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CASE STUDIES

The increase of atherogenic index on fatty acids composition as a consequence of *trans* fat acids reduction in industrialized foods: the Brazilian scenery

Aumento do teor de ácidos aterogênicos como consequência da redução da gordura trans *em alimentos industrializados: o cenário brasileiro*

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Abstract

The use of fats with a low melting point is attractive to the food industry, as it contributes to improving the texture, color and stability characteristics of the food. These fats are obtained from vegetable oils through some processes such as hydrogenation or interesterification. However, the partial hydrogenation process leads to the formation of *trans* fat. In several countries, actions have been taken to eliminate the presence of elaidic acid, a *trans* fatty acid (C18: 1t) from processed foods. This *trans* fatty acid and palmitic acid, a common saturated fatty acid (C16: 0) are proven to be atherogenic. The aim of this work was to evaluate the composition of fatty acids of 39 types of commercialized foods in Brazil, including cookies, snacks, wafers, instant noodles, frozen sandwiches and pizzas, mixtures for food preparation, microwave popcorn, margarines, spreadable cheeses and pastry dough. The lipids were extracted and their Fatty Acid Methyl Esters (FAMEs) identified by Gas-Chromatography (GC). The fatty acids found in greater quantity were oleic, linoleic and palmitic acids; whereas the *trans* fatty acids were detected in 51.3% of the samples. On the other hand, when *trans* fast were reduced in some foods, it could be observed increases in the palmitic acid (C16:0) content. This high content of palmitic acid is justified by the addition of palm oil and its derivatives, which can be used in interesterified oil mixtures or can be directly used in industrialized food formulations, even without interesterification. Governments and organizations in favor of human health should be aware that the use of dietary fatty acids which compromise the atherogenic index is not a healthy alternative. Consumers should therefore be alerted to the risk of consuming foods containing these fats until the food industry is banned from using them or finds healthier alternatives for making food.

Keywords: Elaidic acid; Saturated fat; Fatty acid profile; Atherogenic fatty acids; Industrialized foods; Food analysis.

Resumo

O uso de gorduras com baixo ponto de fusão é atraente para a indústria de alimentos, pois contribui para melhorar as características de textura, cor e estabilidade dos alimentos. Essas gorduras são obtidas a partir de óleos vegetais por meio de processos como hidrogenação ou interesterificação. No entanto, o processo de hidrogenação parcial leva à formação de gordura *trans*. Em diversos países, vêm ocorrendo ações no sentido de eliminar a presença do ácido graxo elaídico (C18:1t) dos alimentos industrializados. Esse ácido graxo *trans* e o ácido graxo saturado palmítico (C16:0) são comprovadamente aterogênicos. O objetivo deste trabalho foi avaliar a composição de ácidos graxos de 39 tipos de alimentos comercializados no Brasil, incluindo biscoitos, salgadinhos, bolachas, macarrão instantâneo, sanduíches e pizzas congeladas, mistura para preparo de alimentos, pipoca de micro-ondas, margarinas, requeijões e massa de pastel. Os lipídios foram extraídos, e seus FAMES- Fatty Acid Methyl Esters, identificados por cromatografia gasosa. Os ácidos graxos encontrados em maior quantidade foram oleico, linoleico e palmítico, enquanto os ácidos graxos *trans* foram detectados em 51,3% das amostras. Por outro lado, em alguns alimentos a gordura *trans* foi reduzida, mas foram observados aumentos no teor de ácido palmítico (C16:0), justificáveis pela adição de óleo de palma e de seus derivados, que podem ser usados em misturas interesterificadas ou podem compor diretamente formulações de alimentos industrializados, mesmo sem interesterificação. Governos e organizações em prol da saúde humana devem atentar para o fato de que o uso de ácidos graxos aterogênicos não é uma alternativa saudável. Os consumidores devem, portanto, ser alertados para o risco do consumo de alimentos contendo essas gorduras, até que as indústrias de alimentos sejam proibidas de utilizá-las ou encontrem alternativas mais saudáveis para a fabricação dos alimentos.

Palavras-chave: Ácido elaídico; Gordura saturada; Perfil de ácidos graxos; Ácidos graxos aterogênicos; Alimentos industrializados; Análise de alimentos.

