

Nutritional characteristics and sensory acceptability of reduced-fat french fries

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Abstract

The Brazilian food industry and government reached a consensus on progressively reducing the content of industrial *trans* fatty acids (TFA) in food products due to its health effects. French fries are popular among young people and this study evaluates four brands of frozen pre-fried French fries marketed in Brazil and four brands of French fries from the main fast-food chains in Brazil regarding their fatty acid profile and total fat content. The total fat content of fast-food chain French fries was 14-21g/100 g, with a total TFA content of 0.01-0.14 g/100 g. In turn, the total fat content of frozen pre-fried French fries ranged from 3.3 to 7.4 g/100 g, with a total TFA content of 0.01-0.03 g/100 g. Deep fat frying of these products did not include partially hydrogenated fat. Two most sold pre-fried French fries brands available in Rio de Janeiro city, Brazil were selected and evaluated using air frying cooking method regarding sensory acceptance. Mean acceptance among consumers was 5.7 and 5.1 for brands A and B, respectively. Brand A was further evaluated by children and young people, with mean acceptance of 4.48 and 7.2, respectively, showing good acceptance for pre-fried French fries with reduced fat content.

Keywords: frying; potato, *trans* fatty acids; sensory acceptance.

Practical Application: Data concerning *trans* fatty acid content of Pre-fried French fries and from the main fast food chains in Brazil resulting from the present study are interesting for healthy eating education among consumers and for Regulatory Policy.

1 Introduction

Some ongoing actions nutritionally improve the quality of processed foods, mainly with respect to reducing the contents of some components such as total fats and industrial *trans* fatty acids (TFA), thus reducing the incidence of chronic diseases.

Currently, some countries have regulations to reduce and to ban the use of partially hydrogenated vegetable oil (PHVO). The European Union compromised to adopt the limit of 2% of industrial TFA in foods by April 2021. Despite the regulations and the efforts of industries towards reduction, some countries have not detected the industrial *trans* fatty acids in their products, while in other countries the levels are still high (Guillocheau et al., 2020).

Regulatory policies based on scientific studies extensively focused on the reduction of industrially produced TFA in the diet worldwide could lead to potential benefits with respect to health outcomes. However, this process should include consumer acceptance so as to be effective at reducing intake and, thus, reducing heart disease risk (Downs et al., 2017).

Concern regarding harmful health effects from the consumption of TFA has led the industry to substitute some ingredients such as frying oils. Another important current aspect is the consumption of total fats. As a way of alerting the population on the consumption of these foods, legislation in some countries requires that information on TFA content be included on the label if it is above the limit per serving.

Reduction in the levels of sodium, sugar, total fat, saturated fats, and *trans* fats in processed foods are strategies and policies of the Brazilian government to promote healthy eating, nutritional education, and reduce diseases (Block et al., 2017). The current Brazilian regulation on nutritional labeling demands the declaration for either *trans* fat and saturated fat (Agência Nacional de Vigilância Sanitária, 2003). Additionally, the limit by January 2023 will be 2 g of *trans* fat per 100 g of total fat (Agência Nacional de Vigilância Sanitária, 2019).

Regarding the intake of TFA, the study of Castro et al. (2009) in São Paulo city (Brazil) showed that the adolescents had the highest mean intake of TFAs, 7.4 g/day, corresponding to 2.9% of energy.

Studies about TFA in food products in Brazil addressing nutritional labeling showed that bakery products, cookies and crackers, candies and desserts, snacks, and convenience foods had the highest percentages of *trans* fat claims (Ricardo et al., 2019).

Information on the total TFA of food products in Brazil is scarce, with variation in the last years. Brazilian cream cracker biscuits showed TFA ranging from 12.2% to 31.2% of the total fatty acids (Martin et al., 2005). Dias et al. (2018) showed results close to zero for many food products; however, for samples of chocolate cookies with cream filling, *trans* fatty acid content was up to 12.92 g / 100 g.

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French fries are products enjoyed by consumers of all ages, especially children and teenagers. These products were originally prepared by deep-frying.

