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TRANS FATTY ACID CONTENT OF SELECTED FOODS IN FIJI

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***Abstract*— This article focuses on studying the effects of processing on *trans* fatty acid content of selected foods that are commonly sold in Fiji. The results of *trans* fatty acid content of 30 manufactured and 34 commonly consumed fast foods and snacks are presented.**

Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopic method was applied to the analysis of *trans* fatty acid content in the food and oil samples. The *trans* fat contents are represented as elaidic acid equivalent. The results for the food samples analyzed showed that bakery products contained the highest amount of *trans* fatty acid content, while the spreads contained the lowest *trans* fat content. The differences in the data have been attributed to the factors that contributed to the higher rate of *cis* to *trans* conversion. These include the materials for the cooking vessels, temperatures and duration for cooking and types of cooking oil or fat used.

Results were correlated with the dietary consumption patterns in different population groups in Fiji. Study shows a positive correlation between the high incidence of non communicable disease in Fiji and the presence of *trans* fatty acid in commonly consumed processed foods. It appears that in the absence of any regulatory mechanism, only a few manufacturers had voluntarily reported the appropriate values of the *trans* fat content in their processed foods on the food labels. It is thus recommended that consumer awareness and a statutory regulatory mechanism for labeling of *trans* fat in different foods should be carried out.

Keywords-trans fatty acids; Attenuated Total Reflectance Fourier Transform Infrared; elaidic acid;

I. INTRODUCTION

The consumption of foods high in *trans* fatty acids have been shown to have adverse effect on human health. Studies have shown a correlation between *trans* fatty acid intake and a change in blood lipid profile [1]; [2]; [3] as well as a relationship between *trans* fatty acids intake and risk of cardiovascular disease [4]; [5]; [6]. In addition, it has also been shown to increase the risk of breast cancer [7] and prostrate cancer [8]; insulin resistance which is a feature of type 2 diabetes [9]; age related macular degeneration which is a leading cause of visual impairment and blindness in developed countries [10]; [11] and adverse affects on child and maternal health [12]. Experimental and epidemiological studies have shown strong need of in depth profiling of *trans* fatty acid levels in different food and in the human diet, and the factors that lead to alteration in the *trans fatty* acid content in oils and fats, thus the importance of this research.

Ethylenic double bonds of unsaturated fatty acids can either be in *cis* configuration, a geometry where both hydrogen atoms are on the same side of the double bond, or in *trans* configuration, where the two hydrogen atoms are on opposite sides of the double bond. Positional isomers result when these double bonds are located on different positions of the aliphatic chain. The *trans* fatty acid isomers differ in physico-chemical, nutritional, biochemical and biological properties from those of *cis* isomers [13].

Trans fatty acids originate from various sources in food namely ruminal biohydrogenation of polyunsaturated fatty acids (PUFA), partial catalysed hydrogenation, thermal treatments and irradiation. Ruminal biohydrogenation of PUFA results from the action of bacterial enzymes which converts polyunsaturated fatty acids from the diet to unsaturated and saturated fatty acid metabolites using various pathways [13].

For the determination and quantitation of *trans* fatty acids in foods, several analytical methods have been reported. Some of these analytical procedures are based on separation techniques generally used for lipid analysis namely gas chromatography [14], thin layer chromatography impregnated with silver nitrate, reverse phase liquid chromatography and liquid chromatography impregnated with silver nitrate [15]. Detection methods for lipid determination are also used for determination of *trans* fatty acids. These methods include infrared spectroscopy and Fourier Transformed infrared spectroscopy (FTIR) [16], flame ionisation detection and mass spectrometry [17]; [18].

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Each of these methods has inherent advantages and drawbacks. Combining two or more techniques results in improved accuracy and reproducibility of results, for instance, use of gas chromatography with mass spectrometry detection wherein preliminary fractionation is out carried using thin layer chromatography impregnated with silver nitrate.

This present study is based on the use of Attenuated Total Reflectance (ATR) Fourier Transform infrared spectroscopy (FTIR) for the determination and quantification of *trans* fatty acids in food samples.

