Variability of fat content and fatty acid composition of selected Jordanian fast foods and their impact on nutritional indices

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The most consumed fast foods were purchased from different restaurants in Amman city, the capital of Jordan. The aim of this study was to evaluate the commonly consumed fast foods in Jordan with respect to fatty acid composition and their nutritional quality. Eleven foods were analysed using Gas Liquid Chromatography. The highest amount of fat was observed in the Halloumi sandwich and Beef Burger. The main fat contributors are meat and cheese. SFA, MUFA and PUFA were found in various amounts in the fast-food samples. The high amount of SFA is found in the Halloumi sandwich and Margherita pizza followed by Vegetarian pizza and Beef Burger. This can be justified by the high amount of SFA in meat and dairy products. Chicken-based products are the most PUFA-rich foods, where Linoleic acid (ω-6) was found in high quantity, whereas linolenic acid (ω-3) was detected in very low amount. All fast food shows a certain amount of trans fatty acid, among them, the highest percentage was found in Beef shawarma and Vegetarian Pizza. Nutritional quality was calculated using the atherogenic and thrombogenic indices, PUFA/ SFA ratio, and ω-6/ω-3 fatty acids ratio. Chicken-based products, mainly chicken shawarma sandwich, showed high fatty acid quality based on their P/S, IA, IT and ω-6/ω-3 as compared with the other food items. As a result, fatty acid modifications are recommended to increase the PUFA/SFA ratio while decreasing the omega6/omega3 ratio and thus improve Jordanian consumers' nutritional quality and preventing health diseases.

Key words: Fast foods, Fat, Fatty acid composition, Nutritional indices.

INTRODUCTION

Fast food consumption is a phenomenon that is common all over the world. These foods are eaten as main meals regardless of social class or age group, and the Jordanian's diet, particularly in urban areas, is becoming more westernised. Many households eat out, eat fast food products or eat ready-to-eat processed foods high in fat and salt, sweeteners, and soft drinks are becoming more popular [1, 2]. Hamburgers, pizzas, fried chicken, and sandwiches are mainly consumed fast foods in the worldwide, in addition, Falafel sandwiches and shawarma are also popular quick meals or light snacks in Jordan [2, 3].
Fatty acid analysis is a quick and accurate way to determine the fatty acid composition of fats and oils. Because the types and proportions of fatty acids, as well as their location in glycerol, affect the physical, chemical, and nutritional properties of fats, which in turn affect food, this information is useful for all aspects of product development, process control, and marketing [4].
The Fatty Acid (FA) catalogue is divided into three categories based on the number of double bonds: saturated fatty acids (SFAs), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA). FAs are distributed to cells and used as fuel for muscular contraction and general metabolism, which can play a positive or negative role in disease prevention and treatment [5].

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The presence of SFA in fast foods may have a negative impact on several factors related to cardiovascular disease and atherosclerosis, with C14:0 and C16:0 fatty acids being among the most atherogenic, whereas C18:0 is thought to be neutral in terms of atherogenicity but thrombogenic [6]. According to a recent study on the effect of fast foods on COVID19 conducted by Bohlouli et al. [7], it was discovered that consumption of fast food (mainly SFA) activates the intrinsic immune system while impairing adaptive immunity, resulting in chronic inflammation and impaired host defence against viruses. Polyunsaturated fatty acids (PUFA), particularly omega-6 (ω-6) and omega-3 (ω-3) fatty acids are proving indispensable in a properly maintained ratio for numerous beneficial health functions [8]. Most natural unsaturated fatty acids in foods are in the cis-isomer form. Trans fatty acids (TFA) are stereoisomers of cis-unsaturated fatty acids that occur naturally [9]. Furthermore, depending on the preparation of these fast foods, traditional vegetable oils and fats obtained through partial hydrogenation or chemical interesterification can be used, resulting in an increase in the trans fatty acids levels, which are known to be harmful to health [10]. TFA raises low-density lipoproteins (LDL) levels, lowers High-density lipoproteins (HDL) levels, and raises the risk of coronary heart disease [4].

To avoid many health problems, various important nutritional indices, such as Omega 6/Omega 3, PUFA/SFA ratio, Atherogenic and Thrombogenic indices, are frequently used to describe the fatty acid composition of foods and to evaluate their nutritional value. The essential ω-3 and ω-6 fatty acids are essential for health and normal physiological functioning of humans, however a high intake of omega-6 polyunsaturated fatty acids (PUFA) in food, combined with a low intake of omega-3 PUFA, has resulted in an imbalance in the ω-6/ω-3 ratio, and thus a high omega 6/omega 3 ratio promotes cardiovascular disease, cancer, inflammatory diseases and play an important role in obesity [8, 11].

Furthermore, while PUFA/SFA is the most used index for evaluating dietary nutritional value, it is too broad and unsuitable for assessing the atherogenicity of foods. Index of atherogenicity (IA) and Index of Thrombogenicity (IT) are the most used nutritional indices to determine lipid quality and fatty acid composition because they outline significant implications and provide clear evidence [5].

This study was performed to monitor the fatty acid composition, presence of any harmful trans fatty acids and the nutritional indices of selected Jordanian fast foods of Amman city.

MATERIALS AND METHODS

SAMPLE PREPARATION

A total of 29 samples from 11 varieties of Jordanian fast foods samples were collected from different fast-food restaurants of Amman. Selected food samples were Falafel sandwich (FL), Chicken shawarma sandwich (CS), Beef shawarma sandwich (BS), Beef burger (BBR), Chicken burger (CBR), Zinger sandwich (ZR), Turkey sandwich (TR), Lebneh and Mortadella sandwich (L&M), Halloumi sandwich (HL), Vegetarian pizza (VP) and Margherita pizza (MP). The number of items purchased depended on their availability in the food outlet. The samples were transported in an insulated ice box until they reached the laboratory. All individual whole samples containing all its ingredients of the same type taken from the same restaurant were cut into pieces, then mixed using a mixer to give one bulk representative sample of the same type of food. All the prepared samples were rapidly transferred to dry clean containers with well-fitting fastenings, labelled and stored in freezers until the time of analysis. Homogenised samples were taken for total lipid extraction.

FAT EXTRACTION

Fat content was determined based on the Soxhlet extraction method by following the AOAC Official Method 963.15 [12]. A homogenous representative samples were taken from the bulk sample of each type of food for the purpose of fat extraction.

