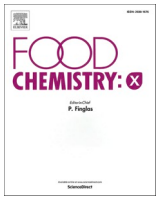
Food Chemistry: X 25 (2025) 102246

Contents lists available at ScienceDirect

Food Chemistry: X

journal homepage: www.sciencedirect.com/journal/food-chemistry-x



Trans fatty acids and saturated fatty acids in margarines and spreads in Kazakhstan: Study period 2015–2021

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ARTICLE INFO

Keywords:
Trans isomer
Monounsaturated fatty acids
Polyunsaturated fatty acids
Saturated fatty acids
Atherogenic index
Thrombogenic index

ABSTRACT

Oil and other fat rich products such as some processed foods can contain unhealthy amounts of trans fatty acids (TFA) and saturated fatty acids (SFA). Diets rich in TFA have been linked to coronary artery disease. It is necessary to quantify and police the type of fat in foods to assess its risk. For the first time, this study quantifies the TFA content in margarines and spreads sold in the Kazakhstan markets in the period from 2015 to 2021. Fatty acid composition, and importantly TFA levels, were determined in 6 brands of margarines and 5 brands of spreads used in the food industry and by consumers directly in 2015–2017, and in 23 brands of margarines and 23 brands of spreads from 2018 to 2021. The study margarines and spreads had 20.0 ± 0.02 % TFA on average until 2018. In contrast, in the period 2018–2021, the TFA average content was 14.2 ± 0.06 % in margarines, and 10.6 ± 0.05 % in spreads, which is still 7.4 and 6 times higher than the regulatory requirements of the Customs Union (Kazakhstan, Russia, Belarus, Kyrgyzstan) and the EU, respectively. The strong cause effect between TFA and cardiovascular diseases urges Kazakhstan and other countries to reduce TFA in commercial products. It also encourages research and implementation of technical measures to provide healthy food products that effectively comply with national and international regulations regarding TFA content. The aim of the study was to analyze changes in the quality of solid fat products produced in Kazakhstan over time, particularly after the Technical Regulations of the Customs Union came into effect on January 1, 2018.

1. Introduction

Fats and oils are part of the essential products consumed by great part of the population. Dietary fats play an important role in a healthy diet (Bajželj et al., 2021). Among dietary fats, high intake of saturated fatty acids (SFA) and trans-fatty acids (TFA) are harmful to consumer health, so there are global efforts to reduce their intake (WHO, 2023a, WHO, 2023b). Some food are naturally rich in SFA and TFA such as dairy products (cheese, milk, butter (WHO, 2023b)). In addition to natural sources of TFA, industrial process, transesterification and hydrogenation, are used across the food industry worldwide to modify vegetable oils and obtain emulsions (margarine, shortenings, spreads) (Iida et al., 2021). During partial hydrogenation of unsaturated fatty acids, changes can occur in their chemical structure: some fatty acids in cis-form, which is more prevalent, become their trans isomers (also called TFAs) (Toshtay et al., 2021; Toshtay & Auezov, 2020). Partial hydrogenation transforms fatty acids with unsaturated bonds (polyunsaturated fatty acids (PUFA)) into partly saturated mixtures of fatty acids, some of which will be trans monounsaturated fatty acid (MUFA) (WHO, 2023b). This process helps to adjust the physico-chemical properties of the processed food. As a result, liquid oil turns into a semisolid or solid fat at room temperature. An example of a change induced by partial hydrogenation takes place when refining oils to deodorize them (eg linseed oil) (Xu et al., 2022). Examples of TFAs resulting from partial hydrogenation are displayed in Fig. 1.

There is evidence that large amounts of TFA in food can lead to coronary disease (Gebauer & Baer, 2023), and restricting industrially produced trans fatty acids (iTFA) can reduce the risk (Brandt et al., 2017). Today, 53 countries have implemented policies to eliminate industrially produced TFA (iTFA) (WHO, 2023). Such policies will save lives and are protecting 3.7 billion people (World Health Organization, 2024). Central Asian countries have much higher mortality rates due to cardiovascular diseases than Western European countries (Bekbossynova et al., 2024) and twice as high as Latin America and the

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https://doi.org/10.1016/j.fochx.2025.102246
Received 7 June 2024; Received in revised form 13 January 2025; Accepted 27 January 2025
Available online 28 January 2025

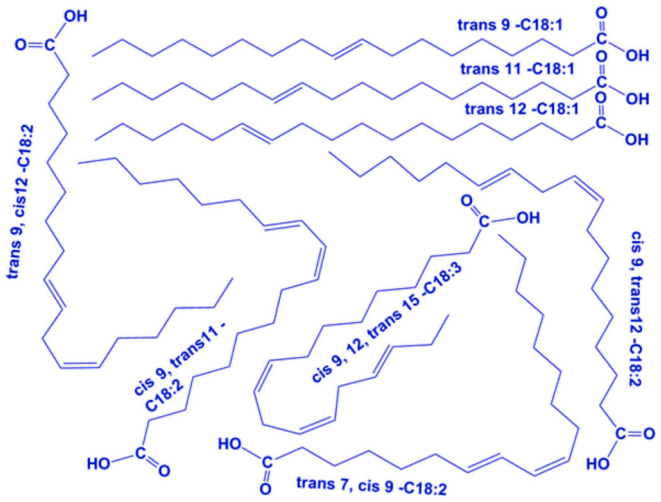

Fig. 1. Common trans fatty acid structures that result from the hydrogenation of fat.

