



Study of the natural aging of Traditionally produced Shea Butter in three communes of Northern Benin: Pehunco, Sinendé, and Kandi

K. Joachim Dalohoun¹, F.C. Alexis Togbé^{1,2*}, Egbemimon Daniel Ahlonsou^{1,2}, Zeynabou Trall NDA², R. Modéran Toklo¹ and Roger Gérard Josse¹

¹Laboratory of Physical Chemistry, Materials and Molecular Modeling (LCP3M), National University of Sciences, Technologies, Engineering Et Mathematics, Benin

²City and Environment Department, Geosciences, Environment and Applications Laboratory, National University of Sciences, Technologies, Engineering Et Mathematics, Benin
finagnon.togbe@unstim.bj

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Abstract

This study investigates the natural aging of traditionally produced shea butter from the northern Beninese communes of Pehunco, Sinendé, and Kandi over a six-month period. The evolution of key quality parameters, including organoleptic properties, unsaponifiable matter, acid value, and peroxide value was monitored under ambient storage conditions. Results indicated significant temporal changes in all metrics. Organoleptic assessment revealed a progressive intensification of color and the emergence of rancid odors in some samples. A significant decline in unsaponifiable matter content (29.16% to 31.80% decrease), indicative of the degradation of bioactive compounds like sterols and tocopherols, was observed. Furthermore, a gradual increase in peroxide value confirmed the advancement of lipid oxidation. While the acid value showed only a modest rise, remaining within quality thresholds, the overall findings demonstrate that natural aging substantially alters shea butter's physicochemical and sensory profile. This study underscores the necessity of optimizing storage conditions, particularly protection from light and oxygen, to preserve the quality, stability, and bioactive integrity of artisanal shea butter for cosmetic and nutritional applications.

Keywords: Shea butter, unsaponifiable matter, cosmetics.

Introduction

Shea butter, a valuable lipid derived from the kernels of the *Vitellaria paradoxa* tree, has been a cornerstone of traditional medicine and cosmetics in sub-Saharan Africa for centuries¹⁻³. Praised for its exceptional emollient, anti-inflammatory, and healing properties, shea butter has garnered global attention and is now a key ingredient in the cosmetics, pharmaceutical, and food industries⁴⁻⁶. Northern Benin particularly the communes of Pehunco, Sinendé, and Kandi, is recognized for the artisanal production of shea butter, which upholds ancestral techniques and preserves both cultural identity and local biodiversity⁷.

Although extensively used, shea butter is susceptible to physicochemical alterations during storage due to natural aging processes⁸. These transformations can affect its composition, stability, and efficacy, thereby impacting its functional quality in cosmetic and therapeutic applications^{9,10}. Understanding the dynamics of these changes is essential to improving product preservation, extending shelf life, and maintaining consistent quality in both local and export markets.

The present study investigates the natural aging of traditionally processed shea butter in selected communes of northern Benin.

Through a comprehensive analysis, we evaluate changes in chemical composition, oxidative stability, and organoleptic characteristics over time. By elucidating the mechanisms underlying shea butter degradation, our research aims to offer evidence-based recommendations for improved production and storage practices.

The implications of this study are twofold: it advances the fundamental knowledge of lipid aging in shea butter, and it provides actionable data to bolster sustainable practices among local producers. Ultimately, this work aims to secure a more competitive position for traditional shea butter in international trade, while simultaneously reinforcing the socio-economic and cultural foundations of rural West Africa.

Materials and Methods

Shea Butter Sample Collection: Shea butter samples were collected from three municipalities (Pehunco, Sinendé, and Kandi) in northern Benin. Representative samples were obtained from local artisanal producers, with strict documentation of all production stages. Samples were transported in sterile, airtight containers to prevent contamination or degradation.

Organoleptic Analysis: Trained panelists conducted sensory evaluations to assess changes in color, odor, texture, and flavor

during aging. Qualitative descriptors and scoring systems were employed to record observations^{11,12}.

Unsaponifiable Matter Determination: The unsaponifiable fraction was quantified using ISO 3596:2000¹³. Samples were saponified with alcoholic potassium hydroxide (KOH), followed by petroleum ether extraction of non-saponifiable compounds. The residue was dried to constant weight.