1 Introduction

The practicality of consuming processed foods is unquestionable. These types of foods are being consumed even as the main meals, regardless of social class and age group and, particularly in Brazil, this is very worrying because these foods are included in school snacks for kids. Basically, these foods include cookies, frozen pizzas, microwave popcorn, instant noodles, margarines, spreadable cheeses and other regional foods, such as cheese bread that is a typical food from the state of Minas Gerais (MG-Brazil), that is prepared with cassava root starch (*Manihot esculenta* Crantz) and regional cheese, and then roasted in the form of small round rolls. In addition, according to the preparation of these processed foods, it can also be used tradicionally vegetable oils and fats obtained by partial hydrogenation or chemical interesterification resulting consequently in an increase in the levels of *trans* fatty acids (elaidic acid, a *trans* fatty acid (C18: 1t) or saturated fatty acids (atherogenics) which are known to be harmful to health (Afonso et al., 2016).

The consumption of *trans* fatty acids raises the level of LDL cholestrol (Low Density Lipoprotein) in the blood, while reducing the level of HDL cholestrol (High Density Lipoprotein), which has a negative correlation with coronary diseases (Mensink & Katan, 1990). Such changes in the profile of these lipoproteins contribute to the deposition of fat in the arteries, favoring the formation of the atheroma plaque as well as its inflammatory process, hindering the blood flow, or even causing total obstruction of the artery (Rafieian-Kopaei et al., 2014). In this way the intake of *trans* fatty acids increases the risk of developing cardiovascular diseases (Niu et al., 2005; Mensink et al., 2003).

In the last years, global discussions about these health hazards have influenced a change in the profile of consumers for healthier foods and consequently some industries have implemented alternative processes to partial hydrogenation (World Health Organization, 2018) such as chemical or enzymatic interesterification, as well as, the addition of palm oil and its derivates and/ or saturated fatty acids (palmitic fatty acid) to reduce or avoid the *trans* fat content in foods. According to Farfán et al. (2015), chemical interesterification is relatively inexpensive, readily available, and easy to use and scale up the process, however, it lacks specificity, offering little or no control over the position in which fatty acids are distributed in the final product. On the other hand, enzymatic interesterification comprises high specificity by allowing to attain not only products free of *trans* fat but also structured fat and oils, as well as offering milder reaction conditions and thus lowers degradation of Long-Chain Polyunsaturated Fatty Acids (LC-PUFAs). However, the chemical interesterification can be more attractive than the enzymatic, particularly for low value-added products.

Overall, there is a global tendency to reduce or eliminate *trans* fat consumption and some countries have taken a prominent position, including the United States of America (USA), seeing that the Food and Drug Administration (FDA) predetermines zero *trans* fat in the production of processed foods, while the European Union (EU) regulates 2%/g of total fat as the maximum *trans* fat in foods. Brazil is following these changes and the Brazilian Health Regulatory Agency (in Portuguese *Agência Nacional de Vigilância Sanitária* (ANVISA)) has recently made a public inquiry and is making arrangements for regulating the *trans* fat content in foods, so the Brazilian scenery is about to change. In this context, ANVISA approved in December 23th, 2019 the resolution RDC N° 332 that provides a gradual reduction of *trans* fat in foods, however, from January 1, 2023 it is stated to stop the production, import, use and supply of partially hydrogenated oils and fats for use in foods and foods formulated with these ingredients (Brasil, 2019). Thus, ANVISA is aligned with The World Health Organization (WHO) movement, that is, with the "REPLACE TRANS FAT" program, which provides a strategic approach to eliminate industrially produced *trans* fat from the national food supply, with the goal of global elimination by 2023 (World Health Organization, 2019).

