

The Effect of Rosemary (*Rosmarinus officinalis* L.) Antioxidant Extract on Palm Cooking Oil

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ABSTRACT

Palm cooking oil is highly susceptible to quality deterioration due to lipid oxidation and degradation reactions during heating. This is characterized by an increased peroxide value and decreased iodine value. This study aimed to evaluate the potential of rosemary extract as a natural antioxidant to maintain palm cooking oil quality. The research used a Completely Randomized Design (CRD) with six concentrations of rosemary extract (0, 200, 400, 600, 800, and 1000 ppm) with three replications. Data were analyzed using ANOVA and a 5% DMRT. The results showed that adding rosemary extract significantly ($P < 0.05$) decreased peroxide value (from 5.587 to 5.084 mEq/kg), increased iodine value (from 59.600 to 60.089), increased cloud point, and color value. Conversely, treatments had no significant effect ($P > 0.05$) on moisture content and free fatty acids. The RSA-DPPH test also confirmed good free radical scavenging activity. In conclusion, the 1000 ppm concentration is the best treatment to effectively suppress the oxidation rate, indicating rosemary extract's high potential for application as a natural antioxidant in palm cooking oil.

Keywords: antioxidant; cooking oil; lipid oxidation; oil quality; rosemary

I. INTRODUCTION

Palm oil is one of the most widely consumed vegetable oils globally and serves as a primary staple in the food industry, particularly as cooking oil (Ketaren, 2012). In its physical and chemical structure, palm oil contains a balanced composition of nearly 50% saturated fatty acids, mainly palmitic acid, and 50% unsaturated fatty acids, such as oleic and linoleic acids (Badan Standardisasi Nasional, 2012). This unique composition provides relatively good stability; however, the oil remains highly susceptible to quality deterioration when subjected to extreme processing conditions.

During frying or high-temperature heating, cooking oil is continuously exposed to oxygen, moisture, and heat, triggering complex degradation reactions, including autoxidation, thermal oxidation, and hydrolysis (Haslina et al., 2020). Lipid oxidation is the most critical reaction, as it initiates the formation of free radicals and primary oxidation products such as hydroperoxides. As the reaction progresses, these compounds decompose into secondary products like aldehydes and ketones, which lead to the development of rancidity, darkening of the oil color, a decrease in the iodine value, and a significant increase in the peroxide value (Ketaren, 2012). This oxidative deterioration not only reduces the nutritional and sensory quality of the fried food but also produces toxic compounds that can adversely affect human health upon continuous consumption.

To inhibit the rate of oxidative degradation and extend the shelf life of cooking oil, the addition of antioxidants is a crucial intervention. Antioxidants function by donating hydrogen atoms to stabilize free radicals, thereby terminating the destructive oxidation chain reaction (Rohadi et al., 2016). While synthetic antioxidants are commonly utilized in the food industry due to their high stability, growing health concerns regarding their long-term side effects and shifting consumer preferences have driven a strong demand for safer, natural antioxidant alternatives (Haslina et al., 2020).

One botanical source with significant potential to replace synthetic antioxidants is rosemary (*Rosmarinus officinalis* L.). Rosemary leaves are exceptionally rich in phenolic bioactive compounds, particularly carnosic acid, carnosol, and rosmarinic acid, which have been widely proven to exhibit strong free radical scavenging activities (Nieto et al., 2018). Although the general antioxidant capacity of rosemary is well recognized, specific studies determining its optimal concentration to effectively maintain the oxidative stability of palm cooking oil under thermal stress remain limited. Therefore, this study aims to evaluate the effect of varying concentrations of rosemary extract on the chemical properties, physical characteristics, and antioxidant activity of palm cooking oil, ultimately determining the most optimal formulation for practical application.

II. MATERIALS AND METHODS

Materials and Tools

The materials used in this study included fresh super sweet corn (The main materials used in this study included commercial palm cooking oil, rosemary

(*Rosmarinus officinalis* L.) leaf extract, and chemical reagents (such as DPPH) for laboratory analysis. The measuring tools and instruments used included standard laboratory glassware (Pyrex), analytical balance, heater, oven, as well as color testing and titration instruments for the chemical and physical analysis of the oil.

Experimental Design

This study employed a Completely Randomized Design (CRD) with a single factor, which was the variation in the concentration of rosemary extract addition. Each treatment was replicated three times, followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. The treatments used were extract concentrations of: P0 (0 ppm/control), P1 (200 ppm), P2 (400 ppm), P3 (600 ppm), P4 (800 ppm), and P5 (1000 ppm).

