QUALITY EFFECT OF REPETITIVE USE OF FRYING OIL BY STREET FOOD VENDORS ON QUALITY OF THE OIL

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ABSTRACT
Background: Frying of food triggers different chemical reactions and most street food vendors use oils repeatedly before discarding in order to reduce cost. This repetitive use coupled with exposure to air can however cause degradation in the oil leading to unpleasant odour and flavor.
Objective: The study determined the effect of repetitive use of frying oil by street fried food vendors on the oil quality.
Methods: Questionnaire was administered to ten vendors in Ilishan-Remo to ascertain how frying oils are stored and how often they reuse oil to fry. Three samples of frying oils **(**10ml each) of three randomly selected street fried foods (fish, yam and *akara*) were obtained every other day for four days and taken to the laboratory where peroxide value and free fatty acid content were analyzed. Data were statistically analyzed using descriptive statistics and the results were presented as mean and standard deviation.
Results: All (100%) respondents reused frying oil frequently and mixed fresh oil with degraded oil constantly. Majority (80%) of the vendors did not store the oil properly after each use. The amount of peroxides (43.125-95.625mEeq/kg) in oil samples exceeded the maximum level of Codex standards (10mEq/kg). The range (0.7% to 3.29 %) of free fatty acids of the oil samples also exceeded the maximum accepted level of 0.3%.
Conclusion: There was a high level of deterioration and rancidity in all the oil samples due to poor storage and excessive repetitive use by the street vendors.
Key words: Rancidity, repetitive use, oil, storage, street foods.

Introduction

Frying is an intense process that triggers numerous chemical reactions in the frying medium and releases excess chemical compounds (1). Frying is a method of food preparation adopted by a lot of food vendors. Most street food vendors use vegetable oils numerous times to fry before discarding it to reduce cost. Previous research studies have shown that vegetable oils are used to fry 3-6 times before they are discarded (2). The oil is eventually discarded when it becomes dark, foamy, and smelly (3). One of the major decompositions that occurs in oil is rancidity. Rancidity is the hydrolysis and/or autoxidation of fats into short-chain aldehydes and ketones which are objectionable in taste and odour (4).Oxidative rancidity occurs when there is break down or degradation by oxygen in the air mostly due to excessive exposure resulting in peroxides while hydrolytic rancidity results from the hydrolysis of triglycerides and free fatty acids are released(5, 6, 7). (15, 16, 19)

Deep-fat frying decreases the unsaturated fatty acids of oil and increases foaming, color, viscosity, density, specific heat, contents of free fatty acids, polar materials, and polymeric compounds (8). Free radicals produced in rancid oils can also have a negative impact on DNA cells, damage the arteries and pose as carcinogens which are substances that cause cancer degradation (1). Furthermore, frequent consumption of rancid oils can expose an individual to accelerated ageing, high cholesterol levels, obesity and abnormal weight gain which in the long run can lead to degenerative/chronic diseases such as cancer, atherosclerosis, neurological disorders and heart diseases (1).

Researches have shown that the continuous use of vegetable oils to fry results in degradation which affects the physical and chemical properties of the quality of oil (1), thus making reused oil unsafe for human consumption. There is a need to investigate the rate at which frying oils are reused by street food vendors in rural-urban communities. Therefore, this study was aimed at determining the effect of repetitive use of frying oil by street fried food vendors on oil quality.

Materials and methods

A cross-sectional survey design and purposive sampling technique was used to select and study 10 out of 20 street fried food vendors and three street fried foods sold within Ilishan town. The vendors selected buy any available (unbranded) frying oil, sell one of the selected fried food and normally top-up used frying-oil to until it is exhausted. Ilishan community is a small town in Ikenne local government area that specialized in petty trading. The major occupations include sales of raw and cooked foods, clothes and house hold equipment. The fried foods sold are *akara*, (fried spiced cowpea paste) yam, fish, puff-puff, eggrolls and buns. Only vendors of single fried food were selected for the research to ensure

pure assessment. Questionnaires were administered after obtain consent from the vendors to elicit information on their demographic status, how the frying oils were stored, how often they were reused and when the oils were discarded. Oil samples used for the different fried foods were collected from the selected vendors who normally top up their used oil (they do not discard until exhausted) every other day for four times. The oil samples were collected using sample bottles before and after reusing, sealed air tight and stored in a freezer for not more than 24 hours and were allowed to thaw at room temperature before analysis.

Chemical analysis of oil samples

All analytical procedures are based on the AOAC (6) and were performed in duplicates.

