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ANALYSIS OF BIAS AND PURITY INDICES IN PACKAGED COOKING OIL AND BULK COOKING OIL USING THE DIFFRACTION GRID METHOD

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Abstract. *Cooking oil is a fundamental daily necessity, and both packaged and bulk oils are susceptible to structural changes and contamination that can influence the bias index. This research aims to analyze the purity of packaged and bulk cooking oil, investigate the relationship between the bias index and usage time, and identify factors influencing the bias index in both types of cooking oil using the diffraction grid method. The study revealed bias indices produced from packaged cooking oil before usage, after 10 minutes of usage, and after 15 minutes of usage, namely 5.08×10^8; 5.22×10^8 and 3.94×10^8, respectively. The bias indices from bulk cooking oil under the same conditions were 4.68×10^8; 3.61×10^8 and 3.37×10^8, respectively. Based on the research results, it is evident that packaged cooking oil exhibits a higher level of purity compared to bulk cooking oil. The relationship between the bias index and usage time is inversely proportional, indicating that the longer the cooking oil is used, the smaller the Refractive Index value becomes.*
Keywords*: oil, index, diffraction*

Abstrak. Minyak goreng merupakan salah satu kebutuhan pokok sehari-hari, baik minyak kemasan maupun curah rentan terjadi perubahan struktural dan kontaminasi yang dapat mempengaruhi indeks bias. Penelitian ini bertujuan untuk menganalisis kemurnian minyak goreng kemasan dan minyak goreng curah, menganalisis hubungan indeks bias terhadap waktu pemakaian, menganalisis faktor apa saja yang mempengaruhi indeks bias pada minyak goreng kemasan dan minyak goreng curah dengan metode kisi difraksi. Dari penelitian yang dilakukan diperoleh Indeks bias yang dihasilkan dari minyak goreng kemasan sebelum pemakaian, setelah pemakaian 10 menit dan setelah pemakaian 15 menit berturut-turut, yaitu 5,08 $\times10^8$; 5,22 $\times10^8$

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dan 3,94 $\times10^8$. Indeks bias yang dihasilkan dari minyak goreng kemasan sebelum pemakaian, setelah pemakaian 10 menit dan setelah pemakaian 15 menit berturut-turut, yaitu 4,68 $\times10^8$; 3,61 $\times10^8$ dan 3,37 $\times10^8$. Berdasarkan hasil penelitian yang dilakukan menujukkan bahwa minyak goreng kemasan memiliki tingkat kemurnian yang lebih tinggi di banding minyak goreng curah. Hubungan indeks bias terhadap waktu pemakaian adalah berbanding terbalik, semakin lama waktu pemakaian minyak goreng, maka semakin kecil nilai indeks biasnya.
Kata kunci: minyak, indeks, difraksi

BACKGROUND

Cooking oil is a food ingredient primarily composed of triglycerides. It serves as a heat transfer medium, enhances flavor, and also contributes to caloric content. The quality of cooking oil is determined by its smoke point, representing the temperature at which the oil begins to smoke during heating (Ariani, 2017).

Vegetable oil contains essential fatty acids or unsaturated fatty acids that can undergo degradation when oxidized due to exposure to air and high temperatures. Used cooking oil has the potential to generate trans fatty acids, contributing to coronary heart disease and elevated cholesterol levels. Despite undergoing multiple filtration processes, this does not eliminate substances that emerge after the oil has been repeatedly heated at high temperatures (Pain, 2005).

A method that can be employed to assess the quality of cooking oil is the refractive index. By measuring this refractive index, we can ensure the quality and purity of the cooking oil. This research aims to analyze the purity of packaged and bulk cooking oil, investigate the relationship between refractive index and duration of use, and identify the factors influencing the refractive index in both packaged and bulk cooking oil. Through this research, it is anticipated that the study will assist the public in comprehending the quality and standards of cooking oil available in the market (Savangatin, 2016).

The refractive index is defined as the ratio of the speed of light in a vacuum (c) to the speed of light in a specific medium (v). The equation is expressed as follows:

$$\boldsymbol{n = \frac{c}{v}} \qquad (1)$$

Information :

n = refraction indeks

c = the speed of light in a vacuum (m/s^2)

v = the speed of light in a medium (m/s^2)

(Rahardjo, 2017).