Frying is an efficient, ease and fast process for food preparation which leads to unique sensory characteristics of flavor and taste. The changes observed in fried food are related to caramelization and Maillard reaction, water evaporation, color development, alteration of texture and oil absorption by fried food (oil uptake). However, the frying process can reduce nutrients, such as proteins, vitamins, essential fatty acids and antioxidants (Bordin et al., 2013; Oke et al., 2018). Furthermore, oxidation compounds observed in frying oils and fried products such as, oxidised triacylglycerols (TAG) monomers, oxidised TAG polymers (dimers and oligomers), cyclic TAG monomers, *trans* TAG monomers and non-oxidised TAG dimers and oligomers have been evaluated regarding their adverse physiological effects (Dobarganes & Márquez-Ruiz, 2015). Other compounds produced during frying process such as *trans*-fat acid and acrylamide are public health problems (Bordin et al., 2013).

In order to reduce the oil uptake during deep fat frying and the formation of undesirable compounds, alternatives process were proposed by Santos et al. (2018) using two domestic equipment (microwave grill and convective oven) and air frying by Shaker (2015).

Currently, oven-baked French fries are also available in the market, despite the fact that some sensory characteristics that contribute to consumer acceptance, such as crispness and consistency, are substantially reduced when using this cooking method. On the other hand, hot air frying, although substantially reducing fat content, usually results in a product of good acceptance by the consumers, even with respect to the texture attribute.

The present study evaluates the nutritional characteristics and sensory acceptance of French fries, a processed food frequently consumed by young people, produced with reduced fat content. Frozen pre-fried French fries were prepared using the air frying method and 120 consumers (aged 18-65), as well as young people (14-25 y) and children (10-13 y) evaluated these products for overall sensory acceptance. Additionally, frozen pre-fried French fries sold in the Brazilian market and French fries from the main fast-food chains in Brazil were evaluated regarding their fatty acid composition and total fat content.

2 Materials and methods

2.1 Sample selection, processing, and characterization

Pre-fried potatoes from four commercial brands and French fries obtained from four major fast-food chains were compared regarding total fat and TFA contents.

Frozen pre-fried potatoes of different commercial brands were purchased in the retail market in Rio de Janeiro City. The process of hot air frying was carried out including batches of 400 g of pre-fried French fries. The cooking conditions were preheating for five minutes and cooking at 200 °C for 16 minutes. Every three minutes the tray was shaken to homogenize the cooking of the samples.

French fries produced by fast-food chains were collected in three different districts of Rio de Janeiro City (Recreio dos Bandeirantes - R, Botafogo - B, and Copacabana - C).

Total fat content and *trans* fatty acid content were determined according to AOAC 996.06 method (Association of Official Analytical Chemists, 2010) and the results were expressed as g of fatty acid /100 g of product, total fat and g of fatty acid /100 g of total fatty acids.

2.2 Sensory acceptance study

The study took place in 2015 and 2016, and it was approved by the Research Ethics Committee of the Ipanema Hospital, Rio de Janeiro city, Brazil (Decision number 1.990.083).

To evaluate the behavior of consumers and target groups regarding the possibility of reducing the fat content of French fries, a study was initially carried out to compare two commercial brands (A and B) previously selected based on their low total fat content.

One hundred and twenty (120) male and female consumers, with age ranging from 18 to 65 years, evaluated two commercial brands of pre-fried French fries. For that purpose, the French fries were prepared in a hot air fryer, and an overall acceptability 9-point hedonic scale was used (Meilgaard et al., 1991). Volunteers consisting of employees and interns of Embrapa Food Agroindustry were recruited for this previous study, considering their interest in participating in the study and the requirement to like and consume French fries. Data analysis used frequency distribution for the sensory scores of overall impression according to the following acceptance ranges: rejection range, comprising scores from 1 to 5 (located between the hedonic terms “disliked extremely” and “indifferent”), which indicated that the judges did not like the sample; and acceptance range, comprising scores from 6 to 9 (located between the hedonic terms “liked slightly” and “liked extremely”).

Further acceptance tests included target groups comprising students from municipal schools (children) and a food technical course (young people), using the commercial brand preferred in the previous study.

Students from municipal schools were previously selected regarding their interest in the research developed by Embrapa Food Agroindustry and the requirement to like and consume French fries. To perform the sensory test, they visited the facilities of Embrapa Food Agroindustry during three days in October/2016. Prior to the test, there was an oral presentation detailing the product for the children that would be proving. Children (n=84) mostly (96%) aged from 11 to 13 years participated in the study. The overall impression of children was evaluated using a facial hedonic scale. Data analysis used frequency distribution for the sensory scores of overall impression according to the following acceptance ranges: rejection range, comprising scores from 1 to 3 (located between the hedonic terms “disliked a lot” and “indifferent”), which indicated that the children did not like the sample; and acceptance range, comprising scores from 4 to 5 (located between the hedonic terms “liked a little” and “liked a lot”).

