

Physicochemical Characteristics and Vitamin A Fortification Levels of Refined Edible Oils Available in the Markets of Ouagadougou, Burkina Faso

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ABSTRACT

Edible oils are vital constituents that provide energy and serve as a carrier of fat-soluble vitamins such as vitamin A. This article aims to evaluate the physicochemical properties and assess the vitamin A content of 45 edible oil samples (37 of palm oil and 8 of cotton seed oil) sold in five markets in Ouagadougou, Burkina Faso. A retinol palmitate standard was used as a control sample for vitamin A content assessment. The physicochemical properties, including the moisture content, acid value, peroxide value, saponification value, and mineral oils content, were determined according to the International Organization for Standardization. Vitamin A levels were assessed by the High-Performance Liquid Chromatography method. The average values of moisture, acid, peroxide contents, and vitamin A were 0.09%, 0.53 mg KOH/g, 6.24 ± 2.92 meq O₂/kg, and 6.70 ± 14.26 mg of Vit A/Kg, respectively. Our samples were soap and mineral oils free. However, several samples did not comply with Codex Alimentarius standards for water content (4.44%), acid peroxide values (10%), and vitamin A levels (80%).

Keywords

Edible oils, Physicochemical parameters, Vitamin A fortification, Burkina Faso.

Introduction

Lipids are diverse compounds found in natural oils and foods that contribute to the organoleptic, physicochemical, and nutritional aspects of various foods [1,2]. Edible oils represent up to 40%

of our energy source [1,3] and serve as carriers for fat-soluble vitamins such as vitamin A [2,4]. In the world, more than 2 billion people suffer from dietary deficiency of vitamins and minerals [5]. These deficiencies are focused in developing countries where strict food safety regulations are not present [4].

The WHO/FAO has outlined quality standards for levels of various edible vegetable oils constituents, including heavy metals,

fatty acid composition, antioxidants, micronutrients, and other physicochemical parameters [6]. In 2012, as part of its policy for fighting micronutrient deficiencies, the Burkinabe government adopted a guideline named "compulsory enrichment of refined vegetable oils with vitamin A and soft wheat flour with iron and folic acid."

Vitamin A deficiency, the leading cause of blindness and visual disturbances, has increased in Burkina Faso during these last two years. This is possibly explained by the decrease in vitamin A coverage in children aged 6 to 59 months, from 76.1% in 2017 to 86.5% in 2016 [7].

Additionally, it is essential to monitor the quality of oil since atmospheric oxygen reacts instantly with lipids and other organic compounds of the oil to cause structural degradation. This leads to a decrease in the quality of food and is harmful to human health [8]. The present study evaluates the physicochemical characteristics and assesses the vitamin A content of the edible oils sold in Ouagadougou.

Methods

Sample Collection

Forty-five (45) edible oil samples (37 of palm oil and 8 of cotton seed oil) were purchased at 5 markets in the city of Ouagadougou, Burkina Faso: "marché de Sankariaré", "Diss yaar", "marché de Zogona", "Toukin yaar", and "marché de Gounghin" (Figure 1). All the oils samples constitute a brand-new oil prior to cooking. These markets were chosen because of their high attendance by the general population and because edible oils are sold in large amounts. Samples were taken in 300 ml amber bottles and kept at a suitable temperature (25-30°C) in the dark. During the samples' collection, we inspected the storage and sales environment to assess the application of good hygiene and conservation practices.

Moisture Content

The water moisture content was assessed according to the International Organization for Standardization (IOS) 662 method [9]. Then (10) g of oil sample was placed in a weighed crucible. The samples were dried for 1 hour in an oven set at 105°C and then allowed to cool in desiccators for 10 minutes and weighed for the first time. Then, the oils were once again placed in an oven at 105°C for 30 minutes and then cooled in a desiccator for a second weighing. The average value was determined, and finally, the difference was calculated using the following equation:

$$\% \text{ Moisture} = \frac{W1 \times 100}{W2}$$

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W1 = weight loss (g) upon drying, W2 = weight (g) of the oil sample.