Research Procedure

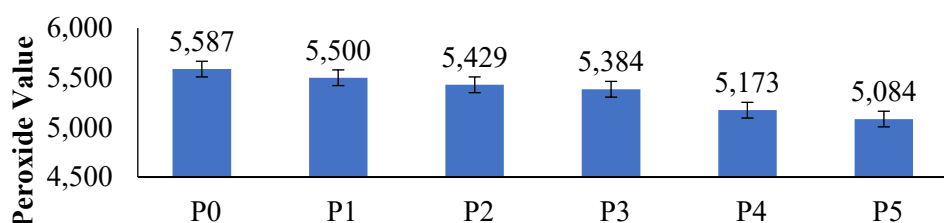
The research process began with the preparation and extraction of rosemary leaves to obtain a concentrated antioxidant macerate. The obtained rosemary extract was then added to the palm cooking oil samples according to the predetermined treatment concentrations (P0 to P5). After the conditioned mixing and heating process, the oil samples were analyzed. The testing parameters included chemical and physical analysis consisting of moisture content, free fatty acids, peroxide value, iodine value, cloud point, color intensity, and antioxidant activity testing of the extract using the RSA-DPPH method.

III. RESULT AND DISCUSSION

Antioxidant Activity

The antioxidant activity test of rosemary extract was conducted using the DPPH Radical Scavenging Activity (RSA) method. Based on the test results, the applied rosemary extract showed an average inhibition percentage of 59.05%. This activity is closely related to the high content of phenolic and diterpene compounds in rosemary leaves, especially carnosic acid, carnosol, and rosmarinic acid. These bioactive compounds work effectively by donating their hydrogen atoms to stabilize DPPH free radicals, thereby inhibiting the chain reaction of radical formation in the oil.

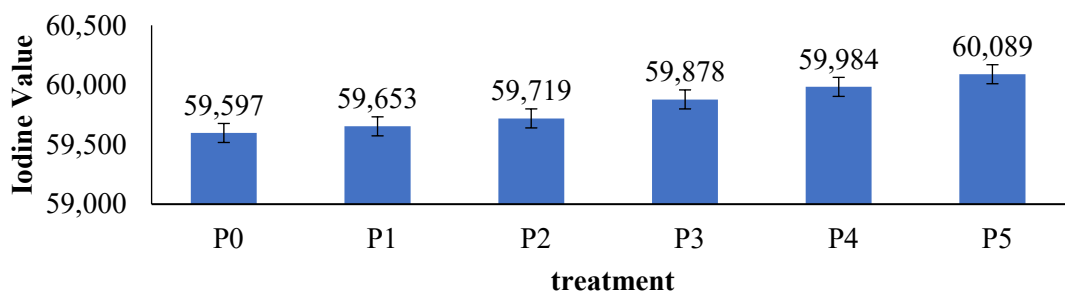
Peroxide Value



The analysis of variance (ANOVA) showed that the addition of rosemary extract had a significant effect ($p < 0.05$) on decreasing the peroxide value of palm cooking oil. The DMRT results indicated that the highest peroxide value was found in the control treatment without extract (P0) at 5.587 mEq/kg and continued to decrease significantly as the extract concentration increased, reaching the lowest point in the P5 treatment at 5.084 mEq/kg.

Although the best treatment at a concentration of 1000 ppm (P5) was able to lower the peroxide value, this value was still above the maximum limit set by the Indonesian National Standard (SNI 3741:2013) for fresh cooking oil (maximum 2 mEq O₂/kg). The overall high peroxide value is suspected to be a result of the thermal treatment process during testing, which accelerated the autoxidation rate. Nevertheless, although it has not met the SNI standard for fresh oil, the addition of rosemary extract proved to be significantly effective in suppressing the rate of oxidative damage when compared to the control sample (P0).

