Effects of thermal treatment on the characteristics quality of some Ghanaian vegetable oils (palm, coconut and groundnut)

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**Effects of thermal treatment on the characteristics quality of some Ghanaian vegetable oils
(palm, coconut and groundnut)**

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Abstract

Introduction: Vegetable oils contain natural antioxidants and other properties reported to impart anti-diabetic properties when consumed, in animal study. In humans however, these oils are subjected to high temperatures during cooking before consumption. High temperature tends to affect the characteristic quality and potential to impart on health benefits such as antidiabetic properties. The objective of this work was to determine the characteristics quality of vegetable

oils after thermal treatment that equates to temperatures oils are subjected to during food processing/cooking.

Methodology: Three portions of 200g of each fresh unrefined red palm oil, coconut oil and groundnut oils in three conical flasks T1, T2 and T3 were heated to room temperature 28°C (T1) to 100° C in boiling water (T2) and to 200° C in electric cooker oven (T3) for 10 minutes. Acid, iodine, peroxide, saponification, unsaponification values of the oils, Phytoconstituents (Flavonoids, polyphenols saponins etc.), Total antioxidant capacity and DPPH (1,1-Diphenyl-2-Picrylhydrazyl) Radical Scavenging Activity were then determined after cooling to room temperature.

Results; Coconut oil heated to 200°C had the least Acid value of 2.89 ± 0.135 whiles Palm oil heated to 100 °C had the highest value of 19.57 ± 0.165 . There were no peroxides formed in Coconut and Palm oils at 28 °C as well as Palm oil at 100 °C. However, peroxides were highest in Coconut oil at 200°C with value of 15.28 ± 2.315 . Saponification value of groundnut oil at 28 °C was the least at 89.52 ± 2.18 and 296.57 ± 1.045 the highest in coconut oil at 200 °C. Heating however increased the unsaponifiable matter in all the vegetable oils used. Phenolic constituents were significantly increased in palm oil at higher temperatures and only significantly increased at 100°C for coconut and groundnut oils. Total antioxidant capacity was not significantly changed in all the oils at higher temperature. Free radical scavenging activity was not significantly changed at higher temperature in all the oils

Conclusion

The quality of the oils in terms of acid value, iodine vale, peroxide value and saponification value, total antioxidant and phenolic content were retained after one heat treatment. This implies

the quality of the oils are maintained after a single heating. The oils may still retain antidiabetic property when consumed after processing.

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Key Words

Vegetable oils, Thermal treatment, Diabetes Mellitus, antioxidant

Introduction

Vegetable oils are triglycerides extracted from plants and termed as plant oils that are mostly liquid at room temperature or fat when solid [1]. Vegetable oils are used for many purposes, mostly for cooking, as fuels, paints, and in skin care product and other pharmaceutical products [2- 3- 4].

Medical benefits from the consumption of vegetable oils are conflicting. Consumption of some of these oils have been associated with the induction of cardiovascular diseases due to their atherogenic effect because they contain high amounts of **omega-6** fats and excessive consumption of omega-6s can create chronic **inflammatory** reactions [5] which is associated with the development of **atherosclerosis** [6- 7], particularly the long chain and saturated fatty acids [8]. Other researchers have found that linoleic acid-rich vegetable oil in place of saturated fat, produced no evidence for reductions in either coronary heart disease mortality or all-cause mortality [9]. A positive association after consumption of some oils have been observed in cardiovascular disease (CVD) and type 2 diabetes mellitus (DM). Consumption of olive oil was inversely associated with serum cholesterol and glucose levels and systolic blood pressure [10]]. Ngala et al showed that 10% by weight vegetable oil: coconut oil, groundnut oil and red palm oil

added to rodent chaw significantly reduced blood glucose level in diabetic mice and showed no dyslipidaemic effect [11].

