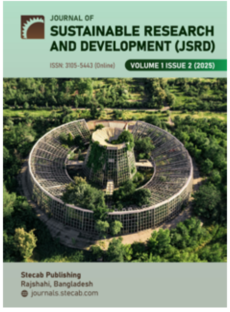

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Research Article

Analysis of Fat-Soluble and Water-Soluble Vitamins in Edible Vegetable Oils Consumed in Nigeria

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About Article

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ABSTRACT

Vitamin deficiencies remain a significant public health concern in Nigeria, where dietary diversity is often limited and micronutrient-enriched foods are scarce. This study, therefore, investigated the concentrations of fat-soluble and water-soluble vitamins in commonly consumed edible vegetable oils in Nigeria to assess their potential contribution to micronutrient intake. The vitamin content of ten commercial oil brands was determined using a UV–visible spectrophotometer. Results showed that vitamin E was the dominant component in all samples, with concentrations ranging from 4.26 to 6.56 mg/100 g. Sample V1 recorded the lowest level, while sample V8 had the highest. Vitamin C followed, with values between 0.61 and 1.17 mg/100 g, whereas other vitamins were detected in lower quantities: vitamin A (0.03–0.42 mg/100 g), vitamin D (0.02–0.11 mg/100 g), vitamin B_1 (0.009–0.024 mg/100 g), vitamin B_2 (0.008–0.016 mg/100 g), vitamin B_3 (0.38–0.71 mg/100 g), vitamin B_6 (0.25–0.34 mg/100 g), and vitamin B_{12} (0.00–0.16 mg/100 g). The high levels of vitamins E and C indicate that vegetable oils are important supplementary dietary sources of antioxidants that may help reduce the prevalence of micronutrient deficiencies and associated health disorders in the Nigerian population.

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1. INTRODUCTION

Vegetable oils are a vital constituent of the human diet and are widely consumed across Nigeria. They supply essential fatty acids, energy, fat-soluble vitamins, and numerous bioactive compounds required for optimal physiological function (Li *et al.*, 2016). Among these, vitamin E stands out as the most abundant and physiologically significant antioxidant present in vegetable oils. It enhances oxidative stability by delaying rancidity, thereby prolonging shelf life (Tangolar *et al.*, 2011). Beyond its technological importance, vitamin E plays a crucial role in reducing the risk of cardiovascular disease, certain cancers, and degenerative disorders (Hammond, 2003; Rader *et al.*, 1997).

Vitamins are organic micronutrients that regulate essential biochemical and physiological processes. Because the human body cannot synthesise most vitamins, sufficient quantities must be supplied through food to sustain normal metabolism (Combs, 2008; Samih & Yildiz, 2005; Uzoekwe *et al.*, 2021). They are commonly grouped based on solubility: fat-soluble vitamins (A, D, E, and K), which dissolve in lipids and can be stored in body tissues, and water-soluble vitamins (vitamin C and the B-complex group), which dissolve in water and are not extensively stored (Okpoji *et al.*, 2025).

Each vitamin performs unique biological functions. Vitamin A (retinol) supports vision, epithelial integrity, and immune defence, while vitamin D enhances calcium absorption and bone mineralisation, thereby preventing rickets in children and osteomalacia in adults. Vitamin E acts as a potent antioxidant that protects cell membranes from oxidative damage, whereas vitamin K is vital for normal blood coagulation (Onoja *et al.*, 2025; Hashemi *et al.*, 2019; Lukaski, 2004; Nahed & Enaam, 2017). Vitamin C (ascorbic acid) contributes to collagen synthesis, tissue repair, and immune resistance and also functions as a primary antioxidant (Akpabio & Ikpe, 2013; Anarado *et al.*, 2023).

