Trans-Fats Profile of Selected Locally Produced Food Products in Makurdi Metropolis

Adoga SO [1], Ikese OC [1], Ogo OA [2], Agbo EO [1] and Agbo GA [1]*

[1]Department of Chemistry, Benue State University, Makurdi, Nigeria [2]Department of Biochemistry, College of Health Sciences, Benue State University, Makurdi, Nigeria

ABSTRACT

In spite of the association of unacceptable levels of *trans* fats in food products with cardiovascular diseases, there is scanty literature on their contents in food products commonly consumed. Presently there is no system to monitor and regulate the amount of *trans* fats in common food products for informed decision taking by consumers. In this work, the *trans* fat composition of seven locally made hydrogenated food products consumed daily were profiled by Soxhlet extraction procedure followed by gas chromatography-mass spectrometry method to determine their *trans* fat concentrations. The *trans* fat concentrations in the food products ranged from 0.72 to 42.34 % or 0.14 to 8.47 mg/kg corresponding to 9-octadecenoic and 13-octadecenoic acids or methyl esters. The *trans* fats values in the food products were high except, in the meat pie (MP) and were above the recommended values set by regulatory agencies. The high *trans* fats values in the food products suggests a need for a reduction in their daily consumption by consumers for healthy dieting and to avoid predisposition to disease conditions that these substances are capable of causing. In the light of the findings, the need to state these *trans* fats values on nutritional facts labels of such food products by producers is recommended.

Keywords: Food-Products, T*rans*-fats profile, Fried-foods, Food-Hydrogenation, Consumers

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****Correspondence:*** *Adoga SO. Department of Chemistry, Benue State University, Makurdi, Nigeria.*
Email: *soadoga@bsum.edu.ng*

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INTRODUCTION

Over 178.5 million people in Nigeria consume hydrogenated food products either directly at home or indirectly from food vendors/supermarkets (National Bureau of Statistics, 2016). In many developing countries including Nigeria, most hydrogenated food products are available to the general public without *trans* fatty acids content on nutritional facts label. *Trans* fatty acids (TFAs) are trans isomers of fatty acids or unsaturated fats with at least one double bond in the trans

configuration. They are formed in foods during processing by partial industrial hydrogenation to vegetable oils (Amrutha Kala AL 2014, Food and Drug Administration, 2013, Centre for Science in the Public Interest, 2016). Naturally, *trans* fatty acids are found in small quantities in some foods including beef, pork, lamb, butter, and milk but, most trans fatty acids in diets come from hydrogenated foods. Therefore, food processing methods, like frying, roasting, etc. have direct link to *trans* fatty acid production. Hydrogenation ensure that trans fats last longer in food without going rancid and today, about 80 % of trans fats are found in processed food products and oils sold in the market (National Centre for Biotechnology Information (NCBI), 2015 and Bhupender, 2011). In foods, TFAs occur in the form of dietary triacylglycerols (lipids) with high melting point and are solid at room temperature. They are formed when liquid oils are turned into solid fats (i.e., hydrogenation), and it increases the shelf life and flavour stability of food.

In the body system, *trans* fats exert their effects by raising the low density lipoprotein (LDL) usually called the "bad" cholesterol and reducing the high density lipoprotein (HDL), usually the "good" cholesterol levels (Md. A. Islam et al., 2019). The general increase in heart related disease ranging from stroke, heart attack, and diabetes are occasioned by but may not be solely limited to the effects of high LDL cholesterol levels (Hu et al., 2001, Food and Nutrition Board, Institute of Medicine of the National Academies, 2005, Heart disease and stroke statistics update 2007). Furthermore, Clayton et al., in 2007 observed a link between a rise in allergic diseases and ingestion of high amounts of these fatty acids. The most challenging issue is the inability of consumers of these foods to know the underlying cause of these health problems. Also, as the number of small and medium scale food processing enterprises in the country continue to surge, the entire human population is at risk of developing signs of heart related diseases majorly due to ignorance and inability to regulate trans fatty acids consumption. There have been an advocation for the total elimination of industrially produced *trans*-fatty acids (TFA) from the food supply or limiting its content to no more than 2 % of total fat in all foods and this is considered as a priority action and developed countries have adopted measures to solve the problem (Mary R. L'Abbe et al., 2009, WHO, 2018; Non-Communicable Disease (NCD) Alliance, 2019; Franco-Arellano et al., 2020). The FDA recommended TFA intake of below 1 % of daily calories, and an intake above that can have a dramatic negative effects on the body according to Dam et al., 2002. Illustratively, diagrams of clogged arteries by *trans* fats as implicated causative agents are shown in Figures 1 (a-g). These diagrams explain the building up of atherosclerotic plaque in the inner walls of arteries leading into occlusion in which trans fats intake have been implicated in the causation of the clogged arteries, increased risk of coronary high disease, in addition, to implication of TFA consumption as an independent risk factor for sudden cardiac arrest according to Karbowka et al., 2011 and the American Heart Association (AHA)/American Stroke Association (ASA), 2015-2016 annual report.

