



ASSESSMENT OF STORAGE STABILITY OF SOME REFINED VEGETABLE OILS FROM SELECTED MAJOR MARKETS IN LAGOS METROPOLIS, NIGERIA



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Received: February 14, 2025, Accepted: April 28, 2025

Abstract

The storage stability of any processed food solely depends on its manufacturing procedures and complete adherence to its recommended specifications in raw materials selection, during processing and storage. Standards and recommended specifications must be strictly adhered to in order to achieve product stability, hence sharp practices must be discouraged in food processing. This study assessed the storage stability of some refined vegetable oils in Lagos markets. Eight samples of branded oils coded as: VEG-MMD, VEG-EMP, VEG-DVK, VEG-GINO, VEG-SNF, VEG-PWR, VEG-GDS, VEG-GLN and one unbranded, VEG-UBD were purchased from selected major markets in Lagos Metropolis. All the branded oils were mid-way to their respective expiration. The following chemical quality indices (free fatty acid, iodine value and peroxide value) and moisture content as physical index were monitored during storage for 12 weeks. The listed parameters were very key in determining the storage stability of vegetable oils. Duncan's multiple range test was used to separate the means after the results were submitted to analysis of variance. Results showed significant ($p < 0.05$) differences in moisture, free-fatty-acids, iodine and peroxide. Within the 12 weeks of storage, the chemical quality indices of VEG-UBD decreased significantly ($p < 0.05$) when compared with the branded oils.

Keywords:

Refined vegetable oil, Chemical properties, Physical composition, Free-fatty-acid, Storage stability.

Introduction

According to Ukom *et al.*, 2018, Vegetable oils as lipids are groups of food constituents which give energy, essential fatty acids, and act as a carrier for fat-soluble vitamins in the body (A, D, E, K). They are biological molecules with a poor water solubility that dissolve in non-polar chemical solvents. The hydrophobic effect and van der Waals interactions describe their intermolecular interactions. Many lipids, on the other hand, are amphipathic proteins that form hydrogen bonds and electrostatic interactions with other molecules and aqueous solvents. (Brandt, 2000). The net consumption of vegetable oils in Nigeria's annual production was 1.6 million tonnes, with domestic supply anticipated at 1.3 million tonnes, leaving a 0.3 million-tonnes deficit which represented imports (Anyanwu *et al.*, 2011). A large part of the deficit was satisfied through the illegal act of smuggling of the products across the borders, thus encouraging adulteration. Food fraud is one of the most pressing and active areas of food study and regulation. It is a growing problem in Nigeria that has resulted in the deaths of many individuals, particularly those from vulnerable groups such as children and the elderly (Opia, 2020). One of the major challenges confronting the human race and food manufacturing in particular is exposing the consumers to adulterated and substandard products in exchange for profit maximization (Asrat and Zalalem, 2014).

Food adulteration is a major threat to food safety and security. The vulnerabilities of food supply chains are mostly due to the fact that they are long, global, and highly interconnected. (Maruchek *et al.*, 2011). Adulteration of the product can occur along its channel of distribution before it gets to the final consumer. The adulteration and involvement

of sharp practices to maximize profit in vegetable oil processing can render the product unstable during storage. Edible vegetable oils are susceptible to oxidation and microbial degradation, which can result in nutritional loss and off-flavors. Deterioration in quality may contribute to the creation of reactive and hazardous oxidation products, which offer health hazards such as cancer and inflammation. (Negash *et al.*, 2019).

The oxidative stability of edible plant oils has been intensively researched in order to determine strategies to enhance their oxidative stability and broaden its applicability (Madhujith T and Subajiny S., 2018). Oxidation (one of the most fundamental reactions in lipid chemistry) is the principal source of quality degradation in fats and oils, and the rate of oxidation dictates the shelf life. Edible oils may deteriorate as a result of lipid oxidation during storage, handling, or cooking. The loss of oil quality is mostly caused by oxidation, which reduces an oil's nutritional value and produces unwanted off tastes, making oils containing food less appealing to consumers. (Fadda *et al.*, 2022). The acceptability and market value of vegetable oil are primarily influenced by its quality and stability (Ofosu *et al.*, 2012). The oxidative stability of oil is one of the most important measures of its maintaining quality (Tan *et al.*, 2017). Vegetable oils are prone to oxidation when exposed to oxygen according to Sacchi *et al.*, (2008). The amount of oxygen in the oil is determined by the parameters utilized in technological processes like centrifugation, decanting, and filtration. It was stated by Velasco and Dobarganes (2002) that one of the key factors determining lipid oxidation is storage temperature. Higher temperatures resulted in more lipid oxidation and loss of nutrients (Liu K *et al.*, 2019). The