Acid Value Determination: Free fatty acid content, indicative of triglyceride hydrolysis during aging was measured via titration with ethanolic KOH (0.1 M) using phenolphthalein as indicator, per NFV 03-906 (AFNOR, 1984) and ISO 660:1999¹⁴.

Peroxide Value Analysis: Lipid oxidation was assessed via AOAC 965.33. Iodide (KI) reacted with peroxides to liberate iodine, which was titrated with sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) to determine peroxide equivalents^{15,16}.

Results and Discussion

Organoleptic parameters: Shea butter samples from the three northern Benin communes were subjected to a natural aging study over a six-month period (January 15 to June 15, 2023), during which they were exposed to environmental conditions in open flasks. Organoleptic assessments, including appearance,

color, texture, odor, and taste were conducted biweekly to monitor temporal changes.

Appearance and Color: At the onset of the study, all shea butter samples exhibited a uniform appearance and a characteristic light-yellow color. During the early weeks of aging, slight oxidation was observed, leading to a mild intensification of the yellow hue and an opaquer appearance. However, after two months of aging, notable differences emerged among the samples from different localities. The sample from Kandi displayed a more intense coloration, while those from Sinendé and Pehunco retained hues closer to the fresh samples (Figure-1).

Texture: Minor textural changes were recorded during the study. In the initial weeks, an increase in firmness and cohesion was observed, likely due to lipid crystallization¹⁷. Overall, the textural changes were subtle and uniform, showing no discernible pattern that could distinguish the samples based on their geographic origin.

Odor and Taste: Odor and taste were evaluated by a panel of trained experts. Initially, all samples exhibited a typical nutty aroma and a mild, slightly sweet taste. As aging progressed, the nutty aroma became more pronounced, indicating a positive evolution in the butter's fragrance. However, after four months, the Pehunco sample began to exhibit a slight rancid odor, possibly due to the degradation of unsaturated lipids¹⁸.

