SALAGA Journal
Vol. 02, No. 2, December 2024, pp. 50~57
ISSN: 3032-2677
DOI: 10.70124/salaga.v2i2.1780

The Effect of Fermentation and Soaking Time on Water Content of Cocoa (*Theobroma cacao L.*)

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Article Info

Keywords:

Fermentation
Sunlight Intensity
Moisture Content
Cocoa
Drying

ABSTRACT

Post-harvest handling, particularly fermentation and soaking, significantly affects cocoa quality. This study investigates the effects of fermentation duration (3, 5, 7 days) and soaking time (1, 2, 3 hours) on the moisture content of MCC 02 cocoa beans. The fermented beans were sun-dried, and moisture content was analyzed using the wet/dry basis method. Results showed the lowest wet basis moisture content of 55.65% for beans fermented for 3 days and soaked for 1 hour, and the highest of 63.1% for beans fermented for 3 days and soaked for 2 hours. After drying, the control sample had a moisture content of 7.7% (63.5% before drying), while the lowest moisture content for beans fermented for 5 days with 1-hour soaking was 7.95%, and the highest was 10.65% for beans fermented for 3 days with 1-hour soaking, exceeding the SNI standard (6-7%). Temperature fluctuations (28 - 37°C) and weather-dependent drying prolonged the process, resulting in higher moisture content than the standard, indicating the need for controlled drying methods.

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1. INTRODUCTION

Chocolate is generally loved by children and adults alike and is popular in various countries, including Indonesia. In reality, chocolate is made from cocoa that undergoes various processing stages to become the food known as chocolate. Chocolate, which remains one of the popular foods to date, experiences an annual increase in production. According to data from Badan Pusat Statistik (BPS, 2023), Indonesia's cocoa consumption has shown a steady increase over the years, reflecting the growing domestic demand for chocolate products. Due to the rising demand for chocolate, the demand for cocoa as the basic ingredient for chocolate is also increasing.

Cocoa plants are extensively cultivated in various countries, including Indonesia. This is because Indonesia possesses abundant and strategic agricultural land that has the potential to enhance cocoa plant productivity. The primary reason for cultivating cocoa plants in Indonesia, aside from the strategic land that can be processed into various products, is the potential to increase the country's foreign exchange earnings. Cocoa fruit in Indonesia significantly contributes to the national budget, amounting to US$ 668 million per year, ranking third in the agricultural sector after oil palm and rubber (Lutfiah, 2018).

The demand for cocoa in Indonesia is increasing because Indonesian cocoa has several advantages, such as having a high melting point, containing chocolate fat, and producing cocoa powder of high quality (Lutfiah, 2018). Farmer efforts to produce cocoa beans with these advantages require more attention during cocoa cultivation and in post-harvest activities.

Post-harvest handling is a crucial stage before cocoa beans are processed into chocolate powder. After the harvesting process, proper post-harvest handling is necessary to produce high-quality cocoa beans. Cocoa post-harvest handling begins with harvesting, followed by the separation of cocoa beans from the skin and placenta attached to the beans, fermentation, soaking, and washing of cocoa, leading to the drying process. Fermentation is a crucial factor in producing high-quality chocolate with the distinctive taste and aroma of cocoa. During fermentation, yeasts, lactic acid bacteria, and acetic acid bacteria play essential roles in breaking down the pulp surrounding the beans, generating heat, and reducing moisture content (De Vuyst & Leroy, 2020). This process also develops flavor precursors that enhance the chocolate's taste and aroma. Soaking further helps in reducing the moisture content by allowing water to penetrate and be removed from the beans, ensuring they are properly prepared for the drying process (Guehi et al., 2010). Therefore, the fermentation process must be carried out as carefully as possible to ensure its successful execution.

In the village of Dengeng-dengeng, Sidenreng Rappang regency, the majority of the population are farmers cultivating cocoa plants. One of the cocoa plant varieties cultivated in Dengeng-dengeng Village is the MCC 02 cocoa, originating from the North Luwu region. Despite the long-standing tradition of cocoa farming in the village, after harvesting and cleaning the cocoa, the farmers immediately dry it under the sunlight. They do not apply proper post-harvest treatments to the cocoa beans, such as fermentation, soaking, and washing, which would result in high-quality cocoa beans with optimal moisture content and a more attractive appearance. This lack of knowledge about proper post-harvest handling of cocoa beans can affect the final outcome of cocoa processing. In addition to fermentation and soaking treatments, the drying process must also be carefully considered; favorable temperatures and weather conditions will accelerate the fermentation process, while adverse conditions can prolong drying time and reduce the quality of cocoa beans.

