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Trans fatty acids in **Europe**: where do we stand?

A synthesis of the evidence: 2003-2013

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Preface

As the European Commission's in-house science service, the Joint Research Centre's (JRC) mission is to provide EU policy makers with independent, evidence-based scientific and technical support throughout the whole policy cycle. As part of *Regulation (EC) No 1169/11* on the provision of food information to consumers, the European Parliament and the Council requested that the European Commission (EC) reports on 'the presence of trans fats in foods and in the overall diet of the Union population. The aim of the report shall be to assess the impact of appropriate means that could enable consumers to make healthier food and overall dietary choices or that could promote the provision of healthier food options to consumers, including, among others, the

provision of information on trans fats to consumers or restrictions on their use. The Commission shall accompany this report with a legislative proposal, if appropriate'.

To address this request, the Directorate-General Health and Consumers (DG SANCO) has called on the JRC to provide evidence on the current presence of *trans* fatty acids (TFA) in foodstuff and TFA intake in Europe. As a result, this report summarises and discusses recent publicly available data regarding the amount of TFA in foodstuff and TFA intake in Europe. This is coupled to a brief introduction on TFA, the health concerns related to their consumption as well as a summary of the different actions that have been used to reduce TFA consumption.

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Glossary

ATR-FTIR	Attenuated Total Reflection–Fourier Transform Infrared
CLA	Conjugated Linoleic Acid
CHD	Coronary Heart Disease
DAM	Dietary Assessment Methods
DG SANCO	Directorate-General Health and Consumers
EC	European Commission
E&IA	Enlargement & Integration Action
EFSA	European Food Safety Authority
E%	Percentage of Energy
FAO	Food and Agriculture Organization of the United Nations
FBO	Food Business Operator
FDA	Food and Drug Administration

GC	Gas Chromatography
GRAS	Generally Recognised as Safe
g	Gram
HDL	High-Density Lipoprotein
HPLC	High Performance Liquid Chromatography
IHCP	Institute for Health and Consumer Protection
IRMM	Institute for Reference Materials and Measurements
iTFA	<i>Trans</i> Fatty Acids of Industrial Origin
JRC	Joint Research Centre
LDL	Low-Density Lipoprotein
mg	Milligram
MS	Member State
MUFA	Monounsaturated Fatty Acids
NICE	National Institute for Health and Clinical Excellence
NYC	New York City
PHO	Partially Hydrogenated Oils
PHVO	Partially Hydrogenated Vegetable Oils
PUFA	Polyunsaturated Fatty Acids
RCT	Randomised Controlled Trial
rTFA	Naturally Occurring Ruminant <i>Trans</i> Fatty Acids
SFA	Saturated Fatty Acids
TFA	<i>Trans</i> Fatty Acids
UK	United Kingdom
USA	United States of America
WHO	World Health Organization
µg	Microgram

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Executive summary

Trans fatty acids (TFA) are a particular type of unsaturated fatty acid. They are naturally present in food products made from ruminant animals such as dairy and meat from cattle, sheep or goat (naturally occurring ruminant TFA or rTFA) but can also be produced industrially (TFA of industrial origin or iTFA). Partially hydrogenated vegetable oils (PHVO) are the primary dietary source of iTFA; they are used in food products such as margarines, shortenings and bakery products. Consumption of TFA is associated with increased risk of coronary heart disease (CHD). Indeed, the latest scientific opinion on TFA by the European Food Safety Authority (EFSA) states that ‘TFA intakes should be as low as is possible within the context of a nutritionally adequate diet’ [1], while others suggest a maximum daily limit of two E% (percentage of energy) TFA or one E% TFA. Many countries have introduced measures to reduce the consumption of TFA. These measures range from voluntary agreements with the private sector to reduce TFA/PHVO in foodstuff and mandatory TFA labelling to imposing maximum limits for TFA in foodstuff. Denmark was the first country to adopt legislation limiting the content of TFA in foods in 2003. Since 2003, Switzerland (2008), Austria (2009), Iceland (2011), Hungary (2013) and Norway (2014) have legislation in place and now also limit the content of TFA in foodstuffs. Several studies point towards the effectiveness of most measures in reducing

TFA in the food chain, albeit to various degrees. Indeed, the last 20 years have witnessed improvements in the fatty acid composition profile of foodstuffs and a decrease in dietary intakes of TFA. Nevertheless, several organisations and researchers call for more coordinated efforts to further reduce the TFA content in the food chain. For example, there are still products with high levels of TFA being sold on the European food market and there are concerns that specific population groups may be at risk of high dietary exposure of TFA.

EU legislation does not regulate the content of TFA in foodstuffs nor does it require its labelling. The European Parliament and the Council have however requested as part of the recent *Regulation (EC) No 1169/11* on the provision of food information to consumers that the European Commission (EC) reports on ‘the presence of trans fats in foods and in the overall diet of the Union population’. It is expected that the results can inform further decisions on introducing, at European level, ‘appropriate means that could enable consumers to make healthier food and overall dietary choices or that could promote the provision of healthier food options to consumers, including, among others, the provision of information on trans fats to consumers or restrictions on their use’.

This report is a first step in addressing this request. The analysis of the most recent

publicly available data confirms reported reduction of TFA in foods but also shows that there are still a number of foods with high levels of TFA (above 2 g TFA per 100 g of fat) in some European food markets. Results from dietary surveys also indicate that although the overall population TFA intake is below the World Health Organization (WHO)-recommended maximum of one E% there are subpopulations exceeding the recommended threshold. As long as products with high TFA content remain

in the food market, it is possible that individuals may consume more than the recommended maximum. As it stands, there appears to be room for improvement of the European situation as regards the presence of iTFA in foodstuffs. Whether to consider introducing or promoting any additional TFA-related measures at European level, and if so, assessing which measure would be most appropriate to further reduce TFA consumption is beyond the scope of this initial analysis.

1. Introduction

1.1. *Trans* fatty acids (TFA)

Trans fatty acids (TFA) are a particular type of unsaturated fatty acid. The Codex Alimentarius defines TFA as ‘all the geometrical isomers of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids having non-conjugated, interrupted by at least one methylene group, carbon-carbon double bonds in the *trans* configuration’ [2]. TFA can be classified as either of industrial origin (iTFA) or naturally occurring ruminant TFA (rTFA). iTFA are formed during partial catalytic hydrogenation of liquid oils, mostly plant oils, which produces the so-called partially hydrogenated vegetable oils (PHVO). The hydrogenation process turns oils into semi-solid and solid fats thus giving them qualities desired by the food processing industry (*e.g.* increased tolerance against repeated heating, prolonged product shelf-life, sensory aspects). iTFA can be found in several food products including certain bakery products (*e.g.* biscuits and pastries), vegetable fats (*e.g.* margarines and spreads), confectionary (fillings and creams) and some fried foods (*e.g.* potato crisps). The final iTFA content in these products varies considerably from <1% up to more than 50% of total fat. rTFA, on the other hand are produced in the rumen of animals such as cattle and sheep, and, for example, can be found in the fat of milk, butter, cheese or beef at levels of 2-9% of rTFA of total fat [1] [3] [4].

1.2. Measuring TFA in foods

TFA in foods can be identified and quantified using validated methods that rely on attenuated total reflection–Fourier transform infrared (ATR-FTIR) spectroscopy and gas chromatography (GC) or high performance liquid chromatography (HPLC) [3] [5]. Different techniques have their respective strengths and weaknesses mostly related to reproducibility, separation ability and precision but also time, costs and resources. For example, GC detects individual TFA isomers and can easily quantify as few as 0.5 μg *trans* per mg of fat. Sample preparation and running time however, are long. On the other hand, the ATR-FTIR method is often used by food manufacturers because of its speed but it only measures the total amount of TFA (non-conjugated) without discriminating between isomers. Importantly though, while methods for estimating the relative contributions of rTFA and iTFA to the total content of foods have been proposed, there are no methods that can easily be applied with confidence to a wide range of foods and distinguish between rTFA and iTFA [3]. rTFA contain mostly the same individual fatty acids as iTFA but with distinctly different abundance, in particular a lower elaidic (predominant in PHVO) to vaccenic (predominant in ruminant fat) acid ratio [6]. Thus, TFA patterns or the elaidic/vaccenic acid ratio can help distinguish between ruminant and partially hydrogenated fats. However, whereas pure ruminant and partially hydrogenated fats are relatively

easy to identify, precisely calculating the proportions of each one in a mixed sample is impossible for reliable routine analyses.

1.3. Health-related implications of TFA consumption

The detrimental effects of iTFA on heart health were first brought to the spotlight in the early 90s [7] [8] [9]. Since then, experimental studies have consistently demonstrated the adverse effects of dietary TFA on blood lipoprotein profile (increased low-density lipoprotein [LDL] cholesterol and decreased high-density lipoprotein [HDL] cholesterol levels amongst others) [10] [11]. On a per calorie basis, TFA appears to increase the risk of coronary heart disease (CHD) more than any other macronutrient. An analysis of several studies indicated a 24, 20, 27 and 32% higher risk of myocardial infarction or CHD-related death when 2 E% derived from carbohydrates, saturated fatty acids (SFA), *cis*-MUFA, and *cis*-PUFA, respectively was replaced by 2 E% derived from the consumption of TFA [12]. A recent study showed that rTFA, conjugated linoleic acid (CLA) and

iTFA increases the LDL/HDL ratio [4]. However, it should be noted that while the levels of iTFA in foods can be as high as 50% of total fat content those of rTFA are normally below 6% [1]. Whether rTFA intake is associated with an increased risk of CHD is not yet clear [1].

1.4. TFA in foods and diets

1.4.1. Current recommendations

TFA do not serve any vital functions in the human body and there is no physiological requirement for them in the diet [13]. The scientific opinion on TFA by the European Food Safety Authority (EFSA) states that ‘TFA intakes should be as low as is possible within the context of a nutritionally adequate diet’ [1]. This opinion is based on the health implications of TFA consumption described above but also on considerations that there is a limit to which the intake of TFA can be lowered without compromising the intake of essential fatty acids and other nutrients (*e.g.* coming from dairy or cattle meat). *Table 1* lists recent recommendations on daily dietary intake of TFA, ranging from ‘as low as possible’ to <2 E%.

Table 1. Examples of dietary recommendations on trans fatty acid intakes for adults.

Organisation issuing the recommendation	Year of publication	TFA intake recommendation
EFSA [1]	2010	As low as possible
World Health Organization (WHO)/Food and Agriculture Organization (FAO) [14]	2003	<1 E%
The Committee on Medical Aspects of Food Policy, United Kingdom [15]	1991	<2 E%
German Nutrition Society, Austrian Nutrition Society, Swiss Society for Nutrition Research & Swiss Nutrition Association [16]	2008	<1 E%
French Food Safety Authority [17]	2001	<2 E%
The Health Council of the Netherlands [18]	2001	As low as possible
US Department of Health and Human Services/US Department of Agriculture [13]	2005	As low as possible
Nordic Council of Ministers [19]	2012	As low as possible

1.4.2. Approaches to reduce dietary intake of TFA

There are several ways in which intake of TFA can be reduced. These include food reformulation (reducing or replacing iTFA in foods and foodstuffs) and supporting related consumer choices (*e.g.* choice of PHVO-free products and choice of low-fat milk, dairy and meat products). There is a range of approaches to reformulate foods and reduce iTFA content for example replacing PHVO with alternative oils and fats and/or mixing of various non-hydrogenated oils. The ‘toolkit’ of oils and fats is vast and includes for example food technological approaches to ‘design’ fats of desired composition and properties, in particular by applying fat interesterification and fractionation processes [20] [21] [22]. Nevertheless, replacement of TFA in certain food products such as fine pastries, specific long-life bakery products and confectionary coatings, still poses technological challenges for achieving the required food functionality [23]. More importantly, the full health profile of the reformulated product has to be considered; for example there are concerns that reformulation may lead to increased SFA content and consumption. A detailed description of possible alternative oils and fats to be used by food technologists, including a list of recommended healthier alternatives to TFA is provided by Eckel *et al.* 2007 [5] and by the Canadian Trans Fat Task Force [24]. Some examples include the use of *cis*-unsaturated fats. Indeed, several studies have shown that for a number of food products, TFA have not simply been replaced by SFA, but the

reformulated products have increased the content of *cis*-unsaturated fats, thus leading to an overall healthier profile of the product [25] [26] [27]. Eckel *et al.* [5] indicate that the transition to ‘zero trans’ or ‘low trans’ products is long and involves economic, supply, formulation, packaging and market research considerations. There are, however, cases that suggest otherwise. For example, the introduction of a TFA legislative limit in Denmark resulted in a reduction of iTFA shortly after (in one year) its introduction without any obvious side effects for the population [28].

Worldwide, several approaches have been implemented to reduce TFA intake. A summary of these is illustrated in *Figure 1* [29] and *Annex I*. As it can be seen, these approaches range from voluntary agreements with food business operators (FBO) to reduce TFA in foodstuffs to mandatory TFA labelling or legislative limits on TFA, and are implemented at national and/or at regional level. Of note, recently the United States (USA) Food and Drug Administration (FDA) has ‘tentatively determined’ that PHVO are no longer to be considered as ‘generally recognised as safe’ (GRAS) additives. The public consultation phase completed on 8th of the March 2014 and a final decision is expected in the near future [30]. Its approval could mean a change in US legislation as ‘food manufacturers would no longer be permitted to sell Partially Hydrogenated Oils (PHOs), either directly or as ingredients in another food product, without prior FDA approval for use as a food additive’.

