

# Ultra-Processed Foods Are the Major Sources of Total Fat, Saturated and Trans-Fatty Acids Among Tunisian Preschool and School Children: A Cross-Sectional Study

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## Research article

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1 **Ultra-processed foods are the major sources of total fat, saturated and trans-fatty acids**  
2 **among Tunisian preschool and school children: a cross-sectional study**

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1    **Abstract**

2    **Background:** Excessive intake of fat and fatty acids is associated with major health hazards such as obesity or  
3    chronic diseases. The aim of this study is to provide the first data on total fat, SFA and TFA intakes and their major  
4    food sources in Tunisian children.

5    **Methods:** A total of 1200 children, aged 3 to 9 years old, were randomly selected from primary schools and  
6    kindergarten under a cross-sectional design. The 24hour recall method and food frequency questionnaire were  
7    used to assess dietary intake over a period of one week.

8    **Results:** The energy percentages of total fat, SFA and TFA in Tunisian children were respectively 29.6, 11.4 and  
9    0.15. No sex differences were found. The WHO recommendations for total fat, SFA and TFA were adopted by 58  
10   %, 39 % and 89 % of the study population, respectively. The leading food groups of fat and fatty acids were ultra-  
11   processed foods, bread and cereals and dairy products. The meat, fish, eggs and fish alternatives were the fifth  
12   main contributors to the total fat and SFA intakes in Tunisian children.

13   **Conclusions:** The implementation of a relevant strategy for fat reduction, especially from ultra-processed foods,  
14   considered as low nutrient energy-dense products, is needed to promote health among children and prevent diet-  
15   related chronic diseases.

16   *Keywords:* Dietary fats, food sources, children, Tunisia.

17

18    **Background**

19    Fatty acids are carboxylic acids with either saturated or unsaturated aliphatic chain <sup>(1-3)</sup>. Saturated fatty acids (SFA)  
20    have no double bonds, while unsaturated fatty acids have at least one double bond in their *cis* or *trans* configuration  
21    <sup>(4)</sup>. The main sources of SFA in food supply are animal products including meat and dairy products <sup>(2, 5)</sup>. Trans  
22    fatty acids (TFA) are produced naturally in ruminants' stomach or industrially by partial hydrogenation of  
23    vegetable oils. Hydrogenation increases the melting point of fats, which make it possible to convert fats from the  
24    liquid state to the semi-solid or solid state <sup>(6, 7)</sup>. The benefits of such process are the increase of flavor stability and  
25    shelf life of unsaturated fatty acids. Several epidemiologic studies have shown that high dietary intakes of SFA  
26    and TFA are associated with an increased risk of cardiovascular disease, diabetes, cancer and dementia in later life  
27    <sup>(8-14)</sup>. Because of these deleterious health effects, the 2018 WHO draft guidelines on saturated fatty acid and trans-  
28    fatty acid intake for adults and children recommend reducing the intake of SFA and TFA to less than 10 % and 1

1 % of total energy intake, respectively. They suggest using polyunsaturated fatty acids as a source of replacement  
2 energy, if needed <sup>(15)</sup>.

3 Given the long-term effect of childhood dietary consumption on adult health and the risks associated with sustained  
4 high intake of SFA and TFA, the aim of this study was to describe eating patterns and to find the leading food  
5 group sources of these fatty acids in Tunisian preschool and school age children.

6

## 7 **Material and Methods**

### 8 **Subjects and study design**

9 The subjects of this study were a cohort of 1200 children aged 3-9 years, randomly selected from primary schools  
10 and kindergarten in Greater Tunis region from April to May 2019. This urban region includes 4 governorates  
11 (Tunis, Manouba, Ariana and Ben Arous). A two-stage clustered sampling was designed by the National Institute  
12 of Statistics. Stratification was made depending on each governorate and urban/rural environments. At the first  
13 level, 30 primary schools and 30 kindergartens were selected from the initial sampling frame. At the second level,  
14 20 children were systematically drawn from each educational institution.

### 15 **Dietary intake assessment**

16 Data on the types and amounts of foods and drinks consumed by children were recorded by trained dieticians. A  
17 detailed and precise description of nutriments was made using photos and known weight of food portions. The  
18 24hour recall method and food frequency questionnaire (FFQ) were used to assess dietary intake over a period of  
19 one week. The energy and nutritional content of identified food items and recipes were estimated by laboratory  
20 analysis, the Tunisian food composition table <sup>(16)</sup>, The USDA table <sup>(17)</sup> and the food processor software <sup>(18)</sup>. The  
21 revised version of AOAC official method 996.06 was adopted for total fat, SFA and TFA analysis <sup>(19)</sup>.

