

# Influence of the Addition of Flavoring on the Sodium Content of Fried Potato Chips and the Fatty Acid Profile

Paula Fernandes Montanher<sup>1</sup>, Luana Nascimento de Paula<sup>2</sup>, Fabio Augusto Garcia Coró<sup>2</sup>,  
Lucia Felicidade Dias<sup>2</sup>, Myka Reghiany Pedrão<sup>2</sup>, Nilson Evelazio de Souza<sup>2,\*</sup>

<sup>1</sup>Department of Chemistry, State University of Maringá, Av. Colombo, 5790, CEP 87020-900, Paraná State, Brazil

<sup>2</sup>Federal Technologic University of Parana, Av. Dos Pioneiros, 3131, CEP 86036-370, Londrina, Parana State, Brazil

**Abstract** The influence of the addition of flavorings on the sodium content and the fatty acid profile of fried potato chips, particularly of trans fatty acids and the centesimal composition, of fried potato chips was investigated. Three brands of two types of flavored fried potato chips (onion plus parsley and barbecue) and the traditional product were assessed. An increase in the sodium content was observed in all flavored products of all brands. Among the flavored products, brand B had the lowest values of sodium (0.40, 0.47 and 0.60 g 100 g<sup>-1</sup> of the unflavored product, onion and parsley, and barbecue, respectively). The total lipid (TL) values were high, ranging from 28 to 35%. All flavors of brand C had the lowest TL content. The fatty acids in the greatest amounts were palmitic acid (16:0), stearic acid (18:0), and oleic acid (18:2n-6). The amounts of trans fatty acids (TFA) were low and under 0.2 g per portion, the limit set by the regulation in force. Among the samples evaluated, brand C had the highest TFA contents, 92, 157, and 95 mg 100 g<sup>-1</sup> of food in the traditional, onion and parsley, and barbecue flavorings, respectively.

**Keywords** Fried Potato Chips, Trans Fatty Acids, Flavorings, Sodium

## 1. Introduction

One of the effects of globalization is undoubtedly new eating habits. More and more often industries are investing in ready or easy-to-prepare foods, to which significant amounts of sugar, salt, fat, food dyes, and flavorings are frequently added[1].

Eating Fried potato chips, one of the ready foods with great acceptability, is one of these new eating habits. Two of the negative effects of the excessive consumption of fried potato chips are their high fat and sodium contents.

Sodium is the main cation in the extracellular fluid and one of the main minerals in the plasma. Its function is mainly modulating the liquid exchange between several body compartments. It is also essential for the maintenance of the osmotic pressure of the blood, plasma and fluids. However, excessive consumption of sodium is related to the development of arterial hypertension, one of the major diseases of modern society[2, 3].

Excessive amounts of sodium are used by the food industry, very often to set off the loss of flavor due to the reduction of the fat content[4].

Besides the salt added to fried potato chips, flavorings may also be used to add flavor and sharpen and/or modify the flavor and aroma of foods. Besides flavor enhancers, such as monosodium glutamate, an amino acid naturally present in foods rich in proteins, and one of the main components responsible for the Umami flavor sensation, which is considered the fifth flavour, are also largely used[5].

While salt and aromas are intentionally added to the product, the high fat contents of fried potato chips result from the frying food processing. This processing involves simultaneous heat and mass transfer. The medium used in the heat transfer (oil or fat) becomes part of the product. The frying conditions determine the distribution of oil, the texture, and the characteristic final flavor of the food[6].

The oils and fats used in the frying process can undergo degradation reactions associated with the food moisture (hydrolytic reactions), the presence of oxygen (oxidative reactions), and heat (thermal reactions). These reactions lead to the formation of various products, many of which have deleterious effects on human health, such as the trans fatty acids (TFA)[7].

The objective of this study was to investigate the fatty acid composition of fried potato chips and the influence of the addition of flavorings on their sodium content.

