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*acta*SATECH 10 (1):91-101(2018)

Journal of Life &Physical Sciences

Quality assessment of oil extracted from commercially sold fried plantain chips within Oshogbo metropolis

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Abstract

This study assessed the quality of oil extracted from plantain chips vended within Oshogbo metropolis. Three different samples of plantain chips were purchased from Oshogbo, Osun state, Nigeria. The chemical properties and fatty acid compositions of the soxhlet-extracted oils were determined according to AOAC methods and by using the Gas Chromatograph equipped with a flame ionization detector (FID), respectively. The iodine values obtained for samples A, B and C were 88.10±0.03, 125.70±0.02 and 140.00±0.01mg/g, respectively. Free fatty acid (FFA) values were 3.82±0.02, 1.52±0.04 and 1.61±0.01 %, for A, B and C respectively. Sample A, B and C had peroxide value of 2.63±0.03, 3.60±0.05 and 4.20±0.04 meq/kg, respectively, while saponification values of samples A, B and C were 182.30±0.01, 232.40±0.01 and 238.00±0.02 mgKOH/g, respectively. The fatty acid compounds found in the samples were, 27 for sample A, 31 for each of samples B and C. Total unsaturated fatty acid was found to be higher than the Total saturated fatty acid. Sample A had the smallest amount of poly-unsaturated fatty acids (PUFAs) compared to the PUFAs content of the other samples. The Oleic acid content was found to be higher in samples A and C, while samples A and C had higher values of mono-unsaturated fatty acids (MUFAs) compared to the MUFAs content of sample B. This study indicates that there are variations in the stability of the oil samples as exhibited by the various values obtained for the chemical parameters.

Keywords: Fried plantain chips; frying; free fatty acids and quality of oil.

Introduction

In Nigeria, the consumption of fried foods is a common practice and consumers prefer the sensorial qualities flavor, appearance, and texture of these fried foods. The diet of many Nigerians is based on the consumption fried pastries and snacks, and some who have busy schedules really on these fried foods which can be eaten quickly. Also, the source of income of many in Africa is based on the selling of pastries and other fried foods. Despite the warnings issued by nutritionists regarding the consumption of fried foods, which contain large amount of calories, cholesterol and saturated fats, they have a growing popularity; a moderate consumption of fat is a way to ensure a balanced and healthy diet (Abiona, 2011).

Frying is a common process in the preparation of food which involves the immersion of food in hot oil with a contact exposed to oil, air and food at a high temperature to form a unique crust, color, flavor and texture. During frying, different varieties of oil and conditions are used in the process (Yamsaengsung and Moreira, 2002) and (Rossell, 2001a). The quality fried products depends on the frying condition such as temperature of the heated oil, frying time, food weight, frying volume, type of oil and kind of food fried (Velar, 1994).

In the presence of oxygen, moisture and trace elements, free radical chemical reactions such as hydrolysis, oxidation, polymerization, isomerization or cyclization take place at the high temperature. The frying process leads to the decomposition of frying oil and the formation of monomeric, polymeric and secondary oxidative compounds, thereby affecting the quality of oil and the fried product which may have negative effect on human health (Andrikopoulos *et al.,* 2002).

The different vegetable oil used for frying is characterized by different fatty acid profiles (Erickson, 2006). In food degradation presence of unsaturated fatty acids is a major contributor. Oxidation and hydrolysis are common reactions that take place in oils. In oxidation, fat which is oxidized with oxygen in the presence of air leads to rancidity flavor of fat, food deterioration (a free-radical chain mechanism) and loss of fat soluble vitamins. Oxidation of fatty acids present gives off flavors and odors to the frying medium and fried foods (Lin *et al.*, 2001). The hydrolysis of fat with an aqueous base such as sodium hydroxide (NaOH) result in glycerol and the fatty acids react with the base, converting them to salts. These salts are called soaps, commonly used in households. Hydrolysis oils having less saponification value is less prone to rancidity.

While oils with high content of saturated fatty acids are more stable in the frying process but due to the negative health consequences linked with the consumption of saturated fatty acids, mono-saturated oils are preferred heart-healthy choice (McDonald and Eskin, 2006). Some oil that can be used for frying includes palm oil, corn oil, cotton oil, soya oil, canola oil, sesame oil and sunflower oil (Valenzuela *et al.*, 2003). This oils have being found to be that mono- and polyunsaturated fats.