II. MATERIALS AND METHODS

A *Selection of food samples*

Food samples that were selected for analysis have high fat content and are commonly consumed by Fiji's population. This selection was based on the 2004 National Nutrition Survey Report [19]. The total fat and *trans* fat content of 64 samples were studied. The food products that were studied included 30 manufactured products and 34 commonly consumed fast foods and snacks. These food items included 7 ready to eat snacks and spreads that were imported while the rest of the food items were produced in Fiji from local and imported ingredients. All samples were purchased from supermarkets, bakeries, restaurants fast food outlets, and cake shops located in the central division of the Fiji Islands. The following samples were selected:

- Biscuits, wafer and crackers: Sweet biscuits (6 flavours from 2 brands, including plain, cream and chocolate varieties); cracker biscuits (2 brands) and wafer (1 flavour)
- Bakery products: Cakes (5 flavours, including iced and non iced cakes); muffins (2 flavours, including chocolate and fruit muffins); scones (2 types/flavours); pies (3 types/flavours, including apple and custard pies)
- Spreads: butter (1 brand); margarine (2 brands, including locally produced and imported samples) and peanut butter (3 brands).
- Crisps, chips and fries: Crisps (6 brands); chips (3 brands) and fries (3 types/brands, including one sample that claimed to be fried in hydrogenated fat).
- Chocolates: dark chocolates (2 brands, made from combinations of cocoa powder, vegetable fat, milk, cream, or milk powder)
- Savories: pastry filled with curry (2 types/brands); lentil fritters (4 types/brands, including plain and with vegetable varieties) and fried lentils and nuts(3 brands, including plain and mixed varieties)
- Fast foods: fried chicken (3 types/brands); fried fish (3 types/brands); pizza (3 types/brands); pizza cheese (1 brand); burger (1 flavour) and nuggets (1 flavour).
- Noodles: (2 brands).

B *Chemicals*

All reagents used were of analytical grade and were obtained from Sigma Aldrich, Australia. These included hexane and primary standards: trielaidin (TE) and triolein (TO) with purity of 99%.

C Extraction of fat from food samples

Edible portions of food samples (about 300g) were individually homogenized in a domestic blender. Fat from food samples were extracted using the Soxhlet method in triplicates. Hexane (boiling point of 68.7°C) was used as extractant. Solvent from the extracted mixture was removed at reduced pressure. Extracted fat samples were filled in vials, the air was replaced with nitrogen gas and the vials were sealed and stored in the freezer at -20°C until they were analyzed for the presence of *trans* fatty acids.

D Trans fatty acid analysis

The *trans* fatty acids in the food and fat samples were analyzed using FTIR spectroscopy with reflectance attachment (AOAC Official Method 2000.10). FTIR spectrometer-capable of making measurements at 4cm^{-1} resolution in the spectral range covering 4000-400 cm^{-1}. Samples were analyzed using a Perkin Elmer Spectrum 100 Series FTIR Spectrometer equipped with Universal ATR Sampling Accessory. The instrument data handling capabilities allowed conversion of spectra to absorbance, scale expansion of the x and y axis, readout of wave numbers to the nearest 0.001 A.U., and integration of the area under the absorption band at 966 cm^{-1}.

Trans calibration standards: (0.3-x)g TO was accurately weighed to the nearest 0.0001g, and xg of TE, into a 10ml beaker, where x equaled 0.0030, 0.0300, 0.0600 and 0.0900g in order to prepare 1, 10, 20 and 30% *trans* calibration standards.

For each neat TE/TO standard mixture, the exact percent *trans* as TE per total triacylglyceride (TAG) was calculated. Each mixture was analyzed and the integrated area under the absorption band at 966 cm^{-1} was determined. Using the first-order regression analysis, the slope and the intercept of the line which best fits the plot of the area of the *trans* band for all of the *trans* standard mixtures (y-axis) as a function of % *trans expressed* as percent TE in TO (x axis) was determined Solid fatty acid was gently melted and mixed before applying the sample over the ATR plate. Samples that appeared cloudy due to the presence of water were treated with anhydrous sodium sulfate and filtered before removing the test sample for analysis.