Young consumers (n= 68) mostly (80%) aged from 14 to 25 years participated in the study. The students of the food technical course were recruited considering their interest in participating in the study and the requirement to like and consume French fries. Prior to the sensory test, there was also an oral presentation for these consumers addressing the product they would be proving. The overall impression was evaluated using a 9-point hedonic scale for young consumers. Data analysis used frequency distribution for the sensory scores of overall impression according to the following acceptance ranges: rejection range, comprising scores from 1 to 5 (located between the hedonic terms “disliked extremely” and “indifferent”), which indicated that the judges did not like the sample; and acceptance range, comprising scores from 6 to 9 (located between the hedonic terms “liked slightly” and “liked extremely”).

Hierarchical cluster analysis was run on overall liking data. Cluster analysis was performed using the XLSTAT Version 2011.4.01 (Addinsoft). Overall liking scores for each sample comprised the analysis variables; and Ward’s hierarchical clustering with Euclidean distance was used to segment assessors. The number of segments was determined by conducting a visual assessment of the dendrogram. Results from preference segments of less than twenty assessors were not interpreted since the base size was considered too small. Furthermore, significant differences among samples were assessed using ANOVA and Student t test ($\alpha = 5\%$).

3 Results and Discussion

The total fat of French fries from four fast-food chains in Brazil ranged from 13.8 to 20.85 g / 100 g (Table 1). Traditionally, fried French fries contain between 12 and 18% fat, depending on the frying temperature, type of fryer, and quality of the raw material (Matthäus et al., 2020). De Meulenaer & Van Camp (2012) reported similar results, from 13.9 to 20.9%, according to different food composition tables.

The maximum levels of C18:1 and C18:2 *trans* isomers were 0.03 and 0.06 g / 100 g of French fries, respectively, while the total TFA content ranged from 0.01 to 0.14 g / 100 g. Only the sample with soybean oil as frying oil showed the presence of C18:3 *trans* isomers (3) (Table 2). Concerning the fatty acid composition present in Table 2, the TFA/total fatty acids less than 0.8% will meet the limit to be adopted by 2023 (2 g / 100 g of fat). The frying oils used in Brazil for the samples evaluated were palm oil (fast-food chain code 1), cottonseed oil (2 and 4), and soybean oil (3), regardless of the provenance (district) evaluated. The TFA content was consistent with heat isomerization from frying or at deodorization and not consistent with frying with partially hydrogenated oil.

According to the Brazilian Regulation (Agência Nacional de Vigilância Sanitária, 2003), products presenting TFA lower than 0.2 g / edible portion may be labeled as free of *trans* fat, considering the portion weight of French fries of fast-food chains around 100 g.

Table 1. Fatty acid composition and total fat content (g / 100 g) in French fries from fast-food chains (codes 1 to 4) collected in Rio de Janeiro city, Brazil.

