced the best dry cocoa beans using wooden boxes. Research conducted by Aryani *et al* (2018) showed that fermenting cocoa beans in a capacity of 7.5 kg using wooden boxes gave a better response than other types of fermentation containers on the quality of fermented dry cocoa beans.

By these several factors, the fermentation capacity which refers to the dimensions of the fermentation container and the duration of fermentation is a very important factor to produce good quality cocoa. The results of research conducted by Arinata (2020) show that the quality of lindak cocoa beans fermented for 3 days produces the best dry cocoa beans using wooden boxes. However, in these various studies, studies have not been conducted on the effect of various types of fermentation and the use of wooden boxes on cocoa bean fermentation. The wooden boxes themselves have various shapes and sizes, ranging from 50 cm x 100 cm, 65 cm x 105 cm and 75 cm x 115 cm. The size depends on the needs of consumers.

Cocoa is one of the plantation commodities that plays an important role in Indonesia today, one of which is as a source of state foreign exchange. Cocoa bean production in Indonesia in the January-March 2018 period totaled 6,125 tons of cocoa production. In the same period in 2019, Indonesia was only able to produce cocoa reaching 3,729 tons, a decrease of 61% compared to 2018. This condition is followed by the quality to be produced, where the quality of dry cocoa beans produced is still relatively low and varied, including beans that are not dry, non-uniform grain size, and unfermented beans (Wahyudi *et al*., 2008)

Cocoa farmers in North Maluku consist of storing alkaline cocoa beans that have not been processed by placing them in plastic sacks and wooden boxes and leaving them for 2 to 3 days and then drying them directly in the sun. The fermentation process occurs naturally but the fermentation results are not perfect and uneven (Bahri, 2006). Wooden boxes are containers that are easily obtained by farmers to be used in the fermentation process in order to improve the quality of cocoa beans.

Communities in the Oba Tidore Kepulauan Subdistrict have very often used wooden boxes to store wet cocoa beans for cocoa bean fermentation, but they do not yet know the exact effect of these containers on the quality of cocoa beans. So it is necessary to conduct research to determine its effect. The purpose of this study was to determine the effect of various types of fermentation on dry cocoa bean husks using wooden boxes. The benefits to be obtained are to provide an alternative method of fermenting cocoa beans using a wooden box container that is simple, cheap, and can be done easily and generate data that can be used as a reference regarding the method of fermenting cocoa beans using a modified wooden box container.

METHODOLOGY

This research was conducted in the laboratory of the Agricultural Product Technology study program, Faculty of Agriculture, Khairun University, Ternate from June 5 to September 13, 2022 which consisted of preliminary treatment which included preparation of laboratory materials and the fermentation process. Furthermore, the results of the analysis of the cocoa bean

fermentation were analyzed in the laboratory of the Faculty of Animal Husbandry, Hasanudin University Makassar. The tools used in the manufacture of fermented cocoa beans are knives and burlap sacks. The ingredients used in the manufacture of fermented cocoa beans include completely ripe or ripe cocoa pods, then the cocoa beans are taken and stored in sacks to remove the pulp or mucus contained in the cocoa beans. The experimental design used was Completely Randomized Design (CRD) with one factor, namely the length of fermentation consisting of each treatment repeated 3 times so that 9 experiments were obtained. The results obtained are analyzed for variance and if there is a significant difference between treatments, the Dancen test will be carried out (Gaspers, 1991). The parameters analysing were consisted of wet Cocoa Bean Fermentation Index, Yield of Dried Cocoa Beans, skin cocoa beans and defective seed levels, Water content, Fat and Polyphenol Contents

RESULTS AND DISCUSSION

Degree of Fermentation Index

The degree of fermentation is an index that compares the absorbance at a wave length of 460 nm and a wavelength of 540 nm (Gourieva & Tserevitinov, 1979). If it is a good fermentation, the fermentation of the resulting index is close to 1. Cocoa beans compare the absorbance at a wavelength of 460 nm and a wavelength of 540 nm. If it is a good fermentation, the fermentation of the resulting index is close to 1.

