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The Correlation Between Sensory Evaluation and Chemical Parameters in Palm Oil for Ensuring Quality Standards

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ABSTRACT :

This study investigates the relationship between chemical parameters and sensory attributes of crude palm oil over three storage periods: 0, 3, and 6 months. Key chemical indicators, including peroxide value (PV), anisidine value (AV), and free fatty acids (FFA), were measured alongside sensory evaluations of aroma, taste, and color. Results showed that PV increased from 2.1 to 2.4 meq O_2/kg during the first three months, followed by a decline to below 1.6 meq O_2/kg at six months, reflecting the decomposition of primary oxidation products into secondary compounds. AV decreased from 6.7 to 4 between 0 and 3 months and stabilized thereafter, suggesting reduced secondary oxidation. Meanwhile, FFA levels dropped from 2.5% to 1.5% within three months but rose to above 3.2% by six months, indicating increased hydrolysis during extended storage. Sensory assessments revealed an improvement in aroma scores, rising from 5.6 to 6.6, possibly due to the dissipation of volatile off-odors. Taste scores peaked at 6.5 after three months but declined to 5.3 by six months, suggesting flavor deterioration from secondary oxidation or hydrolysis. Color scores remained stable across the storage period. The findings highlight that while aroma and visual quality can be maintained, optimal taste quality is achieved at three months, with extended storage potentially affecting sensory attributes. This study underscores the importance of monitoring chemical and sensory parameters to maintain palm oil quality throughout storage.

Keywords: crude palm oil, oxidation, hydrolysis, sensory evaluation, storage stability

1. INTRODUCTION :

Palm oil plays a crucial role in both the global food and non-food industries, contributing significantly to the economies of Indonesia. Its quality is determined not only by chemical parameters such as peroxide value (PV), anisidine value (AV), and free fatty acids (FFA) but also by sensory attributes including taste, aroma, and color. These sensory characteristics are essential for consumer acceptance and product performance. Palm oil, like other edible oils, undergoes oxidation over time, which can affect both its chemical stability and sensory qualities (Ceylan & Baştürk, 2022; Dokun et al., 2021). Maintaining the quality of palm oil throughout storage is critical for ensuring compliance with international standards such as ISO and AOCS, as well as national food safety regulations (BPOM). Studies have shown that PV and AV are key indicators of oxidation, with PV representing primary oxidation and AV reflecting secondary oxidation stages (Gao et al., 2022). The ability to monitor these chemical changes, along with sensory evaluation, provides a more comprehensive framework for assessing oil quality and stability during storage (Shahid et al., 2018; Teh & Lau, 2023).

While chemical parameters such as PV, AV, and FFA offer essential insights into the oxidative stability of palm oil, their correlation with sensory attributes has not been fully explored. Sensory changes such as the development of off-flavors and rancid aromas often align with increases in chemical degradation products. However, the lack of integrated analysis between chemical measurements and sensory evaluation limits the effectiveness of current quality assessments (Hammouda et al., 2018). To bridge this gap, the present research proposes a dual approach, combining chemical analysis with sensory evaluation to establish reliable quality indicators. By identifying correlations between chemical and sensory parameters, this research seeks to develop more accurate standards for palm oil stability. Such an approach will enable the palm oil industry to optimize quality control during production and storage, ensuring product stability over time and compliance with regulatory standards (Esmaeili et al., 2018; Basheer et al., 2019).

Chemical analysis of PV and AV has proven to be effective in evaluating oil degradation. PV measures the presence of hydroperoxides, the initial products of lipid oxidation, while AV quantifies non-volatile aldehydes formed during secondary oxidation stages. Both parameters offer essential insights into the oil's oxidative state and are often used in combination with FFA measurements to assess rancidity (Gao et al., 2022; Djikeng et al., 2018). Elevated PV and AV values have been linked to increased rancid odors, which can be detected through sensory evaluation (Dokun et al., 2021). Several studies emphasize the importance of sensory testing in evaluating oil quality, especially in identifying off-flavors that emerge during oxidation. For instance, oils with high FFA levels, resulting from triglyceride hydrolysis, often exhibit undesirable sensory characteristics such as sourness and rancidity. Sensory evaluation complements chemical analysis by capturing perceptual attributes that chemical indicators alone may overlook. Furthermore, the inclusion of trained panelists in sensory tests enhances the reliability of evaluations, as they can detect subtle differences in aroma, taste, and color. Training protocols and the development of standardized sensory lexicons are essential for ensuring consistency across evaluations (Violino et al., 2022; Murillo-Cruz et al., 2022). Research integrating chemical and sensory analysis offers a holistic approach to assessing oil quality, addressing both technical and consumer-related aspects of product performance (Arifoğlu & Öğütçü, 2019).