Based on the previous description, a study was conducted on the Effect of Fermentation and Soaking Duration on the Moisture Content of Cocoa (Theobroma cacao L.) to provide information to the community on how the duration of fermentation and soaking affects the moisture content of cocoa. Additionally, the aim is to inform the community about the importance of proper post-harvest handling, which significantly influences the moisture content and quality of cocoa beans.

2. MATERIALS AND METHODS

2.1. Materials

The tools used in this research are wooden fermentation box, machete, oven, basin, analog scale, digital scale, thermometer, and luxmeter. The materials used include MCC 02 cocoa beans, clean water, aluminum foil, banana leaves, ziplock plastic, sackcloth, labels, and tissues.

2.2. Research Procedure

The treatment matrix to be applied to cocoa beans.

Table 1. Replication Matrix 1 and Replication 2

	B_1	**B_2**	**B_3**
K_1	K_1B_1	K_1B_2	K_1B_3
K_2	K_2B_1	K_2B_2	K_2B_3
K_3	K_3B_1	K_3B_2	K_3B_3

Where,
K_1 is a 3-day fermentation box, K_2 is a 5-day fermentation box, K_3 is a 7-day fermentation box, B_1 is a 1-hour soaking process, B_2 is a 2-hour soaking process and B_3 is a 3-hour soaking process.
The steps taken in conducting the research are as follows:

2.2.1 Material preparation

This stage marks the initial phase of the post-harvest process for cocoa fruits. First, the harvested cocoa fruits are sorted by separating the black-colored ones. Next, the cocoa pods are broken open using a machete. The cocoa beans are then separated from the placenta and the remaining skin. Following this, the cocoa beans are weighed, with 30 kg allocated for the fermentation sample and 5 kg for the non-fermentation sample (control).

2.2.2 Sample without fermentation

For the non-fermented treatment sample, 5 kg is weighed. Before drying, 10 g of cocoa beans are taken, then oven-dried at 103 °C for 72 hours to obtain the initial moisture content, and the rest is dried under sunlight.

2.2.3 Sample with fermentation

For the samples with the fermentation treatment, first, prepare 6 fermentation boxes measuring 30 cm × 30 cm × 30 cm. Then, weigh cocoa beans for each box, amounting to 5 kg. Subsequently, place the cocoa beans into the fermentation boxes, where K_1 for replications 1 and 2 undergoes fermentation for 3 days, K_2 for replications 1 and 2 undergoes fermentation for 5 days, and K_3 for replications 1 and 2 undergoes fermentation for 7 days. During the fermentation process, the cocoa beans are also turned over daily to ensure even heating. After the fermentation, the cocoa beans are taken out from each box and weighed to determine the weight after fermentation. Then, the cocoa beans from each box are divided into 3 parts with equal weights.

2.3.4 Soaking and washing

The weighed cocoa beans are each placed in prepared bowls (B_1, B_2, and B_3). Separate 10 g of cocoa beans from each bowl and place them in ziplock plastic bags for storage before transferring them to aluminum foil boxes, which will be oven-dried for 72 hours at 103 °C to obtain the initial moisture content. For Cocoa Beans K_1B_1, K_2B_1, and K_3B_1 for replications 1 and 2, they are soaked for 1 hour. K_1B_2, K_2B_2, and K_3B_2 for replications 1 and 2 are soaked for 2 hours, while K_1B_3, K_2B_3, and K_3B_3 for replications 1 and 2 are soaked for 3 hours. After soaking, the cocoa beans are then washed with clean water by rubbing or stirring the cocoa beans until partially clean and then drained. After draining, 10 g of cocoa beans from each bowl is separated and placed in ziplock plastic bags for storage before transferring them to aluminum foil boxes, which will be oven-dried for 72 hours at 103 °C to obtain the initial moisture content.

2.3.5 Drying

In this stage, the washed cocoa beans are then dried under sunlight using sacks; every 2 hours, the cocoa beans need to be turned to ensure even drying, accompanied by temperature measurement using a thermometer and light intensity measurement using a luxmeter. Afterward, separate 10 g of dried cocoa for each and place them in ziplock plastic bags for storage before transferring them to aluminum foil boxes, which will be oven-dried for 72 hours at 103 °C to obtain the dry weight (solid) of the samples.

2.3.6 Observation Parameters

The moisture content is calculated using equations (1) and (2), temperature is measured using a thermometer, and light intensity is measured using a luxmeter.

$$\text{Kabk} = \frac{wt-wd}{wd} \times 100\% \qquad (1)$$

where,
Kabk is the dry basis moisture content (%), Wt is the initial weight of the material (g), and Wd is the weight of the solids (g).

$$\text{Kabb} = \frac{wt-wd}{wt} \times 100\% \qquad (2)$$

where,
Kabb is the wet basis moisture content (%), Wt is the initial weight of the material (g), and Wd is the weight of the solids (g).

