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Physicochemical and Fat-Soluble Vitamins Constituents of Fresh and Reused Vegetable Oil from Abakaliki Metropolis, Ebonyi State

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ABSTRACT

This research work was designed to evaluate the physicochemical and fat-soluble vitamins constituents of fresh and reused vegetable oils from fast food vendors in Abakaliki Metropolis. The physicochemical constituents such as peroxide value, saponification value, iodine value, acid value, free fatty acid value and fat-soluble vitamins like retinol, tocopherol and phytonadione were determined by standard laboratory procedures. The results of physicochemical constituents of reused vegetable oil showed increased acid value, free fatty acid, peroxide value and saponification value in reused vegetable oil with a drastic decrease in iodine value. The results of fat-soluble vitamins composition of reused vegetable oil showed decreased levels of retinol, tocopherol and phytonadione when compared to fresh vegetable oil from fast food vendors in Abakaliki. The results of the study revealed the poor quality of reused vegetable oil by fast food vendors in Abakaliki Metropolis and such practice should be discouraged for healthy nutrition and diet

INTRODUCTION

Edible vegetable oils are group of fat that are derived from some seeds, nuts cereals grain and fruits. It is not all of these vegetable oils are liquid at room temperature. Vegetable oil plays a vital role in human nutrition in provision of high energy (Saha *et al.,* 2005). It has essential fatty acid and bounded with fat soluble vitamins (A D E & K). One gram of edible oil supplies up to 9kcal of energy; which is the double of energy provided by protein or carbohydrates (CHO) (Choudhary *et al.,* 2014).

Vegetable oils were used as fuel in their early invention. It was tested in the compression ignition engine invented by Rudolf Diesel in the Late 1800s (Choudhary *et al.,* 2014). On display at the 1900 Paris exposition, Diesel engine was fueled with peanut oil (No, 2011). From that time till 1950s, there was progressive achievement to substitute vegetable oil for diesel completely (Bockisch, 2015). The interest of using vegetable oil as fuel was never circulate in the labour market due to the abundant supplies, stable market and low price for petroleum, and diesel engine were compelled to be designed to be operated with petroleum product (McCormick *et al.,* 2007). And later, the interest for the use of vegetable oil is revived because; methyl esters of vegetable oils reduce the atmospheric pollution and have others environmental benefit (Demirbas, 2005). Not all the vegetable oils are produced in commercial quantities; the once that are produced in commercial quantities are not considered to be edible as dietary component. Vegetable oils used in foods, are made up of complex mixtures of triacylglycerol (TAG) about 95% and some quantities of diacylglycerol (DAG) about 5% (Capuano *et al.,* 2017). Other components in little quantities are tocopherols/ tocotrienols (about 900mglkg and phytosterols up to 1% (Capuano *et al.,* 2017).

Vegetable oil is widely used for the fashionable gastronomic process called frying, by both domestic and industrial food preparation which increases the consumption of fats (Gertz *et al.,* 2000). Heating of edible oil involves transferring of heat into food processing operation by deep frying the food into hot oil at the same time at about 180^0C of temperature (Debnath *et al.,* 2009). During this process, water vapor from the food also is been transfer to the oil and to the atmosphere (Farid, 2001). Various chemical reactions such as thermal oxidation, polymerization and hydrolysis take place. These reactions lead to the production of insoluble, nonvolatile matters with increased viscosity, dark colouration, increase the framing and decrease the smoke point (Kalogeropoulos *et al.,* 2007).

Reheated oil deteriorates the quality of oil. Most fast-food vendors reuse the deep-fried oil for other cooking/preparation of food without discarding it (Azman, 2012). Without consideration of the harmful effect on our health; consumption of reuse cooking oil by the fast-food vendors has become a regular practice. Repeatedly heating of oils can result in the formation of free radicals, which causes oxidative stress and induce molecular and cellular damage (Reaney, 2014). Risk indications are obesity, physical inactivity, cardiovascular disease, congestive cardiac failure (CCF), arteriosclerosis, hypertension, cancer, and so on; consumption of meat and fat rich food and low intake of fruits and vegetables. Though several environmental factors and lifestyle is an indicator and contributing factor of these problems to human (Ng *et al.,* 2012).

Statement of the Problem

The research is targeted to determine the physiochemical constituent of fresh and reused vegetable oil from fast food vendors in Abakaliki Metropolis. It focuses on the deteriorating quality of reused vegetable oil, and intending to expose the health hazard on the consumption of fast food such as akara by the street vendors. It will equally educate the general public on the reaction process during frying of fast food, in requirement for the completion of internship programme in Alex-Ekwueme-Federal Teaching Hospital, Abakaliki.