autoxidation reaction in olive oil triacylglycerols held in darkness at various temperatures (25°, 40°, 50°, 60°, and 75°C) was studied kinetically confirmed that the reaction constant grows exponentially with temperature (Gómez Alonso *et al.*, 2004). The relationship between storage stability and deterioration of vegetable oil is critical to know. As a result, this study was conducted with that objective in mind.

Materials, Methods

In order to assess the storage stability of the selected vegetable oils over a storage duration of three months, the nine samples (unbranded included) which were mid-way to their expiry dates were analyzed. The storage stability of the selected oils was evaluated by analyzing changes in the major chemical quality indices (moisture, free fatty acid, iodine value, and peroxide value) over time. The sampled oils were poured into a clean, dried and well labeled 100 ml sampling bottles with airtight caps. They were stored for a period of three months under ambient temperature (28±2 °C). The samples were analyzed at an interval of two weeks during storage duration of three months.

Chemicals and reagents

Sigma Chemical provided sodium hydroxide, potassium iodide, sodium thiosulphate, and starch (St. Louis, MO). Fisher Scientific provided isopropyl alcohol solution (IPA), chloroform, cyclohexane, wijs solution, ACS grade glacial acetic acid, and phenolphthalein (Fairlawn, NJ).

Determination of moisture

The AOCS (2017) approach was employed. The moisture content of the selected vegetable oils was determined using an air oven set at 130°C. The oil sample was thoroughly mixed to distribute the water in it uniformly. 5 g of oil sample was weighed inside a tarred moisture dish that has been dried and cooled previously in a desiccator. The sample was then placed in the air oven for 30 min. Thereafter it was removed, cooled to room temperature in a desiccator and weighed.

Calculation:

$$\text{Moisture Content (\%)} = \frac{(W_2 - W_1)}{W_3} \times 100$$

W₁ = weight of dish and oil sample after drying

Where W₂ = weight of dish and oil sample before drying, and

W₃ = oil sample weight.

Determination of free fatty acid

Before weighing, the sample was properly mixed. 10 g of the oil sample was weighed into a 250 ml conical flask and 75 ml of hot isopropyl alcohol solution (IPA) was added to dissolve it. After that, the solution was titrated in the presence of 0.05 M sodium hydroxide (NaOH) with the addition of 2 drops of phenolphthalein as an indicator until the first permanent pink color developed. (AOCS, 2017).

$$\% \text{FFA} = \frac{V \times M \times C}{W_t}$$

Calculation:

Where

V is volume of alkali

M is the molarity of NaOH (0.05M),

W_t is the weight of the sample

C = constant (25.6) as Palmitic for vegetable oil Products (constant).

Determination of iodine value

The test sample was well mixed before being heated to 68 degrees Celsius.

To remove any solid contaminants, it was filtered using two pieces of 10" / 25cm filter paper.

After weighing 0.50 g filtered oil sample into a flask, a 20 ml mixture of cyclohexane and acetic acid in a 1:1 ratio was added to dissolve the sample.

With the use of a pipette, about 25 ml of wijs solution was dispensed into the conical flask containing the test sample.

To achieve an intimate stirring, the conical flask stopped and swirled. The solution was immediately transferred into a dark cupboard for an hour. 20 ml of potassium iodide (KI), followed by 100 ml of distilled water were added. Titration of the solution against 0.1 M sodium thiosulphate solution (Na₂S₂O₃) until the iodine yellow color was almost completely gone was done.

After that, approximately 2 mL of starch indicator solution was added, and the titration was maintained with vigorous shaking until the blue color had disappeared completely.

Simultaneously, the blank testing was carried under the same procedures (AOCS, 2017).

