Bull. Chem. Soc. Ethiop. 1999, 13(2), 173-177.
Printed in Ethiopia
ISSN 1011-3294

SHORT COMMUNICATION

A STUDY OF HEATED VEGETABLE OILS USED BY STREET VENDORS IN FRYING FOODS IN LOME, TOGO

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(Received January 29, 1999; revised August 26, 1999)

ABSTRACT. This study has focused on the chemical changes which occurred in the oils which were subjected to repeated heatings by the female sidewalk vendors in Lome. In addition, a comparison was made between the oils used by the street vendors and the oils used in restaurants and hotels. The results show that iodine values are low suggesting a destruction of unsaturation. Peroxide values indicate the oxidation state of oils subjected to frying.

INTRODUCTION

Frying foods like poultry, fish, yams, etc., is a common practice in West Africa. Vegetable oil is used over and over again and is even added to gravies and sauces. When the level of oil goes down in the frying containers, more oil is added to the old. The people are not aware of the consequences that might result from using this oil. The oil which is being used in deep frying contains polyunsaturated fatty acids (PUFA) like linoleic acid. These fatty acids are easily oxidized [1,2]. Deep fat frying causes destruction of unsaturation and formation of decomposition products containing carbonyl and hydroxyl groups [3]. This phenomenon is increased when fats contain PUFAs.

Nowadays, it is known that deep fat frying also causes formation of many new compounds such as polymeric triglycerides (TG) and oxidized TG derivatives [2,4]. These compounds are then absorbed into the fried foods.

It has been shown that heated fats have certain nutritional toxic effects on rat morphology and physiology such as growth [5], life span and certain tissues such as an enlarged livers [6,7]. Lamboni [8] found that rats fed heated soybean oil exhibited hair loss and dermatitis. Besides, Lamboni and Perkins [9] showed that such rats had a significant increase in their microsomal content of cytochrome P_{450}, which performs a central role in the metabolism of xenobiotics and various endogenous compounds. In fact, they found a significant increase in the activity of NADPH-cytochrome P_{450} reductase (EC 1.6.2.4.) in the experimental group of rats.

This study is focused on the chemical changes which occurred in the oils which were subjected to repeated heatings by the female sidewalk vendors in Lome.

EXPERIMENTAL

Fats. Fresh vegetable oil and vegetable oil which had been heated were collected from the female street vendors. A series of oil samples were also collected from a hotel in Lome. Oils were collected in bottles and kept under nitrogen in a refrigerator before analyses. The collected fresh oils were then used in the laboratories to fry yams and turkey's rumps in a pan at 120, 150 and 200 °C. The oils were analyzed after about 16 hours.

Fatty acid profiles. Fatty acid methyl esters (FAMES) were prepared from oils according to AOCS official method [10]. The FAMES were then analyzed using gas liquid chromatography (GLC) under the following description: GLC 5890 A Gas Chromatograph Hewlett Packard, 28 Psi H_2, column DB-Wax 40 m x 0.18 mm i.d. x 0.30 μm film thickness. The conditions were: 150 °C(1), 4 °C/min, 245 °C.

Iodine value, saponification value, peroxide value and free fatty acids content. Iodine value of oils was measured according to Wijs method of AOCS official method [11]. The saponification value was determined according to AFNOR method [12]. The peroxide value of oils was determined according to AOCS official method [13]. The free fatty acids (FFA) content of oils was analyzed according to AOCS official method [14].

RESULTS

Profiles of some free fatty acids. Heated oils contain more stearic acid ($C_{18:0}$) than non heated oils. The content of unsaturated fatty acids of 18 carbons in the heated oils decreased (Table 1). This may due to the oxidation of unsaturations during the cooling and the re-heating cycles.

It was also noted that the unsaturated fatty acids in the oils collected from the street vendors are more oxidized than the oils collected from a hotel in Lome. The linolenic acid ($C_{18:3n-3}$) content of the former (0.8%) was less oxidized than the hotel oils (0.6%). This may due to differences in the method of frying foods in the hotel.

The heated oils showed greater viscosity and a darker color when compared to the non-heated oils. After the oils were heated, the percentage of unsaturated fatty acids of 18 carbons ($C_{18:2n-6}$) was lower than the non-heated oils (Table 1). According to Rojo and Perkins [15] this result may suggest the presence of PUFA's polymers in the oils after being heated. Those polymers may be retained by the column of the GLC.

Table 1. Free fatty acids composition of oils.

Type of oil	$C_{14:0}$	$C_{16:0}$	$C_{16:1n-7}$	$C_{18:0}$	$C_{18:1n-9}$	$C_{18:2n-6}$	$C_{18:3n-3}$
Fresh oil	0.09	8.5	0.08	5.6	30.1	53.4	1.1
Heated oil (street vendors)	0.18	10.0	0.10	5.9	27.4	50.7	0.8
Heated oil (hotel)	0.16	9.16	0.11	6.7	29.8	51.1	0.6

$C_{14:0}$ = myristic acid, $C_{16:0}$ = palmitic acid, $C_{16:1n-7}$ = palmitoleic acid, $C_{18:0}$ = stearic acid, $C_{18:1n-9}$ = oleic acid, $C_{18:2n-6}$ = linoleic acid, $C_{18:3n-3}$ = linolenic acid.

Iodine value, saponification value, peroxide value and free fatty acids content of the oils. The iodine value, saponification value, peroxide value and FFA measured in the heated oils are presented in Table 2.

