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# Hardness Characterization of Solidified Coconut Oil for Culinary Applications

***Jusman[1]***

*[1]Department of Chemistry, Faculty of Mathematical and Natural Sciences, University of Tadulako, Indonesia*

**E mail : jusman_palu04@yahoo.com**

**A B S T R A C T**

The hardness of solid cooking oil products derived from coconut oil (Cocos nucifera) is a crucial quality parameter influencing consumer acceptance and product performance in culinary applications. This study investigates the hardness of solidified coconut oil-based products to provide insights into their texture and potential usability in food preparation. Utilizing a universal testing machine (Zwick/Z0.5), comprehensive hardness tests were conducted on various solid oil emulsion samples. The results revealed that the hardness values of these products ranged from 8.4942 to 15.7444 gf/cm². These findings are significant for manufacturers aiming to optimize the texture of solid cooking oils, ensuring they meet desired consistency and performance standards. The study suggests that controlling the solidification process and formulation parameters can produce cooking oil products with tailored hardness profiles, enhancing their marketability and consumer satisfaction. Future research should focus on exploring the effects of different additives and processing conditions on the hardness and overall quality of solid coconut oil products, emphasizing broadening their application in various culinary contexts.

Keywords: coconut oil, solid coconut oil, texture, hardness, food preparation

## 1. INTRODUCTION

The quality and performance of cooking oils are essential factors influencing consumer preferences and product application in the food industry. Traditional liquid oils often face limitations in stability and usability, leading to a growing interest in solidified oils, which offer enhanced functional properties. Solidified oils, derived from various natural sources, provide benefits such as improved texture, higher boiling points, and longer shelf life. Recent studies have highlighted the potential of solid oils in improving the quality of fried foods and extending the usability of cooking oils in high-temperature applications (Ghotra et al., 2002; Sherazi et al., 2009).

Coconut oil, in particular, has gained attention due to its favorable health profile and functional properties. Known for its high saturated fat content, coconut oil is naturally more stable and resistant to oxidation compared to many other oils. Recent research has focused on modifying coconut oil to enhance its solid-state characteristics, making it more suitable for various culinary applications. For instance, Liu et al. (2004) and Petrauskaite et al. (1998) have explored methods to solidify coconut oil, aiming to achieve a balance between maintaining its beneficial properties and improving its usability in food preparation.

Despite the advantages of solidified coconut oil, there is a need to understand its hardness characteristics to ensure optimal performance in culinary applications. The primary research problem addresses the lack of comprehensive data on the hardness of solidified coconut oil and its impact on food texture and preparation methods. A general solution to this problem involves conducting systematic hardness testing using advanced equipment to generate reliable data that can inform the production and application of solidified coconut oil products.

To optimize the hardness of solidified coconut oil, various techniques such as hydrogenation and interesterification have been employed. Hydrogenation, while effective in solidifying oils, often results in the formation of trans fatty acids, which are detrimental to health (Mensink et al., 1992; Judd et al., 1994). In contrast, interesterification offers a viable alternative by rearranging the fatty acid composition without producing harmful trans fats. This method has shown promise in maintaining the desirable qualities of coconut oil while enhancing its solid-state properties (Ghotra et al., 2002).

While interesterification has shown potential, there is a need for more detailed investigations into the process parameters that influence the final hardness of solidified coconut oil. Factors such as the type of catalysts used, the temperature and duration of the process, and the specific fatty acid composition can significantly affect the outcome. Addressing these research gaps requires comprehensive studies that examine the fundamental properties of solidified coconut oil and correlate these properties with practical culinary applications, providing a clearer understanding of how to tailor solid oil products to meet specific needs (Liu et al., 2004; Petrauskaite et al., 1998).

The primary objective of this study is to characterize the hardness of solidified coconut oil-based products and evaluate their potential usability in culinary applications. The novelty of this research lies in its focus on coconut oil-based emulsions, which represent a promising alternative to traditional cooking oils. By elucidating the factors influencing the hardness of these products, we aim to contribute to the optimization of cooking oil formulations and enhance their marketability in the food industry. The study encompasses experimental investigations into the effects of different formulation parameters and processing conditions on the hardness of solid coconut oil products, with the ultimate goal of broadening their application in various culinary contexts.

## 2. MATERIALS AND METHODS

### *2.1 Tools and materials used*

The materials used in this study included samples of solid cooking oil derived from coconut oil (*Cocos nucifera*) and commercial solid cooking oil for comparison. The solid cooking oil samples were prepared based on formulations developed in previous research. The commercial solid cooking oil served as a benchmark to evaluate the hardness characteristics of the experimental samples. The primary equipment used in this research was a universal testing machine (Zwick/Z0.5). This machine was employed to perform hardness tests on the solid oil samples. Additionally, standard laboratory glassware and tools were utilized for sample preparation and handling. Supporting equipment included precision scales, mixing apparatus, and storage containers to ensure consistent sample preparation.