## 2. Materials and Methods

\* Corresponding author:

nesouza@utfpr.edu.br (Nilson Evelazio de Souza)

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Three brands of potato chip were analyzed. Two, labeled A and C, are sold worldwide, and B is a Brazilian brand. The samples were purchased in local supermarkets between November 2009 and March 2010. Three flavors of each brand were analyzed in three lots with three units of each flavor. The three units of each lot were pooled and analyzed in triplicate. The packages of brands A and B had 100 g and brand C had 40 g.

The total lipids (TL) were extracted following the method published by Bligh and Dyer[8] and the fatty acid methyl esters were prepared by the Hartman and Lago method[9].

The fatty acids methyl ester were analyzed in gas chromatograph CP-3380 (Varian, USA) equipped with a flame ionization detection (FID) and a 100% cyanopropyl bonded silica capillary column CP-7420 (100 m, 0.25 mm i.d. and 0.25  $\mu\text{m}$  film thickness) (Varian, USA). The gas flow rates used were 1.4  $\text{mL}\cdot\text{min}^{-1}$  for the carrier gas ( $\text{H}_2$ ); 30  $\text{mL}\cdot\text{min}^{-1}$  for the auxiliary gas ( $\text{N}_2$ ), and 30 and 300  $\text{mL}\cdot\text{min}^{-1}$  for  $\text{H}_2$  and the flame synthetic air, respectively. The sample split rate was 1/80. The injector and detector temperatures were 240°C. The column temperature was kept at 197°C for 23 min, raised to 225°C at 20°C  $\text{min}^{-1}$  and held for 15 min.

The column conditions were optimized by Martin *et al.*[10] for the separation of trans fatty acid methyl esters.

The injections of 2- $\mu\text{L}$  volumes were performed in duplicate. The peak areas were determined with the software Workstation version 5.0 (Varian).

The fatty acid methyl esters were identified by comparison with the retention time of standards from Sigma (USA) and by spiking with standards for verification of the increase in the peak areas.

The fatty acid methyl esters were quantified in relation to the internal standard, methyl tricosanoate (23:0) from Sigma (USA). The quantities of the fatty acids in the samples were calculated using the equation proposed by Joseph and Ackman[11].

$$MX = \frac{A_X \cdot M_P \cdot F_{CT}}{A_P \cdot M_A \cdot F_{CEA}}$$

where:

$M_X$  = Mass of fatty acid X in  $\text{mg}\cdot\text{g}^{-1}$  of lipids.

$M_P$  = Mass of the internal standard in milligrams.

$M_A$  = Mass of the sample in grams.

$A_X$  = Area of fatty acid X.

$A_P$  = Area of the internal standard.

$F_{CT}$  = Theoretical correction factor.

$F_{CEA}$  = Factor of conversion of fatty acid methyl esters.

The moisture, ash, and crude protein content of the samples were determined by the AOAC method[12].

The samples were opened for the analysis of sodium by dry path and the readings were performed with a flame photometer from Analyzer®.

### 2.1. Statistical analysis

The results were submitted to variance analysis (ANOVA)

at 5% level of significance using Tukey's test in the software Statistica, version 7.0[13].

## 3. Results and Discussion

The contents of sodium found in fried potato chips are given in Table 1. It ranged from 0.40 to 0.76 g per 100 g of product. All three brands presented significant differences ( $P < 0.05$ ) in sodium contents for the addition of flavorings.

The increase in the amount of sodium in the flavored fried potato chips is related to the addition of flavor enhancers (monosodium glutamate, disodium inosinate, and disodium guanylate), which results in an increase in the salinity of the products[5]. The Brazilian regulations allow the use of food flavor enhancers[14] and set no limit to the amounts added. Amounts are added according to the flavor wanted.

