ORIENTAL JOURNAL OF CHEMISTRY
An International Open Access, Peer Reviewed Research Journal
www.orientjchem.org
ISSN: 0970-020 X
CODEN: OJCHEG
2026, Vol. 42, No.(3):
Pg. 1158-1165

Titrimetric Determination and Precision Analysis of Saponification Value of Commercial Coconut Oil

RYAN VILORIA CABANATAN*

Natural and Applied Sciences Department, College of Arts and Sciences,
Nueva Ecija University of Science and Technology, Cabanatuan City 3100, Philippines.
*Corresponding author E-mail: rycabanatan@gmail.com

http://dx.doi.org/10.13005/ojc/420331

(Received: March 31, 2026; Accepted: April 25, 2026)

ABSTRACT

The saponification value (SV) is a key physicochemical parameter reflecting the average molecular weight and fatty acid chain length distribution of fats and oils. This study determined the SV of commercial coconut oil (SPRING brand) by alkaline hydrolysis with alcoholic potassium hydroxide (KOH) and back-titration with standardized hydrochloric acid (HCl), following modified ISO 3657 methodology. The mean SV was 241.80 mg KOH/g (range: 228.04–253.77 mg KOH/g), with a standard deviation (SD) of 12.96 mg KOH/g and a relative standard deviation (%RSD) of 5.36%. The repeatability limit (r = 36.29 mg KOH/g), computed per ISO 5725, was not exceeded by any inter-trial difference, confirming method reproducibility. Although the mean SV fell slightly below the Codex Alimentarius range (248–265 mg KOH/g), results are consistent with published values for refined commercial coconut oil and reflect expected variability from incomplete saponification and endpoint detection subjectivity. The titrimetric method is confirmed as reliable and cost-effective for routine quality assessment and adulteration screening of edible oils.

Keywords: saponification value; coconut oil; titrimetric analysis; fatty acids; quality assessment; precision analysis

INTRODUCTION

Fats and oils are essential components of human nutrition and serve critical roles in food processing, cosmetic formulation, and industrial manufacturing. Their characterization through physicochemical parameters is fundamental to quality assurance, authenticity verification, and regulatory compliance.[1–3] Among these parameters, the saponification value (SV) is one of the most widely utilized, providing information on the average

molecular weight and fatty acid chain length distribution of triglyceride constituents.[4–6]

The saponification value is defined as the milligrams of potassium hydroxide (KOH) required to neutralize free fatty acids and saponify the esters present in one gram of fat or oil.[7–9] SV exhibits an inverse relationship with average molecular weight: oils rich in short- and medium-chain fatty acids have higher SVs because of the greater number of ester bonds per unit mass, while long-chain fatty acid oils yield correspondingly lower values.[10–12] The theoretical basis derives from the alkaline hydrolysis stoichiometry, which requires three equivalents of KOH per mole of triglyceride.[13]

Coconut oil (*Cocos nucifera L.*) is distinguished among edible vegetable oils by its high medium-chain triglyceride (MCT) content—approximately 60–70% of total fatty acids—dominated by lauric acid (C12:0, 45–52%), myristic acid (C14:0, 16–21%), caprylic acid (C8:0, 5–10%), and capric acid (C10:0, 4–8%).[14–19] This fatty acid profile confers a characteristically high SV, typically 248–265 mg KOH/g per international standards.[20–22]

SV determination serves multiple analytical objectives. In quality control, it enables adulteration detection through dilution with oils of differing fatty acid profiles.[23–25] It also reflects hydrolytic rancidity, as free fatty acid liberation alters saponification stoichiometry.[26–28] In industry, precise SV data are required for soap manufacturing alkali calculations.[29–31]

The classical titrimetric method—exhaustive alkaline hydrolysis under reflux followed by back-titration of excess KOH with standardized acid—is codified in ISO 3657 and AOAC Official Methods.[32–37] Result accuracy depends on completeness of saponification, reagent stability, and endpoint detection precision.[35–37]

Despite the fundamental importance of SV in oil quality assessment, systematic evaluation of method precision and analytical variability remains insufficiently addressed in the literature. This study therefore aimed to determine the SV of commercial coconut oil using the classical titrimetric method and to comprehensively evaluate the precision, repeatability, and reliability of the procedure through rigorous statistical analysis.