3. RESULTS AND DISCUSSION

3.1 Temperature during Fermentation

In this study, the fermentation process was carried out before the drying process. Various fermentation processes are applied, including 3-day fermentation, 5-day fermentation, and 7-day fermentation. Conducting the fermentation process on cocoa beans before drying aims to impart good taste and aroma, enhancing the quality of cocoa. This aligns with the statement by (Hartuti at al, 2020), which suggests that cocoa bean fermentation is intended to create an aroma with a distinctive chocolate and nutty flavor, reduce the bitter and astringent taste of cocoa beans, resulting in a bright and clean chocolate color. The average temperature during the fermentation process can be observed in Table 2.

Table 2. Average Temperature During Fermentation

Day	3-day fermentation	5-day fermentation	7-day fermentation
0	28	28	28
1	31.5	32	32.5
2	37.5	37	36.5
3	37	36.5	37
4		37	36
5		35.5	35.5
6			30.5
7			29

The average temperature during fermentation showed fluctuations from the initial temperature of 28 °C. As seen in Table 2, despite extending the fermentation period to 7 days, the temperatures obtained are still far from the optimum cocoa fermentation temperature of 40-48 °C. The averaged temperature only reaches

37 °C for the highest temperature. The obtained temperature has not reached the optimum level, and this may be attributed to various factors such as the flipping (stirring) process, climate during fermentation, environmental temperature, fruit maturity level, fermentation container, and capacity. The failure to achieve the optimum temperature can undoubtedly impact the moisture content of cocoa because the longer the fermentation process, the lower the moisture content, assuming the fermentation proceeds well at the optimal temperature. This aligns with the statement by (Ifmalinda et al, 2023), which asserts that the moisture content in cocoa beans decreases with the duration of the fermentation process. The reduction in moisture content is attributed to the removal of pulp from cocoa beans due to microbial decomposition, leading to a decrease in the weight of the beans and facilitating the drying process.

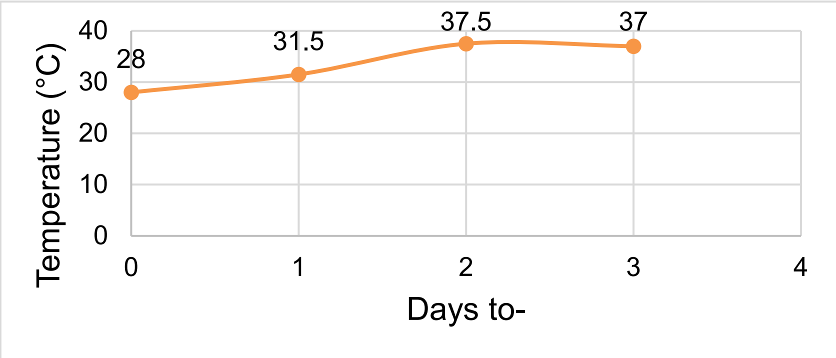

Figure 2. Average Fermentation Temperature Over 3 Days.

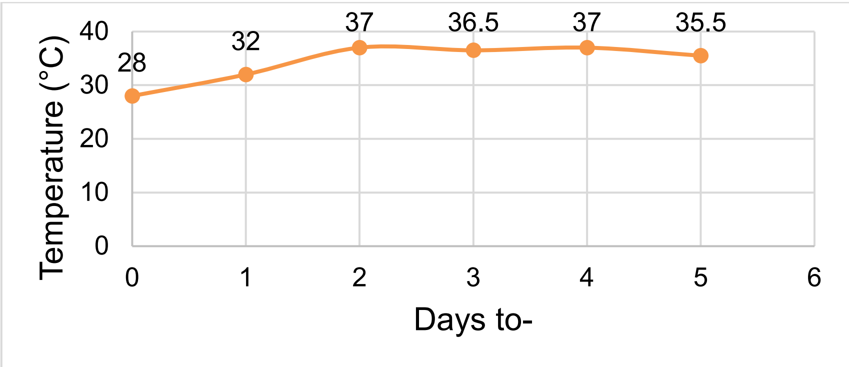

Figure 3. Average Fermentation Temperature Over 5 Days.

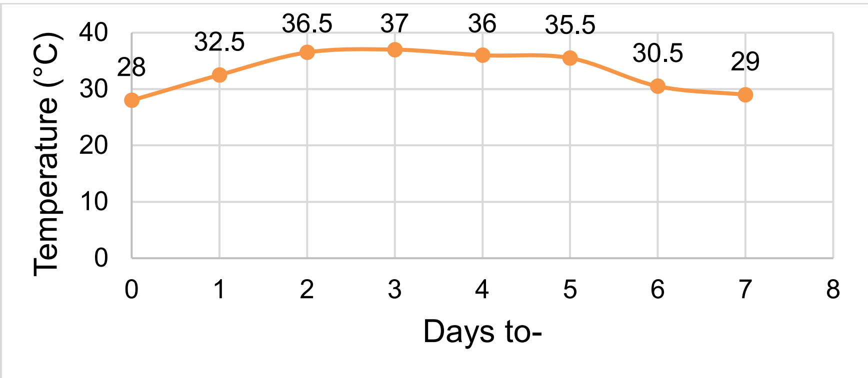

Figure 4. Average Fermentation Temperature Over 7 Days.