FATTY ACID METHYL ESTERS PREPARATION

Fatty acid methyl esters (FAMEs) were produced in accordance with EC Regulation no. 2568/91[13]. In brief, 50 mg of lipid extract was weighed, dissolved in 2 mL of GC grade hexane, and vortexed for 1 minute. After adding 200 µl of 2 M-potassium hydroxides prepared in anhydrous methanol and mixing for 30 seconds until the solution became clear, 200 µl of acetic acid was added and mixed for 30 seconds. The prepared methyl esters were analysed using capillary GLC column (Restek, Rtx-225, USA, cross bond 50%-cyanopropylmethyl 50%-phenylmethyl polysiloxane, 60 m, 0.25 mm/D, 0.25 µm df) immediately after esterification by injection 1.00 µl of the hexane layer through the injection port ofthe GLC (model GC-2010, Shimadzu. Inc., Koyoto, Japan). FAMEs were injected after adjusting the GLC conditions.

For foods containing no milk fat, the initial oven temperature was 165°C, held for 4 minutes, increased at a rate of 2°C/min to 180°C, increased at a rate of 5°C/min to 230°C, and then held for 6 minutes, for a total program time of 36 minutes. For foods containing Milk fat, the initial oven temperature was 70°C, held for 4 minutes, then increased at a rate of 10°C/min to 165°C, then at a rate of 2°C/min to 180°C, then at a rate of 5°C/min to 230°C, and held for 5 minutes, for a total program time of 27.5 minutes. The injector temperature was 250°C, the FID temperature was 260°C, the flow rate was 1 ml/min Helium, and the split ratio used was 80. The fatty acids methyl esters (FAMEs) were identified using chromatogram of a fatty acid standard.

NUTRITIONAL INDICES

The data from the fatty acid composition analysis were used to determine the nutritional quality of the selected fast foods. Nutritional quality was assessed by determination the omega6/omega3 ratio, PUFA/SFA ratio and Index of atherogenicity and thrombogenicity using the following calculations:

- Index of atherogenicity (IA)

Ulbricht and Southgate [14] proposed a new index called "Atherogenic Index" because the PUFA/SFA ratio is too general and unsuitable for assessing the atherogenicity of foods [5]. IA indicating the relationship between the sum of the major saturated fatty acids and the major unsaturated fatty acid classes [15]. It follows as:

$$IA = [(C16:0 + (4 \times C14:0) + C18:0)] / (\Sigma MUFA + \Sigma\omega6 + \Sigma\omega3)$$

- Index of thrombogenicity (IT)

The index of thrombogenicity (IT) was developed with IA by Ulbricht and Southgate [14] which demonstrates a proclivity to form clots in blood vessels. This is defined as the relationship between pro-thrombogenic (SFA) and anti-thrombogenic (MUFAs and PUFA) fatty acids [15]. The following formula was used:

$$IT = (C14:0 + C16:0 + C18:0) / [(0.5 \times \Sigma MUFA) + (0.5 \times \omega6 + (3 \times \omega3) + (\Sigma\omega3 / \Sigma\omega6)]$$

STATYSTICAL ANALYSIS

All measurements were performed in triplicate and mean values were reported. Analysis of variance (ANOVA) using JMP (release 10, SAS institute, Cary, NC) was carried out to determine any significant differences among the parameters associated with the study. Least significant difference (LSD) at a 5% level of probability was determined to separate differences in the properties among the different fast foods.

RESULTS AND DISCUSSION

A total of 29 food items in 11 different food varieties were analysed from February to June 2021. Total fat content (g/100g food), the percentage of fatty acids (g/100g total FA), and the nutritional indices were determined.

FAT CONTENT OF SELECTED FAST FOODS

Figure 1 shows the fat content of selected Jordanian fast foods. The highest amount of fat was observed in HL (12.21%) and BBR (12%), decreased to the lowest amount in LM, TR, FL and VP (5.97, 6.32, 6.51 and 6.99% respectively). The main contributors towards fat are meat and cheese. Studies indicate that dietary intake of total and saturated fat mainly comes from fast foods, snack foods, oils, spreads, other processed foods, and the visible fat of meat, rather than lean meat [16]. Among the properties of Halloumi cheese, which is the main ingredient in Halloumi sandwich, is its high melting point, which enables it to be fried or grilled [17], and therefore it is the major contributor to a high fat level [16].

The USDA [18] reported that the fat content of FL, CBR, TR, were 3.08, 13.5-16.9%, 1.97-2.6%, respectively, which disagreed with the obtained data, however, agreed with the reported MP fat content (5.51-10.1%). Yagope et al. [19] found that BBR had a fat content of 6.72-7.85%; which is lower than our results, however, Ahmed [20] and Babji et al. [21] showed higher fat ranges of 13.45-16.26% and 12.36-25.74% respectively, in beef burgers.

Ahmed et al. [22] mentioned that the fat content of Chicken shawarma sandwiches ranged from 14.42 to 19.54%, which is not consistent with the obtained mean value (9.71%). However, our findings agreed with Ahmed [20] that reported a fat content range of 6.75-10.19%. The results of fat content of BS agreed with the range (i.e., 8.4-10.9%) recorded by Ahmed et al. [22] and disagreed with that (i.e., 10.82-17.64%) recorded by Ahmed [20]. Vegetarian pizza contained 9.13% of fat according to Musaiger et al. [16] and 8.7% according to Musaiger and D'Souza [23]; both of which are higher than the present findings, however, the results of Takruri et al. [24] were lower (5.40%) than the obtained fat result. Our findings may support the assumption that the variation in the fat content of selected foods is mainly due to different factors including the preparation method, cooking procedure, type and amount of added ingredients, type of oil, and time of deep frying [25, 26].