The FTIR spectrometer operating parameters was set up according to the manufacturer's recommendations for using an ATR cell with the following parameters: 1050-900cm^{-1} range, 64 scan and 4 cm^{-1} resolution. Conditions were identical for test samples. Using a disposable pipette, about 50µL of background TO were used as background material for TE/TO calibration standard mixtures) was transferred without weighing on to the surface of the ATR crystal (enough material was used to cover the entire crystal). The reference background material was placed on the horizontal zinc selenide crystal sampling surface of the ATR cell. Single beam spectrum was collected and saved as shown in Fig. 1. The diamond crystal was cleaned with a disposable low lint tissue paper with methanol. Test sample was then placed on the horizontal diamond crystal and single-beam

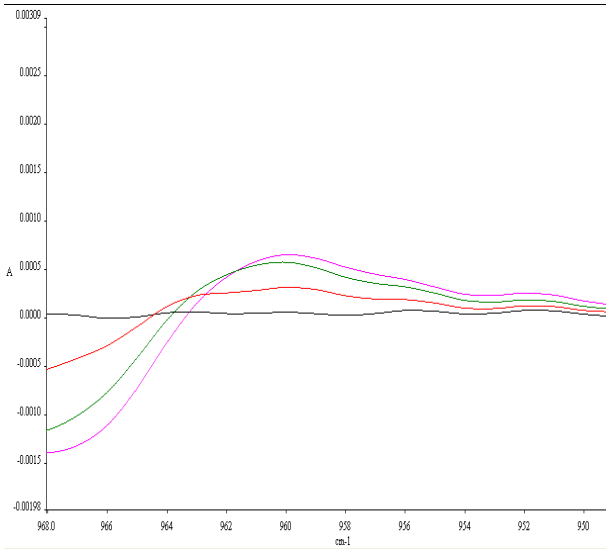
spectrum was collected. The absorbance spectrums were saved after suitable background correction for further analysis and peak area computations [20]. Each sample was analyzed in triplicate.

With the absorbance spectrum wave number scale expanded in the region from 1050-900 cm^{-1}, the area under the 966 cm^{-1} band between the limits 990 cm^{-1} and 945 cm^{-1} was obtained. Instrument software provides for the base line and peak area calculation. The linear regression equation for the peak area vs. % *trans* fatty acid from calibration standard mixtures was obtained.

Using the slope and the intercept from the best fit line for the *trans* standard mixtures, the % *trans* fatty acids for test samples were calculated:

$$\%\ Trans\ \text{fatty acid as TE in the sample} = \frac{\text{area - intercept}}{\text{Slope}}$$

Results were reported to the nearest 0.10% accuracy.



Key:

_____1% Trielaidin

_____10% Trielaidin

_____20% Trielaidin

_____30% Trielaidin

Figure 1. Spectra of triolein (TO) vs. trielaidin (TE) standards.

III. RESULTS AND DISCUSSION

The total fat content as well as *trans* fatty acid content in the 64 food samples are shown in the Table I. *Trans* fatty acids were detected in all food samples analyzed. Sixty samples contained more than 2% *trans* fat per 100g of fat, and three samples were found to contain more than 20% *trans* fat. The mean total *trans* fat content of the ten food groups ranged from 4.41% for spreads to 18.85% for pizza. The highest amount in a single product was determined in a bakery product that was made with hydrogenated fat and lowest amount of *trans* fat was found in a margarine sample. There was high variation of total *trans* fat content with all groups.

TABLE I. TOTAL FAT AND TRANS FAT CONTENT IN 64 FOOD PRODUCTS IN FIJI

Food (n)	**Fat and *Trans* fat content in 64 Food Products in Fiji**		
	Total fat(g)	***Total TFA(%)***	***Total TFA(g/100g food)***
Spreads[a] (6)	61.65 (46.80-75.90)	4.41 (1.89-6.94)	3.28 (1.26-5.30)
Bakery products[b] (12)	11.8 (4.90-18.70)	15.63 (6.43-24.84)	2.53 (0.42-4.64)
Biscuit, wafer and crackers[c] (9)	19.4 (15.20-23.60)	7.68 (4.47-10.90)	1.68 (0.80-2.57)
Chips, crisps and puffs[d] (12)	29.80 (19.60)-40.00	6.71 (3.94-9.49)	2.28 (0.78-3.79)
Fast foods[e] (8)	18.15 (7.30-29.01)	6.23 (5.59-6.87)	1.15 (0.41-1.89)
Pizza[f] (4)	16.16 (3.00-29.30)	18.85 (15.99-21.71)	2.31 (0.64-3.99)
Noodles[g] (2)	18.8 (18.30-19.30)	5.64 (5.20-6.09)	1.05 (1.00-1.11)
French fries[h] (3)	17.70 (12.50-22.90)	6.02 (5.61-6.43)	1.04 (0.80-1.28)
Chocolates [I] (2)	26.35 (25.80-26.90)	8.65 (7.76-9.55)	2.27 (2.09-2.46)
Savories[j] (6)	17.70 (15.10-20.30)	6.71 (5.45-7.97)	1.09 (0.95-1.24)