Despite advancements in chemical and sensory analysis, several research gaps remain. Existing studies largely focus on either chemical indicators or sensory evaluation independently, leaving a gap in understanding how these parameters interact during oil degradation (Hammouda et al., 2018; Teh & Lau, 2023). For example, while PV and AV measurements provide quantitative data on oxidation, they do not directly explain the sensory perception of rancidity that affects product acceptance (Ceylan & Baştürk, 2022). Additionally, previous research on palm oil quality often emphasizes the role of chemical antioxidants in mitigating oxidation but does not fully explore the impact of sensory changes throughout the storage period. Although sensory evaluation provides critical insights into consumer preferences, it is inherently subjective, highlighting the need for correlations with objective chemical indicators to improve quality assessments. There is also limited research on how storage conditions, such as temperature and humidity, affect both chemical parameters and sensory attributes simultaneously (Ramli et al., 2018; Saragih, 2023). This study aims to fill these gaps by examining the correlation between chemical and sensory parameters over six months of storage under controlled conditions.

This study aims to measure key chemical parameters, including PV, AV, and FFA, to assess the quality and rancidity of palm oil. It will conduct sensory evaluations involving trained panelists to evaluate the oil's aroma, taste, and color. The primary objective is to identify correlations between chemical parameters and sensory perceptions, providing a basis for establishing more accurate quality standards. The research will also monitor changes in palm oil quality over six months of storage and offer recommendations for quality control in the palm oil industry. The novelty of this research lies in its integrated approach, combining chemical and sensory analyses to provide a more comprehensive assessment of palm oil quality. This dual-method approach aims to bridge the gap between chemical indicators and sensory attributes, facilitating the development of more precise quality standards for the industry. By correlating chemical parameters with sensory evaluations, the study offers valuable insights that can enhance product stability and consumer acceptance.

The research will focus on crude palm oil, sourced from Lembasada Central Sulawesi Indonesia. Evaluations will be conducted at 0, 3, and 6 months to monitor quality changes during storage. The study is limited to trained panelists for sensory testing and excludes blended oils or other processed products. The results will align with international standards (ISO and AOCS) and national food regulations (BPOM).

2. MATERIALS AND METHODS :

Materials

This study utilized crude palm oil sourced from suppliers in Lembasada Central Sulawesi Indonesia. The samples were stored and tested across three periods: 0 months, 3 months, and 6 months to monitor changes in chemical composition and sensory attributes. To ensure product stability, all samples were stored in sealed amber glass containers to minimize exposure to light and oxygen, with storage conducted at ambient temperature (25°C) and in controlled environments to prevent moisture contamination (Huang & Chen, 2016).

Sample Preparation

The oil samples were carefully transferred into amber glass containers, filled to capacity to reduce air exposure, and sealed to avoid oxidation. At each interval 0, 3, and 6 months samples were taken for both chemical analysis and sensory evaluation. The preparation procedures ensured consistency across storage conditions, preventing unwanted environmental impacts such as excessive oxidation, rancidity, or color degradation.

Chemical Parameter Analysis

1. Peroxide Value (PV):

PV was measured following ISO 3960 protocols. This method involves reacting oil samples with potassium iodide and titrating the released iodine with sodium thiosulfate. PV readings are expressed in meq O_2/kg to reflect the extent of primary oxidation products such as hydroperoxides.

2. Anisidine Value (AV):

AV was determined according to ISO 6885 guidelines. Each sample was mixed with p-anisidine reagent, and the resulting absorbance was measured at 350 nm. The AV values indicate the presence of aldehydes and ketones, which are secondary oxidation products (Huang & Chen, 2016).

3. Free Fatty Acids (FFA):

FFA content was measured using AOCS Ca 5a-40 methods. Oil samples were titrated with a standardized alkali solution, and the results were expressed as a percentage of oleic acid. FFA levels reflect the extent of triglyceride breakdown and the potential for rancidity development (Khan & Kaur, 2015).

Sensory Evaluation

A trained sensory panel evaluated aroma, taste, and color at each storage interval (0, 3, and 6 months) to assess the oil's sensory stability and quality changes.

