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Variation in Fatty Acids Composition Including *Trans* Fat in Different Brands of Potato Chips by GC-MS

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Abstract

Twelve different brands of potato chips were analyzed for their fatty acid compositions with eminence on *trans* fatty acid (TFA) using GC-MS. Results of the present study showed that the dominant fatty acids were saturated fatty acids. Among the saturated fatty acids, palmitic acid (23.91–42.64 %) was found in greater amount in all analyzed chips samples. The amount of TFA's determined was ranged between (4.91–14.13 %). Although there was significant variation in the fatty acid profile of all analyzed chips samples but high amount of palmitic acid and *trans* fat was commonly observed. The results of present study clearly indicated fat used in the manufacturing of chips was partially hydrogenated and palm oil had major contribution. The high level of *trans* as well as saturated fat is startling issue for the health of consumers.

Keywords*:* Chips; Fatty acid profile; *trans* fatty acids; Chromatographic technique.

Introduction

Potato chips are considered as one of the most important products of food industry and they are the top choice in between meal munching for adults and children [1]. In addition, trends among consumers show that they are becoming more aware of the type and quality of food they are consuming as well as its impact on their health. The main parameter to control and monitor the quality of potato chips is based on the amount of fat and type of fatty acids especially *trans* fat contents. The quality of fats plays very important role in food processing technology. Fat oxidation is the main reason of deterioration in the quality of foods and can directly affect many quality characteristics such as flavor, color, texture, nutritive value, and safety of the food. The quality and dietary character of the edible oils has been the topic of concern among food scientists, nutritionists and consumers [2].

Saturated fatty acids (SFA's) are implicated in raising the blood cholesterol level and they show idiosyncratic differences in the ability to bring about an increase in serum cholesterol levels, palmitic acid is somewhat less subsequently, lauric and stearic acids are mildly hypercholesterolemic. The high consumption of saturated fatty acids and cholesterol is mainly responsible for hypercholester-olemia [3], which is in turn responsible for the increase of cardiovascular morbidity and mortality of ischemic origin [4]. In order to simulate the consistency of saturated fat, vegetable oils undergo a process of partial resaturation, known as hydrogenation. *trans* fatty acids (TFAs) are isomers generated by this process to an extent that will depend on processing conditions. The most common TFAs resulting from hydrogenation is elaidic acid (18:1 *n*9 *trans*). There are most favorable influence of monounsaturated fatty acids (MUFAs) on human health except TFAs. In one of the reported study it was quoted that there was no

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change in serum lipoprotein profiles due to TFA in the experimental diets [5]. However, investigation results were conflicted with the early findings [6] about the effect of TFA compared to SFAs and *cis*-MUFAs on serum low-density lipoprotein (LDL) and high-density lipoprotein (HDL) cholesterol levels in individuals fed natural mixed diets containing 10% of energy intake as any of those fats.

Fatty acids from butyric acid to capric acid are neutral with respect to serum cholesterol metabolism, in contrast polyunsaturated fatty acids (PUFAs) have been reported to reduce plasma cholesterol concentrations [7]. Usually vegetable oils contain double bond in cis configuration; however, some double bonds are in the *trans* configuration, so-called TFAs [8]. *TFAs* are also formed during industrial hydrogenation of vegetable oils [9]. There has been concern about the safety of TFA since partially hydrogenated oils were established as alternatives to lard and butter in processed foods [10]. Their results indicated that TFA had as many unfavorable effects on serum lipoprotein profiles as SFA; because TFA increased LDL cholesterol levels but also decreased HDL cholesterol levels. Many processed snack foods, margarines, shortenings, frying oils, baked products, confectionery products and deep-fried products are key component of partially hydrogenated oils [11]. Recently, the oil and fat group of National Centre of Excellence in Analytical Chemistry (NCEAC), University of Sindh, Pakistan published the important data about the quality of margarines and biscuits (Kandhro et al. 2008a; Kandhro et al. 2008b).

The aim of present study was to investigate the intake of amount of total fat and fatty acids especially *trans* fat obtained from chips by the consumers.

Experimental

Samples and reagents

Chips samples were purchased from local supermarkets of Hyderabad and Jamshoro, Pakistan. The selection of the brands was based on the highest consumption among those available in the market. All reagents, chemicals and solvents used were from E. Merck (Darmstadt, Germany). *Trans* and cis fatty acids methyl esters (FAMEs) standards (GLC 481-B and 607) were purchased from Nu-Check- Prep, Inc. (Elysian, MN).