MATERIALS AND METHODS

Collection and preparation of food materials

The food products/samples investigated were; meat pie, fried beef, fried groundnut, fried chicken, doughnut, chin-chin and popcorn were randomly procured from different locations in Makurdi Benue State, Nigeria.

The food products were each ground and homogenized. The homogenized samples were each stored in airtight sample containers until needed for further use.

METHODS

The analytical procedures for the determination of fat from food products namely, extraction of the fats, derivatization and GC-MS analysis as reported by Hewavitharana *et al.*, 2020 was performed on each food product.

Soxhlet extraction

A 5.0 g amount of each homogenized sample was weighed into an extraction cartridge and the Soxhlet apparatus containing the cartridge fitted to a distillation flask containing 150 mL of n-hexane and a few anti-bumping granules (AOAC, 2018). Each sample was extracted for 440 mins (AOAC, 2019). After extraction, the solvent was removed using rotary evaporator.

Preparation of fatty acid methyl esters (esterification)

After Soxhlet extraction, 150 mg of fat extract was placed in a test tube and dissolved using 2.4 cm^3 of *n*-hexane, followed by addition of 0.60 cm^3 aliquot of 2.0 *mol/dm*^{3} methanolic KOH solution. The test tube was capped and shaken vigorously for 20 s and allowed to boil for one minute in a water bath at 70 ^{o}C. After shaking for 20 s, 1.2 cm^3 of 1.0 *mol/dm*^{3} HCI was added and stirred gently. After phase separation, 3.0 cm^3 of *n*-hexane was added and the upper phase containing the fatty acid methyl esters decanted and dissolved in *n*-hexane to 5.0cm^3. Finally, 1.0 µL of the fatty acid methyl ester (FAME) obtained was used for GC-MS analysis.

Gas chromatography-mass spectrometry analyses

Helium at a constant flow rate of 0.58 cm^3/min was used as carrier gas for the GC-MS analysis of the FAME extracts. The following temperature program were maintained: injector temperature of 230 ^{o}C, initial column temperature of 100 ^{o}C (held for 5 min), temperature ramp 10 ^{o}C/min to 240 ^{o}C and held at this temperature for 10 minutes. The total run time was 30 minutes, the injection was performed manually, volume 1.0µl, with a split ratio 1:80. The mass spectrometer was operated in the electron ionization mode with a quadropole temperature of 180 ^{o}C. Data acquisition was realized in the scan mode (range 40-400 m/z). The instrument was tuned daily by operating the software programs (Autotune) and perfluorotributylamine (PFTBA) was the calibration substance. Mass spectrometer parameters was adjusted so that the masses 69, 219 and 502, and their respective isotopes met the target mass- intensity criteria. The fatty acids were identified by comparing their retention times and mass spectral data to the mass spectral data obtained by analysis of standard fatty acid methyl esters solution under the same conditions. Also, a commercial database of mass spectra by Wiley was used.

Mass spectrometry quantitation of fatty acid methyl ester

The response factor (R_i), mean of five injection of the standard solution for each fatty acid methyl ester present in the calibration standard solution, was calculated in relation to palmitic acid according to Equation

(1) " $R_i = \frac{m_{0,i} A_{16:0}}{m_{16:0} A_{0,i}}$ " but not as it appear on the draft copy.

