SUST J Sci Tech, Vol 34(1) 2024, 14-19 ISSN 1682-895X

Comparative Evaluation of Mustard, Soybean, Palm, and Coconut Oils: Insights into Quality and Stability

Munjury Tamanna, Md. Suhel Mia, Md. Hassan Bin Nabi, Md. Monir Ahmed, Md. Mozammel Hoque and Wahiduzzaman*

Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh
*Corresponding Author: Wahiduzzaman (wahid-ttc@sust.edu)

Abstract

This study compared four widely used edible oils-mustard oil, soybean oil, palm oil, and coconut oil-based on their physical and chemical characteristics. Density, pH, specific gravity, iodine, peroxide, acid, and free fatty acid concentration were among the parameters assessed. According to the findings, coconut oil had the lowest iodine value (11.110 ± 0.361), and soybean oil had the highest (124.210 ± 0.464). The peroxide value of mustard oil was the lowest (7±1), whereas palm oil had the highest (10 ± 1). Soybean oil had the highest acid value and free fatty acid content (3.523 ± 0.235, and 3.590± 0.126, respectively), while mustard oil had the lowest values (5.069 ± 0.058, and 4.093 ± 0.029, respectively). These results imply that compared to the other oils, soybean oil may be more susceptible to rancidity and spoiling. However, mustard oil had the lowest free fatty acid level, indicating higher quality, when compared to the other oils.

Keywords : Edible oils; Physico-chemical properties; Soybean oil; Mustard oil; Palm oil; Coconut oil.

1. Introduction

Edible oil is an essential part of our daily diet which provides energy, and essential fatty acids and serves as a carrier of fat-soluble vitamins [1]. 10% or should eat fewer calories per day from saturated fat and 20-35% of total daily calories come from polyunsaturated and Monounsaturated fat. In small quantities Saturated fat diet, is common in meta-analysis. A significant correlation was found between the high use of saturated fat and blood LDL Density, a risk factor for cardiovascular disease will be replaced with saturated fat polyunsaturated and monounsaturated fats [2]. It is commonly known how important edible oil is to sectors of the economy like food, energy, cosmetics, pharmaceuticals, and lubricants. The physical and chemical characteristics of several edible oils are described in the literature [3]. Calculating Physico-Chemical designing a single process, such as distillation, a heat exchanger, a furnace, and piping, requires consideration of the properties of edible oils. The overall quality and viability of a food technique, on the other hand, are significantly influenced by physicochemical qualities [4]. Important Vegetable Oil Qualities include density, iodine value, acid value, and peroxide value. The primary elements of a healthy daily diet are macronutrients like protein, carbs, and fats and micronutrients like vitamins, minerals, and antioxidants [5]. To monitor the compositional quality of oil, various physical and chemical oil composition criteria are used [6]. To prevent utilizing waste oil, it is crucial to keep an eye on the quality of the oil. These are physicochemical criteria that are used to gauge oil performance and quality. such as density, peroxide value, acid value, and iodine standard. An excellent sort of cooking oil is one that has a wide variety of physicochemical parameters that have been established. We can assess the oil for people's health, industrial uses, and other factors by studying its properties. Consumers are strongly encouraged to use low-density oils [7]. A high acid value means that the oil's triglycerides have been transformed. Rancidity of oil is caused by a reaction between fatty acids and glycerol [8]. Finding out the peroxide value, oil quality, and stability may serve as indicators. Measure the period when the rancidity reaction occurred in storage. Peroxide values rising the rancidity of the oil is indicated by relative causes of heightened oil oxidation. Consequently, cooking oil must be provided. If not, oil may have a low acid value that harms people's health. Value of iodine measurement unsaturation level of a fat or vegetable oil. Higher unsaturation increases the oil's likelihood of going bad [9]. This study aimed to find and compare the physiochemical properties of four edible oils based on the local market.

https://doi.org/10.63512/sjst.2024.1003
Received 20 February 2025, Accepted 23 April 2025.

