

Levels of Lipid Peroxidation Products in Fried Protein and Carbohydrate Foods Sold in an Institution of Higher Learning in North Central Region of Nigeria

Ugwu C.E.¹ Okpogba A.N.¹ Ogueche P.N.¹ Dike C.C.¹ Maduka H. C.C.^{1,2} Dagba S. E.²
Adikwu D.²

1.Department of Human Biochemistry Faculty of Basic Medical Sciences, Nnamdi Azikiwe University Nnewe Campus, Anambra State Nigeria

2.Department of Biological Sciences, Federal University of Agriculture Markurdi, Benue State Nigeria

Abstract

Four typical local protein foods namely fried beans (akara), fish, beef and chicken and five carbohydrate foods namely buns, fried yam, potatoes, plantain and jellof rice as commonly consumed in the institution were evaluated for malondialdehyde and malonaldehyde levels as part of nutritional evaluation by our research group. The fried foods were purchased from food vendors within the University and lipid peroxidation assays carried out using standard methods. The levels of lipid peroxidation by malondialdehyde in akara, bony fish, chicken and beef were 3.88 ± 1.29 , 3.39 ± 1.13 , 3.86 ± 1.30 and 2.75 ± 1.38 respectively. In the same manner, the levels of lipid peroxidation aldehydes were 3.43 ± 1.14 , 3.87 ± 1.29 , 1.51 ± 0.75 and 1.66 ± 1.66 for akara, fish, beef and chicken respectively. Among the carbohydrate foods, buns and fried yam had the highest level of malondialdehyde and malonaldehyde while the fried plantain, potatoes and jellof rice contained less of the peroxidation products. All the protein and carbohydrate samples contained degradation products of lipid peroxidation and various levels of deteriorations. The lipid hydrogen peroxide and carbonyls detected call for caution in using frying as a local preparation method of carbohydrates and proteins.

Keywords: lipid peroxidation, frying, carbohydrate, protein.

INTRODUCTION

Frying has been used as a food processing technique since the existence of man. Deep-fat frying is commonly adopted in food processing industries due to its low cost as it produces food of good acceptability (Bordin *et al.*, 2013). Its wide use is related to the speed and ease in preparing foods and the sensory characteristics it gives like taste and unique flavor (Ngadi and Xue, 2009). Frying has become an efficient mode of cooking due to the quick heat transfer and the high temperature used. Deep fat frying of foods has the advantage of preserving the food because the high temperature kills the microorganisms, inactivating the enzymes and decreasing the activity of water on the surface of the food (Fellows, 2006).

The process is dependent on oil and food interacting at higher temperature to produce physical and chemical changes on the food. These changes depend on the type of food, oil, the surface and volume ratio of the oil, heating method, length of time of immersion and the nature of the frying apparatus used (Bordin *et al.*, 2013). The longer the oil is subjected to high temperature and atmospheric air, the higher it can generate oxidized and toxic products (Seppanen and Saari Csallany, 2002; Del Re and Jorge, 2006).

The process of frying may affect the nutritional quality of the food (Corissin and Jorge, 2005). The fat digestion is changed (Ziaifar *et al.*, 2008) while frying process can produce trans fatty acids whose level of intake is related to cardiovascular diseases (Mozaffarian *et al.*, 2004; Tsuzuki *et al.*, 2010). Heat treatment can also change the protein composition and quality in foods (Henry 1998; Oluwaniyi *et al.*, 2010).

The carbohydrate and protein contents of foods when subjected to thermal condition interact with lipids to produce oxidative products which could generate toxic and carcinogenic compounds (Sikorski 2001; Tynek *et al.*, 2001; Bordin *et al.*, 2013). There are few reports on the level of peroxidation products on fried food products in the Nigerian markets. Therefore, this study highlights the level of some lipid peroxidation products sold and consumed at the Federal University of Agriculture Markurdi Benue State Nigeria.

Material and methods.

Sample collection.

Commonly consumed fried protein foods (akara, fish, beef, chicken) labeled A,B,C,D and fried carbohydrate foods (buns, yam, potatoes, plantain, jellof rice) also labeled E,F,G,H,I were purchased from food vendors in the University premises. The samples were blended and 5g of each samples was added to 5ml ethanol and the resulting filtrate used for lipid peroxidation assay.