Caribbean (Barquera et al., 2015). In particular, ~2 million people suffer from cardiovascular diseases in Kazakhstan (where the current population is 20 million), and more than 40 thousand Kazakhs are affected by a stroke every year (Iskakov, 2017). Central Asian countries have less restrictive limits regarding TFA in food than most America and Europe (Global database on the Implementation of Nutrition Action (GINA), 2024).

Following Danish guidelines, the EU adopted standards that limit TFA content in commercial products (other than naturally occurring trans-fat in fat of animal origin) to ≤2 % of the total fat since April 2021 (World Health Organization, 2015a). The US Food and Drug Administration (FDA) required manufacturers to indicate the amount of TFA on the food packaging since 2006 (Food and Drug Administration, 2005) and limited it to 1 % of the total energy intake. The World Health Organization (WHO) issued several recommendations to limit partially hydrogenated oils in food products (World Health Organization, 2012, World Health Organization, 2003a, 2003b), and the WHO (European Office) called for a total prohibition of iTFAs in food products as part of the European health plan "European Food and Nutrition Action Plan 2015–2020" (Ghebreyesus & Frieden, 2018; World Health Organization, 2015b). In 2018, the REPLACE initiative called the industry and countries to eliminate iTFA globally by 2023 (World Health Organization, 2023a, 2023b), and so far Denmark, Lithuania, Poland, Saudi Arabia, and Thailand received certificates for their progress in eliminating iTFAs (WHO, 2024).

Kazakhstan adopted a new standard for determining the content of TFAs in oil and fat products on January 1, 2018. According to the Technical Regulations for Oil and Fat Products, the *trans* isomers content in modified fat products should not exceed 2.0 % of the fat content in products from 2018 (Demin et al., 2020). This is aligned with the call for implementing best-practice policies to eliminate TFAs from national food supplies (World Health Organization, 2023a, 2023b). Hence, the food industry and governmental laboratories need to carry out a stringent control of the composition of fats, and this is expected to impact positively the high incidence of heart diseases. Reports on the content of trans-isomers in fats and oils produced in Kazakhstan are scarce, although pioneer work hinted that trans-isomers in high-fat commercial Kazakh products can be very high (Stender, 2020). This paper explores further the risk highlighted by Stender et al. and seeks to monitor the types and levels of fatty acids in fatty food products in Kazakhstan over a relatively long period of time. Special attention is given to the change in composition encouraged from 2020, that is when strict requirements for the trans isomers content were implemented. Although this work is focused in Kazakhstan, a country with nearly 20 million inhabitants (Worldometer, 2023) it has wider significance given than food habits in Central Asia (eg Russia, Kyrgyzstan, Uzbekistan, Turkmenistan) involve regular consumption of fatty products but have less restrictive TFA limits (World Health Organization, 2024).

This study analyses the composition of fats in food products, with focus on the levels of TFAs and SFAs: high intakes of both groups of substances are known to impact health negatively. In addition, the study carries out a historical examination of fatty acid profiles in Kazakhstan's margarines and spreads. This will inform how regulatory changes implemented in 2020 have influenced public health. This is the first time that a systematic study focused on the characterization of margarines and spreads has been conducted in Kazakhstan.

2. Materials and methods

2.1. Samples and their iodine value

This work includes the analysis of margarines and spreads. Margarines are defined as water-in-fat emulsions that typically contain vegetable oils, water and salt. Food items labeled as spreads are similar in composition to margarines although they are expected to have lower fat content. In contrast, shortenings correspond to fat that is solid at room temperature and is used for baking and cooking (O'Brien, 2009).

All margarines (29) and spreads (28) were produced locally by major manufacturers of solid fat-and-oil products in Kazakhstan. These include Eurasian Foods (Karaganda), which accounts for 83.8 % of the total production volume with the "Golden Standard" series, and "Maslo-Del" (Almaty), which contributes 14.3 % of the total volume with brands such as Jailau, Mamin's Recipe, and Southern. Margarines and spreads were sampled from local supermarkets in Almaty. Annually, within 2 weeks, samples of margarines and spreads were collected and stored in the refrigerator. Subsequently, independent analyses of these samples were carried out in triplicate within a week. The margarines and spreads were given a iodine value based on their fatty acid composition, once derivatized to fatty acid methyl esters, and determined by gas chromatography -flame ionization detector (GC-FID) following the ISO 3961:2018 procedure (ISO 3961, 2018).

2.1. Fatty acid composition

Sample preparation involved: sampling fat (0.1 g), spread it in hexane (1.8 mL) by shaking it manually. This was followed by the addition of 0.5 mL of 10 % sodium methoxide solution in methanol (Sigma-Aldrich, Darmstadt, Germany). After the homogenization of the mixture, its phases eventually separated, the upper transparent layer was sampled and examined (Int. Organ. Stand., 2017; ISO 12966-4, 2015). The identification of fatty acid methyl esters (FAMEs) was based on GC-FID analyses, where the retention times to the derivatized fatty acids were compared with those in the Supelco standard mix number 19945 (FAME Mix, C4-C24, Sigma-Aldrich, USA).

