ECRONICON OPEN ACCESS

EC NUTRITION
Research Article

Effects of Use and Re-Use of Selected Vegetable Oils on the Anti-Nutritional Factors and Antioxidant Activities of Raw Plantain in the Production of Plantain Chips. Note II

Adeyeye Emmanuel Ilesanmi[1]*, Adesina Adeolu Jonathan[1], Popoola Olugbenga Kayode[1] and Adubiaro Habibat Omolara[2]

[1]*Department of Chemistry, Faculty of Science, Ekiti State University, Ado Ekiti, Nigeria*

[2]*Department of Industrial Chemistry, Faculty of Science, Federal University, Oye Ekiti, Nigeria*

***Corresponding Author:** Adeyeye Emmanuel Ilesanmi, Department of Chemistry, Faculty of Science, Ekiti State University, Ado Ekiti, Nigeria.

Received: December 11, 2018; **Published:** April 27, 2019

Abstract

Plantain chips obtained from the use and re-use of coconut and palm oils were investigated for the anti-nutritional factors levels and antioxidant capacities (DPPH, ABTS, FRAP, OH inhibition, NO inhibition, flavonoids and total phenolic (assays) using standard analytical methods. For the selected oils [both use and re-use: first and second re-use and the fresh plantain chips (UPC)] had the following results: anti-nutritional factors (mg/100g) and CV %; tannic acid (1.12 - 4.18, 48.4), total phenol (1.16 - 4.56, 50.4), oxalate (2.16 - 3.24, 12.1), phytin phosphorus (mg/g) (2.78 - 5.34, 22.0), phytic acid (9.88 -18.9, 21.9) and others (g/100g): alkaloids (0.45 - 1.56, 35.1), flavonoids (0.55 - 1.10, 27.8) and lectins (0.20 - 0.66, 45.1). The Chi-square analyses showed that there were no significant differences among the levels as treated based on the various oils except phytic acid. It was observed that all the anti-nutritional factors level were reduced in all the chips obtained from the re-use oils. The first (day) frying showed highest antioxidant activities (for all assays: DPPH, ABTS, FRAP, OH inhibition, NO inhibition, flavonoids and total phenolics) whereas the first and second re-use reduced antioxidant activities for all the assays observed. Therefore, for better antioxidant activities from fried plantain chips, re-use of oil for frying should be discouraged as it leads to reduced antioxidant activities. However, to ensure reduced anti-nutrient levels, the first re-use may be accommodated.

Keywords: *Coconut Oil; Palm Oil; Plantain Chips; Anti-Nutrient; Antioxidant*

Abbreviations

UPC: Unprocessed Plantain Chips; PC1: Fresh Plantain in Each of the Oil = Day 1 (First Frying); PC2: Fresh Plantain Fried in Oil Used in Day 1 = Second Frying; PC3: Fresh Plantain Fried in Oil Used in Day 2 = Third Frying; p: Palm Oil; C: Coconut; DPPH: 2,2:-Diphenyl-1-Picryl Hydroxyl; FRAP: Ferric Reducing Antioxidant Power; OH: Hydroxyl; NO: Nitric Oxide; SD: Standard Deviation, CV: Coefficient of Variation; χ^2: Chi-Square; S: Significantly Different, NS: Not Significantly Different

Introduction

Plantain chip is an integral part of traditional Nigerian meal and also, one of the most popular and readily available crispy snacks on various occasions. Its high demand among the various classes of people may perhaps be due to its characteristic flavour and taste. Plantain chips are usually prepared from mature unripe fruits by frying the slices in oil [1]. Fried foods may contain high amount of fat due to the frying process [2]. The fruits or plants are fried because the high temperature used during the process enables rapid heat

transfer resulting in a very short cooking time [3]. Frying also produces a desirable flavour and crispy texture of the food being fried. During deep frying, the oil is exposed to atmospheric oxygen, high temperature and moisture released from the food and it enters the food, provides nutrients and flavour. One of the major problems associated with the storage of plantain chips and other fried fruits is rancidity, a condition produced by oxidation of unsaturated fats present in food, marked by unpleasant odour or flavour. When a fatty substance is exposed to air, its unsaturated components are converted into hydro peroxides which break down into volatile aldehydes, esters, alcohols, ketones and hydro carbons, some of which have disagreeable odours. Flavours and odours have also been reported as to be affected by the type of oil used for the frying [1]. Adeyeye., *et al.* [1] have reported the use of oils such as refined palm olein, olive and soya bean oil for frying plantain to make chips. Perhaps due to downward trend in economy, small scale makers of plantain chips are fond of continuous re-use of oils for frying. Adeyeye., *et al.* [1] reported decreasing levels of antioxidant activities in plantain chips flour from first frying down to the third frying from use and re-use of refined palm-olein, olive and soya bean oil.

Oil uptake during frying is also needed to be considered during frying because the fat content of a product will also affect its flavour, odour and general organoleptic properties. The frying oil not only acts as heat transfer medium, because they are heated to high temperatures approximately 170 - 180°C, it will start to degrade through hydrolysis and oxidation of fatty acids. The breakdown products themselves give rise to flavour and can further react with carbohydrates, proteins and their decomposition products to produce taste traditionally associated with fried food [4].

Palm oil is an edible vegetable oil derived from the mesocarp of the fruit of the oil palm (*Elaeis guineensis*). Its naturally red colour is attributed to high beta-carotene content [5]. Palm oil is a common cooking ingredient in the tropical belt of Africa, South East Asia and parts of Brazil. It is used in the commercial industries and domestically in the preparation of food in other parts of the world. It's nutritional and health attributes have been well documented [6]. Coconut oil is very commonly used as a tropical edible oil in many Asian and West African cultures and is composed of almost 90 - 95% saturated fatty acids. In Nigeria, it is generally used for food preparations such as frying and cooking. The health and nutritional benefits derived from coconut oil are both compelling and contradictory, mainly due to its high saturated fat content as relates to chronic diseases, especially those involving the cardiac system [7]. Compositionally, coconut oil is derived from the dried kernel or meat of coconut, also known as copra. Chemically, coconut oil primarily comprises of lauric acid (47.5%), a low molecular weight saturated fatty acid known to be a better alternative to other saturated fatty acids, the kind found in butter [8].

Antioxidants are often added to fat containing foods in order to delay the onset or slow the development of rancidity due to oxidation. The main characteristic of an antioxidant is its ability to trap free radicals. Antioxidants play an important role in preventing undesirable changes in flavour, nutritional quality of foods and protect the cells against tissue damage associated with various human diseases [9]. Antinutrients on the other hand are chemicals capable of eliciting very harmful biological responses, although some of them are widely applied in nutrition and as pharmacologically-active agents [10]. Since their biological effects are diverse and complex, continued investigation and research into their occurrences and effects of processing methods on them become necessary. Therefore, this research is aimed at investigating the effects of use and re-use of palm oil and coconut oil on the anti-nutritional composition and antioxidant activities of fried plantain chips with a view to ascertaining the health implications.