### 22 **Data management and statistical analysis**

23 Data entry was carried out in duplicate using Epidata software version 3.1 <sup>(20)</sup>. Data analysis was performed by  
24 Stata 14 software <sup>(21)</sup> taking into account the sampling design (stratification, clustering and sampling weights). The  
25 type I error risk was 0.05.

26

## 27 **Results**

28 The characteristics of the study population according to gender are presented in table 1. The sample was evenly  
29 distributed among household economic levels. Approximately, all household heads have a profession while half  
30 of the mothers do not work. Over two-thirds of household heads and mothers have a high school or university

1 education. A proportion of 60 % of the children were of normal body weight, with about 26 % overweight and 10  
 2 % obese.

3 Table 1. Characteristics of Tunisian children aged 3-9 years old

Physiological characteristics	All		Boys		Girls	
	n	%	n	%	n	%
<b>Boys</b>	582	50				
<b>Girls</b>	582	50				
<b>Age (years)</b>						
3 - 4	350	33.78	191	36.54	159	31.02
5 - 6	334	29.86	162	28.73	172	30.99
7 - 8	307	23.23	149	22.56	158	23.91
9 - 10	173	13.13	80	12.17	93	14.08
<b>Socio-economic factors</b>						
<b>Economic level of the household</b>						
Upper tercile	383	32.19	187	31.49	196	32.89
Medium tercile	392	34.08	197	34.03	195	34.12
Lower tercile	389	33.73	198	34.48	191	32.98
<b>Profession of household head</b>						
Upper/medium	507	44.36	247	42.94	260	45.77
Employee/worker	637	54.04	324	55.26	313	52.81
Not working/retired	20	1.606	11	1.799	9	1.414
<b>Education of household head</b>						
University/Secondary	882	76.38	440	75.91	442	76.85
Primary school or none	282	23.62	142	24.09	140	23.15
<b>Profession of mother</b>						
Upper/medium	332	29.5	160	28.81	172	30.19
Employee/worker	253	22.04	123	21.37	130	22.71
Not working/retired	579	48.46	299	49.82	280	47.1
<b>Education of mother</b>						
University/Secondary	878	76.53	433	75.42	445	77.63
Primary school or none	286	23.47	149	24.58	137	22.37
<b>Anthropometric characteristics</b>						
Stunting	16	1.38	10	1.75	6	1.02
Underweight	37	3.00	19	3.13	18	2.87
Overweight	311	25.96	151	25.18	160	26.74
Obesity	122	9.90	65	10.66	57	9.13

4  
 5 The mean daily total fat, SFA and TFA intakes of boys and girls of all age groups are reported in table 2. The  
 6 percent total fat energy of Tunisian children aged 3 to 9 years old was 29.6. The mean SFA and TFA intakes of  
 7 the studied population were 11.4 (% E) and 0.15 (% E), respectively. No sex differences were found. According  
 8 to age, children aged 3 to 4 years old had significantly higher SFA (11.7 % E) and TFA (0.18 % E) intakes than  
 9 the other age groups (p < 0.0001).

10 **[Table 2 location]**

11 Table 3 presents the percentage of children meeting the WHO recommendations for total fat, SFA and TFA  
 12 according to gender. Up to 58 % of the study population adhered to the WHO recommendations for total fat intake.  
 13 In 41 % of the children, total fat intake was higher than 30 % E. Only 39 % of the children were in compliance

1 with the SFA recommendations. A high proportion of the children aged 3-9 years (89 %) had an adequate TFA  
 2 intake (<1 % E). No gender differences were observed.