Peña-Saldarriaga et al. [27] mentioned that chicken meat is a low-fat and a high-protein source. The burger's low-fat content could be attributed to the fat-free

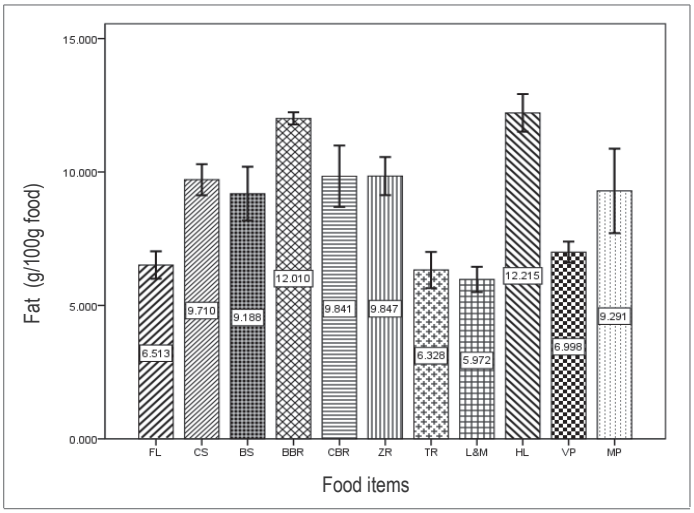

Figure 1 - Fat content (g/100g food) of selected Jordanian fast foods (FL, Falafel sandwich; CS, Chicken shawarma sandwich; BS, Beef shawarma sandwich; BBR, Beef burger; CBR, Chicken burger; ZR, Zinger sandwich; TR, Turkey sandwich; L&M, Lebneh and Mortadella sandwich; HL, Halloumi sandwich; VP, Vegetarian pizza; MP, Margherita pizza).
I---I: Standard Mean of Error (SME).

patty grilling method and the chicken patties with excess fat removed [28]. Also, notable high fat content of turkey sandwich may be attributed to cheese. The chemical composition of mortadella differs according to the type of animal (beef, lamb or chicken), and the modifications used in the original formula to manufacture the products [29]. Vegetarian pizza is typically rich in vegetables which are poor sources of fat [18].

FATTY ACIDS COMPOSITION OF SELECTED FAST FOODS

Saturated fatty acids (SFA)

The result presented in Table I showed the different saturated fatty acid found in food items. The saturated fatty acid that was in the greatest quantity, in all evaluated foods, was the Palmitic acid (C16:0), whose contents varied, on average, between 15.92 and 30.33% of the total acids, followed by Stearic acid (C18:0) and then Myristic acid (C14:0). Palmitic acid levels were the highest of the saturated fatty acid in all samples, however, the high amount of Myristic acid was found in HL and MP (10.94 and 9.40%, respectively) followed by VP (7.46%) with lowest amount detected in FL and CS (0.28 and 0.38%, respectively), as well as Lauric acid which was in low quantities in all food items except HL which contained an appreciable amount of this fatty acid. This was mainly attributed to the relatively high concentrations of Lauric acid in milk fat [30]. BBR and HL had the highest amounts of stearic acid (13.39 and 11.49%, respectively) followed by MP and BS (9.60 and 8.89%, respectively). According to Table I, the highest amounts of SFA were found in HL and MP, followed by VP and BBR. This can be justified by the high amount of SFA in meat and dairy products [31]. Palmitic acid (C16:0) was the predominated SFA; which is the main contributor to increasing the SFA% (Table I). The addition of palm oil and its derivatives, which can be used in interesterified oil mixtures or directly in industrialised food formulations even without interesterification, justifies the high Palmitic acid content in food items [1]. This fatty acid account is responsible for raising cholesterol activity from beef and beef products and therefore, increases cardiovascular diseases [19]. As a result, the use of Palmitic acid for technological purposes can be advantageous, owing to its high melting point (63°C) and lack of unsaturation in its structure. This gives the final product oxidation stability and a creamy texture, resulting in products that are like partially hydrogenated vegetable fats [1]. Furthermore, Afonso et al. [10] mentioned that consuming interesterified Palmitic acid increased the inflammatory process in mice, resulting in a greater atherosclerotic lesion when compared to consuming other oils or fats. As a result of the risks associated with a high intake of Palmitic acid fat, using interesterified vegetable fat or a blend with palm oil to replace hydrogenated vegetable fat may not be a

Table I - Saturated fatty acids (g/100g total FA) composition* of selected Jordanian fast foods

Fatty acids	FL (n=3)	HL (n=2)	VP (n=2)	MP (n=2)	CS (n=3)	BS (n=2)	BBR (n=3)	CBR (n=3)	ZR (n=3)	TR (n=3)	LM (n=3)
C4:0	ND^{d}	0.21^{ab}±0.02	ND^{d}	0.30^{a}±0.02	ND^{d}	ND^{d}	0.20^{ab}±0.04	0.032^{d}±0.00	0.059^{cd}±0.04	0.01^{d}±0.00	0.14^{bc}±0.06
C6:0	ND^{e}	0.61^{ab} ±0.24	ND^{e}	0.82^{a}±0.05	ND^{e}	ND^{e}	0.15^{de}±0.03	0.088^{de}±0.03	0.12^{de} ±0.00	0.41^{bc} ±0.17	0.27^{cd} ±0.08
C8:0	ND^{c}	0.85^{a} ±0.30	ND^{c}	0.63^{a}±0.18	ND^{c}	ND^{c}	0.12^{bc} ±0.01	0.099^{bc}±0.02	0.09^{bc}±0.01	0.28^{b}±0.12	0.20^{bc} ±0.02
C10:0	ND^{d}	2.05^{a} ±0.19	ND^{d}	1.93^{a}±0.14	ND^{d}	ND^{d}	0.40^{cd} ±0.10	0.21^{cd} ±0.08	0.22^{cd} ±0.01	0.89^{b}±0.37	0.61^{bc} ±0.17
C12:0	ND^{b}	13.69^{a}±11.18	2.01^{b}±0.00	2.54^{b}±0.08	ND^{b}	ND^{b}	0.66^{b}±0.12	0.43^{b}±0.06	0.35^{b}±0.04	1.39^{b}±0.37	0.98^{b}±0.26
C14:0	0.28^{f}±0.10	10.94^{a}±1.80	7.46^{b}±0.39	9.40^{ab}±0.8	0.38^{f}±0.09	1.29^{def}±0.61	3.64^{cd} ±0.54	1.22^{ef} ±0.38	1.40^{ef}±0.13	4.44^{c}±1.57	3.15^{cde} ±0.82
C15:0	ND^{d}	0.69^{ab}±0.00	0.76^{a}±0.02	0.94^{a}±0.06	ND^{d}	ND^{d}	0.45^{bc}±0.08	0.12^{d} ±0.03	0.14^{d}±0.00	0.44^{c} ±0.16	0.39^{c} ±0.09
C16:0	18^{bc} ±4.21	27.19^{abc}±7.70	26.58^{abc}±0.35	30.3^{a}±0.62	16.96^{c}±2.21	15.92^{bc}±2.78	23.24^{abc}±1.34	18.26^{abc}±4.25	20.66^{abc}±6.12	23.58^{abc}±3.45	28.07^{ab} ±2.81
C17:0	0.08^{b}±0.01	0.45^{b} ±0.09	0.20^{b}±0.18	0.61^{b}±0.11	0.25^{b}±0.05	1.60^{a}±1.33	0.45^{b}±0.04	0.16^{b} ±0.00	0.17^{b} ±0.01	0.28^{b} ±0.09	0.40^{b} ±0.14
C18:0	5.57^{de}±0.77	11.49^{ab}±1.08	8.30^{bcd}±1.29	9.60^{bc}±1.50	4.97^{e}±0.25	8.89^{bc}±2.35	13.39^{a} ±1.26	5.30^{de} ±0.17	5.32^{de} ±0.10	7.47^{cde} ±0.98	7.29^{cde} ±0.76
C20:0	0.43^{a}±0.02	0.03^{g}±0.00	0.30^{bcd}±0.04	0.03^{g}±0.01	0.14^{efg}±0.03	0.33^{abc}±0.09	0.42^{ab} ±0.04	0.24^{cde}±0.02	0.16^{efg}±0.03	0.11^{fg}±0.02	0.20^{def} ±0.05
C22:0	ND^{f}	0.04^{ef} ±0.00	0.44^{a}±0.11	0.08^{def}±0.00	0.33^{ab}±0.03	ND^{f}	0.03^{ef}±0.00	0.24^{bc}±0.03	0.13^{cde}±0.06	0.17^{cd} ±0.02	0.049^{ef}±0.02
C24:0	ND^{c}	0.02^{bc}±0.00	0.02^{c}±0.00	0.02^{bc}±0.00	0.13^{a}±0.02	ND^{c}	0.012^{ab}±0.00	0.11^{ab}±0.07	0.01^{c}±0.00	0.09^{abc}±0.04	0.04^{abc}±0.02
ΣSFA	24.38^{g}±3.67	68.32^{a}±6.54	46.08^{bc}±2.05	57.29^{ab}±3.59	23.19^{g}±2.57	28.04^{defg}±7.18	43.2^{bcd}±3.47	26.55^{fg}±4.78	28.86^{efg}±6.20	39.62^{cdef}±6.56	41.83^{cde}±4.46