**Table 1.** Sodium content in fried potato chips in g per 100 g of product

	Traditional	Onion and parsley	Barbecue
A	0.58 <sup>a</sup> ±0.109	0.73 <sup>b</sup> ±0.033	0.68 <sup>ab</sup> ±0.033
B	0.40 <sup>a</sup> ±0.002	0.47 <sup>a</sup> ±0.069	0.60 <sup>b</sup> ±0.047
C	0.54 <sup>a</sup> ±0.007	0.76 <sup>b</sup> ±0.004	0.63 <sup>c</sup> ±0.045

Results are mean  $\pm$  standard deviation of triplicate analyses of three lots ( $n = 9$ ). Different letters in the same line indicate significant difference by Tukey's test at 5% level

According to the World Health Organization[15], the recommended daily intake of sodium is 2 g (equivalent to 5 g of salt) for non-hypertensive individuals; for hypertensive individuals the recommended limit is 1 g of sodium per day.

Taking into consideration the WHO recommended values, the consumption of 100 g of the Brand C product with onion plus parsley flavoring (0.76g 100  $\text{g}^{-1}$ ) results in an intake very close to the daily limit for hypertensive individuals.

Table 2 gives the centesimal composition results of fried potato chips. The high amounts of total lipids, ranging from 28 to 37 g 100  $\text{g}^{-1}$  of product, stand out.

The results of the quantification of fatty acids in fried potato chips are given in Table 3, 4 and 5. The statistical analyses of the lots of all samples show a significant difference ( $p < 0.05$ ) in most fatty acids, which indicates the non homogeneity between the lots and standard deviation.

Various factors may lead to the formation of trans fatty acids, including high processing temperature during the oil deodorization and long processing time and high temperature during food frying[16, 17].

According to the product nutritional labels of all flavored fried potato chips investigated, they are irradiated for improved food conservation. Research indicates that irradiation may also lead to the formation of trans fatty acids[18].

**Table 2.** Proximal composition of fried potato chips

Flavoring	Brand	Total Lipids	Protein	Moisture	Ash	Carbohydrates	Calories
Traditional	A	33.93a ± 0.722	8.13a ± 0.450	1.69 ± 0.051	4.20 ± 0.300	52.05a ± 1.300	546.09a ± 7.146
	B	33.32 ± 1.574	7.93 <sup>a</sup> ± 0.594	1.22 ± 0.164	3.78 ± 0.168	54.85 ± 2.504	547.28 ± 7.839
	C	29.39 ± 0.335	6.15 <sup>a</sup> ± 0.438	2.24 <sup>a</sup> ± 0.072	3.16 <sup>a</sup> ± 0.074	58.84 ± 0.535	526.40 <sup>a</sup> ± 2.506
Onion and Parsley	A	34.47a ± 1.023	8.47 <sup>a</sup> ± 0.226	1.97 ± 0.095	4.40 ± 0.017 <sup>a</sup>	50.69ab ± 1.745	546.87ab ± 6.654
	B	33.05 ± 0.300	5.33b ± 0.219	1.20 ± 0.039	3.95 ± 0.180	56.46 ± 0.422	544.67 ± 2.329
	C	30.33 ± 1.078	5.80 <sup>a</sup> ± 0.192	2.00b ± 0.110	3.02 <sup>a</sup> ± 0.169	58.76 ± 1.113	532.16 <sup>a</sup> ± 6.25
Barbecue	A	36.67b ± 0.815	5.95b ± 0.241	1.90 ± 0.079	4.00 ± 0.403	51.48b ± 1.108	559.75b ± 4.010
	B	33.92 ± 0.143	5.49b ± 0.361	1.76 ± 0.393	4.14 ± 0.407	54.81 ± 1.960	545.62 ± 9.068
	C	28.13 ± 1.927	5.00b ± 0.076	2.30 <sup>a</sup> ± 0.037	4.32b ± 0.226	60.60 ± 1.136	512.88b ± 8.232

Results are mean ± standard deviation of triplicate analyses of three lots (n = 9). Different letters in the same line indicate significant difference by Tukey's test at 5% level

