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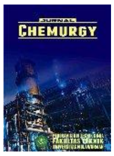

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EVALUASI PENGARUH SUHU PADA *KERNEL SILO DRYER* TERHADAP KADAR AIR KERNEL DI PT PQZ

EVALUATION OF TEMPERATURE EFFECT ON KERNEL SILO DRYER TOWARDS KERNEL MOISTURE CONTENT AT PT PQZ

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Abstrak

Penelitian ini bertujuan untuk menganalisis pengaruh suhu pengeringan pada Kernel Silo *Dryer* terhadap kadar air inti sawit di PT XYZ. Pengendalian kadar air kernel merupakan faktor penting dalam menjaga kualitas *Crude Palm Kernel Oil* (CPKO). Proses pengeringan dilakukan menggunakan Kernel Silo *Dryer* pada variasi suhu 40°C, 50°C, dan 60°C selama tiga jam. Hasil penelitian menunjukkan bahwa peningkatan suhu pengeringan berbanding terbalik dengan kadar air kernel. Pada suhu 60°C, kadar air kernel mencapai standar yang ditetapkan, yaitu di bawah 7%. Sebaliknya, pada suhu 40°C dan 50°C, kadar air masih melebihi batas standar, sehingga berpotensi meningkatkan risiko pertumbuhan jamur dan menurunkan mutu kernel. Faktor-faktor yang memengaruhi efektivitas pengeringan meliputi kondisi pemanas, tekanan uap dari *Back Pressure Vessel* (BPV), serta kebersihan peralatan. Oleh karena itu, optimasi suhu pengeringan dan pemeliharaan peralatan secara berkala sangat diperlukan untuk meningkatkan efisiensi pengeringan dan mempertahankan kualitas kernel.

Kata Kunci: kernel silo dryer, kadar air, temperatur, pengeringan, *crude palm kernel oil*

Abstract

This study aims to evaluate the effect of temperature on the Kernel Silo Dryer toward the moisture content of palm kernels at PT XYZ. Moisture control in palm kernels is crucial to ensuring optimal crude palm kernel oil (CPKO) quality. The drying process using a Kernel Silo Dryer was conducted at varying temperatures of 40°C, 50°C, and 60°C for three hours. Results indicated that higher drying temperatures resulted in lower kernel moisture content. At 60°C, the kernel moisture content reached the desired standard below 7%. However, at 40°C and 50°C, the moisture content exceeded the specified limit, increasing the risk of mould growth and reducing kernel quality. Key factors influencing drying efficiency include heater condition, steam pressure from the Back Pressure Vessel (BPV), and equipment cleanliness. Therefore, temperature optimisation and proper maintenance are essential to improve drying efficiency and maintain kernel quality.

***Keywords**: kernel silo dryer, moisture content, temperature, drying, crude palm kernel oil*

1. INTRODUCTION

Indonesia is the largest palm oil producer in the world, contributing approximately 60.30% of the total global palm oil output. The production of Crude Palm Oil (CPO) has shown a consistent upward trend over the years. Data from the Ministry of Agriculture indicates that CPO production, which stood at only 721.17 thousand tonnes in 1980, has risen dramatically to reach 47.69 million tonnes in 2024. The major CPO-producing regions are located on the islands of Sumatra and Kalimantan, each recording more than 2.5 million tonnes of production between 2020 and 2024. In addition to CPO, Crude Palm Kernel Oil (CPKO) has also become an attractive commodity for various industries. CPO represents 88.95%, while CPKO constitutes the remaining 11.05%. from the total palm oil production (Ministry of Agriculture, 2024). In addition to CPO and CPKO, the biomass residues generated from palm oil processing, such as empty fruit bunches and palm kernel shells, are also utilized as organic fertilizers and as solid fuels for boilers in palm oil mills.

To produce high-quality CPKO, manufacturers must carefully consider the quality of the raw materials used. One of the most critical factors is the moisture content of the palm kernels. In palm oil milling operations, the kernel station serves a vital function in processing palm nuts into kernels, wherein the nuts are first separated from the adhering fibres. The primary output of this station is the cleaned kernel, while the by-products, such as shell and fibre, are generally utilized as solid fuels for boiler operations. After cleaning, the kernels are subsequently pressed to extract Crude Palm Kernel Oil (CPKO).