Fatty acid	Fast-Food Chain - District ^a (g / 100 g)								Minimum	Maximum
	1 - R	1 - C	2 - R	2 - B	3 - R	3 - B	4 - R	4 - B		
C14:0	0.12	0.13	0.10	0.09	0.06	0.04	0.12	0.08	0.04	0.13
C16:0	5.27	5.12	3.54	3.05	2.53	1.87	4.06	2.87	1.87	5.27
C16:1 <i>cis</i>	0.02	0.02	0.05	0.05	0.04	0.03	0.08	0.05	0.02	0.08
C17:0	0.02	0.01	0.01	ND	0.02	ND	0.01	ND	0.00	0.02
C17:1	ND	ND	ND	ND	0.02	ND	ND	ND	0.00	0.02
C18:0	0.77	0.71	0.58	0.59	0.60	0.56	0.82	0.62	0.56	0.82
C18:1 <i>trans</i> isomers	NQ	NQ	0.02	NQ	0.03	0.01	NQ	0.01	<0.01	0.03
C18:1 <i>cis</i> 9	6.09	5.81	2.73	3.04	8.10	9.70	4.25	4.11	2.73	9.70
C18:1 positional <i>cis</i> isomers	0.11	0.10	0.10	0.10	0.19	0.17	0.14	0.11	0.10	0.19
C18:2 <i>trans</i> isomers	0.05	0.04	0.03	0.05	0.06	0.03	0.01	NQ	<0.01	0.06
C18:2 <i>cis</i> 9,12	3.49	3.27	5.92	6.58	7.56	5.51	9.32	6.92	3.27	9.32
C20:0	0.06	0.06	0.04	0.04	0.06	0.06	0.05	0.04	0.04	0.06
C18:3 <i>trans</i> isomers	ND	ND	ND	ND	0.05	NQ	ND	ND	<0.01	0.05
C18:3 omega 3	0.05	0.06	0.06	0.07	0.43	0.30	0.07	0.07	0.05	0.43
C20:1	0.03	0.03	0.01	ND	0.04	0.04	0.01	ND	0.00	0.04
C22:0	0.04	0.03	0.01	0.03	0.10	0.11	0.04	0.03	0.01	0.11
C24:0	0.03	0.02	0.01	0.02	0.05	0.05	0.03	0.02	0.01	0.05
TOTAL FAT	16.97	16.26	13.81	14.33	20.85	19.30	19.88	15.60	13.81	20.85
Saturated fatty acids	6.37	6.21	4.29	3.82	3.42	2.68	5.13	3.65	2.68	6.37
Monounsaturated fatty acids	6.25	5.96	2.89	3.19	8.39	9.94	4.48	4.27	2.89	9.94
Polyunsaturated fatty acids	3.49	3.27	5.92	6.58	7.56	5.51	9.32	6.92	3.27	9.32
<i>Trans</i> isomers C18:1	NQ	NQ	0.02	NQ	0.03	0.01	NQ	0.01	<0.01	0.03
<i>Trans</i> isomers C18:2	0.05	0.04	0.03	0.05	0.06	0.03	0.01	0.00	0.00	0.06
Total <i>trans</i> fatty acids	0.05	0.04	0.05	0.05	0.14	0.03	0.01	0.01	0.01	0.14

^a District: R – Recreio dos Bandeirantes; B – Botafogo; C – Copacabana; ND – Not detected; NQ – Not quantified (< 0.01).

The four commercial brands of pre-fried French fries (PF-1, PF-2, PF-3, PF-4) were evaluated for fatty acid composition so as to select the samples for further sensory acceptance, whose results are presented in Table 3.

Commercial brands presented total fat content ranging from 3.5 to 7.4 g / 100 g of French fries (Table 3), which is around 69%

less than that of fast-food French fries. These differences in the fat content of fried and pre-fried French fries are because the former process is partial; consequently, its oil absorption was lower. The pre-frying followed by air frying was a successful process to reduce the fat intake from French fries. The factors that affect fat uptake of French fries during frying had been reviewed

Table 2. Fatty acid composition (% Fatty acid / Total Fatty acid) of French fries from fast-food chains (codes 1 to 4) collected in Rio de Janeiro city, Brazil.

Fatty acid	Fast-Food chain - District ^a (%)								Minimum	Maximum
	1 - R	1 - C	2 - R	2 - B	3 - R	3 - B	4 - R	4 - B		
C14:0	0.74	0.87	0.76	0.63	0.29	0.21	0.64	0.52	0.21	0.87
C16:0	32.56	33.09	26.88	22.32	12.74	10.16	21.43	19.29	10.16	33.09
C16:1 <i>cis</i>	0.14	0.12	0.39	0.35	0.21	0.17	0.40	0.36	0.12	0.40
C18:0	4.71	4.56	4.36	4.32	3.02	3.04	4.28	4.15	3.02	4.71
C18:1 <i>trans</i> isomers	NQ	NQ	0.17	NQ	0.16	0.05	NQ	0.04	<0.01	0.17
C18:1 <i>cis</i> 9	37.49	37.33	20.66	22.13	40.60	52.49	22.32	27.50	20.66	52.49
C18:1 positional <i>cis</i> isomers	0.67	0.65	0.74	0.75	0.96	0.91	0.75	0.71	0.65	0.96
C18:2 <i>trans</i> isomers	0.31	0.27	0.20	0.35	0.29	0.15	0.06	0.02	0.02	0.35
C18:2 <i>cis cis</i> 9,12	21.53	21.03	44.82	47.99	37.90	29.82	49.00	46.32	21.03	49.00
C20:0	0.37	0.36	0.29	0.28	0.32	0.30	0.27	0.25	0.25	0.37
C18:3 <i>trans</i> isomers	ND	ND	ND	ND	0.23	NQ	ND	ND	<0.01	0.23
C18:3 omega 3	0.32	0.38	0.42	0.48	2.15	1.62	0.38	0.45	0.32	2.15
C20:1	0.17	0.16	0.05	ND	0.21	0.22	0.05	0.03	0.00	0.22
C22:0	0.25	0.22	0.07	0.24	0.50	0.61	0.22	0.20	0.07	0.61
C24:0	0.15	0.13	0.06	0.15	0.23	0.25	0.15	0.12	0.06	0.25