The B-vitamin complex performs multiple metabolic and neurological functions crucial to human health. Vitamins B_1 (thiamine) and B_5 (pantothenic acid) are essential for the synthesis of neurotransmitters such as acetylcholine and act as cofactors in enzymatic decarboxylation processes (Jannusch *et al.*, 2017; Yoshii *et al.*, 2019). Vitamin B_2 (riboflavin) facilitates the metabolism of carbohydrates, lipids, and amino acids through several enzyme-mediated pathways (Kennedy, 2016). Vitamin B_3 (niacin) supports carbohydrate utilisation and participates in non-redox adenosine diphosphate-ribose transfer reactions important for DNA repair and cellular integrity (Fania *et al.*, 2019; Anarado *et al.*, 2025). Vitamin B_6 (pyridoxine) functions as an antioxidant that neutralises free radicals and maintains physiological stability (Akpabio & Ikpe, 2013). Deficiency of vitamin B_6 can cause neurological and dermatological disorders such as depression, confusion, microcytic anaemia, cracked lips, and impaired immune response (McCormick, 2006). Similarly, vitamin B_9 (folic acid) is indispensable for normal cell division and genetic synthesis (Lyon *et al.*, 2020), while vitamin B_{12} (cyanocobalamin) supports nervous-system integrity, cognitive performance, and red-blood-cell formation (Callaghan *et al.*, 2009; Okpoji *et al.*, 2025).

Despite the nutritional importance of these vitamins, widespread micronutrient deficiencies remain a major public-health challenge in Nigeria due to poor dietary diversity, post-harvest losses, and limited fortification of staple foods. Vegetable oils, consumed daily across households, present an under-explored vehicle for vitamin intake, especially in rural and low-income populations where dietary supplements are unaffordable. However, scientific data on the quantitative composition of both fat- and water-soluble vitamins in Nigerian edible oils remain limited.

Therefore, this study specifically aims to determine the concentrations of fat-soluble (A, D, E) and water-soluble (C and B-complex) vitamins in ten widely consumed brands of edible vegetable oils sold in Anambra State, Nigeria, using UV–visible spectrophotometry. The novelty of this study lies in providing baseline data on the micronutrient quality of commonly marketed vegetable oils in Nigeria, thereby contributing to evidence-based strategies for addressing vitamin deficiencies and improving national food-fortification policies.

2. LITERATURE REVIEW

Vegetable oils are an important dietary source of energy and essential micronutrients, including fat-soluble vitamins such as A, D, E, and K, which play critical roles in human metabolism and antioxidant defence. Studies conducted in different regions have reported wide variations in the vitamin composition of edible oils, depending on the raw material, extraction method, fortification level, and storage conditions (Hashemi *et al.*, 2019; Nahed & Enaam, 2017). Globally, vitamin E (tocopherol) has been identified as the most dominant antioxidant vitamin in vegetable oils, contributing significantly to their oxidative stability and nutritional value (Tangolar *et al.*, 2011; Hammond, 2003).

In Nigeria, limited empirical studies have quantified the vitamin composition of edible vegetable oils despite their widespread household consumption. Adejumo *et al.* (2021) analysed eighteen commercial vegetable oils sold in Nigeria using high-performance liquid chromatography (HPLC) and reported alpha-tocopherol concentrations ranging from 0.47 to 9.22 mg/100 g, with significant variation across brands. Their findings confirmed that vitamin E remains the most prevalent micronutrient in edible oils available in the Nigerian market. Similarly, Nahed and Enaam (2017) examined seventeen vegetable oils and found high levels of vitamin E (up to 8.42 mg/100 g) and detectable quantities of vitamins A and D, highlighting their nutritional contribution and antioxidant potential. Rashid *et al.* (2024) also reported comparable findings for pulses and plant-based oils in Bangladesh, suggesting that the vitamin content of plant-derived oils varies significantly by processing method and source.

In the West African context, few comparative analyses exist. Studies conducted in Ghana and Nigeria have shown that locally refined oils may have lower vitamin retention than imported fortified brands due to oxidation during heating, prolonged storage, or poor packaging (Ekwere *et al.*, 2025). This raises nutritional concerns, as vegetable oils serve as the main vehicle for fortification in national programmes aimed at reducing vitamin A deficiency and other micronutrient disorders (John *et al*, 2025). However, while several Nigerian studies have investigated proximate and mineral compositions of edible oils (Aluyor & Ori-Jesu, 2008; Uzoekwe *et al.*, 2021), few have comprehensively profiled both fat-soluble and water-soluble vitamins in commercial vegetable oil brands.