At every stage of palm oil processing, it is essential to minimize oil losses, free fatty acid (FFA) formation, moisture content, impurities, kernel losses, and the proportion of broken kernels and nuts in accordance with established process standards. Attaining these quality parameters requires efficient plant operations, supported by proper material handling and strict adherence to standard operating procedures (Habibiasr, 2019).

This study focuses on the issue of high moisture content observed in kernels discharged from the Kernel Silo Dryer. The Kernel Silo Dryer functions as a drying unit designed to reduce the moisture content of palm kernels, utilizing steam supplied from the Back Pressure Vessel (BPV) as the heating medium. The steam exiting the BPV passes through steam coils within the heater, thereby transferring heat to the surrounding air. The heated air is then directed by a blower into the Kernel Silo Dryer to lower the kernel moisture content. The dried kernels are subsequently conveyed to the kernel bunker, which serves as a temporary storage unit prior to dispatch and distribution. At this stage, the kernel moisture content should not exceed the standard limit of 7%. Moisture levels below this threshold may cause kernel discoloration, whereas levels exceeding 7% can promote mould growth, increase the free fatty acid content, and ultimately reduce the oil yield extracted from the kernels (Habibiasr, 2019; Zakwan *et al.*, 2024).

The moisture content of palm kernels is a critical parameter determining product quality and, therefore, must be routinely monitored at PT XYZ. The target moisture level is generally achieved through heating within a temperature range of 40–60 °C. However, during plant operation, several samples were found to exhibit moisture levels exceeding the specified standard. When the measured moisture content meets the target specification, the drying process is considered effective; conversely, when it exceeds the limit, a process evaluation is required. Such deviations may result from operator error, inadequate supervision, or mechanical malfunctions within the drying system. Ensuring consistent product quality is, therefore, essential. Excessive kernel moisture shortens shelf life, facilitates microbial growth, and ultimately reduces its economic value due to market price depreciation.

2. RESEARCH METHODOLOGY

This study was conducted at PT XYZ between February and March 2024. Data were collected at the Kernel Silo Dryer in the kernel station. Equipment used includes the kernel silo dryer, boiler, heater, analytical balance, porcelain crucibles, spatula, desiccator, and oven. Kernel samples separated from their shells were used as raw material. The Kernel Silo Dryer consists of three main components: a heater, a blower, and a transfer fan.

The experimental procedure began with the operation of the Kernel Silo Dryer at various temperature settings, while maintaining a constant drying duration of three hours. Kernel samples were collected over several days during plant operation. The collected kernels were subsequently ground into a fine powder to ensure sample homogeneity. An evaporating dish was first weighed to determine its tare mass, after which 10 grams of the powdered kernel sample were placed into the dish. The oven was preheated to 103.5 °C, and the samples were dried for three hours under controlled conditions. Upon completion of the drying process, the samples were cooled in a desiccator for approximately 10–15 minutes and then weighed using an analytical balance to determine their final mass.

$$Water\ content = \frac{(mass\ of\ wet\ sample - mass\ of\ dry\ sample)}{mass\ of\ dry\ sample}\ x\ 100\% \qquad (1)$$

(Babalola and Ajagunna, 2004)

3. RESULTS AND DISCUSSION

The Kernel Silo Dryer is designed to reduce the moisture content of palm kernels and to preserve their quality by preventing microbial degradation. This preservation is achieved through a thermal drying process aimed at lowering the kernel moisture content to meet the required commercial standard, typically between 6% and 7%. Furthermore, the drying process facilitates easier material handling in subsequent processing stages.

The drying operation is performed by introducing hot air into the kernel silo (Babalola and Ajagunna, 2004). Inside the silo, a series of baffles are installed to ensure uniform distribution of heated air throughout the system. The hot air is generated as ambient air passes over the heater's steam coils, enabling continuous heat transfer within the unit. The dominant modes of heat transfer in this process are conduction and convection. The drying operation needed approximately three hours, with a processing capacity of about 30 tonnes per batch. Continuous heat supply during operation is expected to effectively reduce the kernel moisture content to a maximum of 7%.

The feed material introduced into the Kernel Silo Dryer consists of a mixture of kernels obtained from both the hydrocyclone and claybath separation units. These kernels are dried for around three hours, resulting in a significant reduction in their moisture content. After the drying stage, the dried kernels are transferred to the kernel bunker, which serves as a temporary storage facility prior to further handling and dispatch.