This study assessed the quality of oil extracted from commercially sold plantain chips within Oshogbo metropolis with a view of ascertaining the quality of the oils used in the frying of the samples

Materials and methods

Materials

The plantain chips (*Musa paradisiaca*) used in this study were obtained from Olaiya Bus-stop Osogbo, Osun state, Nigeria. For the purpose of this study, three different samples of plantain chips were bought.

Methods

Preparation of samples for analysis

Twenty grams (20 g) of samples were weighed and ground using a manual grinder (Red rooster model RRI-34100). The sample was then transferred to an air-tight container to prevent moisture change.

Extraction of oil from plantain chips

Ten grams (10g) of the grounded chips was weighed in a thimble and plugged with a wad of cotton wool, and then the soxhlet apparatus (250 mL) was used to extract the oil from the chips. The extraction was done with 150 mL of petroleum ether (40 – 50°C) as solvent for 6 hours. The solvent was evaporated with a rotary vacuum evaporator (Büchi Rotavapor R-200).

Chemical analysis on samples

Free Fatty Acid, Iodine Value, Saponification Value, Peroxide Value, Thiobarbituric Acid (TBA) Value and Acid Value were all determined by the methods of AOAC. 2005.

Fatty acid composition (fac)

A Gas Chromatograph equipped with a flame ionization detector (FID) at temperature 320^0C and 22 psi hydrogen pressure, 35 psi compressed air respectively and a HP INNOWax column (length = 30 m, i.d = 0.25 mm, film thickness = 0.25 m) was used for the qualitative and quantitative analysis of the fatty acid composition. Oxygen-free nitrogen was used as a carrier gas at a flow rate of 3.0 mL min-1. Other conditions were as follows: initial oven temperature, 180 oC; ramp rate, 5 oC min-1; final temperature, 220 oC; injector temperature, 230 oC; detector temperature, 250 oC; and temperature hold, 2 min before and 10 min after the run. A sample volume of 1.5 µL was injected. FAMEs were identified by comparing their relative and absolute retention times to those of authentic standards. A data-handling program, Chromatography Station for Windows (CSW32), was used for quantification. The FA composition was reported as a relative percentage of the total peak area.

Statistical analysis

The data obtained from the experimental measurements were subjected to a one-way analysis of variance (ANOVA) and the means were separated using Duncan multiple Range Test.

Results and discussion

Chemical properties

Table 1 represents the results obtained for the physiochemical properties of the oil extracted from three (3) different brands of plantain chips. The iodine values of 88.10±0.03, 125.70±0.02 and 140.00±0.01(mg/g) for oils extracted from samples A, B and C respectively, with sample C having the highest value while sample A had the lowest. The iodine value is the measure of the degree of unsaturation which is widely used to characterize fats and oils and is expressed in terms of a percentage of the absorbed iodine. Decrease in iodine value is consistent with decrease in number of double bonds as oil becomes oxidized. The high iodine value observed in sample C, shows that decrease in double bond occurred due to oxidative rancidity in sample which is due to the presence of high value of unsaturated fatty acid in sample C. The higher the iodine value, the rapid the oil tends to oxidize (Kim and Chloe, 2004) hence, more oxidative rancidity occurred in sample C. Since sample A showed the least iodine value, it is therefore less prone to oxidative rancidity.

Free fatty acid (FFA) exist in their free state and are known to get oxidized faster than the fatty acids that are esterified, which means that FFA are harmful to consumers with time. FFA is as a result of hydrolysis during heating e.g frying.

From Table I the (FFA) values of 3.82±0.02 %, 1.52±0.04 % and 1.61±0.01% for oil extracted from samples A, B and C respectively was obtained while oil extracted from sample B had the lowest value of FFA, oil extracted from sample A had the highest FFA value.

Table 1: Physico chemical properties of oil extracted from three (3) different plantain chips sample.