3.2 Cocoa Moisture Content

Moisture content is the amount of water contained in a substance, expressed as a percentage. Moisture content measurement is conducted after the fermentation process and after drying. Before drying, soaking is performed immediately after cocoa fermentation, with soaking durations of 1 hour, 2 hours, and 3 hours for each fermentation product. The determination of moisture content can be calculated using two methods: wet basis moisture content and dry basis moisture content. This is in line with the statement by (Taib et al, 1988), which asserts that there are two methods for determining the moisture content of a substance: wet basis and dry basis.

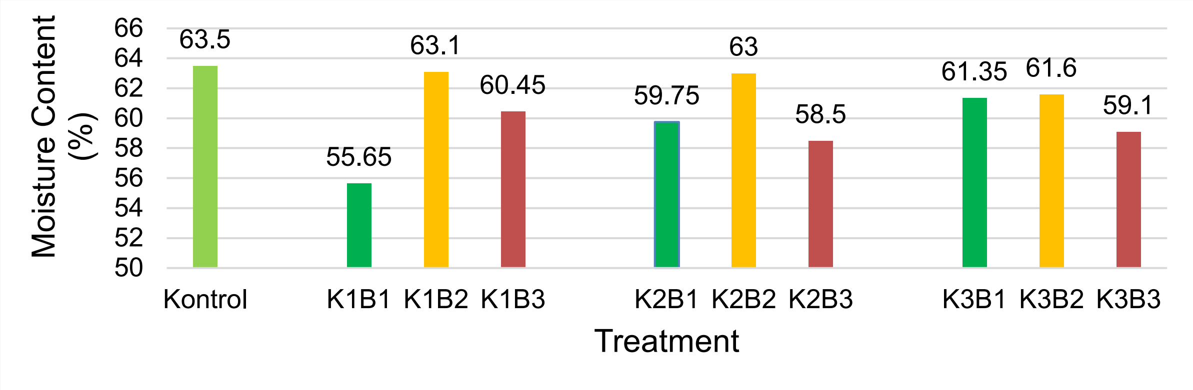

Figure 5. Wet Basis Moisture Content After Fermentation and Before Drying.

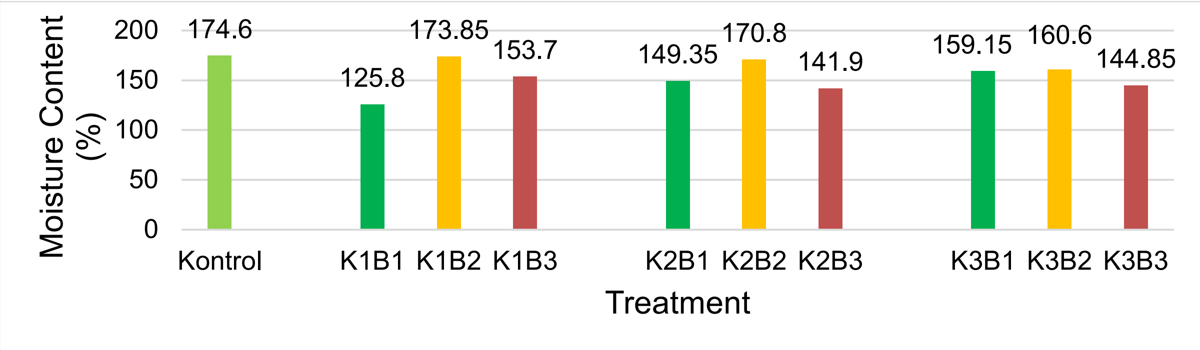

Figure 6. Dry Basis Moisture Content After Fermentation and Before Drying.

In Figure 5 and 6, the average moisture content of the control, or non-fermented cocoa, and cocoa that underwent the fermentation process shows a relatively small difference. This is because after the fermentation process, the cocoa beans undergo soaking for 1 hour, 2 hours, and 3 hours, causing the water content in the cocoa beans to increase again, which ideally should be lower. The wet basis moisture content of cocoa after fermentation and before drying is best for cocoa with a 3-day fermentation treatment and 1-hour soaking duration, with a moisture content of 55.65%. As for the dry basis moisture content of cocoa after fermentation and before drying, the most optimal is for cocoa with a 3-day fermentation treatment and 1-hour soaking duration, with a moisture content of 125.8%. Soaking and washing cocoa with clean water provide a more rounded appearance to the beans. This aligns with the statement by (Lutfiah, 2018), which mentions that the purpose of soaking and washing is to stop the fermentation process, expedite the drying process, reduce impurities adhering to cocoa beans, and improve the appearance of cocoa beans, making them look more rounded.