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Light can be interpreted as a segment of the electromagnetic spectrum perceptible to the human eye. According to Einstein, light exhibits both wave and particle characteristics. It can be regarded as a wave due to its ability to undergo reflection, interference, and diffraction (Aswinda, 2016).

Viscosity is the outcome of friction occurring between adjacent layers within a liquid substance. In gases, viscosity is attributed to collisions among gas molecules, whereas in liquids, viscosity arises from cohesive forces among molecules within the liquid (Giancoli, 2014).

A diffraction grating is a tool used to measure the wavelength, consisting of a series of thin slits equidistantly spaced on a plane. The incident light is perpendicular to the diffraction grating (Wahyuni, 2017).

A diffraction grating can be considered as a tool for analyzing light based on the concept of diffraction. Light passing through a diffraction grating undergoes beam spreading, which can cause light to deviate and result in interference among the beams (Istajarul, 2017).

According to Thomas Young, light is considered as a wave (wave theory of light), where the process of light interference occurs. Young demonstrated this experiment with two slits allowing parallel light rays to pass through two separate slits onto an opaque screen. A detector screen is placed on the opposite side. After the light beam passes through the two slits, a pattern of dark and bright fringes emerges on the screen (Mukhlis, 2021).

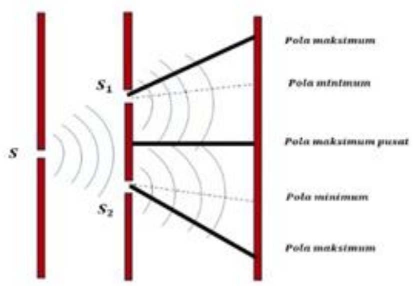

Figure 1. Young's experiment

To accurately determine the location of the fringes on the screen, the grating with spacing d (the slit separation) is much narrower compared to the wavelength of light, and the rays from each slit are parallel to the divergent angle. The distance between two narrow slits for the direction of parallel rays is 1/2 λ when the pattern of bright lines (constructive interference) is formed, as opposed to when encountering the dark edges (destructive interference) where this distance is also 1/2 λ, and its magnitude is given by d sin θ.

With the formula above, bright lines emerge. Bright lines or bright patterns are a result of constructive interference and have the following equation:

$$d \sin \theta = m\lambda \qquad \text{with value } m = 1,2,3,4,....n \qquad (2)$$

The value m represents the order or edge of interference. If it is the first order (m=1), then for a compound slit, interference will occur when $d \sin \theta = (m + 1/2)\lambda$, where the value of m =1, 2, 3, 4,…n (Hidayat, 2012).

Interference occurs when two or more waves combine to form a new wave. Constructive interference takes place when two integrated waves are in phase (mutually reinforcing), resulting in a new wave with maximum amplitude. If the two integrated waves are out of phase, destructive interference (mutual damping) occurs, leading to reduced amplitude (Tsalatsin, 2014).

RESEARCH METHODS

In this research, bulk cooking oil and packaged cooking oil are required as the media to be investigated. A transparent square-shaped container serves as the vessel for the cooking oil. A stopwatch is used to measure the duration, a stove and portable pan function as tools to heat the oil, a power supply provides the voltage source, a diffraction grating is employed to diffract light for data collection, a white screen captures the projection from the laser beam, a meter measures the distance from the grating to the screen and the distance of the formed light on the screen, a red laser acts as the light source, a precision rail serves as a platform to align and stabilize all instruments, precision rail legs support the precision rail to maintain stability, and connecting cables link the voltage from the power supply to the circuit.