With such *trans* fats hazards, researchs for their reduction in the food formulations have been increasingly observed (Ahmadi et al., 2008; Farfán et al., 2015; Afonso et al., 2016; Stahl et al., 2018; Patel et al., 2020). Thus, to avoid the use of *trans* fats, it is noted that interesterified fats with saturated fatty acids, palm oil and its derivatives have been used (D'Agostini & Gioielli, 2002; Mba et al., 2015; Dias et al., 2015) in order to obtain physico-chemical properties similar to hydrogenated fats and, thus, to use the term "zero *trans*" to attract the consumer. However, these fats contain higher levels of saturated fatty acids, especially palmitic acid that is considered an atherogenic agent (Lottenberg, 2009; Afonso et al., 2016). These fatty acids contribute to the formation of the atheroma plaque because they raise the LDL level in the blood. In this way, they increase the risk of cardiovascular diseases with a similar effect to *trans* fats (Lottenberg, 2009; Afonso et al., 2016; Fattore & Fanelli, 2013).

In this context, the aim of this work was to quantify the total fat contents and identify the fatty acid profiles in several processed foods, collected in Brazil, whose manufacture requires the use of lipidic ingredients, as well as investigating the levels of *trans* fats and atherogenic agents by verifying the information declared in their labels.

2 Materials and methods

2.1 Sample collection

Food samples were purchased in aleatory way from supermarkets in the Northern of the state of Rio de Janeiro (RJ), Brazil. Thus, 16 types of processed foods were collected considering two to four samples for each product with different brands from small, medium and multinational industries, totaling 39 samples. Therefore, the following products were included, such as: sweet cookies and savory biscuits with stuffing and without stuffing, salty snacks, frozen snacks and pizzas, popcorn, spreadable cheese, margarine and mixtures for cake and cheese bread preparation. These products contain hydrogenated vegetable fat, vegetable fat, interesterified fat, palm fat, vegetable oil, mixed vegetable oils, margarine or some other lipidic components, and it could be noted that these informations were declared in their label food composition. The collected products were quickly analyzed to avoid degradation. However, when storage was required, this was just for short time and under temperature conditions established by the producer.

2.2 Sample preparation

The extraction and quantification of the lipids was performed according to the method described by Bligh & Dyer (1959). The solid foods were crushed with the entire contents of the package, including seasonings, microwave popcorn and instant noodles. While the composition of the obtained lipids was determined by Gas-Chromatography (GC) throught the Fatty Acid Methyl Esters (FAMEs) using 50 mg of the lipids as described by AOAC (Association of Official Analytical Chemists, 2001).

2.3 Determination of the fatty acids

The fatty acids were determined by GC (Shimadzu CG-2014) equipped with a programmed split/splitless injector, Flame Ionization Detector (FID) and capillary column (100m × 0.25 mm × 0.20 µm film) using Helium as carrier gas. The split ratio was 1:10. The oven temperature was programmed from 80 °C to 250 °C. The injector and detector temperatures were 260 °C. For standards, the Supelco FAME blend of 37 components were used. All reagents used in the chemical analyzes were purchased from the Sigma-Aldrich.

The concentration of each fatty acid in the samples was determined by Equation 1 after the internal normalization of the data. This equation adopts a correction factor (Holland et al., 1997) that eliminates the glycerol mass presents in the lipid extract.

$$FA = \frac{PA \times G \times F}{100} \quad (1)$$

where "FA" is the fatty acid content in the samples (g 100 g^{-1}); "PA" is the percentage of the area of each peak obtained in the standard chromatograph; "G" is the fat content of the sample (g 100 g^{-1}) and "F" is the correction factor (0.91).

3 Results and discussion

According to this study, it could be considered 16 types of processed foods from different brands in order to evaluate experimentally the total fat, fatty acid profiles and essencially *trans* fat content in these products. Then, the obtained results (Tables 1 to 3) were compared to the nutritional information declared in the label of these commercial foods to verify inconsistences. In this context, Tables 1 shows the saturated fatty acids content in the analyzed foods. As can be observed, palmitic fatty acid (C16:0) was detected in greater quantity with levels between 0.2 to 9.44 wt%/ wt of foods. On the other hand, the saturated fatty acids detected in less quantity such as capric acid (C10:0) and arachidic acid (C20:0) were just identified in some foods and in less expressive amounts. Then, these acids were quantified as "others" in Table 1. In addition, stearic acid was also detected, however, it has no atherogenic effect when consumed.

Table 1. Saturated fatty acids content by 100 grams of foods for the evaluated industrial products.