2. Materials and methods

2.1. Sample collection

Four distinct types of edible oils, such as Mustard oil, Coconut oil, Palm oil, and Soybean oil, were bought at a local market in Sylhet City, Bangladesh.

2.2. Density measurement

The following formula was used to calculate the relative densities of oil samples using a relative density (R.D) bottle with a 10 ml capacity:

$$\text{Density } (\rho) = \frac{\text{Mass of the oil sample (M)}}{\text{Volume of the R.D bottle (V)}} \text{ g/ml}$$

2.3. Specific gravity

Specific gravity is the ratio of a material's density to that of a reference substance; alternatively, it is the ratio of a substance's mass to that of a reference substance for a given volume. The ratio of the weight of a volume of the material to the weight of a volume of a reference substance is known as apparent specific gravity. It is evident that when one type of edible oil is replaced with another, the specific gravity either rises or falls above the maximum permitted value. A positive link between specific gravity and the substitution of edible oil can be seen [10].

2.4. Peroxide value

The peroxide value serves as a guideline. Iodine that has been oxidized is concentrated to make potassium iodide. A common measure of acetic acid is used to dissolve a weighted oil sample. The sample is then treated with a solution of saturated KI and chloroform, and the iodine content is measured. Release of KI due to its oxidizing effect. The amount of peroxides determines the type of oil. 0.1 N sodium thiosulfate starch solution is used as an indicator during titration. There was titration as well for blanks [11].

Where PV = Represent the peroxide value(meq O2/kg oil); S = Volume of sodium thiosulphate consumed by the sample oil; B = Volume of sodium thiosulphate used for blank; W = Weight of oil sample; N = the normality of sodium thiosulphate.

$$\text{PV} = (\text{S} - \text{B}) \times \text{W} \times \text{N}$$

2.5. Acid value

The definition of acid value (AV) is the quantity of potassium hydroxide needed in mg. Neutralizes the one gram of oil's free acids. Direct titration is used to determine the acid value. Test the oil using alcohol and a standard potassium hydroxide solution while looking for the presence of the indicator phenolphthalein [12]. The equation was used to determine the acid value:

$$\text{AV} = \frac{56.1 \times \text{V} \times \text{N}}{\text{m}} \left(\frac{\text{mg KOH}}{\text{g sample}}\right)$$

Where, AV = represents the acid value, (mg KOH/g sample); V = Volume of standard potassium hydroxide solution, (mL); N = The normality of potassium hydroxide solution; m = Weight of oil sample (g)

2.6. Free fatty acid value

The free fatty acid value was calculated using the acid value. By dividing the acid value by 2, the FFA content was calculated as oleic acid [13].

$$\%FFA = \frac{\textit{molecular weight of oleic acid} \times \textit{acid value}}{\textit{molecular weight of KOH}} \times \frac{100}{1000}$$

$$= \frac{28.27 \times \textit{acid value}}{56.11} \times \frac{1}{10}$$

$$= \frac{\textit{acid value}}{2}$$

2.7. Iodine value

According to AOAC protocol, the oil's iodine value was determined [14]. 0.25 grams and so of oil. The sample was placed in a conical flask along with 10 mL of CCl_4 and 30 mL of Wiz's solution. The combination was then left to stand for 45 minutes while being sometimes shaken in the dark. To remove any free iodine on the stopper, 10 ml of a 10% KI solution and 100 ml of distilled water were added. The iodine was titrated using a previously standardized $Na_2S_2O_3$ solution, which was added gradually while being constantly shaken until the yellow solution almost completely lost its color. The starch indicator was added in small amounts, and titration was repeated until the blue hue completely vanished. The bottle was shaken erratically in order for the KI solution to absorb any iodine that was still in the CCl_4 solution. For the experiment, the amount of $Na_2S_2O_3$ solution needed was recorded. Along with the sample, a control experiment was carried out. The following calculation was used to determine the percentage of iodine that the oil sample had absorbed.

$$\text{IV} = \frac{(\text{B} - \text{A}) \times \text{N} \times 0.127 \times 100}{\text{W}}$$

Here, B = ml of 0.1N $Na_2S_2O_3$ required by blank; A = ml of 0.1N $Na_2S_2O_3$ required by oil sample; N =

Normality of $Na_2S_2O_3$; W = Weight of oil in g. Here, B = ml of 0.1N $Na_2S_2O_3$ required by blank; A = ml of 0.1N $Na_2S_2O_3$ required by oil sample; N = Normality of $Na_2S_2O_3$; W = Weight of oil in g.