Calculation:

$$\text{Iodine Value} = \frac{12.96N (V_2 - V_1)}{W}$$

Where:

M is the exact molarity of thiosulphate solution used,

V₂ is the volume of sodium thiosulphate solution used for blank and

V₁ is the volume of sodium thiosulphate solution used for sample.

W is the sample weight.

Determination of peroxide value

This determines the primary oxidation state of vegetable oils and was done according to AOCS (1998). After stirring, the oil sample was melted to 65 °C. To dissolve the sample, 10 g of the sample was poured into a conical flask and 30 ml of acetic acid-chloroform in a 3:2 (v/v) mixture was added and swirled in the flask. 0.5 ml of freshly prepared saturated potassium iodide was added to the mixture with a pipette and swirled in the flask continuously for 1 minute, followed by 30 ml of distilled water.

As the solution was being titrated against a saturated-freshly prepared 0.1 M sodium thiosulphate solution, approximately 0.5 ml starch indicator was added until the blue color had just disappeared.

The blank was done at the same time and under the same conditions.

Calculation:

$$\text{Peroxide Value} = \frac{V \times N \times 1000}{W}$$

Where:

V is the volume of sodium thiosulphate solution used for the sample,

N is the molarity of sodium thiosulphate and W is the sample weight.

W is the sample weight.

Results and Discussion

It was observed that the following parameters increased significantly during the storage period of three months: moisture, the free fatty acids and the peroxide value. However, the iodine values were observed to decrease in value during the storage period. Figure 1 showed the patterns of change under ambient storage conditions in the moisture content of selected vegetable oils. The moisture content of VEG-MMD increased from 0.04 ± 0.00 to 0.05 ± 0.01 after 12 weeks of storage. It was observed that VEG-EMP with initial moisture of 0.07 ± 0.01 had increased to 0.08 ± 0.02 after storing it for 12 weeks. The moisture of VEG-DVK and VEG-GINO which were initially at 0.07 ± 0.01 and 0.05 ± 0.00 had increased to 0.09 ± 0.00 and 0.06 ± 0.01 respectively after 12 weeks of storage. The moisture of VEG-ASF increased from 0.05 ± 0.01 to 0.07 ± 0.00 , and that of VEG-PWR increased from 0.06 ± 0.01 to 0.08 ± 0.00 after 12 weeks of storage. VEG-GDS had initial moisture of 0.04 ± 0.02 which increased to 0.06 ± 0.00 while VEG-GLN increased from 0.05 ± 0.01 to 0.06 ± 0.01 after storage. The moisture of VEG-UBD was initially 0.08 ± 0.00 and increased to 0.15 ± 0.01 after the storage.

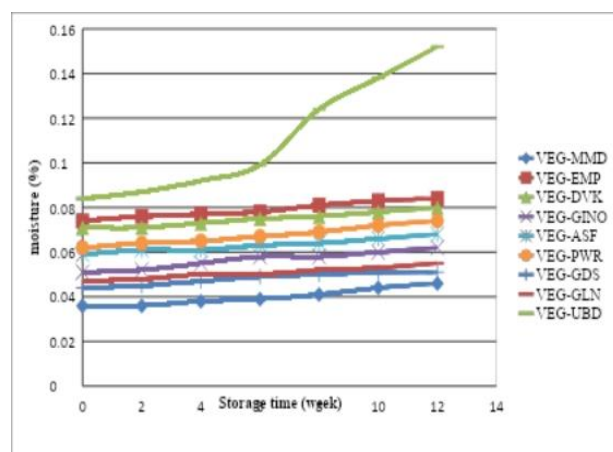


Figure 1: Changes in moisture of vegetable oils under ambient storage

Where: VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sunflower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; VEG-UBD- Unbranded vegetable oil.