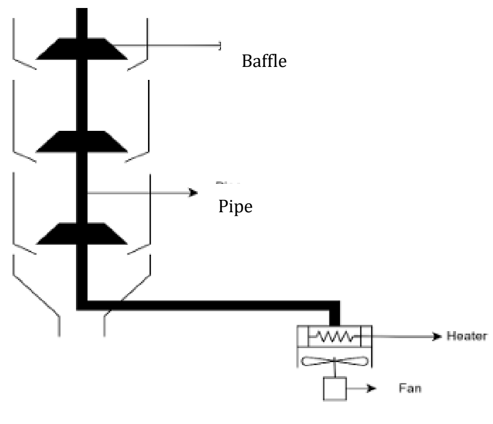

Figure 1. *Kernel Silo Dryer Schematic*

Based on the conducted research, data on the wet and dry weights of the kernels were obtained, as presented in Table 1, while the moisture content percentages are summarised in Table 2. Kernels derived from the hydro cyclone separation process that enter the Kernel Silo Dryer generally exhibit high initial moisture content, ranging between 20% and 21%. To preserve the kernel and prevent deterioration, it is essential that the drying process reduces the moisture level to below 7%. Excessive moisture in kernels promotes fungal and microbial growth, which adversely affects product quality. Therefore, temperature control within the Kernel Silo Dryer is a critical parameter to ensure that the final kernels meet the required quality and moisture specifications.

From the calculations based on the data presented in Tables 1 and 2, the relationship between drying temperature and kernel moisture content was established as follows.

Table 1. Kernel Moisture Observation Data

No	Date	Shift	Moisture Content of Input Kernel					Moisture Content of Output Kernel				
			Empty bottle (Y) (gr)	Y + Wet sample (gr)	Wet sample (gr)	Y + Dry sample (gr)	Dry sample (gr)	Empty bottle (Y) (gr)	Y + Wet sample (gr)	Wet sample (gr)	Y + Dry sample (gr)	Dry sample (gr)
1	26 Feb 2024	Afternoon	56,80	67,16	10,36	65,04	8,24	59,65	69,97	10,32	69,21	9,55
		Night	56,79	66,98	10,20	64,86	8,07	59,66	70,12	10,46	69,37	9,71
2	27 Feb 2024	Afternoon	56,81	66,83	10,02	64,62	7,81	59,66	69,77	10,12	69,08	9,42
		Night	56,79	67,07	10,28	65,01	8,22	59,65	69,71	10,06	68,69	9,04
3	28 Feb 2024	Afternoon	56,79	66,92	10,11	64,74	7,95	69,66	69,76	10,10	69,04	9,43
		Night	56,63	66,85	10,21	64,67	8,04	59,63	69,75	10,11	69,13	9,5
4	29 Feb 2024	Afternoon	56,80	67,06	10,27	64,84	8,04	59,66	70,10	10,44	69,15	9,49
		Night	56,79	67,12	10,33	64,99	8,19	59,66	69,99	10,34	69,38	9,73
5	1 March 2024	Afternoon	56,79	67,04	10,25	64,88	8,09	59,66	69,76	10,11	69,18	9,52
		Night	56,79	66,98	10,19	64,82	8,02	59,66	69,90	10,24	69,15	9,48

Table 2. The Percentages of Moisture Content in Kernel with 3 hour Drying Time

Date	Temperature (°C)	% Moisture Content Input Kernel	% Moisture Content Output Kernel	% Evaporatation of Moisture Content
26 Feb 2024	50	20,66	7,30	13,35
27 Feb 2024	40	21,04	8,52	12,51
28 Feb 2024	60	21,41	6,61	14,80
29 Feb 2024	50	21,13	7,51	13,62
1 March 2024	60	21,16	6,58	14,58