**Table 3.** Fatty acid contents (mg 100 g<sup>-1</sup>) of three brands of traditional flavor fried potato chips

Fatty acids	Traditional		
	Brand A	Brand B	Brand C
12:0	75 ± 3	91 ± 39	53 ± 3
14:0	226 ± 35	279 ± 69	174 ± 8
15:0	12ab ± 2	14b ± 1	9 <sup>a</sup> ± 2
16:0	13091 <sup>a</sup> ± 637	14847 <sup>a</sup> ± 1099	8250b ± 191
16:1n-9	9 ± 1	9 ± 1	8 ± 2
16:1n-7	30 ± 6	37 ± 9	34 ± 4
17:0	27 <sup>a</sup> ± 2	32 <sup>a</sup> ± 4	19b ± 0
18:0	1637 <sup>a</sup> ± 55	1824 <sup>a</sup> ± 159	114b ± 109
18:1t9	19 ± 3	26 ± 2	18 ± 5
18:1n-9	12477 ± 410	13305 ± 736	12908 ± 90
18:1n-7	302 ± 91	343 ± 57	313 ± 70
18:2c9,t12	24 <sup>a</sup> ± 2	26 <sup>a</sup> ± 4	33b ± 1
18:2t9,c12	22a ± 1	23 <sup>a</sup> ± 3	29b ± 0
18:2n-6	2756 ± 336	2875 ± 507	3954 ± 378
18:3 t9,c12,t15	6 ± 1	dq**	7 ± 0
*	5 ± 2	dq**	4 ± 0
18:3n-3	65 ± 19	64 ± 20	45 ± 10
20:0	125ab ± 13	138 <sup>a</sup> ± 12	94b ± 12
20:1n-9	42 ± 1	43 ± 2	41 ± 2
22:0	22 <sup>a</sup> ± 3	24 <sup>a</sup> ± 2	79b ± 13
24:0	25 <sup>a</sup> ± 4	27ab ± 4	37b ± 5
ΣSFA	15240 <sup>a</sup> ± 640	17278 <sup>a</sup> ± 1113	9856b ± 221
ΣPUFA	2820 <sup>a</sup> ± 336	2939ab ± 507	3999b ± 378
ΣMUFA	12860 ± 93	13738 ± 738	13305 ± 114
ΣTFA	76 <sup>a</sup> ± 4	76 <sup>a</sup> ± 5	92b ± 5
n-6	2756 <sup>a</sup> ± 336	2875 <sup>a</sup> ± 507	3954b ± 378
n-3	65 ± 19	63 ± 20	45 ± 10
n-6/n-3	44 <sup>a</sup> ± 14	46 <sup>a</sup> ± 17	90b ± 21

Results are mean ± standard deviation of triplicate analyses of three lots (n = 9). Different letters in the same line indicate significant difference by Tukey's test at 5% level. \*Isomers (18:3t9,c12,c15 and c9,t12,c15) of LNA \*\*dq: detected but not quantified. SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids, TFA: *trans* fatty acids. n-6 = omega-6 fatty acids, n-3: omega-3 fatty acids

**Table 4.** Fatty acid contents (mg 100 g<sup>-1</sup>) of three brands of onion and parsley flavored fried potato chips