FL, Falafel sandwich; HL, Halloumi sandwich; VP, Vegetarian pizza; MP, Margherita pizza; CS, Chicken shawarma sandwich; BS, Beef shawarma sandwich; BBR, Beef burger; CBR, Chicken burger; ZR, Zinger sandwich; TR, Turkey sandwich; L&M, Lebneh and Mortadella sandwich.
*Values are means ±SEM (Standard Error of the Mean)
^{a,b,c,d,e,f,g} different superscripts within the same row indicate significantly (p< 0.05) different data.
ND: not detected, SFA: saturated fatty acids.

Table II -Monounsaturated fatty acids (g/100g total FA) composition* of selected Jordanian fast foods

Fatty acids	FL (n=3)	HL (n=2)	VP (n=2)	MP (n=2)	CS (n=3)	BS (n=2)	BBR (n=3)	CBR (n=3)	ZR (n=3)	TR (n=3)	LM (n=3)
C14:1	ND^{e}	0.75^{ab} ±0.24	0.90^{a}±0.06	0.94^{a} ±0.04	ND^{e}	ND^{e}	0.50^{bc}±0.03	0.11^{de} ±0.03	0.11^{de} ±0.01	0.45^{c} ±0.18	0.33^{cd} ±0.09
C15:1	ND^{f}	0.18^{ab}±0.07	ND^{f}	0.26^{a} ±0.07	ND^{f}	ND^{f}	0.15^{bc}±0.01	0.02^{def}±0.00	0.03^{def}±0.00	0.09^{cd}±0.03	0.07^{de}±0.02
C16:1	0.17^{e} ±0.03	1.34^{bcde}±0.16	1.66^{abc} ±0.12	1.50^{bcd}±0.08	2.73^{a} ±0.88	1.23^{bcde}±0.64	2.32^{ab} ±0.27	0.63^{cde} ±0.08	0.39^{de} ±0.19	0.96^{cde} ±0.22	2.82^{a} ±0.18
C17:1	0.046^{b}±0.01	0.19^{b} ±0.01	0.11 ^{b}±0.07	0.24^{b} ±0.01	0.07^{b}±0.01	0.11^{b} ±0.02	0.81^{a} ±0.17	0.08^{b} ±0.00	0.05^{b} ±0.02	0.14^{b} ±0.04	0.14^{b} ±0.03
C18:1	38.77^{a} ±2.05	21.74^{e} ±3.91	32.6^{abcd}±1.73	24.78 ^{de}±1.09	31.08^{abcd}±2.2	32.94^{abcd}±6.98	34.36^{abc}±0.76	28.88^{bcde}±1.28	27.4^{cde} ±3.02	25.73^{de} ±0.59	36.56^{ab}±4.46
ΣMUFA	38.99^{a} ±2.09	24.23^{d} ±4.39	35.29^{abc} ±1.60	27.75^{cd} ±1.30	33.89^{abc}±3.14	34.29^{abcd}±7.59	38.14^{ab}±1.05	29.74^{bcd} ±1.38	27.99^{cd} ±3.14	27.39^{cd} ±0.57	39.94^{a} ±4.52

FL, Falafel sandwich; HL, Halloumi sandwich; VP, Vegetarian pizza; MP, Margherita pizza; CS, Chicken shawarma sandwich; BS, Beef shawarma sandwich; BBR, Beef burger; CBR, Chicken burger; ZR, Zinger sandwich; TR, Turkey sandwich; L&M, Lebneh and Mortadella sandwich.

*Values are means ±SEM (Standard Error of the Mean)

^{a,b,c,d,e,f} different superscripts within the same row indicate significantly (p< 0.05) different data.

ND: not detected, MUFA: monounsaturated fatty acids

nutritionally adequate replacement [1]. Different types of meat products, including burgers, remain popular among a wide range of consumers, particularly the younger generation [32]. Yagope et al. [19] conducted a study on the fatty acid composition of Sudanese burgers, and the results revealed that the main acids found in beef burgers were SFAs, which are associated with a variety of diseases, including cardiovascular disease, obesity, hypertension, and coronary heart disease. The quality of the burger may vary due to the different raw materials and ingredients used, as well as the processing methods used. The current consumer trend of eating low-fat products is a source of concern for processed meat manufacturers [33].

Margherita Pizzas also showed a mean SFA content of 57.29% (percentage of total fatty acids) due to the presence of cheese and of short-chain fatty acids [34].