Justification of the Study

The research is geared towards tackling the problem of unhealthy use of vegetable oil by the masses. It would equally help to educate the consumers of vegetable oil/ public on the importance of using only fresh vegetable oil instead of reused. This is the first time a physicochemical characterization of fresh and reused vegetable oil from Abakaliki Metropolis is reported. The data generated from this study will serve as a base line data for nutritional policy in the state

Aim of the Study

This study was aimed to investigate the physicochemical characterization of fresh and reused vegetable oil from Abakaliki Metropolis, Ebonyi State.

Specific Objectives

The specific objectives of this research work were to:

i. Determine the physicochemical properties such as acid value, peroxide value, iodine value, saponification value and fat-soluble vitamins (Vitamin A, D, E and K) of fresh vegetable oil from fast food Vendors in Abakaliki Metropolis.
ii. Determine the physicochemical properties such as acid value, peroxide value, iodine value, saponification value and fat-soluble vitamins (Vitamin A, D, E and K) of fresh vegetable oil from fast food Vendors in Abakaliki Metropolis.
iii. Compare the physicochemical constituents of reused and fresh vegetable oil from fast food vendors in Abakaliki Metropolis.

Significance of the Study

The study would expose the society to the danger in taken fast food. It would equally educate them on the risk of consuming reheated oil and waste cooking oil. It would equally help the government in making policies that will guide fast food vendors on the use of oil.

Scope of the Study

The research study covered all fast-food joints around Abakaliki metropolis.

METHODS

Physicochemical Characterization of Fresh and Reused Vegetable Oil from Abakaliki Metropolis.

Acid Value of Fresh and Reused Vegetable Oil

This was determined by the method of AOAC (1980).

Principle

The acid value (AV) is a common parameter in the specification of fats and oils. The acid value is a measure of the amount of *free acids* present in a given amount of fat. The lipids are extracted from the food sample and then dissolved in an ethanol solution containing an indicator. This solution is then titrated with alkali (KOH) until a pinkish color appears. The acid value is defined as the mg of KOH necessary to neutralize the fatty acids present in 1g of lipid. It is a good measure of the breakdown of the triacylglycerols into free fatty acids, which has an adverse effect on the quality of many lipids.

Procedure

The acid value is the number of milligrams of potassium hydroxide required to neutralize 1g of fat or oil. The normal method of determination is titration with a solution of potassium hydroxide (approximately 0.1M in 95% ethanol). The acid value is given by the formula:

$$\text{Acid value} = \frac{56.1 \times V \times M}{W}$$

Where V = number of millititers of potassium hydroxide

M = exact molarity of potassium hydroxide

W = mass or weight of the test sample in grams.

Free Fatty Acid Value of Fresh and Reused Vegetable Oil

This was determined by the method of AOAC (1980).

Principle

The free fatty acid value (AV) is a common parameter in the specification of fats and oils. This is a measure of the amount of *free acids* present in a given amount of fat. The lipids are extracted from the food sample and then dissolved in an ethanol solution containing an indicator. This solution is then titrated with alkali (KOH) until a pinkish color appears. The acid value is defined as the mg of KOH necessary to neutralize the fatty acids present in 1g of lipid. It is a good measure of the breakdown of the triacylglycerols into free fatty acids, which has an adverse effect on the quality of many lipids.

Procedure

The acid value is the number of milligrams of potassium hydroxide required to neutralize 1g of fat or oil. The normal method of determination is titration with a solution of potassium hydroxide (approximately 0.1M in 95% ethanol). The acid value is given by the formula:

$$\text{Free fatty acid value} = \frac{M_r \times V \times M}{10W}$$

Where M_r = relative molar mass (mostly, the value used for Mr = 28.2 = the molecular mass of oleic acid)

⇒ V = number of milliliters of potassium hydroxide

M = exact molarity of potassium hydroxide

W = mass or weight of test sample in grams

$$\because \quad \text{free fatty acid value} = \frac{28.2 \times V \times M}{W}$$

Peroxide Value of Fresh and Reused Vegetable Oil

This was determined by the method of AOAC (1980).

Principle

Peroxides (R-OOH) are primary reaction products formed in the initial stages of oxidation, and therefore give an indication of the progress of lipid oxidation. One of the most commonly used methods to determine peroxide value utilizes the ability of peroxides to liberate iodine from potatssium iodide (Hamilton *et al.,* 1992). The lipid is dissolved in a suitable organic solvent and an excess of KI is added:

$$ROOH + KI_{excess} \rightarrow ROH + KOH + I_2$$

Once the reaction has gone to completion, the amount of ROOH that has reacted can be determined by measuring the amount of iodine formed. This is done by titration with sodium thiosulfate and a starch indicator:

$$I_2 + \text{starch} + 2Na_2S_2O_3\ (\text{blue}) \rightarrow 2NaI + \text{starch} + Na_2S_4O_6\ (\text{colourless})$$

The amount of sodium thiosulfate required to titrate the reaction is related to the concentration of peroxides in the original sample.

