

Trans Isomers of Fatty Acids: Health Risks and Ways to Reduce Consumption

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Abstract

The review presents the analysis of data to assess the health effects of various trans fatty acids. The analysis of the scientific literature indicates that a biological effect is dependent on the type of trans fatty acid. Based on the presented analysis it is shown that the introduction of hygienic rationing content of trans fatty acids (TFAs) should be differentiated according to which of TFAs should be considered to be hazardous to humans. The review presents data justifying the exclusion of some TFAs (rumenic and vaccenic acid) from the total combined content of trans fatty acids while limiting their consumption. These acids are proven to be attributed to functional food factors preventing the risk of various diseases. Rumenic acid and 10-trans-12-cis-octadecadienoic acid may also be used in drug therapy. Due to the positive biological activity of the two isomers of octadecadienoic acid with conjugated bonds, TFAs with conjugated bonds were excluded from the definition of TFAs adopted the Codex Alimentarius Commission and used in official documents of a number of countries. Overview material presented in the article confirms the thesis that the ban on the content of TFAs, or limitation on the legislative level, is a more effective method compared to mandatory labeling. Conducting a valuation of TFAs contents of certain substances is justified from the point of view of analytical chemistry, since the practice of monitoring implemented a method to determine the individual ENG 28 one, two and three double bonds. The article also discussed the various methods for reducing the content of TFAs in food products.

Keywords: *Trans Fatty Acids; Biological Role; The Health Risks; The Reduction of Consumption of Trans Fatty Acids; Regulation of Trans Fatty Acids*

Introduction

In recent decades, the struggle to reduce the content of trans fatty acid trans isomers (TFA) in food products has been actively launched around the world. The main source of TFA in food products is partially hydrogenated (artificially cured) liquid vegetable oils, which are used in the production of food products as a substitute for animal fats, including milk fat, in the production of margarines, and fats for special purpose (confectionery fats, bakery fats etc).

Conclusions about the association of TFA consumption with the risk of developing a number of diseases (cardiovascular, oncological, obesity, type 2 diabetes mellitus, ovulation infertility, as well as a number of diseases of the nervous, immune system and gastrointestinal tract) [1,2] made on the basis of large-scale population studies. In 2003, WHO recommended reducing TFA intake to 1% of the daily

caloric intake, which corresponds to 2% of total fat intake. The most stringent approach to the regulation of trans isomer content in food products was Denmark, later Switzerland, Austria, Iceland, Norway, Turkey and Hungary joined it. In these countries, legislation prohibits the production of food products with a TFA content of more than 2% of the fat content in the product. From 2016, a similar law will be in force in Latvia. Separately, there is a ban on the use of fats containing trans isomers in several states and cities of the United States (Philadelphia, New York, Chicago, Seattle).

Moreover, in the USA, Canada, EU countries, Argentina, Australia, Brazil, the content of TFA is necessarily indicated on the label of food products with an extensive information campaign on their harm through the media with the participation of scientific and health organizations. The accumulated experience and new data on the influence of individual positional and geometric isomers of TFAs allow us to adjust the methods of influence on reducing their content in food products.

The effect of individual trans isomers of fatty acids on human health. Natural vegetable oils, animal fats and marine mammalian fats mainly contain double bond fatty acids in the cis configuration (fatty acid residues are located on one side of the double bond). The formation of their geometric isomers, trans isomers (fatty acid residues are located on opposite sides of the double bond), in the process of hydrogenation of vegetable oils is due to their greater thermodynamic stability compared to cis isomers of fatty acids. In addition, the hydrogenation process is accompanied by the formation of positional TFA isomers, which differ in the location of the double bond relative to the carboxyl group. However, small amounts of TFA are found in fats of some marine mammals, bacteria, a number of seeds, as well as fats of ruminants, which include dairy fat [3]. The formation of TFA in ruminants is associated with the metabolism of polyunsaturated fatty acids from feed, including hydrogenation/dehydrogenation reactions. A very important fact is that TFAs formed during industrial hydrogenation of vegetable oils (industrial TFAs) and TFAs present in ruminant fats (natural TFAs) differ in their qualitative composition and in the quantitative content of individual isomers. In this regard, it is very important to study the effect of individual TFA on human health.

