Food Safety
AUTHORITY OF IRELAND

Trans Fatty Acid Survey (2007)

Retail Products

May 2008

Executive Summary [i]

Fats are essential for health and are made up of fatty acids, however, certain forms of fat are less healthy than other forms of fat. Generally, the saturated fats are less healthy than the monounsaturated fats or polyunsaturated fats. The exception to this rule are the trans-fats which are composed of mono or polyunsaturated fatty acids that that have a certain shape caused by the way in which their hydrogen atoms are arranged around the carbon double bond(s). Most unsaturated fatty acids found in foods will have the hydrogen atoms in what is called a *cis* configuration around the double bond. However, unsaturated fatty acids which have a *trans* configuration, known as trans fatty acids (TFA), may also be present. The result of the trans-configuration is that the fatty acid molecule becomes straighter rather than kinked and in this form it is more like the straight chain shape of saturated fatty acids.

Trans fatty acids (TFA) maybe formed when vegetable oils (or occasionally fish oils) are converted into solid fats such as in margarine and shortenings, by an industrial process known as hydrogenation. As such, foods which use hydrogenated oils as an ingredient may also contain industrial TFA[ii]. Trans fatty acids may also be naturally present in the products of ruminant animals such as cows and sheep[iii].

In 2004 the European Food Safety Authority (EFSA) indicated that evidence from many controlled human intervention studies had shown that diets containing TFA, like diets containing mixtures of saturated fatty acids, consistently resulted in increased serum LDL cholesterol (LDL-C), compared with diets containing cis-monounsaturated or cis-polyunsaturated fatty acids. Elevated LDL-C has been causally linked to coronary heart disease; thus, higher intakes of TFA may increase risk for coronary heart disease (CHD).

It's not clear if TFA that occur naturally *(e.g. products of ruminant animals)* have the same effect on LDL-C and CHD as industrial TFA. In 2004, the EFSA indicated that it was not possible to determine whether there were differences between natural TFA from ruminant animals and industrial TFA from hydrogenated vegetable oils in their effects on metabolic risk parameters such as LDL-C. However, research into this issue is continuing in an attempt to address this important question.

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[i] The results presented in this report relate solely to the individual samples/batches tested and do not necessarily reflect the general status of the products listed.

[ii] For the purposes of this report the term industrial TFA is used to describe TFA which are formed as a result of industrial processes such as hydrogenation and to a lesser extent deodorisation of unsaturated vegetable oils, or through heating and frying of oils at high temperature.

[iii] Biohydrogenation of unsaturated fatty acids in the rumen of ruminant animals such as cows naturally produces TFA which are subsequently present in meat and milk products of these ruminant animals.

In 2007, the Food Safety Authority of Ireland (FSAI) commissioned a study of trans-fats in prepared packaged food sold on the Irish market. This study is reported here. 100 samples of packaged foodstuffs were sampled for analysis of total fat content and fatty acid profile including TFA. The samples comprised a cross-section of products which would be expected to contain industrial TFA as a result of the manufacturing processes or ingredients and those which would contain TFA naturally. However, the natural presence of TFA in products of animal origin was not the focus of the current survey.

Of the 100 products surveyed, 33 *(i.e. 33%)* declared hydrogenated oil (HO) as an ingredient and 67 *(i.e. 67%)* didn't declare HO as an ingredient. However, 37% *(i.e. 25 of total 100 products samples)* of these 67 products not declaring HO as an ingredient were of animal origin. Hydrogenated oils are a possible source of trans-fats. Dried gravies and soups containing HO had the highest concentrations of TFA overall. However, 64% of products declaring HO as an ingredient had levels of ≤2% TFA *(as a percentage of total fat)*. Therefore, it appears that the presence of HO as a component of the ingredient declaration on product labels doesn't necessarily relate to the presence of TFA in products. Overall eighty percent of products surveyed contained ≤2% TFA *(as a percentage of total fat)*.

Of public health concern is the high level of saturated fats identified in products surveyed. Levels of saturated fat in products were high with 34% of all products containing ≥50% saturated fat *(as a percentage of total fat)*. In products declaring HO as an ingredient 51% contained ≥50% saturated fat *(as a percentage of total fat)*.

At present, there are no methods of analysis applicable to a wide range of foods that can distinguish between natural TFA and industrial TFA in foods. This is because there is overlap in the TFA profiles found in ruminant fats and those found in products containing hydrogenated oils and the varying proportions of TFA isomers among different hydrogenated fats. The survey showed that it was not reliable to use TFA profiles to distinguish between naturally occurring TFA and industrial TFA. However, as expected the ratio of trans-11-vaccenic acid to trans-9-elaidic acid in samples of ruminant origin was typically higher. Although, this was not consistent.