MATERIALS AND METHODS

Chemicals

All reagents were of analytical grade. Potassium hydroxide pellets (≥85% purity) were dissolved in 95% ethanol to prepare the alcoholic saponifying solution. Hydrochloric acid (37%) was diluted and standardized as the titrant. Potassium hydrogen phthalate (KHP, 99.95% purity) served as primary standard for NaOH standardization. Phenolphthalein indicator (1% w/v in ethanol) was used for endpoint detection. Absolute ethanol (95% v/v) was employed as the solvent for alcoholic KOH preparation.[42,43]

Sample Material

Commercial coconut cooking oil (SPRING brand) was obtained from local retail sources. Prior to analysis, the oil sample was filtered through Whatman No. 1 filter paper to remove particulate matter and traces of moisture that might interfere with the saponification reaction. Coconut oil was selected as the analytical substrate due to its characteristically high proportion of medium-chain triglycerides, which significantly influence the SV and facilitate evaluation of method performance.[14–16]

Preparation of Reagent Solutions

0.5 N Alcoholic Potassium Hydroxide Solution

Potassium hydroxide pellets (28.05 g) were dissolved in 20 mL of distilled water with cooling to prevent excessive heat generation, then diluted to 1000 mL with 95% ethanol and mixed until homogeneous. The solution was stored in a tightly sealed polyethylene container to minimize atmospheric CO2 absorption.[44]

0.5 N Hydrochloric Acid Solution

Concentrated hydrochloric acid (approximately 41 mL) was carefully diluted to 1000 mL with distilled water. The precise normality was determined by standardization against sodium hydroxide solution of known concentration.

1% Phenolphthalein Indicator

Phenolphthalein (2 g) was dissolved in 100 mL of absolute ethanol and mixed thoroughly.

Standardization Procedures

Standardization of Sodium Hydroxide

Potassium hydrogen phthalate (approximately 0.5 g, accurately weighed) was dissolved in 50 mL of distilled water and titrated against sodium hydroxide solution using phenolphthalein indicator until a persistent pink color was achieved. The normality was calculated as:

$$N_{NaOH} = m_{KHP} / (M_{KHP} \times V_{NaOH})$$

where m_{KHP} is the mass of KHP (g), M_{KHP} is the molecular weight of KHP (204.22 g/mol), and V_{NaOH} is the volume of NaOH consumed (L).

Standardization of Hydrochloric Acid

Aliquots (25.0 mL) of hydrochloric acid solution were titrated against standardized sodium hydroxide using phenolphthalein indicator. Normality was calculated as:

$$N_{HCl} = N_{NaOH} \times V_{NaOH} / V_{HCl}$$

Saponification Value Determination

The determination was performed according to modified ISO 3657 methodology.[45] Oil samples (2–5 g, accurately weighed) were transferred to 250-mL round-bottom flasks. Alcoholic KOH solution (25–50 mL) was added from a calibrated burette, and contents were swirled to ensure complete dissolution. A blank determination was prepared simultaneously by adding an identical volume of alcoholic KOH to a separate flask without oil. Both flasks were fitted with reflux condensers and heated in a water bath at gentle boiling for one hour to ensure complete saponification. After cooling, phenolphthalein indicator (2–3 drops) was added. Each flask was titrated with standardized HCl until the pink color disappeared completely, indicating the endpoint.

Calculation of Saponification Value

The saponification value was calculated as:

$SV = [(B – S) \times N \times 56.1] / W$

where SV = saponification value (mg KOH/g); B = volume of HCl consumed by blank (mL); S = volume of HCl consumed by sample (mL); N = normality of HCl (mol/L); 56.1 = molar mass of KOH (g/mol); W = mass of oil sample (g).