Uzoekwe *et al.* (2021) analysed vitamins in the leaves of Solanum erianthum and Glyphaea brevis using a UV–visible spectrophotometer and detected vitamins A, B_1, B_2, B_3, B_6, B_{12}, C, and E, with pyridoxine (vitamin B_6) exhibiting the highest concentrations. Similarly, Nwolisah *et al.* (2024) assessed the vitamin content of Acalypha wilkesiana leaves through colourimetric and titrimetric methods, reporting fat-soluble vitamin concentrations ranging from 4.12±0.26 mg/kg (vitamin D) to 17.28±1.00 mg/kg (vitamin E), and water-soluble vitamin levels between 0.05±0.02 mg/100 g (vitamin B_2) and 69.61±1.77 mg/kg (vitamin C). Although these studies demonstrate the nutritional potential of plant-based materials, they primarily focused on leafy vegetables rather than edible oils, leaving a substantial knowledge gap in understanding the vitamin profiles of oils consumed daily by the Nigerian population. Therefore, this study fills a critical gap by providing quantitative data on both fat-soluble (A, D, E) and water-soluble (B-complex and B-complex) vitamins in ten widely marketed vegetable oil brands in Nigeria.

3. METHODOLOGY

3.1. Sample collection and preparation

Ten brands of edible vegetable oils were randomly purchased from open markets across Anambra State, Nigeria. The selected brands Power Oil, Laziz Oil, Activa Oil, Golden Terra Oil, Golden Penny Oil, Laser Virgin Oil, Devon Kings Oil, Lahda Oil, Sunola Oil, and Mamador Oil were chosen based on their wide availability and frequent household consumption. Each product was labelled from V1 to V10 for analytical uniformity. Samples were transferred into clean, airtight amber bottles to minimise photo-oxidation and contamination and stored at room temperature until analysis. The randomised sampling ensured that the results represented a fair cross-section of vegetable oils commonly consumed in Nigeria.

3.2. Determination of vitamins

Vitamin concentrations were determined using validated spectrophotometric and titrimetric procedures previously described by Nahed and Enaam (2017), Adejumo *et al.* (2021), and Rashid *et al.* (2024), with slight modifications. All analyses were conducted in duplicate, and mean values were recorded to ensure reproducibility. Blanks, calibration standards, and quality-control samples were included in each analytical batch.

3.2.1. Calibration and validation of analytical methods

Method validation followed AOAC (2016) and IUPAC (2019) recommendations for spectrophotometric assays. Calibration curves were prepared using analytical-grade vitamin standards (Sigma-Aldrich, USA). The calibration range for vitamins A, D, E, and C was 0.01–10 mg/100 g, while B-complex vitamins were calibrated within 0.005–2 mg/100 g. All methods exhibited linear responses with coefficients of determination (R^2) of 0.998 or higher. Precision and repeatability were evaluated through replicate analysis (n = 5) of fortified blank samples, yielding relative standard deviations (RSDs) below 5%. Recovery studies were performed by spiking blank oil samples with known concentrations (1, 5, and 10 mg/100 g) of vitamin standards, and mean recoveries ranged from 92–106% for fat-soluble vitamins and 88–103% for water-soluble vitamins, indicating satisfactory analytical accuracy. The limits of detection (LOD) ranged between 0.002 and 0.008 mg/100 g, while the limits of quantification (LOQ) were between 0.007 and 0.025 mg/100 g. To further confirm analytical reliability, vitamin A and E concentrations were verified using the NIST 3232 fortified oil standard reference material, and results deviated by less than 5% from certified values.