Industrialized Foods	n	Saturated Fat	C4:0	C8:0	C12:0	C14:0	C16:0	C18:0	Others
Corn chips	2	4.32 ± 2.94	0.00	0.00	0.28 ± 0.32	0.17 ± 0.15	3.53 ± 2.45	0.16 ± 0.22	0.00
Wheat snacks	4	3.04 ± 1.67	0.03 ±0.04	0.07 ±0.11	0.02 ± 0.04	0.05 ± 0.06	2.54 ± 1.55	0.31 ± 0.31	0.01 ± 0.00
Salty crackers stuffed	2	10.72 ± 1.10	0.00	0.07 ±0.10	1.41 ± 1.62	0.60 ± 0.33	6.95 ± 1.78	1.59 ± 0.69	0.05 ± 0.02
Stuffed sugar cookies	2	7.38 ± 0.35	0.04 ±0.05	0.00	0.25 ± 0.23	0.18 ± 0.09	5.33 ± 0.56	1.58 ± 0.53	0.00
Unstuffed sweet cookies	2	4.71 ± 2.90	0.00	0.00	0.10 ± 0.02	0.20 ± 0.05	3.82 ± 3.08	0.53 ± 0.17	0.05 ± 0.02
Stuffed wafer	2	11.15 ± 1.26	0.06 ±0.08	0.03 ±0.04	0.16 ± 0.09	0.27 ± 0.00	9.44 ± 1.11	1.16 ± 1.12	0.03 ± 0.02
Mini cake	2	6.66 ± 1.75	0.08 ±0.03	0.04 ±0.01	0.59 ± 0.67	0.30 ± 0.20	4.02 ± 0.08	1.59 ± 0.96	0.00
Instant noodles	2	6.06 ± 0.11	0.09 ±0.01	0.06 ±0.00	0.04 ± 0.00	0.14 ± 0.01	5.24 ± 0.11	0.50 ± 0.01	0.00
Frozen Sandwich	2	2.46 ± 0.58	0.01 ±0.02	0.00	0.04 ± 0.02	0.07 ± 0.06	1.50 ± 0.28	0.71 ± 0.37	0.12 ± 0.05
Microwave popcorn	3	7.57 ± 2.49	0.05 ±0.03	0.01 ±0.02	0.54 ± 0.72	0.27 ± 0.22	5.12 ± 0.69	1.50 ± 1.39	0.04 ± 0.01
Frozen pizza	2	1.87 ± 1.08	0.01 ±0.02	0.02 ±0.03	0.07 ± 0.06	0.24 ± 0.23	1.10 ± 0.62	0.41 ± 0.10	0.02 ± 0.01
Cheese bread mix	2	5.16 ± 3.86	0.00	0.00	0.27 ± 0.28	0.83 ± 1.12	2.64 ±2.07	1.22 ± 1.15	0.17 ± 0.03
Cake mix	3	2.27 ± 1.14	0.04 ±0.03	0.00 ±0.01	0.05 ± 0.02	0.05 ± 0.02	1.15 ± 0.47	0.76 ± 0.32	0.21 ± 0.09
Margarine	3	14.30 ± 6.53	0.11±0.09	0.08 ±0.05	2.61 ± 1.52	0.88 ± 0.50	6.21 ± 2.60	3.98 ± 1.78	0.32 ± 0.07
Spreadable cheese	4	14.08 ± 3.28	0.00	0.00	0.79 ± 0.12	2.77 ± 0.54	7.30 ± 1.78	2.72 ± 0.96	0.40 ± 0.09
Pastry dough	2	0.32 (0.14)	0.00	0.00	0.01 ± 0.01	0.01 ± 0.01	0.20 ± 0.04	0.10 ± 0.03	0.00

n – is related to the samples number referent to different commercial brands.