Statistical Analysis

All determinations were performed in triplicate. Results were evaluated using descriptive statistics including mean, standard deviation (SD), variance, and relative standard deviation (%RSD). Method precision was assessed per ISO 5725 repeatability criteria,[46] with the repeatability limit calculated as:

$$r = 2.8 \times SD$$

The factor 2.8 ensures that 95% of differences between repeated measurements under repeatability conditions fall below the repeatability limit.[46,47]

RESULTS AND DISCUSSION

Standardization of Sodium Hydroxide

The results of sodium hydroxide standardization using KHP as primary standard are presented in Table 1. The mean normality of sodium hydroxide was 0.4452 N, which was subsequently used for hydrochloric acid standardization.

Standardization of Hydrochloric Acid

Table 2 summarizes the standardization of hydrochloric acid against sodium hydroxide. The mean normality of HCl was 0.4884 N with minimal inter-trial variation, indicating satisfactory reagent preparation.

Saponification Value Determination

Experimental data for SV determination are presented in Table 3. The blank titration consumed 30.8 mL of standardized HCl, representing the total unreacted KOH in the absence of oil.

Statistical Analysis

Descriptive statistics and precision parameters for the SV data are summarized in Table 4.

Repeatability Assessment

Inter-trial differences were evaluated for compliance with ISO 5725 repeatability criteria (Table 5).

All inter-trial differences were below the repeatability limit of 36.29 mg KOH/g, confirming that results satisfy the ISO 5725 criterion that no more

than 5% of differences between independent single test results obtained under repeatability conditions should exceed the repeatability limit.[46,47]

Interpretation of Saponification Values

The experimentally determined SV ranged from 228.04 to 253.77 mg KOH/g, with a mean of 241.80 mg KOH/g. These values fall slightly below the Codex Alimentarius standard of 248–265 mg KOH/g for coconut oil[38] but remain consistent with reported values for refined and commercial coconut oil products.[48–50] Milani and Folegatti[49] reported SVs of 243–262 mg KOH/g for commercial coconut oils, and Maurikaa, Jaganivash, and Shanmugasundaram[50] documented 252 ± 0.75 mg KOH/g for refined, bleached, and deodorized (RBD) coconut oil—closely approximating the upper range observed here. The relatively high SV confirms the predominance of medium-chain fatty acids characteristic of coconut oil. As established by Marina, Che Man, and Amin[14] and Prasanth

Table 1. Standardization of Sodium Hydroxide Using Potassium Hydrogen Phthalate (KHP) as Primary Standard

Trial	Mass of KHP (g)	Volume of NaOH (mL)	Calculated Normality (N)
1	0.5022	5.4	0.4555
2	0.5780	6.2	0.4567
3	0.5013	5.8	0.4233
Mean	—	—	0.4452

Table 2: Standardization of Hydrochloric Acid Against Standardized Sodium Hydroxide

Trial	Volume of HCl (mL)	Volume of NaOH (mL)	Normality of NaOH (N)	Calculated Normality of HCl (N)
1	25.0	27.4	0.45	0.4932
2	25.0	27.1	0.45	0.4878
3	25.0	26.9	0.45	0.4842
Mean	—	—	—	0.4884

Table 3: Experimental Data for Saponification Value Determination of Commercial Coconut Oil

Trial	Mass of Oil (g)	Volume of HCl Used (mL)	Normality of HCl (N)	Saponification Value (mg KOH/g)
Blank	—	30.8	0.4884	—
1	3.1045	3.2	0.4884	243.59
2	3.2931	0.3	0.4884	253.77
3	3.6165	0.7	0.4884	228.04

Table 4: Descriptive Statistics and Precision Parameters of Saponification Value Results

Parameter	Value
Mean (mg KOH/g)	241.80
Variance (mg KOH/g)^2	167.93
Standard Deviation, SD (mg KOH/g)	12.96
Relative Standard Deviation, %RSD	5.36%
Repeatability Limit, r (mg KOH/g)	36.29