In 2003, Denmark adopted legislation [31] which limits the content of iTFA in food-

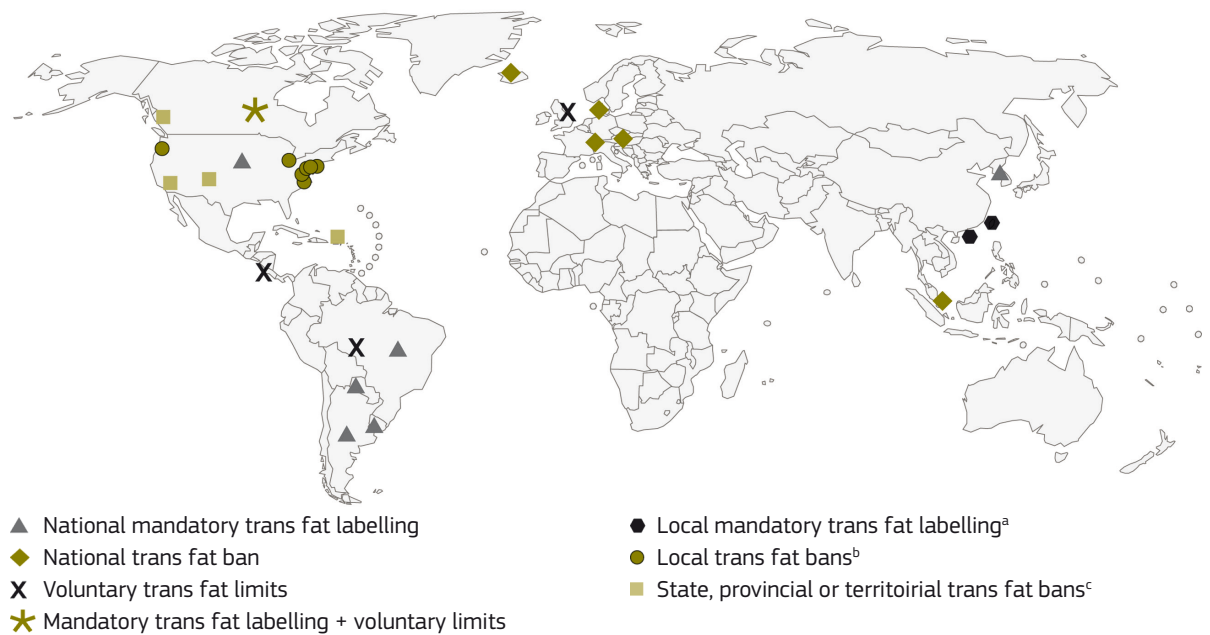


Figure 1. Trans fat policies around the world, 2005-2012. *Reproduced with permission [29].

stuffs destined for human consumption (maximum 2g TFA per 100g of total fat). This move has effectively restricted the use of TFA-containing PHVO in foodstuffs in Denmark. Switzerland (2008) [32], Austria (2009) [33], Iceland (2011) [34], and most recently Hungary (2013) [35] and Norway (2014) [36] have also introduced legislation limiting the content of TFA in foodstuffs (see Table 2).

The TFA content in foodstuff is currently not regulated in Europe except for the EU *Directive 2006/141/EC* on infant formulae and follow-on formulae which sets an upper limit for TFA of 3% of total fat in these products [37] [38]. *Regulation (EC) No 1169/2011* on the provision of food information to consumers [39] makes listing nutritional information mandatory, but the list does not include TFA. Nevertheless, the *Regulation* stipulates that the EC reports on the presence of trans

fats in foods and in the overall diet of the Union population and that it assesses ‘the impact of appropriate means that could enable consumers to make healthier food and overall dietary choices or that could promote the provision of healthier food options to consumers, including, among others, the provision of information on trans fats to consumers or restrictions on their use’.

Evidence from a number of countries indicates that the intake of TFA in the EU has decreased considerably over recent years, owing to several measures that include the legislations cited above as well as reformulation of food products and increased public health awareness [40]. However, only a few reports so far have summarised evidence on total intake of TFA and the contribution of selected food groups to TFA intake in the diet of the European population [1] [3] [41]. In 2004, an EFSA report [3] described

Table 2. European legislation limiting trans fatty acid content of foodstuffs.

Country and decree	Regulation / order ¹
<ul style="list-style-type: none"> • Austria [33] • Austrian Ministerial Decree No. 267 of 20 August 2009 on trans fat content in food (267. Verordnung des Bundesministers für Gesundheit über den Gehalt an <i>trans</i>-Fettsäuren in Lebensmitteln) 	<p>‘It is prohibited to produce or market foodstuffs with a <i>trans</i> fatty acid content exceeding 2g per 100g of total fat content.’</p> <p>‘The limit value as referred to in the above paragraph may be exceeded in the case of processed foodstuffs made from several ingredients, provided the total fat content of the foodstuff is less than 20% and the <i>trans</i> fatty acid content does not exceed 4g per 100g of total fat, or provided the total fat content is less than 3% and the <i>trans</i> fatty acid content does not exceed 10g per 100g of total fat.’</p>
<ul style="list-style-type: none"> • Denmark [31] • Danish Executive Order No. 160 of 11 March 2003 on the Content of <i>Trans</i> Fatty Acids in Oils and Fats (BEK nr. 160 <i>Transfedtsyrebekendtgørelsen</i>) 	<p>‘The content of <i>trans</i> fatty acids in oils, fats and food products must not exceed 2 grams per 100 grams of oil or fat.’</p>
<ul style="list-style-type: none"> • Iceland [34] • Regulation on the Maximum Levels for <i>Trans</i>-Fatty Acids in Foods 	<p>‘It is prohibited to place foods on the market which contain over 2 grams of <i>trans</i>-fatty acids per 100 grams of total fat content.’</p>
<ul style="list-style-type: none"> • Switzerland [32] • Ordonnance du DFI sur les huiles et graisses comestibles et leurs dérivés (817.022.105) 	<p>‘The sum of <i>trans</i> fatty acids should not exceed 2g per 100g of edible vegetable fat.’</p>
<ul style="list-style-type: none"> • Hungary [35] • Hungarian Decree 71/2013 of the Ministry of Human Resources 	<p>‘It is forbidden to place on the market food products in which the amount of <i>trans</i> fats exceeds 2 g for every 100 g of the total fat content of food products provided or sold to end consumers. This does not include the storage of said products in their finished state in order to place them on the market outside Hungary.’</p> <p>‘For processed food products consisting of multiple ingredients, the above paragraph shall not apply if</p> <p>(a) the total fat content of the food product is lower than 20%; in this case, the amount of <i>trans</i> fats may not exceed 4 g for every 100 g of the total fat content of said food product;</p> <p>(b) the total fat content of the food product is lower than 3%; in this case, the amount of <i>trans</i> fats may not exceed 10 g for every 100 g of the total fat content of said food product.’</p>
<ul style="list-style-type: none"> • Norway [36] • Royal Ministry of Trade and Industry 	<p>‘The sale to the final consumer of products that are covered by these Regulations and that contain more than 2 grams of <i>trans</i> fatty acids per 100 grams of fat is prohibited’</p>

the results of the TRANFAIR study that included data collected in 1995-96 in 14 EU countries [42]. In that study, average daily intake of TFA per country ranged between 0.5-2.1 E% in men and between 0.8-1.9 E% in

women. However, in some individuals, the average daily TFA intake was as high as 2.8 E% (90th percentile). A 2010 EFSA report [1] presented information on decreasing rates of TFA intake in many European countries. The results of studies with available information on TFA intake in children (e.g. Denmark, the Netherlands, Sweden and the United

1. The table contains excerpts from various documents regarding legislation/regulation of TFA.

Kingdom (UK)) showed that intakes varied between 0.2 and 0.4 E% (groups with lowest TFA intake; 5th percentile) and 0.8 to 3.3 E% (groups with the highest TFA intake; 95th percentiles).

Another relatively recent report from the European Parliament [41] has indicated that particular subpopulations might consume more than 5 g of TFA per day. There is additional evidence to back up this estimate such as the 2006 ‘food market basket’ investigation conducted by Stender *et al.* [43] which indicates that individuals regularly consuming fast-food products in some European countries could potentially be exposed to high TFA levels in foods. In a follow up study [44], the same authors reported that the TFA content of a ‘high trans menu’ *i.e.* a large fast food serving (French fries and fried chicken) as well as biscuits/wafers/cakes and microwave popcorn in seven European countries varied considerably *e.g.* low in Western European countries but high, despite reductions, in Eastern European countries.

1.5. Examples of approaches to reduce dietary intake of TFA and their outcomes

A systematic review by Downs *et al.* [29] indicates that all types of TFA-related interventions, from voluntary TFA reduction agreements to mandatory TFA labelling or legal TFA limits, have led to a reduction of iTFA in the food supply (albeit to different degrees). Some examples of these approaches, including evidence of their effectiveness where available, are given below.

1.5.1. The case of USA mandatory TFA labelling

Since 2006, USA manufacturers must list TFA on the nutrition facts panel of foods and certain dietary supplements [45]. Supporters of this regulation suggest that the introduction of information in the nutrition facts panel forced the food industry to reformulate its products and resulted in increased public and stakeholder awareness [5]. A recent study by the USA Department of Agriculture looked at changes in the TFA content of new food products (introduced in the market after 2006) and the use of ‘no trans fats’ package claims following the labelling regulation in force at the time [27]. The findings indicate a decline in the TFA content of new food products (from 2005 to 2010) and increasing use of ‘no trans fats’ claims on product packages. Also, many ‘TFA-free’ products contain less SFA, sodium and calories [27].

1.5.2. The case of New York City action

The New York City (NYC) action came into effect in July 2008 and restricted all food service establishments from using, storing, or serving food that contained PHVO with a total of 0.5 g or more TFA per serving [46]. It is one of the few actions targeting foods prepared outside home and it was based on findings that over a third of energy intakes of NYC residents come from foods purchased and prepared outside home [46]. This aspect of the action is important when considering that foods prepared outside home are unaffected by labelling require-

ments. A recent study looked at the effects of the NYC action by comparing the TFA and SFA content of fast-food customer purchases in NYC restaurants before (2007) and after its implementation (2009) [47]. The study showed a statistically significant net decrease in combined TFA and SFA content of food purchases (1.86 g overall mean decrease (13.7 to 11.9 g)) attributed to reformulation and new offerings; mean TFA content per purchase decreased by 2.4 g (from 2.9 to 0.5 g), whereas mean SFA content per purchase increased by 0.55 g (10.8 to 11.4 g) after the implementation of the action. Of note, the observed decreases in the TFA content of food purchases benefited similarly customers living in high- and low-income neighbourhoods.

1.5.3. Voluntary actions to reduce TFA

In 2007, the British Retail Consortium announced its intentions to voluntarily cease the use of TFA in foodstuffs [41]. Around the same time, the UK Food Standards Agency [48] advised the UK Department of Health to maintain its successful voluntary approach rather than adopt a mandatory approach to regulate TFA content of foodstuffs. A 2013 UK survey determined the TFA content of a range of processed foods and indeed showed that levels were reduced considerably as compared to previous analyses of similar foods [49]. There are, however, a number of health professionals and organisations which call for regulatory actions such as the National Institute for Health and Clinical Excellence (NICE) in its 2010 recommendations [50].

In the Netherlands, the Product Board for Margarine, Fats and Oils² representing all trade and production companies in the Dutch edible oils and fats chain, set up a Task Force for Responsible Fatty Acid Composition. This collaborative effort which included restaurateurs, consumers, health foundations and the government initiated a campaign to reduce the use of PHVO and SFA in deep-fat frying in restaurants [51]. This apparently resulted in switching to frying oils which met the agreed limit of less than 5% TFA but also contained less SFA than traditional frying fats [51]. Some argue that the Dutch model is not necessarily applicable to other countries and regions because of the country-specific approach of using public engagement and collaboration to deal with social issues [51].

1.6. Aim of this report

While the TFA content in foodstuffs is currently not regulated at a European level, the recent legislation on food information to consumers (*Regulation (EC) No 1169/2011*) [29] requests that, among other points, the European Commission (EC) reports on the presence of trans fats in foods and in the overall diet of the Union population. This report supports the above request by identifying and summarising publicly available data on the content of TFA in foods and on dietary intake of TFA intake in Europe.

2. <http://www.mvo.nl/home>

2 . Methodology

2.1. Literature search

A structured but broad search of articles published in English was conducted in PubMed and in other electronic bibliographical databases such as The Cochrane Library. Google searches were also performed as some studies referred to unpublished reports and grey literature. Systematic searches were repeated by one of the authors (TM) between October 2012 and August 2013. The search strategy was designed to be as inclusive as possible and focused on two key elements: ‘TFA presence in foods’ and ‘TFA consumption/dietary intakes’. Searches consisted of at least one or a combination of the following terms/keywords; ‘TFA’, ‘food’, ‘food groups’, ‘dietary intakes’, ‘food consumption’, ‘food presence’, ‘PHVO’, ‘fatty acid composition’, ‘nutritional surveys’, ‘socio-economic status’, ‘energy contribution’, ‘food analysis’, ‘food composition tables’, ‘Europe’, ‘European Region³’, ‘original studies’, ‘systematic review’, ‘meta-analysis’, ‘review’ and ‘technical report’. The search was supplemented by cross-checking reference lists of relevant publications. Furthermore, a number of websites of groups or organisations that report

3. Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Iceland, Kosovo, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Montenegro, Serbia, The former Yugoslav Republic of Macedonia, Turkey.

on food, diet, nutrition and public health such as the European Dairy Association and the European Vegetable Oil and Protein Meal Industry were browsed as well. The authors of this report also organised a dedicated TFA workshop where additional data and/or studies were gathered or requested.

2.2. Selection of the evidence

Peer-reviewed papers, reports and grey literature containing European TFA-related data published between January 2005 and August 2013 were considered for inclusion. This time frame was established to exclude data from years prior to the Danish regulation [31]. For studies related to TFA consumption/intakes, the publication period was extended to 2003 because of insufficient data. To be included in the analysis, studies needed to assess TFA content in food(s) and/or consumption/intakes in Europe (including EU Member States (MS), acceding, candidate and potential EU candidate countries). All research designs (*e.g.* cross-sectional studies, randomised clinical trials (RCTs)), population groups (*e.g.* university students, low socio-economic status), TFA measurement methods (*e.g.* IR spectroscopy, silver-ion chromatography) and dietary assessment methods (DAM) (*e.g.* 24-hour dietary recalls, food frequency questionnaires) were included. The following exclusion criteria: (i) non-European studies and (ii) studies published before 2005 (for presence of TFA) and 2003

(for consumption/intakes of TFA) were applied. Evidence was only rejected on initial screening if the reviewer could determine from the title and abstract that the article did not meet the inclusion criteria. Thereafter, the studies identified were assessed for their relevance, including consultation with the authors where necessary. *Table 3* and *Table 4* lists all studies included in the analysis of TFA content in foods and TFA consumption. Evidence presented in a language other than English was translated by the authors of this report. However, it is important to note that language barriers may have limited the interpretation of such evidence.

2.3. Data extraction and analysis

The data reported in the studies were extracted directly into a dedicated Microsoft Excel® data extraction form and double-checked for completeness and accuracy afterwards. This data extraction form included the following information, listed in *Table 3* and *Table 4*:

- TFA presence in foods: country, name of study/report, year of publication, food group analysed, product, product ID, year of sampling, analytical method used, number of samples, unit of measurement.
- TFA consumption/intakes: country, name of study, year of publication, type of study, year of dietary assessment, DAM, population age, age range, women (n), men (n), total subjects (n).