2.8. pH value

A Digital pH meter (Model No. 2211, USA) was used to determine the pH of each homogenized extract. The pH was determined by producing a buffer with a pH of 7.0 and adjusting the temperature to 28°C. Before placing the electrode into the sample solution and measuring pH, the glass electrode was standardized with a standard buffer.

3. Results and discussion

3.1. Physical and chemical composition of oil

3.1.1. Density

Oils with lower density levels are highly valued by consumers. The outcomes summarized in Figure 1 reveal that the highest and lowest densities are 0.871 g/ml and 0.848 g/ml for Coconut oil and Mustard oil respectively. Which was almost similar to Suresh mustard oil and Jui coconut oil having 0.919 and 0.9076 respectively [15]. The densities of palm oil and mustard oil are similar and fall within the ranges described in the literature for these oils (0.84-0.87 g/cm^3 and 0.84-0.85 g/cm^3 for palm oil respectively [16].

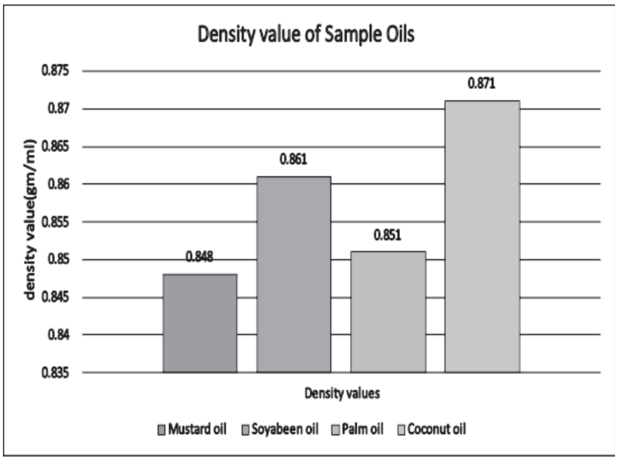

Figure 1. Density values of sample oil.

3.1.2. Specific gravity value

The Soybean Oil has the highest specific gravity of 0.865±0.011, followed by the Coconut Oil at 0.866±0.027. Mustard Oil has a specific gravity of 0.835±0.021, and Palm Oil has a specific gravity of 0.845±0.009 which is almost the same compared with the other edible oil (Figure 2). The literature states that the specific gravity ranges for coconut, palm, and soybean oils are, respectively, 0.908 to 0.921, 0.891 to 0.899, and 0.919 to 0.925 [16]. Specific gravity can be observed in the substitution of edible oil with other types of edible oil, the specific gravity is increasing or decreasing greater than the maximum allowable value for the specific gravity. It can be observed a positive correlation between the substitution of edible oil and specific gravity.

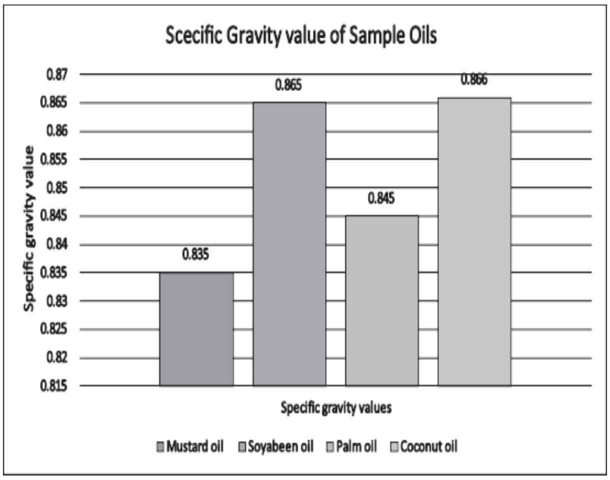

Figure 2. Specific gravity value of sample oils.

