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Characteristics of Peanut Oil and Peanut Meal Produced by Extraction Using an Oil Press Machine

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ABSTRACT

Mechanical extraction of peanut oil using an oil press machine is a relatively simple and environmentally friendly method that can be applied on a small- to medium-scale. This study aimed to determine the characteristics of peanut oil and meal produced by an oil press. The research method employed was experimental and involved a descriptive analysis of the quality parameters of the oil and meal. For the oil, the observed parameters included yield, color (CIELab), and density. For the peanut meal, the observed parameters were moisture, fat, and protein content. Results showed that increasing the extraction temperature increased the yield and density of peanut oil, with the highest values obtained at 200 °C. The lightest oil color was obtained at 180 °C, as indicated by the highest L* value. For the peanut meal, increasing extraction temperature decreased moisture content, with the lowest at 200 °C. However, the meal's residual fat content increased significantly at 200 °C, indicating decreased extraction efficiency at excessively high temperatures. The protein content of the meal ranged from 45.84% to 48.73% and remained relatively stable across all temperature treatments. These results indicate that the characteristics of the resulting peanut oil and meal are affected by extraction temperature; therefore, the extraction temperature must be selected according to the intended use of the final product.

Contribution to Sustainable Development Goals (SDGs):

SDG 6: Clean Water and Sanitation

SDG 11: Sustainable Cities and Communities

SDG 13: Climate Action

SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Peanuts (*Arachis hypogaea* L.) are one of Indonesia's key agricultural commodities. They have a relatively high oil content, ranging from 40 to 56 percent. Peanut oil is widely

used as an edible oil because it contains unsaturated fatty acids, including oleic and linoleic acids, as well as natural antioxidants, such as tocopherols. In addition to producing oil, the extraction process yields peanut meal, which contains protein, fiber, and residual fat. Therefore, peanut meal has potential for further utilization as animal feed or agro-industrial raw material for livestock or a raw material for other agro-industrial products.



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Mechanical oil extraction methods using oil press machines or screw presses are being developed are increasingly being developed because the process is relatively simple and does not require chemical solvents. This method is also more environmentally friendly than solvent-based extraction methods. However, the characteristics of the resulting oil and meal are significantly influenced by the extraction process, particularly the temperature. Temperatures that are too low can make it difficult for the oil to be released from the plant cell tissue. Meanwhile, excessively high temperatures can reduce the quality of the oil and the resulting meal. Therefore, it is important to investigate how extraction temperature affects the characteristics of peanut oil and meal.

1.2. Literature Review

Previous studies have shown that the extraction temperature affects the yield and quality of vegetable oil produced by mechanical pressing. For example, [1] reported that increasing the extraction temperature can improve sesame oil yield because higher temperatures decrease the oil's viscosity, making it easier to extract from plant tissue. [2] also found that extraction temperature affects the color and quality of oil produced by pressing. Furthermore, [3] state that the mechanical pressing process affects not only oil quality, but also the characteristics of the resulting meal.

However, most studies focus on the quality of the oil produced while research on the characteristics of peanut meal, a byproduct of extraction, remains limited. However, peanut meal has a fairly high protein content and holds potential for further utilization. The effect of extraction temperature on the moisture, fat, and protein content of peanut meal must be investigated to determine suitable extraction conditions for the intended use of the final product.

1.3. Research Objective

This study aims to determine the effect of extraction temperature on the characteristics of peanut oil and peanut meal produced by oil pressing. Oil characteristics examined include yield, color, and density, while meal characteristics include moisture, fat, and protein content. This study aims to determine the optimal extraction temperature for producing peanut oil and meal with desirable characteristics.

2. MATERIALS AND METHODS

2.1. Materials and Equipment

The main raw material used in this study was peanuts (*Arachis hypogaea*). The chemicals used included ethanol (Merck), PP indicator, sodium hydroxide (Merck), cyclohexane, glacial acetic acid (Wijs, Merck), potassium iodide (Merck), sodium thiosulfate (Merck), kanji indicator, and hexane (Merck). Equipment included an oil press machine. The analysis apparatus comprised a furnace, scales, an oven, beakers, 250 ml and 500 ml Erlenmeyer flasks, a pipette, and a Soxhlet extractor.

