

1 Ultra-Processed Foods Are the Major Sources of Total Fat, Saturated and Trans-Fatty 2 Acids among Tunisian Preschool and School Children

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11 Abstract

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

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

18 **Results:** The energy percentages of total fat, SFA and TFA in Tunisian children were respectively 29.6, 11.4 and
19 0.15. No sex differences were found. The WHO recommendations for total fat, SFA and TFA were adopted by
20 58 %, 39 % and 89 % of the study population, respectively. The leading food groups of fat and fatty acids were
21 ultra-processed foods, bread and cereals and dairy products. The meat, fish, eggs and fish alternatives were the
22 fifth main contributors to the total fat and SFA intakes in Tunisian children.

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

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

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1 **Conflicts of interest:** none

2 **Author's contributions:** All authors conceived and designed the experiments. Data collection and analysis was
3 performed by Radhouene Doggui and Darine dogui. Jalila El Ati supervised the field survey, the collection and
4 acquisition of data. Darine dogui and Myriam EL Ati-Hellal wrote the article. All authors read and approved the
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6

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10

1 **Introduction**

2 Fatty acids are carboxylic acids with either saturated or unsaturated aliphatic chain [1-3]. Saturated fatty acids
3 (SFA) have no double bonds, while unsaturated fatty acids have at least one double bond in their *cis* or *trans*
4 configuration [4]. The main sources of SFA in food supply are animal products including meat and dairy products
5 [5,2]. Trans fatty acids (TFA) are produced naturally in ruminants' stomach or industrially by partial hydrogenation
6 of vegetable oils. Hydrogenation increases the melting point of fats, which make it possible to convert fats from
7 the liquid state to the semi-solid or solid state [6,7]. The benefits of such process are the increase of flavor stability
8 and shelf life of unsaturated fatty acids. Several epidemiologic studies have shown that high dietary intakes of SFA
9 and TFA are associated with an increased risk of cardiovascular disease, diabetes, cancer and dementia in later life
10 [8-14]. Because of these deleterious health effects, the 2018 WHO draft guidelines on saturated fatty acid and
11 trans-fatty acid intake for adults and children recommend reducing the intake of SFA and TFA to less than 10 %
12 and 1 % of total energy intake, respectively. They suggest using polyunsaturated fatty acids as a source of
13 replacement energy, if needed [15].

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

18 **Material and Methods**

19 **Subjects and study design**

20 The subjects of this study were a cohort of 1200 children aged 3-9 years, randomly selected from primary schools
21 and kindergarten in Greater Tunis region from April to May 2019. This urban region includes 4 governorates (Tunis,
22 Manouba, Ariana and Ben Arous). A two-stage clustered sampling was designed by the National Institute of
23 Statistics. Stratification was made depending on each governorate and urban/rural environments. At the first level,
24 30 primary schools and 30 kindergartens were selected from the initial sampling frame. At the second level, 20
25 children were systematically drawn from each educational institution.

26 **Dietary intake assessment**

27 Data on the types and amounts of foods and drinks consumed by children were recorded by trained dietitians. A
28 detailed and precise description of nutriment was made using photos and known weight of food portions. The
29 24hour recall method and food frequency questionnaire (FFQ) were used to assess dietary intake over a period of
30 one week. The energy and nutritional content of identified food items and recipes were estimated by laboratory

1 analysis, the Tunisian food composition table [16], The USDA table [17] and the food processor software [18].
2 The revised version of AOAC official method 996.06 was adopted for total fat, SFA and TFA analysis [19].

3 **Data management and statistical analysis**

4 Data entry was carried out in duplicate using Epidata software version 3.1 [20]. Data analysis was performed by
5 Stata 14 software [21] taking into account the sampling design (stratification, clustering and sampling weights).
6 The type I error risk was 5 %.

7 **Results**

8 The characteristics of the study population according to gender are presented in table 1. The sample was evenly
9 distributed among household economic levels. Approximately, all household heads have a profession while half
10 of the mothers do not work. Over two-thirds of household heads and mothers have a high school or university
11 education. A proportion of 60 % of the children were of normal body weight, with about 26 % overweight and
12 10 % obese.