We have used Microsoft Excel® to obtain descriptive and frequency statistics in order to analyse and present the data. Data on the presence of TFA in foods are presented as minimum values, maximum values, mean values and standard deviation for total and individual TFA, and as percentages. For the purpose of this analysis, we have assumed that the terms TFA% of total fat and TFA g per 100 g of total fat can be used interchangeably. Hence, such values were merged and are presented in the Results under the term 'g TFA per 100 g total fat'. Similarly, TFA values expressed as % of total Fatty Acid Methyl Esters (FAME) were also considered as g TFA per 100 g total fat⁴. In a limited number of studies [22], TFA values were reported as <2g/100g total fat, <1g/100g total fat rather than a concrete value. This data has also been included in the analysis as a mean

4. In several cases TFA contents are expressed as '% TFA of total FAME'. We acknowledge that in order to arrive at values expressed as '% TFA of total fat', a conversion factor, specific for different types of fat, should be applied. Nevertheless, we decided to treat the TFA values expressed as '% of total FAME' as if they were expressed as '% of total fat' without a conversion factor based on the following considerations: the included data reported as % TFA or g/100 g of total fat or FAME in the various reports and publications considered here are usually based on sums of individual fatty acids, both for TFA and for total fat values. From the various publications it became obvious that the approaches, both for deriving total TFA and total fat values, sometimes include large differences with respect to i) the number of single fatty acids measured and used for summing up, ii) the approach to derive a 'total fat value', iii) the analytical methods used for fatty acid quantification, and iv) the number of foods included to derive a mean value. Thus, the available dataset is highly inhomogeneous and an application of conversion factors ex-post to TFA contents expressed as '% of total FAME' would likely not lead to results closer to the 'true' value nor reduce the inhomogeneity in the overall data. In conclusion, we assume all data expressed as % TFA or g/100 g of total fat or FAME as 'g TFA per 100 g total fat', with the aim to obtain a single dataset for the presence of TFA in foods, standardised to the fat content of the food.

value (1g/100g total fat for a reported value of <2g/100g total fat, and 0.5g/100g total fat for a reported value of <1g/100g total fat). Data on consumption/intakes are presented as means and medians for the overall population and by sex and age groups. The MATLAB™ software was used to obtain presented figures (histogram and boxplots⁵). Colour-coded European map was created using the Eurostat Intranet tool IMAGE.

2.4. Notes to data analysis and data interpretation

Because of the heterogeneity of the studies used for this analysis, the data are reported here in a descriptive manner. No attempts were made to pool data or to compare dif-

ferent studies. For instance, the fact that different sampling protocols and analytical methods were used in different studies does not allow comparison of food TFA contents between these studies. These limitations must be considered when interpreting the findings reported here. The same reasoning applies to the findings concerning TFA consumption/intakes (the use of different food composition tables and of DAMs hampers inter-study comparisons, data pooling, etc.). Because the search strategy used was limited to evidence published in the English language, it is likely that this report does not include all the currently available data published in languages other than English. In an attempt to overcome this limitation, the authors of this report conducted meetings and consultations with relevant stakeholders to identify and include in this analysis as much data as possible.

5. Histogram: a graphical display of the distribution of the data; boxplot: a graph used to show values in the lower and upper quartiles, and the median.

Table 3. Summary of studies reporting trans fatty acid content in food and foodstuff within Europe.

Country	Reference	Year of sampling	Analytical method for TFA analysis	N of foodstuff sampled	Food group (as reported in the study)	Pre-packed/ Non pre-packed	Main reported outcome (units)
Austria	Wagner <i>et al.</i> 2008 [52]	2005-2006	Fat extraction - FAME - GC ^a	106	Convenience products	Pre-packed	<ul style="list-style-type: none"> • % of total and individual TFA^b per total fat • g/100g of product
				20	Margarines and fats	Pre-packed	
				33	Fast foods	Non pre-packed	
Denmark	Bysted <i>et al.</i> 2009 [53]	2004-2007	Fat extraction - FAME - GC ^a	1*	Fast foods	Non pre-packed	<ul style="list-style-type: none"> • TFA% of total fat
				4	Cakes	Pre-packed	
				9	Cookies and biscuits	Pre-packed	
				4	Microwave popcorn French fries (frozen)	Pre-packed	

Table 3. (Cont.)

Country	Reference	Year of sampling	Analytical method for TFA analysis	N of foodstuff sampled	Food group (as reported in the study)	Pre-packed/ Non pre-packed	Main reported outcome (units)
Estonia	Meremäe <i>et al.</i> 2012 [54]	2008-2009, 2011	Folch extraction - FAME - GC ^a	6	Blended spreads	Pre-packed	• % of total and individual TFA ^b per total fat
				12	Margarines	Pre-packed	
				8	Shortenings	Pre-packed	
Finland	Ritvanen <i>et al.</i> 2012 [55]	N/A ^c	Fat extraction - FAME - GC ^a	9	Light spreads	Non pre-packed	• % of total and individual TFA ^b per total fat
				9	Fat spread/ margarine	Pre-packed	
				9	Shortenings	Pre-packed	
				11	Liquid shortenings	Pre-packed	
				11	Vegetable fat half creams	Pre-packed	
				12	Vegetable fat ice creams	Pre-packed	
				2	Vegetable fat cheeses	Pre-packed	
Germany	Kuhnt <i>et al.</i> 2011 [6]	2007-2009	Soxhlet extraction - FAME - GC ^a	27	Margarines/ spreads	Pre-packed	• % of total and individual TFA ^b per total fat
				30	Shortenings/ cooking fats	Pre-packed	
				49	French fries/chips	Non pre-packed	
				12	Croquettes	Non pre-packed	
				37	Puff pastries	Non pre-packed	
				23	Doughnuts	Non pre-packed	
				31	Chocolate products	Pre-packed	
				85	Biscuits	Pre-packed	
				22	Instant products	Pre-packed	
				23	Butters	Pre-packed	
23	Butters	Pre-packed					
Greece	Kroustallaki <i>et al.</i> 2011 [56]	2009-2010	Fat extraction - FAME - GC ^a	31	Margarines	Pre-packed	• % of total and individual TFA ^b per total fat
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	2008-2012	N/A ^c	20	Fast foods	Non pre-packed	• g TFA per 100 g total fat

Table 3. (Cont.)

Country	Reference	Year of sampling	Analytical method for TFA analysis	N of foodstuff sampled	Food group (as reported in the study)	Pre-packed / Non pre-packed	Main reported outcome (units)
Hungary				77	Margarines	Pre-packed	
				57	Bakery products	Pre-packed	
				131	Sweet biscuits / wafers / muffins	Pre-packed	
				33	Cereals	Pre-packed	
				69	Chocolates	Pre-packed	
				14	Fondants / candies	Pre-packed	
				20	Other confectionary products	Pre-packed	
				93	Pastries / cakes	Pre-packed	
				32	Savoury biscuits / crackers / chips	Pre-packed	
				4	Popcorn	Pre-packed	
				40	Convenience products	Pre-packed	
				31	Powder creams and coffees	Pre-packed	
				16	Meat products	Pre-packed	
				49	Dairy products	Pre-packed	
				9	Canned foods	Pre-packed	
				16	Semi-cooked foods	Pre-packed	
				15	Prepared meals, 'ready-to-eat'	Pre-packed	
			4	Ice creams	Pre-packed		
			10	Mayonnaise / salad dressings	Pre-packed		
Ireland	Food Safety Authority of Ireland 2009 [58]	2008	Fat extraction - FAME - GC ^a	119	Fast foods	Non pre-packed	<ul style="list-style-type: none"> • g / 100 g of product • TFA% of total fat
	Food Safety Authority of Ireland 2008 [22]	2007	Fat extraction - FAME - GC ^a	100	Retail products	Pre-packed	<ul style="list-style-type: none"> • g / 100 g of product
Italy	Prandini <i>et al.</i> 2011 [59]	2007-2008	Folch extraction - FAME - GC ^a	52	Cheeses (cow's, goat's, sheep's milk)	Pre-packed	<ul style="list-style-type: none"> • total and individual TFA^b per 100 g total fat
Poland	Zbikowska <i>et al.</i> 2011 [60]	2008*	Fat extraction - FAME - GC ^a	11	Shortenings (solid and liquid frying fats)	Pre-packed	<ul style="list-style-type: none"> • % of total and individual TFA^b per total fat

Table 3. (Cont.)

Country	Reference	Year of sampling	Analytical method for TFA analysis	N of foodstuff sampled	Food group (as reported in the study)	Pre-packed / Non pre-packed	Main reported outcome (units)
Portugal	Albuquerque <i>et al.</i> 2012 [61]	2008-2009	Fat extraction - FAME - GC ^a	18	Potato crisps	Pre-packed	• g/100 g of product
Spain	Ansorena 2013 [62]	2012	Fat extraction - FAME - GC ^a	18	Bakery products	Pre-packed	• total and individual TFA ^b per 100 g total fat • g/100 g of product
Sweden	Mattisson <i>et al.</i> 2011 [63]	2007	Folch extraction - FAME - GC ^a	31*	Sweet and savoury snacks	Pre-packed	• TFA% of total fat • total and individual
							• TFA ^b per 100 g of product
	Mattisson <i>et al.</i> 2009 [64]	2008		45	Various	Pre-packed	• g/100 g of product
	Swedish National Food Administration 2010 [65]	2010	Folch extraction - FAME - GC ^a	11	Cereal products	Pre-packed	• g/100 g of product
				5	Pastries	Pre-packed	
				15	Meats	Both types	
				16	Fish	Both types	
				18	Dairy products	Both types	
				1	Eggs	Both types	
				13	Fats	Both types	
				19	Vegetables	Both types	
				18	Fruits	Both types	
				4	Potatoes	Both types	
				11	Sugar, sweets	Pre-packed	
				5	Beverages	Pre-packed	
UK	Department of Health 2011 [66]	2008	N/A ^c	402	Biscuits/buns/cakes/pastries	Pre-packed	• g/100 g of product
	Roe <i>et al.</i> 2013 [49]	2010	Fat extraction - FAME - GC ^a	435	Processed foods	Both types	• total and individual TFA ^b per 100 g total fat • g/100 g of product
Serbia	Vucic <i>et al.</i> 2012 [67]	N/A ^c	Fat extraction - FAME - GC ^a	8	Vegetable oils	Pre-packed	• % of total and individual TFA ^b per total fat

Table 3. (Cont.)

Country	Reference	Year of sampling	Analytical method for TFA analysis	N of foodstuff sampled	Food group (as reported in the study)	Pre-packed / Non pre-packed	Main reported outcome (units)
Serbia	Kravic <i>et al.</i> 2011 [68]	2007-2009	Soxhlet extraction - FAME - GC ^a	24*	Biscuits	Pre-packed	• % of total and individual TFA ^b per total fat
Turkey	Karabulut <i>et al.</i> 2007 [69]	2005-2006	Folch extraction - FAME - GC ^a	40	Meat products	Pre-packed	• g of total and individual TFA ^b per 100 g total fat
				19	Chocolate products	Pre-packed	
				45	Bakery products	Pre-packed	
				12	Infant formulas	Pre-packed	
				6	Ice creams	Pre-packed	
				2	Powdered whipped toppings	Pre-packed	
				2	Powdered pastry creams	Pre-packed	
				3	Mayonnaise	Pre-packed	
				3	Coffee whiteners	Pre-packed	
				2	Bouillons	Pre-packed	
Switzerland	Richter <i>et al.</i> 2009 [70]	2006-2007	Fat extraction - FAME - GC ^a	31	Fine bakery products	Pre-packed	• g of total and individual TFA ^b per 100 g total fat
				7	Ice creams	Pre-packed	
				22	Snacks/cakes/biscuits	Pre-packed	
				10	Semi-solid fats	Pre-packed	
				4	Various products	Pre-packed	
				7	Fried and fast foods	Non pre-packed	
				21	Oils	Pre-packed	
				14	Sugar products	Pre-packed	
				3	Breakfast cereals	Pre-packed	
European	Stender <i>et al.</i> 2012 [44]	2005, 2009	Fat extraction - FAME - GC ^a				• g/100 g of product
Hungary		2005, 2009		41	Biscuits/cakes/wafers	Pre-packed	
				1	Microwave popcorn	Pre-packed	

Table 3. (Cont.)

Country	Reference	Year of sampling	Analytical method for TFA analysis	N of foodstuff sampled	Food group (as reported in the study)	Pre-packed / Non pre-packed	Main reported outcome (units)
Poland		2005, 2009		58	Biscuits/cakes/wafers	Pre-packed	
				1	Microwave popcorn	Pre-packed	
Czech Republic		2005, 2009		56	Biscuits/cakes/wafers	Pre-packed	
				1	Microwave popcorn	Pre-packed	
France		2005, 2009		39	Biscuits/cakes/wafers	Pre-packed	
				1	Microwave popcorn	Pre-packed	
Germany		2005, 2009		32	Biscuits/cakes/wafers	Pre-packed	
				1	Microwave popcorn	Pre-packed	
UK		2005, 2009		40	Biscuits/cakes/wafers	Pre-packed	
Czech Republic				1	Microwave popcorn	Pre-packed	
Bulgaria		2005		1	Microwave popcorn	Pre-packed	
Romania		2005		1	Microwave popcorn	Pre-packed	
Portugal		2005		1	Microwave popcorn	Pre-packed	
Spain		2005		1	Microwave popcorn	Pre-packed	
Netherlands		2005		1	Microwave popcorn	Pre-packed	
Austria		2005		1	Microwave popcorn	Pre-packed	
Italy		2005		1	Microwave popcorn	Pre-packed	
Sweden		2005		1	Microwave popcorn	Pre-packed	
Finland		2005		1	Microwave popcorn	Pre-packed	
Denmark		2005		1	Microwave popcorn	Pre-packed	

* The authors of the original study sampled a higher number of products but in some products TFA were not detected. For this reason, only the number of products where TFA was detected is reported. ^aFAME extraction - GC: Fatty Acid Methyl Esters - Gas- Chromatography; ^bTFA: *Trans* Fatty Acids; ^cN/A: not available.

Table 4. Summary of studies reporting on trans fatty acid consumption/intakes within Europe.