Determination of malondialdehyde and malonaldehyde in the samples.

The concentration of lipid hydroxides carbonyls present in the fried foods as malondialdehyde was determined by the method of Hunter *et al.* (1963) as modified by Kirkova *et al.* (1995). 0.175 ml of KCL Tris buffer (0.02 M)

pH 7.4 was used as the medium for incubation after which 0.12 ml of 5N HCL was added. After mixing, 0.35 ml of 2% sodium barbituric acid solution was promptly added (TCA, HCL and thiobarbituric solution alone eliminate difficulties that arise due to absorption of colour due to protein precipitates),(Hunter *et al.*, 1963). The tubes were then stopped with cotton wool and placed in boiling water for 10 min and the colour absorbance read at 532 nm. The concentration of the malondialdehyde formed was calculated using the molar extinction coefficient, $1.56 \times 10^4 \text{ cm}^3/\text{mole/s}$ using the formula:

$$\frac{\text{Absorbance} \times 46}{\text{Sample wt/volume}}$$

Where 46 = constant or factor of lipid peroxide absorptivity. The results were presented as means of triplicate determination \pm standard deviations as described earlier (Maduka, 2008).

Malonaldehyde measurement: The lipid hydrogen peroxide determined by malonaldehyde was as described by Wills (1987) by the thiobarbituric acid reactivity. The levels of malonaldehyde formed were calculated using molar extinction coefficient $1.56 \times 10^4 \text{ cm}^3/\text{mole/s}$. Results were expressed as mean \pm standard deviation and could be reproduced within \pm 5%. The experiment was repeated three times.

Statistical analysis. Data was subjected to Analysis of variance (ANOVA). In order to test whether or not significant differences exist between groups, we analyzed the mean values with the paired T-test. The acceptable level of significance was $P < 0.05$. The analysis was carried out on SPSS windows version 16.0.

RESULTS.

Table 1. Lipid peroxidation products in the fried protein food samples.

Samples.	Malondialdehyde(mg/ml)	Malondaldehyde (mg/ml)
A(Akara)	3.880 \pm 1.29	3.433 \pm 1.14
B(Bony fish)	3.391 \pm 1.13	3.876 \pm 1.29
C(Beef)	2.752 \pm 1.38	1.506 \pm 0.75
D(Chicken)	3.856 \pm 1.28	1.661 \pm 1.66

Results are mean \pm SD of triplicate determinations.

Table 2. Lipid peroxidation products in the fried carbohydrate food samples.

Samples.	Malondialdehyde(mg/ml)	Malondaldehyde (mg/ml)
E(Buns)	3.007 \pm 1.00	3.287 \pm 1.09
F(Yam)	2.302 \pm 0.76	4.069 \pm 1.36
G(Potato)	1.150 \pm 0.38	2.099 \pm 3.03
H(plantain)	1.076 \pm 0.35	1.683 \pm 0.56
I(Jallof rice)	0.584 \pm 0.19	0.393 \pm 0.13

Results are mean \pm SD of triplicate determinations.

The level of lipid peroxidation in the fried protein samples is shown in table 1. The results show that the fried protein samples have different levels of degradation products of lipid peroxidation with samples A and B having the highest concentrations of malondialdehyde and malonaldehyde respectively. The results show that sample C has the least lipid peroxidation index. The results in Table 2 represent the lipid peroxidation products in the fried carbohydrate food samples. From the results, samples E and F had the highest levels of malondialdehyde while samples G, H, and I recorded lower levels of malondialdehyde. As regards malonaldehyde, sample G had the highest concentration while sample I was the least. Of all the fried carbohydrate samples, sample I had the least lipid peroxidation products.

Discussion.

After frying, the amount of lipid in the food sample is increased due to the oil used in frying. Because of peroxidation, hydroperoxides (malondialdehyde and malonaldehyde) are generated as the end products of lipid peroxidation. These products can cause cell damages upon consumption of these samples by individuals with deficient scavenging ability of these free radicals. Fried foods are high fat sources in the diet.