Since the consumption of TFA is primarily associated with an increased risk of developing cardiovascular diseases (CVD) and mortality from them, it is this issue that is paid the most attention to. Isolation of individual TFAs and improvement of methods for analyzing their effect on changes in biochemical parameters in the human body made it possible to establish that among trans isomers of oleic acid (9-cis-octadecene), 10-trans-octadecene acid-coke has the greatest effect on the development of CVD [4], not elaidin (9-trans-octadecene), as previously thought. It has been shown that consumption of 10-trans-octadecenoic acid in the composition of butter increases lipid deposition in the aorta [5]. Food intake of both isomers (9-trans-C18: 1 and 10-trans-C18: 1) isolated from butter correlated with an increased risk of atherosclerosis [6,7]. Thus, 10-trans-octa-decadenenoic and elaidic acids have a negative effect on the human body when consumed as part of a food product, regardless of their source: hydrogenated oils or fats of ruminants.

As for the effect of polyunsaturated fatty acids, di- and trisaturated fatty acids containing double bonds in trans configuration, even at a very low concentration, have a very high correlation with the risk of CVD. Recently, it was shown that trans isomers of octadecadienoic acid (C 18: 2) with isolated bonds have a higher correlation with CVD than trans isomers of octadecenoic acid (C 18: 1) [8]. In this case, the cis and trans isomers of octadecadienic acid have the greatest effect on the development of CVD [9,10]. It was also found that 9-trans, 12-trans-octadecadienoic acid has an inhibitory effect on $\Delta 6$ -desaturase, a key enzyme in the biotransformation of polyunsaturated fatty acids: linoleic acid to arachidonic acid and α -linolenic acid to eicosapentaenoic acid which are further involved in the formation of prostaglandins and leukotrienes [11-13]. Violation of the biosynthesis of polyunsaturated fatty acids in children negatively affects the development of the neurological structure of their brain and retina [14-16].

A special place among the trans isomers of oleic acid is occupied by vaccenic acid (11-trans octadecenoic acid), which got its name from the word "vaca" (from Lat. cow), as it dominates the TFA found in milk fat. Vaccenic acid is a precursor of rumenic acid (9-cis-11-trans-octadecadiene). The latter got its name due to its predominance (72.6 - 91.2%) among TFAs with conjugated bonds in ruminant fats (from the English ruminants) [17]. Rumenic acid and its precursor, vaccine acid, are noted to have an effect against several types of cancer. In the human body, vaccine acid supplied with dairy products is 19 - 25% capable of transforming into rumenic acid [18,19].

A more complicated situation has developed with the determination of the biological effects of TFA with conjugated (conjugated) bonds. A recent review compared 47 samples of ruminant fats and synthetic TFAs with conjugated bonds [20]. As a result, it was concluded that TFAs with isolated and conjugated bonds have a negative effect on blood lipoproteins, regardless of their source. However, this study would be correct if individual TFAs of ruminants were compared.

The effect of such individual trans isomers of octadecadienoic acids with conjugated bonds as rumenic acid and 10-trans-12-cis-octadecadienoic acid on the body has been most fully studied. These isomers showed a positive biological activity. Rumenic acid is the only isomer of the 56 TFAs found in fats of ruminants with conjugated bonds, in which no negative effect on the human body was found. The efficacy of using this acid to prevent the development of chemically induced cutaneous papilloma, cancer of the stomach, duodenum and breast has been demonstrated [18,19,21-24]. Natural rumenic acid, isolated from milk fat, had a greater effect than synthetic.