Country	Reference	Type of study/ comments	Year of assessment	Sample N	Age range	Age (y) sub-group (N*)	Sex**	Dietary assessment method	Main reported outcome (units)
Austria	Elmadfa <i>et al.</i> 2008 [71]	National report	2003-2006	2989	14-36 y	N/A ^c	M/F	• 1 x 24-hour dietary recall	• g/day • E% ^b
Finland	Patury <i>et al.</i> 2008 [72]	National survey	2007	2039	25-74 y	• 25-64 y (1576) • 65-74 y (463)	M/F	• 2 x 24-hour dietary recall • 3-day food diary (half sample)	• g/day • E% ^b
	Kyttälä <i>et al.</i> 2008 [73]	National survey	2003-2005	4063	1-6 y	• 1-4 y and 6 y • 7 th -8 th grade	M/F	• 3-day food diary	• g/day • E% ^b
France	Agence Française de Sécurité Sanitaire des Aliments 2009 [74]	National report	2006-2007	3362	3-54+ y	• 3-10 y (570) • 11-14 y (450) • 15-17 y (424) • 18-34 y (442) • 35-54 y (826) • 54+ y (650)	M/F	• 7-day food diary	• g/day • E% ^b
Germany	Bundesinstitut für Risikobewertung 2013 [75]	National food consumption survey	2005-2006	15371	14-80 y		M/F	• dietary history	• g/day • E% ^b
Netherlands	van Rossum <i>et al.</i> 20011 [76]	National survey	2007-2010	3819	7-69 y	• 7-8 y (304) • 9-13 y (703) • 14-18 y (706) • 19-30 y (703) • 31-50 y (699) • 51-69 y (704)	M/F	• 2 x 24-hour dietary recalls	• g/day • E% ^b
	Ocké <i>et al.</i> 2008 [77]	National survey	2005-2006	1279	2-6 y	• 2-3 y (640) • 4-6 y (639)	M/F	• 2 x 1-day food diary • FFQ ^a	• g/day • E% ^b
Spain	Mayneris <i>et al.</i> 2010 [78]	Local survey/representative Catalanian sample	2010	516	18-65, 65+ y	• 18-30 y (89) • 31-50 y (204) • 51-65 y (147) • 65+ y (76)	M/F	• FFQ ^a	• E% ^b

Table 4. (Cont.)

Country	Reference	Type of study/ comments	Year of assessment	Sample N	Age range	Age (y) sub-group (N*)	Sex**	Dietary assessment method	Main reported outcome (units)
Sweden	Swedish National Food Administration 2010 [65]	National survey	2010					• Estimated exposure	• g/day
	Barbieri <i>et al.</i> 2006 [79]	National survey	2003	2495	N/A ^c	• 4 • 2 nd grade • 5 th grade	M/F	• 4-day food diary	• g/day • E% ^b
United Kingdom	Nelson <i>et al.</i> 2007 [80]	National survey/ Representative sample of low income population groups	2003-2005	3728	>2 y	• 2-10 y • 11-18 y • 19-34 y • 35-49 y • 50-64 y • 65+ y	M/F	• 4 x 24-hour dietary recalls	• g/day • E% ^b
	Lennox <i>et al.</i> 2013 [81]	National Infant Survey/ Representative sample	2011	2683	4-18 months	• 4-6 months (329) • 7-9 months (630) • 10-11 months (449) • 12-18 months (1275)	M/F	• 4-day food diary	• g/day • E% ^b
	Bates <i>et al.</i> 2011 [82]	National survey/ Representative sample	2008-2010	2126	>1.5->65 y	• 1.5-3 y • 4-10 y • 11-18 y • 19-64 y • 65+ y	M/F	• 4-day food diary	• g/day • E% ^b
Croatia	Satalic <i>et al.</i> 2007 [83]	Original study/ University students	2006	663	18-30 y	N/A ^c	M/F	-FFQ ^a	• E% ^b

* N for sub-groups where specified

**M/F: male/female

^aFFQ: Food Frequency Questionnaire.

^bE%: percentage of energy.

^cN/A: not available.

2.5. Meetings and consultation with scientific experts

The findings described in this report were also informed by discussions among TFA experts and other relevant stakeholders at a dedicated workshop on *Trans fatty acids in diets: health and legislative implications*, held on 9-10 April 2013 in Zagreb, Croatia, funded under the JRC Enlargement & Integration Action (E&IA) activities⁶ and co-organised by the JRC's Institute for Health and Consumer Protection (JRC-IHCP) and the Institute for Reference Materials and Measurements (JRC-IRMM). The workshop served to collect and discuss data on the presence of TFA in the diets of the Euro-

pean population (particularly within the participants' countries populations and the EU-27) and exchange practices and ideas to reduce the consumption of TFA. The participants filled in a questionnaire about country-specific information regarding the presence of TFA in foods and the intake levels of the population, existence of national policies/actions, established daily recommended (maximum) intake levels and food composition databases. Findings related to data on TFA presence in foods and the diet are incorporated into the Results section. A workshop report summarising the presentations as well as the discussions that took place in dedicated brainstorming sessions is available [84].

6. The countries covered by the E&IA activities are Albania, Croatia, the Former Yugoslav Republic of Macedonia, Israel, Montenegro, Norway, Switzerland, Bosnia and Herzegovina, Faroe Islands, Iceland, Liechtenstein, Moldova, Serbia, and Turkey.

3 . Analysis and discussion

This section presents the results of the data synthesis described above (see *Table 3* and *Table 4*) followed by a brief discussion.

3.1. TFA presence in foods in Europe

The data considered in the twenty-three studies listed in *Table 3* are analysed here in detail. The studies are either peer-reviewed scientific articles or national reports. In total, they contain data on the TFA content of 3 333 food products. However, it should be noted that not all studies report TFA content in a similar manner. For example, some studies discriminate different TFA isomers, others report on total TFA content only and some report TFA content as ‘g TFA per 100 g total fat’ while others report ‘g of TFA per 100 g food’. Therefore, the results below do not always cover all 3 333 food products but rather those for which data was available. In some cases, *e.g.* Mattisson *et al.* 2009 [64], the sum of an ‘x’ number of the same food products was reported as one mean value and is considered as one value in this analysis. It is important to note the many differences between the studies considered here and the limitations these differences entail. Importantly, the results presented below reflect only the data on food products analysed in the studies considered here and should not be seen as representative of the composition of European food products in general.

Because the individual studies considered here report food products/groups in different ways, for the purpose of this analysis, these food products were re-assigned to one of the fourteen food group categories described below⁷. The choice of categories was based on product characteristics (*e.g.* fast food, convenience products) as reported in the publication and reflected groupings used in other reports [81]. *Figure 2* shows this re-distribution of food products into fourteen different food group categories. The majority of the foods analysed for TFA presence in the studies considered here are biscuit, bun, cake and pastry products (35%), followed by products in the categories of fats and oils, convenience, fast food and bread products. Dairy products, milk-based desserts, savoury snacks and meat and meat products were tested less often and are therefore less represented in this analysis.

7. (1) Biscuits, buns, cakes and pastries (2) Fats and oils: Margarines, blended spreads, butter, vegetable oil shortenings (3) Convenience products: ready meals, canned food, instant soups, pizza (4) Fast food products: burgers, fries, takeaway desserts (5) Bread products: bread, bread rolls, breadsticks (6) Dairy products: cheese, cream (7) Various: bullions, aloe vera juice, gluten-free products (8) Savoury biscuits, crackers, crisps, popcorn (9) Chocolate confectionary and chocolate spreads (10) Sugar products: candies, ice cream lollies (11) Meat and meat products: beef, lamp pork sausages (12) Cereal products: breakfast cereals, cereal bars (13) Milk-based desserts: ice-cream (14) Sauces, dressings etc.: gravy, curry sauce.

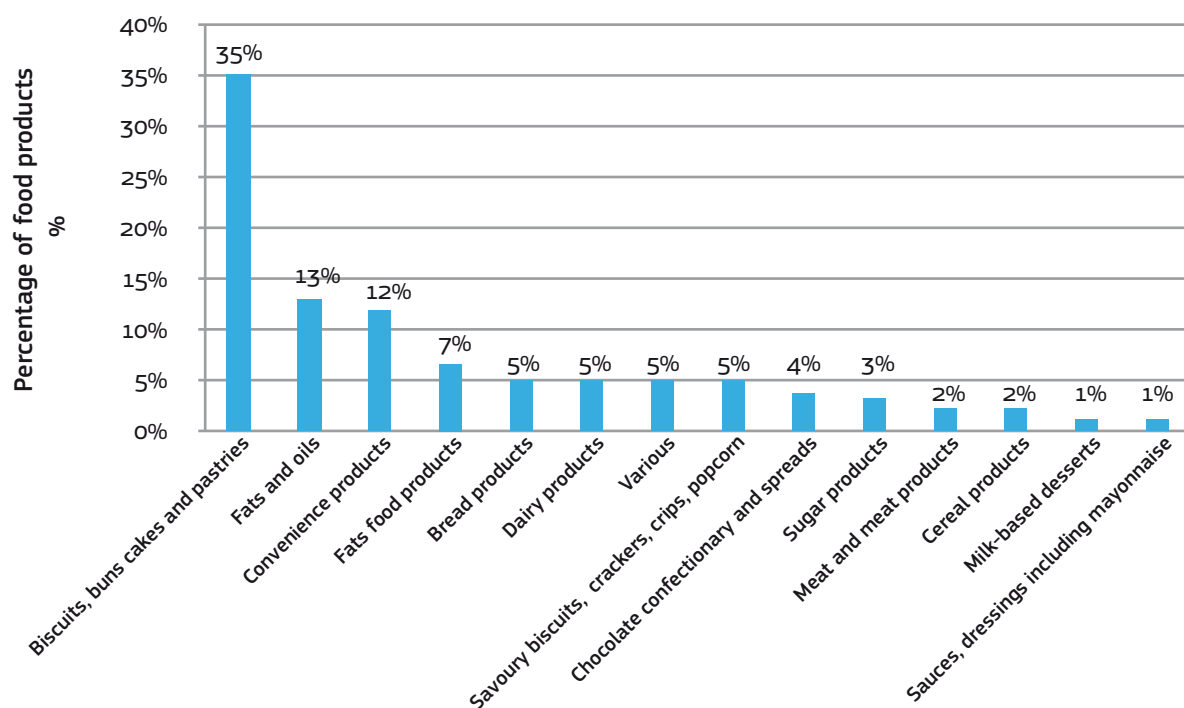


Figure 2. Food products considered in this analysis divided into 14 food group categories. The data concerns 3 333 food products analysed in 23 different studies.

Table 5 provides an overview of the TFA content extracted from the 23 studies, the different units used and TFA isomers analysed. A close analysis of the minimum and maximum values reported clearly show a high variation in the levels of TFA present in different foods in terms of TFA content per 100g total fat (Table 5 and Annex II). These values can be as high as 54.0 g of TFA

per 100g total fat [60] and 49.2 g of TFA per 100g total fat [53] (see Annex II). Overall, the TFA content of the majority of foods analysed is below 2 g of TFA per 100g total fat of which 77% of the foods are below 0.5 g TFA per 100g total fat. However, it must be noted that there are still foods in the European food market with high levels of TFA.

Table 5. Trans fatty acid composition of food products sampled in the 23 studies analysed.

TFA (units as reported in the respective studies)	N	Minimum TFA	Maximum TFA	Mean** TFA	Std. Deviation
TFA (g/100g total fat) ⁴	2503	0.00	54.0	2.42	5.89
TFA (g/100g food product)	1193	0.00	16.8	1.30	2.96
CLA (g/100g total fat)	134	0.01	1.05	0.27	0.28
CLA c9,t11 (mg/g total fat)	52	5.20	10.9	7.47	2.07
CLA C18:2 c9,t11 (% of total fat)	498	0.00	0.00	0.01	0.03

Table 5. (Cont.)

TFA (units as reported in the respective studies)	N	Minimum TFA	Maximum TFA	Mean**TFA	Std. Deviation
16:1 n7t (% of total fat)	159	0.03	0.19	0.09	0.06
18:1 n9t (% of total fat)	159	0.02	6.53	1.45	1.71
18:1 n7t (% of total fat)	159	0.00	7.04	1.52	1.81
18:2n6t (% of total fat)	159	0.06	0.67	0.20	0.17
18:1 trans (g/100g total fat)	197	0.00	53.7	4.96	10.16
18:1 trans (g/100g food)	18	0.00	10.7	1.61	3.38
18:2 trans (g/100g total fat)	55	0.00	6.60	0.54	0.93
18:3 trans (g/100g food)	2	0.05	0.06	0.06	0.01
18:2 n-6 trans (g/100g total fat)	134	0.03	0.84	0.27	0.19
t4-C18:1 FA (% of total fat)	339	0.00	0.00	0.00	0.01
t5-C18:1 (% of total fat)	339	0.00	0.00	0.02	0.03
t6/7/8-C18:1 (% of total fat)	339	0.06	1.46	0.36	0.41
t10-C18:1 (% of total fat)	339	0.06	1.35	0.37	0.37
t11-C18:1 vaccenic acid, TVA (g/100g total fat)	52	0.84	1.70	1.15	0.38
t13/14-C18:1 (% of total fat)	339	0.01	0.46	0.14	0.14
t15-C18:1 (% of total fat)	339	0.02	0.46	0.16	0.12
t16-C18:1 (% of total fat)	339	0.00	0.00	0.05	0.09
t C18:1 (g/100g total fat)	119	0.10	5.50	2.32	1.87
t C18:2 (g/100g total fat)	458	0.00	0.62	0.21	0.18
t C18:3 (g/100g total fat)	119	0.00	0.20	0.11	0.09
t9 C16:1 palmitoleic (g/100g total fat)	18	0.03	0.08	0.05	0.02
Trans isomers C18:1 (g/100g total fat)	18	0.03	0.48	0.20	0.11
t-Linoleic C18:2 D9t, 12t (g/100g total fat)	18	0.03	0.08	0.04	0.01
c-t Linoleic C18:2D9c, 12t (g/100g total FA)	18	0.11	0.22	0.18	0.03
t-c Linoleic C18:2 D9t, 12c (g/100g total fat)	18	0.12	0.23	0.19	0.03

CLA: Conjugated Linoleic Acid; TFA: *Trans* Fatty Acids

*The mean was calculated by the authors of this report, and was based on information reported by the authors of the original papers

‡In a limited number of studies (e.g. 22, 66), TFA values were reported as <2 g/100g total fat, <1g/100g total fat rather than a concrete value. This data has also been included in the analysis as a mean value (i.e. 1g/100g total fat for a reported value of <2 and 0.5g/100g total fat for a reported value of <1)