Procedure

The wheeler method as described by Hamilton *et al.* (1992) was used. A quantity (1ml) of the oil was dissolved in 25ml of a solvent mixture consisting of 60% glacial acetic acid and 40% chloroform and 1ml of 10% saturated solution of potassium iodide was added. The flask was shaken and allowed to stand in the dark for 5 minutes and 75ml of distilled water was added. The mixture was then titrated with 0.1N standard solution of sodium thiosulphate using 2ml of 1% starch solution as indicator. A blank determination was carried out at the same time and the peroxide value was calculated using formula:

$$\text{Peroxide Value} = \frac{(Vs - Vb) \times N \times 100}{W}$$

Where Vs = Volume of sodium thiosulphate used in sample

Vb= Volume of sodium thiosulphate used in blank

N = Normality of sodium thiosphate

W = Weight or mass of the sample in grams

Iodine Value of Fresh and Reused Vegetable Oil

This was determined by the method of AOAC (1980) as described by Harwood (1992) was used.

Principle

When vegetable oil sample is reacted with an excess of Wijs solution (iodine monochloride), the double bonds of the oil is saturated by the halogen, leaving behind some unreacted halogens which are determined by titrating the resulting solution with thiosulfate. The iodine number is defined as the grams of halogens, expressed as iodine, reacting with 100g of oil.

Procedure

Wijs's reagent (iodide trichloride solution) was prepared by dissolving 2g of iodine trichloride in 50ml of glacial acetic acid and mixing with 2.25g of iodine dissolved in 100ml of glacial acetic acid. The mixture was then made up to 25ml with glacial acetic acid and stored in brown glass bottle and kept out of light until use. A quantity of the oil (0.5 ml) was weighed and transferred into a 250 ml glass-stopped bottle. A quantity, 15 ml of chloroform was added to dissolve the oil and 25 ml of Wij's solution was added from a burette. The flask was closed and the content mixed and allowed to stand in the dark for 30 minutes. After standing, 20 ml of 15% potassium iodide solution was added and the bottle stopped and shaken thoroughly and the sides of the bottle and the stopper were washed with 100 ml of recently boiled and cooled water. The solution was titrated with a standard solution (0.1N) sodium thiosulphate, the reagent being added with constant shaking until the yellow colour of the iodine has almost disappeared. Two blank determinations with the same quantities of reagents were carried out at the same time under the conditions. The iodine value was calculated with the formula:

$$\text{Iodine Value} = \frac{12.69 \text{ x } M \text{ x } (V-V^1)}{W}$$

Where M = Molarity of sodium thiosulphate used

W = Weight or mass of oil in grams

V = Volume of $Na_2S_2O_3$ used for the blank

V^1 = Volume of $Na_2S_2O_3$ used for the sample

Saponification Value of Fresh and Reused Vegetable Oil

This was determined by the method of AOAC (1980)

Principle

The saponification number is a measure of the *average molecular weight* of the triacylglycerols in a sample. Saponification is the process of breaking down a neutral fat into glycerol and fatty acids by treatment with alkali:

Triacylglycerol + 3 KOH → Glycerol + 3 Fatty acid salts of potassium

The saponification number is defined as the mg of KOH required to saponify one gram of fat. The lipid is first extracted and then dissolved in an ethanol solution which contains a known excess of KOH. This solution is then heated so that the reaction goes to completion. The unreacted KOH is then determined by adding an indicator and titrating the sample with HCl. The saponification number is then calculated from a knowledge of the weight of sample and the amount of KOH which reacted. The smaller the saponification number the larger the average molecular weight of the triacylglycerols present.

Procedure

A quantity (2 ml) of oil was weighed into a 250 ml cornical flask and 25 ml of 0.5M alcoholic potassium hydroxide solution was added. The flask was connected to a reflux condenser and the mixture heated on a hot plate for 1 hour (by which time the sample was completely saponified as indicated by the absence of any oil matter and appearance of clear solution). The flask and the condenser were cooled; the inside of the condenser was washed down with 10 ml of hot ethanol neutral to phenolphthalein. 1 ml of phenolphthalcin indicator solution was added and the solution titrated with 0.5M standard hydrochloric acid. A blank determination using the same quantity of potassium hydroxide was carried out same time. The saponification value was calculated using the formula:

$$\text{Saponification Value} = \frac{56.1 \text{ x } (V-V^1) \text{ x } M}{W}$$

Where M = Molarity of potassium hydroxide

V = titration volume of the blank

V^1 = titration volume of the oil sample

W = mass of oil used in grams

Determination of Vitamin Composition of Fresh and Reused Oil

Determination of Vitamin E (Tocopherol**):**

This was done by the method of AOAC (2007).