Red palm oil is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palm, primarily the African oil palm (*Elaeis guineensis*,) [12]. Red palm oil is rich in carotenes, such as alpha-carotene, beta-carotene and lycopene, which give it a characteristic dark red color [13,14]. Palm oil is mainly composed of fatty acids, esterified with glycerol. It has a high concentration of saturated fat; palmitic acid and oleic acid which is monounsaturated. Unrefined palm oil is a significant source of tocotrienol, part of the vitamin E family [12]. Coconut oil or copra oil is obtained from the dried kernel of coconut [15]. Coconut (*Cocos nucifera*) oil contains medium chain fatty acids, basically comprises of lauric acid (47.5%) which is reported to be a better alternative to other saturated fatty acids. Groundnut or Peanut oil, is a mild-tasting vegetable oil derived from groundnut (*arachis hypogeal*) [16]. Its major component fatty acids include oleic acid (46.8% as olein), linoleic acid (33.4% as linolein), and palmitic acid (10.0% as palmitin). The oil also contains some stearic acid, arachidic acid, behenic acid, lignoceric acid and other fatty acids [17]. It is believed that the antioxidant carotenes, unsaturation and short chain fatty acids confer the oils their antidiabetic effect [11].

However, the antidiabetic properties of vegetable oil may be deteriorated by thermal effect during food processing that leads to lipid oxidation. Prolonged consumption of repeatedly heated oil has been shown to increase blood pressure and total cholesterol, cause vascular inflammation and vascular changes which predisposes to atherosclerosis as a result of lipid peroxidation [18-19].

This work is a follow up of our earlier publication Ngala et al 2016 [11]. In this work 10% vegetable oils, groundnut oil, coconut oil and red palm oil reduced blood glucose in diabetic mice and had no dyslipideamic effect. Currently we are studying the effect of these oils in diabetic humans. However, humans do not consume these oils only at room temperature as was used in the mice study. In food processing varying temperatures are used, hence the need to determine whether these processing temperatures would have an effect on the quality of the oils, and whether the oils will maintain their antidiabetic properties after processing.

This work therefore involves determining the quality of the vegetable oils after a single heating at different food processing/cooking temperatures.

Methods

The protocol for this study was approved by the Health Service Ethics Committee, School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology Kumasi, Ghana

Fresh unrefined palm was supplied by Benso Oil Plantation Ltd, coconut and groundnut oils were bought from the Ghana Food Distribution Corporation. These Food processing Companies are licensed by the Ghana Standard Authority. The Ghana Standard Authority certified the oils to be of good grade and gave approval for their use. Two hundred grams (200g) of each of the oils were placed in three conical flasks T1 T2 and T3. All the oils in T1 flasks were maintained at room temperature (28⁰C) whilst those in T2 and T3 flasks were heated in water bath and electric oven to 100°C and 200°C respectively for 10 minutes and analysis were then made on the three different oils in their three different temperature treatments after cooling to room temperature using methods from AOAC (1990) [20].

110 **Acid Value Determination**

111 Five grams (5g) of each of the oil treated at T1, T2 and T3 were weighed into a 250ml conical
112 flask. 100ml of freshly neutralized ethanol and 1ml of phenolphthalein indicator were added to
113 each of the oil samples. The mixtures were then boiled for 5min and titrated against a 1M sodium
114 hydroxide solution. The acid value was then calculated using the formula

115
$$\text{Acid Value} = \frac{56.1VN}{W}$$
 where (V = vol. of NaOH used, N = Normality of NaOH and W = wt. of

116 **Iodine Value Determination**

117 To determine the iodine value, 0.5g of treated oil samples were weighed into 2 separate 500ml
118 glass-stopped flasks. Afterwards, 10ml of chloroform was added to each sample to dissolve the
119 oils while two blanks were prepared by adding only 10ml of the chloroform into the 500ml
120 glass-stopped flasks. 25ml of Wij's solution was then added to each flask and swirled gently to
121 mix and incubated in the dark for 30 min. After the incubation, 20ml of (1M) potassium iodide
122 solution was added to each flask, followed by washing down of any free iodine on the stopper
123 with a 100ml freshly boiled and cooled water. The liberated iodine in the flasks was then titrated
124 with 0.1N sodium thiosulphate solution, adding it gradually with vigorous shaking until the
125 yellow color almost disappeared. 1ml of starch indicator was then added while continuing the
126 titration until the blue color disappeared entirely. The volume of the titrant was then recorded
127 and the iodine value was calculated from it using the formula:

128
$$\text{Iodine Value} = \frac{(B-S)*N*126.9}{W} * 100$$

129 (Where B = vol. of titrant for blank, N = normality of Na₂SO₃, S = vol. of titrant for sample,
130 126.9 = MW. Of Iodine, W = weight of sample)

131 **Peroxide value determination**

132 Five grams (5g) of each of the treated oils was weighed into two 250ml glass-stopped
133 erlenmeyer flasks respectively. 30ml of acetic acid-chloroform solution (3:2) was added to each
134 flask and swirled to dissolve. 0.5ml saturated KI solution and 30 ml distilled water were then
135 added, the samples were then titrated slowly with 0.1N sodium thiosulphate solution with
136 vigorous shaking until yellow color almost disappeared. 0.5ml of starch indicator was then added
137 while continuing the titration to liberate all iodine from the chloroform layer until the blue color
138 disappeared entirely. The procedure was then repeated using a blank without oil as the control,
139 the volume of the titrant was recorded and used to calculate for the peroxide value from the
140 formula:

$$141 \quad \text{peroxide value} = \frac{(S-B)*N}{w} * 1000$$

142 (where B = vol. of titrant for blank, N = normality of Na₂SO₃, S = vol. of titrant for sample,
143 126.9 = mw. of iodine, w = weight of sample)

144 **Saponification Value Determination**

145 The saponification values of the vegetable oils were determined by weighing 1.5g each of treated
146 oils into two 250ml Erlenmeyer flasks. 25ml of alcoholic KOH solution was pipetted into each
147 flask including a blank. The sample and the blank flasks were connected to air condensers and
148 kept in a water bath boiling gently. Saponification was completed when the oily solution was

149 clear. After cooling, the condenser was washed down with 10ml ethanol. Excess KOH was then
150 titrated with 0.5N HCL using 1ml phenolphthalein as indicator. Using the titrant obtained, the
151 saponification values calculated obtained using the formula:

$$152 \quad \text{Saponification Value} = \frac{56.1(B-S)*N}{W}$$

153 (Where B = vol. of HCL for blank, N = normality of standard HCL, S = vol. of HCL for sample,
154 W = weight of oil sample)

155 **Unsaponification Value Determination**

156 The unsaponification values of the treated oils were determined by weighing 5g each of the
157 respective treated oils into 250ml Erlenmeyer flasks. 50ml of alcoholic KOH solution was
158 pipetted into each flask. The flasks were then connected to an air condenser and boiled for an
159 hour to complete the saponification process. The condenser was then washed with 10ml ethanol.
160 The saponified mixture was then transferred into a separating funnel, rinsed with water and
161 cooled. 50 ml of petroleum ether was then added to each flask and mixed. The lower soap layer
162 was then transferred into another separating funnel and the process repeated three times to get
163 maximum extraction. The ether extract was then washed 3 times with 25ml portions of aqueous
164 alcohol followed by 25 ml portions of distilled water to ensure that the ether extracts are free
165 from alkali. The ether solution was transferred into a 250ml beaker and all ether evaporated into
166 a flask. While heating on a water bath, 2ml of acetone was added to remove solvents completely.
167 The last traces of ether were removed by drying at 100°C for 30 min till constant weight was
168 obtained. The residues were then dissolved in 50ml warm ethanol neutralized to a
169 phenolphthalein endpoint. The solutions obtained were then titrated with 0.02N sodium

hydroxide solution. The titrant obtained was used to calculate for the unsaponification value of each sample using the formula: $\frac{100(A-B)}{W}$

(Where, A = wt. of residue, B = wt. of FFA in the extract, W = weight of the sample)

Antioxidant Activity Assays.

1. DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical scavenging assay.

The free radical scavenging activity was determined as described by Gorinstein et al. [21] with modifications. 1 ml each of the different concentrations (500 – 15.625 µg/mL) of the extracted oil was added to 3 ml methanol solution of DPPH (20 mg/l) in test tubes. The reaction mixture was kept at 25°C in the dark for 30 minutes. The process was repeated for ascorbic acid (100 - 1.56250 µg/mL) of different concentrations. The absorbance of the residual DPPH was determined at 517 nm in a Multimode Microplate reader. The DPPH radical scavenging activity was calculated according to the following equation:

$$\% \text{ DPPH radical scavenging activity} = \left(1 - \frac{\text{Abs of sample}}{\text{Abs of control}} \right) \times 100\%$$

and the % DPPH radical scavenging activity was plotted against the log concentration of the standard and extracts. The concentration of the extracts and standard required to scavenge 50% of DPPH was expressed as IC₅₀.

2. Total Antioxidant Capacity (Phosphomolybdate assay)

The assay is based on the reduction of molybdenum, Mo⁶⁺ to Mo⁵⁺ by the oil extracts and subsequent formation of a green phosphate-molybdate (Mo⁵⁺) complex at acidic pH. The reagent solution was prepared by the addition of Ammonium molybdate (4mM), disodium hydrogen phosphate (28mM) and sulphuric acid (6mM). 1ml each of different concentrations (1000 – 31.25 µg/mL) of the extract was measured into test tubes. 3 ml of the reagent solution added to

each and incubated at 95°C for 90mins. The ascorbic acid (200 - 1.5625 µg/mL) solutions were also taken through the same procedure and absorbance measured at 695 nm using the multimode microplate reader. The antioxidant capacity was expressed as mg of ascorbic acid equivalent (AAE) per g of extract [22]

3. Total Phenol Content (Folin Ciocalteu assay)

Each of the various solutions (1000 -31.25 µg/mL) of the oil extracts (0.5 ml) were measured into test tubes and 2.5 ml of the Folin-Ciocalteu reagent added to each. Two milliliters of the aqueous sodium carbonate solutions (75mg/ml) were added to each and stored in the oven at 50°C for 10mins and the absorbances read at 760 nm using a multi-mode microplate reader. The gallic acid solutions (50 - 1.5625 µg/mL) was taken through the same procedure and used to plot a calibration curve. The phenolic content was expressed in gallic acid equivalents (mg GAE/ g extract) [23] with some modifications.

Statistical Analysis

Normality of data was checked using the KolmogorovSmirnov test. The data analysis was done using Graph Pad Prism version 8.00 for windows (GraphPad Software, San Diego California, USA). Baseline characteristics were expressed as mean ± standard error of means (SEM). One-way analysis of variance (ANOVA) with Dunnett's test was used for multiple comparisons between the oil groups. $P \leq \text{value} < 0.05$ was considered significant.

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215

216 **Results and Discussion**

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218 **Acid Value**

219 **Table 1.0**

220 Table 1 depicts palm oil had the highest acid value, whilst coconut had the least acid value
221 between the oils. There were no statistically significant changes in the acid values in the
222 individual oils at different temperature treatment (room temperature 100°C and 200°C).

223 The acid value represents the degree of degradation of the oil quality resulting from hydrolysis of
224 triacylglycerols of the oils as a result of temperature and moisture on lypolytic enzyme lipase
225 [24, 25]. It has been well-established that heating of dietary oils and fats results in oxidation, hydrolysis,
226 polymerisation and isomerisation. Heating oil elevate the percentage of peroxide value by 8-fold, free
227 fatty acid value by 15-fold, acid value by 14-fold, *trans* fatty acid isomer value (2.5-fold), *p*-anisidine
228 value (39-fold), total oxidation value (19-fold), and thiobarbituric acid reactive substance (TBARS) value
229 (8.5-fold) compared to the control [26].

230 The reactions are deleterious to the stability of fatty acids and other biochemical parameters of the oil [27-
231 28]. Furthermore, vitamin E, which is a natural antioxidant, in the oil also deteriorates after repeated
232 heating [29]. In most food processing, particularly deep frying may heat oils to above 180°C.