3.1.3. Iodine value

It is the quantity of iodine that 100 grams of edible oil can absorb. It serves as an indicator for the edible oil's level of unsaturation, which is a characteristic that comes naturally to it [17]. Among the oils studied, soybean oil had the highest iodine value (124.210±0.464) indicating that it is most susceptible to oxidation (Figure 3). Despite having a lower iodine value than soybean oil (91.850±4.085), mustard oil still has a high level of iodine. A lower level of unsaturation and a consequently lower sensitivity to oxidation are indicated by the palm oil's iodine value of (51.830±0.295). The lowest degree of unsaturation and least susceptible to oxidation among the examined oils is found in coconut oil, which has an iodine value of (11.110±0.361). Iodine value ranges for coconut, palm, and soybean oils are reported as 6-11, 50-55, and 124-139, respectively, in the literature [18].

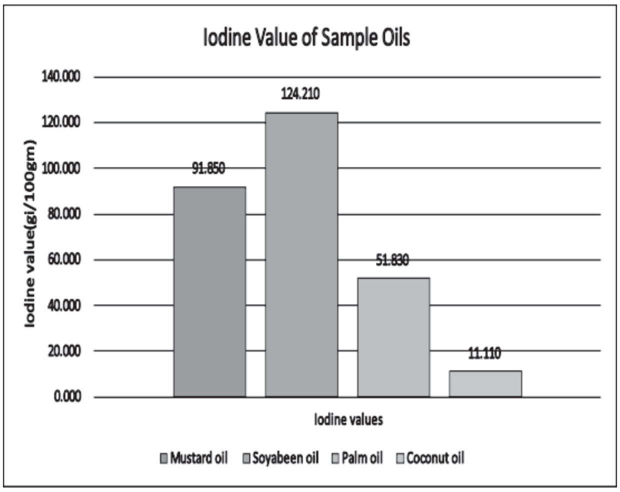

Figure 3. The iodine value of sample oils

3.1.4. Acid value

It represents the amount of KOH in milligrams needed to neutralize the free fatty acids found in one gram of edible oil. Because it analyzes the amount of free fatty acids present, it is used to identify hydrolytic rancidity [19]. The coconut oil comes in second with an acid value of (3.328±0.036) while soybean oil has the lowest acid value at (3.523±0.235). Compared to soybean and coconut oils, mustard oil has a higher acid value of (5.069±0.058) When compared to the other oils examined (Figure 4). Palm oil has the highest acid value (6.133±0.043), indicating that it has undergone greater hydrolysis or lipolysis.

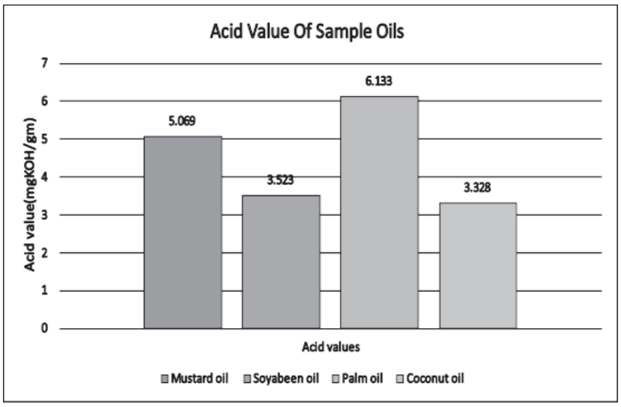

Figure 4. Acid value of sample oils

3.1.5. Free fatty acid value

In this study, the tested oils ranked as follows from lowest to highest FFA content: Soybean oil (3.590±0.126), Coconut oil (3.517±0.0181), Palm oil (3.943±0.022), and Mustard oil (4.093±0.029) (Figure 5). These results indicate that Soybean and Coconut oils have undergone the least amount of hydrolysis/lipolysis compared to the other oils, while Mustard oil has undergone the most. According to a study by Dash et al. [20], the FFA content of the tested oil was found to be 4.07 ± 0.02% which was nearly comparable with Mustard oil.