A fermentation index value of less than 1 indicates that the purple color of anthocyanins is more dominant than brown, a fermentation index value of more than 1 indicates that the cocoa bean has more brown color and indicates that the cocoa bean is fermented perfectly (Yusianto, *et al*, 1995). This statement is also supported by the research results of Supriyanto (2013), Suprianto & Hidayat (2019), that an index value greater than number 1 indicates perfect color. The dry fermented cocoa beans in the sun and fresh cocoa beans are presented in the figure 1.

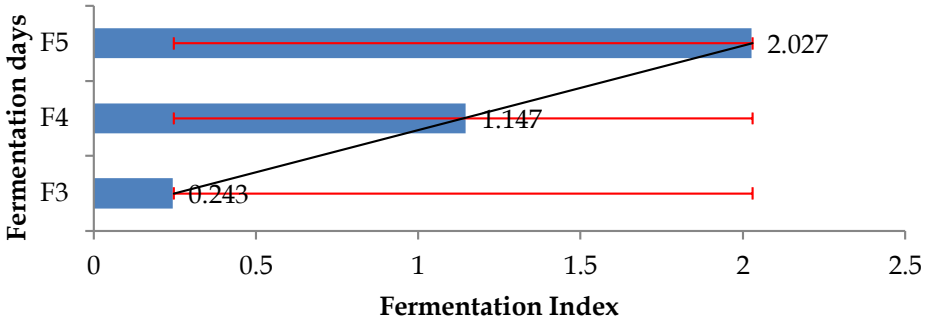

Figure 1. The results of the analysis of the box fermentation index

The results of the fermentation index analysis are shown in Figure 1 above. The figures obtained indicate that until the end of the fermentation index of dry fermented beans for drying is not met, this is presumably because the fermentation temperature is not reached. The fermentation temperature is not reached because the microbes that help fermentation are in less quantities. Determination of the degree of fermentation is also determined physically, namely by observing the color of the bean chips by splitting the cocoa beans crosswise so that the surface color of the split beans can be seen clearly. The color and texture in the cocoa bean, which was originally purple and solid, gradually turns brown and has a cavity in it (Rasadi, 2015).

Fermentation on the fourth day had a good change where the fermentation results showed a value of 1.14 and reached 1 and completely fermented cocoa beans were shown on the 3rd day

to 5th treatment with a value of 2.02. The fermentation index value can be related to the pH in the seed. The lower the pH value, the fermentation index value is increases. The acidity level of the seeds affects the work of enzymes, the lower the pH, the enzymes work more optimally. Enzymes work optimally in the pH range of 4.5-8 (Winarno, 1997).

Yield of Cocoa Beans

Yield of cocoa beans is the ratio between the weight of dry cocoa beans fermented with wet cocoa beans before fermentation. Cocoa beans can be classified into several groups according to SNI 2323:2008, the Indonesian national standard (SNI) used by researchers is SNI that has been amended in 2010 which has been stated by the number of seeds per 100 grams. Seed size classification (number of beans/100 gram) is a special requirement for testing the quality of cocoa beans. The results obtained are as shown in Figure 2.

