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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Abstract

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

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

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

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

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

Background

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

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

Material and Methods

Subjects and study design

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

Dietary intake assessment

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

Data management and statistical analysis

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

Results

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

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

| Physiological characteristics | All | Boys | Girls |
|------------------------------|-----|------|-------|
| Boys                         | 582 | 50%  |       |
| Girls                        | 582 | 50%  |       |
| Age (years)                  |     |      |       |
| 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       |     |      |       |
| Economic level of the household |     |      |       |
| 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 |     |      |       |
| 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  | 1.60 | 11    | 1.79 | 9    | 1.41 |
| Education of household head |     |      |       |
| University/Secondary        | 882 | 76.38| 440   | 75.91| 442  | 76.85 |
| Primary school or none      | 282 | 23.62| 142   | 24.09| 140  | 23.15 |
| Profession of mother        |     |      |       |
| 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  |
| Education of mother         |     |      |       |
| University/Secondary        | 878 | 76.53| 433   | 75.42| 445  | 77.63 |
| Primary school or none      | 286 | 23.47| 149   | 24.58| 137  | 22.37 |

| Anthropometric characteristics |     |      |       |
| 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  |

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

Table 2 presents the percentage of children meeting the WHO recommendations for total fat, SFA and TFA according to gender. Up to 58% of the study population adhered to the WHO recommendations for total fat intake. In 41% of the children, total fat intake was higher than 30 % E. Only 39% of the children were in compliance
with the SFA recommendations. A high proportion of the children aged 3-9 years (89 %) had an adequate TFA intake (<1 % E). No gender differences were observed.

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) | p value |
|---------------|-----------------|--------------|---------------|---------|
| Total fat     |                 |              |               | 0.759   |
| < 15          | <1              | <1           | <1            |         |
| 15-30a        | 58              | 59           | 57            |         |
| > 30          | 41              | 40           | 42            |         |
| SFA           |                 |              |               | 0.420   |
| <10a          | 39              | 40           | 38            |         |
| ≥ 10          | 61              | 60           | 62            |         |
| TFA           |                 |              |               | 0.945   |
| <1a           | 89              | 89           | 89            |         |
| ≥ 1           | 11              | 11           | 11            |         |

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

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

Discussion

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

Our results revealed that ultra-processed foods (mainly cheese and cakes, pies and biscuits) were the greatest source of fat and fatty acids in Tunisian children, followed by bread and cereals for total fat and dairy products for fatty acids. Ultra-processed foods are food products formulated mainly or entirely from processed ingredients, including little or no whole foods. The early consumption of these products could lead to negative health effects such as the development of obesity or chronic diseases. Therefore, it is important to understand the role of food processing and to formulate public health strategies to reduce the consumption of ultra-processed products early in life. Comparison of food sources of fat and fatty acids is not easy, because food groupings differ between the research studies. The definition of the food groups in the present study was based on the Tunisian food composition table and the USDA table. The important contributions of ultra-processed foods, bread and cereals and dairy products in the fat and fatty acids intake of children and adolescents was also found elsewhere. Asakura and Sasaki (2017) reported that meat, dairy products, and confectioneries were the three major sources of SFA in Japanese schoolchildren (26.4 %, 25.7 % and 11.3 % of total SFA intake). According to Wang et al. (2018), the meat, poultry and fish, the milk and the mixtures mainly grain were the leading food sources of saturated fats in US children. The Korean study revealed that milk was the major food source of total fat and SFA in 3-5 years children, with respective percentages contributions of 15.6 and 29.5, followed by pork and eggs. In Costa Rica, bakery products, red meat and dairy products were the main contributors to SFA and TFA intakes in adolescents, while fried eggs, whole milk, sweet breads and fresh cheese were among the major food sources of total fat and SFA in diets of Guatemalan schoolchildren. The principal food groups contributing to the total TFA intake in Spanish children were milks (21 %), processed baked goods (16 %), sweets (12 %), fast food (12 %) and white bread (10 %). They were comparable to those reported in the Canadian study. Generally, the top three food groups contributing to the total fat and SFA intakes in European adolescents were the meat, fish, eggs and meat alternatives (mainly meat), the low-nutrient, energy-dense foods (mainly cakes, pies and biscuits) and the dairy and soya products (mainly cheese). In our study, the meat, fish, eggs and fish alternatives were the fifth main contributors to the total fat and SFA intakes in Tunisian children, with respective percentages of 10.7 and 10.8. This result is probably due to differences in dietary habits between Tunisian population and the other world populations. The average annual meat consumption per capita in Tunisia 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 and 98.3
kg in the United States \cite{34,35}. On the other hand, the mean annual consumption of lean meat in 2015 (19.4 kg for poultry and white meat) is much more important than the consumption of fatty meat (7.1 kg for sheep meat and 3.1 kg for bovine meat) \cite{34}. The general food price index which makes sheep and bovine meat proportionately more expensive than the other food products could explain this trend of meat consumption among Tunisian people \cite{36}.