From this study, first time thermal treatment of oil up to 200°C did not significantly destroy the acid value of the oils. Similar finding was also recorded by Jaarin and Kamisiah in which single heating of palm and soya oils at 200°C did not affect the acid composition of the oils [30].

Iodine Value

Table 2.0

There were no significant changes in the iodine (IV) values of the individual oils after thermal treatment (Table 2.0). However, in between the oils the iodine values were significantly higher in the groundnut oil, followed by palm oil after each thermal treatment. This implies there are more unsaturated bonds in groundnut oil compared to palm oil and coconut oil, and coconut oil had the least unsaturation.

The Iodine value (IV) is a measure of the degree of unsaturation in the oils and determines the vulnerability of the oil to oxidation. The higher the iodine value, the more susceptible the oil is to oxidation [25].

Heating of the various oils (Palm, Coconut and Groundnut oils) up to 200°C had no significant effect ($p > 0.05$) on the iodine values compared to the values of the unheated oils. This was similar to a work reported by Gharby et al. [31], in which heat applied to Virgin Olive oil had no significant effect ($p > 0.05$) in the iodine values of the oil. This implies no change in the degree of unsaturation of the oil after the thermal treatment, and the oils may not be further susceptible to peroxidation as was observed in the acid values.

3.0 Peroxide Value

The peroxides formed within the various oils (Palm, Coconut and Groundnut) at different temperatures are represented in Table 3.

Table 3.

The peroxide value can be defined as the amount of peroxide oxygen per 1 kilogram of fat or oil according to Kaleem *et al* [32]. Oil with peroxide value between 1 and 5 meqO₂/kg is classified as low oxidation state and that between 5 and 10 meq O₂/kg as moderate oxidation and above 10 meq O₂/kg classified as high oxidation state [33].

Oxidative reactions of the oils can be affected by heat [34-35], oils with a higher degree of unsaturation are highly susceptible to autoxidation and hence the best test for autoxidation (oxidative rancidity) is the determination of the peroxide value (PV), because peroxides are intermediates in the autoxidation reaction [36].

There were no peroxides in palm oil at room temperature and at a100°C heating but very low oxidation (6.63 meq O₂/kg) at 200°C. At room temperature coconut oil similarly had no peroxide value but trace amount at 100°C and a very significant quantity at 200°C. Groundnut oil on the other hand showed comparatively significant number of peroxides at room temperature 8.77 ± 0.100 meq O₂/kg and significantly high values at 100°C and 200°C. Autoxidation of palm oil is protected by its high antioxidant properties consisting of vit E, carotenes etc. and comparatively higher degree of saturation [37]. Similar stability was observed in palm oil over soya oil in single heating [30]

Contrarily, because of the high degree of unsaturation in groundnut oil it was more oxidized even at room temperature hence a high peroxide value.

4.0 Saponification Value

The Table 4.0 below represents the mean saponification values of the oils (Palm, Coconut and Groundnut) after being subjected to different temperatures of heating.

Table 4.0

The saponification value of oil is the number of mg of potassium hydroxide (KOH) required to saponify 1g of a fat or oil [38]. High saponification value is an indication that oils are normal triglycerides. The saponification value is also an estimation of the molecular weight of the fat or oil, the higher the molecular weight the smaller is its saponification value because larger molecules have relatively fewer number of carboxylic functional groups per unit mass of the fat. Saponification value also indicates the carbon chain length of the acid present in the oil or fat, the higher the saponification value, the greater is the percentage of the short chain acids present in the glycerides of the oil or fats [1,39]. High saponification number is also an indication of high degree of unsaturation in an oil sample.