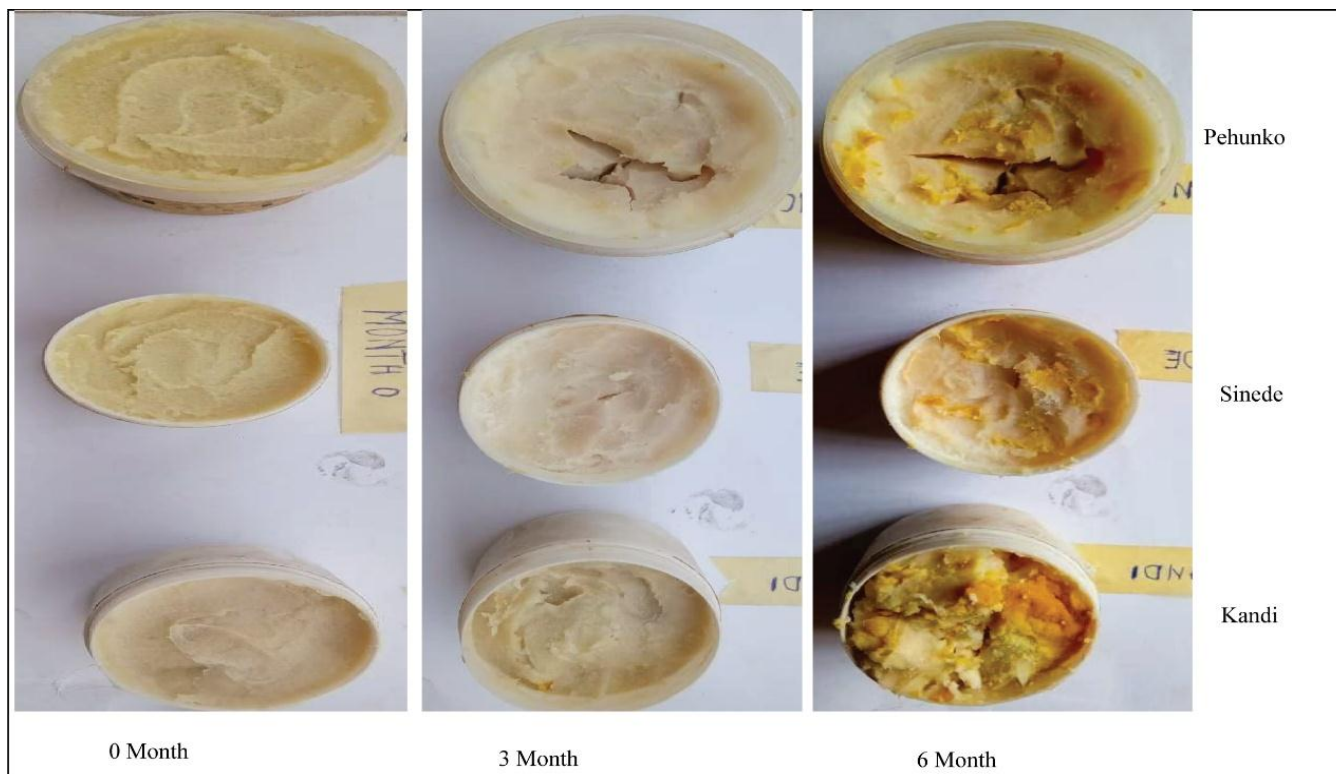


Figure-1: Shea butter samples for 0, 3 and 6 months.

These findings suggest subtle yet significant changes in the sensory characteristics of shea butter over six months of aging. The intensified coloration in the Kandi sample may be linked to increased sun exposure, which could accelerate lipid oxidation. In contrast, the samples from Sinendé and Pehunco maintained coloration closer to that of fresh butter, likely due to different environmental conditions and variations in lipid composition.

Regarding texture, while minor variations occurred over time, these changes were not significant across the three localities. This indicates that lipid crystallization may not play a major role in shea butter aging over a six-month period.

Concerning odor and taste, the nutty aroma intensified during the early months of aging. However, the slight rancidity observed in the Pehunco sample after four months raises concerns about the stability of unsaturated lipids under specific climatic conditions.

Unsaponifiable Matter Index: The quality and stability of shea butter are largely determined by its unsaponifiable fraction, a portion rich in bioactive constituents like sterols, tocopherols, and terpenes that are responsible for its beneficial effects¹⁹. Monitoring the evolution of this index during storage provides valuable insights into the oxidative stability and aging behavior of shea butter.

The unsaponifiable matter index was measured in shea butter samples from Pehunco, Sinendé, and Kandi over a six-month period. This index quantifies the portion of shea butter that cannot be converted into soap during saponification, including sterols, tocopherols, and terpenes²⁰.

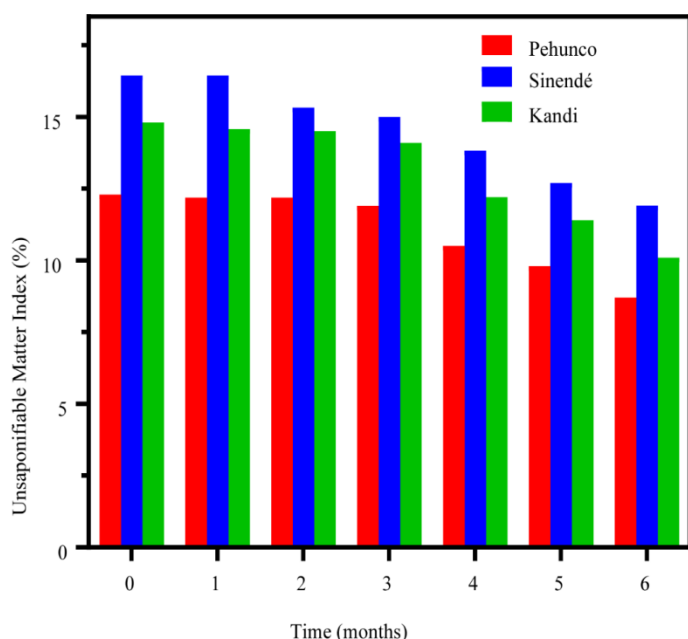


Figure-2: Variation of the Unsaponifiable Matter Index in Shea Butter Samples over Time.

