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Physicochemical and Biochemical changes in cooking oils among road side food vendors in a sub-urban area of Lagos State, Nigeria

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ABSTRACT

Background: Repeated use of vegetable oils for deep frying, leads to physical and biochemical changes, resulting from alteration in the fatty acid composition and formation of free radicals.

Aim: To determine physicochemical and biochemical changes occurring in vegetable oils repeatedly used for deep frying by road-side food vendors in a sub-urban area of Lagos State, Nigeria.

Method: Oil samples used for deep frying were collected from three different vendors on two occasions. Questionnaires were also administered to the vendors. The oil samples and unused oils (control) were analyzed for colours, viscosity, refractive index, iodine value, peroxide value, acid value, free fatty acids, as well as acrylamide and poly aromatic hydrocarbons (PAHs) concentrations. Data were analysed using SPSS version 17.0.

Results: There was no significant difference in refractive index, iodine value and colour intensity between the use and unused oil, whereas, there were significant ($p<0.05$) differences in viscosity, peroxide, acid and free fatty acid values between the control and used oil. All the oil samples had acrylamide level greater than 0.0003 µg/ml. The reused oil samples also had some PAHs levels such as benzo(a) pyrene, naphthalene and benzo(k) fluranthene at levels above 10 ppm.

Conclusion: Continuous use of vegetable oils negatively affected some physicochemical properties of the oils and caused an increase in acrylamide and PAHs concentration. And this may portend serious health risk.

Keywords: Deep frying, viscosity, free radicals and poly aromatic hydrocarbon.

INTRODUCTION

Deep frying is one of the most common and oldest methods of food preparation worldwide. It involves heat and mass transfer. To reduce the expenses, the oils tend to be used repeatedly for frying. When these oils are heated repeatedly, changes in physical appearance such as darkening in colour of the oil take place (Rani et al, 2010), which may alter the fatty acid composition of the oil. Heating also causes the oil to undergo series of chemical reactions like oxidation, hydrolysis and polymerization (Choe and Min, 2007). During this process, many oxidative products such as hydro peroxide and aldehydes are produced, which can be absorbed into the fried food (Choe and Min, 2006). These reactive products may be responsible for the oxidative stress and damage to various organs in the body (Ku et al, 2014).

Vegetable oils are used in various frying processes both commercially and for personal use in Nigeria. They are also used at home in the storage of food and are also useful industrially to make soaps, skin products, candles, perfumes and other personal care and cosmetic products.

The effect of continuous frying of oil was studied in this work with a view to providing nutritionists useful information about the danger it poses to health. International development agencies working in this field of nutrition and cancer can also benefit from this work. This work would also enlighten commercial food outlets and its consumers on the possible threat of the oil when repeatedly heated.

This work was carried out to determine physicochemical and biochemical changes occurring in vegetable oils used by road-side food vendors in a sub-urban area of Lagos State.

MATERIALS AND METHODS

Collection of samples: Samples were collected from three different road-side food vendors at Okokomaiko, Lagos State in capped amber-coloured glass containers.

All chemicals and reagents used are analytical grades from Sigma,

The **Acid value, viscosity, free fatty acid** and **colour intensity** were carried out according to the Manual of methods of analysis of food, oil and fat (2005). However, the **Iodine number and peroxide values** were determined based on the AOCS, 1998.

Poly aromatic hydrocarbons (PAHs) and Acrylamide analysis was carried out using High Performance Liquid chromatography **(HPLC)** based on method described by Bellah and Nelson, 2012.

Statistical Analysis: Measurements of duplicate samples were expressed as standard deviation of mean ± for all rapid methods and standard methods. The data were subjected to one-way analysis of variance. Post hoc's multiple comparison tests was used for comparing the differences between group means. Values of $P<0.05$ were considered be statistically significant (Wei-an chen *et al.*, 2013).