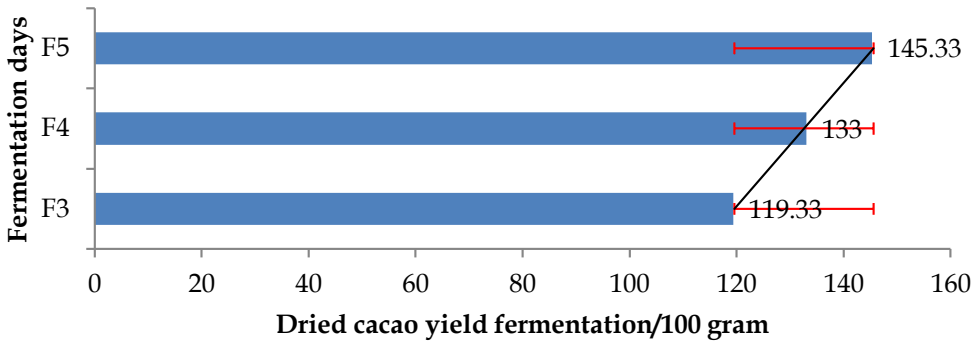

Figure. 2. The result of dried cacao beans yield

The graph above shows that the yield of cocoa beans increased significantly on the 4th and 5th days of fermentation. Where on the 3rd day it was in the range of 119%, but on the 4th day there was an increase of more than 10% and on the 5th it reached 20% compared to the results obtained on the 3rd day of fermentation. This increase indicates that there is a significant increase in the quality of fermented cocoa beans. Based on Figure 2, it shows that the number of beans per 100 grams of dry cocoa beans ranges from 119.33 - 145.33%. The lowest number of seeds per 100 grams was 119.33% in the F3 treatment, and the highest value was 145.33 in the F5.

The results of analysis of variance showed that fermentation on day 3 to day 5 had a highly significant surgical effect on the number of beans per 100 grams of dry cocoa beans. This is the best condition, because the microbial activity in the pulp has been released and does not stick to the surface of the beans and does not inhibit the penetration of oxygen into the pile of fermented cocoa beans (Arinata, 2020) microbial activity will produce acid, alcohol and release heat (exothermal reaction) escapes from the fermentation vessel.

Cocoa Seed Skin Level

Skin content is a waste from cocoa where a high skin content causes cocoa to be less profitable in terms of economy and cocoa consumers, so consumers want the lowest skin content, but strong enough to protect the beans from unfavorable environmental conditions, pests and fungi. The lowest skin content, which is around 11%, is considered a fairly good standard for skin content because the higher the husk content, the less yield that can be consumed, thus lowering the price of cocoa beans. From the research that has been done, it shows that there are differences in each given fermentation treatment as presented in Figure 3.

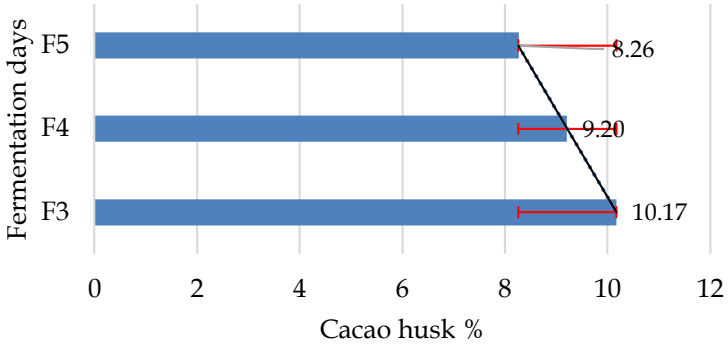

Figure 3. The results of the analysis of the husk content

The graph above shows a decrease in skin levels with different durations. The results of the analysis of skin content on the 3rd day of fermentation amounted to 10.17% and decreased constantly on the 4th and 5th day of fermentation. These results indicate that the longer the fermentation process, the cocoa bean husk content will decrease. The results of analysis of variance showed that fermentation on day 3 to day 5 had a very significant surgical effect on the value of dry cocoa bean husk content. This is because the higher the seed coat content, the lower the yield that can be consumed, which has an impact on the lower price of dry cocoa beans that are marketed. It is known that the percentage of cocoa bean husk content is not only affected by the thickness of the cocoa bean skin, but can also be affected by the remaining pulp attached to the seed coat or other impurities (Rasadi, 2015; Wood & Lass, 1985; Senenayake *et al*., 1997).