The saponification value of coconut oil was significantly higher than that of groundnut and palm oils, (Table 4) this is possibly because of the higher amount of saturation and shorter chain length (lauric acid (C12:0) and or smaller molecular size which confers the property of having a higher saponification value [40]. Even though groundnut oil has the higher unsaturation than the other oils but because of its high chain length and or molecular weight (mainly composed of

linoleic (C18:2) and arachidic acid (C20:0)) therefore rather has the lowest saponification value. However, the saponification values of the oils were significantly increased after thermal treatment, similar effect was observed by Adewole et al on groundnut oil[41]

Table 5

Unsaponifiable are components of an oily (oil, fat, wax) mixture that fail to form soaps when treated with sodium hydroxide (lye) or potassium hydroxide. Unsaponifiable constituents are an important consideration when selecting oil mixtures for the manufacture of soaps. Unsaponification values were similarly significantly increased across the three thermal treatments and were higher for palm oils as compared to the other oils (Table 5)

Total Phenol content

Screening for phytoconstituents in the oils indicated the presence of steroids, Terpenoids, Cardiac glycosides and carotenoids at all the treated temperatures.

Fig 1A, 1B and 1C depicts the total Phenolic capacity of Palm oil (PO) Coconut oil (CO) and groundnut oil (GO)

Fig 1A, Phenolic content of Palm oil (PO)

Fig 1B Phenolic content of Coconut oil (CO)

Fig1C Phenolic content of Groundnut oil (GO)

Phenols contain antioxidant, antimutagenic, and anticancer properties [42]. Flavonoids naturally occurred in polyphenolic compounds and represent one of the most prevalent compounds in vegetables, nuts and fruits [43].

There was a significant ($p \leq 0.001$) increase in phenol content in palm oil and groundnut oil at higher temperatures (Fig 1A, 1B) and a significant increase at 100°C in coconut oil but a significant decrease at 200°C (Fig 1C) over a single heating.

Repeated heating process have been shown to cause loss of phenolic acids and flavonoids. The degree of loss of phenolic acids in oil after heating was less than that of flavonoids. This may confirm that thermal treatment causes oxidation and polymerization of phenolic compounds. The amount of phenolic compound content is related to their antioxidant activity and may be the main mechanism of protection against diseases related to excessive oxygen radical formation exceeding the antioxidant defense capacity [44]

Degradation of natural antioxidants such as phenolic compounds and tocopherol was also observed in virgin olive oils and sunflower oils during domestic frying [45]. Refined and deodorized palm olein, groundnut oils showed a reduction in α -tocopherol and β -carotene levels over repeated heating [46]. In comparison to our finding, in which these compounds did not deteriorate much, may imply that these antioxidants may be stable over short period of single heating but rapidly deteriorate on repeating heating.

Total antioxidant capacity

Fig 2A, 2B and 2C depicts the total antioxidant capacity of Palm oil (PO) Coconut oil (CO) and groundnut oil (GO)

Fig 2A Total antioxidant activity of palm oil (PO)

Fig 2B Total antioxidant activity of Coconut oil (CO)

Fig 2C Total antioxidant activity of Groundnut oil (GO)

Total antioxidant capacity was not significantly changed in palm oil and groundnut oil at all temperature treatment (Fig 2A and 2C). There was only a significant increase at 200°C in coconut oil. (Fig 2B). Antioxidant substances have been shown to accelerate the action of the free radicals by scavenging and detoxification. Phenolics and other natural compounds protect against reactive oxygen species-mediated damage which helps with the avoidance and/or curing of diseases. Antioxidants from, fruits and vegetables are safer as compared to artificial antioxidants such as butylated hydroxytoluene (BHT) known to be carcinogenic [47]. The ingestion of fruits have been associated with reducing aging and mortality from cardiovascular and neurodegenerative diseases [48]. However, Antioxidant activity has been shown to be decreased during heating process observed in in flaxseed hull oil contrary to our finding over a single heating. This implies the oils may still retain their antioxidant property over a single heating/cooking.

DPPH Free Radical Scavenging Activity

357 Fig 3A, 3B and 3C depicts the free radical scavenging activity of Palm oil (PO) Coconut oil
358 (CO) and groundnut oil (GO)

359 Fig 3A DPPH Free Radical Scavenging Activity Palm oil (PO)

360 Fig 3B DPPH Free Radical Scavenging Activity Coconut oil (CO)

361 Fig 3C DPPH Free Radical Scavenging Activity Ground nut oil (GO)

362 The free radical scavenging activity of the oils was significantly decreased at all temperatures
363 compared to ascorbic acid, but within the oils, temperatures had no significant change, in free
364 radical scavenging activity over a single heating/cooking similar to the observation of Siger et al
365 [44].