^a District: R – Recreio dos Bandeirantes; B – Botafogo; C – Copacabana; ND – Not detected; NQ – Not quantified (> 0.01)

Table 3. Fatty acid composition of oil (% fatty acid/total fatty acids) and total fat content (g/100 g) from pre-fried French fries (PF) from different commercial brands and batches collected in Rio de Janeiro City, Brazil.

Fatty acid	Pre-fried French fries													
	PF -1 Batch 1		PF-1 Batch 2		PF-2 Batch 1		PF-2 Batch 2		PF-3 Batch 1		PF-3 Batch 2		PF-4	
	g/100g	%	g/100g	%	g/100g	%	g/100g	%	g/100g	%	g/100g	%	g/100g	%
C12:0	0.01	0.20	0.01	0.15	ND	ND	ND	ND	<0.01	0.07	0.01	0.17	ND	ND
C14:0	0.04	0.96	0.05	0.92	ND	0.08	ND	0.08	0.05	0.76	0.03	0.94	ND	ND
C16:0	1.91	43.13	2.44	44.93	0.33	6.66	0.32	6.65	2.53	41.50	1.44	43.22	0.29	4.14
C16:1 <i>cis</i>	0.01	0.15	0.01	0.13	0.01	0.10	ND	0.10	ND	0.06	ND	0.14	0.01	0.10
C18:0	0.21	4.69	0.27	5.01	0.18	3.61	0.17	3.59	0.32	5.19	0.17	5.13	0.21	2.97
C18:1 <i>trans</i> isomers	NQ	0.00	NQ	0.00	NQ	0.00	NQ	0.00	NQ	0.00	NQ	0.00	0.02	0.28
C18:1 <i>cis</i> 9	1.71	38.55	2.06	37.70	1.44	28.46	1.36	28.41	2.46	40.30	1.25	37.49	5.87	82.91
C18:1 positional <i>cis</i> isomers	0.03	0.70	0.03	0.64	0.04	0.71	0.03	0.71	0.04	0.62	0.02	0.65	0.05	0.69
C18:2 <i>trans</i> isomers	0.01	0.31	0.02	0.32	0.03	0.65	0.03	0.64	0.01	0.12	0.01	0.33	NQ	0.00
C18:2 <i>cis cis</i> 9,12	0.46	10.39	0.51	9.42	2.91	57.63	2.76	57.75	0.62	10.17	0.36	10.85	0.47	6.60
C20:0	0.02	0.40	0.02	0.41	0.01	0.28	0.01	0.28	0.02	0.40	0.01	0.41	0.02	0.30
C18:3 omega 3	0.03	0.67	0.03	0.59	0.03	0.54	0.03	0.57	0.02	0.35	0.02	0.66	0.02	0.42
C20:1	ND	ND	ND	ND	0.01	0.17	0.01	0.17	0.02	0.33	ND	ND	0.02	0.27
C22:0	ND	ND	ND	ND	0.04	0.77	0.04	0.76	ND	ND	ND	ND	0.07	0.94
C24:0	ND	ND	ND	ND	0.02	0.31	0.02	0.31	ND	0.05	ND	ND	0.03	0.37
TOTAL FAT	4.64		5.71		5.28		5.00		6.39		3.49		7.40	
Saturated fatty acids	2.19		2.80		0.59		0.56		2.93		1.66		0.62	
Monounsaturated fatty acids	1.74		2.10		1.49		1.41		2.53		1.28		5.94	
Polyunsaturated fatty acids	0.46		0.51		2.91		2.76		0.62		0.36		0.47	
C18:1 <i>trans</i> isomers	NQ		NQ		NQ		NQ		NQ		NQ		0.02	
C18:2 <i>trans</i> isomers	0.01		0.02		0.03		0.03		0.01		0.01		NQ	
Total <i>trans</i> fatty acids	0.01		0.02		0.03		0.03		0.01		0.01		0.02	

by De Meulenaer & Van Camp (2012) and Arslan et al. (2018). The effect of potato bleaching and film coating was evaluated by Ali et al. (2012) while Arslan et al. (2018) compared equipments and process such as vacuum frying to reduce the oil uptake of French fries that need high investment.