	PARAMETERS					
Samples	Acid Value (mg/KOH)	Peroxide Value (meg/kg)	SaponificationValue (mg/g)	FFA %	TBA mg/1000g	IodineValue (mg/g)
A	8.51±0.01	2.63±0.03	182.30±0.01	3.82±0.02	1.01±0.01	88.10±0.03
B	11.20±0.05	3.60±0.05	232.40±0.01	1.52±0.04	0.08±0.003	125.70±0.02
C	9.80±0.02	4.20±0.04	238.0±0.02	1.61±0.01	0.06±0.002	140.00±0.01

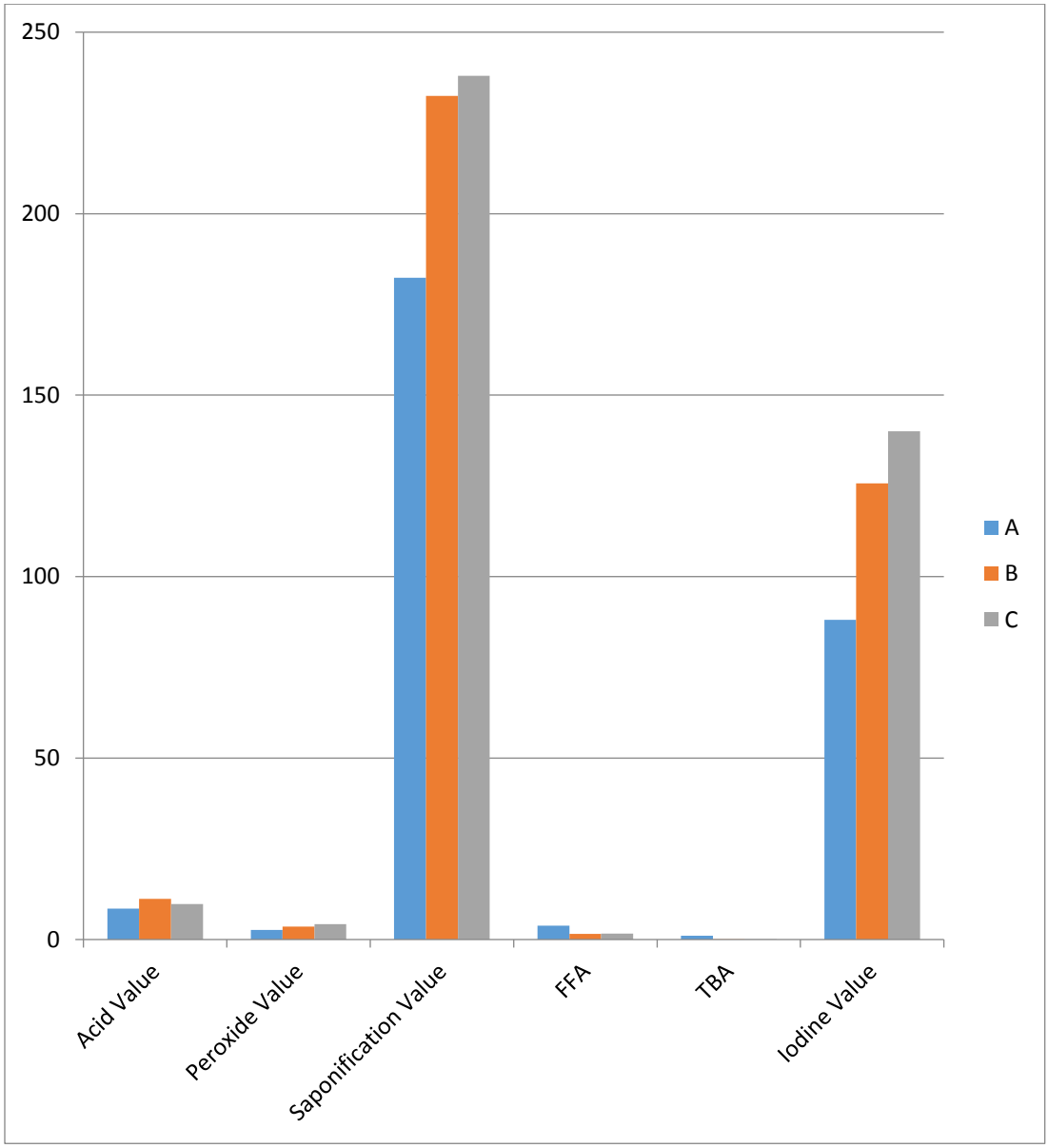


Fig 1: Graphical representation of chemical properties index of oil extracted from three different plantain chips sample.

Sample A had the highest FFA value which indicates that it is harmful and can cause problems for consumers with time since its oil oxidizes faster than oil from other samples.