Acid Value

The acid value determination was done by alkalimetry in an ethero-alcoholic medium according to the International Organization for

Standardization (IOS) 660 method [10]. A mixture of 10 mL of oil sample and 100 mL of ethyl alcohol was heated until the content started boiling. The hot content was cooled and titrated with 0.1N KOH solution until a persistent pink color appeared, using phenolphthalein as the endpoint indicator. A control (ethanol-ether-diethyl mixture without oil samples) was assessed under the same conditions.

The acid value was calculated as follows:

$$\text{Acid value} = \frac{V \times N \times M.wt}{W}$$

V = volume of standard KOH solution in mL, N = normality of standard KOH solution, W = weight of oil sample in grams, M.wt (molecular weight) of KOH = 56.1 g/mol.

Peroxide Value

According to the International Organization for Standardization (IOS) 660 method [10], 2 g of oil sample was dissolved in 25 ml acetic acid/chloroform (15/10) solvent. This solution was further reacted with 1 mL of 15% potassium iodide (KI). The liberated iodine was titrated with 0.01 N sodium thiosulphate using starch solution as an indicator. Blank titration was performed. The peroxide value was calculated as follows:

$$\text{Peroxide value (meq O}_2\text{/kg oil)} = (S-B) \times W \times N$$

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

Saponification Value

The saponification value was determined according to the International Organization for Standardization (IOS) 3657 method [11], 40 g of oil sample was weighed in a conical flask to which were added 50 ml 97% acetone, 3 to 6 drops of bromophenol blue, and 2 to 3 drops of 0.01 N NaOH. Subsequently, the NaOH solution was titrated with 2 to 3 drops of 0.01 N HCl until a blue color was reached for the positive samples. The volume of HCl used for the assay is noted, and the soap content is calculated according to the following formula:

$$\text{Saponification value} = \frac{(B - T) \times N \times 56.1}{W}$$

B= ml of HCl required by the blank, T= ml of HCl required by oil sample, N= Normality of HCl, W=Weight of oil in g

Mineral Oils Content

The detection of mineral oils was done according to AOAC [12] using a mixture of 1 mL oil, a solution of ethanol, and potassium hydroxide. The blend was brought to boil under reflux (for 5 minutes) under permanent agitation until completely removed. Then, 25 ml of distilled water was added to the solution after heating. If there is at least 0.5% mineral oil in the mixture, turbidity develops.

Vitamin A level

We used the French standard NFT 90-210 [13], which is based on the HPLC method for the determination of vitamin A in edible