3 Table 3. Percentage of Tunisian children adhering to WHO recommendations for fat, SFA and TFA by gender

Nutrient (% E)	Total (n = 1164)	Boys (n=582)	Girls (n=582)	<i>p</i> value
Total fat				0.759
< 15	<1	<1	<1	
15-30 <sup>a</sup>	58	59	57	
> 30	41	40	42	
SFA				0.420
<10 <sup>a</sup>	39	40	38	
≥ 10	61	60	62	
TFA				0.945
<1 <sup>a</sup>	89	89	89	
≥ 1	11	11	11	

4 <sup>a</sup> Recommended levels of total fat, SFA and TFA according to WHO  
 5

6 The percentage contributions of the major food groups to the fat and fatty acids intake in the total study population  
 7 can be found in table 4. Ultra-processed foods (mainly cheese and cakes, pies and biscuits) were the major food  
 8 sources of total fat, SFA and TFA intakes in Tunisian children with respective percentage contributions of 32.5,  
 9 28.9 and 48.4. Bread and cereals were the second and the third main contributors to the total fat and SFA  
 10 consumption, respectively. Dairy products were classified at the second and the fourth rank respectively for fatty  
 11 acids and total fat intakes. Beverages and industrial juices didn't contribute to the fat and fatty acids intake.

12 **[Table 4 location]**

13

#### 14 **Discussion**

15 In the present study, we reported for the first time, the intake of total, saturated and trans-fatty acids and their major  
 16 food sources among 3-9 y Tunisian children using a cross-sectional survey. We found that the mean intake of total  
 17 fat falls within the WHO recommendations but a large proportion of the population (41 %) exceeded the  
 18 recommended limit of 30 % E. SFA intake in almost the two-third of the children was greater than 10 % E.  
 19 However, the TFA consumption was under the WHO recommendations for nearly all of them <sup>(15)</sup>. Compared to  
 20 findings on total fat and SFA intake of children and adolescents in other countries, our results are higher than those  
 21 reported in Korea <sup>(22)</sup>, Mexico <sup>(23)</sup> or Japan <sup>(24)</sup>, similar to those found in Guatemala <sup>(25)</sup> or US <sup>(26)</sup> and lower than  
 22 results registered in European countries where the mean total fat intake was 33.3 % E, with a mean SFA intake of  
 23 13.8 % E <sup>(27)</sup>. The consumption of TFA by Tunisian children was very low in comparison with data registered  
 24 elsewhere. Monge-Rojas et al. [2013] reported mean TFA intake of 1.3 % E in Costa Rican adolescents <sup>(28)</sup>, while  
 25 the average dietary intake of TFA in Spanish children aged 4-5 y was 1.36 g/d which corresponds to 0.77 % E <sup>(29)</sup>.

1 Results from Canadian children aged 5-6 y showed a mean TFA intake of 0.71 % E<sup>(30)</sup>. These results are expected  
2 because the overall levels of TFA in most processed food products available on the Tunisian market are low (<1  
3 g/100g of sample), except in margarine (5.56 g/100g).

4 Our results revealed that ultra-processed foods (mainly cheese and cakes, pies and biscuits) were the greatest  
5 source of fat and fatty acids in Tunisian children, followed by bread and cereals for total fat and dairy products for  
6 fatty acids. Ultra-processed foods are food products formulated mainly or entirely from processed ingredients,  
7 including little or no whole foods<sup>(31)</sup>. The early consumption of these products could lead to negative health effects  
8 such as the development of obesity or chronic diseases<sup>(32, 33)</sup>. Therefore, it is important to understand the role of  
9 food processing and to formulate public health strategies to reduce the consumption of ultra-processed products  
10 early in life. Comparison of food sources of fat and fatty acids is not easy, because food groupings differ between  
11 the research studies. The definition of the food groups in the present study was based on the Tunisian food  
12 composition table and the USDA table<sup>(16, 17)</sup>. The important contributions of ultra-processed foods, bread and  
13 cereals and dairy products in the fat and fatty acids intake of children and adolescents was also found elsewhere.  
14 Asakura and Sasaki (2017) reported that meat, dairy products, and confectioneries were the three major sources of  
15 SFA in Japanese schoolchildren (26.4 %, 25.7 % and 11.3 % of total SFA intake)<sup>(24)</sup>. According to Wang et al.  
16 (2018), the meat, poultry and fish, the milk and the mixtures mainly grain were the leading food sources of  
17 saturated fats in US children<sup>(26)</sup>. The Korean study revealed that milk was the major food source of total fat and  
18 SFA in 3-5 years children, with respective percentages contributions of 15.6 and 29.5, followed by pork and eggs  
19<sup>(22)</sup>. In Costa Rica, bakery products, red meat and dairy products were the main contributors to SFA and TFA  
20 intakes in adolescents<sup>(28)</sup>, while fried eggs, whole milk, sweet breads and fresh cheese were among the major food  
21 sources of total fat and SFA in diets of Guatemalan schoolchildren<sup>(25)</sup>. The principal food groups contributing to  
22 the total TFA intake in Spanish children were milks (21 %), processed baked goods (16 %), sweets (12 %), fast  
23 food (12 %) and white bread (10 %)<sup>(29)</sup>. They were comparable to those reported in the Canadian study<sup>(30)</sup>.