Slaty Seed Content

Slaty seeds mean seeds that are not fermented on cocoa lindak showing half or more surface of the seed slices grayish like slate or blue-gray and textureddense and hard like cheese (SNI 2323-2008 in BSN, 2008). Seeds slaty will give it some flavour astringent (astringent) and bitter (taste bitter) excessively and the aroma of cocoa low (Misnawi, 2008). Determination of the degree of fermentation is also determined physically, namely by observing the color of the beans by splitting the cocoa beans crosswise so that the color of the split surface of the beans can be seen clearly. The color and texture inside the cocoa bean which is initially purple and solid gradually changes to a brown color and has a cavity in it. The fermentation process that is too short will produce unfermented beans or the so-called slaty (non-fermented) beans with a solid texture and unattractive color. Yusianto *et al*, (1995) stated that the optimal fermentation time of seeds is about 4-5 days which will produce a brown color in the seeds. The results of the cut test of dry cocoa beans analyzed are as shown in the following figure 4.

The results of the slat seed test shown in the graph above show that on the 3rd day of fermentation there is a figure of 3.13%. Furthermore, there was a decrease as the fermentation time progressed. Where on the 4th day it happened around 1.05% and on the 5th day the fermentation decreased drastically by 0.47%. based on the results obtained in the graph above, it shows that in F5 there are many slaty seeds, namely 3.13%. it means that in F5 a lot of the beans are not completely fermented. Fermented seeds fully marked with a brown color darkens at 80 percent on the outer skin and cotyledons and the presence of pores small inside the seed, whereas on partially fermented dark brown beans but no pores and failed fermentation (bad fermented) purple seeds and there are no pores inside the seeds (SCCP, 2013; Wahyudi *et al*., 2013).

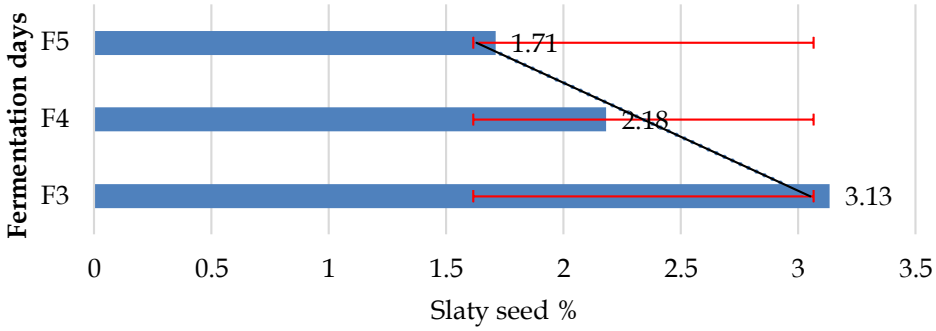

Figure 4. The results of the analysis slaty seeds content

Moldy Seeds

Mold content is moldy seeds in the number of seeds per 100 grams sampled from each treatment, fungal content is influenced by fermentation time and storage conditions used, such as humidity and temperature in the storage box. In this study, observations were made of moldy seeds on the inside of the beans by splitting the cocoa beans transversely so that the surface of the split beans could be seen clearly (Nazaruddin, *et al*, 2006; Moreira *et al*, 2013). The results of the test for the levels of dry cocoa mold that were analyzed are as shown in Figure 5 below:

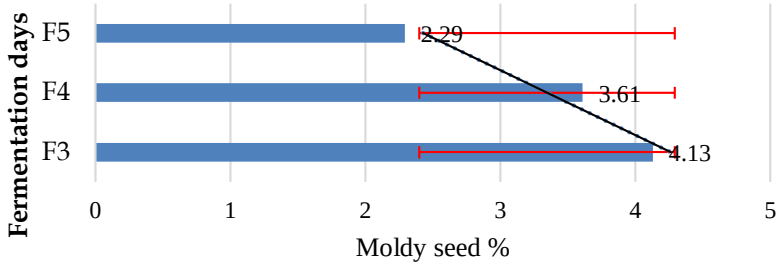

Fig 5. Analysis of moldy seed content

The test results showed a decrease in moldy seeds as shown in graph 5 above. From the figure, it can be seen that the longer the fermentation time the less the number of moldy seeds. This provides information that the amount of water content in the beans is decreasing so that the fungus cannot grow on cocoa beans with low water content (Apriyanto *et al.*, 2016a).