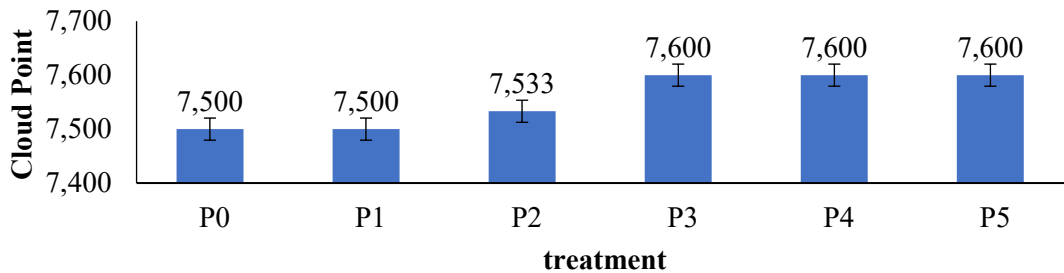
Iodine Value



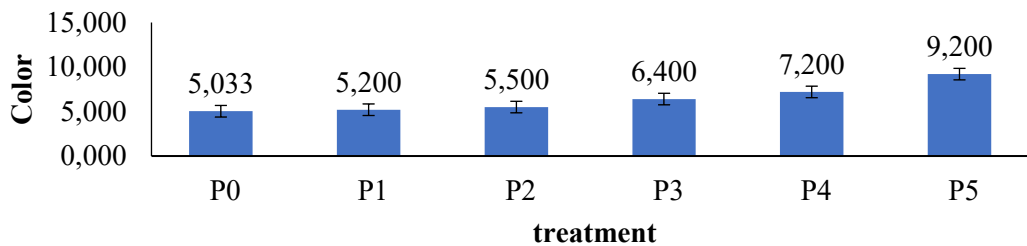
The results showed that the addition of rosemary extract had a significant effect ($p < 0.05$) in maintaining the iodine value of the oil. The lowest iodine value was recorded in the control sample P0 (59.600), while the highest value was obtained in the P5 treatment (60.089). The increase and stability of the iodine value in the P5 treatment

indicate that the rosemary extract was able to prevent oxidative damage optimally, particularly in protecting the double bonds in unsaturated fatty acids from oxygen binding.

Physical Properties (Cloud Point and Color)



The analysis of variance showed a significant difference ($p < 0.05$) in the cloud point. The lowest cloud point was found in treatments P0 and P1 at 7.5°C, and experienced an increase to 7.6°C in treatments P3, P4, and P5.



For the color parameter, the addition of the extract had a significant effect ($p < 0.05$) on the red color value. The lowest color intensity was obtained in the P0 control (5.033) and increased to 9.200 in the P5 treatment. Although P5 provided the best chemical antioxidant protection, the high concentration of the extract caused the oil color to become much darker due to the natural pigments inherent in rosemary leaves. Visually, this makes the oil in the P5 treatment fail to meet the bright color standard set by the SNI.

Moisture Content and Free Fatty Acids

The analysis showed that all treatments had no significant effect ($p > 0.05$) on the moisture content and free fatty acids. The moisture content of all samples was in the range of 0.010-0.011%, and free fatty acids averaged 0.074%. This free fatty acid value meets the maximum limit of SNI 3741:2013, which is a maximum of 0.3%. This confirms that oil damage is dominated by the oxidation pathway, and the addition of extract up to 1000

ppm did not trigger the hydrolysis reaction (breakdown of fatty acid chains by water) during heating.

Moisture Content

Treatment	Moisture Content
P0	0,011 ± 0,00 ^a
P1	0,010 ± 0,00 ^a
P2	0,010 ± 0,00 ^a
P3	0,011 ± 0,00 ^a
P4	0,010 ± 0,00 ^a
P5	0,010 ± 0,00 ^a

Note: Values followed by the same letter in the same column are not significantly different ($p>0.05$).

Free Fatty Acids

Treatment	Free Fatty Acids
P0	0,074 ± 0,00 ^a
P1	0,074 ± 0,00 ^a
P2	0,074 ± 0,00 ^a
P3	0,074 ± 0,00 ^a
P4	0,074 ± 0,00 ^a
P5	0,074 ± 0,00 ^a

Note: Values followed by the same letter in the same column are not significantly different ($p>0.05$).

CONCLUSION

- The addition of rosemary (*Rosmarinus officinalis* L.) extract had a significant effect in suppressing the oxidative damage rate of palm cooking oil. The 1000 ppm concentration treatment (P5) provided the most optimal oxidative stability chemically, marked by the lowest peroxide value (5.084 mEq/kg) and the highest iodine value (60.089). However, application at this concentration has a physical drawback, causing the oil color to darken due to the natural pigments of the extract.
- It is suggested for future research to perform purification stages on the rosemary leaf extract before application, to separate natural color pigments from its antioxidant

bioactive compounds so that the physical quality of the oil still meets the SNI standard. Furthermore, further testing is needed regarding the direct application of this oil on food products to obtain more optimal results.

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