Materials and Methods

Sample collection and treatments

A bunch of fresh matured unripe plantain was purchased from Iworoko market and certified in the Plant Science and Biotechnology laboratory of the Ekiti State University, Ado-Ekiti. The vegetable oils (palm oil and coconut oil) used for the frying were purchased from dealers in Ado-Ekiti, Ekiti State.

The plantain chips and its flours were prepared according to the method described by Adeyeye., *et al* [1].

Antinutrients determination

Determination of phytic acid and phytin phosphorus

4 g of the sample was soaked in 100 ml 2% HCl for 3 hours and then filtered. 25 ml of the filtrate was placed in a 100 ml conical flask and 5 ml of 0.03% NH_4SCN solution was added as indicator. 50 ml of distilled water was added to give it the proper acidity (pH 4.5). This was titrated with ferric chloride solution which contained 0.005 mg of Fe per ml of $FeCl_3$ used until a brownish yellow colour persisted for 5 minutes. Phytin phosphorus (Pp) was determined as follows:

Iron equivalence = titre value x 1.95

Each milligram of iron is equivalent to 1.19 mg of Pp.

Pp = titre value × 1.95 × 1.19 or Titre value x 2.325 [11].

The phytic acid content was then calculated by multiplying the value of Pp by 3.5

Therefore, phytic acid = titre value x 1.95 x 1.19 x 3.5 mg [12].

Phytin phosphorus as percentage of phosphorus (Pp % P) = Pp/P × 100

Determination of tannin

200mg of the sample was weighed into a 50 ml bottle. 10 ml of 70% aqueous acetone was added and properly covered. The bottles were put in an orbital shaker and shaken for 2 hours at 30°C. Each solution was then centrifuged and the supernatant stored in ice. 0.2 ml of each solution was pipetted into test tube and 0.8 ml of distilled water was added. Standard tannic acid solutions were prepared from 0.50 mg/ml stock and the solution made up to 100 ml with distilled water.

0.5ml Folin reagent was then added to both sample and standard followed by 2.5 ml of 20% Na_2CO_3. The solutions were then vortexed and allowed to incubate for 40 minutes at room temperature after which absorbance at 725 nm was red against a reagent blank concentration of the sample from a standard tannic acid curve [13].

Determination of oxalate

1g of the sample was weighed into 100 ml conical flask. 75 ml of 0.75 M H_2SO_4 was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1 hour and then filtered using Whatman filter paper. 25 ml of sample filtrate was collected and titrated hot (80 - 90°C) against 0.1M $KMnO_4$ solution to the point when a faint pink colour appeared that persisted for at least 30 seconds [14]. Oxalate was calculated as follows:

Oxalate = T x 0.9004 (where T = titre value)

Determination of alkaloid

Alkaloid determination was carried out following the procedure of Harborne [15]. 5.0g of the sample was weighed into a 250ml beaker and 200ml of 10% acetic acid in ethanol was added and covered and allowed to stand for 4h. This was filtered and the extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was filtered and the precipitate was collected after and washed with dilute ammonium hydroxide. The residue is the alkaloid which was dried and weighed.

$$\% \text{ Alkaloid} = \frac{\text{Final weight of the dried content}}{\text{Weight of the sample}} \text{x100}$$

Determination of flavonoid

The method of Boham and Kocipai-Abyazan [16] was followed in the determination of flavonoid. 5g of the sample was extracted three times with 100 ml of 80% aqueous methanol at room temperature. The whole solution (125 ml) was filtered through Whatman filter paper. The filtrate was later transferred into an evaporating dish and evaporated into dryness and weighed to a constant weight.

$$\% \text{ Flavonoid} = \frac{\text{Final weight of the dried content}}{\text{Weight of the sample}} \text{x100}$$

Antioxidant assays

Determination of total phenolic content

The total phenolic content of the various plantain chip flour sample was determined by the Folin-Ciocalteu assay as described by Waterman and Mole [17]. 500 µL of Folin reagent was added and mixed with a solution containing 100 µL of the extract and 2 ml of distilled water. 1.5 mL of 7.5% sodium carbonate was then added to the solution and the volume was made up to 10 mL with distilled water. The mixture was left to stand for 2 hours after addition of the sodium carbonate for which the absorbance of the mixture was measured at 760 nm using a Lambda EZ150 spectrophotometer (Perkin Elmer, USA). The standard used was tannic acid. Tannic acid content of samples was determined in triplicates and the results expressed as mg tannic acid equivalents per gram of the sample.

Determination of total flavonoid content

The total flavonoid content of the plantain chip flour sample was determined using a slightly modified method reported by Meda., *et al* [18]. 0.5 mL of the extract infusion was mixed with 0.5 mL methanol, 50 µL of 10% $AlCl_3$, 50 µL of 1mol L^{-1} potassium acetate and 1.4 mL water, and allowed to incubate at room temperature for 30 minutes. Thereafter, the absorbance of each reaction mixture was subsequently measured at 415 nm. The total flavonoid was calculated using quercetin as standard by making use of a seven point standard curve (0 - 100 µg/mL). The total flavonoid content of samples was determined in triplicates and the results were expressed as mg quercetin equivalent per gram of the sample.

Determination of reducing antioxidant activity

The reducing power (FRAP - Ferric Reducing Antioxidant Power) of the extracts was determined by assessing the ability of each extract to reduce $FeCl_3$ solution as described by Oyaizu [19]. 1 mL of the infusion was mixed with 1 mL 200 mM sodium phosphate buffer (pH 6.6) and 1 mL 1% potassium ferricyanide. The mixture was incubated at 50°C for 20 minutes and then 1 mL 10% trichloroacetic acid (TCA) was added. This mixture was centrifuged at 650 x g for 10 minutes. 2 mL of the supernatant was mixed with an equal volume of water and 0.4 mL of 0.1% ferric chloride. The absorbance was measured at 700 nm. The ferric reducing antioxidant power was expressed as mg ascorbic acid equivalent/g of the sample.

Determination of DPPH antiradical assay

In vitro DPPH (DPPH - 2,2 -Diphenyl-1-Picryl Hydroxyl) radical scavenging activity was done according to the method of Williams., *et al.* [20], with some modifications. The stock solution was prepared by dissolving 24 mg DPPH with 100 mL methanol and then stored at -4°C until needed. The working DPPH solution was obtained by mixing 10 mL stock solution with 50 mL methanol to obtain an absorbance of 1.1 unit at 515 nm using the spectrophotometer. 0.5 mL of the extract was diluted with 2 mL of methanol to obtain a mother solution. 450 µL of the mother solution was allowed to react with 2550 µL of the DPPH working solution for 1 hour in the dark. Then the absorbance was taken at 515 nm. The scavenging activity was estimated based on the percentage of DPPH radical scavenged.