Where $m_{0,i}$ is the mass % of FAMEi in the calibration standard solution; $A_{16:0}$ the peak area of 16:0 in the calibration standard solution chromatogram;*m* 16:0 is the mass % of 16:0 in the calibration standard solution; $A_{o,i}$ is the peak area of FAMEi in the calibration standard solution. The content of each fatty acid expressed by mass percentage was calculated according to equation (2): $100\, R_i A_i / {}_{E\,Ri} A_i$ (2)Where, R_i is the response factor for each fatty acid and A_i the peak

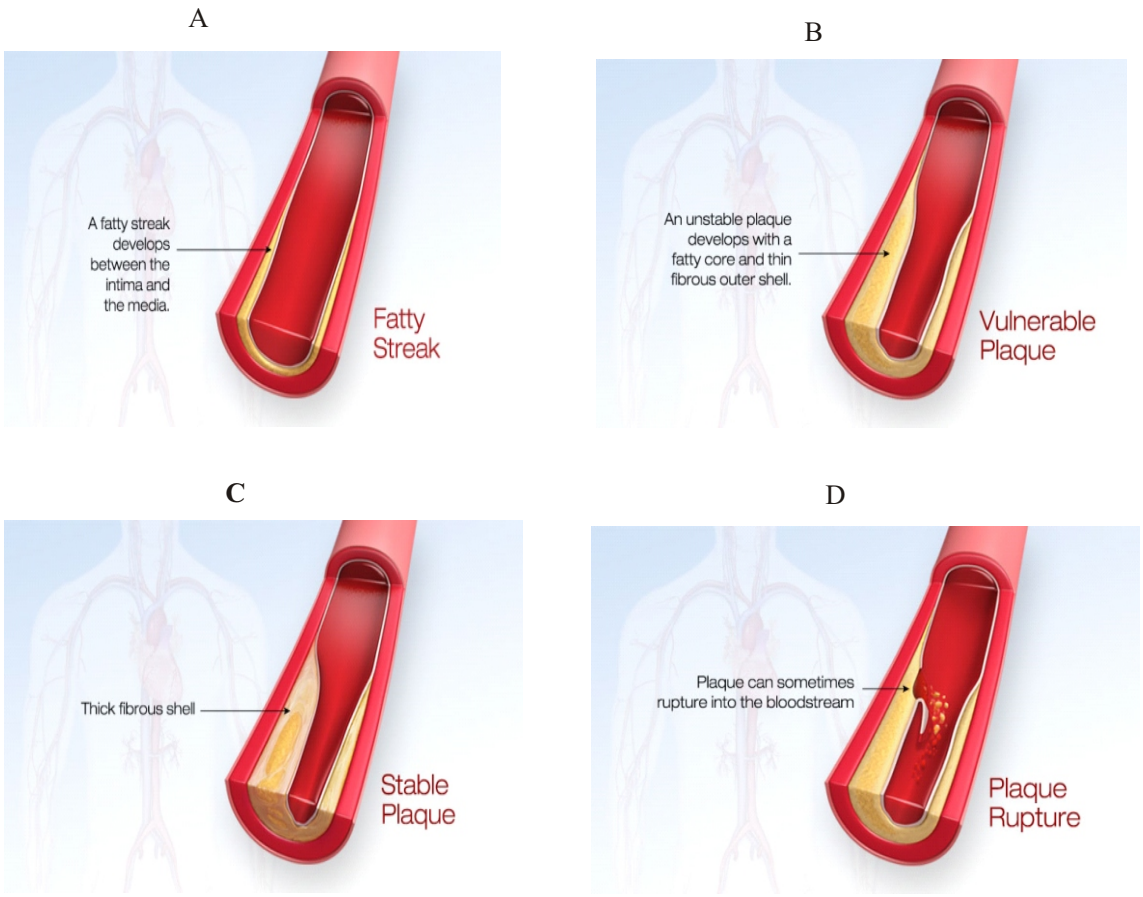
area of the fatty acid methyl ester in the sample solution.