It was found that 10-trans-12-cis-octadecadienoic acid, present in milk fat in minor amounts (<1.5%), helps to reduce body weight by improving energy metabolism, reducing the size of adipocytes and the rate of their formation in adipose tissue, regulation of lipogenesis enzymes [25-27]. Also, this isomer may be involved in the development of insulin resistance in obese men [28,29]. This isomer has been shown to be more effective in preventing colon cancer compared to rumenic acid [30]. However, long-term consumption of the 10-trans-12-cis isomer of octadecadienoic acid, in contrast to rumenic acid, can, on the contrary, stimulate tumor formation [31], as well as have a negative effect on blood lipids and contribute to the development of atherosclerosis [32,33]. Therefore, for a given the isomer of octadecadienoic acid, the dose and duration of its consumption must be accurately estimated. The use of this isomer as a drug should only occur under the strict supervision of a physician.

Thus, some TFA contained in animal fats, such as rumenic acid and vaccine, can be attributed to functional nutritional factors that impede the risks of various diseases. Rumenic and 10-trans-12-cis-octadecadienoic acids can also be used in drug therapy.

Due to the presence of positive biological activity in the two isomers of octadecadienoic acid with conjugated bonds from the definition of TFA adopted by the Codex Alimentarius Commission and used in official documents of several countries (Germany, Canada, USA), all TFA with conjugated bonds were excluded: "Trans isomers fatty acids are all geometric isomers of mono- and polyunsaturated fatty acids having unconjugated carbon-carbon double bonds separated by at least one methylene group up in trans configuration".

Seed oils of some plants, such as bitter melon, catalpa, cherry, pomegranate, calendula, contain di-conjugated triene fatty acids (2 conjugated double bonds, the third isolated), which have strong cytotoxic properties [34,35].

With the development of our knowledge about the biological effects of individual TFAs, it will be necessary to introduce corrections in the determination of TFAs with the exception of isomers that are not harmful to health.

Routes of entry of trans isomers of fatty acids into the human body

There are 4 main sources of TFA in the human body: partially hydrogenated vegetable oils as a part of consumed food products; processes of heating food products containing unsaturated fatty acids; foods containing ruminant fats; TFA synthesized as dietary supplements [conjugated linoleic acid isomers with conjugated bonds - conjugated linoleic acid (CLA)] [1,36]. The composition and content of individual TFAs in each source vary and depend on the mechanism of their formation.

Partially hydrogenated oils

In recent decades, the main source of TFA in our food has been partially hydrogenated vegetable oils, which are used in the production of a wide range of food products. So, the content of TFA in some cocoa butter substitutes used for the production of glazes, pastry tiles and sweets can exceed 50% [37-40]. The composition and content of TFAs formed during the hydrogenation of vegetable oils is influenced not only by the initial fatty acid composition of the oils, but also by the process conditions: catalyst, temperature and duration. However, the

main part of TFA is represented by isomers of octadecenoic acid (from 4-trans to 16-trans-C18: 1) with a predominance of 9-trans-C18: 1 isomers (elaidic acid); 10-trans-C18: 1, as well as 11-trans-C18: 1 (vaccenic acid) [36,40]. The content of diene and triene trans isomers varies depending on the content of linoleic and linolenic acids in the starting oils, but all isomers of hydrogenated oils have only separate double bonds (Table 1).

Thus, partially hydrogenated oils mainly contain those TFAs, the consumption of which correlates with the risk of CVD and mortality from them. As a result of this, attention should be paid to the labeling of the content of TFA in all food products made using margarines, fats for special purpose, cocoa butter substitutes and other fat-and-oil ingredients based on partially hydrogenated oils.

Trans isomers of fatty acids formed during heating oils and fats

In the process of deodorization of vegetable oils, up to 3% of TFA is formed, which are mainly geometric isomers of linoleic and linolenic acids [1,36]. Deodorization at temperatures of 200 - 240°C under vacuum (<3 mbar) and a process time of not more than 60 min prevents the formation of TFA (up to 1%) and allows the initial tocopherols to be retained to the maximum extent. Insignificant amounts of TFA can also be formed during deep-frying at temperatures above 200°C. In these cases, only isomerization of the cis-to-trans bond occurs without the double bond moving along the hydrocarbon chain. In the above processes of heating vegetable oils, the amount of trans isomers of linolenic acid formed is 13 - 14 times higher than the isomers of linoleic acid [1,36].