Sample A, B and C had peroxide value of 2.63±0.03, 3.60±0.05 and 4.20±0.04 (meq/kg) respectively. Peroxide value is the measure of peroxide contained in a sample of fat. The presence of peroxide shows that there are some oxidative activities going on in the oil. Oil having high polyunsaturated fatty acids have high risk of oxidative deterioration at different conditions and depend highly on the storage conditions and fatty acid profile. Peroxide value obtained is 2.63±0.03, 3.60±0.05 and 4.20±0.04 for sample A, B and C respectively. Sample A has the least peroxide value which showed that minimal oxidation occurred in the

oil sample and sample C with the highest peroxide value indicating it more susceptible to rancidity.

Saponification value denotes the weight in mg of potassium hydroxide required to saponify one gram of oil and is the measure of average molecular weight of all the fatty acids present. Sample A, B and C had saponification value of 182.30±0.01, 232.40±0.01 and 238.00±0.02 respectively (mgKOH/g).

Table 2: Fatty Acid profile of oil extracted from three different commercially available plantain chips.

	% COMPOSITION		
Components	**Sample A**	**Sample B**	**Sample C**
C_6:0	0.00±0.00[a]	0.99±0.01[a]	0.11±0.0[a]
C_8:0	0.00±0.00[a]	0.005±0.05[a]	0.55±0.05[a]
C_{10}:0	0.00±0.00[a]	0.12±0.02[a]	0.05±0.02[a]
C_{12}:0	0.10±0.01[a]	0.12±0.01[a]	0.05±0.01[a]
C_{14}:0	6.71±0.03[a]	3.77±0.01[a]	4.50±0.04[a]
C_{14}:1	0.002±0.01[b]	0.13±0.02[b]	0.06±0.03[b]
C_{16}:0	25.64±0.04[a]	26.52±0.04[a]	27.44±0.03[a]
C_{16}:1	7.34±0.02[b]	1.41±0.03[b]	1.01±0.01[b]
C_{18}:0	7.59±0.01[a]	4.77±0.05[a]	4.77±0.05[a]
C_{18}:1	0.005±0.02[b]	0.04±0.01[b]	0.02±0.01[b]
C_{18}:1	8.98±0.03[b]	22.56±0.04[b]	21.07±0.02[b]
C_{18}:1	0.001±0.01[b]	0.004±0.02[b]	0.002±0.03[b]
C_{18}:1	22.28±0.02[b]	12.23±0.03[b]	14.91±0.04[b]
C_{18}:1	0.00±0.00[b]	0.09±0.02[b]	0.04±0.02[b]
C_{18}:2	2.25±0.05[c]	26.61±0.01[c]	24.39±0.05[c]
C_{18}:2	0.006±0.04[c]	0.05±0.05[c]	0.02±0.01[c]
C_{18}:3	0.82±0.01[c]	0.23±0.04[c]	0.13±0.03[c]
C_{18}:3	1.61±0.01[c]	0.21±0.02[c]	0.13±0.02[c]
C_{20}:3	0.01±0.01[c]	0.07±0.03[c]	0.03±0.01[c]
C_{20}:0	0.014±0.04[a]	0.12±0.01[a]	0.05±0.04[a]
C_{20}:1	2.73±0.03[b]	0.45±0.05[b]	0.18±0.02[b]
C_{20}:2	0.002±0.01[c]	0.02±0.02[c]	0.007±0.02[c]
C_{20}:3	0.10±0.02[c]	0.19±0.04[c]	0.14±0.05[c]
C20:4	0.05±0.01[c]	0.01±0.01[c]	0.03±0.01[c]
C20:5	3.47±0.05[c]	0.01±0.01[c]	0.006±0.02[c]
C22:0	0.01±0.01[a]	0.11±0.02[a]	0.05±0.03[a]
C22:1	3.70±0.02[b]	0.04±0.01[b]	0.02±0.01[b]
C22:2	0.024±0.04[c]	0.01±0.01[c]	0.006±0.05[c]
C22:6	6.46±0.03[c]	0.16±0.02[c]	0.17±0.02[c]
C24:0	0.002±0.01[a]	0.01±0.02[a]	0.006±0.02[a]
C24:1	0.002±0.01[b]	0.01±0.04[b]	0.006±0.04[b]
TSFA	40.01±0.01	36.41±0.03	37.58±0.05
MUFA	45.04±0.04	36.40±0.01	37.18±0.02
PUFA	14.80±0.02	27.57±0.02	25.06±0.01
TUFA	59.84±0.06	63.97±0.03	62.24±0.03