Margarines and spreads from the retail network were analyzed with a Chromos GH-1000 gas chromatograph (Dzerzhinsk, Russia) GC-FID using a CP-Sil 88 capillary column 100 m × 0.25 mm × 0.20 μm (Agilent Technologies, Varian Inc., USA). Helium was the carrier gas at 1 mL/min. The temperature of the detector was 260°C and the injector temperature was 250°C. The temperature programme was 100 °C for 4 min, followed by heating from 100 °C to 170 °C at the rate of 5 °C/ min; the temperature was kept at 17 °C for 20 min; and then it was increased to 240 °C at a rate of 5 °C/ min. Finally, system was kept at that final temperature for 18 min. Samples were injected (0.5 μL) in split less mode. All samples were analyzed in triplicate.

2.2. Atherogenic index and thrombogenic index

The atherogenic index (AI) and thrombogenic index (TI) were calculated using Eq. (1) and (2) given by (Ulbricht & Southgate, 1991)

and modified by (Menotti et al., 2024):

$$AI = \frac{[4^{*}(C14:0) + C16:0 + TFA]}{MUFA + (n-6) + (n-3)} \quad (1)$$

$$TI = \frac{[C14:0 + C16:0 + C18:0 + TFA]}{[0.5^{*}MUFA + 0.5^{*}(n-6) + 3^{*}(n-3) + (n-3)/(n-6)]} \quad (2)$$

where (n-6) corresponds to omega-6, (n-3) corresponds to omega-3, MUFA are monounsaturated fatty acids, C14:0 is myristic acid and C16:0 is palmitic acid.

2.2. The ratio of hypocholesterolemic (h)/hypercholesterolemic (H)

The ratio of hypocholesterolemic (h)/hypercholesterolemic (H) fatty acids was calculated using Eq. (3) (Pilarczyk et al., 2015):

$$h/H = \frac{C18:1 + PUFA}{C14:0 + C16:0} \quad (3)$$

2.3. Statistical data treatment

Data processing and statistical evaluation (mean values and standard deviations from triplicate analyses) were performed using Microsoft Excel 2016 (Redmond, WA, USA) and OriginPro 2024 (Chicago, IL, USA). Mean values were compared using confidence intervals at p 0.05.

3. Results and discussion

3.1. Fatty acid composition of margarines and spreads

Margarine is a widely used cooking fat in Kazakhstan and elsewhere. It is made from animal and vegetable fats that have been partially hydrogenated. Its spreads are expected to have low trans-isomer content because they are based on milk and vegetable fat. This study has involved annual monitoring of fatty acids with special focus on TFA in fat products (margarines and spreads) and results are given in Tables 1 and 2 (supplementary materials Tables S1 and S2 include means and their corresponding standard deviations). Considering the recommended ≤2.0 % of total fat content by the WHO and national Kazakh TFA, the TFA content both in margarines (23–32 %) and in spreads (14–27 %) in 2015 was very high. In 2017, the TFA content in the margarines decreased twice, in our opinion due to the addition of palm oil (as indicated by the large palmitic acid amount in samples # 5 and #7 in Table 1). In spreads, the TFA levels found in the study samples were similar than those in 2015 (19.8 % in 2015 and 15.4 % in 2017) (Table 2). Fig. 2 displays the change in TFA in samples of margarines and spreads studied from 2015, 2017 to 2021, where a trend towards healthy reduction of hydrogenated products was not observed. Such composition also contrasts with the commitment and progress made by the International Food and Beverage Alliance (IFBA) to not to exceed the 2 g of iTFA in fats and oils in their products by 2023 (World Health Organization, 2023a, 2023b). Nevertheless, the values found in the Kazakh margarines and spreads analysis agree with the content of TFAs in the fat and oil products reported elsewhere. In particular, the TFA amounts in hard margarines in the Serbian market ranged from 4.5 % to 28.8 %, and margarine with low content of TFA had a large amount of palmitic acid (37.7 %) (Vučić et al., 2015) indicating that the TFA content resulted from a dilution. Similarly high TFA levels were found in margarine in the Peruvian market with partially hydrogenated fats ranges from 38 % to 41 % while in margarines without trans isomers, the amount of palmitic acid ranged between 23.1 % and 42.1 % (Salas-Valerio et al., 2022). In contrast, the TFAs in the margarines and shortenings in the Slovenian markets was 0.1–6.4 % and 0.1–11.2 %, respectively (Abramovič et al., 2018). Kandhro et al. (2008) studied the composition of ten types of margarine produced in Pakistan and found that nine of them contained very large amounts of TFAs (15.6–34.8 %). Santos et al. (2015) showed that reduction of trans isomers in hydrogenated fats was achieved by replacing them with tropical oils rich in unsaturated fatty acids. Beyond margarine and spreads, the amount of TFA in several foods is still large (Aued-Pimentel & Kus-Yamashita, 2021). This is because partially hydrogenated oils were used in their preparation (cookies, cakes, wafers) (Stender, 2019) (WHO, 2003). Our study included less samples from the period 2015–2017 (compared to the period 2018–2021) because the hydrogenation method for margarines and spreads production in the early years (before 2018) was leading to constant high levels of TFA across items.