Determination of ABTS•+ antiradical assay

ABTS radical scavenging activity of the plantain chip flour sample was determined using ABTS antiradical assay as described by Awika., *et al* [21]. The $ABTS^{\bullet+}$ (mother solution) was prepared by mixing equal volumes of 8 mM ABTS and 3 mM potassium persulphate ($K_2S_2O_8$) (both prepared using deionized water) in a volumetric flask, which was wrapped with aluminum foil and allowed to react for a minimum of 12 hours in a dark place. The working solution was prepared by mixing 5 ml of the mother solution with 145 ml phosphate buffer (pH 7.4). A range of trolox (6-hydroxy-2, 5, 7, 8-tetramethylchroman-carboxylic acid) standard solutions (100-1000 µM) were prepared in acidified methanol. The working solution (2.9 ml) was added to the trolox standard (0.1 ml) in a test tube and mixed with a vortex. The test tubes were allowed to stand for exactly 30 minutes. The absorbance of the standards and samples were measured at 734 nm with a Lambda EZ150 spectrophotometer. The result was expressed as µmolTrolox equivalent/g sample, on dry weight basis.

Determination of hydroxyl radical (OH) Scavenging ability

The ability of the plantain chip flour to prevent Fe^{2+}/H_2O_2 induced decomposition of deoxyribose was carried out using the method of Halliwell and Gutteridge [22]. Freshly prepared extract (0 - 100 µL) was added to a reaction mixture containing 120 µl of 20 mM deoxyribose, 400 µl 0.1M phosphate buffer pH 7.4, 40 µL 20 mM hydrogen peroxide and 40 µL 500 mM $FeSO_4$, and the volume was made to 800 µL with distilled water. The reaction mixture was incubated at 37°C for 30 minutes and then stopped by the addition of 0.5 mL of 2.8% TCA. This was followed by the addition of 0.4 ml of 0.6% TBA solution. The reaction tubes were subsequently incubated in boiling water for 20 minutes. The absorbance was then measured at 532 nm with a spectrophotometer.

Determination of nitric oxide (NO) scavenging assay

The nitric oxide radical scavenging capacity of the plantain chip flour was measured by Griess reaction [23]. Sodium nitroprusside (2.7 mL, 10 mM) in phosphate buffered saline (PBS) was added to 0.3 mL of the plantain chip flour sample and incubated at 25°C for 150 minutes. 0.5 mL of the incubated aliquot was added to 0.5 mL of Griess reagent: 1% (w/v) sulfanilamide, 2% (v/v) orthophosphoric acid and 0.1% (w/v) naphthylethylenediamine hydrochloride (prepared in amber bottle and kept away from light). The absorbance was measured at 546nm. Percentage of inhibition of the nitric oxide generation is measured by comparing the absorbance values of control and samples.

Results and Discussion

In table 1, levels of anti-nutritional factors in the plantain chips fried using coconut and palm oils were presented (the results comprised both unprocessed plantain chips [UPC] and fried chips [PC], coconut oil plantain chips [CPC], palm oil plantain chips [PPC]). The results observed are in the following ranges: tannic acid (mg/100g) (UPC; CPC 1,2,3: 4.18; 1.12 - 3.41, PPC 1,2,3: 1.30 - 2.35), total phenol (mg/100g) (UPC; CPC 1,2,3: 4.56; 1.16 - 2.86, PPC 1,2,3: 1.26 - 1.92), oxalate (mg/g) (UPC; CPC 1,2,3:2.61; 2.52 - 2.79, PPC 1,2,3: 2.16 - 3.24), phytin phosphorus (mg/g) (UPC; CPC 1,2,3: 5.34; 2.78 - 4.41, PPC 1,2,3: 3.71 - 5.34), phytic acid (mg/g) (UPC; CPC 1,2,3: 18.9; 9.88 - 15.7, PPC 1,2,3: 13.2 - 18.7), alkaloids (g/100g) (UPC; CPC 1,2,3: 1.56; 0.72 - 1.34, PPC 1,2,3: 0.45 - 1.38), flavonoids (g/100g) (UPC; CPC 1,2,3: 1.10; 0.57 - 0.65, PPC 1,2,3: 0.55 - 0.64) and lectins (g/100g) (UPC; CPC 1,2,3: 0.20; 0.28 - 0.33, PPC 1,2,3: 0.61 - 0.66). Generally, among the samples, the coefficient of variation percent (CV %) ranged from 12.1 - 50.4.

Parameters	Tannic acid (mg/100g)	Total phenol (mg/100g)	Oxalate (mg/g)	Phytin phosphorus (mg/g)	Phytic acid (mg/g)	Alkaloids (g/100g)	Flavonoids (g/100g)	Lectins (g/100g)
UPC	4.18	4.56	2.61	5.34	18.9	1.56	1.10	0.20
CPC1	2.33	2.86	2.52	4.41	15.7	1.22	0.65	0.33
CPC2	3.41	2.51	2.79	2.78	9.88	1.34	0.62	0.28
CPC3	1.12	1.16	2.70	4.18	14.8	0.72	0.57	0.30
PPC1	1.62	1.92	2.79	5.34	18.9	0.45	0.64	0.66
PPC2	2.35	1.91	3.24	3.71	13.2	1.38	0.63	0.62
PPC3	1.30	1.26	2.16	3.71	13.2	1.27	0.55	0.61
Mean	2.33	2.31	2.69	4.21	14.9	1.13	0.68	0.43
SD	1.13	1.16	0.33	0.93	3.27	0.40	0.19	0.19
CV%	48.4	50.4	12.1	22.0	21.9	35.1	27.8	45.1
χ^2	7.62	8.14	0.64	5.14	64.3	0.95	0.21	0.22
Remark	NS	NS	NS	NS	S	NS	NS	NS

Table 1: *Levels of anti-nutritional factors in the plantain chips fried using different vegetable of (coconut [C] and palm [P] oil).*

UPC: Unprocessed Plantain Chips; PC1: Fresh Plantain in Each of the Oil = Day 1 (First Frying); PC2: Fresh Plantain Fried in Oil Used in Day 1 = Second Frying; PC3: Fresh Plantain Fried in Oil Used in Day 2 = Third Frying(PC3) SD: Standard Deviation, CV: Coefficient of Variation; χ^2: Chi-Square at n-1, $_{\alpha=0.05}$; S: Significantly Different, NS: Not Significantly Different

Anti-nutritional factors are compounds which reduce the nutrient utilization and/or food availability of plants or plant products used as human foods and they play a vital role in determining the use of plants for human food. Anti-nutrients in plant foods are responsible for deleterious effects related to the absorption of nutrients and micronutrients. However, some anti-nutrients may exert beneficial health effects at low concentrations. For example, phytic acid, lectins, tannins, saponins, amylase inhibitors and protease inhibitors have been shown to reduce the availability of nutrients and cause growth inhibition [24]. However, when used at low levels, phytate, lectins, tannins, amylase inhibitors and saponins have also been shown to reduce the blood glucose and insulin responses to starchy foods and/or the plasma cholesterol and triglycerides. In addition, phytates, tannins, saponins, protease inhibitors, goitrogens and oxalates have been related to reduce cancer risks [25]. This implies that anti-nutrients might not always be harmful even though they lack nutritive value. From the results, the levels of tannins, phytates and oxalates in both the unprocessed and fried chips in the two oils used were comparably lower than those reported for unripe, ripe and over ripe plantain peels [26] and favourably compared to levels reported for some green leafy vegetables [27]. The total phenolic content values in the samples were considered comparably lower than the values reported for extracts from unripe and ripe plantains [28].