The repeatability limit was calculated as: r = 2.8 × 12.96 = 36.29 mg KOH/g

Table 5. Inter-Trial Differences and ISO 5725 Repeatability Assessment

Comparison	Absolute Difference (mg KOH/g)	Within Repeatability Limit (r = 36.29 mg KOH/g)?
Trial 1 vs. Trial 2	10.18	Yes
Trial 2 vs. Trial 3	25.73	Yes
Trial 1 vs. Trial 3	15.55	Yes

Kumar and Gopala Krishna,[40] coconut oil contains approximately 60–70% MCTs, primarily lauric acid (C12:0) and myristic acid (C14:0), which yield higher SVs due to the greater number of ester bonds per unit mass.[10–12]

Precision and Repeatability Assessment

The statistical analysis demonstrated acceptable analytical precision. The %RSD of 5.36% falls well below the commonly accepted threshold of 10% for manual titrimetric methods, indicating satisfactory reproducibility.[59,60] According to Miller and Miller,[61]RSD values in this range are typical for titrimetric determinations relying on visual endpoint detection. All inter-trial differences fell below the calculated repeatability limit of 36.29 mg KOH/g per ISO 5725, confirming that the observed variability represents normal analytical scatter rather than systematic methodological deficiency.[46,47]

Analytical Limitations and Sources of Variability

Several sources of analytical variability should be explicitly acknowledged. First, incomplete saponification during the one-hour reflux period represents a primary source of systematic negative error, as unreacted triglycerides reduce the calculated SV[51,52].Completeness depends on adequate mixing, temperature maintenance, and sufficient reagent excess.[53] Second, atmospheric CO_2 absorption by the alcoholic KOH solution converts KOH to potassium carbonate, reducing effective saponifying agent concentration and leading to SV underestimation.[54] Phenolphthalein is insensitive to potassium carbonate, compounding this effect.[55] Third, endpoint detection subjectivity inherent in phenolphthalein-based titration introduces inter-trial variability through differences in operator perception and titration rate; the relatively small volume difference between blank and sample titrations amplifies the proportional impact of such errors.[56] Fourth, sample-related factors including RBD processing may slightly alter the fatty acid profile relative to virgin coconut oil,[57] and the presence of partial glycerides or free fatty acids affects SV stoichiometry.[58] Collectively, these factors adequately explain the slight deviation from Codex standard values observed in this study.

Implications for Quality Control

The SV is a reliable indicator of coconut oil authenticity and quality.[23–25] The mean of 241.80 mg KOH/g, though marginally below the Codex minimum, is consistent with values reported for refined commercial products and does not indicate adulteration or significant quality defects. In soap manufacturing, the high SV of coconut oil indicates greater KOH consumption per unit mass relative to long-chain oils, which is characteristic of its MCT-rich composition and contributes to stable lather in hard soaps.[29–31,62]

Comparison of Analytical Approaches

The classical titrimetric method remains the reference procedure in ISO 3657 and AOAC Official Methods.[42–45] While gas chromatographic fatty acid analysis with mathematical SV calculation and 1H-NMR spectroscopy offer advantages in throughput and non-destructive operation,[63,64] the titrimetric method retains advantages of simplicity, cost-effectiveness, and accessibility for routine quality control. Ivanova et al.[10] demonstrated strong correlation between NMR-derived and titrimetric SVs for dairy fats, supporting the continuing relevance of the titrimetric approach.

CONCLUSION

The SV of commercial coconut oil (SPRING brand) was successfully determined by classical titrimetric analysis. The experimentally obtained values ranged from 228.04 to 253.77 mg KOH/g, with a mean of 241.80 mg KOH/g, SD of 12.96 mg KOH/g,

and %RSD of 5.36%. Although the mean falls slightly below the Codex Alimentarius range of 248–265 mg KOH/g, results are consistent with published data for refined commercial coconut oil and are attributable to known analytical sources of variability, including incomplete saponification, CO_2 absorption by reagents, and endpoint detection subjectivity. Statistical evaluation per ISO 5725 confirmed method repeatability, with all inter-trial differences below the calculated repeatability limit of 36.29 mg KOH/g. The titrimetric method is confirmed as reliable and suitable for routine quality assessment, authenticity verification, and industrial evaluation of edible oils. The high SV reflects the predominant MCT composition of coconut oil and supports its applications in food processing, cosmetics, and soap manufacturing.