RESULTS

Table 1: Summary of the questionnaires given to the vendors

	Chijioke	Mama Goodness	Mama Promise
Oil used for frying	Kings Oil	Kings Oil	Kings Oil
Reason for preference	Quality	Quality	Quality
Hours of frying per day	4 hours	9 hours	9 hours
Utilization of remaining oil	Top up	Top up	Filter and Top up
How often is the oil changed	Never	Never	After three days
What is the waste frying oil used for	No waste	No waste	Mixed with flour
How is the fryer cleaned	cold water + soap	cold water + soap	cold water + soap
Any treatment used for oil	No	No	No
What is the Oil used to fry	Beans cake (Akara) and Yam	Beans cake (Akara) and Yam	Beans cake (Akara), fish roll, fish pie, doughnut
Is the same oil used to fry everything	Yes	Yes	Yes

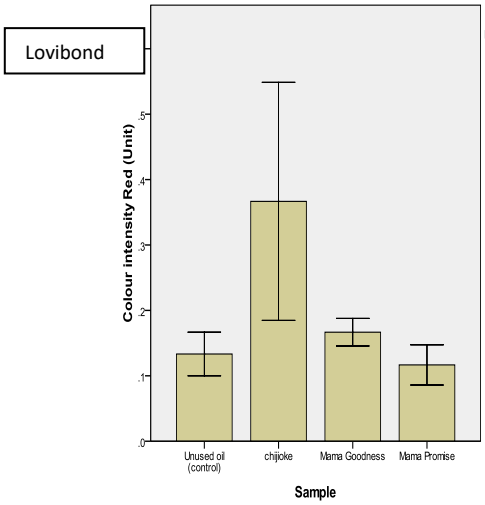

Fig 1: Effect of heat on the colour intensity (red) of the Vegetable oil samples

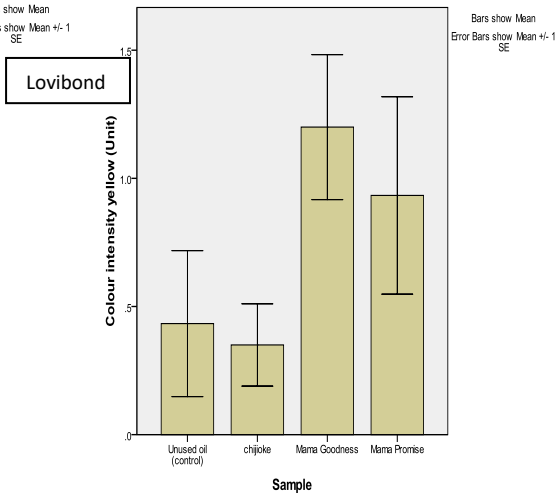

Fig 2: Effect of heat on the colour intensity (yellow) of the vegetable oil samples