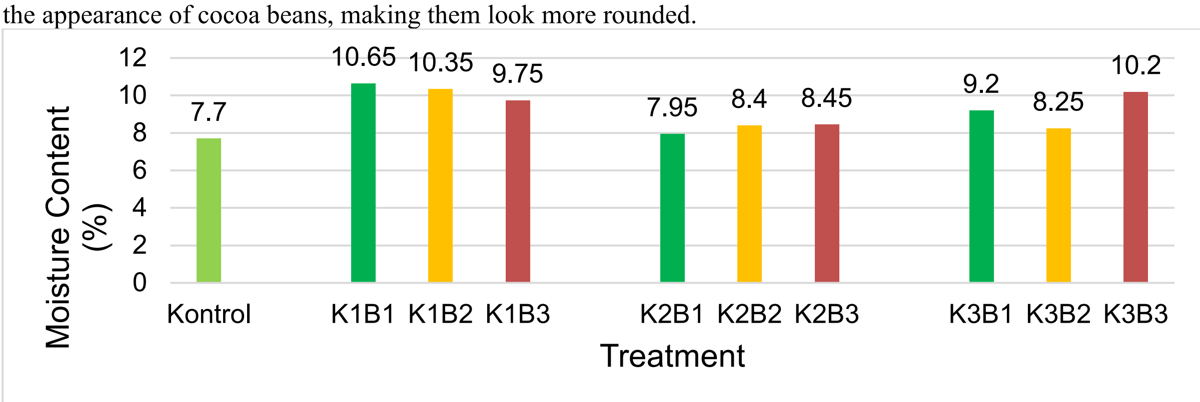

Figure 7. Wet Basis Moisture Content After Fermentation and After Drying.

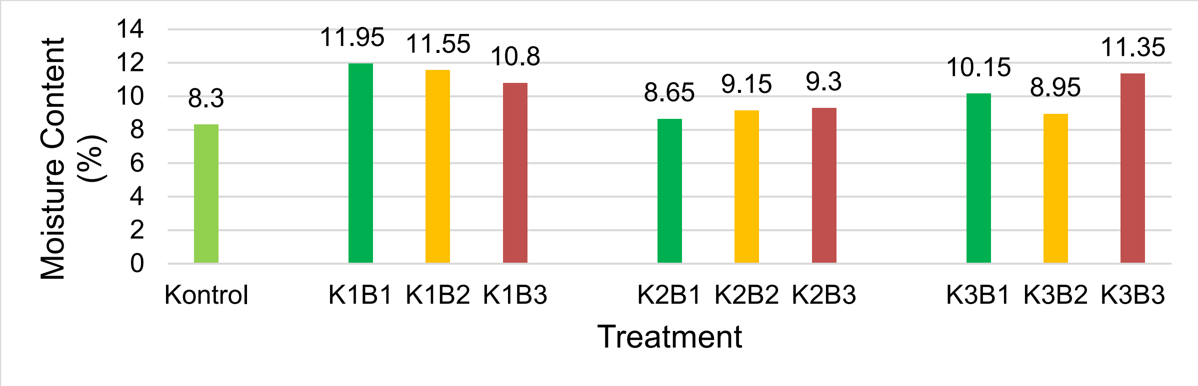

Figure 8. Dry Basis Moisture Content After Fermentation and After Drying.

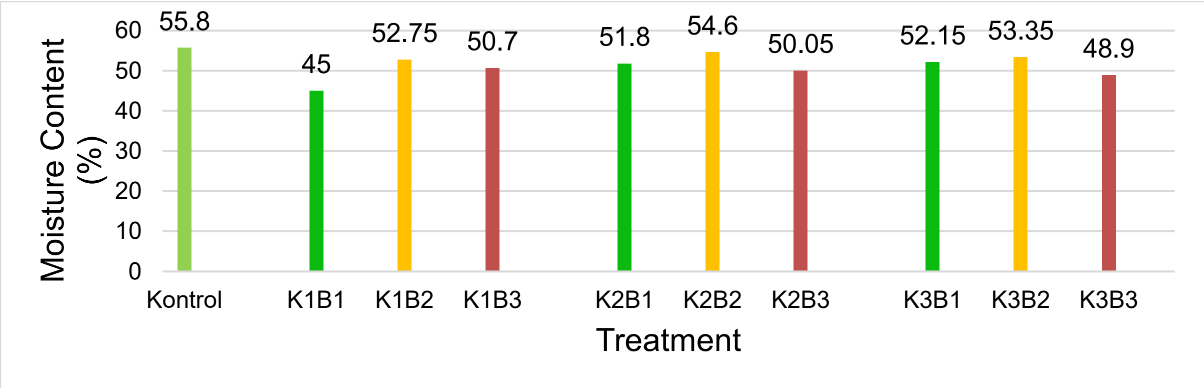

Figure 9. The Difference in Moisture Content Between Wet Basis Before Drying and After Drying.