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

**Conclusion**

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

**Declarations**

**Ethics approval and consent to participate**

All applicable institutional and governmental regulations concerning the ethical use of human volunteers were respected during this study. The survey protocol was reviewed and approved by the Tunisian National Council of Statistics (Visa n°3/2017) and the Ethical Consultative Committee of the National Institute of Nutrition and Food
After being thoroughly informed on the purpose, requirements, and procedures of the survey, all parents gave their free informed consent. All data were handled anonymously during analysis.

Consent for publication
Not applicable

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests

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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 | p value | Age groups | p valuea |
|----------|---------------|-----------|--------|------------|---------|------------|----------|
|          |               |           | Boys   | Girls      |         | 3-4 y      |          |
| Fat total|               |           |        |            |         | 5-6 y      |          |
|          | Mean (s.e.)b  | 49.8 (0.5)| 50.5 (0.7)| 48.9 (0.6)| 0.084  | 46.3 (0.8)| 0.000    |
|          | 95 % CI       | 48.7 - 49.7| 49.1 - 51.9| 47.6 - 50.1|         | 44.7 - 47.8|          |
|          | Mean (s.e.)c  | 29.6 (0.3)| 29.6 (0.6)| 29.6 (0.3)| 0.931  | 29.2 (0.3)| 0.968    |
|          | 95 % CI       | 28.9 - 30.2| 28.5 - 30.8| 29.0 - 30.1|         | 28.5 - 29.9|          |
| SFA      | Mean (s.e.)b  | 19.2 (0.2)| 19.6 (0.3)| 18.8 (0.3)| 0.070  | 18.5 (0.4)| 0.110    |
|          | 95 % CI       | 18.8 - 19.7| 19.0 - 20.2| 18.2 - 19.4|         | 17.8 - 19.2|          |
|          | Mean (s.e.)c  | 11.4 (0.1)| 11.3 (0.1)| 11.4 (0.2)| 0.887  | 11.7 (0.2)| 0.008    |
|          | 95 % CI       | 11.2 - 11.6| 11.1 - 11.6| 11.0 - 11.7|         | 11.3 - 12.0|          |
| TFA      | Mean (s.e.)b  | 0.24 (0.01)| 0.26 (0.02)| 0.23 (0.02)| 0.158  | 0.29 (0.03)| 0.000    |
|          | 95 % CI       | 0.22 - 0.27| 0.22 - 0.30| 0.19 - 0.26|         | 0.23 - 0.34|          |
|          | Mean (s.e.)c  | 0.15 (0.01)| 0.16 (0.01)| 0.14 (0.01)| 0.219  | 0.18 (0.02)| 0.000    |
|          | 95 % CI       | 0.13 - 0.16| 0.13 - 0.18| 0.11 - 0.16|         | 0.15 - 0.22|          |

- Comparison between sexes adjusted for age. b: Mean value (standard error). c: Energy percent
Table 4. Percentage contributions of the major food groups to the total fat, SFA and TFA intakes in Tunisian children

| Rank | Food group                        | Total fat | % | Rank | Food group                        | SFA   | % | Rank | Food group                        | TFA   | % |
|------|-----------------------------------|----------|---|------|-----------------------------------|-------|---|------|-----------------------------------|-------|---|
| 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  |   |

*Percentage contributions of food groups