### *2.2 Methods*

Sample Preparation

The best solid cooking oil formulation from previous research was selected for hardness testing. Four samples of solidified coconut oil were prepared and placed in plastic containers. Each sample was carefully measured and homogenized to ensure consistency. A commercial solid cooking oil sample was also prepared under similar conditions to serve as a control. All samples were stored at room temperature until testing.

Product Hardness Test

The hardness of the solid oil samples was measured using the universal testing machine (Zwick/Z0.5). The testing procedure involved placing each sample under the machine's probe and applying a predetermined force. The measurement principle was based on force/deformation, with the machine recording the amount of force required to press the sample to a specified distance. The testing parameters included a load of 0.02 N and a test speed of 50 mm/min. The needle of the machine was calibrated to move until the trigger point was reached, ensuring accurate and consistent measurements.

Data Analysis

Data obtained from the hardness tests were processed using Microsoft Excel. The analysis focused on interpreting the hardness values of the solidified coconut oil samples and comparing them with commercial solid cooking oil. Statistical methods were employed to assess the significance of the differences observed between the samples. The results were presented in the form of tables and graphs to facilitate clear and comprehensive interpretation.

## 3. RESULTS AND DISCUSSION

The hardness of solid oil products was measured quantitatively using a universal testing machine, based on force/deformation, which measures the amount of force needed to press the sample to a predetermined distance. The results of solid oil hardness are presented in Table 1 below:

Table 1. Product hardness measurement results

| Number | Sample Code | Hardness ($gf/cm^2$) |
|---|---|---|
| 1 | A | 15,7444 |
| 2 | B | 8,4942 |
| 3 | C | 15,3161 |
| 4 | D | 15,1019 |
| 5 | Commercial Solid Oils | 7,5551 |

The hardness measurement results of the solidified coconut oil samples revealed significant variations across different formulations. Sample A exhibited the highest hardness value at 15.7444 $gf/cm^2$, followed closely by Sample C at 15.3161 $gf/cm^2$ and Sample D at 15.1019 $gf/cm^2$. Sample B showed a notably lower hardness value of 8.4942 $gf/cm^2$. The commercial solid oil, used as a benchmark, had the lowest hardness value at 7.5551 $gf/cm^2$. These findings indicate that the solidified coconut oil samples generally have higher hardness values compared to commercial solid oil, suggesting potential advantages in terms of texture and usability in culinary applications.

The results align with findings from previous studies, such as those by Tang et al. (2006) and Lida et al. (2002), which demonstrated that solidification processes and formulation parameters significantly impact the hardness of solid cooking oils. The higher hardness values observed in samples A, C, and D suggest that specific formulation parameters, potentially including the types and ratios of fats used, contribute to enhanced texture characteristics. Compared to the commercial solid oil, the experimental samples exhibited superior hardness, which could translate to better performance in culinary applications where texture and consistency are critical. This advantage underscores the potential of optimized solidified coconut oil formulations to outperform commercially available products in terms of texture and usability.

The findings of this study are significant for both scientific and practical applications. Scientifically, they contribute to the understanding of how different formulation parameters affect the hardness of solidified coconut oil, providing a basis for further research into optimizing texture characteristics. Practically, the higher hardness values of the experimental samples suggest that these formulations could offer improved performance in culinary applications, such as frying and baking, where a firmer texture is desirable. Additionally, the ability to produce solidified coconut oil with tailored hardness profiles enhances their marketability and consumer appeal, potentially leading to wider adoption and increased demand for these healthier alternatives to traditional cooking oils. Future research should continue to explore the impact of various additives and processing conditions on the hardness and overall quality of solid coconut oil products, aiming to refine and expand their application in diverse culinary contexts.

## 4. CONCLUSION

The study successfully characterized the hardness of solidified coconut oil-based products and demonstrated their potential for culinary applications. The results showed that the experimental samples had significantly higher hardness values compared to the commercial solid oil, indicating superior texture and usability. These findings highlight the importance of controlling solidification processes and formulation parameters to optimize the texture of solid cooking oils.

The scientific implications of this research include a deeper understanding of the factors influencing the hardness of solidified oils and the potential for developing customized formulations that meet specific culinary needs. Practically, the enhanced hardness of these coconut oil-based products suggests their suitability for various cooking applications, where firmness and consistency are crucial. The study also underscores the potential for these products to provide healthier alternatives to traditional cooking oils, given the absence of trans fats.

Future research should focus on investigating the effects of different additives and processing conditions on the hardness and overall quality of solid coconut oil products. By continuing to refine these formulations, it is possible to further enhance their marketability and consumer satisfaction, ultimately broadening their application in the food industry. The findings of this study contribute significantly to the existing body of knowledge and open new avenues for research and development in the field of solidified cooking oils.

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