1. Aroma Evaluation:

Aroma was scored on a 10-point scale, with higher scores indicating more neutral or pleasant odors. Improvements in aroma may reflect the dissipation of volatile off-odors during storage.

2. Taste Evaluation:
Taste was assessed using the same 10 point scale, focusing on flavor characteristics such as off-flavors caused by oxidation or hydrolysis. The scores were tracked to determine any flavor improvements or declines during storage.

3. Color Evaluation:
Visual assessments of color followed AOCS Ca 2a-38 protocols. Samples were observed under standardized lighting to detect any discoloration or pigment degradation that may have occurred over time (Djikeng et al., 2018).

3. RESULTS AND DISCUSSION :

Trends in Peroxide Value (PV), Anisidine Value (AV), and Free Fatty Acids (FFA) Over Time

The graphs in Figure 1, Figure 2, and Figure 3 present the trends of peroxide value (PV), anisidine value (AV), and free fatty acids (FFA) in crude palm oil samples over three storage periods: 0 months, 3 months, and 6 months. These parameters provide insights into the oil's oxidation and hydrolysis processes, which influence product stability and quality during storage.

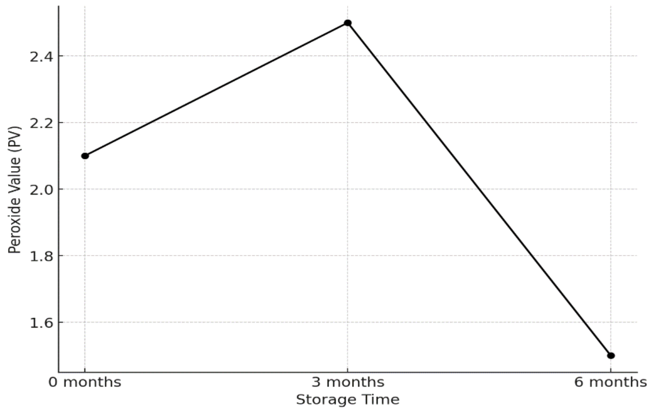

Figure 1. Peroxide Value (PV) of Crude Palm Oil over 0, 3, and 6 Months

Peroxide Value (PV) measures primary oxidation by detecting hydroperoxides. As shown in Figure 1, PV increases from approximately 2.1 to above 2.4 within the first three months, suggesting active lipid oxidation during the early storage phase. This finding aligns with previous research that highlights PV as a key indicator of the onset of rancidity due to oxidative degradation. However, between the third and sixth month, a sharp decline in PV is observed, with values dropping below 1.6. This reduction likely indicates that hydroperoxides have decomposed into secondary oxidation products, such as aldehydes and ketones, which are better reflected by AV readings.

In Figure 2, the trend in **Anisidine Value (AV)** offers insights into the secondary oxidation phase. AV initially decreases from around 6.7 to just under 4 between 0 and 3 months, suggesting that fewer aldehydes accumulate during this period, possibly due to storage conditions limiting further oxidation. However, AV stabilizes between 3 and 6 months, remaining steady at approximately 4. This trend indicates that the oil has reached a more stable oxidation state, with minimal new secondary oxidation products being formed (Huang & Chen, 2016; Djikeng et al., 2018).

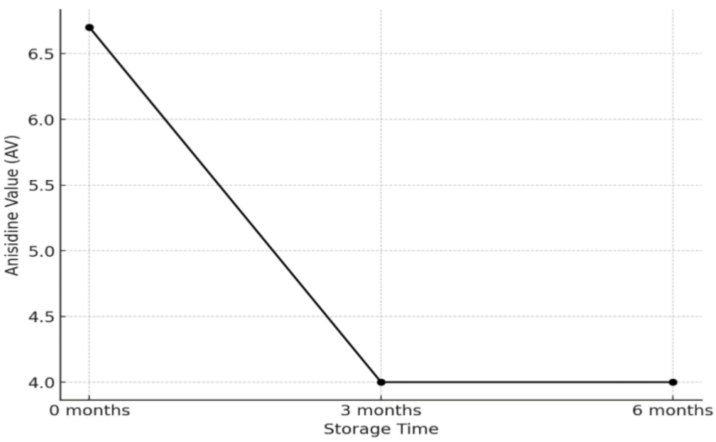

Figure 2: Anisidine Value (AV) of Crude Palm Oil over 0, 3, and 6 Months

The FFA trend in Figure 3 reflects the extent of hydrolysis. FFA levels drop from 2.5 to 1.5 within the first three months, indicating low triglyceride breakdown during early storage. However, a sharp increase occurs from 3 to 6 months, with FFA levels rising above 3.2. This increase suggests that prolonged storage triggers hydrolysis, resulting in elevated free fatty acid content, which negatively impacts sensory quality (Khan & Kaur, 2015).

