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# Evaluation of Some Plant Oils Quality Commonly Sold in Ghana

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## Abstract

Fats and oils are a class of organic compounds called lipids and are usually a mixture of triacylglycerols with their fatty acids in varying proportions. While large types of fatty acids are found in natural fats and oils, only a few of them are important to the body. Vegetable oils are an important part of an energetically balanced and healthy diet. The objective of this study was to evaluate the quality properties of three commonly consumed oils in Ghana. The chemical properties of the three oil samples, vegetable oil (Frytol), palm kernel oil, and coconut oil were analyzed to determine the peroxide value, saponification value, free fatty acid value, iodine value and moisture content. The moisture contents of the oil samples were 0.40%, 3.33% and 0.14% for vegetable oil, palm kernel oil and coconut oil respectively. Palm kernel oil recorded the highest value (11.64%) for free fatty acid and the least value of 0.17% being vegetable oil. Coconut oil recorded the least peroxide value of 0.59 mEqv·$O_2$/kg followed by palm kernel oil (0.78 mEqv·$O_2$/kg) and vegetable oil (0.80 mEqv·$O_2$/kg). A high saponification value was recorded for all the oil samples with coconut oil recording the highest value of 292.12 mg/g KOH. The iodine value of the oil samples ranged from 102.59 to 237.27 mg $I_2$/g). The high iodine values reported in this study is an indication that these oils have a high degree of unsaturation.

## Keywords

Quality, Coconut Oil, Palm Kernel Oil, Frytol, Edible Oil

## 1. Introduction

According to Onwuliri *et al.* [1], fats and oils are a class of organic compounds called lipids and are usually a mixture of triacylglycerols with their fatty acids in varying proportions. While different types of fatty acids are found in natural fats

and oils, only a few of them are important to the human body. Vegetable oils are an important part of a balanced and healthy diet and are reported to provide significant percentage of the total daily energy intake. According to the recommendations by FAO/WHO [2], about 20% - 35% of daily total energy intake should come from fats. Soybean, olive, rapeseed, sunflower and other vegetable oils serve as sources of essential fatty acids [3], that the body cannot synthesize but needs to be provided through food. These essential fatty acids include: linolenic, linoleic and oleic acids.

Oil quality is defined as physical and chemical properties of fats or oils that are necessary for any specific purpose as stated in a product specification or certificate of analysis [4]. According to Turner [5], some of the factors that affect the quality of cooking oils include: growing season of raw materials, soil fertility, post-harvest storage conditions of raw materials and post-process storage conditions such as heat and exposure to air. Also, as reported by Mehmood *et al.* [6], assessing the quality of cooking oils can be judged by testing certain parameters such as free fatty acid value, peroxide value, color and moisture which are influenced by the degree of rancidity, hydrolysis and quality of bleaching of the oil.

Oxidation of oils is a major contributing factor to the reduction of quality and several authors have previously reported factors such as processing procedures, temperature, light and oxygen as the main causes of oxidation in edible oils [7] [8]. Mehmood *et al.* [6], also states that lipid oxidation negatively affects several aspects of the oil which include taste, aroma and nutrition. It also causes health hazards like biological damage to living tissues and an increase in the risk of cardiovascular diseases and some health problems such as diarrhoea and poor growth rate.

In Ghana, a lot of advocacy is being made for the consumption of plant oils as superior to animal fats due to the relatively high levels of unsaturation. However, the conditions under which these hitherto good oils are sold predispose the oils to quality defects. Poor quality vegetable oils are high in trans fats due to their hydrogenation and hence have several health risks due to the high concentrations of free radicals. Free radicals promote tumour growth, increase the risk of coronary artery diseases, cause inflammation in blood vessels and inhibit key enzymes that regulate blood flow [9] [10]. Trans fats have been linked to prostate cancer, colon cancer and breast cancer [11].

Volatile products, such as alcohols, monobasic esters, hydrocarbons, aldehydes and aromatic compounds as well as cyclic compounds, polymers and dimers are products formed from thermal oxidation reactions. These volatiles are known for their undesirable flavour properties. The dimers and polymers formed during oxidation at high temperatures bring about changes in molecular weight, viscosity and heat-transfer efficiency of the oil which affect the quality of the oil and in turn the quality of the foods fried in the oil. This study sought to assess the quality of three cooking oils that are commonly sold in the Ghanaian markets.

## 2. Materials and Methods

### 2.1. Sample Collection

Ten liters each of three plant source cooking oils viz., coconut oil, palm kernel oil and vegetable oil (frytol) material were purchased from the Tema Community One open market in the Greater Accra region. The oil samples were transported to the laboratory in a sealed ice chest and stored in a cool dry place at room temperature until ready for use.