Fatty acids	Onion and Parsley		
	Brand A	Brand B	Brand C
12:0	139 ± 39	112 ± 18	80 ± 4
14:0	218 <sup>ab</sup> ± 21	252 <sup>a</sup> ± 11	215 <sup>b</sup> ± 7
15:0	12 <sup>a</sup> ± 2	15 <sup>b</sup> ± 2	10 <sup>a</sup> ± 1
16:0	12767 <sup>a</sup> ± 453	13147 <sup>a</sup> ± 799	8305 <sup>b</sup> ± 344
16:1n-9	7 <sup>a</sup> ± 1	9 <sup>b</sup> ± 1	7 <sup>a</sup> ± 0
16:1n-7	27 <sup>a</sup> ± 2	35 <sup>b</sup> ± 4	38 <sup>b</sup> ± 2
17:0	22 <sup>a</sup> ± 2	23 <sup>a</sup> ± 1	16 <sup>b</sup> ± 1
18:0	1610 <sup>a</sup> ± 53	1365 <sup>b</sup> ± 38	1057 <sup>c</sup> ± 32
18:1t9	14 <sup>a</sup> ± 4	23 <sup>b</sup> ± 2	82 <sup>c</sup> ± 3
18:1n-9	12405 ± 302	12790 ± 794	12546 ± 472
18:1n-7	953 ± 354	1280 ± 131	1237 ± 98
18:2c9,t12	18 <sup>a</sup> ± 2	24 <sup>ab</sup> ± 8	35 <sup>b</sup> ± 0
18:2t9,c12	15 <sup>a</sup> ± 1	20 <sup>ab</sup> ± 8	30 <sup>b</sup> ± 0
18:2n-6	2886 <sup>a</sup> ± 74	2849 <sup>a</sup> ± 209	4474 <sup>b</sup> ± 186
18:3 t9,c12,t15	5 ± 1	dq**	6 ± 0
*	4 ± 1	dq**	5 ± 0
18:3n-3	62 <sup>a</sup> ± 2	73 <sup>b</sup> ± 4	50 <sup>c</sup> ± 1
20:0	121 <sup>a</sup> ± 5	92 <sup>b</sup> ± 0	67 <sup>c</sup> ± 2
20:1n-9	42 <sup>a</sup> ± 1	36 <sup>b</sup> ± 3	34 <sup>b</sup> ± 0
22:0	22 <sup>a</sup> ± 1	17 <sup>b</sup> ± 1	62 <sup>c</sup> ± 2
24:0	24 <sup>a</sup> ± 2	14 <sup>b</sup> ± 1	29 <sup>c</sup> ± 1
ΣSFA	14985 <sup>a</sup> ± 458	15038 <sup>a</sup> ± 800	9840 <sup>b</sup> ± 345
ΣPUFA	2949 <sup>a</sup> ± 74	2922 <sup>a</sup> ± 209	4524 <sup>b</sup> ± 186
ΣMUFA	13335 ± 465	14151 ± 804	13863 ± 482
ΣTFA	56 <sup>a</sup> ± 8	67 <sup>a</sup> ± 11	157 <sup>b</sup> ± 3
n-6	2866 <sup>a</sup> ± 74	2849 <sup>a</sup> ± 209	4474 <sup>b</sup> ± 186
n-3	62 <sup>a</sup> ± 2	73 <sup>b</sup> ± 4	50 <sup>c</sup> ± 1
n-6/n-3	46 <sup>a</sup> ± 9	39 <sup>a</sup> ± 3	89 <sup>b</sup> ± 4

Results are mean ± standard deviation of triplicate analyses of three lots (n = 9). Different letters in the same line indicate significant difference by Tukey's test at 5% level. \*Isomers (18:3t9,c12,c15 and c9,t12,c15) of LNA \*\* dq: detected but not quantified. SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids, TFA: trans fatty acids. n-6 = omega-6 fatty acids, n-3: omega-3 fatty acids