Fatty acid composition (FAC)

The fatty acid profile of the extracted oil from samples A, B and C showed the presence of twenty seven, thirty-one and thirty-one components respectively. The components includes; Palmitic acid (C16:0), Palmitoleic acid (C16:1), Stearic acid (C18:0), Oleic acid (C18:1) and Linoleic acid (C18:2) which make up the major components of the oil samples. From Table 2, the Total unsaturated fatty acid (TUFAs) is seen to be higher than the Total saturated fatty acid (TSFA). The total unsaturated fatty acids ranged from between 59.84±0.02, 62.24±0.03 and 64.53±0.01 (%) with sample B having the highest value while sample A had the lowest value. The Total saturated fatty acid ranges from 36.41±0.03 to 40.01± 0.01 (%) for all samples. There is also a slight increase in the unsaturated fatty

acid values in samples B and C while the least unsaturated fatty acid value sample A has the highest saturated fatty acids value.

The predominant fatty acids (FAs) ranged from 25.64±0.04 to 27.44±0.03 with sample A having the lowest and sample C having the highest, Stearic acid ranged between 4.77±0.05 to 7.59±0.01 and Oleic ranged 12.23±0.03 to 22.28±0.02 with sample A having the highest and sample B having the lowest. Sample A had the smallest amount of polyunsaturated fatty acids (PUFAs) (14.80±0.02) compared to the PUFAs content of the other samples, samples B (27.52±0.02) and sample C (25.06±0.01). Maintaining concentrations of PUFA is likely to favour enhanced cognitive, learning and memory functions (Yodim*et al.*, 2000). According to Jiang *et al.*, 1998, some properties of PUFAs make them attractive options in the treatment of cancer. Polyunsaturated fatty acids (PUFAs) modify cell membrane phospholipids, modify cellular functions which may reduce tumor motile/invasive potential, are directly toxic to tumour cells, modify the sensitivity of tumor cells to chemotherapeutic agents and to radiation, exert a protective role towards normal tissues (in radiation). Hence, sample C having the highest value of PUFAs will be of greater option in tumor reduction.

The values obtained for Caproic acid (C6:0) ranged between 0.00±0.00 to 0.99±0.01 with sample B having the highest. The value obtained for Lauric acid (C12:0) ranged between 0.05±0.01 to 0.12±0.01 with sample B having the highest value. Only samples B and C shows traces of C6:0, C8:0 and C10.0 respectively. Myristic acid (C14:0) shows values ranging between 3.77±0.01 to 6.71±0.03 with sample B having the lowest and sample A having the highest value.Erucic acid (C22:1) shows that only sample A has traces of C22:1 with the value of 3.70±0.02 while other samples showed slight traces.

Stearic acid (C18:0) is associated with lowering LD cholesterol in comparison with other saturated fatty acids (Hunter *et al.*, 2010) is found healthier than other saturated fatty acids. From Table 2, the stearic acid (C18:0) value obtained ranged from 4.77±0.05 to 7.59±0.01 and Sample A had the highest value of stearic acid.

The highest content of Oleic acid was observed in sanples A and C (22.28±0.02 and 14.91±0.04 respectively) while sample B contained 12.23±0.03. According to Terés *et al.*, 2008 Oleic acid may be responsible for the hypotensive (blood pressure reducing) effects of olive oil. Oleic acid may hinder the progression of adrenoleukodystrophy (ALD), a fatal disease that affects the brain and adrenal glands. Oleic and monounsaturated fatty acid levels in the membranes of red blood cells have been associated with increased risk of breast cancer (Valeria *et al.*, 2001).Thus consumption of sample A and C may hinder progression of ALD and since sample A and C have high values of MUFAs and oleic acid value it is therefore associated with increased risk of breast cancer. It was observed that sample A and C had higher value of monounsaturated fatty acids (MUFAs) (45.04±0.04 and 37.18±0.02 respectively) compared to the MUFAs content of sample B (36.40±0.01). According to Mensink and Katan, 1990, the highest composition of monounsaturated fatty acids (MUFAs) in samples of oil is associated with a decreased risk of coronary heart disease. Hence oil with high amount of MUFA induces a desirable effect on the health benefits therefore Sample A and C has a greater ability of reducing the risk of coronary heart disease.