Table 2 shows unsaturated fatty acids content in the analyzed samples and also the *trans* fats found in some foods. As can be observed, the detected fatty acids in greater quantities were oleic acid (18:1) and linoleic acid (C18:2), whereas the smallest quantities were related to myristoleic acid (C14:1), γ-linolenic (C18:3-n6) and the α-linolenic acid (C18:3-n3) in some foods and also included as "others" in Table 2. In addition, two other aspects should be observed: a) moderate values of elaidic acid, a *trans* fatty acid (C18:1t), which it is the main *trans* fatty acid formed during partial hidrogenation in industrial processes, was detected in several foods, and also the linolelaidic acid (C18:2t), detected in small quantities, was included in the column referent to total *trans* fat; and b) the α-linolenic acid, that is essential for human health, was detected in very low quantity.

Table 2. Unsaturated fatty acids content expressed in g/100 g of food for the evaluated industrial products.

Industrialized Foods	n	Unsaturated Fat	Trans Fat	C16:1	C18:1	C18:1-t	C18:2	C20:1	Others
Corn chips	2	7.87 ± 2.17	0.00	0.00	6.37 ± 1.80	0.0 ± 0.00	1.47 ± 0.33	0.03 ± 0.04	0.00
Wheat snack	4	12.80 ± 7.05	0.08 ± 0.15	0.03 ± 0.03	5.05 ± 2.16	0.08 ± 0.15	7.34 ± 5.92	0.37 ± 0.70	0.02 ± 0.01
Salty crackers stuffed	2	09.31 ± 1.49	0.17 ± 0.05	0.00	5.18 ± 0.04	0.17 ± 0.05	3.97 ± 1.52	0.15 ± 0.06	0.00
Stuffed sugar cookies	2	7.53 ± 0.43	0.09 ± 0.12	0.00	5.55 ± 0.62	0.09 ± 0.12	1.93 ± 0.12	0.00	0.05 ± 0.03
Unstuffed sweet cookies	2	13.12 ± 10.1	0.00	0.00	10.36 ±8.18	0.00	2.69 ± 1.85	0.07 ± 0.10	0.00
Stuffed wafer	2	12.73 ± 0.01	0.00	0.00	9.81 ± 0.88	0.00	2.89 ± 0.94	0.03 ± 0.05	0.00
Mini cake	2	6.63 ± 0.87	0.00	0.00	4.49 ± 0.14	0.00	2.01 ± 0.65	0.09 ± 0.13	0.09 ± 0.02
Instant noodles	2	6.79 ± 0.07	0.00	0.00	5.28 ± 0.05	0.00	1.51 ± 0.02	0.00	0.00
Frozen sandwich	2	3.64 ± 0.57	0.44 ± 0.08	0.05 ± 0.09	3.28 ± 0.43	0.44 ± 0.08	1.22 ± 0.04	0.06 ± 0.01	0.00
Microwave popcorn	3	5.88 ± 1.26	1.13 ± 1.90	1.35 ± 2.34	3.14 ± 2.54	1.13 ± 1.90	1.33 ± 1.11	0.06 ± 0.02	0.00
Frozen pizza	2	2.96 ± 1.15	0.17 ± 0.07	0.04 ± 0.03	1.26 ± 0.42	0.17 ± 0.07	1.50 ± 0.63	0.14 ± 0.06	0.01 ± 0.01
Cheese bread mix	2	2.70 ± 0.62	0.75 ± 0.78	0.11 ± 0.16	2.25 ± 0.54	0.71 ± 0.73	0.29 ± 0.14	0.00	0.13 ± 0.02
Cake mix	3	2.01 ± 0.68	0.49 ± 0.42	0.00	1.22 ± 0.65	0.49 ± 0.42	1.10 ± 0.95	0.06 ± 0.10	0.00

Table 2. Continued…

Industrialized Foods	n	Unsaturated Fat	Trans Fat	C16:1	C18:1	C18:1-t	C18:2	C20:1	Others
Margarine	3	35.13 ± 11.9	0.05 ± 0.08	0.00	9.79 ± 3.62	0.05 ± 0.08	22.81 ± 7.44	2.37 ± 0.98	0.16 ± 0.05
Spreadable cheese	4	6.87 ± 2.40	0.32 ± 0.26	0.31 ± 0.24	6.15 ± 2.64	0.32 ± 0.26	0.32 ± 0.07	0.03 ± 0.07	0.13 ± 0.07
Pastry dough	2	0.71 ± 0.38	0.04 ± 0.06	0.00	0.22 ± 0.04	0.08 ± 0.06	0.34 ± 0.48	0.03 ± 0.04	0.13 ± 0.06

n – is related to the samples number referent to different commercial brands.