The results showed a decrease in the iodine value in the oils as they were used over a four-day period. The measured peroxide value was the lowest in the non-heated oils while it increased as the oils were used in frying. The oils were cooled to room temperature, and this process allowed peroxide formation, which is evidenced by the increased peroxide value. The saponification value measured in heated oils followed the same trend and reached 210 mg/g in the oils collected from the street vendors. The amount of free fatty acids increased when the oils were heated as indicated in Table 2.

In contrast, when the cooled oils were used again the next day, the peroxides decomposed. This destroys the quality of the oil. In fact, the peroxide value decreased during the re-heating of the oils during frying days two and three. At the end of the frying process, the oils became darker and more viscous. This may suggests the formation of polymers as stated by Perkins [6].

Table 2. Chemical parameters of collected oils.

Parameters	Fresh oils			1st day of frying			2nd day of frying			3rd day of frying			4th day of frying		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Iodine value (g/100)	94.2	86.6	90.0	92.0	82.0	86.0	87.0	76.0	78.0	75.0	71.0	70.0	68.0	65.0	64.0
Free fatty acid (mg/g)	0.20	0.19	0.20	0.42	0.38	0.40	1.20	1.22	1.17	1.44	1.37	1.39	1.60	1.53	1.51
Saponification Value (mg/g)	173	185	180	180	193	188	196	200	199	203	203	201	204	210	203
Peroxide value (meq/kg)	17	16	16	-	24	23	35	37	36	-	39	38	-	47	45

1 = Oil collected from a hotel in Lome. 2 = Oil collected from pans of street vendors who sell fried yams and turkey's rumps. 3 = Oil collected from other pans of street vendors who sell fried yams and turkey's rumps.

Laboratory heated oils. The results of heating fresh vegetable and peanut oils in our laboratory to temperatures: 120, 150 and 200 °C are compiled in Table 3. Although quite different, the results are similar to those measured in the samples from a hotel and the samples from the street vendors.

Table 3. Chemical parameters of laboratory heated oils.

Parameters	Non-heated oil		120 °C and 16 h rest		150 °C and 16 h rest		200 °C and 16 h rest	
	F-VO	F-PO	H-VO	H-PO	H-VC	H-AC	H-VC	H-AC
Iodine value (g/100)	111.3	89.8	94	85.6	88	82.9	81	79.8
Free fatty acids (mg/g)	0.20	0.17	1.44	1.48	1.57	1.50	1.75	-
Saponification value (mg/g)	172	176	193	190	201	198	207	-
Peroxide value (meq/kg)	17	18	25	23	31	34	-	-

F-VO = fresh vegetable oil, H-VO = heated vegetable oil, F-PO = fresh peanut oil, H-PO = heated peanut oil.

DISCUSSION

In many parts of Africa, fried food are eaten. These foods are fried in oil which has been used for several days. When the oil is used again, its quality is decreased. The iodine value of the oils dropped from 94 to 64 due to the loss of unsaturation. In addition, the oils became darker and more viscous. This suggests a rise in polymeric products. Johnson *et al.* [16] indicated that thermal oxidation products from PUFAs are responsible for much of the loss of the nutritional value of the oils.

The increase in the peroxide value suggests that the peroxides are formed in the oils during storage. However, the analysis of the oils during frying showed a decrease in the peroxide value when compared to the initial peroxide value after heating and cooling to room temperature. These results are in accordance to Nawar's finding [17] who stated that peroxide value of vegetable oils increases when heated over time and then decreases. Such oils should be thrown away so that consumers can avoid these polymers. These fatty acid polymers are toxic to animals as stated by Crampton [1], Perkins and Kummerow [3], Lamboni and Perkins [9].

Furthermore, when heated oils are kept at room temperature and used again for frying foods, they are subjected to the formation of lipid hydroperoxide free radicals [18]. After formation, lipid hydroperoxide molecules decompose forming aldehydes, such as hexanal and many other aldehydes, ketones, etc. as well as higher molecular weight products. These compounds cannot decompose after oxidation since charcoal heat is not sufficient. These chemical products will then stay in the oil and become toxic to the people who eat such fried foods. The heating period and frying procedure (continuous or intermittent) influence oxidation [6]. Continuous heating is less damaging than the intermittent heating and cooling as done by street vendors in Lome. Also, street vendors fry yams which have been soaked in salt water, which adds water to the heated oil. This may increase the free fatty acid content due to hydrolytic cleavage of TG (Table 2). Free fatty acids become a substrate for oxidation and when the level of unsaturated fatty acids is high and the peroxide value increases too.

Sometimes, the street vendors in this study heated oils until it started smoking before adding foods. They believe that the oil must be very hot in order to fry the foods correctly. This is not a good practice since the oil is usually cotton seed oil, which contains unsaturated fatty acids (Table 1).

Nowadays, it is known that lipids are correlated to cardiovascular disease. Foods may absorb the oils in which they are fried [19]. Studies involving cooking oils have reported a pathogenetic role of endogenous lipid oxidation in a series of diseases [20,21] like atherosclerosis. In fact, free radicals have been implicated in cell damage through lipid oxidation like one of the first stages of atherosclerosis [22]. Generated hydroperoxides have also been identified as an atherosclerosis accelerative compound inducing lesion in the endothelium membrane [23,24]. In addition, lipid peroxides have been found in patients with cardiovascular disease [23]. Therefore, it is necessary to educate people about frying foods and the consequences that may result from eating foods fried in used oil.

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