Other studies have also found an increase in the content of this fatty acid in processed foods, particularly those with lower Trans-fat content, with the incorporation of high palmitic oils or even purified fatty acids being used as a strategy [1, 35]. As a result of such changes in the lipid profile of foods, the use of new alternatives to partially hydrogenated fats containing approximately 30% Trans-fat must be carefully monitored. In fact, the food industry tends to use blends or interesterification of soybean with palm oil in the production of margarine and vegetable fats [1].

On the other hand, Mohamed et al. [33] found that high levels of SFA in chicken burgers may be attributed to the fiber content of some treatments. This absorbs more fats during frying and reduces the amount of oil used. Also, Rapeseed oil, animal fat, and palm fat are commonly added to feed mixtures for poultry. In the American diet, approximately, animal fats account for roughly 60% of SFA, the majority of which are Palmitic acid (C16:0) and Stearic acid (C18:0) [31]. The general public is increasingly vocal in their opposition to palm fat inclusion. The reasons are both ecological (due to forest decline) and nutritional (due to palm fat high content of SFA) [36].

In addition to Palmitic acid, Lauric and Myristic acids, which were found in lower concentrations in the fast-food samples studied, have been linked to the aetiology of heart disease by increasing plasma low density lipoprotein cholesterol [37]. Palmitic acid, according to Musaiger et al. [16], is a major cholesterol-raising SFA in the diet. Stearic acid was also found in fast foods, but it had no effect on total cholesterol or lipoprotein cholesterol levels in humans, also no atherogenic effect when consumed [1].

Monounsaturated fatty acids (MUFA)

The results showed in Table II represent the monounsaturated fatty acids (MUFA) content of selected fast foods. As can be observed, the MUFAs detected in less quantities such as Myristoleic acid (C14:1), Pentadecenoic acid (C15:1), Palmitoleic acid (C16:1)

and Heptadecenoic acid (C17:1) were just identified in some foods and in less expressive amounts. However, Oleic fatty acid (C18:1) was detected in greater quantities with levels between 21.74 to 38.77%. This agrees with Otemuyiwa and Adewusi [37] who found that the Oleic acid was the major unsaturated fatty acid in Nigerian fast foods.

Oleic acid was the most abundant unsaturated fatty acid found in Jordanian fast foods, primarily in plant products (FL and VP) and meat products (CS, BS, BBR, CBR and LM). This finding agreed with Yagope et al. [19] who found that Oleic acid was the major fatty acid in beef meat and accounts for about 33% of the fatty acid in beef. Also, Skřivan et al. [36] and Alagawany et al. [8] reported that Oleic acid was the most abundant FA in the abdominal fat of all chickens and are found in olive oil and animal fat.

The present data showed that LM and FL had the highest MUFA contents (Table II), however, the rest of food items had MUFA levels somewhat in the range of 24.23-38.14%, with the lowest amount in HL. This agreed with Kapshakbayeva et al. [17] who found that Halloumi had MUFA content of about 27% of the total fatty acids.

Oleic acid was the main unsaturated fatty acid that contributed to the increase of total MUFA in the examined foods (Table II). The most abundant MUFA, i.e., Oleic acid (C18:1), is found in most vegetable oils, this is the case of falafel which is well-known for its high olive oil content and one of the primary differences between olive oil and other oils is its high oleic acid content [38 - 40]. Study reported by Orsavova et al. [41], revealed that olive oil has of about 66.4% Oleic acid and a total of 68.2% MUFA, interestingly, MUFAs made up most of the fatty acid compositions in olive oil, with oleic acid (C18:1) being the most abundant.

On the other hand, FL showed the lowest amount of Palmitoleic acid, this agreed with Al-Mrazeeq et al. [42] who mentioned that the addition of olive oil decreased the Palmitoleic acid contents.

Epidemiological evidence suggests that a higher proportion of MUFA, particularly Oleic acid, in the diet is associated with a lower risk of coronary heart disease (CHD) [40]. Lopez et al. [40] recommended the use of olive oil as a major source of Oleic acid to replace a comparable amount of saturated fat while not increasing total daily calories. It has been established that MUFAs may lower LDL cholesterol while possibly increasing HDL cholesterol [41]. In contrast to PUFAs that protect against insulin resistance, Oleic acid may promote insulin resistance; also reduce systolic and diastolic blood pressure in susceptible individuals by lowering the risk of stroke [31].

Polyunsaturated fatty acids (PUFA)

Table III shows the polyunsaturated fatty acids (PUFA) content in the analysed samples. As can be observed, PUFA detected in highest quantities was linoleic acid (C18:2) which ranged between 4.69-38.94%, where-

Table III - Polyunsaturated fatty acids (g/100g total FA) composition* of selected Jordanian fast foods

Fatty acids	FL (n=3)	HL (n=2)	VP (n=2)	MP (n=2)	CS (n=3)	BS (n=2)	BBR (n=3)	CBR (n=3)	ZR (n=3)	TR (n=3)	LM (n=3)
C18:2 (ω-6)	34.13^{a} ±4.45	4.69^{c} ±1.38	12.51^{bc} ±0.71	11.46^{bc} ±5.39	38.93^{a} ±4.84	28.98^{ab} ±15.64	13.42^{bc} ±4.36	38.94^{a} ±4.99	38.11^{a} ±7.97	28.45^{ab} ±6.13	16.65^{bc} ±0.73
C18:3(ω-3)	0.44^{c} ±0.04	0.30^{c} ±0.03	0.71^{c} ±0.36	0.39^{c} ±0.17	3.34^{ab} ±0.66	2.63^{abc} ±1.84	1.33^{bc} ±0.39	3.91^{a} ±0.87	3.69^{a} ±1.13	3.21^{ab} ±0.83	0.99^{c} ±0.23
ΣPUFA	34.57^{ab} ±4.40	4.99^{d} ±1.42	13.22^{cd} ±1.07	11.86^{cd} ±5.57	42.28^{a} ±5.43	31.61^{abc} ±17.49	14.75^{cd} ±4.73	42.86^{a} ±5.86	41.80^{a} ±9.04	31.67^{abc} ±6.96	17.65^{bcd} ±0.89

FL, Falafel sandwich; HL, Halloumi sandwich; VP, Vegetarian pizza; MP, Margherita pizza; CS, Chicken shawarma sandwich; BS, Beef shawarma sandwich; BBR, Beef burger; CBR, Chicken burger; ZR, Zinger sandwich; TR, Turkey sandwich; L&M, Lebneh and Mortadella sandwich

*Values are means ±SEM (Standard Error of the Mean).