Extraction of the lipids

Total lipid extraction was carried out by hexane extraction under the operating conditions specified in [12], and expressed as a percentage by mass of the product as received. Fat obtained from chips samples was transferred into 10 mL glass vials. The decanted samples were all frozen at -18 ^{0}C until further analysis.

Determination of fatty acid composition

FAMEs were prepared using IUPAC standard [13] method 2.301 for the determination of fatty acids composition of the chips samples. GC-MS chromatograms obtained were compared with National institute of standard technology (NIST) Library which give best information about the classification of fatty acid composition.

GC-MS conditions

The GC-MS analysis for FAMEs was performed on Agilent 6890 N gas chromatography instrument coupled with an Agilent MS-5975 inert XL mass selective detector and an Agilent autosampler 7683-B injector (Agilent Technologies, Little Fall, NY, USA). A capillary column HP-5MS (5% phenyl methylsiloxane) with dimension of 30 m, 0.25 mm i.d, 0.25 µm film thickness (Agilent Technologies, Palo Alto, CA, USA) was used for the separation of fatty acid methyl esters. The initial temperature of 150 ^{0}C was maintained for 2 min, raised to 230 ^{0}C at the rate of 4 ^{0}C/min, and kept at 230 ^{0}C for 5 min. The split ratio was 1:50, helium was used as a carrier gas with a flow rate of 0.8 ml/min. The injector and detector temperatures were 240 and 260 ^{0}C, respectively. The mass spectrometer was operated in the electron impact (EI) mode at 70 eV in the scan range of 50–550 m/z [14].

Calculations and statistical analyses

The identification of methyl esters were carried out by NIST and Willy libraries installed within GC-MS software. Two samples of each brands were collected and each sample was analyzed thrice and reported as mean (n = 2 x 3).

Results and Discussion

The fatty acid profile of the 12 selected brands of chips mostly consumed in Pakistan are given in the Table 1. Samples were coded as CB-1 to CB-12. SFAs including C12:0, C14:0, C16:0, C18:0 and C20:0 were identified and quantified. Among these C16:0 and C18:0 were the dominant, ranged between 23.91-42.64% and 3.57-9.36%, respectively. This clearly indicated that palm oil was frequently used in the preparation of chips. Furthermore, it was also observed that fatty acid profile of oils extracted from the chips had no matching with any single conventional oil. The SFAs were analyzed in chips varied from 14.9 to 50.4% with a mean value 40.7%. The sample CB-1 contained the least while CB-4 showed the highest amount of SFAs. Saturated fatty acids with the chain length of (C12:0–C16:0) carbon atoms have been reported to be atherogenic, stearic acid (C18:0) neutral, while oleic and polyunsaturated fatty acids (PUFAs) produced a blood lipid lowering effect [15-17].

Among the mono-unsaturated fats, the main analyzed fatty acids were C18:1n9 trans and C18:1n9 cis. The amount of these fatty acids were ranged between 4.91-14.13% (CB-4, CB-8) and 33.23-57.15% (CB-8, CB-1), respectively. The highest amount of TFAs indicated the partially hydrogenated oils were used in the production of chips samples. Oleic acid (C18:1n9) is considered to be responsible for lowering the LDL (bad) cholesterol levels. Similarly PUFAs have beneficial effects on normal health and chronic diseases, such as regulation of lipid levels [18] and cardiovascular [19]. Estimates were provided for food groups based on product type, the contribution to *trans*-fat intake is as follows: related products, fried potatoes 8%; potato chips, corn chips, popcorn (salty snacks) 5% [20]. In present study the determined amount of TFAs is higher than above said values in all analyzed samples except CB-4. PUFA has major importance for biological and nutritional value of food products. Thus, *trans* fat differences found between the present study and the other reported values could be attributable due to differences between countries product recipes or formulations rather than changes in manufacturing practices. While cis PUFAs (C18:2 n9, 12; C18:2 n8, 11 and C18:3 n9, 12, 15) fatty acids were analyzed in considerable amounts ranging from (4.0 to 10.26, 2.01 to 8.18 and 0.98 to 4.32) respectively. Among the long chain cis-MUFA (C20:1 n11) was also detected in considerable amount ranged from (0.22 to 1.16). Fig. 1 is the representative chromatogram of the analyzed chips sample.