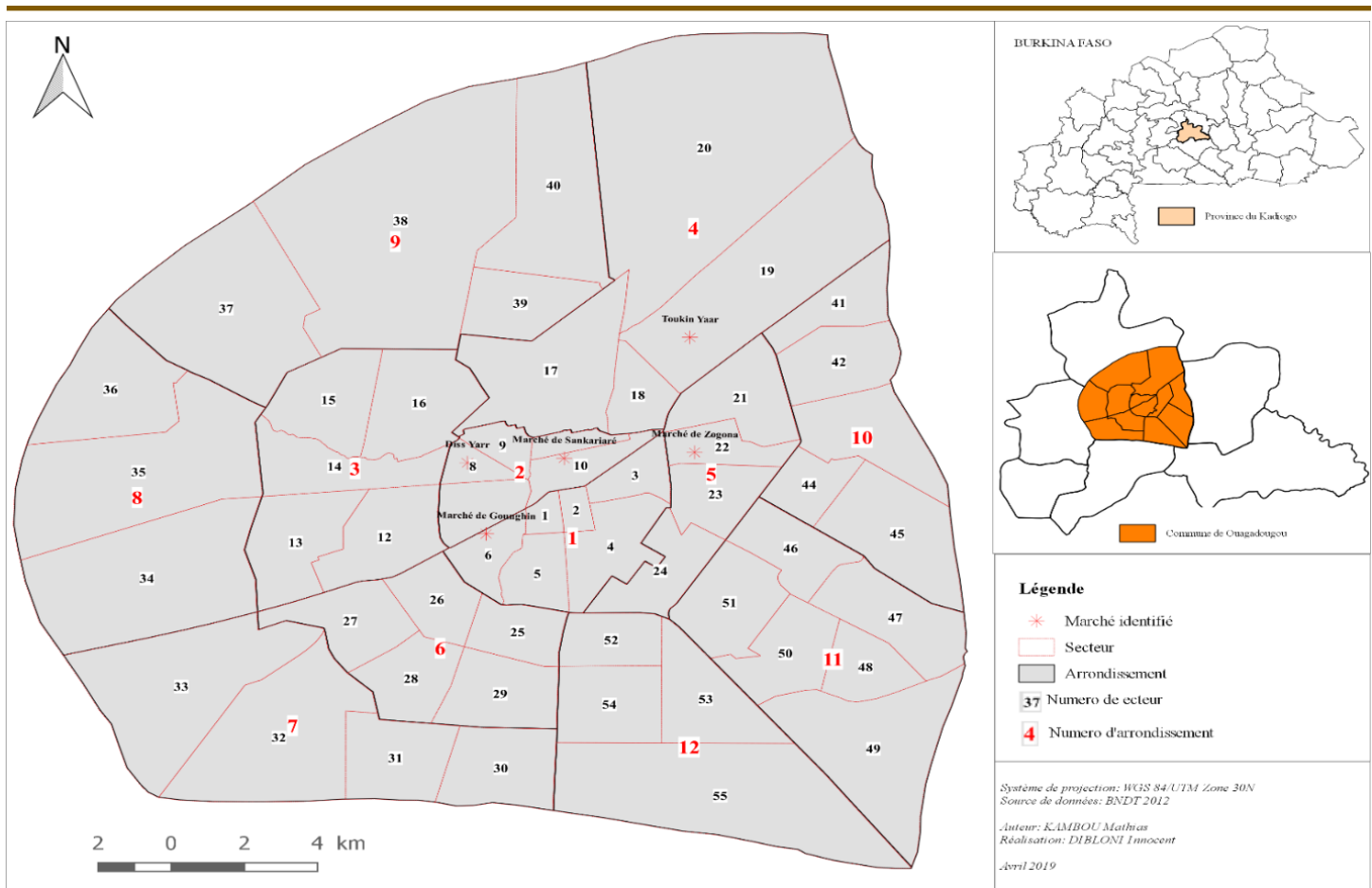


Figure 1: Markets where samples were collected.

oils. The treatment of the sample is composed only of extracting vitamin A from the oil with acetone. Nine (9) ml of acetone was added to 1 g of oil previously taken from a 10 ml volumetric flask. The mixture was stirred well using a vortex stirrer. 1.5 ml of this mixture was withdrawn and introduced into vials. The samples thus prepared were introduced into the HPLC to quantify the content of vitamin A in each sample. The chromatographic conditions are the following: thermo Scientific Ultimate 3000 HPLC chain, mobile phase: methanol, flow rate: 1ml / min, isocratic mode, wave length: excitation (325 nm), emission (480 nm), analytical column = Agilent eclipse plus C18 (3.5 μ m, 3x100 mm). The retinyl palmitate concentration of the oil sample was estimated by using the following equation:

$$\text{Retinyl palmitate} \left(\frac{\text{mg}}{\text{kg}} \right) = \frac{(V \times C)}{W}$$

V = Volume of dissolution, C = Concentration obtained by HPLC, W = Weight of oil sample

Results

The quality of palm oil and cottonseed oil was analysed by evaluating physicochemical properties such as water and volatile material content, acid peroxide, moisture content, and saponification values. The retinyl palmitate concentration value was also assessed.