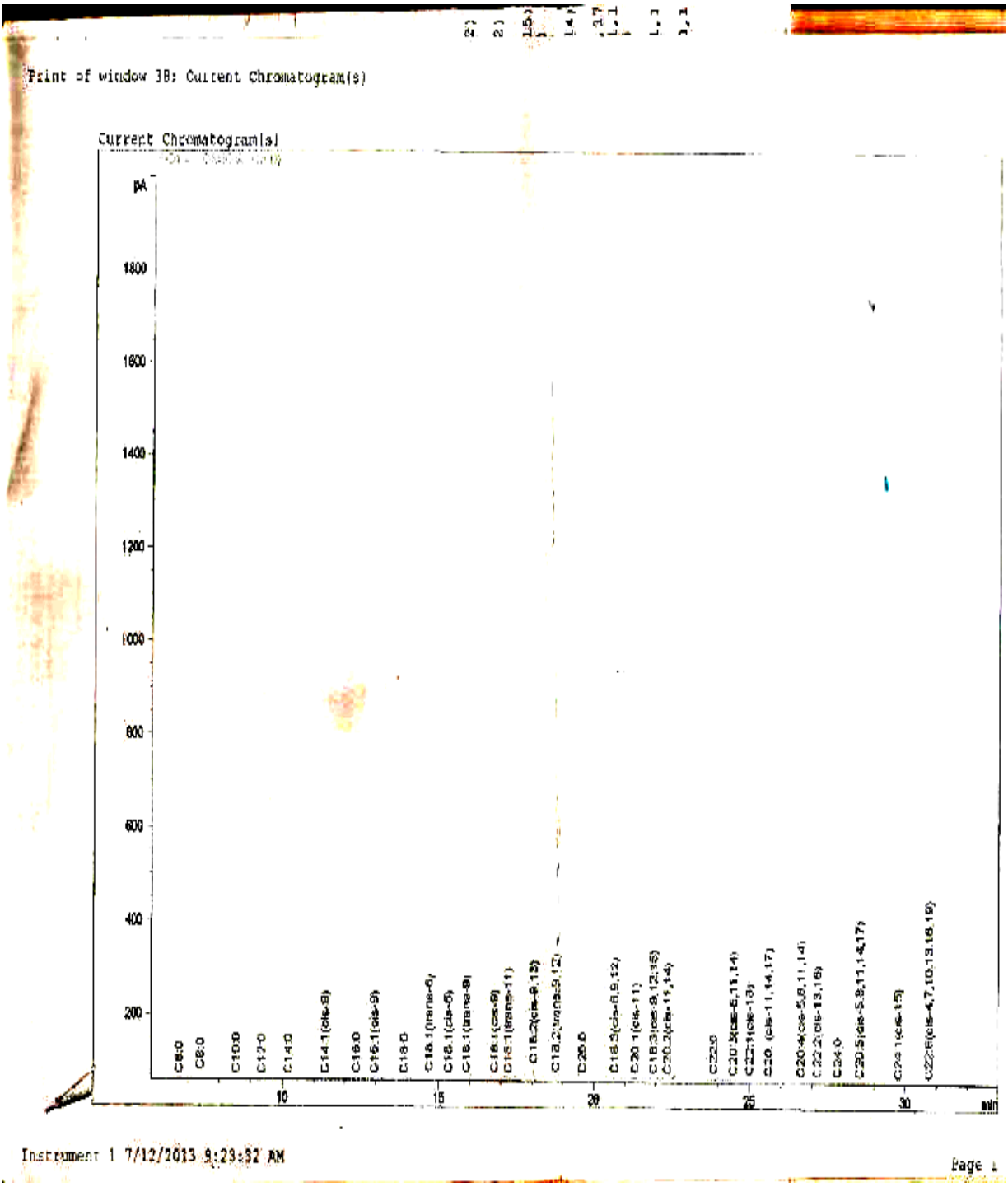
Conclusion

The main objective of this study is to assess the quality of oil extracted from commercially sold plantain chips within Oshogbo metropolis.