Also, in these processes minor amounts of cyclic fatty acid isomers are formed. Thus, in the process of deodorization of vegetable oils, as well as during deep-frying, 1 - 3% TFAs are formed, similar to those found in partially hydrogenated oils. These processes are a constant source of TFA entering the human body. Therefore, special attention should be paid to the necessity of marking the content of TFA in deodorized vegetable oils and deep-fried food products.

Fatty acid trans isomers synthesized as dietary supplements

In connection with the discovery of a positive effect on ruminic acid (9-cis-11-trans-octadecadienoic acid) and the absence of negative effects on the human body, the production of synthetic CLA was started. However, synthetic CLA, in contrast to milk fat CLA, is a mixture of equal amounts of only two isomers: 9-cis-11-trans-octadecadienoic acid and 10-trans-12-cis-octadecadienoic acid. At the same time, ruminic acid predominates in ruminants in conjugated TFAs, while 10-trans-12-cis-octadecadienoic acid is present only in minor amounts. In addition, negative effects on health were found in 10-trans-12-cis-octadecadienoic acid [31-33].

Therefore, synthetic CLA should be taken only under the supervision of a physician. The use of synthetic CLA as enriching additives for food products is considered premature. In this regard, it is necessary to develop a mechanism for legislative regulation the products enriched with synthetic CLA before they enter the market of Russian Federation.

Fatty acid trans isomers synthesized in ruminant rumen

The main sources of TFA of natural origin are dairy and meat products of ruminants. The predominance of certain TFAs in ruminant fats depends on the ratio of various unsaturated fatty acids in their diet. However, unlike chemical hydrogenation, which leads to a randomized (random) mixture of isomers, double bonds formed in ruminant fats with the participation of rumen cellulolytic enzymes are located in specific positions and their profile is determined by the animal's primary diet: forage or feed concentrate.

In a recently published review by Nuela Aldai, *et al.* [36] provides data on the fatty acid composition of milk fat and ruminant meat. The trans isomers of hexadecenoic (C16: 1), octadecenoic (C18: 1) and eicosenoic acids (C20: 1) were identified in them with a quantitative predominance of C18: 1 isomers. C16: 1 trans isomers have a double bond at positions 3 to 15 with a predominance of 9-trans-hexadecenoic acid; C18: 1 trans isomers have a double bond in positions 4 to 17 with incense of 11-trans-octadecenoic acid (vaccenic acid); C20: 1 trans isomers have a double bond at positions 6 to 17, with 13-trans, 15-trans and 16-trans-eicosenoic acids predominant. However, the latest data obtained for beef samples from Canada (Alberta) and the USA (Ontario and Ohio), as well as lambs from Spain, showed a

predominance of 10-trans-octadecenoic acid in TFA, while rumenic acid is already did not prevail among isomers with conjugated bonds [36,41,42].

An increase in the amount of 10-trans-octadecenoic acid was noted in the fat of dairy cows, in fat and muscle of cattle with a high content of linoleic acid in their diet (vegetable oils or their seeds) and a low content of dietary fiber, with a decrease in forage and an increase in feed concentrates, as well as with an increase in the content of easily digestible carbohydrates, for example, from barley [36]. A shift towards the formation of 10-trans-octa-decadenecenoic acid is enhanced by a combination of several factors, for example, at the same time a high content of easily digestible carbohydrates and oils / oilseeds with a high content of linoleic acid in the diet of animals. Under these conditions, isomers of 10-trans and 11-trans-octadecenoic acids prevail over all other TFAs with one double bond.

Two other criteria that lead to an increase in the total content of TFA in ruminants are the presence of fish oils and ionophore antibiotics, in particular monensin, in the diet [36]. The increase in the content of TFA in fats in the first case is not directly related to the consumption of eicosapentaenoic and docosahexaenoic acids, but indirectly leads to the accumulation of already formed TFA. Ionophore antibiotics are used as feed additives to improve their digestibility, as well as increase productivity, accelerate the growth of beef and dairy cattle. In addition, monensin is used in poultry and rabbit husbandry for the treatment and prevention of coccidiosis. Cellulolytic microorganisms involved in feed biotransformation processes are very sensitive to ionophore antibiotics, which leads to an increase in the total content of TFA in animal fats. However, ionophore antibiotics non-specifically inhibit cellulolytic microorganisms; therefore, they do not alter the qualitative composition of TFAs.