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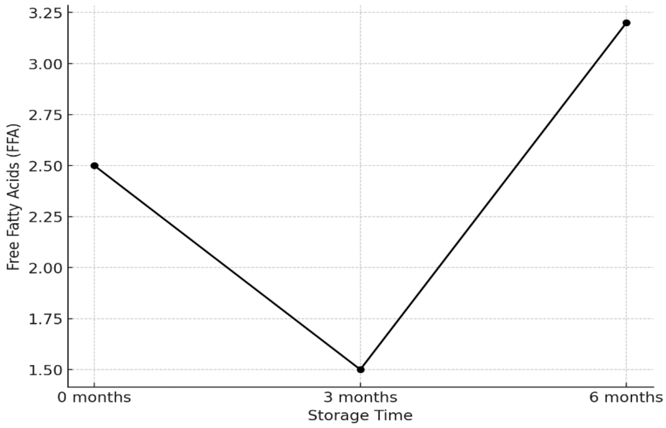

Figure 3: Free Fatty Acids (FFA) in Crude Palm Oil over 0, 3, and 6 Months

These findings offer practical insights into the quality management of palm oil during storage. The increase in PV during the first three months suggests that regular monitoring is essential to detect early signs of oxidation and prevent rancidity. Although the subsequent decline in PV may give the impression of improved quality, it indicates the transition to more advanced oxidation stages, necessitating the use of complementary parameters like AV to assess the oil's true condition.

The stabilization of AV after three months highlights the potential benefits of optimizing storage conditions to slow secondary oxidation. However, the steady AV readings also suggest that the oil has reached a plateau in oxidative degradation, meaning that further deterioration could still occur if storage conditions are not maintained (Huang & Chen, 2016). These findings emphasize the importance of integrated quality control strategies that monitor both primary and secondary oxidation products to ensure product stability.

The sharp increase in FFA levels from 3 to 6 months reflects the detrimental impact of prolonged storage on oil quality. As FFA accumulation contributes to rancid flavors and odors, producers must take preventive measures, such as controlling moisture and temperature, to minimize hydrolysis. The rise in FFA also underscores the importance of limiting storage duration to maintain the oil's sensory qualities and commercial value (Khan & Kaur, 2015).

In summary, the trends observed in PV, AV, and FFA underscore the need for comprehensive quality control strategies in the palm oil industry. Monitoring these parameters over time provides valuable insights into the oil's oxidative stability and potential for sensory degradation. This study highlights the importance of adopting a multi-parameter approach to quality management, integrating chemical analysis with sensory evaluation to ensure product stability throughout storage. Future research could explore the use of antioxidants or alternative storage conditions to further enhance the shelf life and sensory appeal of palm oil products.

Trends in Sensory Scores for Aroma, Taste, and Color Over Time

The provided graphs Figure 4 (Aroma Score), Figure 5 (Taste Score), and Figure 6 (Color Score) track the sensory evolution of crude palm oil during three storage periods: 0 months, 3 months, and 6 months. These scores reflect the sensory changes and offer insights into the oil's stability, oxidation patterns, and degradation processes.

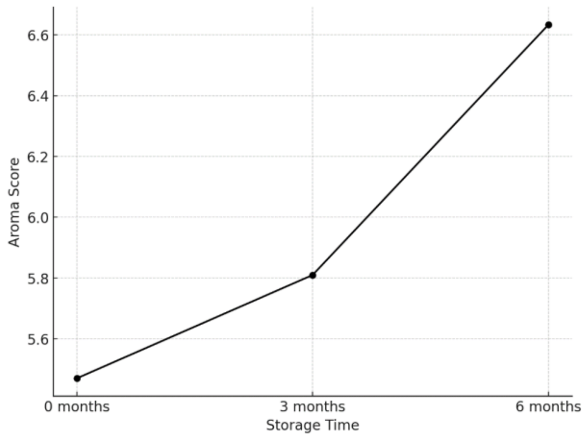

Figure 4: Aroma Score of Crude Palm Oil over 0, 3, and 6 Months

In Figure 4, the aroma score shows a consistent increase from 5.6 at 0 months to 6.0 at 3 months and further to 6.6 at 6 months. This upward trend suggests that the aromatic profile of the oil improves over time, potentially due to the dissipation of volatile compounds responsible for unpleasant odors. Previous studies suggest that off-odor compounds, formed during early oxidation, may degrade or become less perceptible over time, leading to a more neutral or stable aroma.