Recommendations

Based on the findings and identified analytical limitations, the following measures are recommended to improve method performance:

1. Reagent preparation and storage: Alcoholic KOH should be freshly prepared or stored in tightly sealed containers with minimal headspace to prevent CO_2 absorption. Standardization should be performed immediately before use.
2. Saponification conditions: Extending the reflux period beyond one hour or employing a higher reagent excess may improve completeness of saponification, particularly for samples of unknown composition.
3. Sample mass optimization: Using larger oil samples (5–10 g) increases the volume difference between blank and sample titrations, reducing the proportional impact of endpoint detection errors on precision.
4. Instrumental endpoint detection: Potentiometric titration with automated endpoint determination eliminates subjective color assessment and may improve inter-analyst reproducibility.
5. Comprehensive quality assessment: SV should be evaluated alongside complementary parameters—acid value, iodine value, and peroxide value—to provide holistic oil quality characterization.

Applications

Saponification value determination finds application across multiple sectors: food industry quality control for oil identity verification, adulteration detection, and regulatory compliance; soap and detergent manufacturing for alkali requirement calculations; cosmetic formulation for selection of oils with appropriate physicochemical properties; biodiesel production for feedstock composition assessment; and nutritional research for fatty acid chain length characterization and MCT content estimation.

ACKNOWLEDGEMENTS

The author acknowledges the laboratory facilities and technical support provided by the Natural and Applied Sciences Department, College of Arts and Sciences, Nueva Ecija University of Science and Technology. Appreciation is extended to the Bachelor of Science in Food Technology (BSFT) students who contributed to data collection and preliminary analysis.

Funding

This study was conducted without financial support from any external funding agency.

CONFLICT OF INTEREST

The author declares no conflict of interest regarding the publication of this manuscript.

REFERENCES

1. Gunstone, F. D. Vegetable Oils in Food Technology: Composition, Properties and Uses, 2nd ed.; Wiley-Blackwell: Oxford, UK, **2011**.
2. O'Brien, R. D. Fats and Oils: Formulating and Processing for Applications, 3rd ed.; CRC Press: Boca Raton, FL, **2009**.
3. Akoh, C. C.; Min, D. B. Food Lipids: Chemistry, Nutrition, and Biotechnology, 4th ed.; CRC Press: Boca Raton, FL, **2017**.
4. AOAC International. Official Methods of Analysis, 21st ed.; AOAC International: Rockville, MD, **2019**.
5. Knothe, G. *J. Am. Oil Chem. Soc.***2002**, *79*, 847–854.
6. Choe, E.; Min, D. B. *J. Food Sci.* **2007**, *72*,