2.2. Research Procedure

The research procedure consisted of two steps: First, groundnuts were pressed using an oil press machine. Then, the characteristics of the resulting oil and groundnut meal were

tested. First, the materials were prepared. Then, groundnuts were extracted using an oil press machine at several temperature levels (160 °C, 180 °C, and 200 °C) to obtain groundnut oil and meal. The second step was to test the characteristics of the groundnut oil and meal produced by the oil press. An experimental method was employed for the research. The obtained data were then processed and presented descriptively

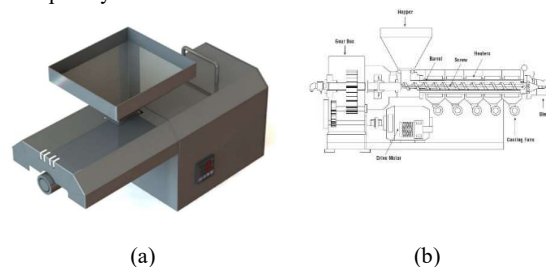


Figure 1. Oil Press Machine: (a) External View, (b) Internal View

2.3. Analysis Procedures

The observations carried out in this study included observations of the peanut oil in terms of yield, color, and density. Meanwhile, observations of the peanut meal focused on its moisture, fat content, and protein content. The test procedures are as follows:

2.3.1. Yield [4]

Yield is the percentage of the main raw material that becomes the final product. It can be expressed as a decimal or percentage. The calculation is as follows (1):

$$\text{Yield}(\%) = \frac{\text{weigh of final product}}{\text{weight of initial product}} \times 100\% \quad \dots (1)$$

2.3.2. Color

Color measurements were obtained using the Color Analyzer app on a Samsung M15 mobile phone. The CIELab color space was used, in which L* represents lightness, a* represents the red component, and b* represents the yellow component. To capture the color, the sample was placed on white paper exposed to light. The Color Analyzer app then analyzed the color by opening the phone's camera and pointing it at the sample. The app displayed the L*, a*, and b* values and the color of the sample. The results are numerical data for each variable (L*, a*, b*), which serve as a reference for color analysis.

Explanation:

L* = lightness, ranging from 0 (black) to 100 (white).

a* = hue, ranging from +1000 (red) to -80 (green).

b* = color intensity (chroma), ranging from +70 (blue) to -70 (yellow).

2.3.3. Specific Gravity [5]

Wash, clean, and rinse successively with ethanol and diethyl ether. Dry the inside of the pycnometer with a stream of dry air, then replace the stopper. Place the pycnometer in the weighing cabinet for 30 minutes, then weigh it (m). Fill the pycnometer with distilled, boiled water and allow it to cool to 20°C, being

careful to avoid forming air bubbles. Immerse the pycnometer in a water bath at $20^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$ for 30 minutes. Replace the stopper and dry the pycnometer. Leave it in the balance cabinet for 30 minutes, then weigh it with its contents (m_1). Empty the pycnometer and wash it with ethanol and diethyl ether. Dry it with a stream of dry air. Fill the pycnometer with the oil sample, taking care to avoid air bubbles. Immerse the pycnometer in a water bath at $20^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$ again for 30 minutes. Replace the cap and dry the pycnometer. Leave the pycnometer in the balance cabinet for 30 minutes, then weigh it again (m_2). Calculate the specific gravity using the following formula (2):

$$\text{Specific gravity} = \frac{m_2 - m}{m_1 - m} \quad \dots\dots (2)$$

Explanation:

m = Mass of empty pycnometer (g)

m_1 = Mass of pycnometer filled with water at 20°C (g)

m_2 = Mass of pycnometer filled with sample at 20°C (g)