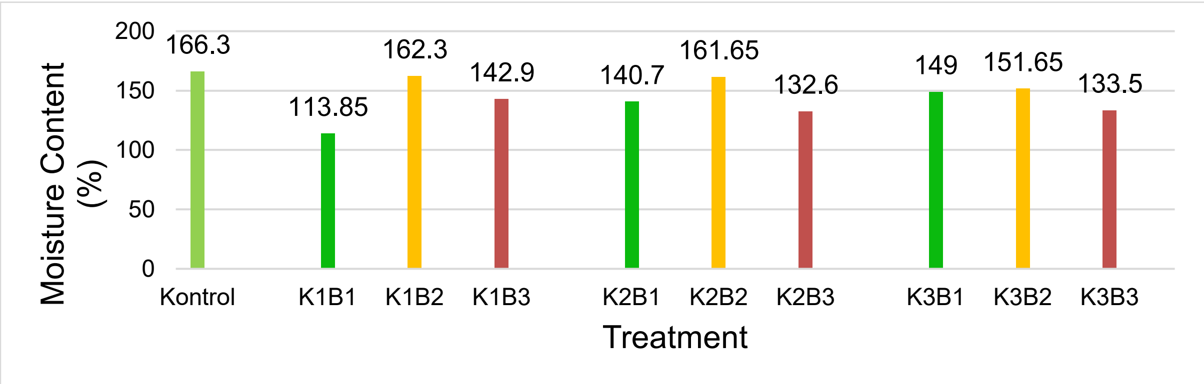

Figure 10. The Difference in Moisture Content Between Dry Basis Before Drying and After Drying.

In Figure 7 and 8, it is evident that the average moisture content after drying has a noticeable difference between the control treatment and fermented cocoa. The wet basis moisture content of cocoa after fermentation and after drying is best for untreated or control cocoa, which has a moisture content of 7.7%, and for fermented cocoa, the optimal moisture content is found in 5-day fermented cocoa with 1-hour soaking, reaching 7.95%. As for the dry basis moisture content of cocoa after fermentation and after drying, the best is untreated or control cocoa, which has a moisture content of 8.3%, and for fermented cocoa, the optimal moisture content is found in 5-day fermented cocoa with 1-hour soaking, reaching 8.65%. These moisture content results do not comply with the Indonesian National Standard (SNI), and this is because drying was stopped before reaching the equilibrium moisture content. The moisture content that is relatively close to the SNI standard is observed in the control or untreated treatment. In the figure, it is evident that the moisture content in cocoa fermented for 3 days with 1-hour soaking reaches up to 11.95%, which is significantly higher than the SNI cocoa moisture content standard of 6-7%. The difference in moisture content before drying and after drying is noticeable, indicating that untreated or control cocoa carries the most water, whether it is in terms of wet basis moisture content at 55.8% or dry basis moisture content at 166.3%. For fermented cocoa, the treatment that carries the most water for wet basis moisture content is 5-day fermented cocoa with 2-hour soaking at 54.6%, and for dry basis moisture content, it is 3-day fermented cocoa with 2-hour soaking at 162.3%. The variability in the obtained moisture content is influenced by several factors, including the temperature during fermentation, temperature during drying, drying duration, and weather conditions during the drying process. This aligns with the statement by (Ifmalinda et al, 2023), which states that the final moisture content value is less than the moisture content value specified by the SNI. This is influenced by the temperature variations used and the duration of the drying process.

3.3 Temperature during Drying

During the cocoa drying process, temperature data is collected using a thermometer, and light intensity is measured using a luxmeter every 2 hours, simultaneously with the turning of cocoa to ensure even drying. Temperature measurements are conducted to determine the temperature level during drying, as the drying process is carried out using direct sunlight without a drying tool. Temperature is a crucial factor that significantly influences the drying process, especially in direct drying using sunlight. This aligns with the statement by (Ifmalinda et al, 2023), which emphasizes the importance of temperature measurement as it is a critical factor affecting drying characteristics.