24 Generally, the top three food groups contributing to the total fat and SFA intakes in European adolescents were  
25 the meat, fish, eggs and meat alternatives (mainly meat), the low-nutrient, energy-dense foods (mainly cakes, pies  
26 and biscuits) and the dairy and soya products (mainly cheese)<sup>(27)</sup>. In our study, the meat, fish, eggs and fish  
27 alternatives were the fifth main contributors to the total fat and SFA intakes in Tunisian children, with respective  
28 percentages of 10.7 and 10.8. This result is probably due to differences in dietary habits between Tunisian  
29 population and the other world populations. The average annual meat consumption per capita in Tunisia is around  
30 32.5 kg in 2015 which is close to the global average of 34.3 kg, but far from 69 kg in the European Union and 98.3

1 kg in the United States <sup>(34, 35)</sup>. On the other hand, the mean annual consumption of lean meat in 2015 (19.4 kg for  
2 poultry and white meat) is much more important than the consumption of fatty meat (7.1 kg for sheep meat and  
3 3.1 kg for bovine meat) <sup>(34)</sup>. The general food price index which makes sheep and bovine meat proportionately  
4 more expensive than the other food products could explain this trend of meat consumption among Tunisian people  
5 <sup>(36)</sup>.

6 Given the result that a large proportion of Tunisian children exceeded the recommended levels of total fat and SFA  
7 intake, the implementation of several policy actions is necessary to prevent diseases and promote health in Tunisia.  
8 In this context, the WHO regional office has developed a policy guidance with recommended actions for countries  
9 in the Eastern Mediterranean Region to reduce national fat intake. These recommendations include the  
10 establishment of mandatory labelling schemes for saturated fatty acids content that are easily understandable for  
11 most consumers and the replacement of industrially produced TFA with healthier oils and fats <sup>(37)</sup>. Future health  
12 policies should focus primarily on reducing the children's intake of ultra-processed foods and increasing the access  
13 to high nutritive quality foods such as vegetables, fruits, whole-grain products and animal source foods with health-  
14 promoting fats (e.g., fish) <sup>(38)</sup>.

15

## 16 **Conclusion**

17 Since 41 % and 61 % of Tunisian children consumed excess fat and SFA respectively, there is a need of rapid  
18 intervention for fat reduction in Tunisian population. Intake of TFA was relatively low compared to other research  
19 studies. Nevertheless, elimination of industrial TFA is strongly recommended due to its association with increased  
20 risk of heart attack and death. The major dietary sources of total fat, SFA and TFA in Tunisian children, were  
21 ultra-processed foods, bread and cereals and dairy products. As ultra-processed foods are considered as low  
22 nutrient, dense energy foods, public health nutrition efforts should continue to reduce the consumption of these  
23 products and promote the intake of healthy diets.

24

## 25 **Declarations**

### 26 **Ethics approval and consent to participate**

27 All applicable institutional and governmental regulations concerning the ethical use of human volunteers were  
28 respected during this study. The survey protocol was reviewed and approved by the Tunisian National Council of  
29 Statistics (Visa n°3/2017) and the Ethical Consultative Committee of the National Institute of Nutrition and Food



1 Technology. After being thoroughly informed on the purpose, requirements, and procedures of the survey, all  
2 parents gave their free informed consent. All data were handled anonymously during analysis.

3 **Consent for publication**

4 Not applicable

5 **Availability of data and materials**

6 The datasets used and/or analysed during the current study are available from the corresponding author on  
7 reasonable request.

8 **Competing interests**

9 The authors declare that they have no competing interests

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12 **Author's contributions:** All authors conceived and designed the experiments. Data collection and analysis was  
13 performed by RD and DD. JEA supervised the field survey, the collection and acquisition of data. DD and  
14 MEAH wrote the article. All authors read and approved the final manuscript.