The research involves two experiments: one with packaged oil using gratings of 100 heated for 10 minutes and 15 minutes, and the other with bulk oil using gratings of 100 heated for 10 minutes and 15 minutes. The procedural steps are as follows:

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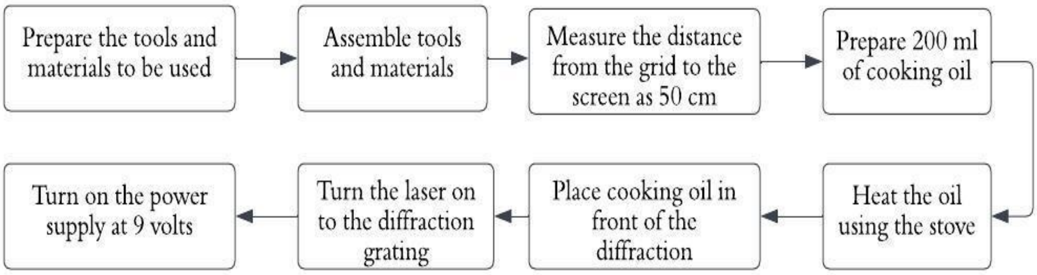

RESULTS AND DISCUSSION

a. Packaged Cooking Oil

In the first experiment, the analysis of the refractive index in packaged cooking oil is conducted. In this experiment, a grating with 100 slits is used, and the quantity of oil is 200 ml. The applied voltage is 9 volts, and the distance from the grating to the screen is 50 cm. Table 1 displays the diffraction grating results for the packaged cooking oil before usage. Table 2 presents the diffraction grating results for the packaged cooking oil after 10 minutes of usage. Table 3 shows the diffraction grating results for the packaged cooking oil after 15 minutes of usage.

Table 1. Experimental results of packaged cooking oil before use

T	P_{right}	P_{left}
$T_p - T_1$	3,3 ± 0,05 cm	3,3 ± 0,05 cm
$T_p - T_2$	6,6 ± 0,05 cm	6,6 ± 0,05 cm
$T_p - T_3$	9,9 ± 0,05 cm	9,9 ± 0,05 cm
$T_p - T_4$	13,2 ± 0,05 cm	13,2 ± 0,05 cm

Table 2. Experimental results of packaged cooking oil after 10 minutes of use

T	P_{right}	P_{left}
$T_p - T_1$	3,1 ± 0,05 cm	3,1 ± 0,05 cm
$T_p - T_2$	6,3 ± 0,05 cm	6,3 ± 0,05 cm
$T_p - T_3$	9,5 ± 0,05 cm	9,5 ± 0,05 cm

Table 3. Experimental results of packaged cooking oil after 15 minutes of use

T	P_{right}	P_{left}
$T_p - T_1$	3,3 ± 0,05 cm	3,4 ± 0,05 cm
$T_p - T_2$	6,2 ± 0,05 cm	6,5 ± 0,05 cm

The time taken for light to reach the projection screen in packaged cooking oil before usage, after 10 minutes of usage, and after 15 minutes of usage, is 0.85 s; 0.70 s and 0.65 s, respectively. The resulting refractive indices from the packaged cooking oil before usage, after 10 minutes of usage, and after 15 minutes of usage are 5.08×10^8; 4.22×10^8 and 3.94×10^8.

b. Bulk Cooking Oil

In the second experiment, the analysis of the refractive index in bulk cooking oil is conducted. In this experiment, a grating with 100 slits is used, and the quantity of oil is 200 ml. The applied voltage is 9 volts, and the distance from the grating to the screen is 50 cm. Table 4 displays the diffraction grating results for the bulk cooking oil before usage. Table 5 presents the diffraction grating results for the bulk cooking oil after 10 minutes of usage. Table 6 shows the diffraction grating results for the bulk cooking oil after 15 minutes of usage.

Table 4. Diffraction grating results from bulk cooking oil before use

T	**P_{right}**	**P_{left}**
$T_p - T_1$	3,1 ± 0,05 cm	3,1 ± 0,05 cm
$T_p - T_2$	6,3 ± 0,05 cm	6,4 ± 0,05 cm

Table 5. Diffraction grating results from bulk cooking oil after 10 minutes of use

T	**P_{right}**	**P_{left}**
$T_p - T_1$	3,2 ± 0,05 cm	3,0 ± 0,05 cm
$T_p - T_2$	6,2 ± 0,05 cm	6,5 ± 0,05 cm

Tabel 6. Diffraction grating results from bulk cooking oil after 15 minutes of use

T	**P_{right}**	**P_{left}**
$T_p - T_1$	3,5 ± 0,05 cm	3,5 ± 0,05 cm
$T_p - T_2$	7,0 ± 0,05 cm	7,0 ± 0,05 cm

The time taken for light to reach the projection screen in packaged cooking oil before usage, after 10 minutes of usage, and after 15 minutes of usage is 0.78 s; 0.60 s and 0.56 s, respectively. The resulting refractive indices from the packaged cooking oil before usage, after 10 minutes of usage, and after 15 minutes of usage are 4.68×10^8; 3.61×10^8 and 3.37×10^8.