Table 1: *Trans*-fatty acids composition of the analysed food products

Food products	Fatty Acids	Conc. (mg/Kg)	Conc. (%)
MP	9 OA	0.14	0.72
FB	9 OA	2.17	10.86
FG	13 OA	8.47	42.34
FC	13 OA	3.27	16.36
DN	13 OA	3.53	17.65
CC	13 OA	6.57	32.83
PC	13 OA	1.74	8.68

Meat pie (MP), Fried beef (FB), Fried groundnut (FG), Fried chicken (FC), Doughnut (DN), Chin-chin (CC) and Popcorn (PC) 9-Octadecenoic acid, 13-trans-Octadecenoic acid or methyl esters

Dilution factor: 10 g of food product in 20 mL of dichloromethane



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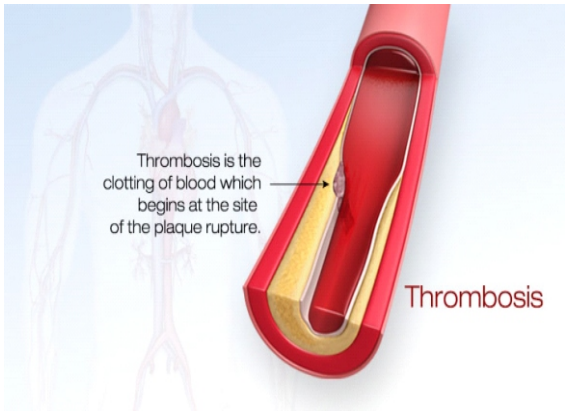

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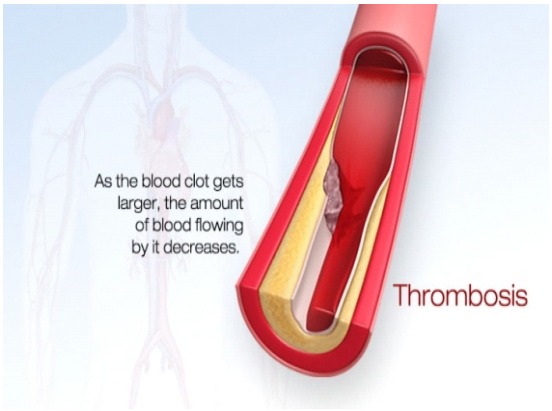

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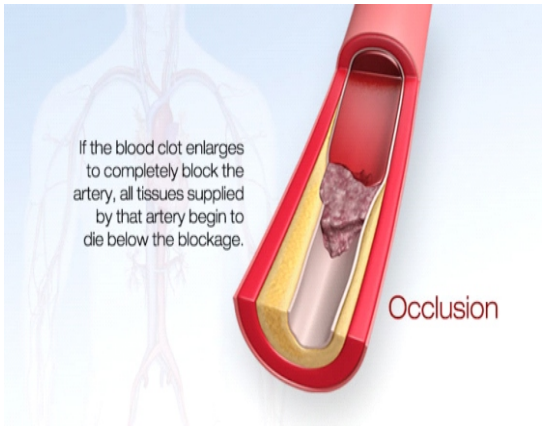

RESULTS AND DISCUSSION

The results in Table 1 showed *trans* fatty acid values in concentrations, ranges from 0.72 to 42.34 % or 0.14 to 8.47 mg/kg for the studied food products. Fried groundnut and meat pie have the highest and the least concentrations of *trans* fat respectively. The high concentration of *trans* fat in groundnut may be due to the fact that groundnut contained oil that is already high in fatty acids (Anyasor et al, 2009) and the frying process may have converted some of the fatty acids to their *trans* isomers. The *trans* fatty acids and fatty acid methyl esters identified were 9-Octadecenoic acid, 13-Octadecenoic acid, and their fatty acids methyl esters. The presence of fatty acids may be due to incomplete derivatization into fatty acids methyl esters during the esterification reaction (Figures 2a-g: *trans* fats chromatograms for food products studied).

The results showed a considerable high value of *trans* fatty acids, and the high value of TFAs was observed in all of the food products studied except, in one to be above the 2 % recommended *trans* fatty acids value by regulatory bodies like the United States Food and Drug Administration (FDA), National Agency for Food and Drug Administration and Control (NAFDAC) and World Health Organization (WHO) in any fried food, beverage and beef products. The reason for high value of *trans* fatty acids in the food products may be that the hydrogenation process is highly selective. The conditions for high selectivity hydrogenation are low hydrogen pressure, moderate stirring speed, and high process temperature, and all these factors played out during the processing of the food products