2.3.4. Moisture content [6]

Heat the beaker and its lid in an oven at a temperature of $(100 \pm 2)^{\circ}\text{C}$ for approximately one hour and cool in a desiccator for 20 to 30 minutes, then weigh on an analytical balance (beaker and lid) (W_0). Place 2 g of the sample into the beaker, cover it, and weigh it (W_1). Heat the beaker containing the sample with the lid off, placing the lid next to the beaker in an oven at a temperature of $(100 \pm 2)^{\circ}\text{C}$ for 3 (three) hours after the oven has reached $(100 \pm 2)^{\circ}\text{C}$. Cover the dish whilst it is still in the oven, transfer it immediately to a desiccator and cool for 20 to 30 minutes, then weigh. Reheat for 1 hour and repeat the process until the change in weight between 1-hour heating cycles is ≤ 2 mg (W_2). Perform the procedure in duplicate, and calculate the moisture content of the sample. The moisture content can be calculated using the formula (3):

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1 - W_0} \times 100\% \quad \dots\dots (3)$$

Explanation:

W_0 = the weight of the empty dish and its lid, expressed in grams (g),

W_1 = the weight of the dish, its lid and the sample before drying, expressed in grams (g),

W_2 = the weight of the dish, its lid and the sample after drying, expressed in grams (g).

2.3.5. Fat Content [7]

Dry the fat flask containing a few boiling stones for one hour. Then, cool it in a desiccator, weigh it (W_0), and connect it to the Soxhlet extractor. Place an extraction thimble or a filter paper sleeve (preferably supported by a glass bead) into the Soxhlet extractor. Rinse the hydrolysis flask and the drying flask with three 5-ml portions of petroleum ether or hexane. Pour the solvent into the Soxhlet and fill it to two-thirds capacity over the water bath. Extract for 4 hours at an extraction rate exceeding $30\times$. Dry the fat flask with the fat in an oven at $100\text{--}101^{\circ}\text{C}$ for 1.5-2 hours. Cool in a desiccator, weigh (W_1), and repeat the drying process until the consecutive weight measurements of the fat differ by less than 0.05%. The fat content can be calculated using the following formula (4):

$$\text{Fat Content (\%)} = \frac{W_1 - W_0}{m} \times 100\% \quad \dots\dots (4)$$

Explanation:

m = sample weight, expressed in grams (g)

W_0 = weight of the empty fat flask, expressed in grams (g)

W_1 = weight of the fat flask and fat, expressed in grams (g)

2.3.6. Protein Content [7]

Weigh approximately 2.0 g of the sample into a Kjeldahl flask, add a boiling stone, then add 5 g of K_2SO_4 , 200 mg of CuSO_4 , and 30 ml of concentrated H_2SO_4 . Shake thoroughly, then heat over direct heat in a fume hood, initially at low heat. After the fumes have dissipated, increase the heat until the liquid turns a clear green. Cool, then add 150 ml of distilled water and slowly add 50% NaOH solution until the liquid becomes alkaline. Immediately install the Kjeldahl flask in the distillation apparatus. Heat rapidly until the ammonia evaporates completely. Collect the distillate in an Erlenmeyer flask containing 50 mL of 0.1 N standard hydrochloric acid solution and 3 drops of 1% phenolphthalein indicator. Heat the end of the glass distillation tube to ensure it is immersed in the 0.1 N hydrochloric acid solution. Distillation is terminated when the distillate no longer reacts alkaline. The distillation results were treated with 3 drops of phenolphthalein indicator and then titrated with a standard 0.1 N sodium hydroxide solution. The endpoint of the titration was reached when the color changed from pink to a constant color. Then, a blank was determined and treated the same as the sample. The protein content can be calculated using the following formula (5):

$$\% \text{ Protein} = \frac{(V_1 - V_2) \times N \text{ HCl} \times \text{Ar} \times N \times f \times k}{\text{mg sample}} \times 100\% \quad \dots\dots (5)$$

Explanation:

V_1 = volume of HCl titrated sample

V_2 = volume of HCl titrated blank

N HCl = normality of HCl

fk = conversion factor

mg sample = mass of sample in milligrams

3. RESULT AND DISCUSSION

3.1 Analysis of Peanut Oil

3.1.1. Yield

Table 1 shows the average peanut oil yield obtained at various extraction temperatures.