The entry into force of Customs Union Technical Regulation 024/2011 at the beginning of 2018 contributed to the appearance of fat and oil products (for example, samples No. 9, 24, 29, 35, 37, 55) on the Kazakhstan market with a TFA content of less than 2.0 %. This was a result of "Eurasian Foods" company using fat base supplied by "Efko-Almaty", which was obtained through the process of transesterification using sodium ethylate (methylate) as a catalyst (this is estimated from the composition found in these fat products). We also estimate that palm oil was added to regulate the content of solid triglycerides in this case.

Despite the new regulation, out of the 23 margarine samples tested from 2018 to 2021 (data compiled in Table 1), only three samples contained <2.0 % of the trans isomers. Spreads presented a similar situation with a low number of samples <2.0 % of TFA (see Table 2). Furthermore, fat products have been sold in Kazakhstan from 2018 till 2021 with trans isomer content of 20–38 % (e.g. samples #10, 15, 21, 23, 25, 27, 28, 46, 48, 56, and 57), which is 10–19 times higher than the permissible limit, probably due to the use of non-selective nickel catalysts in the hydrogenation process (Toshtay, 2024; Toshtay et al., 2015).

During the period from 2019 to 2021, the performance indicators of margarines and spreads deteriorated even among manufacturers utilizing the transesterification method. There was a rise in the content of trans isomers from 2.5 to 6.5 % (see sample #41–43, 45, 47, and 49–54 in Table 2), although the rise was not evident with the iodine values. Using the transesterification method together with palm oil solves the problem of trans isomers to an extent, but on the other hand, it leads to a significant increase in SFAs in the product. For instance, the proportion of SFAs in sample #29 (Table 1) and #53 (Table 2) was higher than 50 % while the requirement for saturated fat is no more than 25 % of the total fat (Stahl et al., 2018).

Palm oil contains 40 % palmitic acid, 8.7 % stearic acid, and an overall saturated fatty acid content of 51.0 % (Patil et al., 2023). From Tables 1 and 2, it can be observed that the there was widespread incorporation of palm oil in margarines and spreads in Kazakhstan since 2017 and it reached its peak in 2021, which was the end of the study. Hence, there was an increase in the content of palmitic acid of 4–5 times margarines, at 35.6–45.3 % (Table.1), and in spreads, at 42.7–45.8 % (Table.2), both presented TFA levels much above the national and international standards.

The consumption of C18:1 trans isomers with food is associated with an increased risk of atherosclerosis, type 2 diabetes, and has very high association with cardiovascular disease (CVD) (Mozaffarian et al., 2009). For instance, with a conditional daily intake norm (CDIN) of TFA set by the WHO at 2.2 g, Kazakhstan's consumer intake was approximately 12 g of margarine daily which contains 20–40 % TFA. The 12 g have been estimated from the annual production of margarine in the country reported in 2023 (63,000 t) (Freedom Finance Global/Optimism.kz, 2024) and divided into the population of Kazakhstan (20,000,000 inhabitants) and 365 days. Consequently, they consume 2.4–4.8 g of TFAs daily, exceeding the WHO's CDIN for iTFA. From the samples analyzed, margarine #2, 4, 10, 21–23, and 27 (2.3–5.1 %) and spread #30, 33, 40, 46, 48, 56, and 57 (1.3–7.7 %) contained large amounts of C18:2 t trans linoleic acid. di- and tri-unsaturated fatty acids, which contain double bonds in the trans configuration, are strongly correlated with the risk of CVD, even at very low concentrations. Jakobsen and Overvad (2012) showed that the trans-isomers of linoleic acid (C18:2 t) with the isolated double bonds correlate with CVD more

Table 1
Average fatty acids and trans isomers content ($n = 3$) in domestic margarines (%) purchased from local shops. The corresponding standard deviations are given in Supporting information S1.