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

18 Table 3 presents the percentage of children meeting the WHO recommendations for total fat, SFA and TFA
19 according to gender. Up to 58 % of the study population adhered to the WHO recommendations for total fat intake.
20 In 41 % of the children, total fat intake was higher than 30 % E. Only 39 % of the children were in compliance
21 with the SFA recommendations. A high proportion of the children aged 3-9 years (89 %) had an adequate TFA
22 intake (< 1 % E). No gender differences were observed.

23 The percentage contributions of the major food groups to the fat and fatty acids intake in the total study population
24 can be found in table 4. Ultra-processed foods (mainly cheese and cakes, pies and biscuits) were the major food
25 sources of total fat, SFA and TFA intakes in Tunisian children with respective percentage contributions of 32.5,
26 28.9 and 48.4. Bread and cereals were the second and the third main contributors to the total fat and SFA
27 consumption, respectively. Dairy products were classified at the second and the fourth rank respectively for fatty
28 acids and total fat intakes. Beverages and industrial juices didn't contribute to the fat and fatty acids intake.

29

30 **Discussion**

1 In the present study, we reported for the first time, the intake of total, saturated and trans-fatty acids and their major
2 food sources among 3-9 y Tunisian children using a cross-sectional survey. We found that the mean intake of total
3 fat falls within the WHO recommendations but a large proportion of the population (41 %) exceeded the
4 recommended limit of 30 % E. SFA intake in almost the two-third of the children was greater than 10 % E. However,
5 the TFA consumption was under the WHO recommendations for nearly all of them [15]. Compared to findings on
6 total fat and SFA intake of children and adolescents in other countries, our results are higher than those reported
7 in Korea [22], Mexico [23] or Japan [24], similar to those found in Guatemala [25] or US [26] and lower than
8 results registered in European countries where the mean total fat intake was 33.3 % E, with a mean SFA intake of
9 13.8 % E [27]. The consumption of TFA by Tunisian children was very low in comparison with data registered
10 elsewhere. Monge-Rojas et al. [2013] reported mean TFA intake of 1.3 % E in Costa Rican adolescents [28], while
11 the average dietary intake of TFA in Spanish children aged 4-5 y was 1.36 g/d which corresponds to 0.77 % E [29].
12 Results from Canadian children aged 5-6 y showed a mean TFA intake of 0.71 % E [30]. These results are expected
13 because the overall levels of TFA in most processed food products available on the Tunisian market are low (<1
14 g/100g of sample), except in margarine (5.56 g/100g).

15 Our results revealed that ultra-processed foods (mainly cheese and cakes, pies and biscuits) were the greatest
16 source of fat and fatty acids in Tunisian children, followed by bread and cereals for total fat and dairy products for
17 fatty acids. Ultra-processed foods are food products formulated mainly or entirely from processed ingredients,
18 including little or no whole foods [31]. The early consumption of these products could lead to negative health
19 effects such as the development of obesity or chronic diseases [32,33]. Therefore, it is important to understand the
20 role of food processing and to formulate public health strategies to reduce the consumption of ultra-processed
21 products early in life. Comparison of food sources of fat and fatty acids is not easy, because food groupings differ
22 between the research studies. The definition of the food groups in the present study was based on the Tunisian
23 food composition table and the USDA table [16,17]. The important contributions of ultra-processed foods, bread
24 and cereals and dairy products in the fat and fatty acids intake of children and adolescents was also found elsewhere.
25 Asakura and Sasaki (2017) reported that meat, dairy products, and confectioneries were the three major sources of
26 SFA in Japanese schoolchildren (26.4 %, 25.7 % and 11.3 % of total SFA intake) [24]. According to Wang et al.
27 (2018), the meat, poultry and fish, the milk and the mixtures mainly grain were the leading food sources of
28 saturated fats in US children [26]. The Korean study revealed that milk was the major food source of total fat and
29 SFA in 3-5 years children, with respective percentages contributions of 15.6 and 29.5, followed by pork and eggs
30 [22]. In Costa Rica, bakery products, red meat and dairy products were the main contributors to SFA and TFA