Determination of peroxide value

Peroxide value was a measure of the peroxides contained in the oil. The principle is based on the treatment of a test portion in a mixture of acetic acid and chloroform solution in the presence of potassium iodide followed by titration of free iodide with sodium thiosulphate solution (6). Two milliliter of sample was weighed into 250ml Erlenmeyer flask, 30ml acetic acid (chloroform solution) was added and thereafter 1ml of saturated potassium iodide solution was added and the flask swirled until the sample completely dissolved in solution. Thirty ml distilled water was added and the flask stored in a dark cupboard for 2-3mins, the solution was titrated gradually with 0.01 normal sodium thiosulphate solution ($Na_2S_20_3$) solution and constantly and vigorous shaken until the yellow colour almost disappeared, 1ml of starch indicator solution was added, titration and shaking of the flask continued until all the iodine from chloroform layers had been liberated.

$$\text{Peroxide value (PV)} = \frac{V \times N \times 1000}{\text{Weight of sample}}$$

Where: V = volume of $Na_2S_20_3$ solution

N = normality of 0.01N $Na_2S_20_3$ solution

W = weight of samples (g)

Fresh oils usually have peroxide values below 10mEq/kg. Rancidity occurs when the peroxide value is higher than 20mEq/kg.

Determination of free fatty acid (FFA)

The free fatty acid or acid value is a measure of the extent to which the glycerides in the oil is been decomposed by lipase action. The decomposition was gradually accelerated by heat and light. The oil was dissolved in organic solvents (iso propanol) and free fatty acids neutralized with standard alkali solution (6). Twenty-five ml diethyl ether, 25ml alcohol, and 1ml of phenolphthalein were mixed, carefully neutralized with 0.1M sodium hydroxide,1g of the oil was added to the mixed neutral solvent and titrated with aqueous 0.1M sodium hydroxide, shaking constantly until pink color which persisted for 15 seconds was obtained.

$$\text{Acid value} = \frac{\text{Titration (ml)} \times 5.6L}{\text{weight of sample used}}$$

The free fatty acid figure was calculated as oleic acid, in which case the acid value was equal to two times the free fatty acid value (Acid value = 2 x FFA) (7).

Statistical analysis

Statistical analysis was carried out using SPSS 20.0 software. The data generated were analyzed using descriptive statistics such as means, standard deviations, percentages and frequencies which were compared with allowable limits of Codex Standards (7). The differences between the days were determined using ANOVA. Duncan test (separation of means) was used to test the existence of significant difference between oil reused across the different days.

Results

Table 1 shows the demographic data of the street fried food vendors. Some (20.0%) were between the ages of 21-30 years old, 30.0% were 31-40 years old while 40.0% were 41-50 years old, 90.0% were female and 70.0% Yoruba and 30.0% Igbo. About 70% were married while 30.0% were widowed. Majority (80.0%) of the respondents were Christians and 20.0% Moslems. Over half (60%) of the respondents completed secondary school education, 30% had primary school education and 10.0% had no education. Most (80.0%) of the respondents came from monogamous homes while 20.0% came from polygamous homes.

Table 1: Demography of the street fried food vendors

Variable	Frequency	Percentage (%)
Age (years)		
≤ 20	0	0.0
21 – 30	2	20.0
31 – 40	3	30.0
41 – 50	4	40.0
51 and above	1	10.0
Total	10	100.0
Sex		
Female	9	90.0
Male	1	10.0
Total	10	100.0
Ethnic group		
Yoruba	7	70.0
Igbo	3	30.0
Hausa	0	0.0
Total	10	100.0
Marital status		
Single	0	0.0
Married	7	70.0
Widow	3	30.0
Widower	0	0.0
Divorced/ separated	0	0.0
Total	10	100.0
Religion		
Christianity	8	80.0
Islam	2	20.0
Total	10	100.0
Educational level		
No education	1	10.0
Primary education	3	30.0
Secondary education	6	60.0
Tertiary education	0	0.0
Total	10	100.0
Family type		
Monogamy	8	80.0
Polygamy	2	20.0
Total	10	100.0

Table 2: shows the storage and practice of repetitive use of oil of the fried food vendors. Half (50%) of the respondents stored their frying oil in kegs, 30% in plastic bottles and 20% in bowls with covers. Majority (80%) keeps the stored oil in open air and 20% closed stores. It was shown than 100% of the respondents reused oil of the previous day to fry on a new day, about 80% reused the oil to fry 5-8 times and 20% 2-4 times. More than half (70%) of the respondents said they reused the same oil for about 4 days while 30% used the same oil for 3 days. All (100%) the respondents topped-up used oil with fresh oil before it dries up for continuous use.