Principle

Tocopherol occurs in the fatty portion of food. The method for the determination depends upon the oxidation of the tocopherol in alcoholic solution by ferric chloride and subsequent spectrophotometric measurement of the red colour produced when the resultant ferrous reacts with α-dipryiadyl.

Procedure

Exactly 5g of sample was weighed into 100 ml flask fitted with reflux condenser. Ten ml of absolute alcohol and 20 ml of alcoholic sulphuric acid were added. The solution was refluxed for 45 minutes and cooled. 50 ml of water was the added. The resulting solution was poured into a separating funnel with acid and another 50 ml of water. Extraction was done with 30 ml of diethyl ether. The extract was evaporated with a very low heat. The residue was then dissolved with 10mls of absolute ethanol. The aliquots of the solution and standards (0.3-3.0 mg Vitamin E) were transferred to a 200 ml volumetric flask and added 5 ml of absolute alcohol followed by 1.1 Conc. Nitric acid drop wise with swirling. The flask was place in a water bath of 90°C for 3 minutes and cooled under running tap and adjusted with alcohol. The absorbance was measured at 470 nm against a blank containing 5 ml of absolute alcohol and 1 ml nitric acid. This procedure was repeated for the remaining two fruits samples.

Vitamin A (Retinol)

This was done by the method of AOAC (2007).

Principle

Vitamin A (retinol) is released from a sample when treated with petroleum ether and trichloroacetic acid. The volume of the trapped vitamin is determined by spectrophotometric methods. The absorbance is proportional to the vitamin A content in the sample.

Procedure

One gram of the sample was macerated with 20 ml of petroleum ether and filtered into a beaker. The residue was washed again with 10 ml of petroleum ether. Both filtrates were combined and evaporated to dryness. 0.2 ml of chloroform acetic anhydride was added in the ratio of 1:1. This was followed by 2 ml of trichloroacetic acid in chloroform 1:1. The absorbance was measured at 520 nm against a reagent blank. This procedure was repeated for the remaining two fruits samples.

Determination of Vitamin D

The Determination of the ergocalciferol contents in the test samples were carried out using the method described by AOAC (1990).

Procedure

Fivegram of sample was measured and weighed into 250ml beaker. 100ml of absolute alcohol was added to extract of vitamin D. the mixture was filtered through a Whatman No 1 filter paper. 5 drops of 0.1% pyragallol solution added to the filterate evaporated to about 1ml. 3 drops of 10% aluminium chloride solution was asses and heat in a water tube until a red violet colour trust develop in the test tube. 10ml of absolute alcohol was added to the crust in the tube to dissolve it and made ready for reading of absorbance at wavelength of 625nm. Standards of vitamin D of range 0-5µg/ml were also prepared from stock solution of vitamin D. The absorbance was red on spectronic 2ID spectrophotometer at a wavelength of 625nm.

$$\text{Vitamin D (mg/l)} = \frac{\text{Absorbance of sample X Gradient factor X Dilution factor}}{\text{Weight of sample}}$$

Determination of Vitamin K

The Determination of the phyloquinon contents in the test samples were carried out using the method described by AOAC (1990).

Procedure:

Vitamin K is 2-methyl-1-1, 4-napthoquinone known as menadine. Five grams of sample was measured and weighed into a 250ml beaker and 30ml of butyl alcohol was added. The mixture was thoroughly shaken to obtain a homogenous solution. The resulting mixture was filtered through a Whatman No 42, filter paper into a 100ml volumetric flask and made up to mark with butyl alcohol 10ml aliquot of the filtrate was pipette into a 30ml centrifuge tube and 3 drops of 2,4-dinitro phenyl hydrazine was added to develop the blue colour which will subsequently change to bluish green upon addition of 3ml of alcoholic ammonia. Standard solution of vitamin K from 0.2µg/ml were prepared and treated as samples to obtain a gradient factor. The absorbance of standards and sample were read on a spectronic 2ID spectrophotometer of wavelength of 480nm.

Vitamin K in (mg/l) is calculated using the formula:

$$= \frac{\text{Absorbance of sample X Gradient factor X Dilution}}{\text{Weight of sample}}$$

Statistical Analysis

Data were expressed as the mean+_ standard deviation of three measurements for the analytical determination using the GraphPad Prism 8.0.2 (263). The data are presented as the mean ± standard error of means (SEM). Differences were considered significant when the $p<0.05$.