In these products, C18:1 and C18:2 *trans* isomers levels were up to 0.02 and 0.03 g / 100 g, with TFA content ranging from 0.01 to 0.03 g / 100 g, indicating that no hydrogenated fats were used as frying oil.

Commercial pre-fried French fries showed differences in fatty acid composition, indicating that PF1 and PF3 were pre-fried in palm oil, PF2 in high linoleic sunflower oil, and PF4 in high oleic sunflower oil (Table 3).

Two commercial pre-fried French fries were selected for consumer sensory acceptance based on the different frying oil used and the availability of brands in the Brazilian market. However, when evaluating new lots for TFA content, brands A and B showed results consistent with frying with high linoleic sunflower oil. The results of acceptance led to the selection of brand A for the sensory analysis of target groups, and additional TFA analyses confirmed high linoleic acid sunflower oil as frying oil (Table 4).

Total fat content was around 75% lower in pre-fried French fries compared to fast-food French fries. The total fat content of new lots of brands A and B ranged from 3.3 to 5.8 g / 100 g. Regarding TFA isomers, no *trans* C18: 1 was quantified, while the highest C18:2 *trans* content was 0.03 / 100 g, i.e., less than

0.2 g / serving (85 g), which is the limit determined by Brazilian regulation. Thus, such low TFA content would allow labeling these pre-fried French fries as “zero” or “does not contain” *trans* fats in Brazil.

The results of the sensory evaluation of the two commercial brands of frozen pre-fried French fries showed good acceptance by about 50% of consumers (Table 5), as observed in cluster 2, composed by 56 consumers. However, the significant difference ($p < 0.05$) between means for the attribute “global acceptance” in cluster 3, formed by about 30% of the total (31) consumers, implies a preference for brand A.

The pre-fried French fries from brand A were therefore selected for a validation test, which consisted in evaluating the acceptance of French fries with reduced fat content by target groups (mainly children and young people).

For children ($n=84$), mostly (96%) aged from 11 to 13 years, the mean overall liking score of reduced-fat French fries was 4.48, which corresponds to the term “liked a little” on the rating scale. The percentage of children who gave approval scores for overall impression (acceptance range, comprising scores from 4 – “liked a little” – to 5 – “liked a lot”) was 90% (Table 6). Moreover, 80% of them claimed they would consume the French fries in their homes, despite the reduced fat content.

For young consumers ($n= 68$), mostly (80%) aged from 14 to 25 years, the average overall liking score of reduced-fat French fries was 7.62, which corresponds to the term “liked moderately” on the scale. The percentage of young consumers

Table 4. Fatty acid composition of oil (% fatty acid/total fatty acids) and total fat content (g/100 g) from selected pre-fried French fries (PF) utilized in sensory analysis.

Fatty acid	Brand A		Brand B		Brand A			
	g/100g	%	g/100g	%	Young people test		Children test	
					g/100g	%	g/100g	%
C14:0	<0.01	0.11	<0.01	0.09	ND	ND	ND	ND
C16:0	0.23	7.25	0.28	7.16	0.25	7.16	0.38	6.83
C16:1 <i>cis</i>	<0.01	0.14	<0.01	0.12	ND	ND	<0.01	0.11
C18:0	0.10	3.23	0.15	3.73	0.13	3.74	0.20	3.59
C18:1 <i>trans</i> isomers	ND	ND	ND	ND	ND	ND	NQ	NQ
C18:1 <i>cis</i> 9	0.94	29.70	1.04	26.60	0.94	26.82	1.52	27.24
C18:1 positional <i>cis</i> isomers	0.03	0.81	0.03	0.76	0.03	0.75	0.04	0.74
C18:2 <i>trans</i> isomers	0.02	0.52	0.02	0.62	<0.01	0.11	0.03	0.62
C18:2 <i>cis cis</i> 9,12	1.78	56.22	2.29	58.83	2.06	59.05	3.27	58.77
C20:0	0.01	0.28	0.01	0.31	0.01	0.31	0.02	0.27
C18:3 omega 3	0.02	0.67	0.02	0.58	0.03	0.95	0.03	0.59
C20:1	ND	ND	0.003	0.08	ND	ND	0.010	0.18
C22:0	0.02	0.74	0.03	0.79	0.03	0.80	0.04	0.78
C24:0	0.01	0.32	0.01	0.33	0.01	0.32	0.02	0.28
TOTAL FAT	3.31	-	4.07	-	3.65	-	5.81	-
Saturated fatty acids	0.38	-	0.48	-	0.43	-	0.65	-
Monounsaturated fatty acids	0.97	-	1.07	-	0.96	-	1.57	-
Polyunsaturated fatty acids	1.78	-	2.29	-	2.06	-	3.27	-
C18:1 <i>trans</i> isomers	ND	-	ND	-	ND	-	<0.01	-
C18:2 <i>trans</i> isomers	0.02	-	0.02	-	<0.01	-	0.03	-
Total <i>trans</i> fatty acids	0.02	-	0.02	-	<0.01	-	0.03	-