In ruminant fats, trans isomers of octadecenoic acid have been identified with both conjugated (absent in partially hydrogenated oils) and separate double bonds (see Table 1). Of the diene isomers with separate double bonds, 8-trans-12-cis and 9-cis-13 trans isomers prevail, also found in partially hydrogenated oils, but in smaller quantities. Conversely, in partially hydrogenated oils, this group of isomers are dominated by 9-trans-12-cis- and 9-cis-12-trans isomers, also present in ruminant fats, but in smaller quantities. In the presence of high content of linolenic acid in milk and muscular tissues of ruminants, 9-cis-11-trans-15-cis-octadecatrienic, 9-cis-13-trans-15-cis-octadecatrienic, 9-cis- 11-trans-15-trans-octadecatrienoic acid and 9-trans-11-trans-15-cis-octadecatrienoic acid (see table 1). Depending on the diet of animals, the total content of TFA with two and three double bonds varies from 1.3 to 4.0g per 100g of milk fat and from 0.8 to 4.5g per 100 g of muscle tissue fat [36]. When enriching feed with fish oils in ruminant fats, TFAs with 20 and 22 carbon atoms were also identified.

The amount of biologically active rumenic acid (9-cis-11-trans-octadecenoic) in milk fat depends on both the breed of cows and the feed consumed by it. A greater amount of rumenic acid is found in the milk of pasture cows [43,44].

Improving our knowledge about the effect of individual TFAs on human health, as well as the dependence of their profile on the nutrition of ruminants, will help to avoid the undesirable TFA profile in final meat and dairy products and, conversely, increase the presence of healthy rumenic and vaccenic. The stimulation of agricultural producers in favor of research on the effect of feeding diets on the amount and composition of TFA in ruminant fats will help to ensure that the content of TFA is on the label of dairy and meat products.

A comparison of individual TFAs of industrial and natural origin (See table 1) indicates that their qualitative composition is characterized by the presence of the same isomers (except for TFAs with conjugated bonds), but the quantitative content is different. This once again confirms the need to indicate TFA as part of any food product containing a fat fraction.

Ways to reduce the content of trans isomers of fatty acids in food products

Following WHO recommendations in 2003 to reduce TFA consumption by less than 1% of the total caloric intake of the daily diet [45], it was recommended in 2011 to limit the content of partially hydrogenated oils in food products [46]. The strategy for achieving the goal set by WHO differs in different countries of the world and is based on restricting the content of TFA at the legislative level or voluntarily and/or on the mandatory labeling of TFA in food products (Table 2).

TFA	Partially hydrogenated oils	Ruminant fats ^{a)}	
Monounsaturated	18:1>>>16:1>20:1 (c&t) All position, random	18:1>16:1>20:1(c&t) All positions, specific	
Dienes	c/t-18:2>>c/t-16:2> 20:2	Specific c/t-18:2, 20:2, etc.	
		Separated double bonds	Cojugated double bonds (CFA)
Mono trans	c 9,t 12-18:2 t 9,c12-18:2 c 9,t 13-18:2 t 9,c 12-18:2 t 8,c12-18:2 t 9,c 15-18:2 t 10,c 15-18:2	t 8,c12-18:2/c 9,t13-18:2 c 8,t13-18:2/t 11c15-18:2 t 9,c12-18:2/c 9,t12-18:2	t 7,c 9 t 8,c 10 c 9,t 11 t 9,c 11 t 10,c 12 c 11,t 13 t 11,c 13
Di trans	t 9,t 12-18:2	t 9,t 12-18:2 t 9,t 15-18:2	t 6,t 8/ t 9,t 11 t 7,t 9/ t 10,t 12 t 8,t 10/ t 11,t 13
Trienes			
Mono trans	c/c/t-18:3=t/c/c-18:3> c/t/c-18:3	Specific c/c/t-18:3 metabolites c 9, t 11,c 15-18:3/ c 9, t 13,c 15-18:3	
Di trans	t 9, c 12,t 15-18:3 (trace)	c/t/t-18:3 (trace amounts of t,t-non CFA) c/t/t - CFA: c 9, t 11, t 15 t 9, t 11, c 15	

Table 1: Differences in the trans isomers (TFA) between partial hydrogenated vegetable oils and ruminant fat [9].