^{a,b,c,d} different superscripts within the same row indicate significantly (p< 0.05) different data.

PUFA: polyunsaturated fatty acids.

as linolenic acid (C18:3) was detected in very low quantities (0.30-3.91%). HL had the lowest amount of both fatty acids (linoleic and linolenic acids) and therefore, the lowest PUFA contents, followed by MP. However, CS, CBR, ZR, and FL had the highest amount of linoleic acid, as well as the highest amount of linolenic acid (except for FL), and thus, chicken-based products were the most PUFA-rich foods.

In this study, chicken-based products had the highest amount of PUFA. This agreed with Mozdziak [43] who reported that chicken meat is a low-fat source of healthy nutrition rich in unsaturated fat. The result showed that PUFA content of fast food made of beef was lower than that of made of chicken. Linoleic acid (C18:2) was the primary contributor to the PUFA composition of chicken sandwich. Fernandez and Juan [34] found comparable results for Jordanian fast food made of chicken and beef.

Chicken meat contains less saturated and more unsaturated fatty acids than beef [44], however, BS (a beef product) showed high amount of PUFA. This can be reflected to the mixing of chicken with beef that might have changed the fatty acid profile of BS [42]. According to our findings, the increase in PUFA content of Falafel sandwich was mainly due to an increase in linoleic acid and, to a lesser extent, an increase in linolenic content. This could be attributed first to the high content of chickpeas with omega 6 and to the vegetable oil used in the frying process [45, 46]. Each restaurant has its own preparation and ingredients, as well as a different type of oil used for falafel frying. According to Deol et al. [47], soybean oil is primarily composed of PUFAs, specifically linoleic acid (C18:2), an omega-6 (ω-6) fatty acid that accounts for 55% of soybean oil. Also, Orsavova et al. [41] found that safflower and sunflower oil are high in PUFAs, particularly linoleic acid (79 and 62.2%, respectively). However, both oils have low linolenic fatty acid content (0.16, 0.15%, respectively). On the other hand, studies were conducted to determine the effect of olive oil on sausage, and it was discovered that the addition of olive oil decreased Myristic, Palmitic, Palmitoleic, and Stearic acids contents while increasing the Oleic and linoleic acid contents, which was like our findings for falafel sandwich [42]. Afshari et al. [32] also reported that the increase in PUFA concentration was attributed to the incorporation of linoleic and linolenic acid-containing vegetable oils such as canola and olive oils.

Trans fatty acids (TFA)

Trans fatty acids (TFA) levels of selected fast foods in Jordan are presented in Figure 2. Values varied from 0.56% to 6.04%. Beef Shawarma (BS) contributed for the highest percentage of TFA (6.04%) among the food items followed by VP, BBR and MP and decreased to the lowest amount in LM sandwich.

Trans fatty acids are known to occur naturally in meats, milk, and dairy products. They are also found in foods made with hydrogenated or partially hydrogenated oils [9]. Takruri et al. [24] found that BS contain 2.64% TFA, indicating that TFA came from its origin (animal). As previously stated, the addition of chicken skin may result in an increase in PUFA, which allows for an increase in TFA. This indicated that the part of the chicken contained skin, which was high in TFA, and that the ingredients in shawarma, such as vegetable oil, were also high in TFA [48].

Fernandez and Juan [34] studied the fatty acid composition of some Spanish fast foods. The authors found that the TFA in beef burger with cheese is 3.9%, which agreed well with the current data (3.89%). This was explained by the process of biotransformation by bacteria in the stomach of a ruminant animal, which results in the natural presence of TFA in milk, milk products, and meat from these animals [48], like what was observed in HL and MP.

The current data clearly showed that VP contains more TFA than Takruri et al. [24] (4.38%). This high concentration resulted from the hydrogenation of oils [34]. The use of vegetable oils and fats obtained through partial hydrogenation or chemical interesterification, resulting in an increase in TFA or SFA levels, both of which are known to be harmful to health [10]. Natural vegetable oils contain mostly unsaturated fatty acids that are all the cis configuration type; trans isomers appear when vegetable oils are partially hydrogenated for the purpose of making margarines, shortenings, and a wide range of food products [34]. According to Mohammadi-Nasrabadi et al. [49], the amount of TFA in a falafel sandwich is about 0.52%, which contradicts our findings (2.04%). This increase may be due to a variety of factors, including heat treatments of oils and, most likely, deodorisation [34]. The TFA content of oil that had been used five times or more was four times that of unused oil, prolonged heating, repeated use of frying oils, and the addition

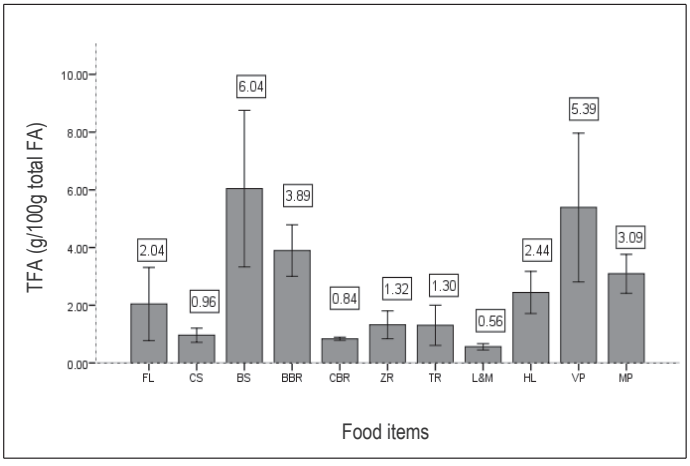

Figure 2 - TRANS fatty acids (g/100 g total FA) of selected Jordanian fast foods (FL, Falafel sandwich; CS, Chicken shawarma sandwich; BS, Beef shawarma sandwich; BBR, Beef burger; CBR, Chicken burger; ZR, Zinger sandwich; TR, Turkey sandwich; L&M, Lebneh and Mortadella sandwich; HL, Halloumi sandwich; VP, Vegetarian pizza; MP, Margherita pizza)
I---I: Standard Mean of Error (SME).

of new oils to old ones can all explain the high TFA content in FL [50]. This may result in the production of certain toxic compounds that are harmful to human health, such as oxidized fatty acids and TFA [48]. Also, to achieve the desired final product characteristic, non-hydrogenated, partially hydrogenated, and hydrogenated oils, as well as a combination of these oils, could be used in food preparation. Furthermore, the type of oil/fat used may vary depending on regional and national availability, costs, and the current supplier [9].