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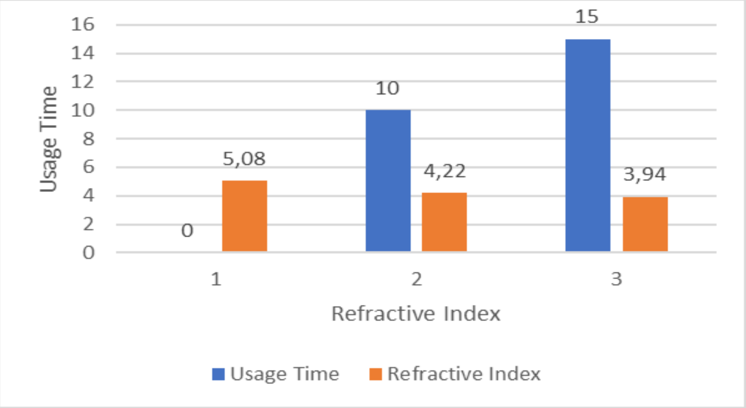

Figure 2. Relationship between refractive index and time in packaged cooking oil

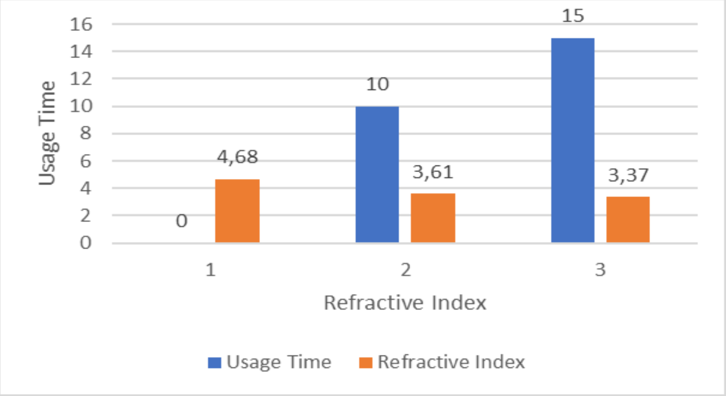

Figure 3. Relationship between refractive index and time in bulk cooking oil

Based on the analysis of experimental data, it is evident that there is a correlation between the refractive index and the duration of frying oil usage. The longer the duration of oil usage, the smaller the refractive index value tends to be. This study also reveal several factors influencing the refractive index and purity of frying oil, including the viscosity or thickness of the oil and the level of oil transparency. Both packaged and bulk cooking oil, prior to usage, exhibit higher viscosity compared to after 10 to 15 minutes of usage. The thicker the liquid, the greater the resulting refractive index. Additionally, the transparency level of packaged cooking oil appears clearer than that of bulk cooking oil.

The more transparent the cooking oil, the purer it is, and the greater the diffracted light. The research findings indicate that the purity level of packaged cooking oil is higher than that of bulk cooking oil. The refractive index of packaged cooking oil exhibits higher viscosity and refractive index values compared to bulk cooking oil.

CONCLUSIONS

The study revealed bias indices produced from packaged cooking oil before usage, after 10 minutes of usage, and after 15 minutes of usage, namely 5.08×10^8; 5.22×10^8 and 3.94×10^8, respectively. The bias indices from bulk cooking oil under the same conditions were 4.68×10^8; 3.61×10^8 and 3.37×10^8, respectively. Based on the research results, it can be concluded that packaged cooking oil has a higher level of purity compared to bulk cooking oil. The relationship between the refractive index and the duration of oil usage is inversely proportional; the longer the duration of frying oil usage, the smaller the refractive index value tends to be. Factors influencing the refractive index in both packaged and bulk cooking oil include the viscosity or thickness of the oil and the transparency level. Thus, the diffraction grating method can be utilized to identify characteristics related to the purity level of cooking oil.

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