^{a)}: Fatty acids associated with a t10 shift (i.e. those enhanced when a combination of low fiber, high polyunsaturated fatty acid, and ionophore antibiotics are included in ruminants' diet).

In Denmark, Austria, Switzerland, Norway, Iceland, Hungary and Turkey, there is a legislative restriction on TFA content of less than 2% of the total fat content in food products delivered to final consumers.

After lengthy consultations and discussions, the US Food and Drug Administration (FDA) decided in June 2015 to ban the use of partially hydrogenated, high-TFA oils in food production, previously operating only in individual states and cities, with a transitional period of 3 years (RIA Novosti, 06.16.15; ADVIS.RU, 06.19.15).

The Ministry of Health of Latvia has developed rules limiting the maximum allowable amount of TFA in food products at a level of no more than 2g per 100g of total fat content. With the assumption: in products with a fat content of less than 20%, TFA should not.

They should exceed 4g per 100g of total fat content and in products with a fat content of less than 3% - 10g per 100g of total fat content. The rules will apply to all food products - domestic and imported. The new standards should enter into force on January 1, 2016, the transition period will be valid until January 1, 2018.

From the first of January 2018 in the countries of the Eurasian economic community, within the framework of the Technical Reglament TR CU 024/2011 "Technical Reglament for Oil-and-Fat Products", a limit on TFA content has been introduced for margarines, milk fat substitutes, confectionery and bakery fats, frying fats, cocoa butter equivalents – max 2% on fat basis. In cocoa butter substitutes as well as other food products the content of TFAs not limited. The requirement to specify the TFA content on the label applies only to fat-and-oil products.

Currently, Russian legislation, within the framework of the Technical Regulation of the Customs Union TR CU 024/2011 "Technical Regulation for Oil and Fat Products", limits the content of TFA only in certain types of oil and fat products: up to 20% for hard margarines and special fats, up to 8% for milk fat substitutes, soft and liquid margarines, spreads and melted mixtures of vegetable-creamy and vegetable-fatty oils with a gradual decrease in the content of TFA to 2% of the fat phase by 2018. In other types, fat and oil products, as well

Country	Requirements	Since when	Restrictions on the content of TFA
Denmark	Mandatory	Jan 2004	Max 2% fat basis – applies to products sold to final consumer
Austria	Mandatory	Jan 2009	Max 2% fat basis Max 4% fat basis for food products with less than 20% fat
Switzerland	Mandatory	Jan 2009	Max 2% fat basis
Iceland	Mandatory	August 2011	Max 2% fat basis
Hungary	Mandatory	01.01.2016	Overall max 2% TFA (2g max per 100g) on total fat basis in final product Derogation for processed food containing multiple ingredients i.e.: A max 4% TFA (4g per 100g) if the total fat content of the food is below 20% A max 10% TFA (10g per 100g) if the total fat content of the food is below 3%
Latvia			
Norway	Mandatory		Max 2% TFA (2g max per 100g) on total fat basis in final product. No derogation
Turkey	Mandatory		Max 2% (2g max per 100g) on total fat basis in final product If product containing <1% TFA, can claim «TFA free»
Belgium	Mandatory	Withdrawn	Proposal on Max 2% fat basis + palm and coconut
UK	Voluntary	2011	Industry commitments: Max 2% fat basis Eliminate partial hydrogenation
Germany	Voluntary	June 2012	Industry commitments: Max 2% fat basis No limit for B2B margarine
Spain	Voluntary		Industry commitments
Slovenia	Voluntary		Industry commitments
Romania	Voluntary		Industry commitments: Max 20% fat basis for school food of which max 5% saturated fat and max 1% TFA

Table 2: Requirements in various EU countries regarding the content of trans-isomer acids (TFA) in food products.

as other food products, the content of TFAs not limited to. The requirement to place TFA content on the product label applies exclusively to oil and fat products.