Initial unsaponifiable matter (Figure-2) varied significantly across regions ($p < 0.001$), with Sinendé ($16.45 \pm 0.05\%$) > Kandi ($14.81 \pm 0.01\%$) > Pehunco ($12.295 \pm 0.005\%$). After one month of exposure to natural climatic conditions, Pehunco ($12.19 \pm 0.01\%$) and Sinendé ($16.45 \pm 0.05\%$) showed no significant variation in the unsaponifiable matter ($p > 0.05$), while Kandi experienced a small but significant decrease to $14.58 \pm 0.02\%$ ($p < 0.05$). These minor variations may be due to natural heterogeneity in the lipid composition of artisanal shea butter. All sites exhibited significant time-dependent reductions in unsaponifiable matter ($p < 0.05$), with final 6-month values declining to $8.71 \pm 0.01\%$ (Pehunco), $11.91 \pm 0.01\%$ (Sinendé), and $10.01 \pm 0.1\%$ (Kandi); representing 29.16% (average 9.84%), 27.6% (average 11.72%), and 31.80% (average 11.54%) decreases from baseline, respectively.

Linear regression confirmed the significant time-dependent decrease ($R^2 = 0.868 - 0.965$, $p < 0.001$ for all sites), with the most pronounced reduction occurring between months 4–6 (Figure-5a).

The observed progressive decline did not correlate with the initial concentration (Figure-5d); and is likely linked to oxidative degradation of thermolabile and photo-sensitive components, such as tocopherols and phytosterols, particularly under the influence of environmental conditions including heat, light, and oxygen exposure²¹. The more pronounced degradation in the Kandi sample may be attributed to more intense sunlight exposure or differences in microclimatic conditions.

Overall, this analysis highlights the sensitivity of the unsaponifiable fraction to aging processes, which could compromise the functional and cosmetic properties of shea butter over time. These findings underline the importance of optimizing storage conditions and packaging to preserve the bioactive integrity of shea butter during shelf life.

Acid Value: Hydrolytic degradation in shea butter is primarily assessed through the acid value (AV), a parameter that reflects the concentration of free fatty acids (FFAs) generated by triglyceride hydrolysis²². This process, typically accelerated by enzymatic action or exposure to heat and humidity, results in increased AVs, a direct indicator of rancidity that compromises the butter's organoleptic and nutritive value²³. Over a six-month period simulating natural aging, shea butter samples sourced from Pehunco, Sinendé, and Kandi were analyzed monthly for acid value, with the first measurement taken at baseline (post-production). The objective was to assess the rate and extent of hydrolysis of triglycerides under typical artisanal storage conditions.

The quality and stability of shea butter are inversely related to its acid value, a parameter that measures the extent of free fatty acid release. Elevated acid values typically signify degradation of unsaturated fatty acids, whereas lower values are indicative of superior product quality.

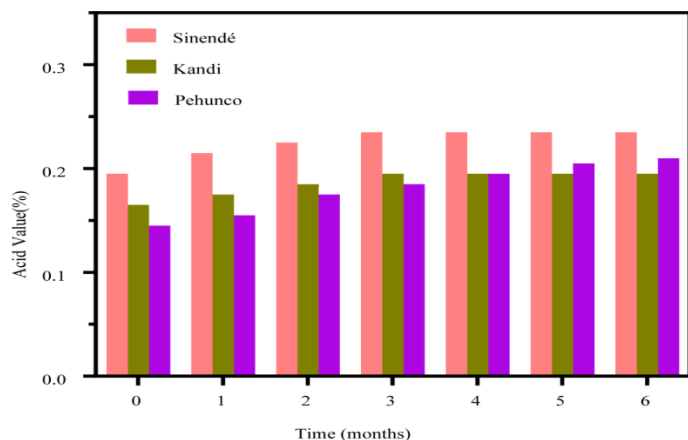


Figure-3: Variation of the Acid content in Shea Butter Samples over Time.

Initial acid value analysis of freshly produced shea butter revealed significant regional variation ($p < 0.001$), with Pehunco (0.145 ± 0.005) showing significantly lower free fatty acid content than Sinendé (0.195 ± 0.005) and Kandi (0.165 ± 0.005). These values confirm the high quality of fresh product, as all fell below the 0.5% threshold for premium-grade sheabutter²⁴.

Following six months of storage under ambient conditions, a modest but statistically significant increase ($p < 0.05$) in acid values was recorded across all samples (Figure-3). Specifically, the Sinendé and Kandi samples reached acid values of 0.235 ± 0.005 and 0.195 ± 0.005 , respectively, while the Pehunco sample increased to 0.21. This slight and linear increase ($R^2 = 0.693 - 0.936$, $p < 0.05$), as shown by (Figure-5b) represent 18.73%, 12.96 % and 11.152% of baselines respectively for Pehunco, Sinendé, and Kandi.