The α -linolenic acid was found only in 5.4% of the samples with contents between 0.02% and 0.15% (wheat snack comprising 0.04%; stuffed sugar cookie 0.11%; mini cake 0.05%; cheese bread mix 0.09%; and also, two samples of margarine (0.02 and 0.15%). These industrialized foods contain one of the essential fatty acids for human health. On the other hand, the omega-3 family has been found in few vegetable oils, among which are the soya, canola and linseed (Zambiazi et al., 2007). This fatty acid should be present in the nourishment in less than 0.5% of the total consumed energy, which implies in less than 1.1 g in a 2000 kcal diet (World Health Organization, 2008). Its high content in relation to saturated fatty acids reduces the atherogenic index of the food (Abramovič et al., 2018).

Trans fatty acid, predominantly elaidic acid, could be found in more than half of the analyzed foods, i.e., in 20 of the 39 samples studied, but in all cases in concentrations below 4 g/100 g of food. Figure 1 shows, by illustrative way, the chromatographic profile of the coconut and chocolat cake mix, cheese bread mix, microwave popcorn, pastry dough and frozen sandwich samples that presented the highest content of elaidic fatty acid ranging around 7 to 21% approximately, in relation to the total value of fatty acids in foods.

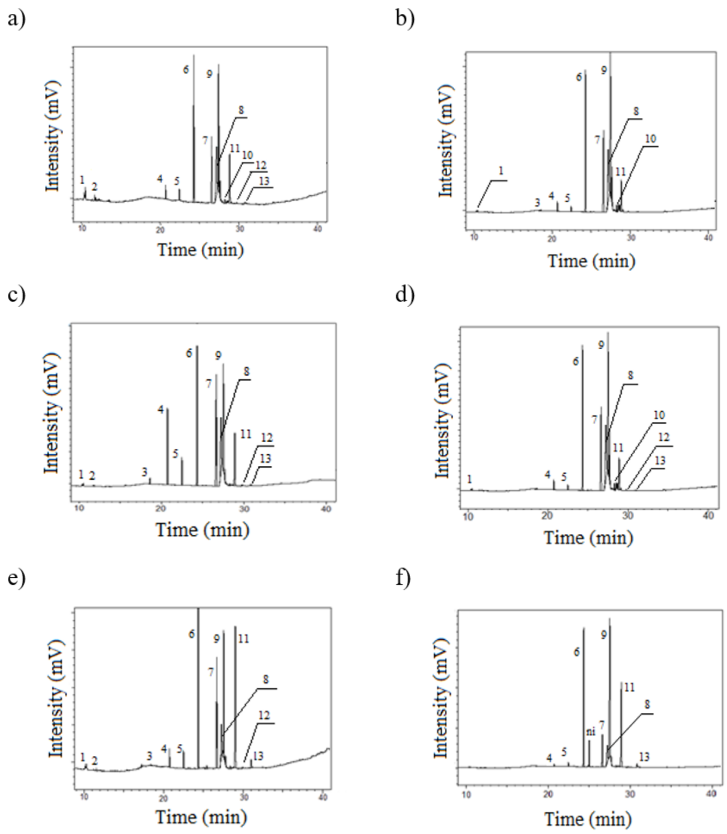

Figure 1. Atherogenic index and *trans* fatty acids detected in several foods by Gas Chromatography (GC): a) coconut cake mix; b) chocolate bread mixture, c) microwave popcorn; d) cake mix; e) pastry dough and f) frozen sandwich. Fatty acids identification: 1- Butyric acid (C4:0); 2- Caproic acid (C6:0); 3- Capric acid (C10:0); 4- Lauric acid (C12:0); 5- Myristic acid (C14:0); 6- Palmitic acid (C16:0); 7- Stearic acid (C18:0); 8- Elaidic acid (*trans*-9-octadecenoic acid); 9- Oleic acid (C18:1); 10- Linolelaidic acid (omega-6 *trans* fatty acid); 11- Linoleic acid (C18:2); 12- Arachidonic acid (C20:0) and 13- Linolenic acid (C18:3).