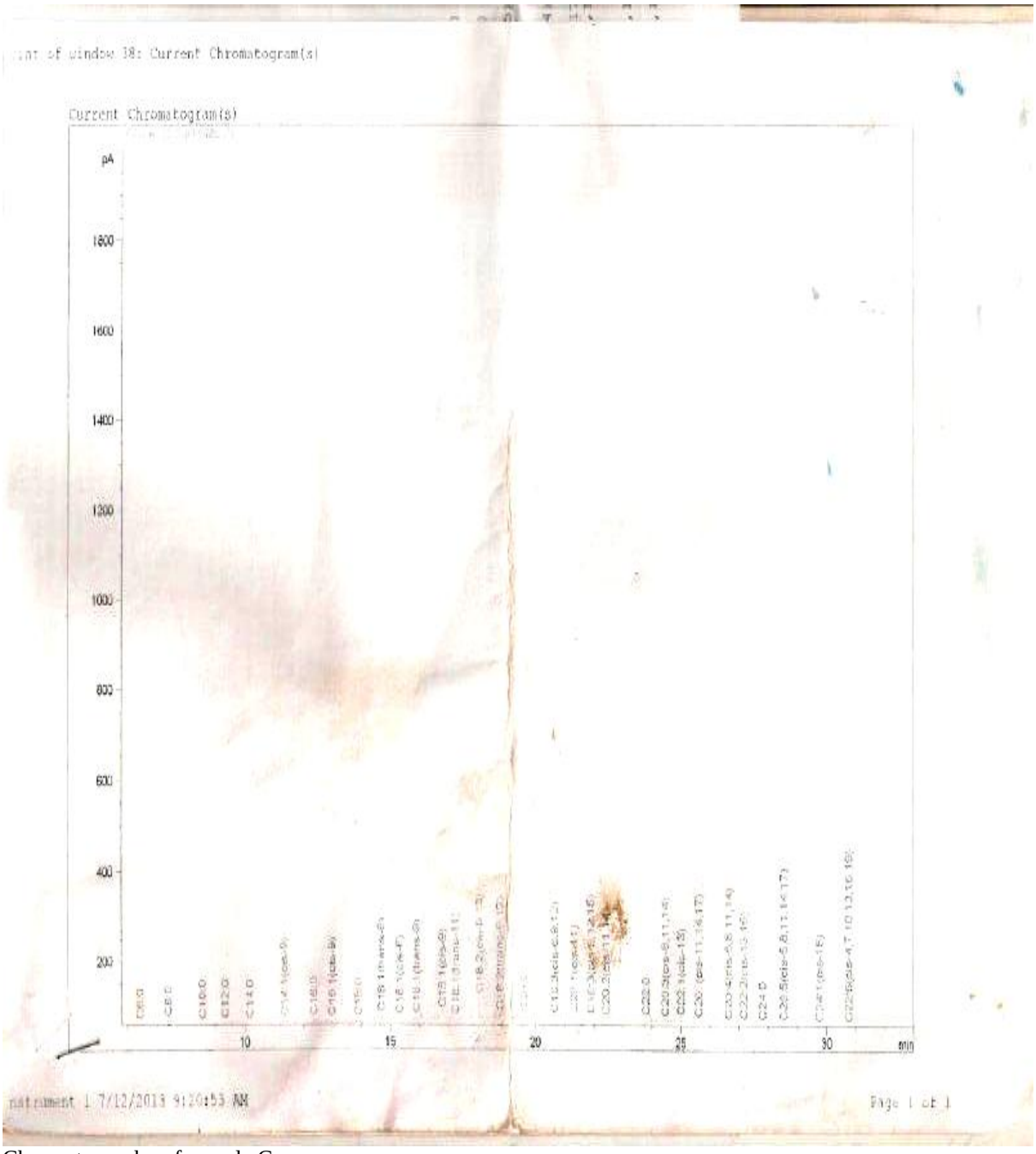
From the results obtained, sample A was the most stable in terms of Iodine value and this is due to its low iodine value followed by samples B and C. Sample A had the best stability while sample C had the least stability against lipid oxidation and therefore sample C is not a good choice for consumption. In terms of the peroxide value, sample C had the highest peroxide value and this indicates that there may be more rancidity problem in sample C. In terms of free fatty acid (FFA), sample A was the least stable and can therefore oxidize faster when compared with sample B and C.