Water Content

Moisture content is one of the important factors in determining the quality of cocoa beans because it is related to the shelf life of cocoa beans. Cocoa beans that have a high moisture content will be easily attacked by insects and fungi. According to SNI 2323-2008, the standard moisture content in cocoa beans should not exceed 7.5%. This is because if the water content exceeds the standard, not only the yield but also the risk of being attacked by bacteria and fungi, but if the water content is less than 5%, then the seed coat will be easily broken or brittle (Wahyudi *et al.*, 2008). The measurement results in the moisture content of cocoa beans are presented in Figure 6.

The results of determining the moisture content of dried cocoa beans showed the highest percentage of water content in the fermentation treatment on day 3 with a water content of 7.8% where this result was due to the presence of a layer of pulp or placenta that was still attached to the dried cocoa beans which could not be decomposed by microbes. due to the short

fermentation process. While the perfect fermentation is shown on the fourth day of fermentation with a value of 7.4% and the fifth day of 6.6% fermentation so that it can be accepted because it does not exceed the standard of Standard national of Indonesia (SNI 2323-2008 ; Zaouli, 2006).

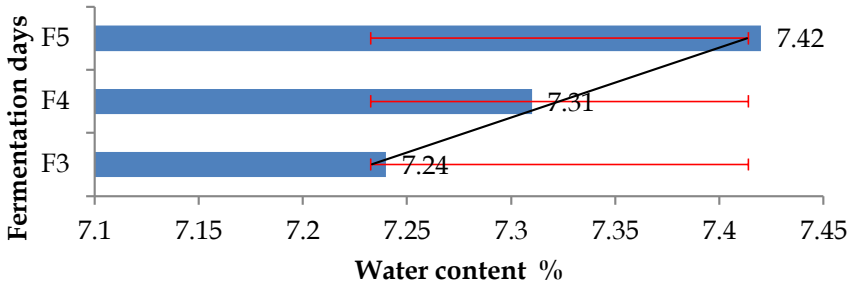

Figure 6. Graph of the average value of water content

Fat Content

Fat content is generally expressed as a percentage of the dry weight of the seed chips. Cocoa butter is a mixture of triglycerides, which are glycerol compounds and three fatty acids. More than 70% of the constituent glycerides consist of three monounsaturated compounds, namely oleodipalmitin, oleodistearin and oleopalmistearin. In cocoa fat there is also a small amount of unsaturated triglycerides (Wahyudi *et al*, 2008).

Determination of fat content by solvent, in addition to fat also includes phospholipids, sterols, free fatty acids, carotenoids and other pigments. Therefore the results of the analysis are called crude fat (Takrama, 2006). The amount of fat content of dry cocoa beans from each treatment used is as shown in Figure 7.