On the other hand, some foods that are traditionally cause for concern due to their impact on health either by the form of preparation and/or their nutritional composition, such as snacks, margarines and some stuffed biscuits, among others, presented values of elaidic acid below 1.0%, which is not very expressive from a nutritional and public health (Table 3).

Table 3. Total fat and fatty acids content including elaidic acid in relation to the total fatty acids for each analyzed food.

Foods	*Total fat (g)	Fatty acid content (%)				Declared ingredients in the food labels
		C16:0	C18:1	C18:2	C18:1-t	
Corn chips	13.4 ± 0.8	28.9 ± 18.3	52.8 ± 18.1	12.1 ± 3.4	0.00	Palm, soybean and sunflower oil
Wheat snack	17.6 ± 9.3	15.4 ± 8.2	38.2 ± 27.6	40.3 ± 19.7	0.48 ± 0.9	Soybean and sunflower oil, vegetable fat
Salty crackers stuffed	22.6 ± 0.7	33.7 ± 7.5	25.2 ± 0.6	19.2 ± 6.7	0.82 ± 0.2	Vegetable fat and hydrogenated vegetable fat
Stuffed sugar cookies	16.5 ± 0.3	35.4 ± 3.1	36.8 ± 3.5	12.8 ± 1.0	0.59 ± 0.8	Vegetable fat and vegetable oil
Unstuffed sugar cookies	19.7 ± 7.8	26.9 ± 27.9	53.0 ± 24.6	14.1 ± 4.7	0.00	Sunflower oil and interesterified vegetable fat
Stuffed wafer	26.2 ± 1.4	39.5 ± 2.6	41.0 ± 1.5	12.2 ± 4.6	0.00	Vegetable fat
Mini cake	14.7 ± 2.9	30.8 ± 6.7	34.2 ± 5.7	14.9 ± 1.9	0.00	Vegetable fat and hydrogenated vegetable fat
Instant noodles	14.1 ± 0.2	40.8 ± 0.3	41.1 ± 0.2	11.7 ± 0	0.00	Vegetable fat
Frozen sandwich	7.3 ± 1.4	22.8 ± 0.1	34.6 ± 0	18.8 ± 3.0	6.7 ± 0.1	Vegetable fat and hydrogenated vegetable fat
Microwave popcorn	16.7 ± 4.6	35.0 ± 8.2	24.2 ± 16.4	10.4 ± 9.0	5.7 ± 9.4	Vegetable fat
Frozen pizza	5.5 ± 2.4	21.2 ± 3.3	25.6 ± 2.6	30.0 ± 0.4	4.1 ± 3.1	Soybean oil
Cheese bread mix	9.8 ± 3.6	27.1 ± 13.1	25.8 ± 3.5	3.8 ± 2.9	10.1 ± 11.8	Vegetable fat
Cake mix	5.4 ± 1.6	22.8 ± 2.4	23.9 ± 6.2	17.0 ± 20.3	10.5 ± 10.3	Vegetable fat and hydrogenated vegetable fat
Margarine	54.7± 20.1	12.2 ± 1.3	19.7 ± 1.2	46.4 ± 2.7	0.1 ± 0.1	vegetable oil, interesterified vegetable oils
Spreadable cheese	23.5 ± 6.3	34.5 ± 1.8	27.9 ± 6.1	1.2 ± 0.9	1.6 ± 0.9	Milk cream, hydrogenated vegetable fat and butter
Pastry dough	1.2 ± 0.2	18.2 ± 6.0	19.4 ± 0.4	40.0 ± 21.1	4.1 ± 5.8	Swine fat and vegetable fat

*Total fat content refers to any lipid fraction extracted according to the Bligh and Dyer method (Bligh & Dyer, 1959).