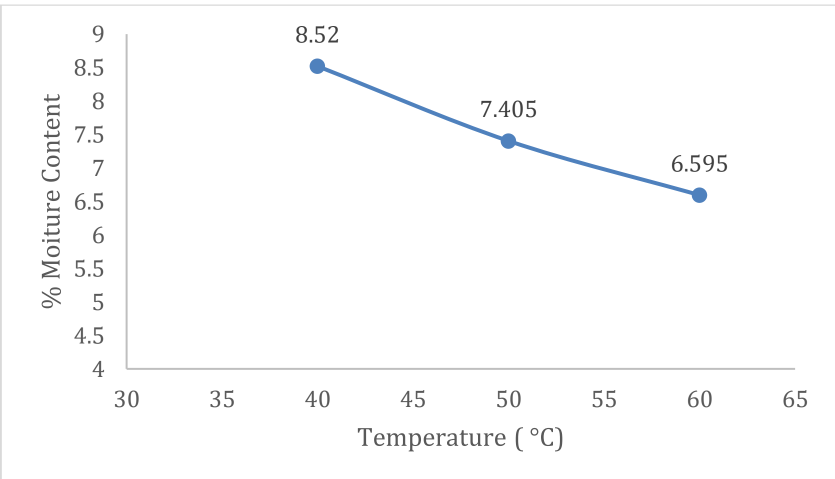

Figure 2. The Effect of Temperature on % Kernel Moisture Content

The graph above illustrates the effect of drying temperature on the moisture content of palm kernels. According to drying theory, higher temperatures accelerate the rate of moisture removal (Akowuah *et al.*, 2018; Charmongkolpradit *et al.*, 2021). Research conducted by Akowuah et al. (2018) demonstrated that the moisture content of maize grains decreased significantly to 13% at mean drying temperature of 52.8°C ± 5.4°C compare to other temperature variations. In this research, as depicted, the relationship between temperature and moisture content is inversely proportional the higher the temperature applied, the lower the resulting moisture content, and vice versa. From the plotted data, it is observed that at 60°C, the resulting kernel moisture content complies with the specified standard of 7.0%. On the other hand, at 40°C and 50°C, the measured moisture contents were 7.30%, 8.52%, and 7.51%, recorded on 26 February, 27 February, and 29 February 2024, respectively. Research conducted by Study conducted by Kraiem et al. (2023) showed that increasing the air temperature effectively reduced both the moisture content and the drying time, thereby accelerating the overall drying process. The result from their study revealed that the moisture content of corn kernels at 50°C, 60°C, and 70°C was 0.24 kg/kg dry basis, 0.20 kg/kg dry basis, and 0.175 kg/kg dry basis, respectively.

Ideally, the kernel moisture content should remain below the 7% limit, assuming a constant drying duration of three hours. However, field analysis revealed a discrepancy between theoretical expectations and actual plant performance. This deviation can be attributed to the drying temperature not reaching 60°C. The first contributing factor is the condition and cleanliness of the heater unit. When the heater surfaces are contaminated with dust or residues, heat transfer efficiency is significantly reduced, impeding proper system performance (Goswami, Pillai and McGranaghan, 2023; Inamdar *et al.*, 2023; Unnikrishnan and Mulky, 2023; Yahya *et al.*, 2023). The second factor is the insufficient steam pressure supplied to the heater due to low pressure in the Back Pressure Vessel (BPV). This situation occurred because the main boiler was undergoing maintenance on its furnace section. Consequently, a smaller-capacity auxiliary boiler was temporarily used, which produced lower steam flow and reduced operating temperature, resulting in inefficient drying performance.

According to Babalola et al. (2005), the moisture content of palm kernels is directly proportional to the relative humidity (Rh) of the surrounding air. Wet kernels entering the Kernel Silo Dryer lose moisture when exposed to hot air, becoming drier upon discharge. However, once the dried kernels are exposed to ambient air with high relative humidity, they tend to reabsorb water vapour until moisture equilibrium is reached. The moisture migration between the kernel and the surrounding air at different humidity levels is independent of temperature. Therefore, it is strongly recommended that oil extraction from the kernels be carried out immediately after drying to prevent reabsorption of atmospheric moisture, which could compromise both the drying efficiency and oil yield.

4. CONCLUSION

The conclusion drawn from this study indicates that an increase in the drying temperature within the Kernel Silo Dryer results in a corresponding decrease in the moisture content of the palm kernels. Conversely, when the operating temperature is relatively low, the resulting moisture content remains high, which consequently accelerates fungal growth and leads to deterioration of kernel quality. The moisture content of the dried kernels exiting the Kernel Silo Dryer ranged between 6.0% and 8.0%.

The performance and efficiency of the Kernel Silo Dryer are primarily influenced by several operational factors, including drying temperature, steam supply pressure, heating duration, and the cleanliness of the air passage grids within the silo. Proper control and maintenance of these parameters are therefore essential to ensure optimum drying performance and consistent product quality.

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