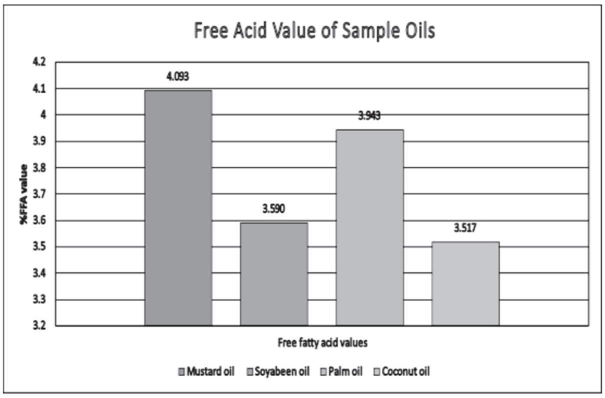

Figure 5. Free fatty acid value of sample soils

3.1.6. Peroxide value

Peroxide value (PV) is a measurement of how much fat or oil has undergone rancidity reactions during storage and can be used as a sign of the product's quality and stability [21]. Additionally, it was discovered that the oil sample samples' peroxide value increased with storage duration, temperature, and contact with air. The amount of rancidity in the oil can be determined by its peroxide value [22]. Ranges of peroxide values are closely connected to the given standard value of 10 meq/kg by the Standard Organization of Nigeria (SON) (2000) and Nigerian Industrial Standard (NIS) (1992) [23]. The studied oils' peroxide values were 12±1 for mustard oil, 15±1 for soybean oil, 10±1 for palm oil, and 7±1 for coconut oil (Figure 6). The peroxide value, which gauges the level of oxidation in the oil, is a crucial factor in determining the quality of oils.

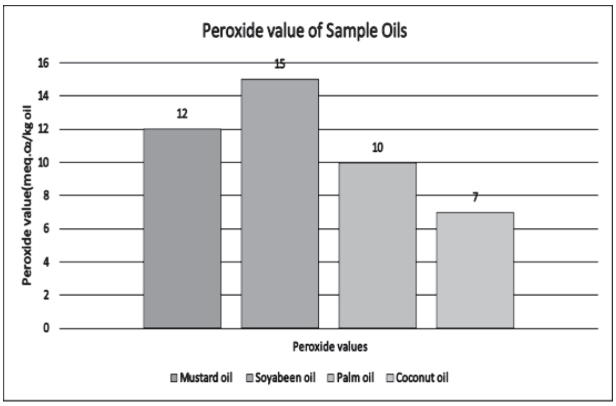

Figure 6. Peroxide value of sample oils.

High peroxide levels may be an indication that the oil is rancid or has significantly degraded due to oxidation. These findings imply that Coconut Oil, followed by Palm Oil, Mustard Oil, and Soybean Oil, has the least amount of oxidation. A higher peroxide value causes the rancidity off-flavor taste, rancidity, color change, and off-odors and a lower peroxide value gives the oil better quality. Fresh oils have peroxide values of less than 10 milliequivalents per kilogram of fat or oil; at peroxide levels of between 30 and 40 milliequivalents per kilogram, a rancid flavor becomes apparent [24]

3.1.7. pH value

pH was found in Soybean oil has the lowest pH value of 3.590±0.040, followed by Coconut oil with a pH of 3.517±0.025 (Figure 7). The Mustard oil has a pH of 4.093±0.015, and the Palm oil has a pH of 3.943±0.081 which is acidic. If we see the vegetable oil that is suitable for cooking is typically neutral in pH and between 6.9 and 6.7 [25]. The pH of the oil drops as the temperature rises because FFA is produced when vegetable oil triglycerides are heated.