RESULTS AND DISCUSSION

Physicochemical Characterization of Fresh and Reused Vegetable Oil from Abakaliki Metropolis

The results showed increased acid value, free fatty acid, peroxide value and saponification value in reused vegetable oil with a decrease in iodine value as shown in Figures 1-5.

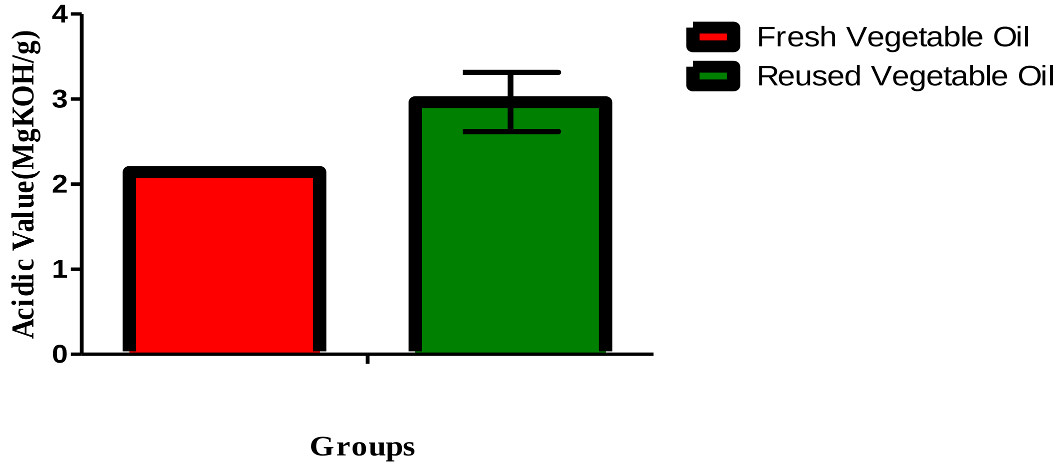

Figure 1. Acid Values of Fresh and Reused Vegetable Oil from Abakaliki Metropolis
Data are Shown as Mean ± S.D (n=3)

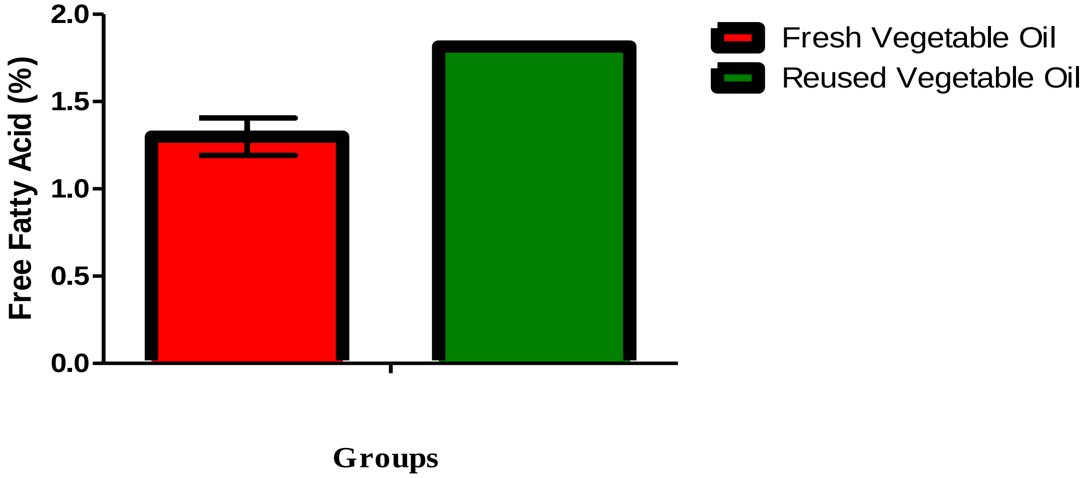

Figure 2. Free Fatty Acid Values of Fresh and Reused Vegetable Oil from Abakaliki Metropolis
Data are Shown as Mean ± S.D (n=3)