Nº of product	year	C14:0	C16:0	C18:0	*cis* C18:1	*trans* C18:1	*cis* C18:2	*trans* C18:2	*cis* C18:3	*trans* C18:3	C20:0	C22:0	SFA (%)	MUFA (%)	PUFA (%)	Total *trans* (%)	Iodine Value
1H	2015	0.08	7.29	11.18	32.69	22.97	22.50	0.59	1.34	ND*	0.54	0.56	19.91	55.66	24.43	23.56	91.4
2 H	2015	0.12	8.26	11.62	44.21	23.05	8.61	2.47	0.42	ND	0.42	0.50	21.25	67.25	11.50	25.52	78.1
3 H	2015	0.07	6.85	10.26	33.17	20.99	24.24	1.09	2.06	ND	0.56	0.55	18.44	54.16	27.40	22.08	95.8
4 H	2015	0.05	5.50	8.79	40.94	27.18	8.29	3.82	2.20	1.43	0.68	0.43	15.67	68.25	16.08	32.43	89.8
5 T	2017	0.67	26.77	7.07	33.82	7.78	21.90	0.40	0.16	ND	0.33	0.35	35.69	41.82	22.49	8.18	75.0
6H	2017	0.09	6.84	16.98	34.57	12.04	13.84	1.27	11.34	1.60	0.36	0.23	24.65	47.22	28.14	14.91	100.0
7 T	2018	0.78	34.43	5.68	32.45	1.22	22.76	1.21	0.22	0.04	0.35	0.28	41.96	33.81	24.24	2.47	71.3
8H	2018	0.37	18.57	8.24	33.82	11.57	10.82	0.86	1.26	2.41	0.39	0.30	28.24	56.47	15.29	14.84	77.4
9 T	2018	0.70	31.65	5.57	30.65	1.37	28.20	0.35	0.19	ND	0.34	0.33	38.98	32.28	28.74	1.72	77.7
10H	2018	0.16	7.04	11.77	44.21	20.41	6.43	5.01	0.91	1.74	0.38	0.45	20.25	65.65	14.10	27.16	83.2
11 T	2019	0.99	27.81	9.29	28.12	3.46	26.52	1.77	0.26	ND	0.51	0.43	39.43	32.01	28.56	5.23	77.2
12 T	2019	0.60	24.56	10.48	32.43	6.20	23.75	0.63	0.14	ND	0.33	0.27	36.49	38.99	24.51	6.83	76.1
13 T	2019	0.81	28.46	10.06	29.08	3.14	26.49	0.52	0.15	ND	0.34	0.31	40.36	32.48	27.16	3.66	75.1
14 T	2019	0.84	29.34	8.15	26.41	1.74	31.12	0.76	0.16	ND	0.36	0.29	39.33	28.63	32.04	2.50	80.2
15H	2019	0.19	8.95	15.07	38.12	18.52	15.59	1.69	0.37	ND	0.41	0.42	25.03	57.31	17.66	20.21	78.2
16H	2019	0.10	7.20	17.50	41.77	15.88	13.45	1.92	0.28	ND	0.32	0.34	25.46	58.89	15.64	17.80	77.9
17 T	2019	0.69	27.18	9.31	27.09	5.03	28.83	0.60	0.15	ND	0.34	0.28	37.95	32.48	29.57	5.63	79.3
18 T	2019	0.88	30.78	8.37	28.05	2.90	26.31	1.39	0.15	ND	0.35	0.23	40.88	31.27	27.85	4.29	75.2
19H	2020	0.15	6.67	13.67	44.35	17.85	14.94	1.22	0.21	ND	0.11	0.28	21.11	62.53	16.36	19.07	82.4
20 T	2020	0.84	26.29	6.69	33.01	5.17	24.44	1.37	0.26	ND	0.16	0.45	35.21	38.74	26.05	6.54	77.6
21H	2020	0.12	8.83	10.02	44.15	25.30	7.81	2.92	0.14	ND	0.22	0.46	19.68	69.56	10.76	28.22	78.9
22H	2020	0.57	13.39	8.22	32.67	2.84	38.04	2.03	0.41	ND	0.49	0.21	23.13	36.39	40.48	4.87	101.7
23H	2020	1.42	13.51	11.05	27.64	31.99	9.31	4.14	0.11	ND	0.26	0.42	26.66	59.63	13.71	36.13	74.8
24 T	2021	1.01	35.63	4.05	32.16	0.64	24.57	0.59	0.18	ND	0.26	0.28	41.22	33.10	25.34	1.23	72.5
25H	2021	0.37	8.67	11.24	34.57	26.41	14.96	1.80	0.95	ND	0.59	0.23	21.10	61.18	17.72	28.21	84.1
26H	2021	0.63	12.57	11.89	45.03	6.20	18.74	0.58	2.23	ND	0.46	0.45	26.52	51.93	21.55	6.78	83.9
27H	2021	0.42	11.53	13.06	27.62	35.44	7.96	2.25	0.32	ND	0.37	0.53	25.90	63.57	10.53	37.69	73.2
28H	2021	0.36	7.93	10.58	30.31	28.90	17.85	1.55	0.27	ND	0.71	0.54	20.47	59.86	19.67	30.45	85.7
29 T	2021	1.12	45.25	3.48	38.55	0.0	10.56	0.42	0.13	ND	0.27	0.10	50.22	39.09	10.69	0.42	52.2

ND*-not detected; SFA - saturated fatty acids (%); MUFA- monounsaturated fatty acids (%); PUFA- polyunsaturated fatty acids (%); Iodine value (g I_2/100g); H- estimated hydrogenation method from the composition found; T- estimated transesterification method from the composition found.

Table 2
Average fatty acids content and trans isomers (n = 3) in domestic spreads (%) purchased from local shops. The corresponding standard deviations are provided in Supporting Information S2.