Moisture Content

Moisture content in the analysed samples varied from 0.02% to 0.37%, with an average of 0.09%. Specifically, these values range from 0.02 to 0.22%, with an average of $0.09 \pm 0.03\%$ for palm oil and 0.06 to 0.37% with an average of $0.12 \pm 0.10\%$ for cottonseed oil (Figure 2) (p-value = 0.3168). These moisture content values agree with those previously reported in Burkina Faso [14,15] and Benin [16]. Our results indicate that 4.44% of the samples had higher rates than the *Codex Alimentarius* compliance standard ($\leq 0.2\%$ m/m). This high value of moisture content in our samples could be linked to the extraction process and may therefore influence the conservation of the oil by promoting the hydrolysis of free fatty acids and their oxidation. Previous studies have found that oils produced using low technology displayed higher moisture [17,18]. Therefore, a possible cause for the high value of moisture could be the poor refining processes. Additionally, an oil sample containing high water content could deteriorate more quickly during storage. For example, a moisture content that ranges from 0.05 to 0.3 may lead to rancidity in edible oils [19,20].

Acid content

The acid content in the samples ranged from 0.15 to 2.16 mg with an average of 0.53 mg KOH/g of oil. This content varies from 0.15 to 2.16 mg with an average of 0.57 for palm oils and 0.17 to

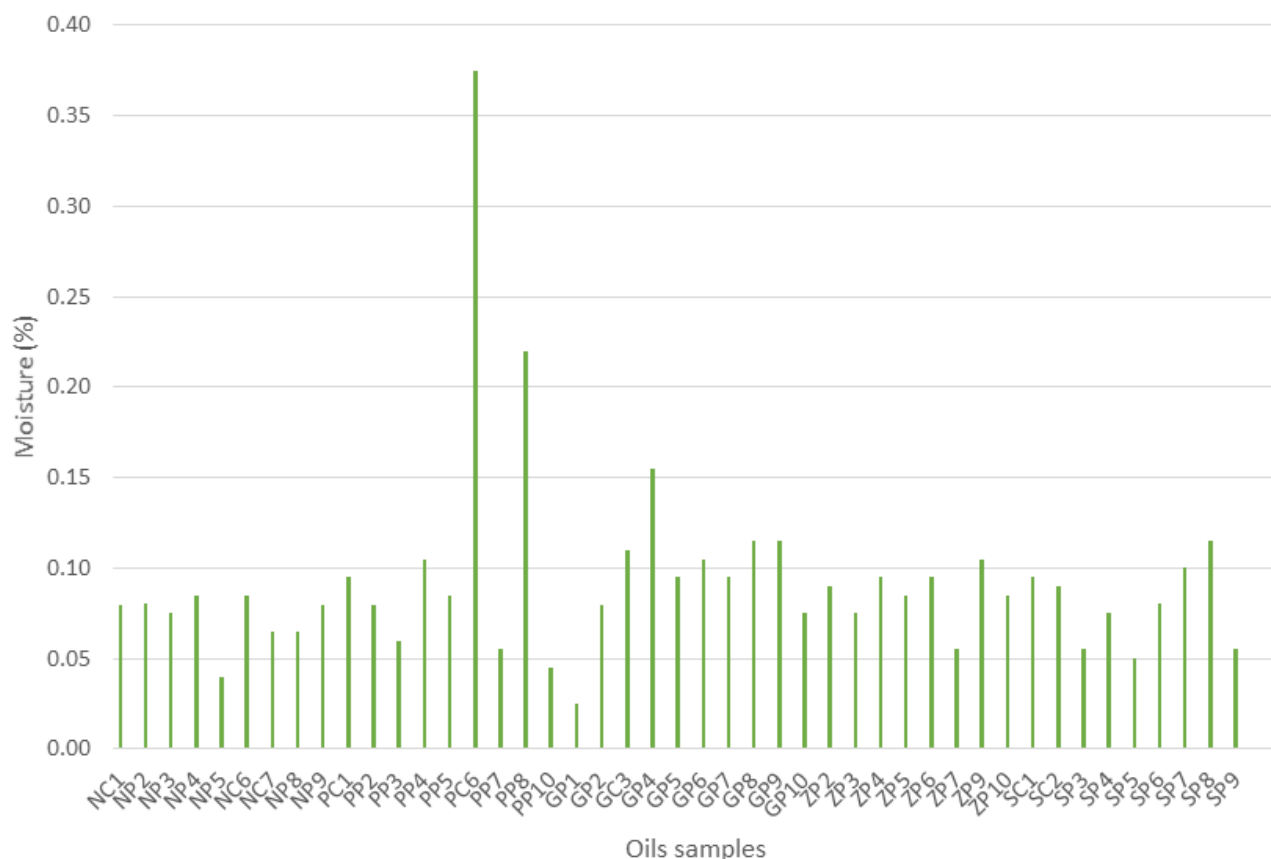


Figure 2: Moisture content of edible oils.