The fatty acids groups and the important ratios are presented in Table 1. The cis-PUFAs which are nutritionally important were found in the range of 4.0–13.29%. The ratio of saturated to unsaturated FA in analyzed chips samples was found in between 0.18-1.02, which clearly indicated the high proportion of SFAs. The prevalence of unsaturated over SFAs (smaller ratio) is considered to be positive from the nutritional point of view. The ratio of trans/cis-FA represents the degree of formation of artificial TFA from the natural cis forms of unsaturated fatty acids of the chips samples and the ratio varied between 0.10 and 0.33, which corresponds to a higher content of TFA and showing that chips manufacturers are not serious to reduce the *trans* content in their product and still using the conventional technology in the processing and production of chips. These results also indicated that there was a great variation in the quality of local commercially available brands. The saturated+TFA fraction ranged from 28.63 to 57.80% and achieved a very high mean value of 50.68%. There is strong agreement among nutritional experts that intakes of TFAs and SFAs should be as minimum as possible to control the risk of coronary heart disease.

Table 1. **Saturated and unsaturated fatty acids composition (mean percentage – FAMEs) of Chips samples.**

Samples	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	CB-9	CB-10	CB-11	CB-12
C12:0	0.46±0.01	0.18±0.01	0.27±0.05	1.99±0.05	-	-	-	-	-	-	0.96±0.04	-
C14:0	0.64±0.02	0.76±0.02	1.32±0.04	-	0.51±0.02	0.59±0.02	0.94±0.04	0.51±0.02	1.96±0.05	1.09±0.05	1.86±0.05	0.58±0.02
C16:0	5.33±0.20	37.31±1.50	27.54±1.20	42.64±1.98	40.54±1.80	26.98±1.20	23.91±1.10	37.30±1.40	35.57±1.25	35.60±1.20	37.76±1.40	38.08±1.50
C18:0	8.12±0.31	5.87±0.24	8.40±0.24	5.49±0.20	3.58±0.08	9.36±0.40	9.00±0.40	4.71±0.10	8.31±0.40	6.52±0.20	7.5±0.30	3.57±0.05
C18:1n9*trans*	13.70±0.59	5.13±0.21	11.50±0.48	4.91±0.10	7.62±0.20	13.70±0.50	11.90±0.50	14.13±0.50	11.00±0.50	8.26±0.40	8.96±0.40	9.14±0.20
C18:1n9cis	57.15±2.50	41.26±1.65	39.26±1.56	37.01±1.41	38.45±1.50	37.58±1.20	45.22±1.25	33.23±1.40	33.33±1.20	39.31±1.50	38.94±1.50	39.53±1.40
C18:2 n9,12	10.26±0.51	-	-	-	-	7.32±0.20	7.41±0.30	-	5.50±0.20	7.27±0.20	4.00±0.10	-
C18:2 n8,11	2.01±0.05	8.18±0.21	7.94±0.24	6.20±0.20	6.53±0.30	-	-	6.07±0.20	-	-	-	6.78±0.30
C18:3 n9,12,15	1.02±0.04	0.98±0.02	2.12±0.05	1.03±0.05	1.51±0.05	3.31±0.08	1.18±0.05	2.04±0.04	4.32 ±0.10	0.53±0.01	-	1.20±0.05
C:20:0	0.35 ±0.01	0.25±0.01	0.46±0.02	0.21 ±0.01	0.29±0.01	0.18±0.01	0.24±0.01	1.15±0.05	-	1.38 ±0.05	-	-
C20:1 n11	0.92±0.04	-	1.16±0.05	0.41±0.02	0.95 ±0.04	0.95±0.02	0.22 ±0.01	0.85 ±0.04	-		-	1.10±0.05
Groups and ratio between the types of fatty acids from the composition of Chips samples.												
SFA	14.90	44.37	37.99	50.43	44.92	37.11	34.09	43.67	45.84	44.59	48.08	42.23
Total UFA	85.09	55.55	62.00	49.56	55.06	62.88	65.9	56.32	54.15	55.37	51.90	57.75