N^{o} of product	year	C14:0	C16:0	C18:0	*cis* C18:1	*trans* C18:1	*cis* C18:2	*trans* C18:2	*cis* C18:3	*trans* C18:3	C20:0	C22:0	SFA (%)	MUFA (%)	PUFA (%)	Total *trans* (%)	Iodine Value
30 T	2015	2.04	21.51	9.50	32.52	13.82	13.86	0.52	1.07	0.23	0.41	0.35	36.06	46.93	17.01	14.57	70.8
31H	2015	1.85	8.88	13.27	39.88	24.83	3.56	1.29	0.94	0.50	0.66	0.35	27.29	65.35	7.36	27.06	70.4
32H	2015	3.92	15.04	12.45	29.95	17.26	11.49	0.60	1.04	ND	0.49	0.37	36.59	49.98	13.43	17.86	66.8
33H	2017	1.29	9.16	15.40	36.38	12.23	9.91	1.81	7.70	2.26	0.44	0.26	28.57	49.55	21.88	16.30	88.9
34H	2017	1.17	17.99	8.97	35.67	14.11	18.67	0.34	0.62	ND	0.35	0.45	30.09	50.28	19.63	14.45	77.8
35 T	2018	1.80	30.87	5.31	28.95	1.01	25.92	0.41	0.24	ND	0.28	0.28	42.73	30.69	26.58	1.51	72.6
36H	2018	1.38	16.33	9.60	35.51	11.71	12.54	0.93	0.56	0.74	0.41	0.56	30.18	55.05	14.77	13.38	73,5
37 T	2018	1.46	29.25	5.47	32.05	0.60	26.78	0.36	0.23	ND	0.29	0.31	39.86	32.77	27.37	0.96	75.8
38H	2018	1.19	14.09	11.04	40.50	11.54	9.91	0.87	1.72	1.12	0.43	0.37	28.83	57.55	13.62	13.53	75.1
39H	2018	0.26	14.05	9.38	40.58	13.48	11.42	0.68	2.61	2.39	0.48	0.47	24.98	57.79	17.23	14.49	83.5
40H	2018	0.50	10.02	18.06	45.19	15.49	5.88	2.48	0.25	ND	0.23	0.66	30.43	60.96	8.61	17.97	67.9
41 T	2019	2.39	22.14	13.45	33.71	6.41	16.18	0.66	0.12	ND	0.30	0.29	42.08	40.96	16.95	7.07	64.7
42 T	2019	2.77	29.29	9.49	29.78	3.40	17.79	0.85	0.19	ND	0.37	0.26	47.25	33.92	18.83	4.25	61.9
43 T	2019	4.02	27.60	9.91	29.11	4.17	16.49	0.52	0.14	ND	0.31	0.24	48.41	34.45	17.14	4.69	60.0
44H	2019	0.18	6.79	19.68	42.74	9.65	17.34	1.13	0.24	ND	0.32	0.46	27.43	53.86	18.71	10.78	78.8
45 T	2019	1.08	31.214	8.49	28.77	2.91	25.29	0.58	0.19	ND	0.45	0.23	41.89	32.11	25.99	3.49	72.8
46H	2019	0.11	7.65	13.99	36.78	25.2	9.11	3.46	0.56	0.73	0.77	0.29	23.02	63.12	13.86	29.39	79.4
47 T	2019	1.42	27.12	8.20	27.95	2.87	27.80	0.56	0.12	ND	0.22	0.16	39.99	31.53	28.48	3.43	76.5
48H	2019	0.10	7.78	13.02	37.91	26.57	8.13	3.56	0.49	0.49	0.54	0.47	22.22	65.11	12.67	30.62	78.8
49 T	2019	2.45	30.4	8.93	32.19	2.45	18.89	0.52	0.13	ND	0.28	0.15	44.98	35.49	19.53	2.97	64.5
50 T	2019	2.18	29.01	11.48	32.38	3.95	16.18	0.88	0.12	ND	0.27	0.18	45.73	37.09	17.18	4.83	61.8
51 T	2019	0.98	34.03	8.14	30.11	2.88	21.91	0.58	0.14	ND	0.30	0.13	43.95	33.37	22.68	3.46	68.1
52 T	2019	1.66	26.65	7.24	26.49	2.54	30.09	0.63	0.13	ND	0.26	0.19	39.75	29.40	30.85	3.17	78.8
53 T	2020	2.14	42.66	4.11	32.42	2.48	12.85	0.29	0.56	ND	0.18	0.10	51.24	35.05	13.70	2.77	54.6
54 T	2020	0.78	43.04	2.84	36.75	1.60	13.52	0.62	0.52	ND	0.22	0.10	46.97	38.38	14.65	2.22	58.8
55 T	2021	0.78	45.86	2.40	40.48	0.67	8.69	0.60	0.12	ND	0.23	0.04	48.52	42.12	9.36	1.27	52.4
56H	2021	2.19	13.98	8.45	36.11	27.31	5.20	2.79	0.25	ND	0.38	0.22	27.99	63.77	8.24	30.10	69.3
57H	2021	0.12	11.83	10.52	42.25	24.03	5.21	2.63	0.41	ND	0.30	0.19	24.89	66.52	8.59	26.66	72.4

ND*-not detected; SFA - saturated fatty acids (%); MUFA- monounsaturated fatty acids (%); PUFA- polyunsaturated fatty acids (%); Iodine value (g I_2/100g); H- estimated hydrogenation method from the composition found; T- estimated transesterification method from the composition found.