Table 2: Storage and pattern of reuse of frying oil by the street fried food vendors

Variable	Response	Frequency	Percentage (%)
Storage of frying oil	Plastic bottle	3	30.0
	Keg	5	50.0
	Bowl with cover	2	20.0
Total		10	100.0
Storage condition	Inside closed store	2	20.0
	Outside in the open	8	80.0
Total		10	100.0
Reuse of oil	Yes	10	100.0
	No	0	0.0
Total		10	100.0
Frequency of daily reuse	2 – 4 times	2	20.0
	5 – 8 times	8	80.0
Total		10	100.0
Days reused oil	2 days	0	0.0
	3 days	3	30.0
	4 days	7	70.0
Total		10	100.0
Top-up of oil	Yes	10	100.0
	No	0	0.0
Total		10	100.0

Table 3 shows a range of PV of 43.1 – 95.6mEq/kg with increasing levels each day. The increased levels which were 4 to 9 times higher than the Codex Standards (7) for peroxides of refined oils are 10mEq/kg. Significant colour (dark) change was also noticed with all the oil samples from day to day.

Table 3: Mean peroxide value (PV) of the frying oil samples

Samples	DAY 1		DAY 2		DAY 3		DAY 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Oil used for fish	74.4	±5.5	85.0	±8.4	95.6	±13.4	93.1	±13.4
Oil used for *akara*	43.1	±9.4	54.4	±35.6	57.5	±11.0	43.1	±7.5
Oil used for yam	60.6	±60.6	79.4	±30.0	63.8	±10.5	59.4	±11.4

The % FFA ranged from 0.7% to 3.29% in the oil samples (Table 4). There was high %FFA in the frying oils with increasing levels each day and oil used for fish had the highest value. The maximum allowable %FFA for refined oils according to Codex (7) is 0.3%. This indicates the occurrence of hydrolytic rancidity.

Table 4: Mean percentage of free fatty acid of the samples used by the vendors

Oil Samples	DAY 1		DAY 2		DAY 3		DAY 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Oil used for fish	1.5	±0.4	2.6	±0.5	2.9	±0.5	3.3	±0.5
Oil used for *akara*	2.2	±0.4	1.7	±0.3	1.2	±0.5	1.6	±0.6
Oil used for yam	0.7	±0.2	1.4	±0.5	1.6	±0.3	0.8	±0.2

Discussion

Frequent heating leads to deterioration in frying oils (8) and lipid oxidation results in peroxides which are responsible for primary oxidation in oil (9). This study showed oxidative rancidity due to poor storage and excessive/repetitive use of the frying oil samples. Previous researches have shown that vegetable oils with more unsaturated fatty acids are more likely to become rancid easily (8) and the results of this study validated those findings. The end products of oil degradation during frying that are responsible for rancidity and colour change are aldehydes, peroxide, ketones, acids, and polymers (9) and the maximum level for peroxide value of edible fats and oils is 10 mEq/kg. There was an increase in the amount of peroxides in all oil samples between days 1 and 2 of sample collection. During the interview, it was observed that the vendors did not store the oil in air tight containers instead they were exposed to air. The increase in peroxide value was most likely caused by continuous exposure of the oil to light, high temperatures and oxygen in the atmosphere, which reacted with the oil to produce peroxides.

Studies have reported increase in peroxide value of oil upon continuous heating (10). This showed that the same oil from Day 1 of sample collection was used in Day 2 (which was the third day of the first sample collection) for the three selected food samples even though fresh oil was added to the used oil. This however suggested that there was a very high rate of degradation in the frying oils (if not topped-up) and that mixing of fresh frying oil to already used one should be discouraged. There was a decrease in the amounts of peroxides between Day 3 and 4 but the peroxide level of the oil samples still exceeded the maximum level of 10mEq/kg. The decrease showed that the greater part of the frying Oil had been replaced with fresh oil before frying while some already used oil had mixed with the fresh frying oil.

Degraded frying oils result in loss of nutritive value and causes damaging health effects due to the toxic substances produced (9, 17). The results showed that all oil samples had %FFA that exceeded the maximum limit of 0.3%. Between Days 1 and 2, the *akara* and yam frying oil samples had decrease in %FFA which was probably due to mixing of the deteriorated oil of the previous day with fresh oil by the vendors. The same deteriorated oil for fish was reused in Day 2and leading to increased FFA value with length of use for frying. For the yam oil, there was a decrease between Days 3 and 4 showing that much fresh oil was mixed with the degraded oil.

It has been proven that water can promote the hydrolysis of triacylglycerols to form a combination of mono and diacylglycerols, glycerols and free fatty acids (3). This validated the significantly high %FFA in fish oil compared to that of the *akara* and yam oil. In deep fat frying, acids are produced by hydrolysis of fats to form free fatty acids (12) and this is known as hydrolytic rancidity. Free fatty acids content was an indicator of oil quality in food industries as it results in the development of off-flavours in oils and fried products (13, 18). The increase in FFA value was not an unswerving parameter for degradation of frying oil because it is difficult to differentiate between FFA formed by oxidation or by hydrolysis (14, 15).