Recommendations

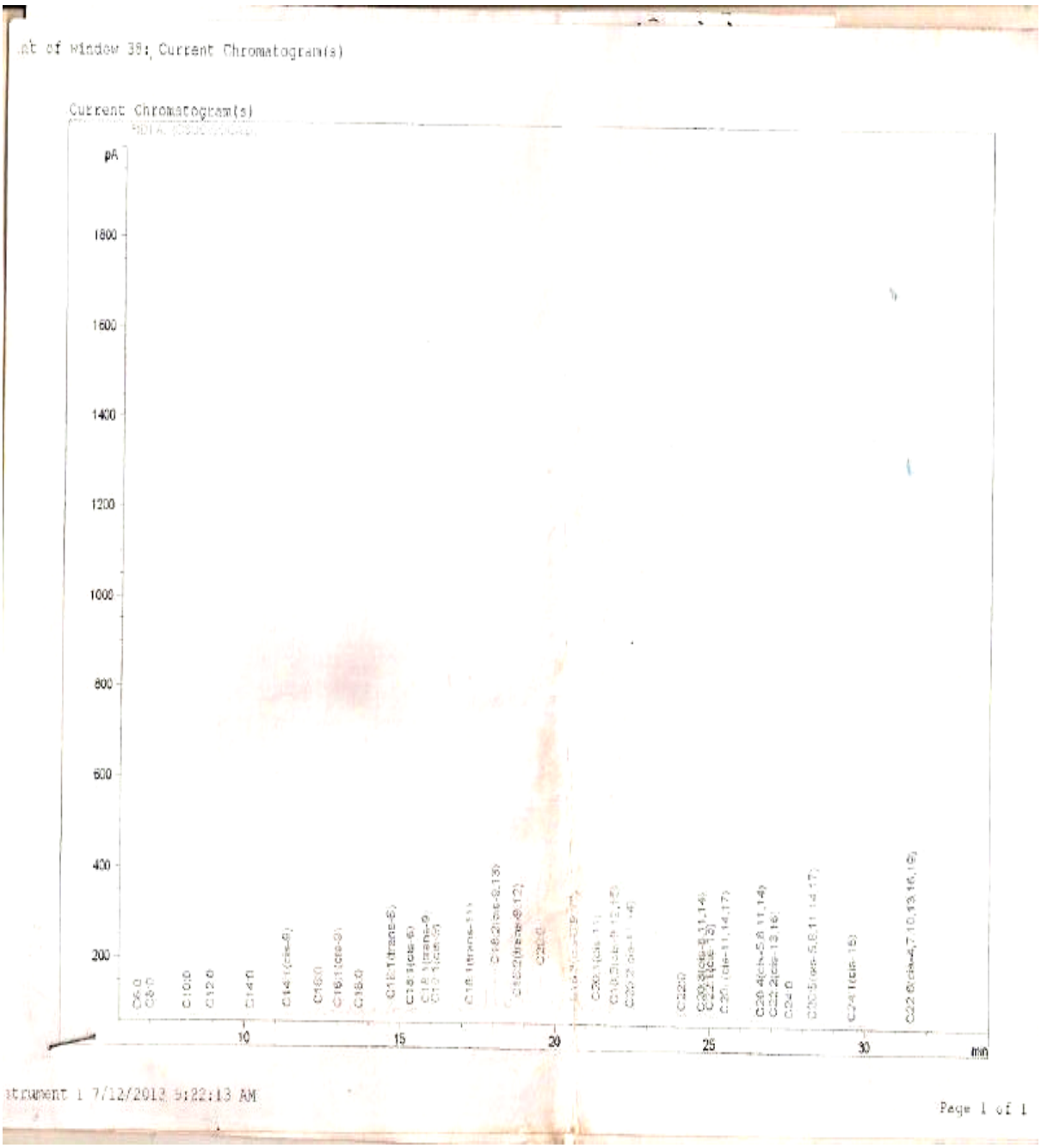
The producer of plantain chips should be enlightened on the type of oil required during the production of plantain chips due to risks involved in the consumption of some oils. Sample B which is more prone to obesity and rancidity should not be taken at all and though, samples A and C are better when compared to sample B but sample A and C should not be consumed daily because of the disease associated with it over consumption. Generally, findings revealed the need for a quality control on the chips by Government regulating Agencies.



Chromatograph of sample B.



Chromatography of sample C.



Chromatography of sample A

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