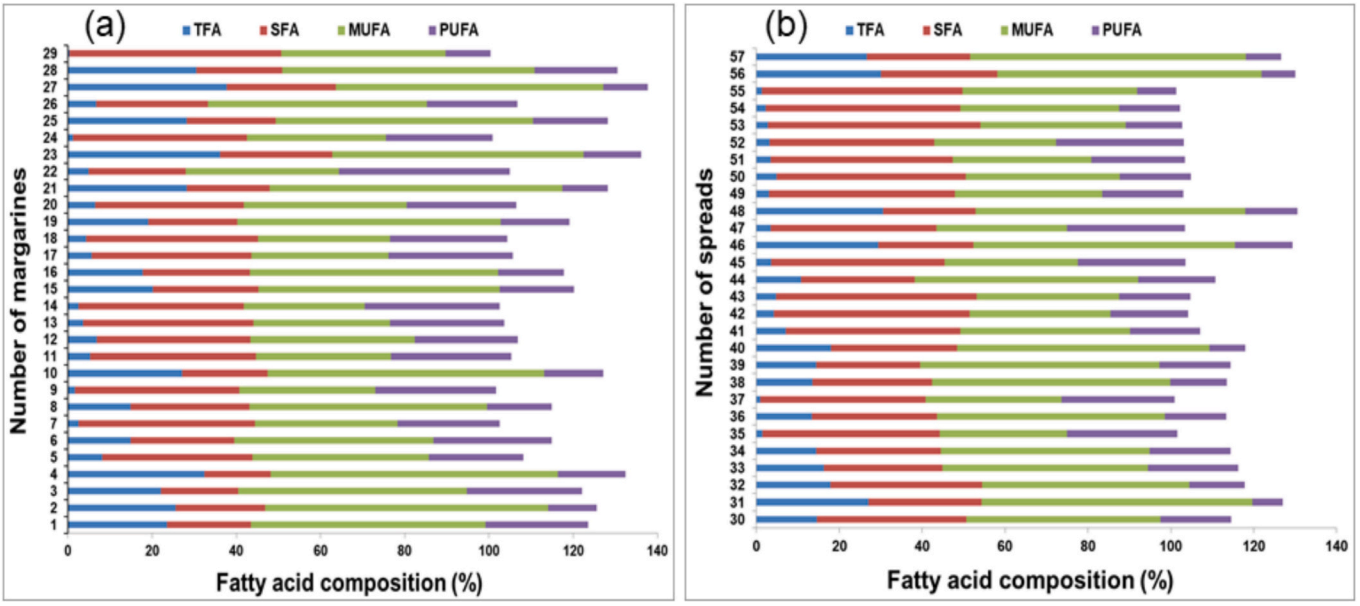

Fig. 2. Overview of temporal change in the content of trans fatty acids in margarines (a) and spreads (b) in Kazakhstan. The bars correspond to mean values without considering standard deviations.

than that for trans-isomers of oleic acid (C18:1 t). Furthermore, it has been demonstrated that the impaired biosynthesis of polyunsaturated fatty acids impacts the neurological structure of the brain and retina in children negatively (Bowen et al., 2016). It is evident that there has been a widespread issue with high TFA content in margarines and spreads across various markets, including Kazakhstan. Despite efforts to address this concern through the addition of alternative fats like palm oil, significant reductions in TFA content have not been consistently achieved. This poses a health risk as excessive TFA consumption is associated with various adverse health effects. Moving forward, further research and concerted efforts are necessary to develop strategies that effectively reduce TFA levels in margarine and spread products to align with international health guidelines and ensure public health and safety.

According to the labels, some margarines (#1, 3, 4, 6, 8, and 26) as well as spreads (#30, 32, 33, 38, 39) were fortified with the linolenic acid (C18:3). However, only margarine #6 had more than 11 % of linolenic acid while the other margarines contained C18:3c isomers ranging from 0.1 to 1.0 %. This is a very low fortification, in contrast, linoleic acid was found in large amounts (21.9–38.0 %) in margarines (#1, 3, 5, 7, 9, 11–14, 17, 20, 22, and 24) and spreads (#35, 37, 45, 47, 51, and 52).

Several studies have demonstrated that fat rich in omega-3 reduces the risk of cardiovascular disease (D'Eliseo & Velotti, 2016) and is beneficial for some types of cancer as well as blood pressure and inflammation in children (Calder, 2017). According to our results, the studied margarines and spreads are also good sources of oleic acid, which ranged from 26.4 % to 45.2 %. Several epidemiological studies may have associated consumption oleic acid with the reduced risk of cardiovascular disease, type 2 diabetes, and obesity (Sales-Campos et al., 2013).

3.2. Atherogenic index, thrombogenic index and ratio of hypocholesterolemic (h)/ hypercholesterolemic (H) fatty acids

The atherogenic index measures the ratio between saturated and unsaturated fatty acids. The first group is considered proatherogenic (promoting adhesion of lipids to the cells of the immunological and circulatory systems), and the second group is considered anti-atherogenic (inhibits aggregation and reduces the levels of esterified fatty acids, cholesterol, and phospholipids, preventing micro- and macrocoronary diseases) (Garaffo et al., 2011; Senso et al., 2007). The thrombogenic index indicates the likelihood of blood clots formed in the vessels. This is defined as the relationship between prothrombogenetic (saturated) and antithrombogenetic fatty acids (monounsaturated (MUFA) and polyunsaturated acids (PUFA) ω-6 and ω-3 (Ghaeni & Ghahfarokhi, 2013; Pietrzak-Fiećko et al., 2017).