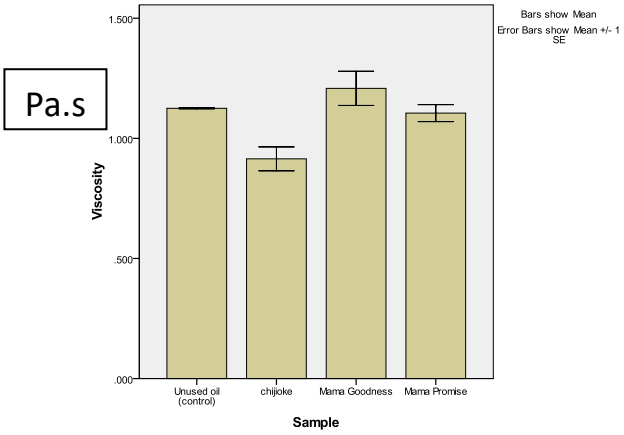

Fig 3: Effect of heat on the viscosity of the vegetable oil samples

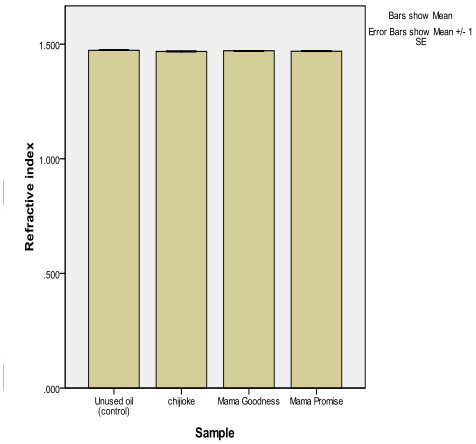

Fig 4: Effect of heat on the refractive index of the vegetable oil samples

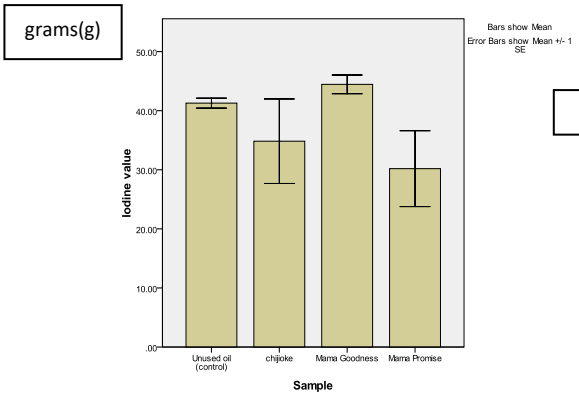

Fig 5: Effect of heat on the iodine value of the Vegetable oil samples

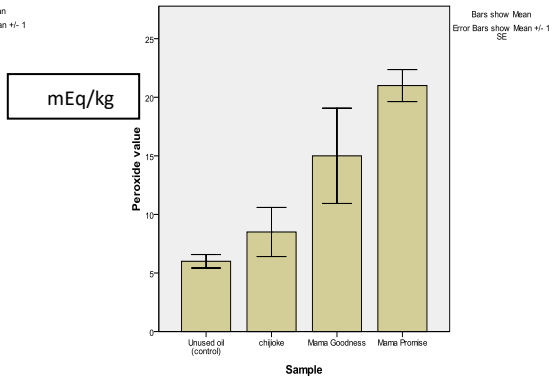

Fig 6: Effect of heat on the peroxide value of the Vegetable oil samples

mg of NaOH/g of oil

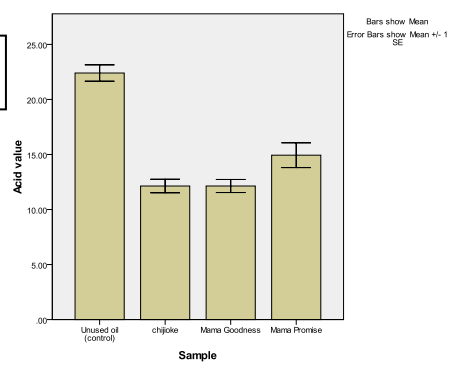

Fig 7: Effect of heat on the acid value of the Vegetable oil

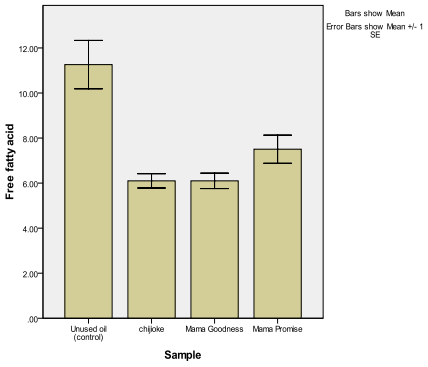

Fig 8: Effect of heat on the free fatty acids measurement of the Vegetable oil samples

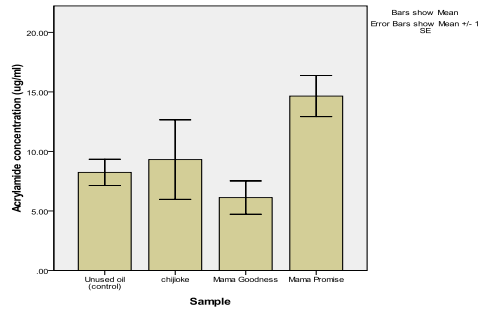

Fig 9: Effect of heat on the concentration of acrylamide present in the Vegetable oil sample