0.74 mg with an average of 0.37 for cotton oils (Figure 3). Our results indicate that 22.22% of the samples, especially in palm oil, had values higher than *Codex Alimentarius* standards (≤ 0.6 mg KOH/g of oil) for the acid values. A previous study reported values of 0.71 ± 0.38 mg KOH/g and 0.23 ± 0.11 mg KOH/g in groundnut oils and cottonseed oils, respectively [14]. The highest acid values of 2.75 mg KOH/g and 2.728 mg KOH/g were reported in Nigeria and Ethiopia [20,21]. The acid number is a function of the content of free fatty acids in the oil and characterizes the state of deterioration of this oil by hydrolysis [22]. Therefore, a high acidity justifies oil oxidation and the presence of free fatty acids formed during extraction and /or storage.

Peroxide content

The peroxide content varied from 1.25 to 14.71 meq of active oxygen/Kg of oil with an average of 6.24 ± 2.92 (Figure 4). These indices range from 1.25 to 14.71 meq with an average of 5.98 ± 2.11 meq active oxygen/kg for palm oils and from 3.62 to 11.34 meq with an average of 7.44 ± 3.1 meq of active oxygen/kg for cotton oils (p-value = 0.08884). The peroxide values above are comparable to those reported on olive oils in Morocco [23] and on edible vegetable oils in Benin [16]. Ten percent (10%) of our samples had values greater than ten meq O₂/Kg, the maximum value set by the *Codex Alimentarius* concerning refined oils, which would indicate extensive oxidation of these oil samples. Indeed, the increase in the peroxide index could be explained by primary

oxidation leading to the formation of primary compounds of the peroxide and free radical type [24]. As mentioned above, this peroxide index is related to the high moisture content value leading to the hydrolysis of free fatty acids and its oxidation. These values can also be explained by the inadequate storage, conservation, and distribution conditions where the oils are generally in contact with oxygen in the air and light (Figure 5). Indeed, edible oil quality is primarily determined by physicochemical characteristics due to its nature, processing procedure, and environmental factors when it stays on the market shelf [25]. Generally, peroxide value is used to indicate the quality and stability of oils and fats at the early stages of marketing [26]. For instance, studies have shown that unsuitable or prolonged storage conditions are the leading causes of the increase in the peroxide index [27,28].

Soap content

The qualitative test revealing soap contents and mineral oils was negative, indicating that our samples are free of these substances. Indeed, these saponification values agree with *Codex Alimentarius* standards ($\leq 0.005\%$ w/w) and could justify a good mastery of the refining processes of the oils analysed. The lower saponification values suggest that the mean molecular weight of fatty acids is lower or that the number of ester bonds is less and might imply that the fat molecules did not interact with each other [29]. In addition, the absence of mineral oils in this study agrees with the previous report in Burkina Faso [14], which is consistent with the