Figure 2 shows the change in free fatty acids of the selected vegetable oils over a storage period of 12 weeks storage. It was observed that the free fatty acids increased gradually over a storage period in all the samples except in VEG-UBD where the increment was rapid. The free fatty acid for VEG-PWR was 0.08 ± 0.01 in the first week and it increased to 0.19 ± 0.00 after 12 weeks of storage. VEG-EMP was analyzed to be 0.08 ± 0.01 in the first week and it increased to 0.12 ± 0.01 in the 12th week of storage. For VEG-DVK,

the free fatty acid was 0.07 ± 0.01 in the first week and it also increased to 0.19 ± 0.00 after 12 weeks of storage. VEG-MMD was found to be 0.08 ± 0.00 for free fatty acid in the first week, after 12 weeks of storage, it increased to 0.14 ± 0.01 . VEG-GINO increased in free fatty acid from 0.08 ± 0.01 to 0.10 ± 0.04 after storing it for 12 weeks. The free fatty acid for VEG-ASF increased from 0.09 ± 0.01 to 0.12 ± 0.00 in the 12th week of storage. VEG-GDS was observed to increase in free fatty acid from 0.08 ± 0.02 in the first week to 0.14 ± 0.01 after storing it for 12 weeks. VEG-GLN had initial free fatty acid of 0.08 ± 0.00 which increased to 0.17 ± 0.01 in the 12th week of storage. VEG-UBD with initial free fatty acids of 0.13 ± 0.01 was observed to have increased to 0.24 ± 0.00 after storage.

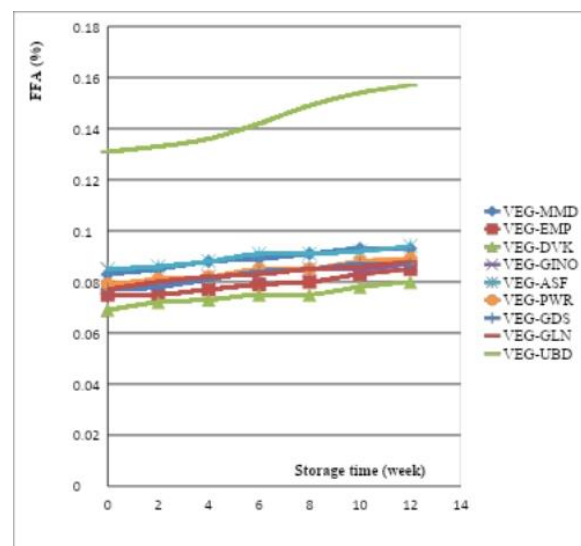


Figure 2: Changes in free fatty acid of vegetable oils under ambient storage conditions

Where: VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sunflower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; VEG-UBD- Unbranded vegetable oil.

The iodine values were observed to decrease in value during storage as shown in figure 3. This implies that the degree of unsaturation decreased over a storage period. The iodine value depends on some factors such as the source of the oil and the degree of refining of the oil. The iodine value for VEG-PWR decreased from 60.65 ± 0.20 in the first week to 60.40 ± 0.20 after 12 weeks of storage. For VEG-EMP, the iodine value decreased from 58.29 ± 0.27 in the first week to 57.93 ± 0.20 after storage. In VEG-DVK, it decreased from 58.22 ± 0.35 in the first week to 58.03 ± 0.30 . For VEG-MMD, the iodine value decreased from 60.38 ± 0.44 in the first week to 60.06 ± 0.31 after 12 weeks of storage. VEG-GINO had an initial iodine value of 58.50 ± 0.06 which decreased to 58.21 ± 0.13 . The iodine value of VEG-ASF decreased from 119.48 ± 0.14 to 119.29 ± 0.21 and that of VEG-GDS and VEG-GLN decreased from 118.59 ± 0.322 to 118.33 ± 0.253 and 111.2 ± 0.19 to 111.01 ± 0.34 respectively. The iodine

value of VEG-UBD decreased from 55.44 ± 0.65 to 54.13 ± 0.53 after storage.