It was recommended that TFA consumption be limited to less than 1% of total energy intake (approximately 2 g/day) [48, 51]. TFA levels in chicken products were lowest in CS, CBR, and L&M, but slightly higher in ZR and TR. Frying chicken did not result in the formation of trans fatty acids in the meat; however, TFA appeared in the skin of the fried meat due to oil absorption, and the maximum TFA content was obtained after 15 minutes of frying, as in the case of the zinger sandwich. In addition, using corn oil to fry chicken meat at 170°C for 4 minutes did not result in the formation of TFA in the meat [48]. The amount of TFA in TR, on the other hand, could be due to the presence of cheese as an ingredient in the sandwich. TFA have been shown to raise LDL cholesterol while decreasing HDL cholesterol, potentially increasing the risk of heart disease. Its high consumption is linked to other health problems such as breast cancer, and diabetes [48]. TFA is typically restricted in ruminants (about 2-5% of fat is TFA), however partially hydrogenated oil (PHO) has a much higher TFA content (typically 25-45%) than ruminant-derived foods or foods that have been cooked or processed [52]. This study provides a large database on TFA levels in various fast foods most consumed in Jordan, which encourages us to improve the hydrogenation process by modifying temperature, pressure, catalyst, and starting oils to reduce TFA formation. Furthermore, new food technologies, such as genetic engineering of oil seed plants, may result in a lower TFA content in the United State diet [9]. The World Health Organisation (WHO) movement, specifically the “REPLACE TRANS FAT” program, which provides a strategic approach to eliminating industrially produced Trans fat from national food supplies, with the goal of a global elimination by 2023 [53].

THE NUTRITIONAL INDICES OF SELECTED JORDANIAN FAST FOODS

Different important nutritional indices are frequently used in this study to describe the fatty acid composition of foods, to evaluate the nutritional value of fatty acids and to explore their potential usage in disease prevention and treatment.

OMEGA 6/OMEGA 3 RATIO

Table IV illustrated the nutritional indices of selected Jordanian fast foods. Linoleic acid (Omega 6) was the most common PUFA. This agreed with the obtained results by Semma [54]. As seen in Table IV, all food items contained linoleic acid (C18:2 ω-6) as the major unsaturated fatty acid, while linolenic acid (C18:3 ω-3) presented in very low quantities. Both ω-6 and ω-3 are essential fatty acids, which mean they cannot be synthesized in the human body and must be obtained through diet [55]. The beneficial effects of these PUFAs are determined by the ratio of omega-6 (ω-6) to omega-3 (ω-3) fatty acids [37]. The ω-6/ω-3 ratio is considered as the most important factor in maintaining a healthy dietary pattern [41]. The ideal ratio of ω-6 to ω-3 fatty acids is generally accepted to be about 4:1, which means that a healthy diet should contain one to four times the amount of omega-6 fatty acids as omega-3 fatty acids [31, 37]. On the other hand, Simopoulos [56] mentioned that the brain is the most important organ in biological development and growth, and that the balance of omega-6 and omega-3 PUFA metabolites in the brain is close to 1:1. As a result, a ratio of 1:1 to 2:1 ω-6/ω-3 fatty acids should be the target ratio for human health. According to Table IV, all selected Jordanian fast foods have a ratio omega 6/omega 3 above the literature within the range of 9:1 to 81:1, with the higher ratio belongs to Falafel sandwich which was much higher than the recommended value.

Omega-3 fatty acids were in all foods consumed over eternities of evolution: meat, wild plants, eggs, fish, nuts, and berries. However, new phenomena in human evolution promoted dietary changes that are the results of modern agriculture and agribusiness, resulting in grain-based animal feeds instead of animal grazing, and the production of vegetable oils from seeds such as corn, sunflower, safflower, cottonseed, and soybean that are high in omega-6 fatty acids but low in omega-3 [56]. Consumption of omega-3 fatty acids reduces the inflammation caused by rheumatoid arthritis, lowering the food’s atherogenic index [31, 57]. High omega-6 consumption has been linked to an increased occurrence of health problems such as type 2 diabetes, obesity, and coronary artery disease [8]. Orsavova et al. [41] reported that the high ratio of ω-6/ω-3 is relatively due to the high consumption of plant oils rich in ω-6 PUFAs and low consumption of marine fish products. This ratio has increased to between 10:1 and 20:1 in Western diets, which is highly inappropriate for normal growth and development [56]. Furthermore, the typical American diet contains 11 to 30 times more ω-6 fatty acids than ω-3 fatty acids, a phenomenon that has been proposed as a significant factor in increasing the rate of inflammatory disorders in the United States, the fact that high levels of omega-6 PUFA and a very high omega-6 to omega-3 ratio (as found in the data) promote the pathogenesis of many diseases, including cardiovascular disease, cancer, inflammatory and autoimmune diseases, and interfere with normal brain development [31, 56].

Table IV - Nutritional quality indexes* of selected Jordanian Fast foods

Item	FL (n=3)	HL (n=2)	VP (n=2)	MP (n=2)	CS (n=3)	BS (n=2)	BBR (n=3)	CBR (n=3)	ZR (n=3)	TR (n=3)	LM (n=3)
ω-6/ω-3	81.14^{a}±18.03	15.27^{b}±2.64	22.72^{b}±10.48	28.06^{b} ±1.4	12^{b} ±1.19	13.47^{b} ±3.5	9.88^{b} ±0.85	10.59^{b} ±1.46	11.38^{b}±1.76	9.03^{b}±0.43	18.29^{b}±3.65
IA	0.34^{c}±0.07	2.94^{a}±0.60	1.33^{bc}±0.05	1.99^{b}±0.34	0.31^{c}±0.04	0.48^{c} ±0.18	0.99^{bc}±0.18	0.40^{c}±0.11	0.47^{c} ±0.14	0.88^{bc}±0.26	0.85^{bc}±0.16
IT	0.63^{c}±0.12	3.27^{a}±0.32	1.62^{bc} ±0.12	2.42^{b}±0.43	0.48^{c}±0.08	0.73^{c}±0.32	1.40^{bc}±0.27	0.57^{c}±0.17	0.68^{c}±0.26	1.02^{bc}±0.27	1.25^{bc}±0.20
PUFA/SFA	1.53^{ab}±0.41	0.07^{c} ±0.02	0.28^{bc} ±0.03	0.21^{c}±0.11	1.92^{a} ±0.45	1.37^{abc}±0.97	0.36^{c}±0.12	1.77^{a} ±0.45	1.68^{a}±0.55	0.92^{abc}±0.37	0.43^{bc}±0.05

FL, Falafel sandwich; HL, Halloumi sandwich; VP, Vegetarian pizza; MP, Margherita pizza; CS, Chicken shawarma sandwich; BS, Beef shawarma sandwich; BBR, Beef burger; CBR, Chicken burger; ZR, Zinger sandwich; TR, Turkey sandwich; L&M, Lebneh and Mortadella sandwich

*Values are means ±SEM (Standard Error of the Mean)

^{a,b,c} different superscripts within the same row are significantly (p< 0.05) different.