R77–R86.
7. ISO 3657:2020. Animal and Vegetable Fats and Oils—Determination of Saponification Value; International Organization for Standardization: Geneva, Switzerland, **2020**.
8. AOCS Official Method Cd 3-25. Saponification Value. In Official Methods and Recommended Practices of the AOCS, 7th ed.; American Oil Chemists' Society: Urbana, IL**, 2017**.
9. Metrohm. Acid Value and Free Fatty Acids in Edible Oils—Application Note AN-T-112; Metrohm AG: Herisau, Switzerland, **2025**.
10. Ivanova, M.; Hanganu, A.; Dumitriu, R.; Tociu, M.; Ivanov, G.; Stavarache, C.; Popescu, L.; Ghendov-Mosanu, A.; Sturza, R.; Deleanu, C.; Chira, N.-A. *Foods***2022**, *11*, 1466.
11. Gentilli, D.; Caretti, F. Saponification. In Encyclopedia of Food Sciences and Nutrition, 2nd ed.; Caballero, B., Ed.; Academic Press: Oxford, UK, **2003**; pp. 5095–5098.
12. Bockisch, M. Fats and Oils Handbook; AOCS Press: Champaign, IL, **1998**.
13. Bashyal, J. Saponification: Reaction, Mechanism, Values, Examples, Uses. ScienceInfo **2023**.
14. Marina, A. M.; Che Man, Y. B.; Amin, *I. Trends Food Sci. Technol.* **2009**, *20*, 481–487.
15. Dayrit, F. M. *J. Am. Oil Chem. Soc.* 2015, *92*, 1–15.
16. Wallace, T. C. *J. Am. Coll. Nutr.***2019**, *38*, 97–107.
17. Prasanth Kumar, P. K.; Gopala Krishna, A. G. Grasas Aceites **2015**, 66, e062.
18. Ghani, N. A. A.; Channip, A.-A.; Hwa, P. C. H.; Jaʿafar, F.; Yasin, H. M.; Usman, A. *Food Sci. Nutr.* **2018**, *6*, 1298–1306.
19. Mansor, T. S. T.; Che Man, Y. B.; Shuhaimi, M.; Abdul Afiq, M. J.; Ku Nurul, F. K. M. *Int. Food Res. J.* **2012**,*19*, 837–845.
20. Codex Alimentarius Commission. Standard for Named Vegetable Oils (CXS 210-1999, Rev. 2019); FAO/WHO: Rome, Italy, **2019**.
21. International Coconut Community. APCC Quality Standard for Virgin Coconut Oil; Asian and Pacific Coconut Community: Jakarta, Indonesia, **2009**.
22. Codex Alimentarius Commission. Codex Standard for Named Vegetable Oils (CODEX STAN 210-1999); FAO/WHO: Rome, Italy, **2015**.
23. Kanwal, R.; Musharraf, S. G. *Food Chem.* **2024**, *441*, 138361.
24. Rohman, A.; Che Man, Y. B. *Food Res. Int.* **2010,***43*, 886–892.
25. Odoom, W.; Edusei, V. O. *Asian J. Agric. Food Sci.* **2015**, *3*, 494–499.
26. Choe, E.; Min, D. B. Compr. Rev. *Food Sci. Food Saf.* **2006**, *5*, 169–186.
27. Frankel, E. N. Lipid Oxidation, 2nd ed.; Woodhead Publishing: Cambridge, UK, **2012**.
28. Geng, Z.; Zhou, Y.; Qu, Y.; Sa, R.; Liang, J.; Wang, X.; Sun, C. *Food Sci. Nutr.* **2023**, *11*, 2639–2647.
29. Alum, B. N. *INOSR Appl. Sci.* **2024**, *12*, 51–56.
30. Sajjadi, B.; Abdul Raman, A. A.; Arandiyan, H. *Renew. Sustain. Energy Rev.* **2016***, 63*, 62–92.
31. BYJU'S. Saponification Value—Formula, Derivation, and Determination. **2022**.
32. Pomeranz, Y.; Meloan, C. E. Food Analysis: Theory and Practice, 3rd ed.; Chapman & Hall: New York, **1994**.
33. Nielsen, S. S. Food Analysis, 5th ed.; Springer: Cham, Switzerland, **2017**.
34. Kirk, R. S.; Sawyer, R. Pearson's Composition and Analysis of Foods, 9th ed.; Longman Scientific and Technical: Harlow, UK, **1991**.
35. AOAC International. Guidelines for Standard Method Performance Requirements; AOAC International: Rockville, MD, **2016**.
36. Thompson, M.; Ellison, S. L. R.; Wood, R. *Pure Appl. Chem.* **2002**, *74*, 835–855.
37. Horwitz, W.; Albert, R. J. *AOAC Int.* **2006**, *89*, 1095–1109.
38. Codex Alimentarius Commission. Standard for Named Vegetable Oils (CXS 210-1999, Amended 2019); FAO/WHO: Rome, Italy, **2019**.
39. Coconut Development Board; Central Food Technological Research Institute. Coconut Oil: Chemistry, Production and Its Applications—A Review; Coconut Development Board: Kochi, India, **2010**.
40. Prasanth Kumar, P. K.; Gopala Krishna, A. G. *Grasas Aceites***2014**, *65*, e018.
41. Gopala Krishna, A. G.; Gaurav, R.; Bhatnagar, A. S.; Prasanth Kumar, P. K. *Indian Coconut J.* **2010**, *53*, 15–27.
42. AOAC International. Official Methods of Analysis, 21st ed.; AOAC International: Rockville, MD, **2019**.