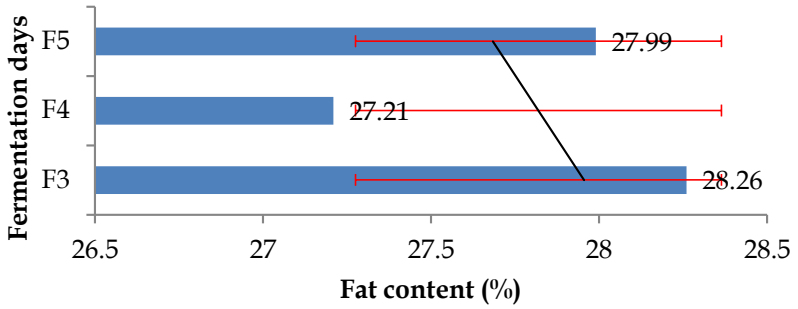

Figure 7. The results of the average fat content

In Figure 7 the results of the determination of fat content show that the longer the fermentation process, the fat content of cocoa beans increases as seen on the fourth day of fermentation with a value of 7.90 and the fifth day of fermentation 8.46. The results of analysis of variance showed that fermentation on day 3,4 to day 5, had a non-surgical effect on the fat content of fermented cocoa beans. This increase in fat content is caused by the water content which tends to decrease during the fermentation process which affects the resulting fat yield (Jespersen *et al*., 2005). In addition, according to Yusianto *et al* (1997), the fat content of unfermented cocoa beans is 0.07-5.69% lower than that of fermented cocoa beans depending on the fermentation time.

Polyphenol

Polyphenols are natural compounds found in plants, one of which is cocoa. This compound has the ability as an antioxidant, anti-aging (anti-aging), anti-inflammatory and anti-diabetic

(Paembong 2012). While (Jinap *et al.*, 2013) state that fermented cocoa beans contain various polyphenolic compounds, about 60% of the total polyphenols in the form of flavanol monomers (epicatechins and catechins) and procyanidin oligomers (dimers and decamers) with varying concentrations.

The components of this compound have strong antioxidant activity with physiological properties, namely inhibiting the activity of -amylase and -glucosidase (Nielsen, 2006; Camu *et al.*, 2013). In this study, the levels of polyphenols contained in the seeds were observed. The results of the dry cocoa polyphenol content test were analyzed as shown in Figure 8.

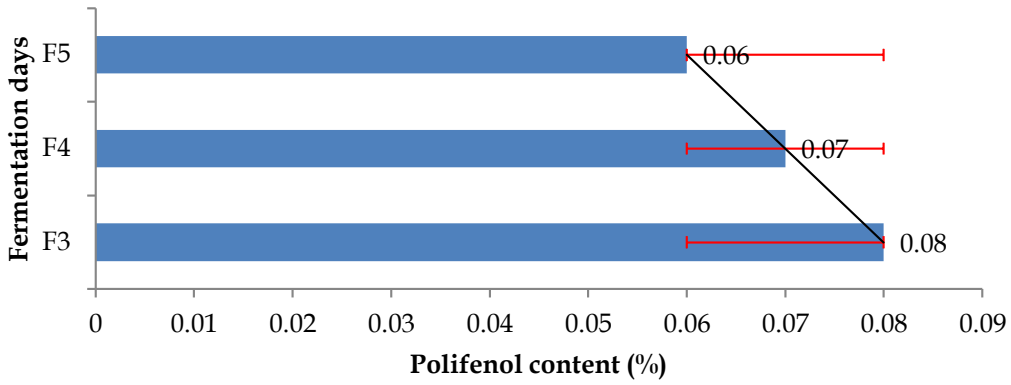

Figure 8. Results of analysis polyphenols content

The graph above shows the polyphenol content at each fermentation time where the largest amount of polyphenol content was found on the 5th day of fermentation (F5). Then from the picture, it can be seen that there was a change in the amount of polyphenols on the 3rd (F3), 4th (F4) and 5th day.

The results of analysis of variance showed that fermentation on day 3,4 to day 5, had a very significant surgical effect on the water content of fermented cocoa beans. However, the moisture content of dry cocoa beans resulting from complete and incomplete fermentation is smaller than that without fermentation, which is less than 7.5% but not less than 5% so that it meets SNI 2323:2008 which requires a maximum moisture content of dry cocoa beans of 7, 5% (BSN, 2008; Weissberger *et al.*, 1971).