Generally, the results showed that levels of anti-nutritional factors in the samples obtained from the two oils used were comparably close perhaps due to the fact that they share similar chemical properties [7,29].

The Chi-square analysis showed that the effects of use and re-use of the palm and coconut oils on the anti-nutritional factors were not significantly different except for phytic acid. Re-use of both oils exhibited similar trends in their effects on the levels of anti-nutrient of the fresh (unprocessed) and fried products.

Table 2 presents the differences (including % values estimated from the differences) in the levels of anti-nutrients between fresh (unprocessed) and processed plantain chips obtained from the use of coconut and palm oils. From the results, it was observed that there were reductions in the levels of anti-nutritional factors based on the comparison between fresh plantain and fried plantain chips flour from the respective oils (UPC/PPC1, UPC/PPC2 and UPC/PPC3) cutting across all the anti-nutrients considered however, for lectins significant increment was noticed.

Differences	Tannic acid (mg/100g)	Total phenol (mg/100g)	Oxalate (mg/g)	Phytin Phosphorus (mg/g)	Phytic acid (mg/g)	Alkaloids (g/100g)	Flavonoids (g/100g)	Lectins (g/100g)
UPC-CPC1 (% Diff)	+1.85 (44.3)	+1.70 (37.3)	+0.09 (3.45)	+0.93 (17.4)	+3.29 (17.4)	+0.34 (21.8)	+0.45 (40.9)	-0.13 (65.0)
UPC-CPC2 (% Diff)	+0.77 (18.4)	+2.05 (45.0)	-0.18 (6.90)	+2.56 (47.9)	+9.06 (47.8)	+0.22 (14.1)	+0.48 (43.6)	-0.08 (40.0)
UPC-CPC3 (% Diff)	+3.06 (73.2)	+3.40 (74.6)	-0.09 (3.45)	+1.16 (21.7)	+4.12 (21.8)	+0.84 (53.9)	+0.53 (48.2)	-0.10 (50.0)
UPC-PPC1 (% Diff)	+2.56 (61.2)	+2.64 (57.9)	-0.18 (6.90)	0.00 (0.00)	0.00 (0.00)	+1.11 (71.2)	+0.46 (41.8)	-0.46 (230)
UPC-PPC2 (% Diff)	+1.83 (43.8)	+2.65 (58.1)	-0.63 (24.1)	+1.63 (30.5)	+5.76 (30.4)	+0.18 (11.5)	+0.47 (42.7)	-0.42 (210)
UPC-PPC3 (%Diff)	+2.88 (68.9)	+3.30 (72.4)	+0.45 (17.2)	+1.63 (30.5)	+5.76 (30.4)	+0.29 (18.6)	+0.55 (50.0)	-0.41 (205)
CPC1-CPC2 (% Diff)	-1.08 (46.4)	+0.35 (12.2)	-0.27 (10.7)	+1.63 (37.0)	+5.77 (36.9)	-0.12 (9.84)	+0.03 (4.62)	+0.05 (15.2)
CPC1-CPC3 (% Diff)	+1.21 (51.9)	+1.70 (59.4)	-0.18 (7.14)	+0.23 (5.22)	+0.83 (5.30)	+0.50 (41.0)	+0.08 (12.3)	+0.03 (9.09)
CPC2-CPC3 (% Diff)	+2.29 (67.2)	+1.35 (53.8)	+0.09 (3.23)	-1.40 (50.4)	-4.94 (50.0)	+0.62 (46.3)	+0.05 (8.06)	-0.02 (7.14)
PPC1-PPC2 (% Diff)	-0.73 (45.1)	+0.01 (0.52)	-0.45 (16.1)	+1.63 (30.5)	+5.76 (30.4)	-0.93 (207)	+0.01 (1.56)	+0.04 (6.06)
PPC1-PPC3 (% Diff)	+0.32 (19.8)	+0.66 (34.4)	+0.63 (22.6)	+1.63 (30.5)	+5.76 (30.4)	-0.82 (182)	+0.09 (14.1)	+0.05 (7.58)
PPC2-PPC3 (% Diff)	+1.05 (44.7)	+0.65 (34.0)	+1.08 (33.3)	0.00 (0.00)	0.00 (0.00)	+0.11 (7.97)	+0.08 (12.7)	+0.01 (1.61)

Table 2: *Summary of the differences in the levels of anti-nutritional factors in the plantain chips from table 1.*

% Diff: Percentage Difference; +: Enhancement in the Level of Anti-Nutritional Factor of the Reference; -: Decrease in the Level of Anti-Nutritional Factor of the Reference.

Enhancement in lectins levels were observed in the following categories of fried products compared with unprocessed sample: UPC/CPC1, UPC/CPC2, UPC/CPC3, UPC/PPC1, UPC/PPC2, UPC/PPC3 by a value range of -0.1 - -0.46 g/100g but reduced in CPC1/CPC2, CPC1/CPC3, PPC1/PPC2, PPC1/PPC3 and PPC2/PPC3 in values of + 0.01 - +0.05 g/100g. Various degrees of enhancements were also noticed in the levels of oxalate as follows: UPC/CPC2 (-0.18, 6.9%), PPC1/PPC2, CPC1/CPC2 (-0.12. 9.84 %), (-0.09, 3.45%), UPC/PPC1 (-0.18, 6.90%), UPC/PPC2 (-0.63, 24.1%), CPC1/CPC3 (-0.18, 7.14%), for alkaloids: PPC1/PPC2 (-0.93, 207%) and PPC1/PPC3 (-0.82, 182%), also for tannic acid the following categories were enhanced: CPC1/CPC2 (-1.08, 46.4%) and PPC1/PPC2 (-0.73, 45.1%). It is interesting to note that apart from the above-listed categories of enhancements, all other anti-nutritional factors were observed to reduce during frying (first day frying down to the third day frying) to varying degrees of reduction (tannic acid: 18.4 - 73.2%, total phenol: 34.4 - 74.6%, oxalate: 3.23 - 33.3%, phytin phosphorus: 0.00 - 50.4%, phytic acid: 0.00 - 50.0%, alkaloids: 7.97 - 71.2%, flavonoids: 1.56 - 50.0% and lectins: 1.61 - 9.09%). There have been several reports from the literature on effects of different heat treatments on the plant secondary metabolites (anti-nutrients). For instance, phytic acid and trypsin inhibition activities have been reported to have undergone reduction in three types of bean (black bean, faba bean and dry bean) during roasting and autoclaving [30], moist cooking and roasting were reported

to bring about reduction in the levels of phytate, phytin phosphorus, tannic acid and alkaloids in the whole seeds, cotyledon and testa of *Treculia africana* seeds flour [31], raw *Terminalia catappa* L (Tropical almond) kernels had most of the anti-nutritional factors reduced by roasting [32]. Repeated use of olive oil, soya bean oil and refined palm olein for frying plantain chips have also been reported to enhance the reduction of anti-nutritional factors in the plantain chips flour [1], tannin contents of *Dolicos lablab* seeds have also been reportedly reduced during cooking or autoclaving to a level between 70 and 60% [33]. If proper and adequate treatment were applied to plantain chips, anti-nutritional factors tend to reduce and consequently increase in nutritional values (such as fats and minerals).