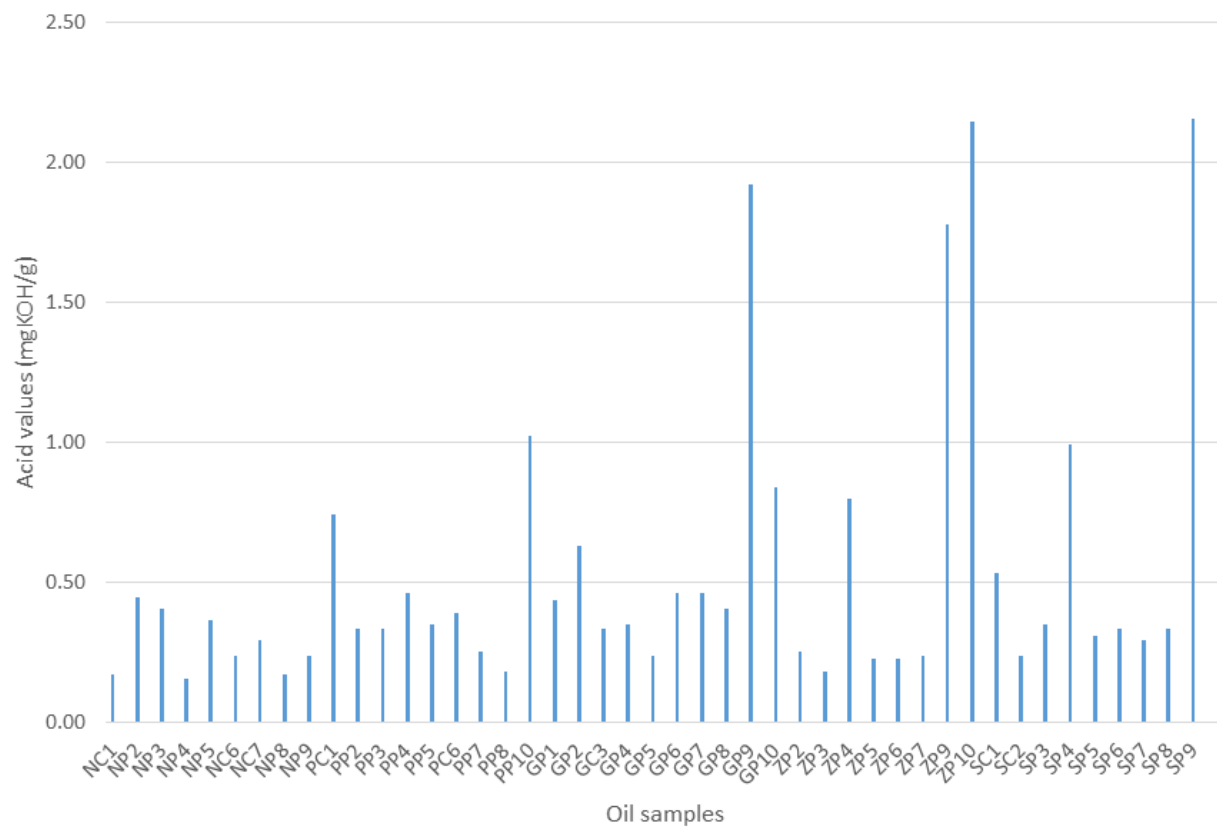


Figure 3: Acid values of edible oils.