CONCLUSION

By the results of the treatment and discussion, it can be concluded that after fermenting cocoa beans using wooden boxes, the results obtained were an increase in the fermentation index of dry cocoa beans on the 3rd to 5th days (0.243, 1.147 and 2.027). This number indicates a change in color from purple to brown. Furthermore, the yield of dry cocoa beans, the content of moldy beans, and the skin content were at quality levels B and C and the water content and fat content still met the requirements of SNI-2323-2008. Polyphenols as antioxidants are in the range of 0.06 - 0.08. Based on this research it is also recommended that the fermentation process of beans use wooden boxes because it meets the requirements of the Indonesian National Standard for Cocoa Quality Number 2323-2008.

ACKNOWLEDGEMENTS

I would like to thank to Indonesian Higher Education who has great support this research by provide funding. I do hope the result of this research will be going to increase cocoa beans quality and economic society in Tidore Island and North Maluku Province.

REFERENCES

Ariska, A., Supriyanto, Chusnul, H. (2019). *Pengaruh Daya Energi Mikro dan Keasaman Biji Kakao Segar terhadap Indeks Fermentasi dan Aktivitas Antioksidan Pasta Kakao*. Tesis UGM. http://etd.repository.ugm.ac.id/penelitian/detail/183237#filepdf

Afoakwa, E. O., Quao, J., Budu, A. S., Takrama, J., & Saalia, F. K. (2011). Effect of Pulp Pre-Conditioning on Acidification, Proteolysis, Sugars and Free Fatty Acids Concentration During Fermentation of Cocoa (Theobroma Cacao) Beans. *International Journal of Food Sciences and Nutrition*, *62*(7), 755-764. https://doi.org/10.3109/09637486.2011.581224

Apriyanto, M. (2016). Study on Effect of Fermentation to The Quality Parameter of Cocoa Bean in Indonesia. *Asian J. Dairy & Food Res*, *35*(2), 160-163. http://dx.doi.org/10.18805/ajdfr.v35i2.10724

Arinata, N., Yulianti, N. L., Arda, G. (2020). Pengaruh Variasi Dimensi Wadah dan Fermentasi terhadap Mutu Biji Kakao Kering (Theabroma Cacao L). *Jurnal Beta (Biosistem dan Teknik pertanian), 8* (2), 211-222.

Aryani, N. L. P. N. A., Yulianti, N. L., & Arda, G. (2018). Karakteristik Biji Kakao Hasil Fermentasi Kapasitas Kecil dengan Jenis Wadah dan Lama Fermentasi yang Berbeda. *Jurnal BETA (Biosistem dan Teknik Pertanian)*, *6*(1), 17-24.

Badan Standarisasi Nasional. (2008). *Standard Nasional Kualitas Biji Kakao Indonesia Nomor 1- 2323 (2)*, 1–37.

Camu, N., De Winter, T., Addo, S. K., J. S., Bernaert, H., & De Vuyst, L. (2013). Fermentation of Cocoa Beans: Influence of Microbial Activities and Polyphenol Concentrations on The Flavor of Chocolate. *Journal of the Science of Food and Agriculture*, *88*(13), 2288-2297. https://doi.org/10.1002/jsfa.3349

Gaspersz. (1998). *Statistical Proses Control: Penerapan Teknik-Teknik Statistik dalam Manajemen Bisnis Total.* Jakarta: Yayasan Indonesia Emas.

Hartuti, S., Bintoro, N., Karyadi, J. N. W., & Pranoto, Y. (2018). Fermentasi Isothermal Biji Kakao (Theobroma cacao. L) dengan Sistem Aerasi Terkendali. *Agritech*, *38*(4), 364-374. https://doi.org/10.22146/agritech.35412

Jespersen, L., Nielsen, D. S., Hønholt, S., & Jakobsen, M. (2005). Occurrence and Diversity of Yeasts Involved in Fermentation of West African Cocoa Beans. *FEMS Yeast Research, 5*(2) 441-453. https://doi.org/10.1016/j.femsyr.2004.11.002.