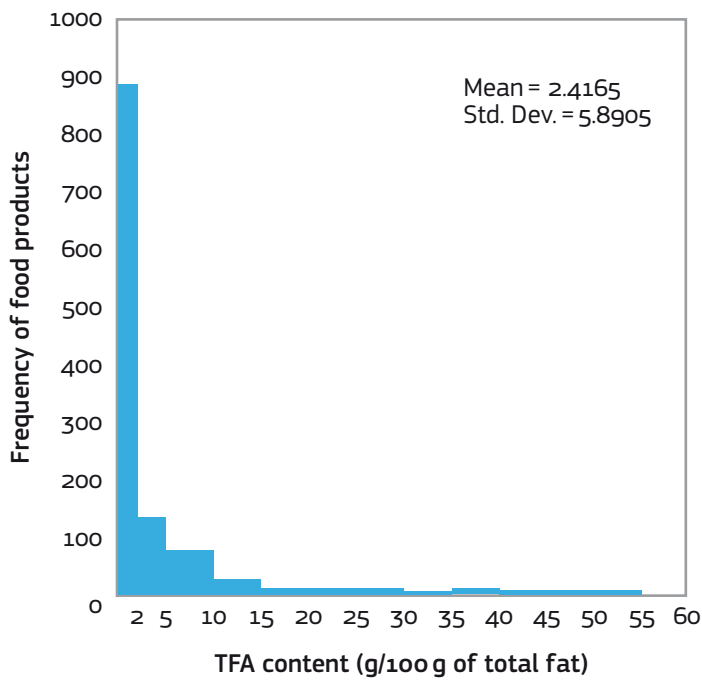
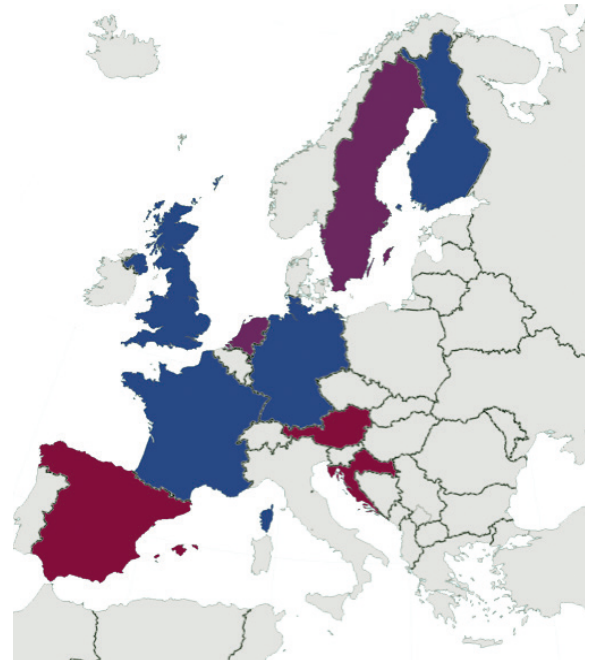


Figure 3. Distribution of trans fatty acid content in the food products ($n=1\ 225$) sampled in the 23 studies analysed. The products included are those where the TFA content was expressed as TFA g/100 g total fat.

3.2. TFA intake in Europe

The data contained in the thirteen studies listed in *Table 4* are analysed here in detail. These studies are based on national surveys, national reports, local surveys, original studies or food market basket surveys providing data on population exposure to TFA. As previously shown, not all studies report intakes of the same population groups and not all provide information by gender and age groups (see *Table 4*). The majority of TFA intakes reported in the studies are expressed as ‘g TFA per day’ and/or as ‘TFA fraction of energy intake (E%)’. Again, it is important to note the many differences between the studies considered here and the limitations



■ Not representative country sample
■ Representative country sample (narrow age range)
■ Representative country sample (wide age range)

Figure 4. Availability of data on trans fatty acid consumption/intakes in the EU28. Colour codes are listed above; no data was found for the countries in grey.

these differences entail and that the results should not be seen as representative of European TFA intake in general.

Table 6 provides an overview of mean and median TFA intake (TFA E% and TFA g per day) by gender and age. Among the population groups analysed here, male and female Croatian University students aged 18-30 years [83], Swedish boys aged 8 and 11 years [79], Spanish males and females aged 18-30 years [78], British male and female participants of the *Low Income and Nutritional Survey* [80], and French females aged 3-10 years and >55 [74], all have average intake values

above the WHO maximum recommended level of 1 E%. The highest median E% TFA intakes are observed in British male and female participants of the *Low Income and Nutritional Survey* [80], followed by Swedish males and females [79] of all ages who also have the highest TFA intakes (g) per day together with German males [75].

TFA contribution to E% for both males and females is presented in *Figure 5, Figure 6 and Table 6*. Despite the large variability and wide range of intake (accounted for by e.g. differences

in population groups, years of assessment), the data indicate that the groups assessed on average have a TFA intake below 1 E%. Nevertheless, up to 25% of surveyed individuals aged 20-30 years have TFA intakes above this maximum level. The TFA intake values described here do not discriminate between iTFA and rTFA. Only in the German [75] and French studies [74] were the intakes of rTFA explicitly mentioned and estimated at approximately 0.5 E%. These estimates may vary throughout Europe depending on the population and geographical region.

Table 6. Trans fatty acid intake of various population groups as reported in the 13 studies analysed.

Country	Study	Gender	Age or age range (y)	Mean TFA E%	Median TFA E%	Mean TFA (g/day)	
Austria	Elmadfa <i>et al.</i> 2008 [71]	M/F	14-36	0.39	0.23	0.97	
Finland	Patury <i>et al.</i> 2008 [72]	M	25-64	0.4	-	1.1	
		M	65-74	0.4	-	0.8	
		F	25-64	0.4	-	0.8	
		F	65-74	0.4	-	0.6	
		Kyttälä P <i>et al.</i> 2008 [73]	F	1	0.3	0.2	0.3
		F	2	0.4	0.5	0.5	
	F	3	0.4	0.6	0.6		
	F	4	0.5	0.6	0.7		
	F	6	0.5	0.7	0.8		
	M	1	0.2	0.2	0.3		
	M	2	0.4	0.5	0.5		
	M	3	0.4	0.6	0.6		
M	4	0.5	0.6	0.7			
M	6	0.5	0.7	0.8			
France	AFSSA 2009 [74]	M	18-34	0.93	0.95	2.66	
		M	35-54	0.94	0.94	2.67	
		M	55	0.96	0.94	2.56	

Table 6. (Cont.)

Country	Study	Gender	Age or age range (y)	Mean TFA E%	Median TFA E%	Mean TFA (g/day)	
France		F	18-34	0.99	0.99	2.03	
		F	35-54	0.97	0.95	2.03	
		F	>55	1	0.99	2.02	
		M	3-10	0.99	0.98	1.92	
		M	11-14	0.93	0.91	2.11	
		M	15-17	0.91	0.87	2.15	
		F	3-10	1.02	0.99	1.77	
		F	11-14	0.96	0.96	1.86	
		F	15-17	0.93	0.9	1.71	
			M/F	>18	1	-	2.3
			M/F	<18	0.8	-	1.9
	Netherlands	van Rossum <i>et al.</i> 2011 [76]	M	7-8	-	0.5	1.1
		F	7-8	-	0.5	1.2	
		M	9-13	-	0.5	1.3	
		F	9-13	-	0.5	1.2	
		M	14-18	-	0.5	1.4	
		F	14-18	-	0.5	1.2	
		M	19-30	-	0.5	1.5	
		F	19-30	-	0.5	1.2	
		M	31-50	-	0.5	1.5	
		F	31-50	-	0.6	1.2	
		M	51-69	-	0.6	1.5	
		F	51-69	-	0.6	1.3	
		Ocké <i>et al.</i> 2008 [77]	M	2-3	0.8	0.7	1.2
			F	2-3	0.7	0.7	1.1
		M	4-6	0.8	0.8	1.4	
		F	4-6	0.8	0.8	1.4	
Spain	Mayneris <i>et al.</i> 2010 [78]	M/F	18-30	1.05	-	-	
		M/F	31-50	0.88	-	-	
		M/F	51-65	0.79	-	-	

Table 6. (Cont.)

Country	Study	Gender	Age or age range (y)	Mean TFA E%	Median TFA E%	Mean TFA (g/day)
Spain		M/F	51-65	0.79	-	-
UK	Nelson <i>et al.</i> 2007 [80]	M	19-34	1.2	-	3.1
		M	35-49	1.4	-	3.1
		M	50-64	1.3	-	2.7
		M	>65	1.3	-	2.5
		M	2-10	1.2	-	2.2
		M	11-18	1.2	-	3
		F	19-34	1.2	-	2.1
		F	35-49	1.2	-	2.1
		F	50-64	1.2	-	2.1
		F	>65	1.4	-	2.2
		F	2-10	1.1	-	1.9
		F	11-18	1.2	-	2.4
	Lennox <i>et al.</i> 2013 [81]	M/F	4-6*	0.1	-	0.1
		M/F	7-9*	0.2	-	0.2
		M/F	10-11*	0.3	-	0.3
		M/F	12-18*	0.5	-	0.6
	Bates <i>et al.</i> 2011 [82]	M	4-10	0.8	0.7	1.3
		M	11-18	0.7	0.7	1.6
		M	19-64	0.7	0.7	1.8
		M	>65	0.9	0.8	1.9
		F	4-10	0.8	0.7	1.3
		F	11-18	0.7	0.7	1.3
		F	19-64	0.7	0.7	1.3
		F	>65	0.8	0.8	1.4
		M/F	1.5-3	0.7	-	0.9
		M/F	4-10	0.8	-	1.3
		M/F	11-18	0.7	-	1.5
		M/F	19-64	0.7	-	1.5
		M/F	>65	0.8	-	1.6

Table 6. (Cont.)

Country	Study	Gender	Age or age range (y)	Mean TFA E%	Median TFA E%	Mean TFA (g/day)
Croatia	Satalic <i>et al.</i> 2007 [83]	M	18-30	1.1	1.2	-
		F	18-30	1.2	1.1	-
		M/F	18-30	1.1	-	-
Sweden	Barbieri <i>et al.</i> 2006 [79]	F	4	0.9	0.9	1.6
		F	8	0.9	0.9	1.9
		F	11	0.9	0.8	1.8
		M	4	0.9	0.8	1.6
		M	8	1	0.9	2.1
		M	11	1	0.9	2.1
		M	11	1	0.9	2.1
Germany	BfR 2013 [75]	M**	14-80	0.80	0.73	2.3
		F**	14-80	0.74	0.7	1.59
		M***	14-80	0.66	0.62	1.9
		F***	14-80	0.65	0.61	1.4

E%: percentage of energy; M/F: male/female, y: years

*age in months

**data from 2009

***data from 2013

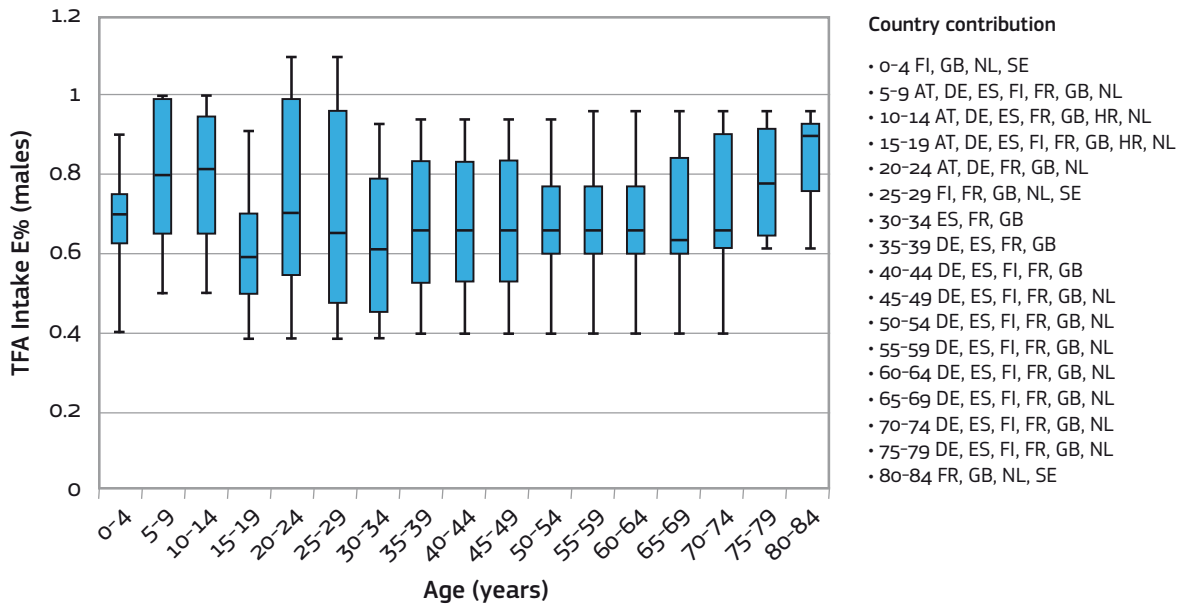


Figure 5. Boxplot representing trans fatty acid intake (reported as contribution to total energy intake) for european males stratified by age. The data is based on the 13 studies reported in Table 4; country⁸ sources for different age groups are defined in the right hand panel.

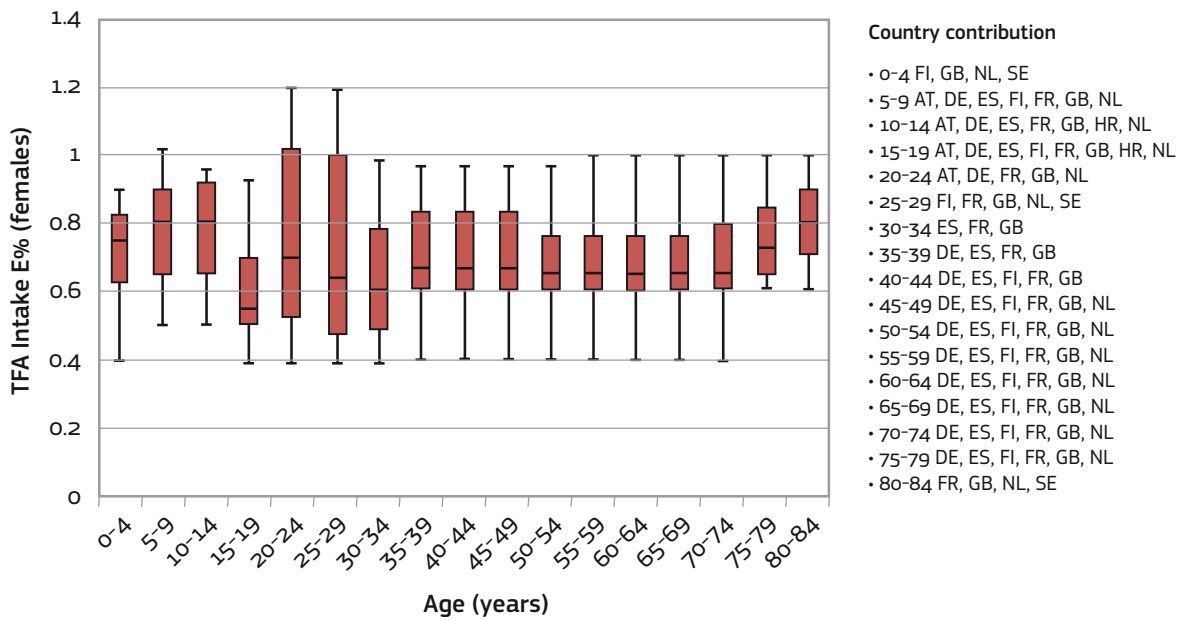


Figure 6. Boxplot representing trans fatty acid intake (reported as contribution to total energy intake) for european females stratified by age. The data is based on the 13 studies reported in Table 4; country⁸ sources for different age groups are defined in the right hand panel.