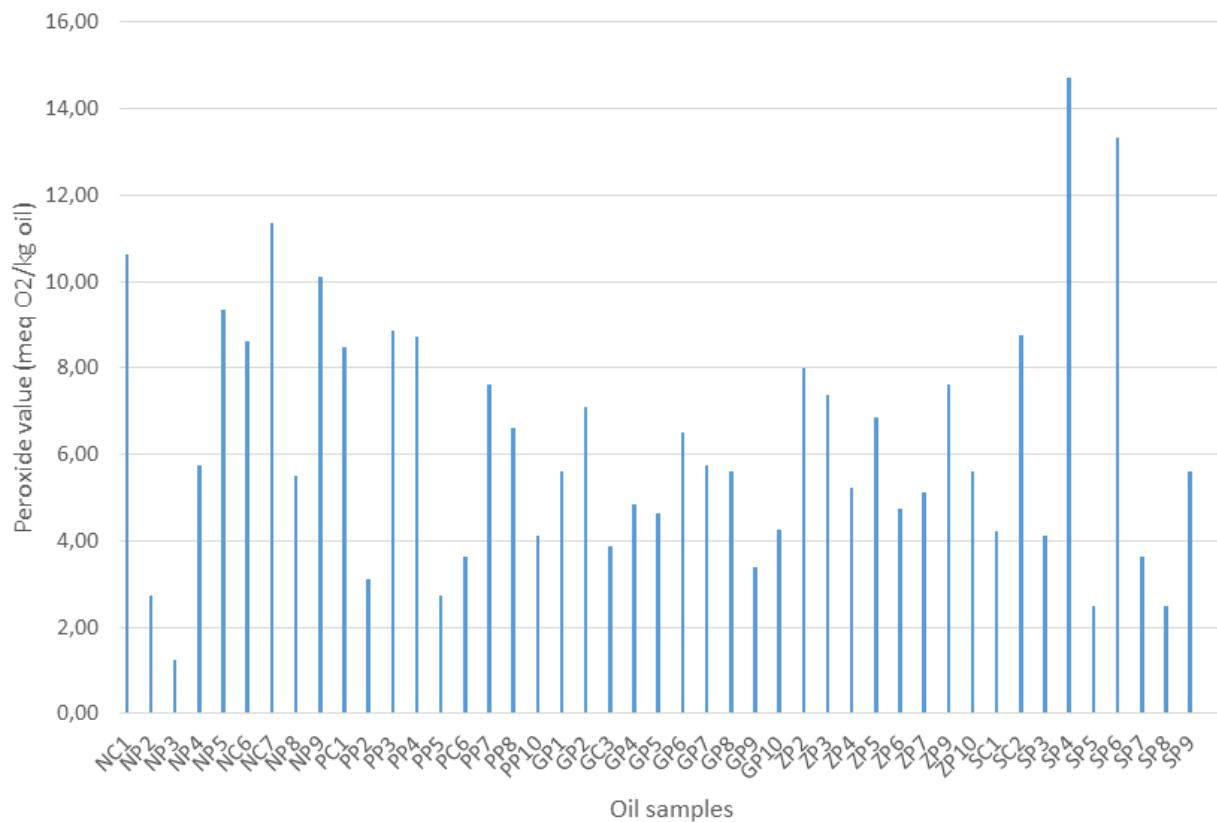


Figure 4: Peroxide values of edible oils.



A: Storage in plastic bags



B: Storage in fuses



C: Storage in plastic containers



D: Storage in bottles

Figure 5: Storage, conservation and distribution conditions.