Jinap, S., Jamilah, B., & Nazamid, S. (2013). Effects of Incubation and Polyphenol Oxidase Enrichment on Colour, Fermentation Index, Procyanidins and Astringency of Unfermented and Partly Fermented Cocoa Beans. *International journal of food science & technology*, *38*(3), 285-295. https://doi.org/10.1046/j.1365-2621.2003.00674.x

Moreira, I. M. D. V., Miguel, M. G. D. C. P., Duarte, W. F., Dias, D. R., dan Schwan, R. F. (2013). Microbial Succession and The Dynamics of Metabolites and Sugars During The Fermentation of Three Different Cocoa (Theobroma Cacao L) hybrids. *Food Research International*, *54*(1), 9–17. http://doi.org/10.1016/j.foodres.20 13.06.001

Nazaruddin, R., Seng, L. K., Hassan, O., dan Said, M. (2006). Effect of Pulp Preconditioning on The Content of Polyphenols in Cocoa Beans (Theobroma Cacao) During Fermentation. *Industrial Crops and Products Journal*, *24*(1), 87–94. http://doi.org/10.1016/j.indcrop.2006.03.013.

Nielsen, Dennis Sandris. (2006). *Cocoa fermentation practices in the Ivory Coast*. Ph.D. Thesis of Department of Food Science, The Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Nielsen, D. S., Teniola, O. D., Ban-Koffi, L., Owusu, M., Andersson, T. S., & Holzapfel, W. H. (2006). The Microbiology of Ghanaian Cocoa Fermentations Analysed using Culture-Dependent and Culture-Independent Methods. *International Journal of Food Microbiology*, *114*(2), 168-186. http://doi.org/10.1016/j.ijfoodmicro.2006.09.010

Paembong, A. (2012). *Mempelajari Perubahan Kandungan Polifenol Biji Kakao (Theobroma cacao L) dari Hasil Fermentasi yang Diberi Perlakuan Larutan Kapur* (Doctoral dissertation, Universitas Hasanuddin). http://repository.unhas.ac.id/id/eprint/10430

Rasadi, Y. (2015). *Karakteristik Fisik Dan Kimia Biji Kakao (Theobroma Cacao l.) Hasil Fermentasi Variasi Wadah Kotak Kayu, Krat Plastik dan Daun Pisang di Pusat Penelitian Kopi dan Kakao Indonesia*. Skripsi Sarjana Universitas Jember. http://repository.unej.ac.id/handle/123456789/72861

Senanayake, M., Jansz, E. R., & Buckle, K. A. (1997). Effect of Different Mixing Intervals on The Fermentation of Cocoa Beans. *Journal of the Science of Food and Agriculture, 74*(1), 42-48. https://doi.org/10.1002/(SICI)1097-0010(199705)74:1%3C42::AID-JSFA768%3E3.0.CO;2-U

Semuel Frenclin Keff & Supryanto. (2013). *Pengaruh Fermentasi Biji Kakao Kering Non Fermentasi terhadap Indeks Fermentasi*. Tesis Universitas Gadjah Mada. http://etd.repository.ugm.ac.id/penelitian/detail/63709#filepdf.

Wahyudi, T., Panggabean, T. R., & Pujiyanto. (2013). *Cocoa, Manajemen Agribisnis, Dari Hulu Sampai Hilir 5*. Jakarta: Penebar Swadaya.

Wahyudi, T, Pangabean, T. R., & Pujiyanto. (2008). *Panduan Lengkap Kakao*. Jakarta: Penyebar Swadaya.

Weissberger, W., Kavanagh, T. E., Keeney, P. G. (1971). Identification and quantification of several non-volatile organic acids of cocoa beans. *Journal of Food Science*, *36*(6), 877-879. https://doi.org/10.1111/j.1365-2621.1971.tb15550.x

Wood, G. A. R., Lass, R. A. (1985). *Cocoa 4th Edition*. London: Longman

Yusianto, W. T., & Sumartono, B. (1997). Pola Cita Rasa Biji Kakao Dari Beberapa Perlakuan Fermentasi. *Pelita Perkebunan*, *11*, 117-131.