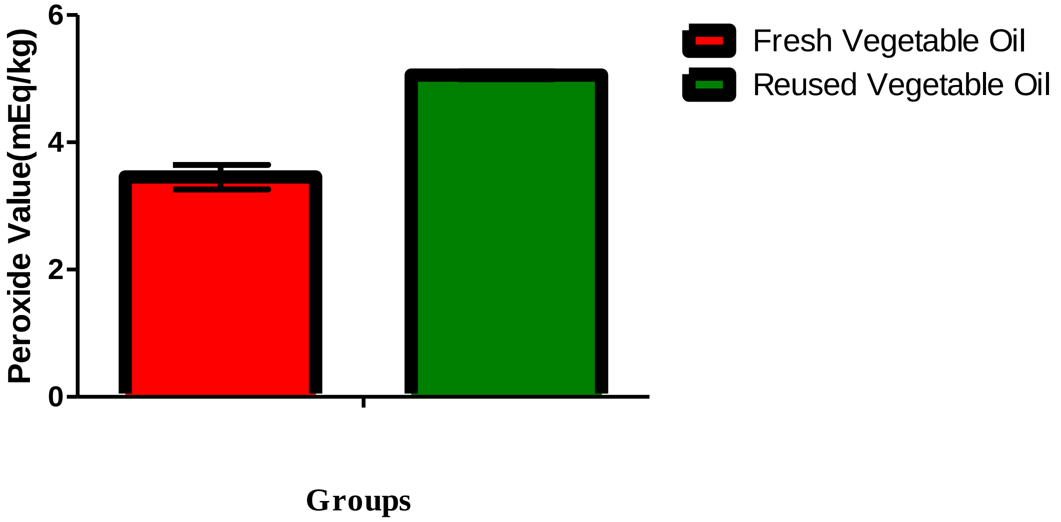

Figure 3. Peroxide Values of Fresh and Reused Vegetable Oil from Abakaliki Metropolis
Data are Shown as Mean ± S.D (n=3)

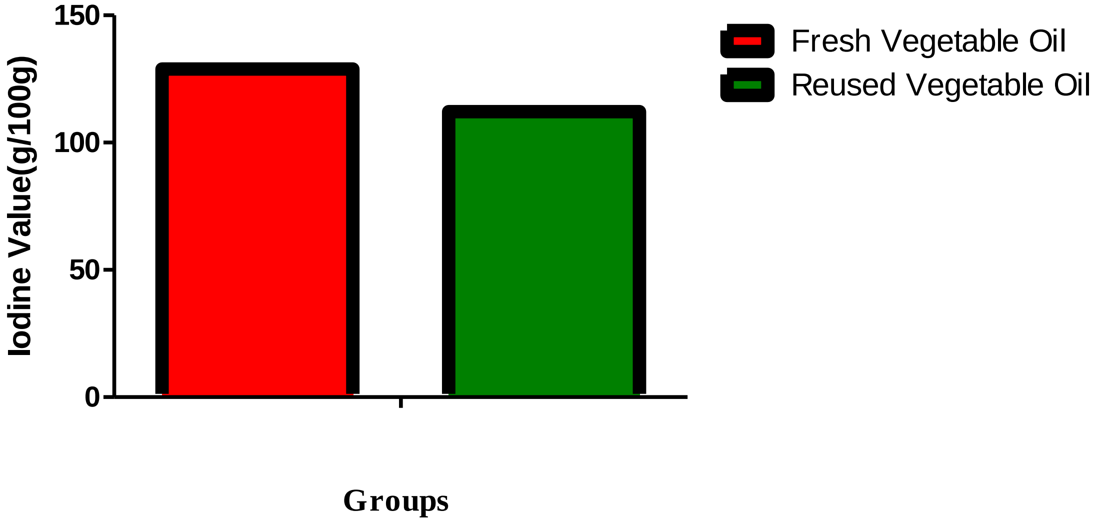

Figure 4. Iodine Values of Fresh and Reused Vegetable Oil from Abakaliki Metropolis
Data are Shown as Mean ± S.D (n=3)