43. ISO 3657:2020. Animal and Vegetable Fats and Oils—Determination of Saponification Value; International Organization for Standardization: Geneva, Switzerland, **2020.**
44. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, 9th ed.; Cengage Learning: Boston, MA, **2014**.
45. ISO 3657:2013. Animal and Vegetable Fats and Oils—Determination of Saponification Value; International Organization for Standardization: Geneva, Switzerland, **2013**.
46. ISO 5725-2:2019. Accuracy (Trueness and Precision) of Measurement Methods and Results—Part 2: Basic Method for the Determination of Repeatability and Reproducibility; International Organization for Standardization: Geneva, Switzerland, **2019**.
47. Hogan, R. How to Perform a Repeatability Test for Estimating Uncertainty. ISOBudgets **2024**.
48. News-Medical. Seven Important Parameters for Analysis of Edible Oils and Fats. **2019**.
49. Milani, A.; Folegatti, L. Riv. *Ital. Sostanze Grasse***2024**, *101*, 1–24.
50. Maurikaa, C.; Jaganivash, B.; Shanmugasundaram, S. *Int. J. Chem. Stud*. **2020**, *8*, 2433–2438.
51. Akbar, M. Saponification of Oil; Scribd: San Francisco, CA, **2019**.
52. Vipsen. Saponification Value: A Key Indicator for Evaluating the Quality of Vegetable Oils; VIPSEN: Vietnam, **2025**.
53. Amrita Vishwa Vidyapeetham Virtual Lab. Estimation of Saponification Value of Fats/Oils (Procedure); Amrita University: Coimbatore, India, **2025**.
54. Harris, D. C. Quantitative Chemical Analysis, 9th ed.; W. H. Freeman: New York, **2016**.
55. Christian, G. D.; Dasgupta, P. K.; Schug, K. A. Analytical Chemistry, 7th ed.; Wiley: Hoboken, NJ, **2014.**
56. Miller, J. N.; Miller, J. C. Statistics and Chemometrics for Analytical Chemistry, 7th ed.; Pearson: Harlow, UK, **2018**.
57. Kapila, N.; Seneviratne, K. N. *J. Food Process. Preserv*. **2013**, *37*, 885–890.
58. Firestone, D. Physical and Chemical Characteristics of Oils, Fats, and Waxes, 3rd ed.; AOCS Press: Urbana, IL, **2013**.
59. AOAC International. Guidelines for Standard Method Performance Requirements. *J. AOAC Int.***2016**, *99*, 1614–1616.
60. Taverniers, I.; De Loose, M.; Van Bockstaele, E. *Trends Anal. Chem.***2004,***23*, 535–552.
61. Miller, J. N.; Miller, J. C. Statistics and Chemometrics for Analytical Chemistry, 7th ed.; Pearson Education: Harlow, UK, 2018.
62. Woollatt, E. The Manufacture of Soaps, Other Detergents and Glycerine; Ellis Horwood: Chichester, UK, **1985**.
63. AOCS Official Method Cd 3a-94. Saponification Value Calculated from Fatty Acid Composition. In Official Methods and Recommended Practices of the AOCS, 7th ed.; American Oil Chemists' Society: Urbana, IL, **2017**.
64. Guillén, M. D.; Ruiz, A. *Trends Food Sci. Technol*. **2001**, *12*, 328–338.