### 2.2. Physico-Chemical Analysis

#### 2.2.1. Moisture Content Determination

The moisture content of the samples was determined using the method of AOCS [12]. Five grams (5 g) of each oil samples were dried at 70˚C at a constant pressure of 70 mm Hg for a period of 5 hours. The weight loss was calculated as:

$$\%\ \text{Moisture content} = \frac{W2 - W3}{W2 - W1} \times 100$$

where; $W1$ = initial weight of empty moisture cans; $W2$ = weight of moisture cans + sample before drying; $W3$ = final weight of moisture cans + sample after drying

#### 2.2.2. Free Fatty Acid (FFA) Determination

The method of AOCS [12] was used to determine the FFA using 5 g of the oil samples and 95% ethanol/ether (1:1) with phenolphthalein as an indicator. A titration with 0.1 N NaOH was done against the oil samples shaking constantly until a pink colour persisted. The FFA was calculated as follows:

$$\%\text{FFA}\left(\text{as oleic}\right) = \frac{\text{Vol. of NaOH}\left(\text{ml}\right) \times \text{Normality of NaOH} \times 28.2\ \text{mg}}{\text{sample weight}}$$

#### 2.2.3. Peroxide Value Determination

Five grams (5 g) of the oil samples were weighed into a dry 250 mL stoppered conical flask. Chloroform (10 mL) was added to the oil samples to dissolve the oil by swirling. Glacial acetic acid (15 mL) and 1 mL fresh saturated aqueous solution of KI was added, shook for 1 min and the flask was placed in the dark for 1 min. Water (75 mL) was added to the mixture and titrated with 0.01 M sodium thiosulphate solution using a soluble starch solution (1%) as an indicator. The flask was shaken vigorously during the titration to transfer the liberated iodine from the chloroform layer to the aqueous layer. The procedure was repeated for a blank sample and the peroxide value was then calculated [12].

$$\text{Peroxide value} = \frac{\left(V - V_o\right)T}{M} \times 10^3\ \text{meq kg}$$

$V$ = Titre value of sample

$V_o$ = Titre value of blank

$T$ = Motality of thiosulphate solution

$M$ = Weight of sample

#### 2.2.4. Saponification Value Determination

Two grams (2 g) of the oil samples were weighed into a flask and 25 mL of 0.5 N alcoholic KOH was added. The blank sample was prepared by putting 25 mL of the alcoholic KOH in a similar flask. Both flasks were fit to condensers and contents were boiled for 1 h, swirling the flask from time to time. The flasks were allowed to cool and then the condensers were washed with distilled water. The excess KOH was titrated with 0.5 N HCl using phenolphthalein as an indicator and the saponification value was then calculated [12].

$$\text{Saponification value} = \frac{28.05 \times (\text{blank} - \text{sample titration})}{\text{weight of sample}}$$

#### 2.2.5. Iodine Value Determination

Two grams (2 g) of the oil samples were weighed into an empty dry flask and 20 mL of carbon tetrachloride and 25 mL of Wijs solution from a pipette were used to dissolve the oil. A blank sample was prepared alongside following the same procedure. The flasks were stoppered and swirled to mix well the contents and were allowed to stand in a dark cupboard for 30 min at room temperature. After 30 min the flask was removed and to each of the flasks, 20 mL of 15% KI followed by 100 mL of distilled water was added. The liberated iodine was slowly titrated with a 0.1 N thiosulphate solution until the yellow colour just disappears. At this stage, 2 mL of starch solution was added and a blue colour that appears was discharged by further slow titration of thiosulphate. The iodine value was calculated as follows:

$$\text{Iodine value} = \frac{126.9 \times N \times (B - S)}{\text{Weight of sample}}$$

where $B$ = Blank titration;

$S$ = Sample titration;

$N$ = the normality of Sodium thiosulphate solution;

126.9 = Atomic weight of the iodine.

### 2.3. Data Analysis

Data obtained were analyzed using one-way Analysis of Variance (ANOVA) laid on a completely randomized design using Excel Data spreadsheet. Values for $p < 0.05$ were considered statistically significant.

## 3. Results and Discussion

### 3.1. Moisture Content of Oil Samples

The three different oil samples which were vegetable oil (frytol), palm kernel oil and coconut oil had moisture contents of 0.40%, 3.33% and 0.14% respectively (**Figure 1**). A p-value of 0.001 was obtained from the statistical analysis of the mean moisture content values of the three different oils signifying that there was a statistically significant difference between the oil samples. Palm kernel oil was found to have the highest moisture content among the selected oil samples. Ac-

cording to Samuel and Alabi [13], it is of interest to know the moisture content of palm kernel oil and this must be within 10% to prevent unpleasant odour and mould formation on storage. Even though palm kernel oil recorded the highest moisture content, it is within the 10% range and hence will not easily form mould during storage.

According to Codex Standards for fats and oils from vegetable sources (1999), the maximum level of moisture in vegetable oils should be 0.2%. Coconut oil had moisture content below the standard indicating that it could be acceptable. Vegetable oil (Frytol) and palm kernel oil had moisture content that was above the standard indicating that their quality is not up to standard and this could be associated with poor handling during their packaging.

### 3.2. Chemical Properties of Oil Samples

The chemical properties that were analyzed were saponification value, peroxide value, free fatty acid value and iodine value (Table 1). The free fatty acid (FFA) value of fat and oils predicts the extent of hydrolytic rancidity and oil deterioration [14]. Palm kernel oil was found to have the highest FFA of 11.64% as shown in Table 1 and this was above the 5% limit established by Codex Alimentarius [15]. This anomaly can be attributed to the high temperature and/or relative humidity in the storage environment. Subsequently, the palm kernel oil obtained from the market is not of good quality and can have adverse health effects on the consumer. Conversely, vegetable oil (frytol) and coconut oil were within the range of reference indicating they are of good quality and fit for human consumption.