Conclusion

The peroxide and %FFA values exceeded the maximum levels when compared to the Codex Standards. The oil samples contained high amounts of peroxides due to exposure to atmospheric oxygen by the vendors leading to the occurrence of oxidative rancidity. Conclusively, there was degradation of the frying oils samples after repetitive (minimum of 3 days with several use per day) use and improper storage affecting the quality of the oils.

Limitation of this study

The study did not cover the quality of the fresh oils used because they were bought from the open market by the vendors without any standard (unbranded) required. Also, the study started in-between frying oils used and as such samples of fresh frying oils were not obtained

References

1. Nancy Idun-Acquah, Mensah G. Y (2016). Repetitive use of vegetable cooking oil and effects on physio-chemical properties- case of frying with redfish (*Lutjanu sfulgens*). Science and Technology, 1: 8-14.
2. Obeng M. E (2013). Assessment of waste vegetable oils from hotels for bio-deisel feedstock and CO_2savings in Ghana. International Journal of Engineering Research and Science and Technology, 2: 1-12.
3. Isabella L. N, Luciana O. d, Grazieli, B. P and Daurea, A. D (2016). Nutritional issues concerning street foods. Journal of Clinical Nutrition and Dietetics, 1-9.
4. Peter P. Klemchuk (2000). Antioxidants in Ullmann's Encyclopedia of Industrial Chemistry. Wiley-VCH, Weinhein. Doi: 10.1002/14356007.a03_091.
5. Cheo E and M. D. B (2007). Chemistry of deep-fat frying oils Institute of Food Technologists Vol 00, Nr. 0, 2007-Journal of Food Science R1 doi: 10.1111/j.1750-3841.2007.00352
6. Delafield, F. (1984). Hacmatoxvlin and eosin for general staining. Staining of Animal tissues theoretical and Practical. London: Oxford University Press.
7. AOAC (2011). Official methods of analysis of AOAC International (18th ed.). Gaithersburg, MD, USA: AOAC International.
8. Codex Alimentarius (2000). Codex Standards for Named Vegetable Oils. CODEX STAN 210. Volume 8. CX-STAN 210 – 1999.
9. Naohiro, G and Wada, S (2006). The importance of peroxide value in assessing food quality and food safety. Journal of the American Oil chemists' society. 83(5): 473-474,
10. Annabelle, A. Callano (2012). Rancidity of Used Cooking Oil and Heavy Metal Analyses on Selected Street-Vended Foods. UIC Research Journal, 18(1): 77-86.
11. Serjouie A, Tan CP, Mirhosseini H and Y Bin Che Man (2010). Effect of vegetable-based oil blends on physiochemical properties of oils during deep-fat frying. American Journal of Food and Technology, 5(5): 310-323.
12. Galliard, T. (1994). Rancidity in cereal products. Pp. 141-159 in: Rancidity in Foods. 3rd edition. J.C. Allen and R.J. Hamilton, eds. Chapman and Hall. London, UK.
13. Stevenson S. G, Vaisey-Genser M and N. A. M Eskin (1984). Quality control in the use of deep-frying oils. 61: 1102-1108.
14. Diop A, Sarr S. O, Ndao S (2014). Effect of deep-fat frying on chemical properties of edible vegetable oils used by Senegalese households. African Journal of Food Agriculture Nutrition and Development. 14(6): 2218-2238.
15. Frega N, Mozzan M and Lercker G. 1 (999). Effect of free fatty acids on oxidative stability of vegetable oil. Journal of American Oil Chemists Society, 76: 325–329.
16. Lawson, C. (2008). Rancidity and Antioxidants.
17. Lawson, H. A (1995). Survey of quality of used frying oils from restaurants. Journal of American Oil Chemists Society, 68: 857–862.
18. Chammen K, Gertz C and Stier R (2015). Recommendations for used frying oils and fats; 6th International Symposium on Deep-Frying — errors and myths of industrial and catering frying: German Society for Fat Research (DGF). http://www.dgfett.de/ material/recomm.php
19. Evbuowman B. O, Lawson J. N, Atuka M. M (2013). Some physicochemical properties of cashew nut (*Anacardium occidentale*) and palm kernel (*Elaeis guineensis*) oil using straight run gasoline. International Journal of Science and Engineering Investigations, 2: 20
20. Ashaye O. A and Olusoji O. C (2006). Evaluation of some quality attributes of soybean oils in Ibadan. African Journal of Agricultural Research, 1(1): 017-019