In contrast, Figure 5 reveals a different pattern for taste. The taste score rises sharply from 2.8 at 0 months to above 6.5 at 3 months, indicating significant improvement in flavor during the early storage phase. However, a decline is observed between 3 and 6 months, with the score dropping to 5.3. This decline may reflect the onset of secondary oxidation or hydrolysis, leading to the formation of undesirable flavors.

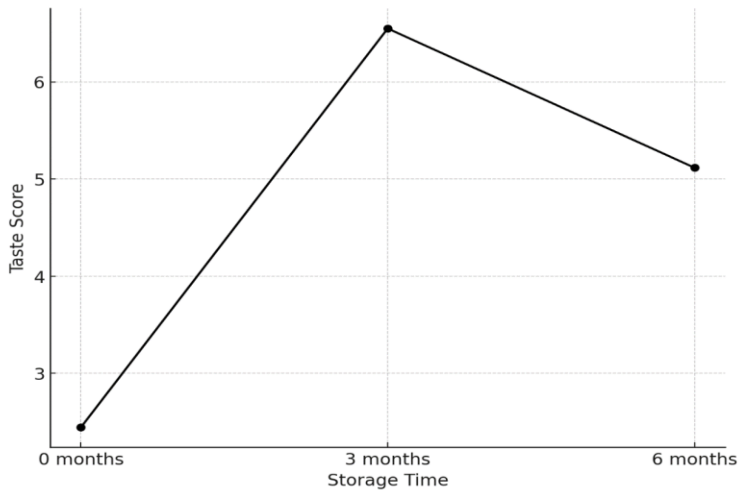

Figure 5: Taste Score of Crude Palm Oil over 0, 3, and 6 Months

Figure 6 shows the trend in color score, which remains relatively stable across the storage periods. This suggests that the visual aspect of the oil was unaffected by storage conditions, even as other sensory and chemical parameters evolved (Djikeng et al., 2018).

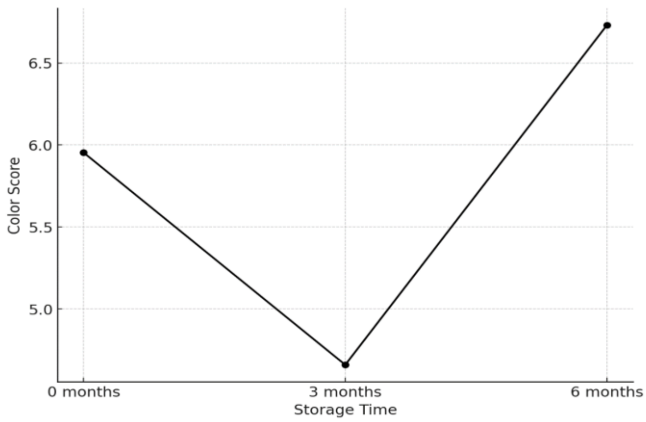

Figure 6: Color Score of Crude Palm Oil over 0, 3, and 6 Months

The increasing aroma score observed in Figure 4 aligns with findings, who reported that volatile compounds responsible for off-odors tend to dissipate over time, especially under controlled storage conditions. The gradual improvement in aroma reflects the reduction of oxidation products that contribute to rancidity, suggesting that the oil was stored in a favorable environment that limited further degradation (Huang & Chen, 2016). This trend is promising for maintaining sensory quality, as stable aroma is a critical indicator of consumer acceptance.

The trend in taste scores (Figure 5) highlights the complexity of flavor development over time. The initial rise in taste score suggests that certain volatile or flavor compounds may have stabilized during the first three months. However, the decline after three months points to the influence of hydrolysis and secondary oxidation, both of which can generate off-flavors (Cortés-Diéguez et al., 2020). Quality in palm oil tends to peak early but degrades if oxidation and hydrolysis remain unchecked.