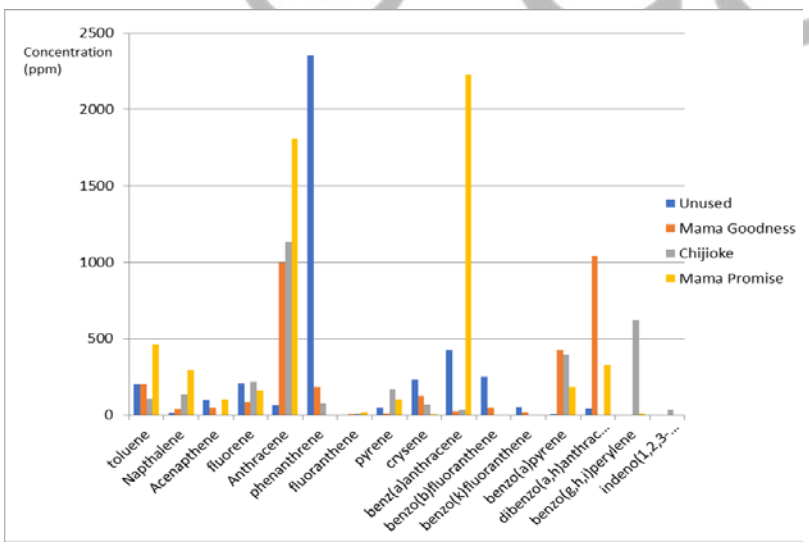

Fig 10: Effect of Heat on the Polycyclic Aromatic Hydrocarbons (PAHs) of vegetable oil samples collected on Day 1.

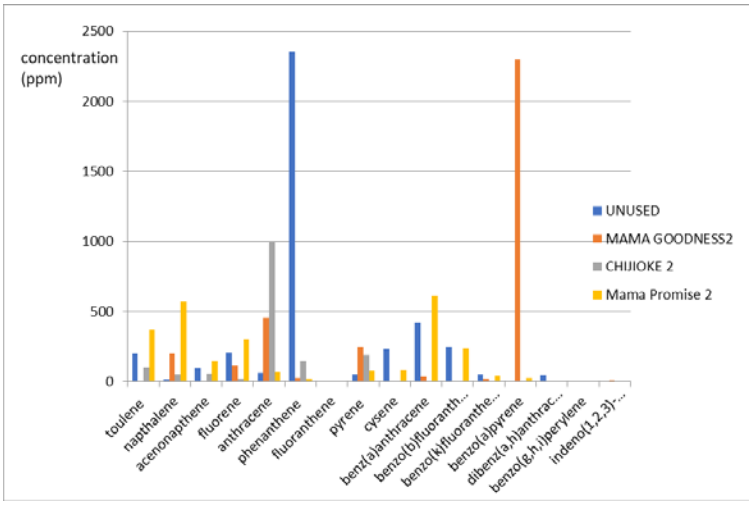

Fig 11: Effect of Heat on the Polycyclic Aromatic Hydrocarbons (PAHs) of vegetable oil samples collected on Day 2

DISCUSSION

Frying of substances with vegetable oil (i.e. application of heat to the oil) will increase some parameters in the oil while also decreasing some other parameters in the same oil. (AbdulHamid *et al*., 2014; Bordin et al., 2013). These can however be affected by the "treatment and care" of this oil before, during and after use.

The questionnaire administered assisted in getting information on the "treatment and care" of these oils. Some of the questions asked had the same answers with the other vendors possibly because of the type of business being done. All of the vendors preferred "Kings" oil because of its quality (does not evaporate easily), and would top up their oils when they are drying up. Also, they all prefer to wash their fryers with cold water and soap. Of all, only Chijioke performed frying for 4 hours per day while the remaining two vendors fried for 9 hours per day. Though, each of them fried more than one food item, none of them used different oils .

This may however not affect the results if they all fried the same food items but Mama Promise differed in the type of food items she fried (only having *akara* in common with the rest). This questionnaire proved useful in explaining some of the results.

During frying, there should be a change in the colour intensity of the oil being used (Glenn, 2006) but there was no significant difference in the colour intensity (red and yellow) of the vegetable oil samples making colour intensity not significant in respect to heating. This may

be attributed to the quality of the oils or due to the topping of the used oil with fresh oils (unused) as claimed by the vendors in the questionnaire.

Increase in temperature generally leads to decrease in viscosity (Lemuel et al, 2014). There was no specific trend in the viscosity of the vegetable oil samples (used and unused) but vegetable oil sample of Chijioke with the least frying time had the lowest viscosity (lower than the unused) which was significantly different ($p<0.05$) from the remaining oil samples.