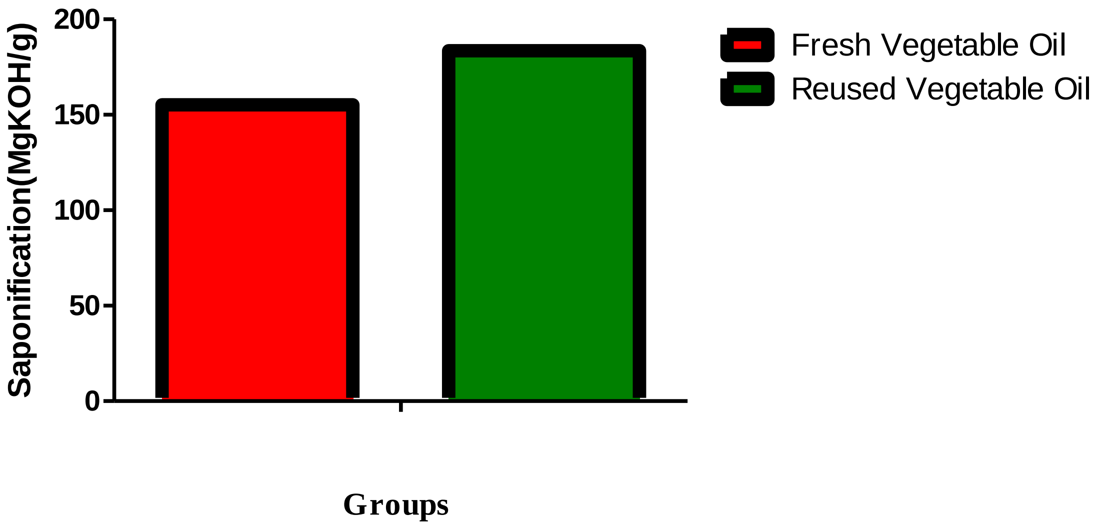

Figure 5. Saponification Values of Fresh and Reused Vegetable Oil from Abakaliki Metropolis
Data are Shown as Mean ± S.D (n=3)

Vitamin Compositions of Fresh and Reused Vegetable Oil from Abakaliki Metropolis

The results of vitamin analysis of fresh and reused vegetable oil showed decreased levels of retinol, tocopherol and phytonadione in reused vegetable oil as shown in Figure 6.

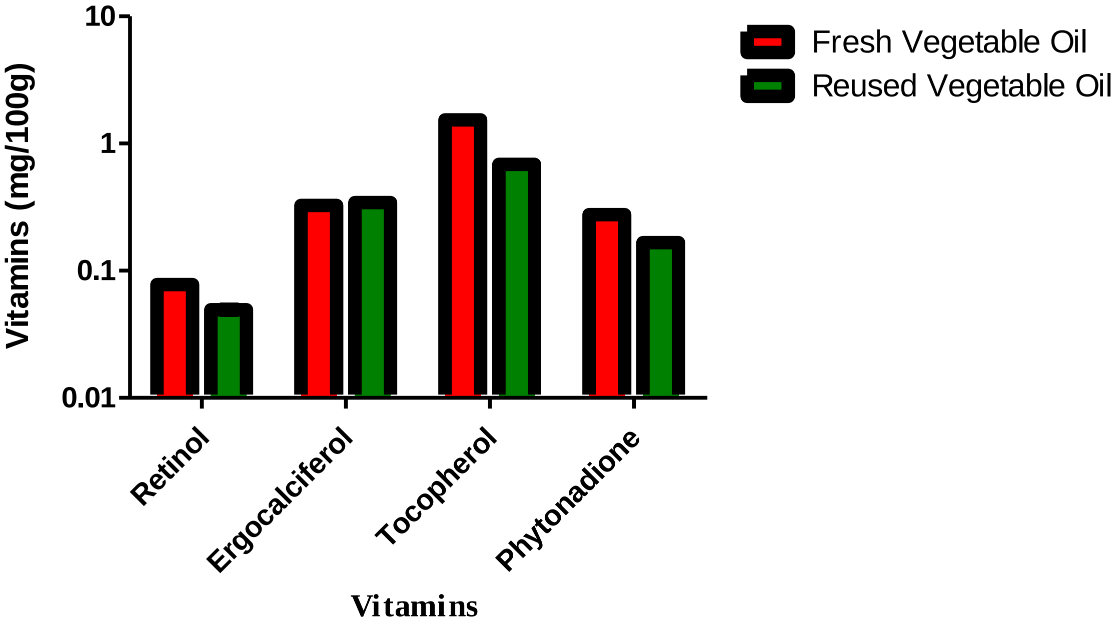

Figure 6. Vitamin Composition of Fresh and Reused Vegetable Oil from Abakaliki

The observed increase in acid, free fatty acid, peroxide and saponification values in reused vegetable oil with a decrease in iodine value showed the poor quality of the oil used by fast food vendors in Abakaliki Metropolis (Figures 1-5). According to 2006 standard for virgin oils and cold pressed fats and oils, good quality oil should have low peroxide, acid, free fatty acid, and saponification values when compare to poor quality oil. Iodine value decrease is indicative of the increased rate of oxidation during heating and could be attributed to oxidation and polymerisation reactions involving the double bonds (Adam et al., 2008).