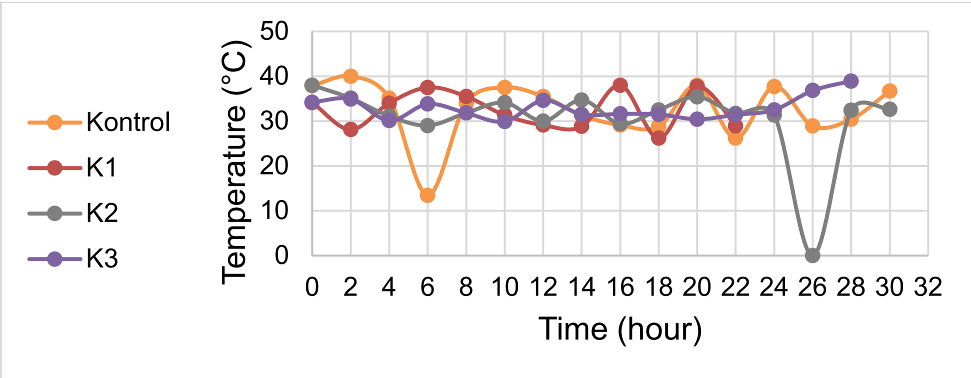

Figure 11. Temperature During Drying.

Figure 11 shows the temperature of cocoa during the drying process. The temperature fluctuates depending on weather conditions. An upward graph indicates an increase in temperature under clear weather, while a downward graph indicates a decrease under unfavorable weather. Therefore, if the weather is unfavorable or rainy, the drying process must be stopped to prevent adverse effects on the cocoa beans. However, during the study, high rainfall intensity resulted in a consistently decreasing graph. The higher the temperature used during drying, the faster the drying process. This aligns with Ifmalinda et al. (2023), who state that temperature is directly proportional to drying duration; the higher the temperature, the faster the drying process, and vice versa. These unstable temperatures affect the obtained moisture content, necessitating a controlled drying process to maintain consistent drying temperatures

3.4 Sunlight Intensity

During the drying process, in addition to temperature measurements, sunlight intensity is also measured using a sunlight intensity measuring tool, namely a luxmeter. The measurement of sunlight intensity is conducted simultaneously with temperature measurement. This aligns with the statement by (Zamharir et al, 2016), which asserts that sunlight intensity is measured with the assistance of a measuring tool called a luxmeter.

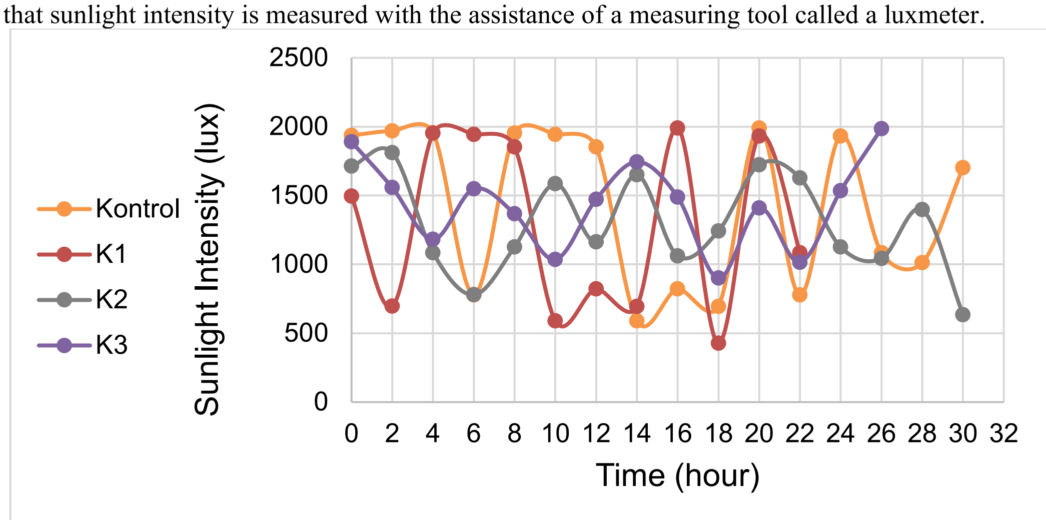

Figure 12. Sunlight Intensity During Drying.

In Figure 12, it shows the sunlight intensity during the drying process. Sunlight intensity fluctuates depending on the weather conditions during drying. If the weather is good, sunlight intensity will increase, but if the weather is cloudy, sunlight intensity will decrease. Drying using direct sunlight is highly dependent on weather conditions, which can lead to prolonged drying and less favorable appearances. This aligns with the statement by (Zamharir et al, 2016), which mentions that drying with this technique is highly dependent on weather conditions during sun exposure. During clear weather, sun exposure can proceed well, but conversely, during cloudy or rainy weather, sun exposure cannot be conducted at all.

4. CONCLUSION

Based on the research that has been done, it can be concluded that the moisture content from fermentation and soaking treatments exceeded the standard (SNI). However, the 5-day fermentation with 1-hour soaking yielded the best result (7.95% moisture). The high moisture content was attributed to temperature fluctuations during sun drying, which occurred in the rainy season, prolonging drying time. Thus, a temperature-controlled drying process is required to maintain consistent conditions.