Increased frying with vegetable oil also leads to increase in the refractive index (light penetration) of the vegetable oil samples depending on the type of food items fried (Glenn, 2006). There was a significant decrease ($p<0.05$) in the refractive index from the unused oil sample to the samples collected from Chijioke. Though, the Chijioke oil sample was significantly lower than that of Mama Goodness and Mama Promise. This was expected according to Glenn since the vendor (Mama Promise) whose oil had the highest refractive index was one of the two that fried for nine hours per day and she also fried more food items than the other.

Iodine value is a measure of the degree of unsaturation in vegetable oils which decreases with increase in temperature (Adejumo et al, 2013). But there was no significant difference in the iodine value of the vegetable oil samples collected from the vendors; this may be due to the quality of the oil as claimed by the vendors. It can also be attributed to the oils being topped up with fresh oils (unused) during frying.

Peroxide value is a measure of the degree of lipid oxidation, increasing with increase in temperature (Thomas, 2002). In the samples collected from the vendors, there was a significant increase in the peroxide value from the unused oil sample to that of the used samples; significantly increasing (($p<0.05$) from that of Chijioke to that of Mama Goodness and to that of Mama Promise. This was expected as the peroxide value of the unused oil had the least peroxide value with oil samples collected from Chijioke having the least peroxide value of the used oil samples which can be attributed to having the least frying time (4 hours per day) against the remaining used oil samples (9 hours per day).

Acid value of vegetable oil is a measure of oil acidity which also reflects the amount of fatty acids hydrolyzed from triacylglycerols. Thus, an increase in acid value will also lead to an increase in free fatty acids. Generally, acid value increases with increase in temperature (Thomas, 2002), but in this study, there was a significant decrease ($p<0.05$) in the acid value

from the unused oil sample to the remaining used samples (which was not supposed to be as explained by Thomas earlier) with Chijioke having the least acid value which may be attributed to his frying time lower than the remaining ones (with higher frying time). The abnormality in the acid value may be as a result of the packaging material the vegetable oil is stored when smuggling it into the country since okokomaiko is close to the border. This same explanation applies to the decrease in the free fatty acids content.

There is no specific safe limit for acrylamide concentration in fried oils (Friedrich and Werner, 1983). Acrylamide is formed as a result of the maillard reaction between amino acids and reducing sugars. There was no significant difference in the concentration of acrylamide between the used sample and the unused samples making acrylamide concentration not significant in the vegetable oil samples. This may also be attributed to the quality of the vegetable oil since it can be said that there were no spontaneous maillard reactions in the used vegetable oil samples (Ayala *et al*., 2014).

Generally, Polycyclic Aromatic Hydrocarbons (PAHs) increase with increase in temperature (Zhu and Wang, 2003) but the results of the samples did not show any specific pattern in the concentration of the Polycyclic Aromatic Hydrocarbons for both Day 1 and Day 2 with most being higher in the used oils compared to the control. This irregularity may be attributed to the type of packaging materials (like polythene) that were used in transporting the oil into the country (the normal plastic material is not always used) or maybe attributed to the type of storage material the vegetable oil is stored in after use since none of the vendors disposed his or her oil immediately after first use. One or more factors may have led to the trend of these results. PAHs with four to six benzene rings have the highest concentration of PAHs. Benzo (a) pyrene and dibenz (a,h) anthracene are known for their high carcinogenicity (Friedrich and Werner, 1983). On Day 1, oil sample collected from Mama Goodness had the highest concentration of both benzo(a)pyrene and dibenz(a,h)anthracene having the values; 424.85 ppm and 1041.27 ppm respectively which are greatly higher than the unused (7.48 ppm and 45.65 ppm respectively). On Day 2, vegetable oil sample collected from Mama Goodness also had the highest concentration of benzo(a)pyrene having the value; 2296.48 ppm which is greatly higher than the unused (7.48 ppm) while dibenz(a,h)anthracene was not detected in all the used samples.

CONCLUSION

The results of this study showed that continuous heating of vegetable oil by road-side food vendors (for frying) at Okokomaiko did not affect the colour intensity (yellow and red), iodine value and acrylamide concentration of the vegetable oil but it affected the viscosity, refractive index, peroxide value, acid value and free fatty acids content of the vegetable oils. Continuous heating also affected the concentration of some PAHs present in the vegetable oil samples. The oil samples from the two vendors with the highest frying time had elevated levels of PAHs with high carcinogenicity.

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