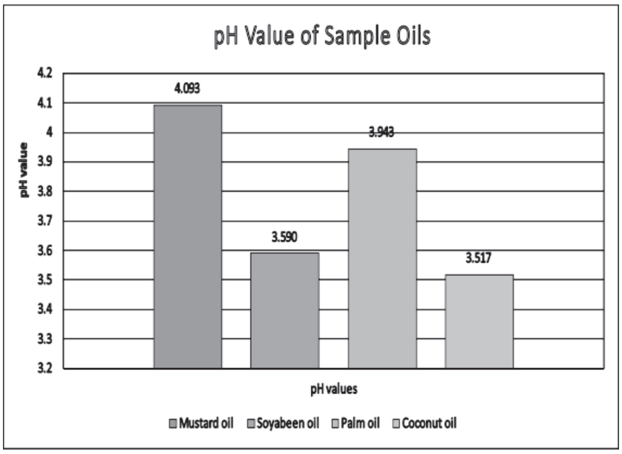

Figure 7. pH value of oil samples.

4. Conclusion

This comparative analysis of edible oils highlights significant variations in their physico-chemical properties, which can influence their stability, quality, and potential applications. The findings suggest that coconut oil, with its lowest iodine value, is the least prone to oxidation, making it a more stable option. Mustard oil exhibited the lowest peroxide, acid, and free fatty acid values, indicating superior oxidative stability and quality. In contrast, soybean oil had the highest iodine, acid, and free fatty acid values, suggesting a greater susceptibility to rancidity and degradation over time. These insights can help consumers, food manufacturers, and researchers make informed choices regarding oil selection based on nutritional quality, shelf life, and intended use.

Acknowledgment

We wish to express our gratitude to the Food Chemistry Lab, Department of Food Engineering and Tea Technology, SUST where the whole experiment was carried out.

References

1. Begum, R., Hasan, M., Akter, S., & Rahman, M. (2024). Fortified edible oils in Bangladesh: A study on vitamin A fortification and physicochemical properties. Heliyon, 10(3).

2. Aramburu, A., Dolores-Maldonado, G., Curi-Quinto, K., Cueva, K., Alvarado-Gamarra, G., Alcalá-Marcos, K., ... & Lanata, C. F. (2024). Effect of reducing saturated fat intake on cardiovascular disease in adults: an umbrella review. Frontiers in Public Health, 12, 1396576.

3. Memon, H. D., Mahesar, S. A., Kara, H., Sherazi, S. T. H., & Talpur, M. Y. (2024). A review: Health benefits and physicochemical characteristics of blended vegetable oils. Grain & Oil Science and Technology, 7(2), 113-123.

4. Pratap, R., Yasir, M., Dubey, R. C., & Shukla, A. K. (2024). The Physiological Repercussions of Thermo-Oxidized Sesame Oil. BIO Integration, 5(1), 964.

5. Yeasmin, M. S., Chowdhury, T. A., Rahman, M. M., Rana, G. M., Uddin, M. J., Ferdousi, L., ... & Khan, M. S. (2024). A comparison of indigenous vegetable oils and their blends with optimal fatty acid ratio. Applied Food Research, 4(1), 100421.

6. Lopresto, C. G., De Paola, M. G., & Calabrò, V. (2024). Importance of the properties, collection, and storage of waste cooking oils to produce high-quality biodiesel-An overview. Biomass and Bioenergy, 189, 107363.

7. Say, M., Heng, P., Kong, S., Tan, C. P., Phal, S., Nat, Y., & Tan, R. (2024). Characterization of Physicochemical Properties of Cooking Oils Sold in Phnom Penh, Cambodia. Journal of Food Science and Nutrition Research, 7(1), 28-36.

8. Begum, A., & Jain, B. P. (2024). Adulteration in edible oil (mustard oil) and ghee; detection and their effects on human health. International Journal of Biochemistry and Molecular Biology, 15(6), 141.

9. Wan, S., & Tang, L. (2024). Comprehensive electrochemical and machine learning-based study of rancidity in four edible oils over various storage periods. International Journal of Electrochemical Science, 19(11), 100799.

10. Eckey, E. W. (1954). Vegetable fats and oils (Vol. 78, Issue 1). LWW.

11. Marinova, E. M., Seizova, K. A., Totseva, I. R., Panayotova, S. S., Marekov, I. N., & Momchilova, S. M. (2012). Oxidative changes in some vegetable oils during heating at frying temperature. Bulgarian Chemical Communications, 44(1), 57-63.