The antioxidants assay variations of unprocessed and fried plantain chips using coconut and palm oils respectively were represented in figures 1-14. Variations in the total flavonoids content of the unprocessed and fried plantain chips were shown in figures 1 and 2; for the total phenol, figures 3 and 4; ferric reducing antioxidant power (FRAP) (mg Ascorbic acid/g), figures 5 and 6; ABTS (µmolTroloxEq/g), figures 7 and 8; DPPH (µmolTroloxEq/g), figures 9 and 10; % NO inhibition, figures 11 and 12 and % OH inhibition, figures 13 and 14. The highest enhancement in the levels of antioxidant assays as shown in the figures were CPC1and PPC1, This suggests that frying plantain chips only once will enhance the level of antioxidant activity in the product better than the repeated use of oil frying. All antioxidants are working in concert as a team, the (antioxidant system), responsible for prevention of the damaging effects of free radicals and toxic products of their metabolism. However, the antioxidant (team) acts to control levels of free radical formation as a coordinated system where deficiencies in one component impact the efficiency of others [34].

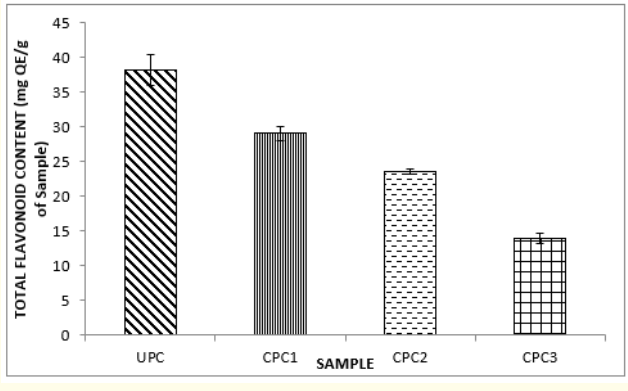

Figure 1: *Variation in total flavonoid content of the unprocessed and processed plantain chips using coconut oil and its re-use.*

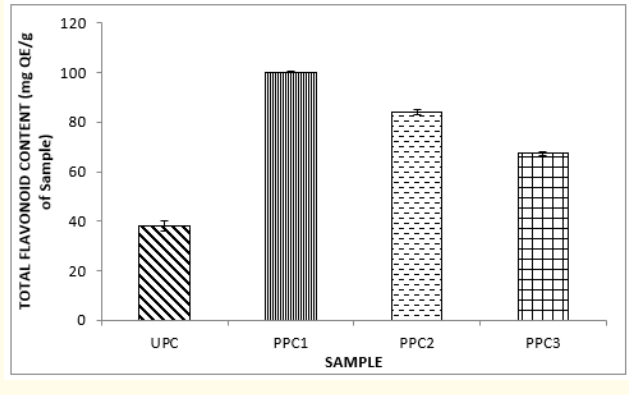

Figure 2: *Variation in total flavonoid content of the unprocessed and processed plantain chips using palm oil and its re-use.*

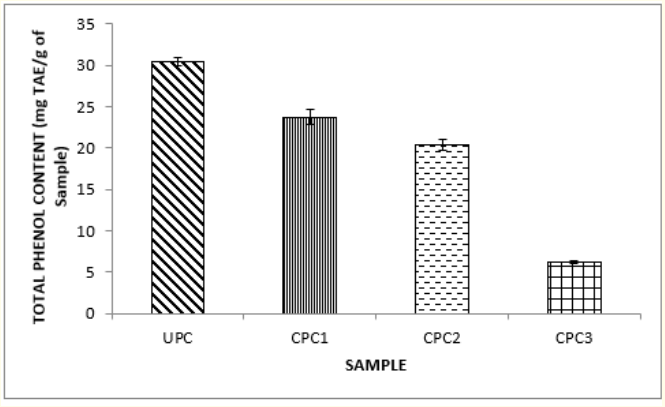

Figure 3: *Variation in total phenol content of the unprocessed and processed plantain chips using coconut oil and its re-use.*

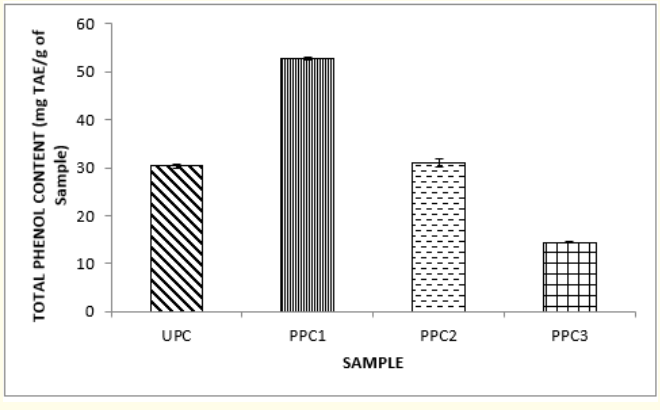

Figure 4: *Variation in total phenol content of the unprocessed and processed plantain chips using palm oil and its re-use.*

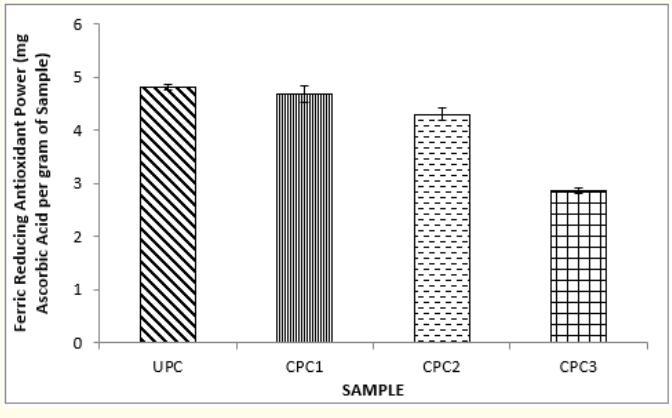

Figure 5: *Variation in ferric reducing antioxidant power (FRAP) of the unprocessed and processed plantain chips using coconut oil and its re-use.*