In addition, the total fat content in the analyzed foods (Table 3) varied from 1.2 to 54.7% for pastry dough and margarine, respectively, followed by stuffed wafers (26.2%) and spreadable cheese (23.5%). These data are consistent with several authors which attribute 59.4% of fat to margarine (Pérez-Farinós et al., 2016), 20.16% of fat to stuffed wafers, cookies and biscuits (Albuquerque et al., 2018) and 23.4% of fat to spreadable cheese (Universidade Estadual de Campinas, 2011), respectively.

According to Brazilian legislation, nutritional information data specified in the industrialized foods label may be 20% above or below from the real value (Brasil, 2003). In this sense, the total fat content declared on the nutritional labels of the sixteen different types of evaluated foods was consistent with those determined experimentally in this work. However, an undesirable situation was observed in relation to the total fat content declared on the labels of half of the spreadable cheese and a kind of sugar cookies without stuffed whose detected values were higher than reported in their samples.

Thus, the situation of *trans* fat was once more dramatic. At the end of the 20th century and the beginning of the 21st century, it could be detected high levels of *trans* fatty acids in foods, for example, Mario Fernández & Juan (2000) reported microwave popcorn with 46% of *trans* fat and Tavella et al. (2000) found margarines with approximately 38% of *trans* fat. However, as of 2010, there was a significant reduction in the concentration of this fatty acid in foods from several countries (Roe et al., 2013; Pérez-Farinós et al., 2016; Albuquerque et al., 2018).

Brazilian law does not impose limits on the use of *trans* fats, however, industries have reduced their use probably due to changes in the consumers profile that have been looking for healthier foods, rejecting products with *trans* fat content. On the other hand, with the reduction of *trans* fat there has been an increase in the presence of saturated fatty acids in foods and the data presented in this paper clearly pointed out to this fact (Table 1 and 3). The saturated fatty acid present in the greatest quantity, in all evaluated foods, was the palmitic acid (C16:0), whose contents varied, on average, between 12.2% and 40.8% of the total acids (Table 3). Other studies have also pointed out the increase in the content of this fatty acid in processed foods, especially foods that had reduced *trans* fat content (Dias et al., 2015) using as a strategy the incorporation of high palmitic oils or even purified fatty acids. Thus, by such changes in the lipid profile of foods, it is evident that the use of new alternatives to the use of partially hydrogenated fats containing about 30% of *trans* fat (United States Department of Agriculture, 2019) must be carefully observed. In fact, there has been a tendency of the food industry to use blends or interesterification of soybean oil with palm oil in the manufacture of vegetable fats (Trattner et al., 2015) and margarines.

Therefore, the use of palmitic acid for technological purposes can be convenient, essentially due to its high melting point (palmitic and elaidic acids have 63 °C and 43 °C of melting point, respectively, according to Vianni & Braz-Filho, 1996) and ausence of unsaturations in its structure. This gives the final product stability to oxidation and creamy texture in order to obtain similar products to partially hydrogenated vegetable fats. In triacylglycerols, the natural position of unsaturated fatty acids is the sn-2 position, except in breast milk. The fatty acid that occupies this position is absorbed more efficiently. Thus, the insertion of palmitic acid into sn-2, as occurs in the interesterification process, increases the atherogenic index (D’Agostini & Gioielli, 2002, Fattore & Fanelli, 2013). In addition, Afonso et al. (2016), observed that the consumption of interesterified palmitic acid increased the inflammatory process in mice, consequently there was a greater atherosclerotic lesion when compared to the consumption of other oils or fats.

Thus, through the hazards related to the high intake of palmitic acid fat, the use of interesterified vegetable fat or blend with palm oil to replace hydrogenated vegetable fat might not be a nutritionally adequate solution.

4 Conclusions

The total fat contents in the analyzed foods ranged from 1.2%, in pastry dough to 54.7% in margarine. The occurrence of *trans* fat was low, with values identified up to 3.32 wt% and detected only in 51.3% of the foods. In contrast, the contents of palmitic acids were up to 10.23 wt%. This demonstrates that industries are replacing partially hydrogenated fats with raw materials rich in palmitic acid. Consequently, this substitution may not bring about the desired health effects, since palmitic acid is one of fatty acids that increase the atherogenic index, particularly when is replaced to the partially hydrogenated fats. Then, new alternatives or technologies must be developed to avoid problems regarding these foods in the human health.

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