REFERENCES

Brooker, DB., F. W. Bakker-arkema and C. W. Hall. 1974. Drying Cereal Grain. The AVI Publishing Company, Inc. Wesport.

De Vuyst, L., & Leroy, F. (2020). Functional role of yeasts, lactic acid bacteria and acetic acid bacteria in cocoa fermentation processes. *FEMS Microbiology Reviews*, *44*(4), 432–453. https://doi.org/10.1093/femsre/fuaa014

Firdaus, A. I. 2018. Tingkat Produksi Kakao (Theobroma cacao L.) Klon MCC 02 pada Berbagai Umur Tanam Yang Berbeda. Skripsi. Politeknik Pertanian Negeri Pangkep: Makassar.

Gonibala, M., Handry, R. dan Maya, ML. 2017. Kajian Fermentasi Biji Kakao (Theobroma Cacao L.) Menggunakan Fermentor Tipe Kotak Dinding Ganda Dengan Aerasi. Skripsi. Universitas Sam Ratulangi: Manado.

Guehi, T. S., Dadie, A. T., Koffi, K. P. B., Dabonne, S., Ban-Koffi, L., Kedjebo, K. D., & Nemlin, G. J. (2010). Performance of different fermentation methods and the effect of their duration on the quality of raw cocoa beans. *International Journal of Food Science and Technology*, *45*(12), 2508–2514. https://doi.org/10.1111/j.1365-2621.2010.02424.x

Hartuti, S., Juanda dan Rita, K. 2020. Upaya Peningkatan Kualitas Biji Kakao (Theobrama Cacao L.) Melalui Tahap Penanganan Pascapanen. Jurnal Industri Hasil Perkebunan. Vol. 15 (2) : 38-52.

Hayati, R., Yusmanizar., Mustafril dan Harir, F. 2012. Kajian Fermentasi dan Suhu Pengeringan pada Mutu Kakao (Theobroma cacao L.). JTEP: Jurnal Keteknikan Pertanian. Vol. 26 (2).

Ifmalinda., Edo, S. dan Dinah, C. 2023. Pengaruh Suhu Pengeringan terhadap Mutu Kakao (Theobroma cacao L.) Varietas Klon BL 50 Pasca Fermentasi. Teknotan. Vol. 17(2).

Junaedi, S. T., Syahruni, T. dan Basri, B. 2017. Kajian Penggunaan Klon Unggul Kakao Pada Perkebunan Rakyat Di Kabupaten Bone, Jurnal AgroPlantae Budidaya dan Pengelolaan Tanaman Pertanian dan Perkebunan. Vol. 6(1) : 46–49.

Lutfiah, A. 2018. Pengaruh Lama Pengeringan Biji Kakao (Theobroma cacao L.) dengan Alat Pengering Cabinet Driyer terhadap Mutu Biji Kakao. Skripsi. Fakultas Teknologi Pangan dan Agroindustri Universitas Mataram: Mataram.

Pranowo, D. dan Edi, W. 2016. Kompatibilitas Lima Klon Unggul Kakao Sebagai Batang Atas dengan Batang Bawah Progeni HALF-SIB Klon Sulawesi 01. Jurnal Tanaman Industri dan Penyegar. Vol. 3(1) : 29-36.

Syarifuddin, A. 2019. Pertumbuhan Bibit Kakao (Theobroma cacao L.) Klon MCC 02 pada Komposisi Media Bokasi Kotoran Sapi dan Tanah yang Berbeda. Skripsi. Politeknik Pertanian Negeri Pangkep: Makassar.

Taib. G., Sa'id, E. G. dan Wiraatmaja, S. 1988. Operasi Pengeringan pada Pengolahan Hasil Pertanian. Mediyatama Sarana Perkasa: Jakarta.

Taringan, E. B. dan Tajul, I. 2017. Beberapa Komponen Fisiokimia Kakao Fermentasi dan Non Fermentasi. Jurnal Agroindustri Halal. Vol. 3 (1).

Yunindanova, M. B., Dimas, R. A. M. dan Sigit. M. 2021. Peningkatan Kualitas dan Kuantitas Biji Kakao Melalui Intensifikasi Perawatan Kakao, Introduksi Alat Budidaya dan Pengering Sistem Hybrid. Abdihaz: Jurnal Ilmiah Pengabdian pada Masyarakat. Vol. 3 (1) : 8-15.

Zamharir., Sukmawaty dan Asih, P. 2016. Analisis Pemanfaatan Energi Panas Pada Pengeringan Bawang Merah (Allium Ascalonicum L.) Dengan Menggunakan Alat Pengering Efek Rumah Kaca (Erk). Jurnal Ilmiah Rekayasa Pertanian dan Biosistem. Vol. 4(2).