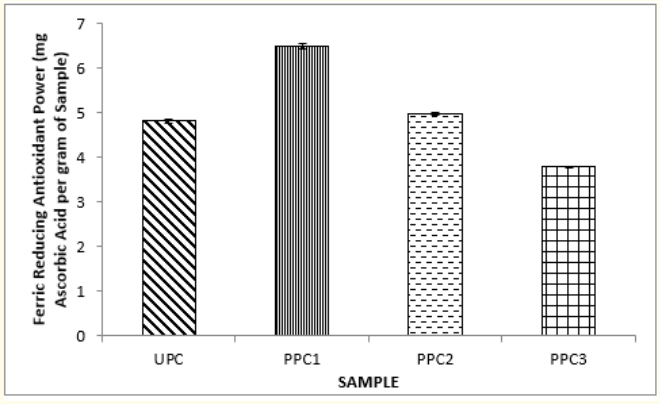

Figure 6: *Variation in ferric reducing antioxidant power (FRAP) of the unprocessed and processed plantain chips using palm oil and its re-use.*

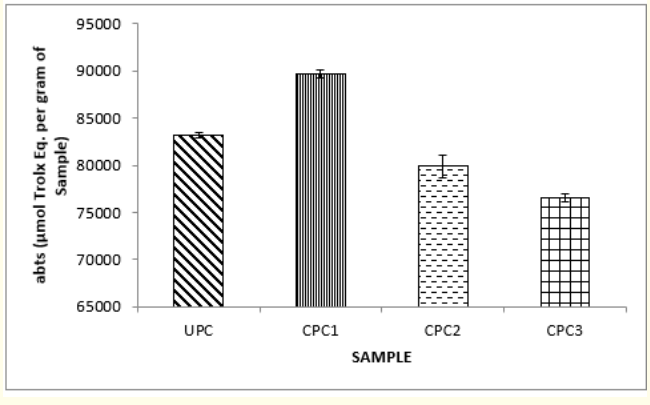

Figure 7: *Variation in ABTS of the unprocessed and processed plantain chips using coconut oil and its re-use.*

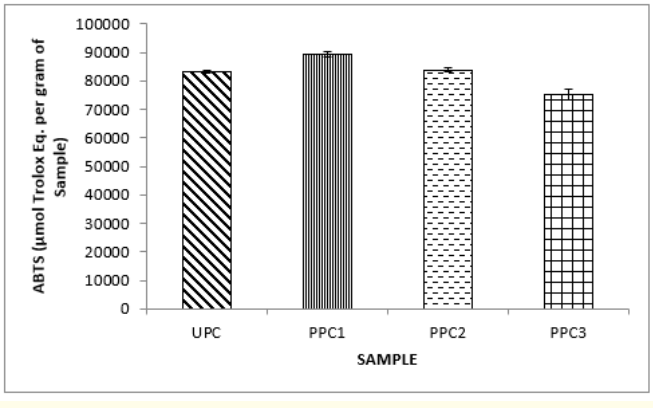

Figure 8: *Variation in ABTS of the unprocessed and processed plantain chips using palm oil and its re-use.*

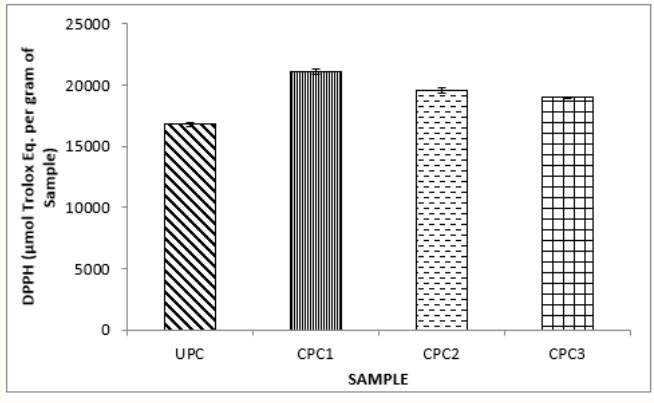

Figure 9: *Variation in DPPH of the unprocessed and processed plantain chips using coconut oil and its re-use.*

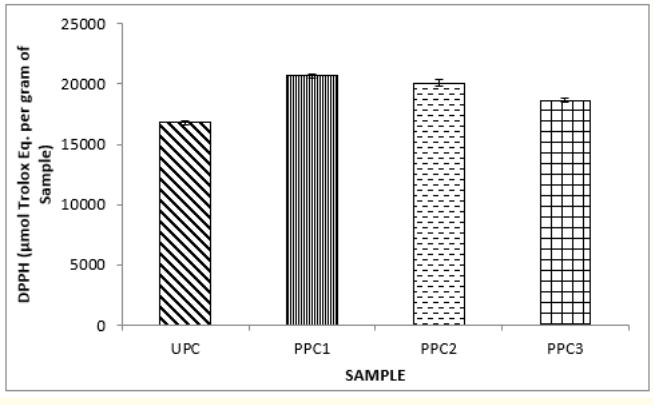

Figure 10: *Variation in DPPH of the unprocessed and processed plantain chips using palm oil and its re-use.*

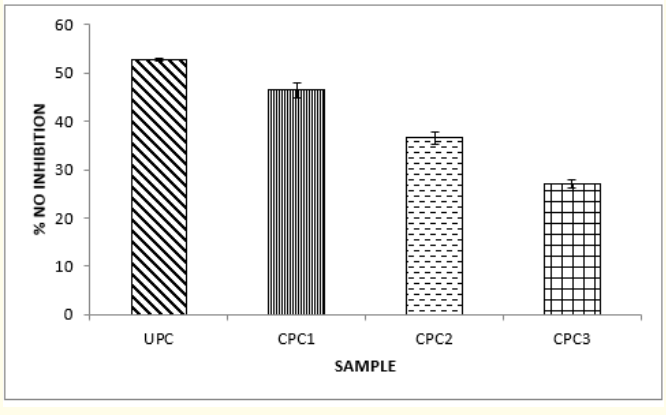

Figure 11: *Variation in % NO inhibition of the unprocessed and processed plantain chips using coconut oil and its re-use.*

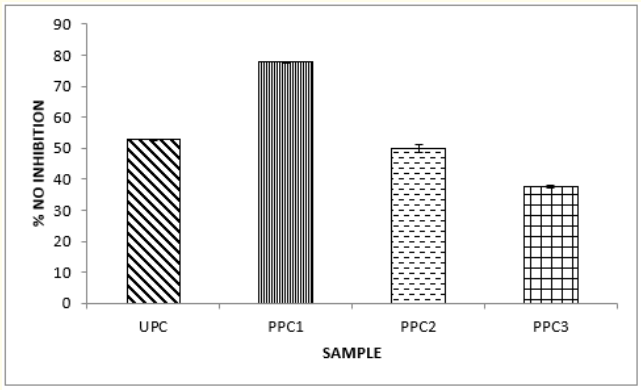

Figure 12: *Variation in % NO inhibition of the unprocessed and processed plantain chips using palm oil and its re-use.*