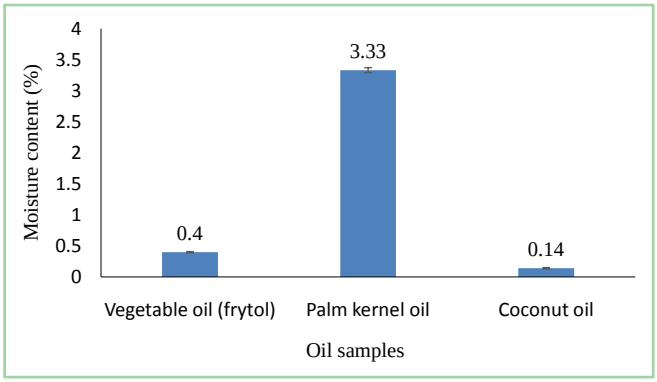


Figure 1. Moisture content of different oil samples.

Table 1. Quality parameters of different oil samples commonly consumed in Ghana.

| Oil Type | Saponification value (mg KOH/g) | Iodine value (mg $I_2$/g) | Peroxide value (mEq $O_2$/kg) | Free fatty acids value (%) |
|---|---|---|---|---|
| Vegetable oil (Frytol) | 242.91 ± 0.17$^a$ | 237.27 ± 0.01$^c$ | 0.80 ± 0.00$^b$ | 0.167 ± 0.00$^a$ |
| Palm kernel oil | 283.16 ± 0.20$^b$ | 215.566 ± 0.01$^b$ | 0.78 ± 0.01$^b$ | 11.64 ± 0.01$^c$ |
| Coconut oil | 292.12 ± 0.31$^c$ | 102.59 ± 0.01$^a$ | 0.59 ± 0.00$^a$ | 0.84 ± 0.00$^b$ |

Data are presented as Mean ± S.D. Means within a column with different superscripts are statistically significantly different at $p < 0.05$.

A p-value of 0.001 was obtained from the statistical analysis of the mean free fatty acid values of the three different oils signifying that there was a statistically significantly different among the oil samples. Free fatty acids are products of hydrolysis and therefore it is expected that the higher the moisture content of the oil, the higher the FFA content [14] and these similarities were observed in the study where palm kernel oils had the highest FFA value and moisture content.

Peroxides are primary products of oxidation of unsaturated fatty acids [15] and often their presence in fats and oils shows induction of oxidation. The peroxide values ranged from 0.59 to 0.80 mEqv $O_2$/Kg with coconut oil recording the lowest followed by palm kernel oil and vegetable oil (frytol). Statistically, there was no significant difference between the oil samples. The low PV in coconut oil could be attributed to the high concentration of lauric acid, a short-chain saturated fatty acid, which is less susceptible to oxidative rancidity. The Codex standards of peroxide value (PV) for refined oils must not be above 10 mEq $O_2$/kg [16]. The current study recorded a peroxide value below 10 mEq $O_2$/kg and hence all the plant oils studied can be argued to be within the standard indicating that the 3 different oils types are of good quality based on their peroxide value.

Ekwu and Nwagu [17] state that peroxide value is an indication of the amount of hydroperoxides in oil and hence measures the extent to which rancidity reactions have occurred during storage. Since all the 3 different oils types were within the standard, this could mean that they did not undergo any rancidity reactions before the analysis.

Saponification value (SV) is the quantity of KOH (expressed as milligram of KOH) needed to completely saponify one gram of fat sample [18]. It is also a measure of the average molecular weight of the fatty acids in triglycerides [19]. The results of the saponification values are displayed in **Table 1**. The SV ranged from 242.91 to 292.12 mg KOH/g. The three different oil samples, vegetable oil (frytol), palm kernel oil and coconut oil, had a saponification value of 242.92, 283.16 and 292.12 respectively. A p-value of 0.001 was obtained from the statistical analysis of the mean saponification values of the three different oils signifying that there was a statistically significant difference between the oil samples.

The iodine value (IV) of the three different oil types ranged from 102.59 to 237.27 mg $I_2$/g. A p-value of 0.001 was obtained from the statistical analysis of the mean iodine values of the three different oils signifying that there was a statistically significant difference between the oil samples. Iodine value is a measure of unsaturation of fats and oils and is expressed as the quantity of iodine absorbed per gram of sample [16]. Vegetable oil (Frytol) recorded the highest IV followed by palm kernel oil which is an indication of high degrees of unsaturation. This explains why vegetable oil is liquid at room temperature because it has a high amount of unsaturation and therefore less of saturated fats which are

semi-solid at room temperature.

## 4. Conclusion

The study revealed that all the oils were suitable for cooking but handling practices can influence the various parameters that were measured. However, the high FFA value recorded for palm kernel oil is of concern due to the health effect associated with high FFA values.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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