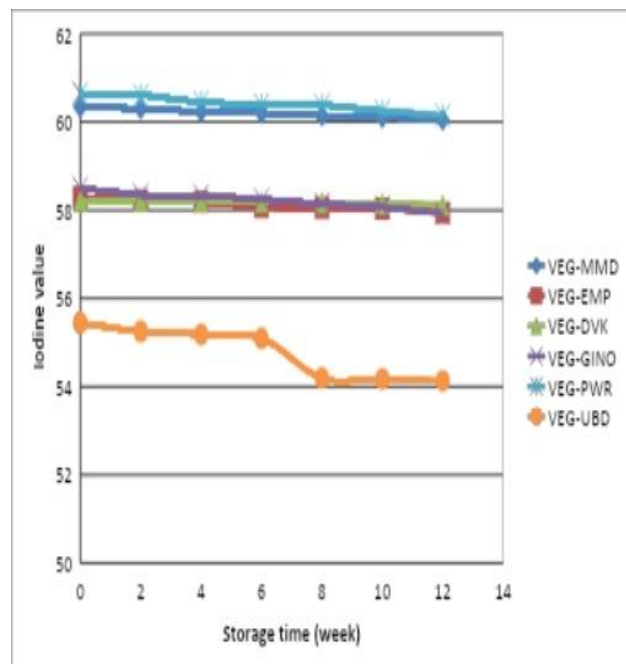


Figure 3: Changes in Iodine value of vegetable oils under ambient storage condition

Where: VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sunflower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; VEG-UBD- Unbranded vegetable oil.

Figure 4 showed change in peroxide values of the selected vegetable oils under ambient storage condition. The peroxide value was 0.38 ± 0.005 meq/kg for VEG-PWR in the first week, this increased to 0.89 ± 0.003 meq/kg in the 12th week of storage. The peroxide value for VEG-EMP was 0.29 ± 0.026 meq/kg in the first week of analysis and it increased to 0.517 ± 0.031 meq/kg after storage. For VEG-DVK, the peroxide value increased from 0.363 ± 0.03 meq/kg in the first week of storage to 0.625 ± 0.033 meq/kg after storage. For VEG-MMD, it increased from 0.443 ± 0.030 (meq/kg) in the first week to 0.604 ± 0.021 meq/kg. That of VEG-GINO increased from 0.26 ± 0.02 to 0.43 ± 0.03 meq/kg. The peroxide value of VEG-ASF increased from 0.17 ± 0.02 to 0.29 ± 0.01 meq/kg after 12 weeks of storage. The result also indicated that the peroxide value of VEG-GDS increased from 0.18 ± 0.02 to 0.35 ± 0.05 meq/kg. VEG-GLN with initial peroxide value of 0.34 ± 0.03 increased to 0.39 ± 0.03 meq/kg. VEG-UBD whose origin cannot be traced had an initial peroxide value of 0.71 ± 0.05 which increased to 1.69 ± 0.03 meq/kg after storing it for 12 weeks.

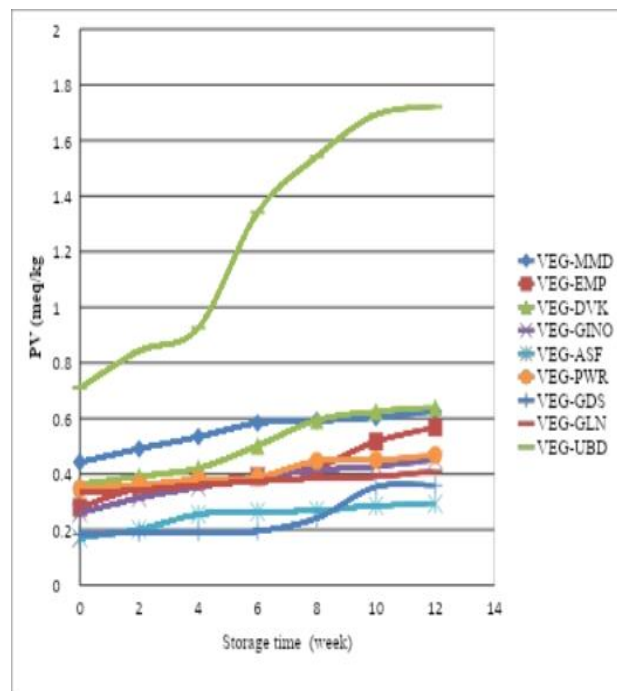


Figure 4: Changes in peroxide value of vegetable oils under ambient storage condition

Where: VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sunflower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; VEG-UBD- Unbranded vegetable oil.

Conclusion

All the changes observed indicated that the quality of refined vegetable oils deteriorates over a given period of time. The longer the oils stay, the more its quality deteriorates. The storage study also showed that all the chemical tests: moisture, free fatty acid, iodine and peroxide values were within the limit for all the samples at the end of the storage except in VEG-UBD.

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