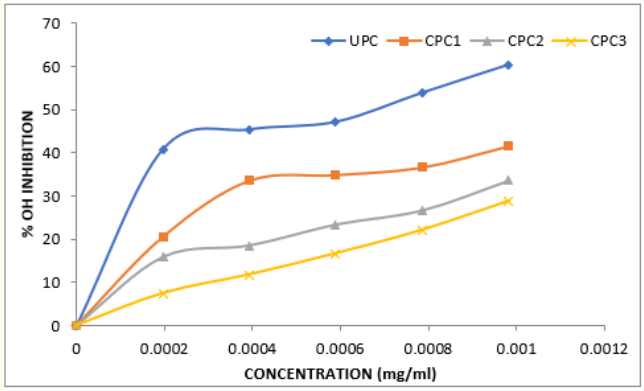

Figure 13: *Variation in % OH inhibition of the unprocessed and processed plantain chips using coconut oil and its re-use.*

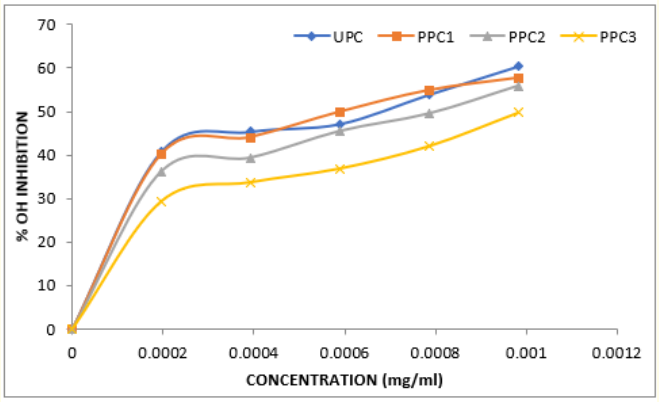

Figure 14: *Variation in % OH inhibition of the unprocessed and processed plantain chips using palm oil and its re-use.*

The increase in the antioxidant parameters during the first frying operation for all the chips in the various oils considered may be due to attractions in chemical structures/composition, causing them to be more readily available and detected in the supernatants of the extract [35]. Oladele and Santosh [36] reported increase in soluble polyphenols contents of boiled unripe plantain in non-extractable polyphenols in the grilled sample of plantains. The first frying process increased antioxidant capacities according to ABTS, OH, NO and FRAP assays compared with the unprocessed, second and third frying processes. These observations were in agreement with the reports from the works of Dewanto., *et al.* [37], Turkmen., *et al*. [38] and Francisco and Resurreccion [39] on the effects of heat treatments on the antioxidant capacities of pepper, green bean, broccoli, spinach, sweet corn and pea nut respectively. The effects of home cooking methods, such as frying on the antioxidant activity of vegetables have also been reported by Jimenez-Monreal., *et al.* [40] and their results were in perfect agreement with the present observations. It is possible that heat disrupts the cell wall and releases antioxidant compounds, leading to an increase in antioxidant capacity mainly for the first frying process [1].

Generally, the frying process resulted in different types of bonds being formed between phytochemicals present and cell structure which subsequently resulted in higher or lower cleavage of phenolic bonds according to the type of heat applied, resulting in the different responses observed in the present study [1].

Conclusion

The study showed that both coconut and palm oil were good for frying plantains. The results for the unprocessed (fresh) and processed (fried) plantain chips [from the two oils (use and re-use: first, second and third frying)] recorded low levels of anti-nutritional factors and fairly high levels of antioxidant activities that could support good health. However, the highest level of antioxidant activities were observed in the products from the first day frying compared to the products obtained from the first and second re-use of oils. For optimum antioxidant activity of fried plantain chips, re-use of oil for frying should be avoided as it leads to reduction in the antioxidant activities. Therefore, for better antioxidant activities from fried plantain chips, re-use of oils (coconut and palm) for frying should be discouraged as it leads to reduced antioxidant activities. However, to ensure a reduced anti-nutrient levels, the first re-use may be accommodated but sparingly.

Conflict of Interest

Authors declare no conflict of interest.

Bibliography

1. Adeyeye EI., *et al*. "Effects of Use and Re-use of selected Vegetable Oils on the Anti-nutritional and Antioxidants contents of raw and Fried plantain Chips. Note 1". *CPQ Nutrition* 1.6 (2018): 1-29.
2. Nur Arina AJ and Azrina A. "Comparison of phenolic content and antioxidant activity of fresh and fried local fruits". *International Food Research Journal* 23.4 (2016): 1717-1724.
3. Rojas-Gonzalez JA., *et al*. "Effect of deep-fat frying on ascorbic acid, carotenoids and potassium contents of plantain cylinders". *International Journal of Food Sciences and Nutrition* 57.1-2 (2006): 123-136.
4. Aida SA., *et al*. "A study on reducing fat content of fried banana chips using a sweet pre-treatment technique". *International Food Research Journal* 23.1 (2016): 68-71.
5. Poku K. "Small Scale Palm Oil processing in Africa". Agriculture and Consumer Protection. FAO. Agricultural Services Bulletin. Pub. England 148.62 (2002): 44-48.
6. Chandrasekharan N., *et al*. "Changing nutritional and health perspective of palm oil". *Brunei International Medical Journal* 2 (2000): 417-427.

7. Nevin KG and Rajamohan T. "Beneficial effects of virgin coconut oil on lipid parameters and in vitro LDL oxidation". *Clinical Biochemistry* 37.9 (2004): 830-835.

8. Feranil AB., *et al*. "Coconut oil is associated with a beneficial lipid profile in pre-menopausal women in the Philippines". *Asia Pacific Journal of Clinical Nutrition* 20.2 (2011): 190-195.

9. Arai Y., *et al*. "Dietary intakes of flavonoids, flavones and isoflavones by Japanese women and the inverse correlation between quercetin intake and plasma LDL cholesterol". *Journal of Nutrition* 130.9 (2000): 2378-2383.

10. Soetan KO. "Phamacological and other beneficial effects of anti-nutritional factors in plants: A review". *African Journal Biotechnology* 7.25 (2008): 4713-4721.

11. Young SM and Greaves JS. "Influence of variety and treatment on phytin content of wheat". *Journal of Food Science* 5.1 (1940): 103-108.

12. Wheeler EL and Ferrel RE. "A Method for phytic acid determination in wheat and wheat fractions". *American Association of Cereal Chemists* 48 (1971): 313-320.

13. Makkar AOS and Goodchild AV. "Qualification of tannins". A laboratory manual, ICARDA, Aleppo, Syria (1996).

14. Day RA and Underwood AL. "Quantitative analysis, 5th edition". Prentice Hall Publication, London (1986).

15. Harborne JB. "Phytochemical methods". Capman and Hall, Ltd., London (1973): 49-188.

16. Boham BA and Kocipai-Abyazan R. "Flavonoids and condensed tannins from leaves of Hawairan vaccinium valiculatum and V. calycinium". *Pacific Science* 48.4 (1974): 458-463.

17. Waterman PG and Mole S. "Analysis of Phenolic Plant Metabolites". Blackwell Scientific Publications, Oxford (1994).

18. Meda A., *et al*. "Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity". *Food Chemistry* 91.3 (2005): 571-577.

19. Oyaizu M. "Studies on product of browning reaction prepared from glucose amine". *Japanese Journal of Nutrition and Dietetics* 44.6 (1986): 307-315.