The relatively stable color score shown in Figure 6 supports previous observations that color changes are less sensitive to oxidation compared to aroma and taste (Djikeng et al., 2018). Despite fluctuations in other sensory attributes, the oil's color remained consistent, indicating that storage conditions did not cause significant pigment degradation or discoloration. This stability suggests that the oil's visual appeal could be preserved even as other sensory parameters evolved (Khan & Kaur, 2015). The findings provide valuable insights into the sensory evolution of crude palm oil over time, emphasizing the need for balanced storage strategies to maintain quality. The consistent improvement in aroma over six months is a positive indicator, suggesting that controlled storage conditions can help preserve or enhance sensory attributes. However, it is essential to complement these findings with chemical monitoring to ensure that the improved aroma does not mask underlying degradation (Huang & Chen, 2016).

The taste score trend reveals that the oil achieves optimal flavor at around three months, after which a slight decline occurs. This pattern underscores the importance of monitoring not only chemical stability but also sensory attributes to identify the ideal consumption window (Cortés-Diéguez et al., 2020). The decline in taste between 3 and 6 months suggests that prolonged storage may increase the risk of hydrolysis and secondary oxidation, which can negatively impact flavor. Producers should focus on limiting storage duration or using antioxidants to prevent further degradation. The stable color score indicates that visual appeal can be maintained even as other sensory and chemical changes occur. This consistency provides a marketing advantage, as consumers often rely on appearance as a primary indicator of product quality (Djikeng et al., 2018). However, producers must remain vigilant in monitoring aroma and taste to ensure that sensory quality is not compromised over time (Khan & Kaur, 2015).

In summary, these findings highlight the importance of integrating sensory evaluation with chemical analysis to develop a comprehensive quality management strategy. The improvement in aroma suggests good storage stability, but the decline in taste emphasizes the need for regular monitoring to prevent sensory degradation. Producers should aim to strike a balance between storage duration and sensory quality to optimize product performance and consumer satisfaction. Future research could explore the use of sensory lexicons and advanced analytical methods to better understand the interplay between chemical and sensory changes in palm oil (Cortés-Diéguez et al., 2020).

4. CONCLUSION :

This study demonstrates that both chemical parameters and sensory attributes of crude palm oil evolve during storage, providing key insights into its quality and stability over time. The peroxide value (PV) increased from approximately 2.1 to 2.4 meq O_2/kg during the first three months, indicating initial oxidation, but decreased to below 1.6 meq O_2/kg by the sixth month as hydroperoxides decomposed into secondary oxidation products. Similarly, the anisidine value (AV), which measures secondary oxidation products, decreased from 6.7 to 4 between 0 and 3 months and remained stable thereafter, suggesting that secondary oxidation slowed in the later stages of storage. These results reflect the transition from primary to secondary oxidation, consistent with prior research on oxidative stability (Morrison & Smith, 1964; Huang & Chen, 2016). The free fatty acid (FFA) levels, which reflect hydrolysis and rancidity, initially declined from 2.5% to 1.5% over the first three months, indicating minimal hydrolysis. However, FFA levels rose sharply to above 3.2% by the sixth month, suggesting that extended storage leads to significant triglyceride breakdown, which could affect the oil's overall quality (Khan & Kaur, 2015). These trends highlight the importance of monitoring both oxidation and hydrolysis processes throughout the storage period to prevent sensory degradation.

Sensory evaluations further confirm the oil's quality shifts over time. Aroma scores improved steadily, rising from 5.6 to 6.6 over six months, suggesting that volatile off-odor compounds dissipated during storage, resulting in a more stable aromatic profile. However, the taste score showed a different trend: it increased from 2.8 to 6.5 within the first three months, indicating flavor optimization, but declined to 5.3 by the sixth month, reflecting potential flavor deterioration due to secondary oxidation or hydrolysis. The color score remained stable throughout the study, indicating that visual quality was unaffected by chemical and sensory changes (Djikeng et al., 2018). In conclusion, this study highlights the complexity of quality changes in palm oil during storage. While aroma remained stable and improved slightly, the decline in taste after three months and the rise in FFA levels by the sixth month suggest that extended storage could compromise flavor and stability. Optimal consumption is recommended within three months to ensure the best flavor, although the oil retains acceptable aromatic and visual qualities for up to six months. These findings emphasize the need for balanced storage practices and regular monitoring of chemical and sensory parameters to maintain palm oil quality.

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