The gradual rise in acidity didn't display any correlation with the initial content ($p > 0.05$; Figure-5e) and is likely attributable to hydrolytic degradation of triglycerides, driven by exposure to environmental factors such as oxygen and humidity. Under these circumstances, triglycerides break down, releasing free fatty acids and causing a time-dependent increase in acid value.

Importantly, despite this increase, the acid values remained within a low range, underscoring the overall chemical stability of the shea butter throughout the storage period affirming its suitability for prolonged shelf life in these regions. Nonetheless, the findings highlight the importance of adopting appropriate storage conditions, particularly maintaining dryness and minimizing exposure to air to reduce fatty acid hydrolysis and preserve product quality.

Peroxide Value: The peroxide value (meq O_2 /kg) is a key indicator for evaluating lipid oxidation and the onset of rancidity in shea butter during storage. This parameter quantifies the levels of peroxides and hydroperoxides, which are the primary chemical species generated during the early phase of lipid oxidation²⁵.

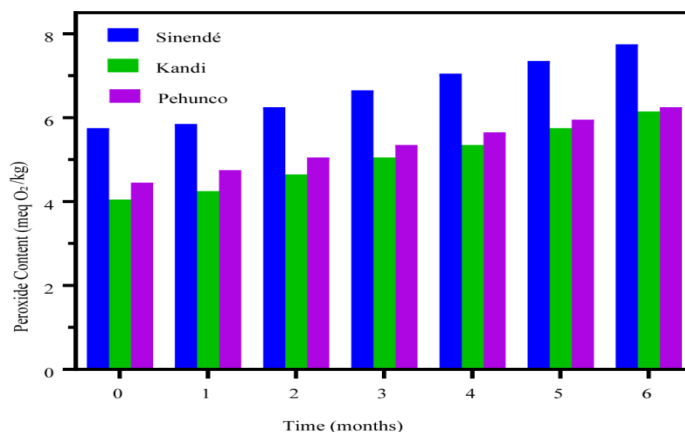


Figure-4: Variation of the Peroxide content in Shea Butter Samples over Time.

As shown in Figure-4, the peroxide value quantifies the extent of lipid oxidation in shea butter by measuring the peroxides generated through reaction with atmospheric oxygen. At the beginning of the study (time 0), the shea butter samples from Pehunco, Sinendé, and Kandi exhibited peroxide values of 4.45 ± 0.05 meq/kg, 5.75 ± 0.05 meq/kg, and 4.05 ± 0.05 meq/kg, respectively, significantly different each other ($p < 0.05$). These initial values are relatively, indicating minimal oxidation in the fresh samples²⁴.

During the early months of storage, a gradual increase in peroxide values was observed across all three localities, suggesting a progressive formation of peroxides resulting from the oxidation of unsaturated lipids in the shea butter under exposure to oxygen and light. Environmental factors such as direct sunlight exposure in open containers likely contributed to this oxidative process.

By the sixth month of storage, a more pronounced and statistically significant increase ($p < 0.05$) in peroxide values was recorded, reaching 6.25 ± 0.05 meq/kg, 7.75 ± 0.05 meq/kg, and 6.15 ± 0.05 meq/kg for Pehunco, Sinendé and Kandi, respectively (Figure). This marked and linear rise ($R^2 = 0.984 - 0.993$; $p < 0.05$) as shown by Figure-5c may be attributed to an acceleration of oxidation reactions and increased degradation of unsaturated lipids. Although not statistically significant ($p > 0.05$), there is a noticeable correlation between the initial peroxide content and the increase over time ($R^2 = 0.6897 - 0.9997$ for the six months) as displayed by (Figure-5f).

Over time, the shea butter samples demonstrated progressively higher peroxide values, indicating a gradual deterioration of product quality and stability. The development of rancidity, evidenced by these changes, negatively impacts the butter's organoleptic and nutritional characteristics. Therefore, ensuring proper storage is paramount to preserving its overall quality and efficacy.