In addition to saturated palmitic acid, which constitutes about 25 % of all animal fats, the saturated fatty acids (SFA) such as lauric (12:0), myristic (14:0) and stearic (18:0) have hypercholesterolemic effect. According to Ulbricht and Southgate (1991) the ratio between PUFA and SFA could be used to predict the effects of diet on plasma cholesterol levels. The comparison of the quality indicators of lipids in the fatty phase of margarines and spreads obtained by the hydrogenation method or by transesterification with the palm oil was conducted using the atherogenicity and thrombogenicity indices, as well as the ratio of h and H fatty acids for hypocholesterolemia.

A comparison among the samples obtained through hydrogenation and transesterification is presented in Tables 3 and 4. The SFA content is of decisive importance but not the trans-isomer concentration. For example, a comparison between samples #28 and #29 (Table 3) shows a ~ 30 % difference in the trans isomer content, and the hydrogenated sample had 2.5 times less SFA content. Therefore, the calculated indicators point to that the trans isomer content of the samples was large. The samples obtained through transesterification exhibit ratio values close to those of hydrogenated samples, or have only a slight advantage, when their levels of TFAs are similar (trans fatty acids ratio less than 1.3). Similar results were observed when comparing the parameters obtained for spreads (see Table 4).

These results support the rejection of hydrogenation with nickel catalysts and the use of palm oil stearin as alternative methods, as they will not help to improve oil and fat quality. SFA is not less harmful than the trans-isomers. The oil and fat products that meet international standards should contain no more than 2.0 % of trans-isomers (margarines and shortenings, and spreads within 2.5–5.0 %), and not more than 25–30 % of saturated fats. This study shows that most products analyzed from a relatively large sample of popular commercial fatty food products in Kazakhstan surpass the legal requirements of fatty acids. Hence policing TFAs in food products in Kazakhstan, and probably elsewhere, is needed to safeguard our health.

Table 3
Comparison of quality indicators of hydrogenated and transesterified margarines with the added palm oil.

№	№ sample margarine	AI	TI	h/H	Total trans, %	Trans ratio	SFA content, %	Ratio of SFA
1	№ 9	0.60	1.29	1.84	1.72	15.8	38.98	1.9
	№ 10	0.48	1.19	8.10	27.16		20.25	
2	№ 21	0.27	0.72	5.24	4.87	5.8	23.13	1.2
	№ 22	0.47	1.23	6.14	28.22		19.68	
3	№ 24	0.70	1.44	1.57	1.23	22.9	41.22	1.95
	№ 25	0.49	1.25	5.80	28.21		21.10	
4	№ 25	0.30	0.88	5.0	6.78	4.2	26.52	1.26
	№ 26	0.49	1.25	5.8	28.21		21.10	
5	№ 28	1.0	2.0	1.1	0.42	72.5	50.22	2.45
	№ 29	0.50	1.26	6.0	30.45		20.47	

Table 4
Comparison of quality indicators of hydrogenated and transesterified spreads with the added palm oil.

№	№ sample spread	AI	TI	h/H	Total trans,%	Trans ratio	SFA content, %	Ratio of SFA
1	№ 32	0.70	1.38	1.70	1.51	8.9	42.73	1.4
	№ 36	0.51	1.16	2.91	13.38		30.18	
2	№ 37	0.60	1.23	1.94	0.96	13.9	30.18	1.3
	№ 36	0.51	1.16	2.91	13.38		39.86	
3	№ 43	0.94	1.8	1.5	4.69	2.3	48.41	1.8
	№ 44	0.25	1.0	8.80	10.78		27.43	
4	№ 32	0.60	1.23	1.94	0.96	18.6	39.86	1.1
	№ 37	0.56	1.55	2.29	17.86		36.59	

4. Conclusions

From the analysis of oil and fat products sold in Kazakhstan's distribution network, the quality of oil and fat products consumed by the population as a whole does not meet international and national standards. The food industry appears in Kazakhstan (at least until 2021) to rely on technology of hydrogenation of vegetable oils that depends on the nickel catalysts which leads to products with a large content of trans-isomers (20–38 %). This is despite the January 1, 2018, Technical Regulations of the Customs Union in Kazakhstan, which limits the content of trans-isomers in oil and fat products to $\leq$2.0 %.

An alternative approach is using the palm oil component stearin, which doubles the amount of SFAs. However, this does not lead to less harmful products as compared to the trans-isomers. From the analyses carried out in this study, the composition of fat in margarines and spreads in Kazakhstan must improve. There were only 11 % of fat and oil products released in the market between 2018 and 2021 that contained less than 2 % of trans isomers, 44.5 % contained- less than 7.0 %, and 7.0 % contained up to 38 % of TFAs. These conditions may have associated cardiovascular health consequences. Improving processes in the food industry as well as in food monitoring will benefit the food secotr and society. This can also give an opportunity of new developments in food manufacturing as well as improving public health.

We envision a pathway to increasing the quality of solid fat products by replacing non-selective yet inexpensive nickel catalysts with catalysts with higher selectivity. Furthermore, it is crucial to undertake efforts to ensure a balanced fatty acid composition in both liquid and solid fat-and-oil products.

CRediT authorship contribution statement

Kainaubek Toshtay: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ali Auyezov:** Methodology, Conceptualization. **Seitkhan Azat:** Software, Investigation. **Rosa Busquets:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No.AP23490282 and AP14871087) for providing financial support. RB acknowledges the visiting Professor programme at Satvayev University.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fochx.2025.102246.

Data availability

The data that has been used is confidential.

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