1 intakes in adolescents [28], while fried eggs, whole milk, sweet breads and fresh cheese were among the major
2 food sources of total fat and SFA in diets of Guatemalan schoolchildren [25]. The principal food groups
3 contributing to the total TFA intake in Spanish children were milks (21 %), processed baked goods (16 %), sweets
4 (12 %), fast food (12 %) and white bread (10 %) [29]. They were comparable to those reported in the Canadian
5 study [30]. Generally, the top three food groups contributing to the total fat and SFA intakes in European
6 adolescents were the meat, fish, eggs and meat alternatives (mainly meat), the low-nutrient, energy-dense foods
7 (mainly cakes, pies and biscuits) and the dairy and soya products (mainly cheese) [27]. In our study, the meat, fish,
8 eggs and fish alternatives were the fifth main contributors to the total fat and SFA intakes in Tunisian children,
9 with respective percentages of 10.7 and 10.8. This result is probably due to differences in dietary habits between
10 Tunisian population and the other world populations. The average annual meat consumption per capita in Tunisia
11 is around 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
12 and 98.3 kg in the United States [34,35]. On the other hand, the mean annual consumption of lean meat in 2015
13 (19.4 kg for poultry and white meat) is much more important than the consumption of fatty meat (7.1 kg for sheep
14 meat and 3.1 kg for bovine meat) [34]. The general food price index which makes sheep and bovine meat
15 proportionately more expensive than the other food products could explain this trend of meat consumption among
16 Tunisian people [36].

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

26

27 **Conclusion**

28 Since 41 % and 61 % of Tunisian children consumed excess fat and SFA respectively, there is a need of rapid
29 intervention for fat reduction in Tunisian population. Intake of TFA was relatively low compared to other research
30 studies. Nevertheless, elimination of industrial TFA is strongly recommended due to its association with increased

1 risk of heart attack and death. The major dietary sources of total fat, SFA and TFA in Tunisian children, were ultra-
2 processed foods, bread and cereals and dairy products. As ultra-processed foods are considered as low nutrient,
3 dense energy foods, public health nutrition efforts should continue to reduce the consumption of these products
4 and promote the intake of healthy diets.

5 **Ethics**

6 The study protocol received the approval of the Ethics Committee on Human Research of the National Institute of
7 Statistics and the National Institute of Nutrition and Food Technology. Verbal consent was obtained from all
8 parents before inclusion in the study.

9 **Conflict of interest**

10 The authors declare that they have no conflict of interest.

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

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Physiological characteristics	All		Boys		Girls	
	n	%	n	%	n	%
Boys	582	50			5	
Girls	582	50			6	
Age (years)					7	
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
Socio-economic factors					11	
Economic level of the household					12	
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
Profession of household head					16	
Upper/medium	507	44.36	247	42.94	260	43.77
Employee/worker	637	54.04	324	55.26	313	51.81
Not working/retired	20	1.606	11	1.799	9	1.494
Education of household head					20	
University/Secondary	882	76.38	440	75.91	442	72.85
Primary school or none	282	23.62	142	24.09	140	23.15
Profession of mother					23	
Upper/medium	332	29.5	160	28.81	172	30.49
Employee/worker	253	22.04	123	21.37	130	23.71
Not working/retired	579	48.46	299	49.82	280	47.1
Education of mother					27	
University/Secondary	878	76.53	433	75.42	445	77.63
Primary school or none	286	23.47	149	24.58	137	23.37
Anthropometric characteristics					29	
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

1 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 ^a	
Fat total	(g/d)	Mean (s.e.) ^b	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)	0.000
		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) ³	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)	0.008
		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)	0.000
		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)	0.000
		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	

2 ^a - Comparison between sexes adjusted for age. ^b- Mean value (standard error). ³Energy percent3
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1 Table 3. Percentage of Tunisian children adhering to WHO recommendations for total fat, SFA and TFA by gender

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Nutrient (% E)	Total (n = 1164)	Boys (n=582)	Girls (n=582)	p value	
Total fat				0.759	3
< 15	<1	<1	<1		4
15-30 ^a	58	59	57		
> 30	41	40	42		5
SFA				0.420	6
<10 ¹	39	40	38		
≥ 10	61	60	62		7
TFA				0.945	8
<1 ¹	89	89	89		
≥ 1	11	11	11		9

^a Recommended levels of total fat, SFA and TFA according to WHO

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11 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	% ¹	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

12 ^a Percentage contributions of food groups

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