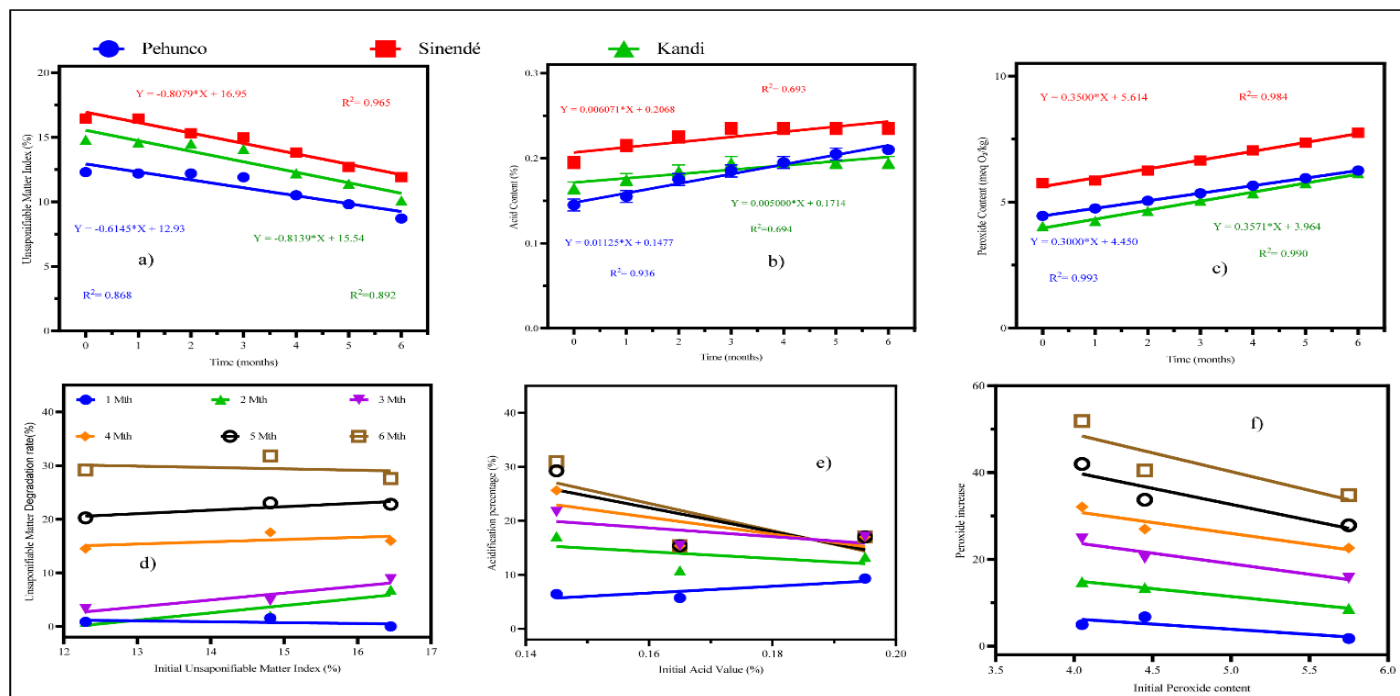


Figure-5: Linear regression of unsaponifiable matter, acid value, and peroxide value of shea butter and their correlation to initial concentrations.

Conclusion

This study on the aging of artisanal shea butter from the municipalities of Pehunco, Sinendé, and Kandi in northern Benin highlighted significant changes in organoleptic parameters, unsaponifiable content, and peroxide value over time. The results demonstrated that the natural aging of shea butter leads to variations in its sensory and chemical properties, which may have important implications for its quality and stability.

Regarding organoleptic properties, the study revealed notable changes in color, odor, and taste of shea butter during the six-month aging period. These variations are likely attributable to oxidation reactions and the degradation of unsaturated compounds, as well as interactions with environmental conditions such as exposure to sunlight and air in open containers. These findings underscore the importance of considering storage duration in the formulation and use of shea butter to preserve its sensory and nutritional qualities.

The unsaponifiable index, a key indicator of shea butter quality, also showed a significant decline during aging. A progressive decrease was observed in samples from all three locations, which may be linked to the degradation of sterols, tocopherols, and other essential unsaponifiable compounds responsible for the beneficial properties of shea butter. These results emphasize the need to account for storage time to maintain the quality and efficacy of shea butter.

Similarly, the peroxide value, an indicator of lipid oxidation, progressively increased over the aging period. This rise reflects the formation of peroxides resulting from the oxidation of unsaturated lipids in the presence of oxygen and light. These findings highlight the critical importance of proper storage conditions to prevent rancidity and maintain shea butter stability.

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