In a number of countries (USA, Canada, EU countries, Argentina, Australia, Brazil, Great Britain, Korea, Taiwan), the content of TFA is indicated without fail in food labeling [1]. Canada takes precedence in this issue. Here since the late 1980s, a number of companies on a voluntary basis began to indicate the content of TFA on the labels of packaged food products. In January 2003, a law was passed in the country on the obligatory indication of TFA (separately from saturated fats) in the composition of food products with fat phase in them. As a result of the introduction of labeling rules, the consumption of TFA in Canada decreased from 9–12 to 2.2 g / day per person [47].

The International Margarine Association of the Countries of Europe (IMACE) stated that the use of voluntary measures since 2004 to reduce trans isomers in margarine sold in the EU has already led to a 76% decrease in TFA in this product. The organization supported the idea of mandatory labeling of TFAs regardless of their source on food packaging [48].

With the significant success of mandatory labeling in the process of reducing the consumption of TFA in food products, the following disadvantages exist. Firstly, these measures are related to packaged products, while in the field of public catering, the consumer is not informed in any way about the content of TFA in the composition of dishes, which makes it possible to use partially hydrogenated oils with

a high content of TFA in their preparation. Secondly, obligatory labeling by the presence of TFA often excludes the labeling of dairy and meat products. It is also incorrect to ignore the TFA of ruminants, because their composition directly depends on the diet of animals. In addition, there is an erroneous opinion that TFAs of ruminants have a different physiological effect on the human body compared to TFAs of industrial origin. Whereas at the moment only two trans isomeric acids, rumenic (found only in ruminant fats) and vaccenic (found in all sources of TFA of industrial and natural origin), a positive effect on the human body in the absence of negative effects has been established. Improvement of legislation in the field of labeling of TFAs should be aimed at addressing these issues.

Since 2014, in Israel, on packages of food products of both local and imported production with a fat content of $\geq 2\%$, a complete list of TFA, cholesterol and saturated fatty acids contained in it should be indicated regardless of the source of their origin [49]. Based on the accumulated material by various methods of reducing the TFA content in food, in 2014 WHO concluded that introducing a ban on TFA content or restricting them at the legislative level is more effective than compulsory labeling.

In 2014, WHO products concluded that introducing a ban on the content of TFAs or restricting them at the legislative level is more effective than compulsory labeling. In this regard, the WHO European office called for a complete ban on the content of industrial TFA in food products as part of the European plan European Food and Nutrition Action Plan 2015 - 2020 [50]. It is impossible to exclude TFAs from the composition of dairy and meat products, however, their fatty acid profile can be regulated by changing the diets of animal feed. Moreover, the labeling of TFAs in all food products containing the fat phase, regardless of the source of their origin, is necessary to inform the consumer of the possible risks and should be as mandatory as indicating the content of sugar, salt, total and saturated fats.

To put the content of TFA on the label of any food product, it is necessary to solve the following questions: introduce the term “trans isomers of fatty acids” and determine the lower level of TFA in the product, meaning “absence of TFA”. At the moment, there is no unity in the world community on any of the above issues.

In Australia, New Zealand and France, the following definition of TFA is accepted: “Trans fatty acids mean the total amount of unsaturated fatty acids in which one or more double bonds are in the trans configuration and are declared as trans fats.” A similar definition has been adopted by the European Food Safety Authority (EFSA). With this approach, no distinction is made between TFAs from various sources, which, of course, is true, but rumenic and vaccenic acids with effect opposite to other TFAs are not excluded.

Isomers with conjugated bonds are excluded from the definition adopted by the Codex Alimentarius Commission, as well as the definitions of TFAs in Germany, Canada and the USA. However, recent studies have established a proven beneficial biological effect in the absence of negative effects only on rumenic acid. While the other isomer, 10-trans-12-cis-octadecadienoic acid, can have both positive and negative effects. The effect on the body of the remaining trans isomers of fatty acids with conjugated bonds has not yet been clarified. As a result, removing from the definition of all TFAs with conjugated bonds until their effect on the human body is clarified is not correct, but acceptable based on the current state of the issue.