20. Williams RB., *et al*. "Use of a free radical method to evaluate antioxidant activity". *Lebensmittel-Wissenschaft und -Technologie* 28.1 (1995): 25-30.

21. Awika JM., *et al*. "Screening Methods to Measure Antioxidant Activity of Sorghum (Sorghum bicolor) and Sorghum Products". *Journal of Agricultural and Food Chemistry* 51.23 (2003): 6657- 6662.

22. Halliwell B and Gutteridge J. "Formation of a thiobarbituric-acid-reactive substance from deoxyribose in the presence of iron salts. The role of superoxide and hydroxyl radicals". *FEBS Letters* 128.2 (1981): 347-352.

23. Sangameswaran B., *et al*. "In vitro antioxidant activity of roots of Thespesia lampas dalz and gibs". *Pakistan Journal of Pharmaceutical Sciences* 22.4 (2009): 368-372.

24. Shanthakumari S., *et al*. "Nutritional evaluation and elimination of toxic principles in wild yam (Dioscorea spp.)". *Tropical and Subtropical Agroecosystems* 8.3 (2008): 319-225.

25. Ugwu FM and Oranye NA. "Effects of some processing methods on the toxic components of African breadfruit (Treculia africana)". *African Journal of Biotechnology* 5.22 (2006): 2329-2333.

26. Akinsanmi AO., *et al*. "Assessment of the nutritional, anti-nutritional and antioxidant capacity of unripe, ripe and overripe plantain (Musa parasidiaca) peels". *International Journal of Advanced Research* 3.2 (2015): 63-72.

27. Agbaire PO. "Nutritional and anti-nutritional level of some local vegetables (Vernomiaanydahra, manihotesculenta, Teiferiaoccidentalis, Talinumtriangulare, Amaranthusspinosus) from Delta State, Nigeria". *Journal of Applied Sciences and Environmental Management* 15.4 (2011): 625-628.

28. Ibukun OE and Johnson OD. "Effect of ripening on the phytochemicals constituent and antioxidant properties on plantain. (Musa paradisiacal)". *Journal of medicinal Plants Research* 6.37 (2012): 5077-5085.

29. Obahiagbon FI and Ilori EG. "Antioxidant effects of onion and garlic extracts on palm oil used in the production of plantain chips". *Journal of Chemical Society of Nigeria* 41.2 (2016): 92-95.

30. Osman AM. "Effects of different processing methods on nutrient composition, antinutritional factors and in-vitro protein digestibility on Dolichos Lab lab bean. (Lablab purpureus L. Sweet)". *Pakistan Journal of Nutrition* 6.4 (2007): 299-303.

31. Adesina AJ and Adeyeye EI. "Relative Effects of Traditional Processing Methods on the Nutritional and Anti-Nutritional Composition of raw Treculia africana Seeds Flour". *Journal of Bio Innovation* 4.4 (2015): 135-151.

32. Adesina AJ. "Effects of roasting on the nutritional and anti-nutritional composition of raw Terminalia catappa L (Tropical almond) Kernels". *Malaya Journal of Biosciences* 2.2 (2015): 119-131.

33. Vijayakumari K., *et al*. "Effect of various water treatments on certain anti-nutritional compounds in the tribal pulse, Dolichos lablab Var. vulgaris L". *Plant Foods Human Nutrition* 48.1 (1995): 17-29.

34. Peter FS. "Natural Antioxidants in Poultry Nutrition: New Developments". 16th European Symposium on Poultry Nutrition (2007): 669-667.

35. Cohen MF., *et al*. "Roles of Plant Flavonoids in interaction with Microbes: from protection against pathogens to mediation mutualism in S.G. Pandalai". *Recent Research in Plant Physiology* 2 (2001): 157-175.

36. Oladele E and Santosh K. "Effect of domestic cooking on the polyphenolic content and antioxidant capacity of plantain (Musa paradisiaca)". *World Journal of Dairy and Food Sciences* 6.2 (2011): 189-194.

37. Dewanto V., *et al*. "Processed Sweet Corn has higher antioxidant activity". *Journal of Agricultural and Food Chemistry* 50.17 (2002): 4959-4964.

38. Turkmen N., *et al*. "The effect of cooking method on total phenolics and antioxidants activity of selected green vegetables". *Food Chemistry* 93.4 (2005): 713-718.

39. Francisco MLLD and Resurreccion AVA. "Total phenolics and antioxidant capacity of heat-treated peanuts skins". *Journal of Food Composition and Analysis* 22.1 (2009): 16-24.

40. Jimenez-Monreal AM., *et al*. "Influence of cooking methods non antioxidant activity of vegetables". *Journal of Food Science* 74.3 (2009): H97-H103.Chandrasekharan N., *et al*. "Changing nutritional and health perspective of palm oil". *Brunei International Medical Journal* 2 (2000): 417-427.

41. Nevin KG and Rajamohan T. "Beneficial effects of virgin coconut oil on lipid parameters and in vitro LDL oxidation". *Clinical Biochemistry* 37.9 (2004): 830-835.

42. Feranil AB., *et al*. "Coconut oil is associated with a beneficial lipid profile in pre-menopausal women in the Philippines". *Asia Pacific Journal of Clinical Nutrition* 20.2 (2011): 190-195.

43. Arai Y., *et al*. "Dietary intakes of flavonoids, flavones and isoflavones by Japanese women and the inverse correlation between quercetin intake and plasma LDL cholesterol". *Journal of Nutrition* 130.9 (2000): 2378-2383.

44. Soetan KO. "Phamacological and other beneficial effects of anti-nutritional factors in plants: A review". *African Journal Biotechnology* 7.25 (2008): 4713-4721.

45. Young SM and Greaves JS. "Influence of variety and treatment on phytin content of wheat". *Journal of Food Science* 5.1 (1940): 103-108.

46. Wheeler EL and Ferrel RE. "A Method for phytic acid determination in wheat and wheat fractions". *American Association of Cereal Chemists* 48 (1971): 313-320.

47. Makkar AOS and Goodchild AV. "Qualification of tannins". A laboratory manual, ICARDA, Aleppo, Syria (1996).

48. Day RA and Underwood AL. "Quantitative analysis, 5th edition". Prentice Hall Publication, London (1986).

49. Harborne JB. "Phytochemical methods". Capman and Hall, Ltd., London (1973): 49-188.

50. Boham BA and Kocipai-Abyazan R. "Flavonoids and condensed tannins from leaves of Hawairan vaccinium valiculatum and V. calycinium". *Pacific Science* 48.4 (1974): 458-463.

51. Waterman PG and Mole S. "Analysis of Phenolic Plant Metabolites". Blackwell Scientific Publications, Oxford (1994).

52. Meda A., *et al*. "Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity". *Food Chemistry* 91.3 (2005): 571-577.

53. Oyaizu M. "Studies on product of browning reaction prepared from glucose amine". *Japanese Journal of Nutrition and Dietetics* 44.6 (1986): 307-315.

Volume 14 Issue 5 May 2019