[a] Margarines, butter, peanut butter
[b] Scones, cakes, pies, muffins.
[c] Biscuits with cream, cookies, wafers, crackers
[d] Chips, popcorn, puffed snacks, crisps.
[e] Nuggets, burger, fried chicken, fried fish
[f] Chicken pizza, cheese pizza
[g] Noodles
[h] French fries
[i] Plain chocolate, biscuit coated with chocolate
[j] Lentil fritters, lentil and vegetable fritters, fried pastry filled with curry

B. Variations in Trans Fatty Acids in a Food Group

The current study revealed that there is a wide variability of *trans* fatty acid content among foods even within the same category. There are several reasons for the variability. First, most of the fatty foods invariably use hydrogenated vegetable oil and the production of hydrogenated oils can result in variable content of *trans* fatty acids. Various factors affect the resulting *trans* fatty acid content of the starting oil which includes temperature, hydrogenation pressure, type and amount of catalyst and agitation. Second, a single hydrogenated or non-hydrogenated fats or oils or combinations of both may be used by food producers to

produce a product with desired characteristics. In addition, the use of hydrogenated and non-hydrogenated fats and oils in food products varies on their availability and the cost of the various edible oils [21]. Finally, fried foods may have been fried in oils (hydrogenated or unhydrogenated) which may have been re-heated several times.

C. International Comparisons

The current study shows that the *trans* fatty acids in food samples ranged from 1.89-24.84% of total fat content. This large variation is similar to the *trans* fatty acid values in similar studies conducted in other developed countries; where there is either mandatory or voluntary labeling of *trans* fatty acids. In a study on foods from Austria [22], the *trans* fatty acid content ranged from 0.21g per 100g fat in breakfast cereals to 34.00g per100g fat in cooled ready to eat product. Similarly, the *trans* fatty acid content in selected foods in an African American community ranged from 0.51g per 100g fat in cookies to 19.13g per 100g fat in margarine [23]. In China, the *trans* fatty acid content ranged from <0.50g per 100g fat to 300.90g per 100g fat in pie [24]. In Turkey [25], wheat flour cookies were reported to have 17.00g *trans* fat per 100g fat while in Brazil, crackers were reported to have up to 31g *trans* fat per 100g fat [26].

The *trans* fatty acid content does not only vary within a food product group, but it can also vary for the same product of the same company purchased from different countries. For instance, variation in the presence of *trans* fatty acids in a large serving of food from McDonalds (171.00g of French fries and 160.00g of chicken) was reported as less than 1.00g in Denmark and Germany to 10.00g in New York (McDonalds) and 24.00g in Hungary (KFC) [27].

The results from the current study along with the results from other recent studies from all over the world shows that industrially produced *trans* fatty acid is still present in food products. However, one should note that there is no legislation for the labeling of *trans* fatty acids in food products in Fiji as compared with other countries.

D. Public Health Relevance

In Fiji, diet related non communicable diseases are a leading course of death [28]; [29]. Hence, there has been a strong effort to reduce the population's consumption of saturated fat. As a result, the food industry has been using hydrogenated vegetable shortening as they claim to have no cholesterol and low saturated fat content. Hydrogenated vegetable shortening are high in *trans* fatty acids and this may be one of the reasons for high incidence of non communicable diseases in Fiji such as cardiovascular diseases [28] and diabetes [29].

IV. CONCLUSION

This is the first ever detailed study on *trans* fatty acid content of foods commonly sold in Fiji. A database of *trans* fatty acids for 64 foods has been developed, and this would be available at the University of the South Pacific's library. This database could be used to estimate the *trans* fatty acid intake of Fiji's population.

Sixty four food samples were analyzed using ATR-FTIR spectroscopy for the presence of *trans* fatty acids. A substantial number of products contained a total amount of *trans* fatty acid that was higher than the tolerable limit of 2% of total fats in force in Denmark, the only country in the world that has a legal limit for *trans* fatty acids. Hence, the public health authorities in Fiji should initiate the legal process to introduce a *trans* fatty acid limit for Fiji in order to reduce the incidence of non communicable disease.

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