ω-6/ω-3: omega 6 to omega 3 ratio, IA: atherogenic index, IT: thrombogenic index, PUFA/SFA: polyunsaturated to saturated fatty acids ratio.

PUFA/ SFA

In the case of available lipid fraction in food products, the PUFA/SFA ratio is one of the most important parameters for evaluating nutritional quality [32]. The recommended "healthy" PUFA/SFA ratio for good nutritional quality is greater than 0.4. Other recommendations, however, suggest a PUFA/SFA ratio of about 1. The American Heart Association (AHA) recommends a PUFA/SFA ratio of greater than one for the Step-1 diet and greater than 1.4 for the Step-2 diet [32, 34].

Table IV shows the PUFA/SFA content of various Jordanian fast foods, ranging from 0.07 to 1.92. The highest ratios were in CS, CBR, and ZR, and the lowest ones were in HL.

In the present study, FL, CS, BS, and CBR meet this criterion (>1), however, TR is close to 1 (i.e., 0.92), whereas Halloumi, L&M, beef burger sandwiches, and pizza (VP and MP) had ratios ≤ 0.45. This could be due to the increased use of animal fat sources in foods rather than vegetable oils [58]. It was hypothesized that all PUFAs in the diet can lower LDL cholesterol (LDL-C) and serum cholesterol levels, whereas all SFAs contribute to high serum cholesterol levels. As a result, the higher this ratio, the greater the positive effect [5]. Chicken products, in general, have higher PUFA/SFA ratio, this is consistent with Chen and Liu [5], who stated that the PUFA/SFA ratio of chicken ranges from 0.308 to 2.042 for various dietary treatments.

ATHEROGENIC AND THROMBOGENIC INDICES

The atherogenicity and thrombogenicity indices are the most widely used to evaluate fatty acid composition because they outline significant implications and provide clear evidence [5]. They indicate the potential for stimulating platelet aggregation [59].

Table IV illustrates that HL had the greatest IA and IT values among all foods investigated in this study (2.94 and 3.27, respectively), followed by MP (1.99 and 2.42, respectively) and VP (1.33 and 1.62, respectively). The lowest IA and IT values among all foods were for CS (0.31 and 0.48, respectively) followed by FL, CBR, ZR and BS with IA values of 0.34, 0.40, 0.47 and 0.48, respectively, and IT values of 0.63, 0.57, 0.68 and 0.73, respectively. This depends on the differentiation in saturated and unsaturated fatty acids between foodstuffs. The main SFA favouring lipid adhesion to cells of the immunological and circulatory system are C14.0, C16.0, and C12.0, which are considered pro-atherogenic and pro-thrombogenic, whereas C18:0 is thought to be neutral in terms of atherogenicity but thrombogenic, and thus, the high IA and IT values in HL and pizza were primarily attributed to high C14:0 and C16:0 SFA [6, 60]. However, foods exhibited the lowest IA and IT values (CS, CBR, ZR, BS and FL) because of their high MUFA and PUFA levels, which are considered anti-atherogenic and anti-thrombogenic because

they inhibit plaque aggregation and lower levels of esterified fatty acid, cholesterol, and phospholipids, thereby preventing the appearance of micro- and macro- coronary diseases [15].
For these reasons, it is advised to consume foods or products with lower IA and IT, which can lower total cholesterol and LDL-C levels in human blood plasma [61].
Chen and Liu [5] provided detailed information about the literature related to IA and IT. IA values for meat ranged from 0.165 to 1.32, while dairy products had values ranging from 1.42 to 5.13. Dietary treatment is the most important factor influencing IA in ruminants. The ranges of IT values for meat and dairy products are 0.288 to 1.694, and 0.39 to 5.04, respectively. Afshari et al. [32] also found that burgers had an IA of around 1.6 and a IT of around 1.8, however, the use of canola-olive oil reduced IA and IT to 0.51 and 0.49, respectively.
In brief, the IA and IT can both be used to evaluate the potential effects of fatty acid composition on cardiovascular health. A fatty acid composition with lower IA and IT values has better nutritional quality, and its consumption may lower the risk of coronary heart disease (CHD). However, no organisation has yet provided the IA and IT recommended values [5]. Very low levels of the mentioned indices are recommended in a "Healthy" diet [32]. Thus, the lower the IA and IT values, the greater the potential for coronary artery disease protection and the higher the nutritional quality of food [59]. Diets rich in MUFAs were found to be very effective in lowering the risk of CHD. Indeed, because of their effect on lowering blood cholesterol, MUFAs have been recognised as being as beneficial to human health as the PUFA ω-3 class [60]. Foods with high omega-3 content, in comparison to SFAs, have a lower IA [57].
Consuming dietary fatty acids that increase the atherogenic and thrombogenic indices is an unhealthy option, which governments and organisations concerned with human health should consider. Consumers should be warned about the dangers of eating fast foods containing these fats until the food industry prohibits their use or develops healthier alternatives, also eating foods or products with lower IA and IT is beneficial to cardiovascular health [1, 5].

CONCLUSION

This study provides a large database on the fatty acid composition and nutritional quality of the most popular fast food in Amman, Jordan. The results indicated that cheese was the major contributor to high fat in the studied fast foods, and the main sources of TFA in the diet were the partially hydrogenated fats used in the preparation of fast-food products and in food manufacturing. This has prompted health officials to issue a warning and some lawmakers to pass legislation to reduce the presence of TFA in food. Chicken based products, mainly chicken shawarma sandwich, showed high fatty acid quality based on their P/S, AI, TI and ω-6/ω-3 as compared with the other food items. However, most Jordanian fast foods do not follow international guidelines for nutritional indices of fatty acids. As a result, fatty acid modification and incorporation with omega-3-rich oils are recommended to increase the PUFA/SFA ratio while decreasing the omega 6/omega 3 ratio and thus, improve the nutritional quality of the Jordanian consumers' diets.

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