The results of peroxide values of the reused vegetable oil showed high peroxide value when compared to fresh vegetable oil (Figure 3). The result of the peroxide value agrees with Conte et al. (2018) who reported that there were an accumulation of peroxides during heating. The peroxide value of reused vegetable oil increased with heating. This may be attributed to further decomposition of the less-stable primary oxidative products (hydroperoxides) to form aldehydic compounds. According to Ababi and Deris, (2011) the primary product of lipid oxidation is hydro peroxide, which is referred to as peroxides. According to Allendorf, (2010) the peroxide value for frying temperature increased with time. In general, the peroxide value increased with storage time. Oils exposed to both atmospheric oxygen and light showed a much larger increase in peroxide value during storage.

High saponification value observed in reused oil showed its usefulness in production of liquid soap and shampoo industries. The saponification value gives an idea about the number of ester equivalents per unit mass of the oil or biodiesel. Saponification value is an indication of the size or nature of fatty acid chains esterified to glycerol and gives a measure of the average length of the fatty acid chain that makes up a fat (Garrett and Grisham, 2012). In combination with acid values, saponification values are useful in providing information as to the quantity, type of glycerides and mean weight of the acids in a given sample of oil. Saponification is only of interest if the oil is for industrial purposes, as it has no nutritional significance. But due to the fact that each fat has within the limits of biological variation, a constant fatty acid composition, determination of the saponification value is a reasonable means of characterizing the fat (Mohammed and Ali, 2015).

Acid value is the main parameter used to assess the quality of oil; especially when heated. The increase in acidity level could be as a result of free fatty acids formation from hydrolysis of the fat and oxidative chain reaction (Warner and Moser, 2009). Free fatty acid value is used to indicate the quality of oil used for frying. Thermal hydrolysis takes place within the oil phase than oil water interface (Choe and Min, 2007). The result of acid value agrees with the result of Amatsubo et al., (2006). The changes in acid value of different vegetable oil; soybean, corn, cottonseed oil, etc happen during heating in superheated steam, which were compared with the changes as a result of heating in hot air (dry oven). The acid value increases with increase in temperature for the both. As a matter of facts, the acid value of the oils in hot air was higher than that of supper heated steam.

The decrease of iodine value of reused vegetable oil from Abakaliki Metropolis (Figure 4) correlated well with the decrease of unsaturated fatty acids. Iodine value decrease is indicative of the increased rate of oxidation during heating and could be attributed to oxidation and polymerisation reactions involving the double bonds (Adam et al., 2008).

The result of iodine value correlated with the report of Conte et al. (2018) which observed that when sunflower oil is heated for 50 hours at 1800C, the iodine values of the oil decreases as the heating time increased. The iodine values of sunflower oil and palm oil were initially 101.2 and 615 after 50hours of heating and the values declined to the 9% of initial reading. Various reports n cotton seed canola and groundnut oil, assess the initial iodine values were 107.7, 103.5 and 97.5mg iodine/100g fat. As the oil was subjected to heating of about 1950C, the iodine value reduced sequentially after two hours of exposing to heat (Kamisah et al., 2012). Zialifar et al. (2008) revealed that study on soybean oil blended with cotton, palm, sunflower vegetable oil reduced with the heated time of 180-190C; the point reduced to level of 129.8-106.7, 96.2 and 94.4 respectively.

The content and the composition of the fat-soluble vitamins such as tocopherols, retinol and phytonadione in vegetable oil are further important criteria for the assessment of the quality of oil and are presented in Figure 6. The tocopherols are important components of the unsaponifiable fraction in vegetable oils. They can be interesting for applications in dietary, pharmaceutical, or biomedical products (Ivanov and Aitzetmüller, 1995). Tabee et al. (2008) found different results for the stability of oils with similar MUFA contents during heating depending on the amounts of tocopherol and phytosterols present in the oils. In the present work, the contents of tocopherols, retinol and phytonadione were higher in fresh vegetable oil relative to reused vegetable oil, which is in agreement with previous research of Ramirez-Tortosa et al. (1999) which reported a decrease in the levels of these vitamins as a result of heat and method of processing refine olive oil (ROO) and virgin olive oil (VOO). During heating and processing part of the tocopherols and micronutrients are removed. This removal substantially reduces the nutritional value of ROO (Gladine et al., 2011). After heating, the tocopherol, retinol and phytonadione were depleted in reused vegetable oil. Nissiotis and Tasioula-Margari, (2002) also reported that tocopherol was completely depleted during 100 h of heating at 1000 C, even when the oxidation was not accelerated by bubbling air through the sample. All of the tocopherol compounds present in the VOO and ROO before heating have disappeared after the heating process.

CONCLUSION

The results of this study show that the reused vegetable oil caused significant changes in the physicochemical characteristics and decreased levels of tocopherol, retinol and phytonadione. The results of the study showed increased saponification, acid, free fatty and peroxide vales with a decrease iodine values in reused vegetable oil in Abakaliki Metropolis.

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