8. AT: Austria, DE: Germany, ES: Spain, FI: Finland, FR: France, GB: Great Britain, HR: Croatia, NL: Netherlands, SE: Sweden.

4. Concluding remarks

In response to concerns about TFA intake and CHD risk, several measures have been implemented throughout the world leading to a decrease in TFA intake and demonstrating that reduction of iTFA in foods is feasible. At European level, six governments – Austria, Denmark, Iceland, Switzerland, Hungary and Norway – have addressed this issue with restrictive legislation. The results of this study confirm a reduction of TFA content in foodstuffs and TFA intake over the last two decades but also demonstrate that there are still a number of foods with high TFA levels in the European food market *e.g.* high TFA content reported in shortenings [60] and popcorn [53].

It is important to note that the results reported here relate only to the products sampled in the studies that were included in the analysis. They constitute a fraction of products available in the food market and are not representative of the European food market. Data from 2013 (unpublished⁹) showed that in Eastern European countries there are still popular foods (*e.g.* biscuits) that contain TFA amounts well above 2 g of TFA per 100 g fat. The same products could be found in Balkan speciality corner shops outside these countries, *e.g.* Denmark where a limit on TFA content in foods is in place.

9. Addendum: The data referred to here have been published during the layout of this report and can be found in the following article *BMJ Open* 2014;4:e005218 doi:10.1136/bmjopen-2014-005218

While most of the products analysed in the studies considered in this report were pre-packed products, we have looked in detail at the TFA content of non pre-packed loose foods and observed that several of these products contained TFA (>2 g of TFA per 100 g fat). This is important when considering the possibility of implementing policies related to mandatory TFA labelling on pre-packed foods as such policies could potentially exempt non pre-packed loose items. Of note, under the current legislation, MS can also request nutrition labelling of non pre-packed foods. The use of iTFA-containing oils appears to vary depending on the country. For example, a European study by Stender *et al.* [43] showed that TFA levels in fast food fried chicken and fries varied considerably depending on the country.

Although this analysis indicates that the current fragmentation of policies and actions across different European countries has been successful, there is still room for improvement. The lack of recently published TFA-related data for most MS highlights the importance of monitoring TFA reduction efforts and evaluating the effectiveness and efficiency of TFA-related policies.

As in the analysis of the TFA content in foods, also the results on TFA intake presented here should be interpreted with caution. Overall, the population average daily TFA consumption reported in the

studies considered here is below the WHO-recommended maximum of 1 E% (Table 5). However, a higher mean of 1.4 TFA E% was observed in the *British Low Income Diet and Nutrition Survey* [80] for males aged 35-49 years and females aged >65 years. Similarly, British males aged 19-34 years and 35-49 years reported the highest TFA intakes as g per day (3.1). It follows that a crude overall measure of relatively low TFA intake at population level does not rule out that sub-groups may be exceeding the maximum recommended intake. In addition to this, there is limited information on TFA intake in specific population groups such as children or sub-group populations (e.g. low income groups). There also may be distortions of the actual intake arising from incomplete and often outdated food composition data and, from the limitations of current dietary assessment methods.

While not clearly stated in all studies, we believe that a good proportion of the products sampled in different studies and considered in this analysis were affected by reformulation efforts (given the 2005 timeframe inclusion criterion). This analysis did not assess whether the low TFA levels seen in most of the products are coupled to healthier overall nutrient profiles. However as already discussed, three articles do indicate this to be the case in most instances [25] [26] [27]. Different studies and surveys included in the analysis performed here were conducted independently and relied on different

methodologies to sample, calculate and report TFA contents in foods or TFA dietary intake. For this reason, a large part of the data could not be grouped and also could not be compared. This limitation stresses the further need for using standardised and validated data collection methods to inform practice.

While there appears to be room for improvement of the European situation with regards to the presence of iTFA in foods, it should also be said that the situation is likely to continue improving. Whether to consider introducing or promoting any additional TFA-related measures at European level, and if so, assessing which measure would be most appropriate to further reduce TFA consumption was beyond the scope of this initial analysis. This point was however discussed in the workshop *Trans fatty acids in diets: health and legislative implications* held on 9-10 April 2013 in Zagreb, Croatia. Further information can be found in the workshop report [84] and a table summarising the discussions regarding different public health approaches to further reduce TFA intake in Europe and the relevant criteria to be considered when comparing these approaches is included in supplementary *Annex III*. The data and ideas presented in both reports shall inform and support the public debate on TFA to ensure the provision of the healthiest possible food choices in Europe.

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6. Annexes

Annex I – Table S1. *Trans fatty acids regulations outside Europe.**

Country	Policy/measure	Details
Argentina	Mandatory nutrition labelling	
Australia/ New Zealand [85]		TFA must be declared on a label if the manufacturer makes a nutrition content claim about cholesterol or SFA, TFA, PUFA, MUFA, omega-3, omega-6 or omega-9 fatty acids. The Australian federal government and the Quick Service Restaurant Industry undertook roundtable discussions in September 2007 on reducing trans fat in foods without replacing them with SFA. Some restaurants have voluntarily included nutrition information on product packaging, in stores and on websites to raise awareness about trans fats.
Brazil	Mandatory nutrition labelling	
Canada	Legislation – mandatory nutrition labelling plus voluntary measure	Territorial TFA ban in British Columbia.
China	Legislation – mandatory nutrition labelling	If any (partially) hydrogenated fat is used, the level of trans fat has to be highlighted.
Colombia	Mandatory nutrition labelling	
Costa Rica	Self-regulation	
Gulf Cooperation Council**	Legislation – legislation limiting TFA content of foodstuffs and mandatory nutrition labelling	Maximum trans fat content of vegetable oils and soft spreadable margarines is 2% of the total fat, and the trans fat content for all other foods is 5% of the total fat content including ingredients sold to restaurants. The amount of TFA in a food, including dietary supplements shall be included in the Nutrition Facts, expressed in grams and % Daily Value (shown in a column on the right side of the Nutrition Facts table). Terms ‘trans fatty acids’ and ‘trans fat’ can be used interchangeably. ‘trans’ is shown indented underneath ‘Fat’ declaration, in the same section as the ‘Saturated fatty acid’ declaration, and the word ‘trans’ is italicized. Label declaration of trans fat content information is not required for products that contain less than 0.5 g of total fat per 100 g if no claims are made about cholesterol, SFA, MONO, PUFA and TFA. Where a claim that a food product is ‘trans fat free’ is made on the label or in an advertisement, the amount of trans fat shall be less than 0.5 g of total fat in 100 g.
Hong Kong	Mandatory nutrition labelling	

* Compiled from Downs *et al.* 2013 [29], the European Food Information Council [87], the WHO’s publication directory [88], country notifications, ministerial websites, and other publications unless specified.

** United Arab Emirates, The Kingdom of Bahrain, The Kingdom of Saudi Arabia, The Sultanate of Oman, Qatar, Kuwait.

Table S1. (Cont.)

Country	Policy/measure	Details
India	Legislation–legislation limiting TFA content of foodstuffs and mandatory nutrition labelling	Food labelling rules mandate that foods using hydrogenated fats or bakery shortenings must specifically declare this on the label, and mention that they contain trans fat.
Israel	Legislation–mandatory nutrition labelling	In addition to Israel’s mandatory nutritional labelling requirements appearing in various regulations and standards, the Israel Ministry of Health has decided to add a Front of Pack label for the following reasons: to encourage the food industry to re-formulate and improve food products; to provide customers with nutritional values of consumed food; to use a simple and clear labelling system; to emphasize key ingredients and to make them accessible; to encourage customers to decrease consumption of SFA, TFA, sugars, sodium and redundant calories and to provide consumers with information to help them to shop wisely.
Malaysia	Legislation–mandatory nutrition labelling	Mandatory labelling of MONO, PUFA, SFA and TFA if a claim is made regarding fatty acids.
Paraguay	Mandatory nutrition labelling	
Peru	Legislation–legislation limiting TFA content of foodstuffs	On 24 April 2014, the National Ministry of Health signed a resolution that within 6 months of entering into force requires; fats, vegetable oils and margarines to not exceed 2 g TFA per 100 g/ml total fat; and all other processed foods and non-alcoholic drinks to not exceed 5 g TFA per 100 g/ml total fat. Within 36 months of entering into force, the use of TFA resulting from hydrogenation is to be discontinued completely.
Singapore	Legislation–legislation limiting TFA content of foodstuffs and mandatory nutrition labelling	The Agri-Food & Veterinary Authority of Singapore has reviewed the Food Regulations and proposes the following amendments: <ul style="list-style-type: none"> – adoption of a trans fat limit of 2 g per 100 g product for edible fats and oils, – mandatory nutrition labelling (in the form of a nutrition information panel) for retail packs of edible fats and oils (trans fat content to be declared in the nutrition information panel).
South Africa	Legislation–legislation limiting TFA content of foodstuffs and mandatory nutrition labelling	The sale, manufacturing and importation of any oils and fats, including emulsions with fat as the continuous phase, either alone or as part of processed foods, which are intended for human consumption or assumed to be intended for human consumption, in the retail trade, catering businesses, restaurants, institutions, bakeries etcetera, of which the content of Trans-Fat exceeds 2 g per 100 g of oil or fat, is prohibited. Subject to sub-regulation 2(1) and regulation 4, in cases where Trans-Fat in the end product may be deriving from both partially hydrogenated fat or oil in an ingredient or additive, as well as from ingredients from ruminant animal origin, the Trans-Fat content per individual ingredient at the mixing bowl stage–(a) shall be kept on record for the purpose of compliance with these Regulations; and (b) subject to regulation 3, where the claim ‘Trans-Fat free’ is made, the Trans-Fat content which shall be declared in the table with nutritional information on the label shall be the sum of analytical values per individual ingoing ingredient, excluding natural TFA. Fats and oils shall, when applica-

Table S1. (Cont.)

Country	Policy/measure	Details
South Africa (cont.)	Legislation—legislation limiting TFA content of foodstuffs and mandatory nutrition labelling	ble, be further qualified by the term ‘hydrogenated’; (e) subject to the requirements of the Regulations Relating to Trans-fat in foods, where a partially hydrogenated fat/oil is used as an ingredient, and it contains less than 2 g trans-fat per 100 g fat/oil, such fats and oils shall be further qualified by the term ‘partially hydrogenated’. Where a claim that a foodstuff is ‘Trans-Fat free’ is made on the label or in an advertisement, the content of Trans-Fat shall be less than 1 g per 100 g of the total fat or oil in the final product.
South Korea	Legislation—mandatory nutrition labelling	Mandatory nutrition labelling on foods covered by the nutrition labelling requirements (bread, chocolate, processed milk, sausage (mixed with fish), instant noodle (cup), fruit and vegetable juice, kimbab (pre-packaged), hamburger, sandwich).
Taiwan	Mandatory nutrition labelling	
Uruguay	Mandatory nutrition labelling	
USA [86]	Legislation—mandatory nutrition labelling*** plus voluntary measure	City-level TFA bans exist in Albany, Baltimore, Boston, Cleveland, Montgomery, New Jersey, New York City, Philadelphia and Seattle, and there is a state-level ban in California and Colorado.

*** Trans fat declaration is voluntary when the total fat content of a food is less than 0.5 g (§ 101.9(c)(2)(ii)). In addition, if a manufacturer does not declare the trans fat content because total fat amount is less than 0.5 g, then the statement ‘Not a significant source of trans fat’ must be placed at the bottom of the table of nutrient values. This statement indicates why information that is required to be declared is omitted and provides necessary information to assist in making healthy dietary choices. In relation to the current revision of the Nutrition Facts Panel, the FDA was requesting comment on whether mandatory labelling of trans fat would still be necessary if this determination was finalized.