3.2.2. Determination of vitamin A (Retinol)

Vitamin A was determined using a modified colourimetric method. One gram of each oil sample was saponified with one millilitre of a saponification mixture under reflux at 60 °C for 20 minutes in the dark to prevent photo-oxidation. After cooling, twenty millilitres of distilled water were added, and the unsaponifiable fraction was extracted twice with ten millilitres of petroleum ether (boiling range 40–60 °C). The combined extracts were dried over anhydrous sodium sulphate and evaporated to dryness in a water bath at 60 °C. The residue was re-dissolved in one millilitre of chloroform, mixed with two millilitres of trichloroacetic acid (TCA) reagent, and absorbance was measured at 325 nm using a Genesys 10 UV–visible spectrophotometer. Concentrations were determined from a vitamin A palmitate calibration curve.

3.2.3. Determination of vitamin E (Tocopherol)

Vitamin E was analysed using the Emmerie Engel method with minor modifications. About 2.5 g of oil was homogenised in fifty millilitres of 0.1 N sulphuric acid and allowed to stand overnight. The mixture was filtered, and 1.5 mL aliquots of the filtrate, standard, and blank were separately combined with ethanol and xylene, centrifuged, and the upper xylene phase was collected. This was reacted with α,α′-dipyridyl reagent, and absorbance was measured at 520 nm. Vitamin E concentration was quantified against an α-tocopherol standard curve and expressed in milligrams per kilogram (mg kg^{-1}) of oil.

3.2.4. Determination of vitamin D (Cholecalciferol)

Vitamin D_3 was analysed colourimetrically following Rashid *et al.* (2024). A working standard was prepared by dissolving 25 mg of pure cholecalciferol in a 1:9 mixture of chloroform and methanol. Each 0.1 mL oil sample was treated identically, followed by the addition of 1.6 mL of 0.25 M hydrochloric acid, 0.5 mL of 15% trichloroacetic acid, and 0.5 mL of 0.375% thiobarbituric acid in succession. After colour development, absorbance was measured at 464 nm against a reagent blank, and concentrations were calculated from a standard calibration curve.

3.2.5. Determination of Water-Soluble Vitamins (C and B-Complex)

Water-soluble vitamins (C, B_1, B_2, B_3, B_6, and B_{12}) were determined using validated spectrophotometric and titrimetric procedures adapted from Uzoekwe *et al.* (2021). Each analysis included triplicate runs with internal quality controls and matrix-spiked recovery standards. Absorbances were measured at 540 nm (vitamin C), 261 nm (vitamin B_1), 242 nm (vitamin B_2), and 635 nm (vitamin B_{12}). Vitamins B_3 and B_6 were quantified by titration using perchloric acid, with calculations based on molar equivalence factors. Results were expressed in milligrams per 100 grams (mg/100 g) of oil.

3.3. Statistical analysis

All determinations were carried out in duplicate, and mean concentrations were calculated. Statistical analysis was performed using SPSS (Version 25.0). Descriptive statistics were used to summarise the vitamin contents, while one-way analysis of variance (ANOVA) was applied to evaluate differences among oil brands. Correlation analysis was performed to assess the relationship between different vitamins, and significance was considered at $p < 0.05$.

4. RESULTS AND DISCUSSION

4.1. Vitamin composition of edible vegetable oils

The concentrations of both fat-soluble and water-soluble vitamins detected in the analysed vegetable oil samples (V1–V10) are presented in Table 1. The results indicate wide variations among brands, reflecting differences in processing, fortification, and storage conditions.

Table 1. Vitamin contents of vegetable oil samples (mg/100 g)

Vitamins (mg/100g)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
A	0.17	0.23	0.42	0.18	0.03	0.06	0.07	0.03	0.07	0.04
D	0.05	0.07	0.02	0.02	0.11	0.07	0.04	0.02	0.05	0.03
E	4.26	4.49	4.39	5.63	4.27	4.69	4.28	6.56	4.72	4.28
C	0.70	0.64	0.76	0.78	0.84	0.61	0.86	0.76	0.84	1.17
B1	0.013	0.024	0.016	0.015	0.016	0.017	0.012	0.015	0.010	0.009
B2	0.012	0.015	0.011	0.008	0.012	0.013	0.016	0.016	0.015	0.015
B3	0.60	0.71	0.49	0.50	0.38	0.59	0.61	0.61	0.60	0.39
B6	0.28	0.28	0.30	0.28	0.30	0.27	0.30	0.28	0.34	0.25
B12	0.16	0.15	0.12	0.10	0.04	0.11	ND	0.10	0.06	0.10

Note. ND = Not detected.