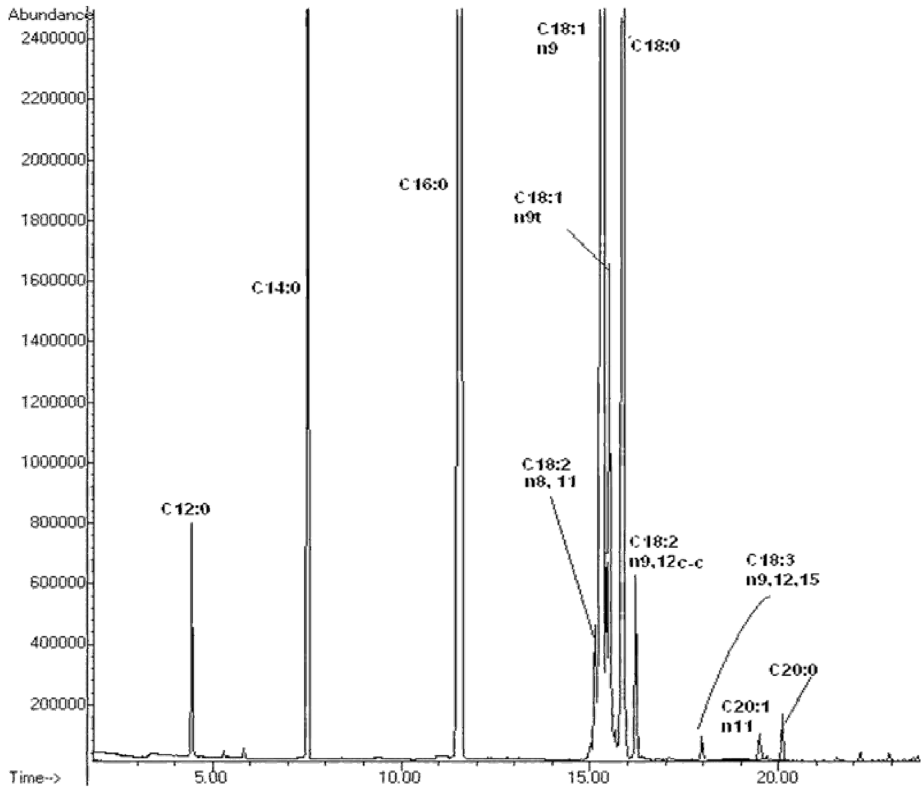

Figure 1. **Representative fatty acids Chromatogram of chips analysed by GC-MS.**

Table 2. **Total fat content, gram/serving of *trans* fatty acid.**

Samples	wt of sample (g)	Total fat g/100g	total fat g/serving	trans g/100 g	trans fat g/serving
CB-1	10.12	21.15±0.85	2.14	13.73	0.29
CB-2	10.13	19.75±0.63	2.00	5.13	0.10
CB-3	10.14	33.56±0.54	3.40	11.52	0.39
CB-4	10.12	25.48±0.81	2.58	4.91	0.13
CB-5	10.20	29.85±0.75	3.04	7.62	0.23
CB-6	10.15	37.13±1.20	3.77	13.72	0.52
CB-7	10.16	24.61±1.10	2.50	11.87	0.30
CB-8	10.10	28.35±1.20	2.86	14.13	0.40
CB-9	10.30	31.54±1.50	3.25	11.0	0.36
CB-10	10.40	34.85±0.75	3.62	8.26	0.30
CB-11	10.17	18.72±0.86	1.90	8.96	0.17
CB-12	10.21	25.41±0.68	2.59	9.14	0.24
Mean Values	10.18	27.53±1.12	2.81	10.0	0.29

The level of total fat content, total fat g/serving and *trans* g/serving are shown in Table 2. The total fat contents of the chips ranged from 18.72 to 37.13% with a mean value of 27.53%. The lowest and highest fat content was found in C-11 and C-6 respectively, these levels were comparably higher than the reported values [21], while total fat g/serving and total *trans* fats g/serving was ranged at 1.90 to 3.77 and 0.17 to 0.52 with a mean value of 2.81 and 0.29g, respectively in the same samples. The mean values of results indicated that from the 10.18g of chips contain 2.81g of total fat and 0.29g /serving of *trans* fat.

Conclusion

The results of this study indicated that the all analyzed samples contained considerable amounts of fat, SFA's and TFA's. Not only high level of fat and saturated fatty acids but also TFA is very dangerous for the health of consumers. Therefore, special attention is needed for the quality of fat used in the manufacturing of chips. Proper nutritional labeling of foods with special reference to the main fatty acid classes including TFA's contents is essential providing complete information to the consumers for their better selection. Using GC-MS, good resolution was achieved which helped for identification and accurate quantification of individual fatty acids.

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