Table 1: Average Peanut Oil Yield

Treatment	Average Yield (%)
Extraction temperature 160°C	27.3 ± 0.02
Extraction temperature 180°C	29.6 ± 0.14
Extraction temperature 200°C	30.7 ± 0.31

As the extraction temperature rises, the yield increases, as shown in Table 1. Yield is significantly influenced by extraction temperature, the moisture content of the material, and the extraction rate [1], [3]. This is consistent with research by Piravi-Vanak et al [2], who observed a 10% increase in candlenut oil yield as the extraction temperature increased from 30 to 120°C . As the extraction temperature increases, the viscosity of the oil within the peanut cells decreases, making it easier for the oil to be released from the cells [8].

3.1.2. Color

Color is the most important quality parameter influencing consumers' food purchasing preferences [9]. Table 2 shows the Lab color values of peanut oil obtained at various extraction temperatures.

Table 2. Color Values of Peanut Oil

Treatment	Color Value			Color
	L	a	b	
Extraction temperature 160 °C	67.213	-4.363	47.979	Slightly Bright
Extraction temperature 180 °C	71.420	-4.152	71.997	Bright
Extraction temperature 200 °C	66.255	-3.370	45.303	Slightly Dark

Table 2 shows that an extraction temperature of 180 °C yields the brightest oil (high L value) and the most intense yellow color (high b* value), which indicates the optimal extraction of yellow pigments (carotenoids), leaving them intact without significant damage. A decrease in the L value (brightness) occurs at 200 °C. At a low temperature (160 °C), the extraction of yellow pigments may be suboptimal, resulting in a lower b* value compared to 180 °C. The more negative greenish hue (a*) may indicate that green pigments (chlorophyll) are still present in sufficient quantities. At very high temperatures (200 °C), brightness decreases again (L* drops), and yellowness (b*) decreases from its peak at 180 °C. This is likely due to the degradation of yellow pigments (carotenoids) and other thermal reactions, such as oxidation and the formation of dark compounds. Greenness (a*) also fades (approaching zero), indicating that chlorophyll and other green pigments have degraded. This is consistent with research by Falade and Oboh, (2015) stating that heating sesame oil to 220 °C reduces β -carotene content, resulting in darker sesame oil than untreated oil. Thus, the darker and more intense the oil color becomes with higher extraction temperatures (L* and b* values decrease and ΔE increases), due to pigment extraction and the Maillard reaction [2], [11].

3.1.3. Density

Table 3 shows the average density values of peanut oil obtained at various extraction temperatures.

Table 3: Average Density of Peanut Oil

Treatment	Average Density (g/cm ³)
Extraction temperature 160 °C	0.9080 ± 0.00
Extraction temperature 180 °C	0.9125 ± 0.01
Extraction temperature 200 °C	0.9144 ± 0.01

As shown in Table 3, an increase in extraction temperature increases the density of the resulting peanut oil. Density is influenced by fatty acid composition, minor compound content (e.g., phospholipids and pigments), and water content. The higher the concentration of high-molecular-weight compounds extracted, the higher the density tends to be [12]. An increase in oil density at higher extraction temperatures may be associated with the extraction of additional non-triglyceride compounds, such as phospholipids, pigments, waxes, and

minor polar compounds [13]. Higher temperatures enhance the solubility and release of these compounds into the oil phase, which contributes to higher density values.

3.2 Peanut Meal Analysis

3.2.1 Moisture content

Table 4 shows the average moisture content of peanut meal obtained at various extraction temperatures.

Table 4. Average Moisture Content of Peanut Meal

Treatment	Average Moisture content (%)
Extraction temperature 160 °C	6.03 ± 0.09
Extraction temperature 180 °C	5.80 ± 1.7
Extraction temperature 200 °C	3.29 ± 0.28

As shown in Table 4, the higher the extraction temperature, the lower the resulting meal's moisture content. The meal produced at 160 °C had the highest moisture content, at 6.03%. This value decreased to 5.80% at 180 °C and reached its lowest value, 3.29%, at 200 °C. This pattern indicates that extraction temperature directly affects the amount of moisture remaining in the peanut meal. This is consistent with research by [14] stating that high temperatures increase oil extraction efficiency and indirectly reduce residual moisture content.