The analysis revealed that vitamin E (tocopherol) was the predominant vitamin across all the edible vegetable oils examined, with concentrations ranging from 4.26 to 6.56 mg/100 g. Sample V1 recorded the lowest level, while sample V8 exhibited the highest. These values are consistent with the range of 0.00–9.22 mg/100 g reported by Adejumo *et al.* (2021) for Nigerian vegetable oils and fall within the limits established for commercial edible oils worldwide (Nahed & Enaam, 2017). Vitamin E is known for its antioxidant role in stabilising oils by inhibiting lipid peroxidation and retarding rancidity, thereby extending shelf life and enhancing nutritional quality (Aluyor & Ori-Jesu, 2008).

Among the remaining vitamins, fat-soluble vitamins A and D were detected at comparatively lower levels. Vitamin A ranged from 0.03 to 0.42 mg/100 g, with the highest concentration in sample V3 and the lowest in samples V5 and V8. These values are below the 1.40 mg/100 g reported by Irabor *et al.* (2020) for Calliandra surinamensis oil, indicating that most of the analysed brands may not meet the desired fortification levels recommended for combating vitamin A deficiency. Vitamin D_3 content varied between 0.02 and 0.11 mg/100 g, with sample V5 having the highest concentration, consistent with fortification practices that target essential fat-soluble nutrients for bone health and calcium metabolism.

The water-soluble vitamins (vitamin C and the B-complex) were detected in trace to moderate quantities. However, due to possible analytical interferences and the limited lipid solubility of these vitamins, the present data for water-soluble fractions should be interpreted cautiously until further validated against certified reference materials. The detection of vitamin C and B-vitamins may indicate minimal water-phase retention during oil processing or partial fortification, but these results cannot yet be considered definitive evidence of their consistent presence in all oil brands.

Vitamin B_2 (riboflavin) appeared as the least prevalent micronutrient, with concentrations between 0.008 and 0.016 mg/100 g, while vitamin B_6 ranged from 0.25 to 0.34 mg/100 g. Sample V9 had the highest vitamin B_6 level, whereas sample V10 contained the lowest. Vitamin B_{12} was detected in all samples except V7, where it was below the detection limit. These findings are comparable to earlier reports on plant-based matrices, where the B-vitamin group was found in low but nutritionally relevant concentrations (Nwolisah *et al.*, 2024; Gropper *et al.*, 2009).

The results indicate that fat-soluble vitamins (A, D, and E) are more reliably quantified and nutritionally significant in the analysed edible vegetable oils, reflecting both fortification and natural retention. In contrast, the water-soluble vitamin data while providing preliminary insight should be viewed as exploratory until method validation is strengthened. The consistent dominance of vitamin E confirms its essential antioxidant role and underlines the importance of edible oils as a potential dietary source of fat-soluble micronutrients for Nigerian consumers.

5. CONCLUSION

The study evaluated the concentration of vitamins in some edible vegetable oils commonly sold in Nigeria. The studied samples labelled V1– V10 showed a great variation. The study revealed that Vitamin E and Vitamin C were recorded as the second most predominant vitamins, and Vitamin B2 was the least predominant vitamin, with concentrations. The samples labelled V2 and V8 had the highest positive vitamin contributions among the ten edible vegetable oils analysed. The findings suggest that the vegetable oil samples contained appreciable quantities of vitamins and are a richer source of vitamin E (an antioxidant), which will help prevent them from going rancid during storage and thus increase their shelf life, followed by vitamin C, and this suggests that the vegetable oil samples, when well utilised, would contribute greatly towards meeting the requirement for growth and adequate protection against diseases arising from malnutrition and free radicals.

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