Annex II – Table S2. Food products with trans fatty acid content of ≥ 2 g per 100 g of total fat,

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Poland	Zbikowska <i>et al.</i> 2011 [60]	Shortening 15	54.0
Denmark	Bysted <i>et al.</i> 2009 [53]	Popcorn 1	49.2
Sweden	Mattisson <i>et al.</i> 2011 [63]	Micro popcorn (USA) 2466	43.9
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 3A	42.5
Sweden	Mattisson <i>et al.</i> 2011 [63]	Tofutti creamy smooth 2428	40.3
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 4A	40.0
		Biscuits 9A	39.8
Estonia	Meremäe <i>et al.</i> 2012 [54]	Shortening 8	39.5
Sweden	Mattisson <i>et al.</i> 2011 [63]	Tofutti cheddar sliced 2429	38.2
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Chocolate egg	37.3
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 6A	36.9
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Other confectionery products 12	36.3
		Chocolate egg	36.2
Poland	Zbikowska <i>et al.</i> 2011 [60]	Shortening 14	35.6
Estonia	Meremäe <i>et al.</i> 2012 [54]	Margarine 6	34.9
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 70	30.2
		Chocolates 19	30.2
		Sweet biscuits, wafers, muffins 47	29.8
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 17B	28.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Fondant, candies 10	27.6
		Fondant, candies 5	27.5
		Sweet biscuits, wafers, muffins 65	27.2
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 5A	26.4
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Cereals 24	26.2
		Fondant, candies 6	25.8
		Margarines 14	25.3
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 2A	24.8

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Cereals 25	23.9
Poland	Zbikowska <i>et al.</i> 2011 [60]	Shortening 17	23.1
Ireland	Food Safety Authority of Ireland 2008 [22]	Dried Gravy 96	22.5
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 108	21.9
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 7A	21.1
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Chocolate egg	20.3
		Fondant, candies 11	20.1
		Sweet biscuits, wafers, muffins 90	19.5
		Sweet biscuits, wafers, muffins 110	18.8
		Powder creams and coffees 14	18.8
Ireland	Food Safety Authority of Ireland 2008 [22]	Dried Gravy 97	18.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 124	18.2
Turkey	Karabulut <i>et al.</i> 2007 [69]	Wheat flour cookie	17.71
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 60	17.2
Poland	Zbikowska <i>et al.</i> 2011 [60]	Shortening 16	16.3
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 84	15.7
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 8A	14.6
		Biscuits 24C	14.5
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 17	14.1
Sweden	Mattisson <i>et al.</i> 2011 [63]	Wheat wholemeal rusks krisprolls 2450	14.1
Austria	Wagner <i>et al.</i> 2008 [52]	Instant soups	13.8
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 26	13.6
		Fondant, candies 7	13.4
		Margarines 20	13.1
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 19C	12.6

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 48	12.5
		Sweet biscuits, wafers, muffins 78	12.3
		Sweet biscuits, wafers, muffins 91	12.2
		Sweet biscuits, wafers, muffins 38	12.2
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 22C	12.0
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 16	10.9
		Sweet biscuits, wafers, muffins 33	10.9
Ireland	Food Safety Authority of Ireland 2008 [22]	Dried Chicken Soup 71	10.7
		Dried Tomato Soup 73	10.7
		Dried Chicken & Bacon Soup 75	10.6
		Dried Beef & Vegetable Soup 72	10.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 28	10.5
		Powder creams and coffees 3	10.5
		Sweet biscuits, wafers, muffins 62	10.4
Ireland	Food Safety Authority of Ireland 2008 [22]	Reduced Fat Spread 59% 7	10.4
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 105	10.3
		Sweet biscuits, wafers, muffins 71	10.1
		Sweet biscuits, wafers, muffins 106	10.1
		Sweet biscuits, wafers, muffins 103	9.9
		Margarines 47	9.7
		Sweet biscuits, wafers, muffins 57	9.7
		Sweet biscuits, wafers, muffins 104	9.6
		Chocolates 14	9.5
Hungary		Sweet biscuits, wafers, muffins 29	9.1
Estonia	Meremäe <i>et al.</i> 2012 [54]	Blended spread 6	9.0
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 18	9.0
		Pastry, cakes 64	9.0

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Ireland	Food Safety Authority of Ireland 2008 [22]	Fresh Lamb Gigot Chops 22	9.0
Denmark	Bysted <i>et al.</i> 2009 [53]	Frozen potato 2	8.9
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 89	8.7
		Pastry, cakes 72	8.2
		Sweet biscuits, wafers, muffins 10	8.0
Denmark	Bysted <i>et al.</i> 2009 [53]	Cookies 17	8.0
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 13B	8.0
		Biscuits 23C	8.0
Austria	Wagner <i>et al.</i> 2008 [52]	Industrial margarines	7.8
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 11	7.8
		Margarines 23	7.7
		Sweet biscuits, wafers, muffins 107	7.7
Estonia	Meremäe <i>et al.</i> 2012 [54]	Shortening 3	7.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 27	7.5
		Bakery products 28	7.4
Germany	Kuhnt <i>et al.</i> 2011 [6]	Doughnuts	7.3
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 38	7.3
		Sweet biscuits, wafers, muffins 66	7.3
		Pastry, cakes 39	7.2
Ireland	Food Safety Authority of Ireland 2008 [22]	Vegetable Fat Spread 70% 1	7.2
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Bakery products 39	6.9
		Sweet biscuits, wafers, muffins 9	6.9
		Sweet biscuits, wafers, muffins 21	6.9
		Fondant, candies 14	6.9
Ireland	Food Safety Authority of Ireland 2008 [22]	Irish Cheddar 30	6.9
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Pastry, cakes 76	6.8
		Pastry, cakes 28	6.6

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Ireland	Food Safety Authority of Ireland 2008 [22]	Reduced Fat Blend 59% 2	6.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 29	6.5
		Margarines 30	6.5
		Sweet biscuits, wafers, muffins 96	6.5
		Pastry, cakes 69	6.5
		Semi-cooked food 13	6.5
		Pastry, cakes 83	6.3
Ireland	Food Safety Authority of Ireland 2008 [22]	Irish Cheddar 31	6.3
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 69	6.2
		Pastry, cakes 78	6.2
		Pastry, cakes 14	6.1
Switzerland	Richter <i>et al.</i> 2009 [70]	Fine bakery products	6.0
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 27	5.9
		Fondant, candies 13	5.9
		Margarines 50	5.8
		Bakery products 40	5.8
		Pastry, cakes 77	5.8
		Sweet biscuits, wafers, muffins 119	5.7
		Fondant, candies 8	5.7
		Pastry, cakes 74	5.7
		Margarines 36	5.6
		Sweet biscuits, wafers, muffins 18	5.6
Ireland	Food Safety Authority of Ireland 2008 [22]	Vegetable Fat Spread 70% 9	5.6
Turkey	Karabulut <i>et al.</i> 2007 [69]	Stick cracker	5.52
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 37	5.5
		Pastry, cakes 55	5.5
		Semi-cooked food 12	5.5

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Ireland	Food Safety Authority of Ireland 2008 [22]	Vegetable Fat Spread 70% 18	5.5
		Irish Cheddar 29	5.5
Turkey	Karabulut <i>et al.</i> 2007 [69]	Cake, filled and covered	5.33
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Pastry, cakes 4	5.3
		Pastry, cakes 57	5.3
Turkey	Karabulut <i>et al.</i> 2007 [69]	Wafer roll, filled	5.27
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Bakery products 26	5.2
		Pastry, cakes 56	5.2
		Pastry, cakes 70	5.2
		Pastry, cakes 73	5.2
		Pastry, cakes 90	5.2
		Semi-cooked food 11	5.2
Ireland	Food Safety Authority of Ireland 2008 [22]	English Cheddar 32	5.2
Switzerland	Richter <i>et al.</i> 2009 [70]	Ice creams	5.14
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 130	4.9
		Pastry, cakes 15	4.9
		Pastry, cakes 46	4.9
Austria	Wagner <i>et al.</i> 2008 [52]	Cooled ready to eat products	4.8
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Chocolate egg	4.8
		Pastry, cakes 42	4.8
Ireland	Food Safety Authority of Ireland 2009 [58]	Fish and Chips (product 118)	4.8
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 45	4.7
Ireland	Food Safety Authority of Ireland 2008 [22]	Irish Butter 10	4.7
Turkey	Karabulut <i>et al.</i> 2007 [69]	Digestive, biscuit	4.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Bakery products 2	4.6
		Chocolate egg	4.6
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 14B	4.6

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Bakery products 35	4.5
		Pastry, cakes 7	4.4
		Pastry, cakes 8	4.4
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 10A	4.4
Austria	Wagner <i>et al.</i> 2008 [52]	Pasta dishes	4.3
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Pastry, cakes 36	4.3
Denmark	Bysted <i>et al.</i> 2009 [53]	Cookies 19	4.3
Estonia	Meremäe <i>et al.</i> 2012 [54]	Margarine 12	4.25
Austria	Wagner <i>et al.</i> 2008 [52]	Other products	4.2
Ireland	Food Safety Authority of Ireland 2009 [58]	Hamburger 3	4.2
Sweden	Swedish National Food agency 2010 [65]	Dairy products (low price)	4.1
		Dairy products (standard price)	4.1
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Chocolate egg	4.1
Ireland	Food Safety Authority of Ireland 2008 [22]	Irish Cheddar 28	4.1
Ireland	Food Safety Authority of Ireland 2009 [58]	Quarter Pounder 2	4.1
		Cheeseburger 4	4.1
		Quarter Pounder 3	4.1
Switzerland	Richter <i>et al.</i> 2009 [70]	Snacks, cakes and biscuits	3.9
Ireland	Food Safety Authority of Ireland 2009 [58]	Beef Burger 10	3.9
Switzerland	Richter <i>et al.</i> 2009 [70]	Semi-solid fats	3.8
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 113	3.8
		Pastry, cakes 40	3.8
Ireland	Food Safety Authority of Ireland 2009 [58]	Beef Burger 9	3.8
Austria	Wagner <i>et al.</i> 2008 [52]	Dough	3.7
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 61	3.7
Ireland	Food Safety Authority of Ireland 2009 [58]	Beef Burger 8	3.7
Turkey	Karabulut <i>et al.</i> 2007 [69]	Hazelnut cocoa cream	3.6

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Bakery products 42	3,6
Turkey	Karabulut <i>et al.</i> 2007	Cookie, filled	3,5
Estonia	Meremäe <i>et al.</i> 2012	Blended spread 1	3,5
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 69	3,5
		Sweet biscuits, wafers, muffins 32	3,5
		Sweet biscuits, wafers, muffins 86	3,5
Denmark	Bysted <i>et al.</i> 2009 [53]	Cake 4	3,5
Switzerland	Wagner <i>et al.</i> 2008 [52]	Desserts	
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 42	3,4
		Bakery products 22	3,4
Ireland	Food Safety Authority of Ireland 2009 [58]	Chicken Nuggets 4	3,4
Turkey	Karabulut <i>et al.</i> 2007 [69]	Wafer	3,3
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 131	3,3
		Chocolate egg	3,3
Ireland	Food Safety Authority of Ireland 2009 [58]	Hamburger 2	3,3
		Beef Burger 6	3,3
		Beef Burger 7	3,3
		Hawaiian Pizza 2	3,3
Switzerland	Richter <i>et al.</i> 2009 [70]	Whipped cream, cappuccino	3,2
Ireland	Food Safety Authority of Ireland 2009 [58]	Beef Burger 5	3,2
Germany	Kuhnt <i>et al.</i> 2011 [6]	Butter	3,1
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Pastry, cakes 6	3,1
		Pastry, cakes 53	3,1
		Pastry, cakes 86	3,1
		Margarines 35	3,0
		Sweet biscuits, wafers, muffins 59	3,0
		Fondant, candies 9	3,0

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Hungary		Pastry, cakes 48	3.0
Turkey	Karabulut <i>et al.</i> 2007 [69]	Sandwich, biscuit	2.9
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 46	2.9
		Pastry, cakes 38	2.9
		Dairy Products 1	2.9
Ireland	Food Safety Authority of Ireland 2009 [58]	Double Burger 3	2.9
		Cheeseburger 3	2.9
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 51	2.8
		Bakery products 24	2.8
		Fondant, candies 1	2.8
		Pastry, cakes 65	2.8
		Semi-cooked food 14	2.8
		Ice creams 4	2.8
Ireland	Food Safety Authority of Ireland 2009 [58]	Cheeseburger 2	2.8
		Beef Burger 4	2.8
		Margarita Pizza 1	2.8
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 118	2.7
		Pastry, cakes 33	2.7
		Pastry, cakes 68	2.7
		Pastry, cakes 93	2.7
		Powder creams and coffees 16	2.7
Ireland	Food Safety Authority of Ireland 2009 [58]	Lamb Kebab	2.7
Germany	Kuhnt <i>et al.</i> 2011 [6]	Puff pastries	2.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 34	2.6
Hungary		Sweet biscuits, wafers, muffins 127	2.6
		Pastry, cakes 32	2.6
		Pastry, cakes 63	2.6
Ireland	Food Safety Authority of Ireland 2009 [58]	Cheeseburger 1	2.6

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Ireland		Beef Burger 3	2.6
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 48	2.5
		Chocolate egg	2.5
		Chocolate egg	2.5
		Pastry, cakes 66	2.5
Switzerland	Richter <i>et al.</i> 2009 [70]	Fried and fast food	2.5
Ireland	Food Safety Authority of Ireland 2009 [58]	Hamburger 1	2.5
Turkey	Karabulut <i>et al.</i> 2007 [69]	Puff pastry dough	2.4
Austria	Wagner <i>et al.</i> 2008 [52]	Potato chips	2.4
UK	Roe <i>et al.</i> 2013 [49]	Cod, fried in batter, takeaway	2.4
Turkey	Karabulut <i>et al.</i> 2007 [69]	Mini cake, filled and covered	2.4
Ireland	Food Safety Authority of Ireland 2009 [58]	Beef Burger 2	2.4
Sweden	Mattisson <i>et al.</i> 2011 [63]	Danish pastry bake off 2451	2.34
Turkey	Karabulut <i>et al.</i> 2007 [69]	Beef burger fried	2.33
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Margarines 3	2.3
		Sweet biscuits, wafers, muffins 64	2.3
		Pastry, cakes 3	2.3
		Savoury biscuits, crackers, chips 25	2.3
Ireland	Food Safety Authority of Ireland 2008 [22]	Hazelnut Milk Chocolate Spread 99	2.3
		Beef Burger 1	2.3
		Meat Pizza 4	2.3
Denmark	Bysted <i>et al.</i> 2009 [53]	Cookies 18	3.1
Sweden	Mattisson <i>et al.</i> 2011 [63]	Danish pastry bake off 2453	2.23
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Sweet biscuits, wafers, muffins 3	2.2
		Sweet biscuits, wafers, muffins 95	2.2
		Sweet biscuits, wafers, muffins 111	2.2
		Chocolate egg	2.2
		Other confectionery products 17	2.2
Ireland	Food Safety Authority of Ireland 2009 [58]	Double Burger 2	2.2

Table S2. (Cont.)

Country	Reference	Food products*	TFA (g per 100 g of total fat)
Ireland		Fish and Chips 86	2.2
		Meat Pizza 1	2.2
Germany	Kuhnt <i>et al.</i> 2011 [6]	Chocolate products	2.1
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Bakery products 1	2.1
		Bakery products 12	2.1
		Pastry, cakes 67	2.1
		Soups, convenience products 39	2.1
Poland	Zbikowska <i>et al.</i> 2011 [60]	Shortening 21	2.1
Ireland	Food Safety Authority of Ireland 2008 [22]	Irish Butter 11	2.1
Ireland	Food Safety Authority of Ireland 2009 [58]	Margarita Pizza 2	2.1
UK	Roe <i>et al.</i> 2013 [49]	Potato chips, takeaway	2.05
Austria	Wagner <i>et al.</i> 2008 [52]	Hamburger	2.04
Turkey	Karabulut <i>et al.</i> 2007 [69]	Chocolate bar	2.04
Germany	Kuhnt <i>et al.</i> 2011 [6]	Instant products	2.02
Turkey	Karabulut <i>et al.</i> 2007 [69]	Sucuk (fermented sausage)	2.01
Hungary	National Food and Nutrition Institute of Hungary 2013 [57]	Pastry, cakes 31	2.0
		Powder creams and coffees 4	2.0
		Powder creams and coffees 5	2.0
Poland	Zbikowska <i>et al.</i> 2011 [60]	Shortening 22	2.0
Serbia	Kravic <i>et al.</i> 2011 [68]	Biscuits 29C	2.0

* Numbers and/or letters *e.g.* biscuits **7A**, shortening **16** represent coding of food product as reported in the original publication.