The decrease in moisture content occurs because an increase in temperature increases the evaporation rate and mass transfer of water to the material's surface [15]. Additionally, heating can damage cell tissue and accelerate water diffusion out of the material [16].

Reducing the moisture content at higher extraction temperatures improves the storage stability of peanut meal. Lower moisture levels inhibit microbial growth and reduce the risk of spoilage. A moisture content below 10% is generally considered favorable for extending the shelf life of oilseed meals and minimizing biochemical deterioration [17]. Therefore, peanut meal produced at 200 °C has better storage stability than meal produced at lower temperatures. However, excessively high temperatures may induce thermal damage to some nutritional components and affect the functional properties of meal proteins [18].

3.2.2 Fat Content

Table 5 shows the average fat content of peanut meal obtained at various extraction temperatures.

Table 5. Average Fat Content of Peanut Meal

Treatment	Average Fat Content (%)
Extraction temperature 160 °C	8.81 ± 6.4
Extraction temperature 180 °C	9.58 ± 1.8
Extraction temperature 200 °C	21.38 ± 0.86

As shown in Table 5, the residual fat content in the meal increases sharply at 200 °C. At temperatures between 160 and 180 °C, however, the increase remains relatively small. This indicates that oil extraction efficiency decreases at very high

temperatures [19]. The sharp increase in residual fat content at 200 °C suggests that excessively high temperatures may negatively affect the pressing mechanism. At high temperatures, protein denaturation and the collapse of cellular structures may occur, causing the material to become compact and less permeable to oil. These changes can reduce the efficiency of oil drainage during mechanical pressing and result in more residual oil remaining in the meal. Additionally, excessive moisture evaporation at high temperatures can harden the material's structure, reducing the effectiveness of mechanical compression. Singh et al., [20] make the same point, stating that the optimal extraction temperature in an oil press is usually within the range of 120–160 °C. Savoie et al. [3] stated that excessively high temperatures during mechanical pressing may reduce extraction efficiency due to structural changes in the material and altered oil flow behavior. Excessively high temperatures reduce extraction efficiency by altering the physical properties of the oil and the material.

3.2.3 Protein Content

Table 6 shows the average protein content of peanut meal obtained at various extraction temperatures.

Table 6. Average Protein Content of Peanut Meal	
Treatment	Average Protein Content (%)
Extraction temperature 160 °C	48.12 ± 0.05
Extraction temperature 180 °C	45.84 ± 1.25
Extraction temperature 200 °C	48.73 ± 0.19

As shown in Table 6, the protein content of peanut meal ranges from 45.84% to 48.73%. The highest content, 48.73%, was observed at 200 °C, while the lowest, 45.84%, was observed at 180 °C. In general, the research results indicate that increasing the extraction temperature does not significantly change the protein content of peanut meal.

The absence of a significant downward trend in protein content suggests that peanut protein remains relatively stable under heat treatment during the extraction process. This is consistent with the findings of [1], who state that mechanical pressing of high-oil-content materials can increase protein concentration in the meal due to oil loss during extraction. Additionally, Frank [19] reported that heat treatment during vegetable oil extraction affects the functional quality of proteins, such as solubility and emulsifying power, more than total protein content. The relatively high protein content in peanut meal indicates that this byproduct of the extraction process still has potential as a feed ingredient or a protein source in plant-based food products.

4 CONCLUSION

Based on the research results, it can be concluded that increasing the extraction temperature using an oil press machine affects the characteristics of the resulting peanut oil and meal. Higher temperatures tend to increase the yield and density of the oil, while the best color is obtained at 180 °C. An increase in temperature of peanut meal decreases its moisture content. However, the residual fat content increases at 200 °C, indicating reduced extraction efficiency at excessively high

temperatures. The protein content of the peanut meal ranges from 45.84% to 48.73%, remaining relatively stable across various extraction temperatures. This means the extracted meal still has potential as a protein source. In general, extraction temperatures between 180 and 200 °C produce superior oil and meal characteristics. However, the optimal temperature must be selected based on the intended use of the final product.

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