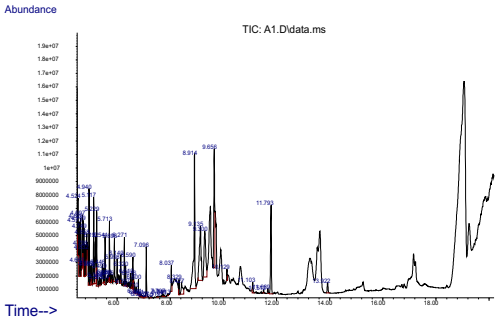

Figure 2 a: *trans* fat chromatogram for

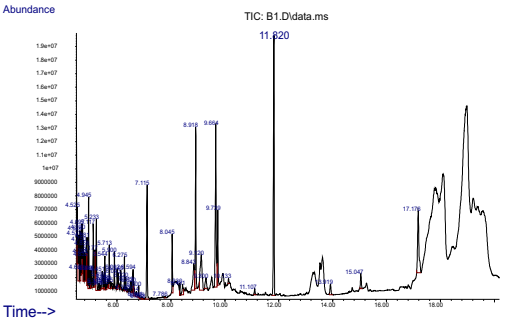

Figure 2 b: *trans* fat chromatogram for FB

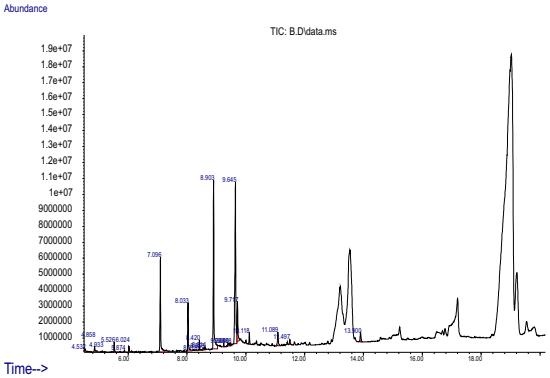

Figure 2 e: *trans* fat chromatogram for DN

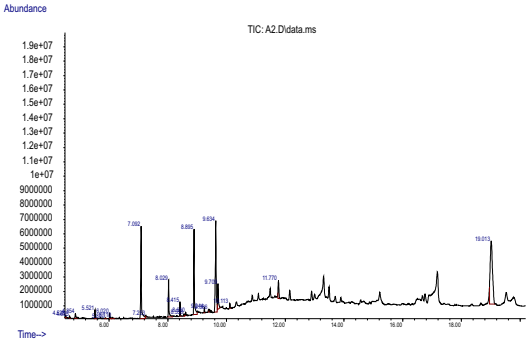

Figure 2 f: *trans* fat chromatogram for

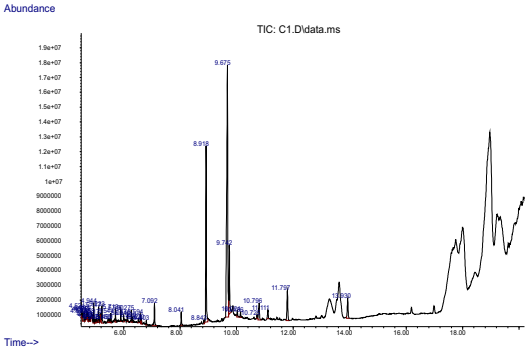

Figure 2 c: *trans* fat chromatogram for FG

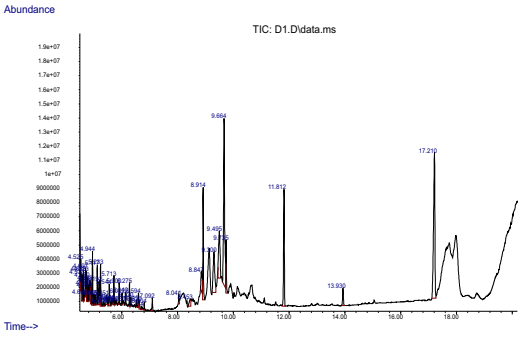

Figure 2 d: *trans* fat chromatogram for FC

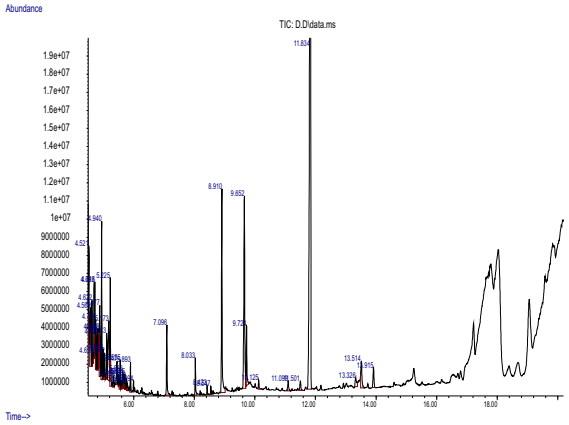

Figure 2 g: *trans* fat chromatogram for PC

investigated (Clayton et al., 2007).