Oxidation affects many reactions among food components producing both pleasant and unpleasant products. The lipid components in fried food are susceptible to oxidation (Wasowicz *et al.*, 2004). Harmful effects of lipid oxidation products in foods include loss of flavor, colour, nutrient value and accumulation of deleterious compounds (Wasowicz *et al.*, 2004). There have been interests on the nutritional and toxicological implications of lipid oxidation in foods (Frankel, 1996). The oil that is rich in polyunsaturated fatty acids is usually susceptible to oxidation. The interaction of lipid oxidation products with vitamins and proteins is a major nutritional challenge. Some reports have interpreted the effects of feeding lipid oxidation products to experimental animals as due to oxidative damage (sanders, 1989; Kubow, 1990; Addis and Warner, 1991; Eder, 1999).

Our results showed various degrees of lipid peroxidation products in the fried protein and carbohydrate products studied. Of particular notes are sample A (akara) a fried bean product that is rich in protein and sample B (fish) which had appreciably higher concentrations of both lipid oxidation products. In terms of the fried carbohydrate foods, sample E (buns) produced by frying a mixture of flour and oil was appreciably high in malondialdehyde and malonaldehyde respectively while the fried potatoes, plantain and rice were low in their levels of lipid oxidation products.

This may be suggesting that the level of deterioration varied across all the samples showing the degree of degradation and variations in composition of the frying oils used. The methods of frying used, the type of food, and frying equipment and length of time of frying may have contributed to the varying degrees of oxidation noticed in the study.

Fried foods are popular among Nigerians and they are sources of high fat diets. Studies have shown that concentrations of lipid peroxidation products and toxic polymers (Saka *et al.*, 2002) and polymer compounds (Velasco *et al.*, 2005) increase due to oil oxidation with time during frying. Our previous reports had shown that there were varying degrees of malondialdehyde and malonaldehyde in fruit juices sold in two different Nigerian cities as part of our survey of the safety of food products sold in the Nigerian markets (Maduka *et al.*, 2014 a,b). Malondialdehyde is a reactive bi-functional aldehyde compound that interacts with DNA and proteins (Addis, 1986; Kubow, 1990) while fatty acid peroxides have been demonstrated to accelerate atherosclerosis (Kubow, 1990). In conclusion, the findings from the study demonstrate that all the samples contained degradation products of lipid peroxidation and various levels of deteriorations which could limit the safety of the safety of the preparation procedure in local terms.

References

1. Bordin K, Kunitake M, Aracava KK, trindade CSF.(2013). Changes in food caused by deep fat frying-A review. Archives Latino Americanos de Nutrition. 63(1):5-13.
2. Ngadi M, Xue J.(2009). Food frying: modifying the functional properties of Batters. In:Novel food processing:effects of rheological and functional properties. Ahmed J, Ramaswany HS, Kasapis S, Boye JIB(Eds), CEC Press, Canada. Pp 437-457.
3. Fellows PJ.(2006). Food processing technology. Principles and practice. Artmed, Sao Paulo, Brazil. Pp. 608.
4. Del Re PV, Jorge N. (2006). Behavior of vegetable oils for frying discontinuous frozen pre-fried products. Ciene Technol. Aliment. 26:53-56.
5. Seppanen CM, Saari Csallany A. (2002). Formation of 4-hydroxynonenal, a toxic aldehyde, in soybean oil at frying temperature. Journal of the American Oil Chemists Society. 79:1033-1038.
6. Corissin MS, Jorge N. (2005). Oxidative changes in oils from cottonseed, sunflower and palm oil used for frying frozen cassava. Alim. Nutri. 17:25-34.
7. Ziaifar AM, Achir N, Courtois F, Trezzani I, Trystram G.(2008). Review of mechanisms, conditions, and factors involved in the oil uptake phenomenon during deep fat frying process. International Journal of food Science and Technology. 43:1410-1423.
8. Mozaffarian D, Pischon T, Hankinson SE, Rifai N, Joshipura K, Willett WC.(2004). Dietary intake of trans fatty acids and systemic inflammation in women. American Journal of Clinical Nutrition. 79:606-612.
9. Tsuzuki W, matsuoaka A, Ushida K.(2010). Formation of trans fatty acids in edible oils during the frying and heating process. Food Chemistry. 123:976-982.
10. Henry CJK.(1998). Impact of fried foods on macronutrient intake, with special reference to fat and protein. Grasasy Aceites. 49:336-339.
11. Oluwaniyi OO, Dosumu OO, Awolola GV.(2010). Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishes commonly consumed in Nigeria. Food Chemistry. 123:1000-1006.
12. Sikorski ZE.(2001). Chemical and functional properties of food proteins. Sikorski ZE(ed), Technomic Publishing Company, 490.
13. Tynek M, hazuka Z, pawlowicz R, Dudek M.(2001). Changes in the frying medium during deep-frying of food rich in proteins and carbohydrates. Journal of food Lipids.251-261.
14. Wasowicz E, Gramza A, hes M, Jelen HH, Korczak J, Malecka M, Mildner-Szkudlarz S, Rudzinska M, Samotyja U, Zawirska-Wojtasiak R.(2004). Oxidation of lipids in food. Polish Journal of Food and Nutrition Sciences. (13/54).87-100.
15. Frankel EN.(1996). Oxidation of polyunsaturated lipids and its nutritional consequences. Oils-fats-lipids. In: Proceedings of the 21st World Congress of the ISF, vol. 2, PJ Barnes and Associates, Bridgewater. 265-269.
16. Sanders TAB.(1998). Nutritional aspects of rancidity. In: Rancidity in foods. Allen JC, Hamilton RJ.(eds). Elsevier, London. Pp. 125-139.
17. Addis PB, Warner GJ.(1991). The potential health aspects of lipid oxidation products in food. In: Free Radicals and Food Additives. (Auroma, OI, Halliwell, B), Taylor and Francis, London. Pp. 77-119.