ND – Not detected; NQ – Not quantified (< 0.01).

Table 5. Overall liking scores for pre-fried French fries from two commercial brands, prepared using hot air frying.

	Number of participants	Brand A	Brand B
Total	120	5.7 ^a	5.1 ^b
Cluster 1	33	3.1 ^a	2.8 ^a
Cluster 2	56	6.6 ^a	7.1 ^a
Cluster 3	31	6.8 ^a	3.9 ^b

*Means obtained from 9-point hedonic scale ranging from 1 (disliked extremely) to 9 (liked extremely); different letters in each line indicate statistically significant difference ($p \leq 0.05$) between means, t test.

Table 6. Overall liking scores for reduced-fat French fries of the data collected by target consumer groups.

Profile	Children (aged 11-13)	Young (aged 14-25)
Mean score	4.48 ± 0.82*	7.62 ± 1.09**
% approval***	90	98

* Means obtained from facial hedonic scale ranging from 1 (disliked a lot) to 5 (liked a lot) of data collected by children; ** Means obtained from 9-point hedonic scale ranging from 1 (disliked extremely) to 9 (liked extremely) of data collected by youngsters; ***Percentage of participants that liked pre-fried French fries: rates varying from 4 (liked a little) to 5 (liked a lot) of facial hedonic scale; rates varying from 6 (liked slightly) to 9 (liked extremely) of 9-point hedonic scale.

who gave scores in the acceptance range (rated in the hedonic scale from 6 – “liked slightly” to 9 – “liked extremely”) was 98%. Again, 80% of them claimed they would consume the French fries in their homes, despite the reduced fat content.

These results were very encouraging and similar findings were obtained by Shaker (2015) in the comparison of deep fat frying and air frying of raw potato strips (moisture around 77%). No difference was observed for organoleptic attributes of taste, appearance, color, odor, and overall acceptability, while air frying product showed higher evaluation regarding crispness, hardness and oiliness.

Nevertheless, the air frying and deep fat frying of fresh potatoes were compared by Teruel et al. (2015). There was a substantial reduction of fat content for air frying process with similar moisture contents and color characteristics for both products, although air frying required typically 21 min in relation to 9 min in the case of deep fat frying and the products showed different sensory characteristics. Alternative process to deep-frying were tested by Santos et al. (2018) using two domestic equipment (microwave grill and convective oven), with fresh potatoes and four different frying oils (sunflower, soybean, canola, and olive oil). Regardless the oil used, most of sensory attributes presented higher scores for deep-frying, followed by microwave and oven.

The good sensory acceptance of pre-fried French fries by children and young people pointed out that it is possible to consume a traditional product with lower fat content that can be easily prepared at households by hot air cooking. However, the change of consumer patterns demands much effort.

The very low TFA content observed for the products evaluated and the conclusion that the frying process did not use hydrogenated fat are very favorable from the point of view

of public health. Nevertheless, the four commercial brands of pre-fried French fries and the four fast-food chains included in the study concern Rio de Janeiro city. Hence, further research should assess TFA content in other foods enjoyed by children and young people in the country.

4. Conclusion

French fries with low total fat and low *trans* fatty acids obtained by air frying process evaluated by sensory panels, were approved by children (11-13 y) and young people (14-25 y). No hydrogenated fat was used in deep fat frying of French fries from fast food chains and pre-fried French fries evaluated from the Brazilian market.

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