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1 **Tables**

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3 Table 2. Intake of total fat, SFA and TFA according to gender and age among Tunisian children aged 3-9 years

Nutrient	Unit	Total	Gender			Age groups					
			Boys	Girls	<i>p</i> value	3-4 y	5-6 y	7--8 y	9-10	<i>p</i> value <sup>a</sup>	
Fat total	(g/d)	Mean (s.e.) <sup>b</sup>	49.8 (0.5)	50.5 (0.7)	48.9 (0.6)	0.084	46.3 (0.8)	51.0 (1.0)	52.3 (0.9)	50.9 (1.2)	<b>0.000</b>
		95 % CI	48.7 – 49.7	49.1 - 51.9	47.6 - 50.1		44.7 - 47.8	49.0 - 52.9	50.6 - 54.1	48.5 - 53.3	
	(% E) <sup>c</sup>	Mean (s.e.)	29.6 (0.3)	29.6 (0.6)	29.6 (0.3)	0.931	29.2 (0.3)	30.4 (1.0)	29.3 (0.4)	29.2 (0.5)	0.968
		95 % CI	28.9 - 30.2	28.5 - 30.8	29.0 - 30.1		28.5 – 29.9	28.5 – 32.3	28.6 – 30.1	28.3 – 30.2	
SFA	(g/d)	Mean (s.e.)	19.2 (0.2)	19.6 (0.3)	18.8 (0.3)	0.070	18.5 (0.4)	19.7 (0.4)	19.6 (0.4)	19.4 (0.6)	0.110
		95 % CI	18.8 – 19.7	19.0 - 20.2	18.2 - 19.4		17.8 - 19.2	18.9 - 20.5	18.7 - 20.4	18.1 - 20.7	
	(% E)	Mean (s.e.)	11.4 (0.1)	11.3 (0.1)	11.4 (0.2)	0.887	11.7 (0.2)	11.5 (0.2)	10.9 (0.2)	11.0 (0.3)	<b>0.008</b>
		95 % CI	11.2 - 11.6	11.1 - 11.6	11.1 - 11.7		11.3 – 12.0	11.2 – 11.9	10.5 – 11.3	10.5 – 11.5	
TFA	(g/d)	Mean (s.e.)	0.24 (0.01)	0.26 (0.02)	0.23 (0.02)	0.158	0.29 (0.03)	0.25 (0.03)	0.24 (0.03)	0.13 (0.02)	<b>0.000</b>
		95 % CI	0.22 – 0.27	0.22 - 0.30	0.19 - 0.26		0.23 - 0.34	0.20 - 0.30	0.18 - 0.29	0.08 - 0.18	
	(% E)	Mean (s.e.)	0.15 (0.01)	0.16 (0.01)	0.14 (0.01)	0.219	0.18 (0.02)	0.15 (0.02)	0.14 (0.02)	0.08 (0.01)	<b>0.000</b>
		95 % CI	0.13 - 0.16	0.13 - 0.18	0.11 - 0.16		0.15 - 0.22	0.12 - 0.18	0.10 - 0.17	0.05 - 0.10	

4 <sup>a</sup> - Comparison between sexes adjusted for age. <sup>b</sup> - Mean value (standard error). <sup>c</sup> - Energy percent

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1 Table 4. Percentage contributions of the major food groups to the total fat, SFA and TFA intakes in Tunisian children

Total fat			SFA			TFA		
Rank	Food group	% <sup>a</sup>	Rank	Food group	%	Rank	Food group	%
1	Ultra-processed foods	32.5	1	Ultra-processed foods	29.0	1	Ultra-processed foods	48.4
2	Bread and cereals	20.5	2	Dairy products	22.7	2	Dairy products	47.1
3	Vegetables, legumes and fruits	16.1	3	Bread and cereals	17.3	3	Fat and oils	04.4
4	Dairy products	11.7	4	Vegetables, legumes and fruits	12.9	4	Bread and cereals	00.1
5	Meat, fish and eggs	10.7	5	Meat, fish and eggs	10.8	5	Beverages and industrial juices	00.0
6	Fat and oils	05.8	6	Fat and oils	05.2	6	Meat, fish and eggs	00.0
7	Potatoes and grains	02.0	7	Potatoes and grains	01.6	7	Potatoes and grains	00.0
8	Beverages and industrial juices	00.2	8	Beverages and industrial juices	00.2	8	Vegetables, legumes and fruits	00.0

2 <sup>a</sup> Percentage contributions of food groups

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