18. Kubow S. (1990). Toxicity of dietary lipid peroxidation products. *Trends Food Sci. Technol.* 1:67-71.
19. Edder K.(1999). The effect of a dietary oxidized oil on lipid metabolism in rats. *Lipids.* 34:717-725.
20. Addis PB.(1986). Occurrences of lipid oxidation products in foods. *Food Chem. Toxicol.* 24:1021-1030.
21. Finley JW, Given P.(1986). Technological necessity of antioxidants in the food industry. *Food Chem. Toxic.*24:999-1006.
22. Gurr MI.(1988). Lipids: Products of industrial hydrogenation, oxidation and heating. In: *Nutritional and Toxicological Aspects of Food Processing* (Walker, R, Quatrucci E). Taylor and Francis, London, Pp. 139-155.
23. Pokorny J, Kolakowska A.(2003). Lipid-protein and lipid-saccharide interactions. In: *Chemical and Functional Properties of Food Lipids.* Sikorski ZE, Kolakowska A (eds), CRC Press LLL, Pp.345-362.
24. Hunter FE.Jr., Gebicki JM, Hoffstein PE, Weinstein J and Scott A. (1963). Welling and lysis of rat liver mitochondria induced by ferrous ions. *Journal of Biological Chemistry.* 238(2):828-835.
25. Kirkova et al 1995.
26. Wills DE. (1987). Evaluation of lipid peroxidation in lipids and biomembranes. In: Snell K and Mullock B(eds). *Biochemical Toxicology.* Oxford IFL Press, chapter 6, 127-152.
27. Saka S, Aouacheri W, Abdennour C.(2002). The capacity of glutathione reductase in cell protection from toxic effect of heated oils. *Biochimie.* 84(7):661-665.
28. Velasco J, Marmesat S, Berdeaux O, Marquez-Ruiz G, Dobarganese C. (2005). Quantitation of short-chain glycerol-bound compounds in thermoxidized and used frying oils. A monitoring study during thermoxidation of olive and sunflower oils. *Journal of Agric food Chemistry.* 53(10):4006-4011.
29. Maduka HCC, Mohammed IH, Okpogba AN, Ugwu CE., Dike CC, Maduka AA, Ogueche PN, Gadaka MA. (2014). Biochemical assessment of some common commercial fruit juices consumed in Maiduguri metropolis, Borno State Nigeria. *Journal of Natural Sciences Research.* 4(10):94-98.
30. Maduka HCC, Ugwu CE, Dike CC, Aguru AN, Okpogba AN, Ogueche PN, Maduka AA, Gadaka NA, Alike SO, Okonkwo CO.(2014). Assessment of some commercial fruit juices commonly consumed in Federal university of Agriculture Makurdi, Benue State Nigeria, for lipid peroxidation intermediates and antioxidant vitamins. *Advances in Life sciences an Technology.*24:49-52.