The presence of *trans* fatty acids in the food products might be due to isomerization during the partial hydrogenation process (frying) and the nature or sources of the oils used during preparation of the food products, (Salimon et al, 2014; NCBI, 2015). Comparatively, these values conformed to the *trans* fatty acids contents in oil-bearing foods reported for fried food, beverage and beef products. Although, the *trans* fatty acid values reported for fried meat product was 11.36, and 5.86 % for fried chicken, in excess of the current values. Also, other similar products with alarming TFA value of 35-50 % were reported to be available in the market (Bansal et al., 2009).

According to Clayton et al., (2007), *trans* fatty acids content production in food was important for many decades, just to reduce hydrogen use and improve the physical, chemical and organoleptic characteristics of fats. Furthermore, Clayton et al., (2007), reported the mechanism for the formation of geometric and positional isomers during hydrogenation based on the semi-hydrogenation/dehydrogenation sequence. Accordingly, during hydrogenation, a hydrogen atom is capable of entering any end of the double bond and form a free radical site, possibly bound to the catalyst. The free radical site is unstable and if the catalyst is partially covered by hydrogen, a hydrogen atom neighbouring carbon can be eliminated and thus regenerate the double bond or lead to formation of a positional isomer. Because the formation of a free radical site allows free rotation, the double bond formed may present either *cis* or *trans* configuration.

During food frying, *trans* fatty acid formation is related to the process temperature and oil time according to Filho (2004). When partially hydrogenated fats are used, the formation of *trans* fatty acid is generally lower, however, the high initial contents of these acids results in a larger concentration of *trans* isomers in fried food (Clayton A Martin et al., 2007). For instance, the formation of *trans* isomers during sun flower oil heating in an open container as reported by Clayton A Martin et al., 2007, started to increase at 150 °C and was much higher from 250 °C on. After heating for 20 minutes at 200, 250, and 300 °C, the *trans* isomers concentration increased at 356.5 %, 773.9 % and 3026.1 % respectively in relation to the initial value of (0.22 mg/g). In compliance with the results and recommendations from similar studies on high trans fatty acids values, several European Countries have determined that the frying oil temperature must not exceed 180 °C, and in France, it has been established that the oil commercially used in frying must contain 3 % alpha linolenic acid at most in order to decrease degradation of unsaturated fatty acids and to lower formation of monounsaturated *trans* fatty acid (MTFA) and poly unsaturated *trans* fatty acid (PTFA) during frying.

More also, Sanibal and Filho, (2004) reported a significant increase in monounsaturated *trans* fatty acid formation in oil with increasing heating time during potato frying in soybean oil at around 180 °C, with oil filtering and repositioning every 10 hours. A larger poly unsaturated *trans* fatty

acid group after 10-hour frying correspond to an increase of 55.2 % relative to the amount initially present in oil (2.1 %) was reported. Therefore, from the foregoing food frying, process temperature and oil use time have a correlation to *trans* fatty acid formation in foods, and therefore, the need to state the value of TFAs on nutritional facts label of food should be emphasized. Also, this may serve as a response to demand by consumers for improved fat quality in food to enable informed decision-making among consumers of these products and in order to avoid associated risks and effects due to TFAs accumulation in the body from dietary intake.

CONCLUSION

The study revealed that there were significantly high values of *trans* fatty acids in the hydrogenated food products investigated. The values were above the 2 % recommended by regulatory agencies. The high TFAs values detected in the food samples require that similar products be investigated for *trans* fatty acids content and then profiled. Moreover, the high *trans* fatty acid content calls for the need to state the value of TFAs in fats, oils and all hydrogenated food products on nutritional facts label as a basic requirements in the testing of food material especially, and also, for informed decision-taking by consumers of the products.

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Conflict of interest

The authors declare that they have no conflict of interest.

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