**Table 5.** Fatty acid contents (mg 100 g<sup>-1</sup>) of three brands of barbecue flavored fried potato chips

Fatty acids	Barbecue		
	Brand A	Brand B	Brand C
12:0	93 <sup>a</sup> ± 2	96 <sup>a</sup> ± 2	56 <sup>b</sup> ± 2
14:0	222ab ± 16	238 <sup>a</sup> ± 29	173 <sup>b</sup> ± 8
15:0	14 <sup>a</sup> ± 1	14 <sup>a</sup> ± 2	8 <sup>b</sup> ± 0
16:0	13517a ± 1331	13530 <sup>a</sup> ± 1524	7996 <sup>b</sup> ± 380
16:1n-9	14 <sup>a</sup> ± 1	15 <sup>a</sup> ± 0	11b ± 1
16:1n-7	40 ± 1	41 ± 3	40 ± 2
17:0	26 <sup>a</sup> ± 2	27 <sup>a</sup> ± 4	16 <sup>b</sup> ± 0
18:0	1465 <sup>a</sup> ± 36	1381 <sup>a</sup> ± 149	906 <sup>a</sup> ± 48
18:1t9	24 ± 3	37 ± 14	18 ± 1
18:1n-9	14443 <sup>a</sup> ± 605	13397ab ± 358	12245 <sup>b</sup> ± 632
18:1n-7	252 ± 22	268 ± 7	261 ± 27
18:2c9,t12	28 <sup>a</sup> ± 1	25 <sup>a</sup> ± 1	34 <sup>b</sup> ± 2
18:2t9,c12	25 <sup>a</sup> ± 1	22 <sup>a</sup> ± 1	30 <sup>b</sup> ± 2
18:2n-6	3001 <sup>a</sup> ± 201	2643 <sup>a</sup> ± 139	3980 <sup>b</sup> ± 231
18:3 t9,c12,t15	9 ± 0	dq**	8 ± 2
*	9 <sup>a</sup> ± 0	dq**	6 <sup>b</sup> ± 1
18:3n-3	81 <sup>a</sup> ± 6	66b ± 4	39 <sup>c</sup> ± 3
20:0	109 <sup>a</sup> ± 2	99 <sup>a</sup> ± 6	68 <sup>b</sup> ± 5
20:1n-9	43 <sup>a</sup> ± 1	39a ± 0	33 <sup>b</sup> ± 3
22:0	24 <sup>a</sup> ± 4	25 <sup>a</sup> ± 6	63 <sup>b</sup> ± 6
24:0	26ab ± 5	19 <sup>a</sup> ± 1	29 <sup>b</sup> ± 2
ΣSFA	15495 <sup>a</sup> ± 1332	15430 <sup>a</sup> ± 1531	9316 <sup>b</sup> ± 383
ΣPUFA	3082 <sup>a</sup> ± 201	2709 <sup>a</sup> ± 139	4020 <sup>b</sup> ± 231
ΣMUFA	15011 <sup>a</sup> ± 605	13759 <sup>ab</sup> ± 358	12581 <sup>b</sup> ± 632
ΣTFA	95 ± 3	85 ± 14	95 ± 4
n-6	3001 <sup>a</sup> ± 201	2643 <sup>a</sup> ± 139	3980 <sup>b</sup> ± 231
n-3	81 <sup>a</sup> ± 6	66 <sup>b</sup> ± 4	39 <sup>c</sup> ± 3
n-6/n-3	37 <sup>a</sup> ± 3	40 <sup>a</sup> ± 3	101 <sup>b</sup> ± 9

Results are mean ± standard deviation of triplicate analyses of three lots (n = 9). Different letters in the same line indicate significant difference by Tukey's test at 5% level. \*Isomers (18:3t9,c12,c15 and c9,t12,c15) of LNA \*\* dq: detected but not quantified. SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids, TFA: trans fatty acids. n-6 = omega 6 fatty acids, n-3: omega-3 fatty acids

The nutritional labels of the products investigated informed zero contents of trans fatty acids. Foods are considered to have zero trans fatty acids when their content is lower or equal to 0.2 g per helping [19]. Thus, the information in the food labels of all products was confirmed, as none presented more than 0.2 g per portion of 25 g (label portion size).

The addition of flavorings to fried potato chips was found to be associated with the sodium content, which was high in all the investigated brands.

The total trans fatty acid contents of the three brands of fried potato chips were low and within the regulation values. A trans fatty acid content reduction was also observed over the years, with the consequent improvement of the product. However, due to the large amounts of saturated fatty acids and total lipids in fried potato chips, moderation in their consumption is advisable.

The replacement of hydrogenated vegetable fat resulted in a decrease in trans fatty acids, as demonstrated by the samples analyzed; however, it also increased the saturated fatty acid content.

The n-6/n-3 ratio of all samples was above the literature recommendation, which ranges from 2:1 to 3:1 [20] and 5:1 to 10:1 [21]. The current ratio ranged from 39 to 100, with brand C presenting the highest values for all flavors.

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