366 The DPPH (1,1-diphenyl-2-picrylhydrazyl) radical is used widely to determine the antioxidant
367 activities of plant extracts and foods. The method is based on the reduction of DPPH in methanol
368 solution in the presence of a hydrogen-donating antioxidant, bringing about a color change from
369 purple to yellow, measured at 517 nm. (Fig 3A, 3B and 3C)

370 The absorbance of DPPH from heated oil (Flaxseed hull oil) showed a higher antioxidant activity
371 of 49.74%. This implies heated flaxseed hull oil contains less antioxidant compounds which
372 decreased the DPPH radical scavenging capacity. The scavenging potential of plant constituents
373 have been shown to be related to polyphenolic compounds [44]. The mechanism by which the
374 constituents of flaxseed hull oil, exhibit free radical scavenging activity is still unclear. The
375 antioxidative activity of flaxseed hull oil may be due to the presence of polyphenols [49].
376 Polyphenols and flavonoid, vitamin E and C are heat labile and degrade even at the time of the

oils extraction processes which involve the use of heat [50]. It was therefore not surprising that measurement of vitamin E and C were below detectable limits, and of course vit C is a water soluble.

Conclusion

There were no significant changes of acid value in groundnut oil, palm oil and coconut oil at higher temperature compared to the room temperature value, hence there was no significant degree of degradation of the oil quality resulting from hydrolysis of triacylglycerols of the oils as a result of heating. The Iodine value which is a measure of the degree of unsaturation in the oils was not significantly changed, therefore these oils are less susceptible to oxidation at high temperatures. Palm oil and coconut oil had low peroxide value at room temperature, no significant change at 100°C but a significant increase at 200°C. Groundnut oil on the other hand had comparatively significant peroxide value at room temperature and much higher values at the higher temperatures. The saponification value of coconut oil was significantly higher than that of groundnut and palm oils possibly due to its comparative higher unsaturation and smaller molecular weight. The phenolic constituents in all the oils were not significantly changed after thermal treatment, hence the total antioxidant and free radical scavenging activities were significantly retained. The overall quality of the oils was not significantly changed in just one heating. This implies these vegetable oils may still retain their antidiabetic properties after a single thermal treatment in food processing/cooking.

Abbreviations

CO: Coconut oil; GO: Groundnut oil; PO: Palm oil.

DECLARATION

Ethics approval and consent to participate

The protocol for this study was approved by the Health Service Ethics Committee, School of Medicine and Dentistry, Kwame Nkrumah University of Science and Technology Kumasi Department of Health Service Publication No 83-23, revised 1985

Consent for publication

All authors have given their consent for the publication of this manuscript

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

RAN developed the concept and design of the study and coordinated the data collection and prepared the manuscript for publication. JB supervised the project assisted in critically reviewing of the manuscript. EOA and DB generated the data for the work and assisted in analysis and interpretation of the data. SK participated in analysis and interpretation of the data. All authors read and approved the final manuscript.

Acknowledgement

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Figures

Figure 1

A: The effect of thermal treatment on the Phenolic content of Palm oil

B: The effect of thermal treatment on the Phenolic content of Coconut oil

C: The effect of thermal treatment on the Phenolic content of Groundnut oil

Figure 2

A: The effect of thermal treatment on the Antioxidant capacity of Palm oil

B: The effect of thermal treatment on the Antioxidant capacity of Coconut oil

C: The effect of thermal treatment on the Antioxidant capacity of Groundnut oil

Figure 3

A: The effect of thermal treatment on the Free Radical Scavenging Activity of Palm oil

B: The effect of thermal treatment on the Free Radical Scavenging Activity of Coconut oil

C: The effect of thermal treatment on the Free Radical Scavenging Activity of Groundnut oil

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