12. Sitinjak, E. M., Masmur, I., Marbun, N. V. M. D., Gultom, G., Sitanggang, Y., & Mustakim. (2022). Preparation of Mg, Ca, Sr and Ba-based silicate as adsorbent of free fatty acid from crude palm oil. Chemical Data Collections, 41, 100910. https: doi.org 10.1016 j.cdc.2022 100910

13. Manzoor, M., Anwar, F., I bal, T., & Bhanger, M. I. (2007). Physico-Chemical Characterization of Moringa concanensis Seeds and Seed Oil. Journal of the American Oil Chemists' Society, 84(5), 413-419. https: doi.org 10.1007 s11746-007-1055-3

14. Udensi, E. A., & Iroegbu, F. C. (2007). Quality assessment of palm oil sold in major markets in Abia State, Nigeria. Agro-Science, 6(2), 25-27.

15. Hasan, M, Jahan, R., Alam, M., hatun, M., & Al-Reza, S. (2016). Study on Physicochemical Properties of Edible Oils Available in Bangladeshi Local Market. Archives of Current Research International, 6 (1), 1-6. https: doi.org 10.9734 ACRI 2016 29464

16. Gunstone, F. D. (2013). Composition and Properties of Edible Oils. In W. Hamm, R. J. Hamilton, & G. Calliauw (Eds.), Edible Oil Processing (pp. 1-39). John Wiley & Sons, Ltd. https: doi.org 10.1002 9781118535202.ch1

17. Remiro, V., Romero-de-Ávila, M. D., Segura, J., Cambero, M. I., Fernández-Valle, M. E., & Castejón, D. (2024). Rapid and Non-Invasive Determination of Iodine Value by Magnetic Resonance Relaxometry in Commercial Edible Oils. Applied Sciences, 14(24), 11530.

18. Gunstone, F. D. (2013). Composition and Properties of Edible Oils. In W. Hamm, R. J. Hamilton, & G. Calliauw (Eds.), Edible Oil Processing (pp. 1-39). John Wiley & Sons, Ltd. https: doi.org 10.1002 9781118535202.ch1

19. Lu, Y., Xiong, R., Lin, X., Zhang, L., Meng, X., & Luo, Z. (2024). CsPbBr3 NCs confined and in situ grown in ZIF-8: A stable, sensitive, reliable fluorescent sensor for evaluating the acid value of edible oils. ACS Applied Materials & Interfaces, 16(32), 42772-42782.

20. Dash, D. R., Pathak, S. S., & Pradhan, R. C. (2021). Extraction of oil from Terminalia chebula kernel by using ultrasound technology: Influence of process parameters on extraction kinetics. Industrial Crops and Products, 171, 113893. https: doi.org 10.1016 j.indcrop.2021.113893

21. Zhang, N., Li, Y., Wen, S., Sun, Y., Chen, J., Gao, Y., ... & Yu, X. (2021). Analytical methods for determining the peroxide value of edible oils: A mini-review. Food chemistry, 358, 129834.

22. Knothe, G., & Dunn, R. O. (2003). Dependence of oil stability index of fatty compounds on their structure and concentration and presence of metals. Journal of the American Oil Chemists' Society, 80, 1021-1026.

23. Obumneme-Okafor, N. J. (2010). THE STANDARDS ORGANISATION OF NIGERIA (SON) AND THE PROTECTION OF THE CONSUMER IN NIGERIA. The Nigerian Academic Forum, 19(2), 1-6.

24. Ali, A. M., & Awow, M. K. The Effect Of Ant?ox?dants On Perox?de Value In Ed?ble O?l.

25. Baig, A., Zubair, M., Sumrra, S. H., Nazar, M. F., Zafar, M. N., Jabeen, ., Hassan, M. B., & Rashid, U. (2022). Heating effect on uality characteristics of mixed canola cooking oils. BMC Chemistry, 16(1), 1-11.