There isn't common criterion for determining the lower limit of the TFA content in food products for labeling “trans free” (free of TFA).

According to the labeling law adopted in the USA, the content of TFA on the label must be indicated separately from the column “nutritional value of the product” [1]. TFAs of animal origin are not separated from TFAs of industrial origin and should also be indicated on the labeling of dairy and meat products (isomers with conjugated bonds are not included in the concept of TFAs). The law on labeling allows for the presence of < 0.5 g TFA per 100 g of product to label it as “0g TFA”. The Labeling Act, adopted in Canada, also provides for the indication of the content of TFA in all food products, if available [1]. Product with a TFA content of less than 0.2 g /100 g may be labeled as “Free of trans fat” (free from TFA). In the EU countries there is no concept of “trans free” products. So, on the label of Swiss chocolate you can see the inscription that the content of TFA in it is at the level of thousandths of a percent.

In the Eurasian economic community the questions connected with reducing the TFA in different food products are under discussion. A major success was legislative restriction of TFA content in oil-and-fat products to 2% on fat basis. However, there are not other mechanisms for reducing the TFA content in other products, including dairy and meat products. Moreover, in the Russian legislation, on the one hand, there is no definition of the term “trans isomers of fatty acids”, on the other hand, according to the requirements for labeling of food products (Technical Regulation of the Customs Union TR TS 022/2011 “Food products in terms of labeling”), - TFAs are indicated in total with saturated fatty acids, while the latter, unlike the former, are necessary for normal functioning of the body and can lead to negative consequences only when consumed above the recommended daily allowance (6 - 9% of the total calorie daily diet). Combining TFA with saturated fats is a violation of consumer rights, misleading them, which contradicts the main goals of technical regulations.

The adoption of the interstate standard GOST 31754 - 2012 on the determination of the mass fraction of TFA in food products by various methods, harmonized with ISO methods, currently allows determining up to 28 individual TFAs with one, two and three double bonds [51]. It's huge a step forward, since before that, according to the current Russian legislation (Federal Law No. 90 - Ф3 “Technical regulations for oil and fat products”), the content of TFA oil-and-fat products was determined only in terms of methyl ester of elaidic acid, i.e. it was taken into account only content of elaidic acid. However, the accepted standard does not allow the determination of TFA with conjugated bonds. In addition, the widespread adoption of standardized methods requires modern equipment, calibration standards for individual TFAs, specially trained personnel at all oil and fat enterprises in the industry and not only in certification centers and large research institutes and laboratories.

Taking into account the accumulated world experience in terms of reducing the consumption of TFA by the population of various origin, as well as the instrumental and analytical base available in Russia, we believe that as soon as possible it is necessary to amend the Technical Regulations of the Customs Union in terms of:

1. Definitions of the term “trans isomers of unsaturated fatty acids” (TR CU 021/2011 “On food safety”). We propose to take the determination of the Codex Alimentarius Commission as a basis, excluding vaccenic acid from it.
2. Indications in the labeling of all food products with a fat content of 2% or more of TFA content separately from saturated fats (TP CU 022/2011 “Food products in terms of their labeling”) with the introduction of a transitional period for adapting manufacturers to new labeling requirements. At this stage, TFA with conjugated bonds (there are no standardized methods for their determination) and vaccenic acid (based on its exclusion from the term TFA) will drop out of the definition of TFA. This, of course, will make natural dairy and meat products more attractive than their surrogates.
3. Introduction of the concept of “TFA is absent” or “without TFA” with the definition of the lower limit of the content of TFA. In this part, approaches used in the USA can be used.

Conclusion

The proposed legislative initiatives should be accompanied by education of the population about the harmful effects of TFA on human health through special broadcasts on radio and television, publication of scientific and popular science articles in magazines and newspapers of various levels.

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