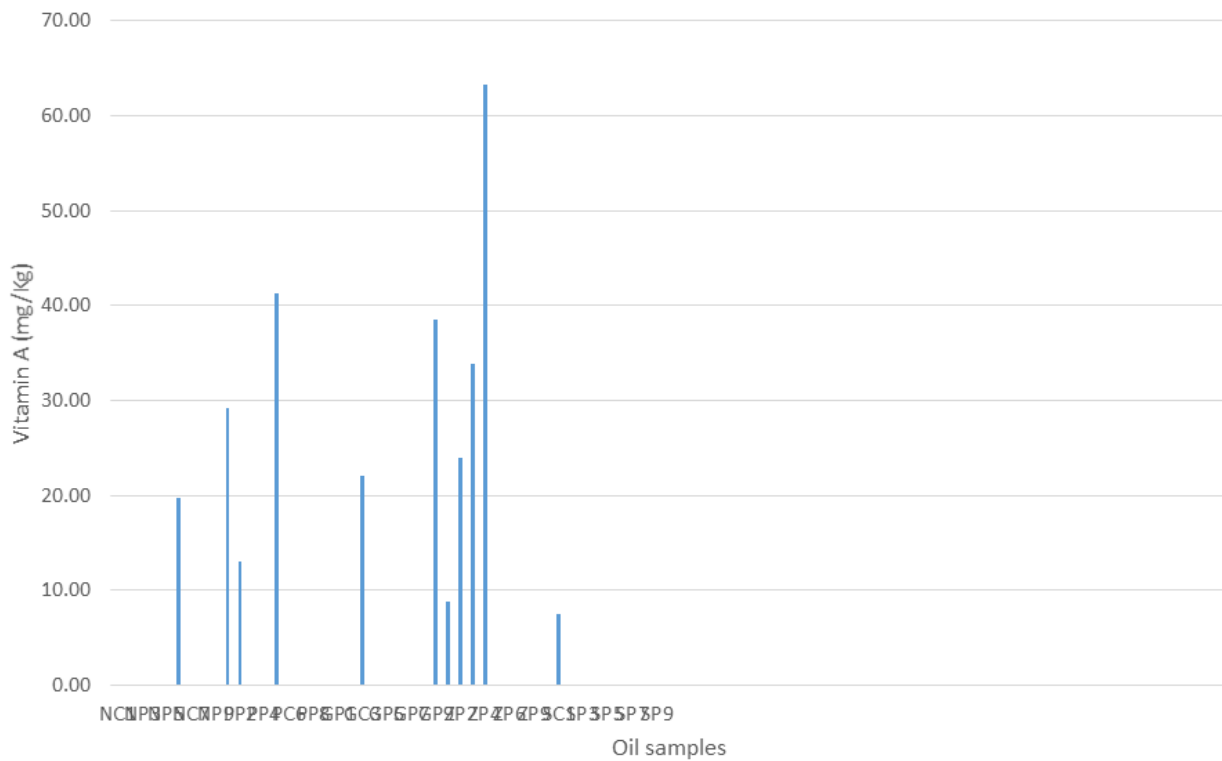


Figure 6: Vitamin A values of edible oils.

Codex Alimentarius standards. This result is interesting for the consumer's health because the mineral oils present in recycled packaging could be carcinogenic when they migrate to food. According to this, several studies have addressed the exposure to mineral oil, and there has been sporadic and inconsistent support for an association with bladder cancer [30,31].

Vitamin A content

As for the vitamin A content of our samples, it varied from 0 to 63.36 mg of Vit A/Kg of oil with an average of 6.70 ± 14.26 (Figure 6). Eighty percent (80%) of our sample had insufficient Vitamin A contents based on the *Codex Alimentarius* compliance standard (11 to 24 mg Vit A/Kg of oil) (p-value = 0.1797). Our study's average vitamin A content was lower than that reported in Bangladesh [26]. This difference could be explained by the poor quality of the technological fortification process resulting in a degradation of vitamin A during storage (unsuitable packaging) and distribution. Indeed, the two most fragile fat-soluble vitamins are vitamins A and E [32]. Therefore, the supply of oxygen and light associated with an inadequate heat treatment may degrade Vitamin A by oxidation [32]. Our finding is of great concern because the lack of vitamin A is still a significant health problem in most developing countries [33] and is more prevalent among infants and school-age children, adolescents, and pregnant and lactating women [34]. Vitamin A is essential for tissue growth and plays a crucial role in vision, cell differentiation, embryonic development, spermatogenesis, immune response, and epithelial cell integrity [26]. The World Health Organization (WHO) estimates that 190 million pre-schoolers and 19 million pregnant women are deficient in vitamin A [35]. Vitamin A deficiency is one of the most important causes of preventable childhood blindness. It contributes to morbidity and mortality from infections, especially in children and pregnant women [35], and has its most significant prevalence in low and middle-income countries [35]. A recent study demonstrated that low serum retinol concentrations are prevalent among schoolchildren in Burkina Faso [36].

Understanding the physicochemical properties and the vitamin A content of edible oil samples is very important for to improve the diet of populations. Nowadays consumers prefer natural and healthy, beneficial food products [37,38].

Indeed, palm oil has a unique fatty acid composition and antioxidant properties, which makes it suitable for numerous food applications such as frying; cooking justifying that is one of the most utilized oils by food manufacturers [39].

Conclusion

Various physicochemical characteristics of oils available in the market were studied. It can be concluded that these oils have acceptable quality parameters such as soap content and mineral oils. However, some samples did not comply with *Codex Alimentarius* standards for water content, acid peroxide values, and vitamin A content. The consumption of these oils would pose health risks to consumers. Therefore, appropriate measures such as implementing a standard regulatory monitoring system to ensure that the enriched edible oil contains adequate amounts of vitamin A

are necessary. Along with this, the quality of production, storage, and sale of these oils must be closely monitored to preserve consumers' health. The main limitation of the present study is the low number of samples collected, which makes it difficult to generalize the results.

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