Annex III – Table S3⁵. A comparison of different approaches to further reduce trans fatty acid in foods and diets in Europe. This table was originally published in [84].

Approach Criteria	Legal Limits (Approach 1)	Mandatory Labelling of TFA (Approach 2)	Voluntary Labelling of TFA (Including claims of 'TFA-free') (Approach 3)	Voluntary Reformulation (Agreement)* (Approach 4)	Keep Status Quo ** (Approach 5)	Comments
1 Does this measure apply to all products?	Yes	No	No	No	No	Labelling in both forms does not guarantee maximum possible reduction of TFA
2 Does this measure apply to out-of-home eating?	Yes	No	No	Yes	N/A	
3 Does this measure apply to packaged foods?	Yes	Yes	Yes	Yes	Yes	
4 Does this measure apply to non-packaged foods?	Yes	No	No	Yes	No	
5 Distinction between rTFA and iTFA	Measure does not apply to rTFA	No distinction, which may affect consumption of dairy and other labelled ruminant-derived products	No distinction. However, dairy and meat products as well as products containing rTFA (butter) would likely not be labelled voluntarily	N/A. If accompanied by labelling see Approach 3	N/A	
6 Phasing out of iTFA-containing products from the market 1. Completeness 2. Speed	1) Complete 2) Depends on the timeline given in the legislation (e.g. 1 year in Denmark)	1) Incomplete 2) Depends on timeline for labelling enforcement given in the legislation and potential reformulation efforts by industry	1) Incomplete 2) Requires a short time needed for changes to current legislation. Then it depends on potential reformulation efforts by industry	1) Incomplete 2) Depends on reformulation efforts by industry	1) Incomplete 2) Depends on potential reformulation efforts by industry	

Table S3⁵. (Cont.)

Criteria	Approach	Legal Limits (Approach 1)	Mandatory Labelling of TFA (Approach 2)	Voluntary Labelling of TFA (Including claims of 'TFA-free') (Approach 3)	Voluntary Reformulation (Agreement)* (Approach 4)	Keep Status Quo ** (Approach 5)	Comments
7	What are the costs for the consumer?						
7a	F7a00d price	Reformulation costs may shift to the consumer (however, current experience from Denmark suggests very little effects on final food price to the consumer)	Possibility of price disparities between reformulated products and cheaper alternatives	Possibility of price disparities between reformulated products and cheaper alternatives	Possibility of price disparities between reformulated products and cheaper alternatives	Price disparities exist	Price disparities may lead socially disadvantaged consumers to choose the cheaper and potentially higher TFA alternatives; this in turn may increase health inequalities
7b	Time	None	Yes	Yes	None, unless accompanied by labelling	Yes	Consumer needs to invest time in reading the labels. Approaches 3-5 are possibly more time-consuming
8	What are the costs for the food industry?						
8a	Costs of R&D (reformulation-research on the new product)	Reformulation costs incurred by all	Not applicable unless followed by reformulation	Not applicable unless accompanied by reformulation	Reformulation costs incurred by those who reformulate	Reformulation costs incurred by those who reformulate	
8b	Cost of alternative process	Too speculative	Too speculative	Too speculative	Too speculative	Too speculative	Too speculative because of the lack of information on costs of alternative process
8c	Costs of labelling (including analysis)	No	Yes	Yes	No, unless accompanied by labelling	None	
9	What are the costs for the government?						
9a	Costs of implementation	Yes	Yes	Yes	No	N/D	Approach 3 has implementation costs but not as a high as Approach 2

Table 53⁵. (Cont.)

Criteria	Approach	Legal Limits (Approach 1)	Mandatory Labelling of TFA (Approach 2)	Voluntary Labelling of TFA (Including claims of 'TFA-free') (Approach 3)	Voluntary Reformulation* (Agreement)* (Approach 4)	Keep Status Quo ** (Approach 5)	Comments
9b	Costs of enforcement including sampling and analysis	Yes	Yes	Yes	Yes, if accompanied by labelling	No	Costs of enforcement will be probably highest in Approach 1
9c	Cost for raising consumer awareness (campaigns and education)	No	Yes	Yes	Yes, if accompanied by labelling	Yes, consumers should be educated on ingredients listed as PHVO or FHVO	
10	Does it foster competition?	No	Yes	Yes	Little, if not accompanied with labelling	No	
11	Does it foster innovation?	Yes	Yes	Yes	Yes	No	
12	What are the possible issues related to TFA information to consumers?	None	<ul style="list-style-type: none"> Only the knowledgeable consumer is empowered to make healthy (low TFA or TFA free) choices of packaged foods; however, labelling of an additional nutrient in labelled foods may be to the detriment of other relevant information Too much focus on the level of TFA in the label may take attention away from other nutrients (e.g. saturated fats or sugars), in particular in combination with TFA The consumer will have no information about TFA on non-packaged foods (e.g. saturated fats or sugar), in particular in combination with TFA The consumer will have no information about TFA on non-packaged foods Possibility of TFA nutrient claims, such as 'low in TFA', 'reduced TFA', 'TFA-free' 	<ul style="list-style-type: none"> Labelling of an additional nutrient in labelled foods may be to the detriment of other relevant information. Too much focus on the level of TFA in the label may take attention away from other nutrients (e.g. saturated fats or sugars), in particular in combination with TFA The consumer will have no information about TFA on non-packaged foods The consumer will have no information on the presence of TFA when TFA labelling is absent except from PHVO mentioned in the ingredient list Possibility of TFA nutrient claims, such as 'low in TFA', 'reduced TFA', 'TFA-free' 	<ul style="list-style-type: none"> If accompanied by labelling see Approach 3 If not accompanied by labelling – no information to the consumer at point of purchase except for PHVO mention in the ingredient list; the knowledgeable consumer would be able to avoid packaged products containing PHVO 	<ul style="list-style-type: none"> Information present on ingredient list as PHVO or FHVO Only the knowledgeable consumer is able to avoid packaged products containing PHVO Possible difficulty in identifying the presence of PHVO in ingredients' list. (small font size, variable position in the list of ingredients) Difficulty in evaluating the difference between PHVO and FHVO No legal definition of PHVO; absence of PHVO should guarantee absence of ITFA, however, presence of PHVO does not allow estimation of TFA content The consumer has information about TFA on non- packaged foods Possibility of PHVO-free claims 	

Table S3⁵. (Cont.)

Approach Criteria	Legal Limits (Approach 1)	Mandatory Labelling of TFA (Approach 2)	Voluntary Labelling of TFA (Including claims of 'TFA-free') (Approach 3)	Voluntary Reformulation (Agreement)* (Approach 4)	Keep Status Quo (Approach 5)	Comments
<p>13 Are there potential disadvantages for more vulnerable groups?</p>	<p>No</p>	<p>Yes</p> <ul style="list-style-type: none"> • TFA containing-products available in the market • Less informed consumers more vulnerable • Any price disparities might affect mostly low income populations 	<p>Yes</p> <ul style="list-style-type: none"> • TFA containing-products available in the market • Less informed consumers more vulnerable • Any price disparities might affect mostly low income populations 	<p>Yes</p> <ul style="list-style-type: none"> • TFA containing-products available in the market • Any price disparities might affect mostly low income populations 	<p>Yes</p> <ul style="list-style-type: none"> • TFA containing-products available in the market • Price disparities affect mostly low income populations 	
<p>14 Public health benefits</p>	<p>Yes Highest</p>	<p>Yes but</p> <ul style="list-style-type: none"> • Measure targets only packaged foods • Depends on reformulation by industry • Depends on nutrition literacy of population 	<p>Yes but</p> <ul style="list-style-type: none"> • Measure targets only packaged foods • Depends on reformulation by industry • Depends on nutrition literacy of population • Depends on consumer preference for products carrying TFA free claims 	<p>Yes but</p> <ul style="list-style-type: none"> • Measure depends on Industry participation • Coverage of food products on the market 	<p>N/A</p>	

Table S3[§]. (Cont.)

Approach Criteria	Legal Limits (Approach 1)	Mandatory Labelling of TFA (Approach 2)	Voluntary Labelling of TFA (Including claims of 'TFA-free') (Approach 3)	Voluntary Reformulation* (Approach 4)	Keep Status Quo ** (Approach 5)	Comments
15 Does it affect the functioning of the internal EU market?	No (or positively as it provides the same rules everywhere in the common market)	No but it counter-acts some existing national policies (see below)	No	No	Different regulatory measures affect internal market negatively	
16 Can it affect World Trade Organisation agreements?	Yes	No	No	No	No	
17 Does it counteract existing national measures?	No	Yes, <ul style="list-style-type: none"> • Countries with legal limits will enforce a senseless measure • Additional burden to industry in countries with far reaching voluntary agreements 	N/A	N/A	N/A	

Table S3[§]. (Cont.)

Approach	Legal Limits (Approach 1)	Mandatory Labelling of TFA (Approach 2)	Voluntary Labelling of TFA (Including claims of 'TFA-free') (Approach 3)	Voluntary Reformulation (Agreement)* (Approach 4)	Keep Status Quo ** (Approach 5)	Comments
Criteria 18 Proportionality of the measure**: 1) Legitimate aim for measure? 2) Suitable to achieve the aim? 3) Necessary to achieve the aim (any less onerous way of doing it)? 4) Measure reasonable (considering the competing interests of different groups at hand)?	1) Yes, TFA health issues are still present to some extent at EU level, alternatives to the use of TFA (PHVO) exist, protection of citizens' health will be improved by providing (only the) healthier options 2) Yes, highly effective to entire population and covering all foods 3) Aim can in principle be achieved also by voluntary reformulation; if voluntary agreement is taken up by all food products within a short time 4) With the wide availability of alternatives to PHVO it may be reasonable to ask industry to apply alternative solutions; nevertheless, this last issue would probably need a consultation with stakeholders	1) Yes, consumers have a right for information on TFA and for being empowered to make healthy (TFA free/low TFA) choices should products containing iTFA not be restricted 2) Only to a certain extent because the measure does not cover all iTFA containing food products and does not guarantee widespread reduction of TFA in foods nor that consumers will make the healthy (TFA free/low TFA) choice; consumers may also be unable to cope with the task of making overall healthy dietary choices based on complex nutrition information 3) Yes, providing the consumer with a basis to make an informed decision to avoid/reduce iTFA intake from packaged foods can NOT be achieved through a voluntary labelling scheme because products still containing iTFA would likely not be labelled 4) Given the current requirements of the FIC regulation (1169/2011), in particular labelling of total and saturated fat, it seems reasonable to require labelling of TFA as analysis should not require high additional costs; again a consultation would help answering this point	1) Yes, allowing TFA labelling, and in particular TFA nutrient claims ('low in TFA', 'zero TFA', 'free of TFA'), may provide the necessary incentives to the industry to reformulate and market the healthier options to the consumer 2) Measure can in principle lead to reduction of iTFA on packaged foods; however, wide coverage of food products would only be achieved in case reformulated products gain a clear market advantage (so that other food producers have to follow); unclear outcome 3) Less onerous would only be status quo (PHVO in ingredients list), which is also less effective in incentivising industry to reformulate 4) Since the measure would introduce voluntary labelling there is no obligation and therefore no burden imposed	1) Yes, TFA health issues are still present to some extent at EU level, alternatives to use of TFA (PHVO) exist, and protection of citizens' health will be improved 2) Yes, in principle can be highly effective if a high percentage of industry participates and a high coverage of food products on the market is achieved 3) Less onerous would only be status quo, which is also less effective than an additional clear pledge and action by the food industry 4) Alternatives to PHVO are now widely available and are also already promoted to end users of vegetable oils; it seems more than reasonable (in particular in the absence of legal measures) to call on that part of the food industry that hasn't yet implemented alternatives or reduced TFA contents to engage in reformulation on a voluntary basis		

§ Adapted from [84]

* Agreements promoting reformulation of foods. No specific labelling or claim agreements contemplated in this case.

** Status Quo: As it stands, in Europe different MSs have different approaches in place. Status quo also reflects the implementation of the EU Regulation 1169/2011 [39] in which the expression 'fully hydrogenated' or 'partly hydrogenated', must accompany the indication of hydrogenated oil (animal or vegetable origin) or fat, when present as part of the ingredient list.

*** Four stages of a proportionality test [89]. N/A: Not applicable, N/D: not defined.

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Abstract

Trans fatty acids (TFA) are a particular type of unsaturated fatty acid. They are naturally present in food products made from ruminant animals such as dairy and meat from cattle, sheep or goat (naturally occurring ruminant TFA or rTFA) but can also be produced industrially (TFA of industrial origin or iTFA). Consumption of TFA is associated with increased risk of coronary heart disease (CHD). The European Food Safety Authority (EFSA) states that 'TFA intakes should be as low as is possible within the context of a nutritionally adequate diet'. Denmark was the first country to adopt legislation limiting the content of TFA in foods in 2003. In Europe, Switzerland (2008), Austria (2009), Iceland (2011), Hungary (2013) and Norway (2014) have legislation in place limit the content of TFA in foodstuffs. EU legislation does not regulate the content of TFA in foodstuff nor does it require its labelling. The European Parliament and the Council have, however, requested as part of the recent *Regulation (EC) No 1169/11* on the provision of food information to consumers that the European Commission (EC) reports on 'the presence of trans fats in foods and in the overall diet of the Union population'. It is expected that the results can inform further decisions on introducing, at European level, 'appropriate means that could enable consumers to make healthier food and overall dietary choices or that could promote the provision of healthier food options to consumers, including, among others, the provision of information on trans fats to consumers or restrictions on their use'. This report is a first step in addressing this request. The analysis of the most recent publicly available data confirms reported reduction of TFA in foods but also shows that there are still a number of foods with high levels of TFA (above 2g TFA per 100g of fat) in some European food markets. Results from dietary surveys also indicate that although the overall population TFA intake is below the World Health Organization (WHO)-recommended maximum of 1 E% there are subpopulations exceeding the recommended threshold. As long as products with high TFA content remain in the food market, it is possible that individuals may consume more than the recommended maximum. As it stands, there appears to be room for improvement of the European situation as regards the presence of iTFA in foodstuffs.

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