In relation to labelling, 97% of samples were compliant with the labelling requirements for nutritional information. Nine percent of products made a specific claim in relation to the presence or absence of TFA and listed TFA in nutritional labelling. The commonest claim was "Virtually Trans Fat Free". However, under health claims legislation that came into force in Europe in July 2007, this particular claim is no longer allowed. One product exceeded its stated nutritional claim for TFA. As regards other labelling issues it was concluded that the listing of oil and fat components in ingredient declarations differed markedly between products. This is a concern as consumers must be able to make informed

choices when purchasing products. As such labelling must be consistent and easy to understand.

In summary the current FSAI survey of 100 retail products available on the Irish market has indicated that overall levels of TFA in surveyed products are low. However, levels of saturated fats in many products are high and public concerns over the health effects of trans-fats have become the focus of much debate. There is no doubt that the trans-fat content of foods needs to be reduced and maintained as low as possible. However, creative solutions to reformulation are needed by the food industry. This should not include the replacement of trans-fats with saturated fats, even in the short term, because this is not a sustainable solution for the improvement of dietary health.

Abbreviations

Guideline Daily Amount(s)	GDA
Saturated	SAT
Monounsaturated Fatty Acid(s)	MUFA
Polyunsaturated Fatty Acid(s)	PUFA
Trans Fatty Acid(s)	TFA
Hydrogenated Oil(s)	HO
The European Food Safety Authority	EFSA
The Food Safety Authority of Ireland	FSAI
Low Density Lipoprotein Cholesterol	LDL-C
High Density Lipoprotein Cholesterol	HDL-C
Coronary Heart Disease	CHD
European Union	EU
World Health Organisation	WHO
Conjugated Linoleic Acid	CLA

List of Tables

List of Figures

Table of Contents

1. Background

There are three broad categories of fat found in food, saturated (SAT), monounsaturated (MUFA) and polyunsaturated (PUFA) fat. Fats are composed of fatty acids[iv]. Consumption of fat allows the human body to store energy, absorb fat-soluble vitamins and supplies essential fatty acids such as omega-3 and omega-6 fatty acids which the human body can't make. However, it is important to control the overall fat intake in the diet as well as the intake of specific fats such as SAT fats and trans fatty acids (TFA).

1.1 What are Trans Fatty Acids?

Trans fatty acids *(i.e. also known as trans fats)* are chemically classified as unsaturated fatty acids but tend to behave biochemically more like SAT fatty acids (Rogers *et al.,* 2001). TFA are geometrical isomers of MUFA and PUFA having at least one non-conjugated, (interrupted by at least one methylene group), carbon-carbon double bond in the trans configuration [v] (Codex, 1985; EFSA, 2004) unlike most unsaturated fatty acids in foods which have the cis configuration (Kodali, 2005). However, precise definitions of TFA vary among countries.

1.2 What are the Sources?

Trans fatty acids (TFA) maybe formed when vegetable oils (or occasionally fish oils) are converted into solid fats such as in margarine and shortenings, by an industrial process known as hydrogenation *(i.e. hydrogenation involves the addition of hydrogen atoms across the unsaturated double bonds of the particular triglycerides)*. As such, foods which use hydrogenated oils as an ingredient may also contain industrial TFA. Hydrogenation also increases the shelf-life and flavour stability of foods containing these fats. Industrial TFA are also formed in small amounts during the refining of liquid vegetable oils and during the heating and frying of oils at high temperatures (Mehta & Swinburn, 2001; EFSA, 2004; IFST, 2007; Wassell & Young 2007).

Biohydrogenation of unsaturated fatty acids in the rumen of ruminant animals such as cows *(i.e. by bacterial transformation)* also produces TFA which are subsequently present in the meat and milk of these animals (EFSA, 2004; Kodali, 2005; IFST, 2007). However, the nature of TFA produced by bacterial transformation is different from those formed by industrial processes such as hydrogenation (Kodali, 2005). Small amounts of TFA, derived from animal feed, are also present in poultry and pork fat (IFST, 2007). Categories of food which may be a source of TFA include:

[iv] **Fat** means total lipids, and includes phospholipids; **Saturates** means fatty acids without double bond; **Monounsaturates** means fatty acids with one *cis* double bond; **Polyunsaturates** means fatty acids with *cis, cis*-methylene interrupted double bonds (Directive 90/496/EEC). At room temperature a fat which is normally liquid is typically called an oil

[v] Naturally occurring fatty acids typically have a *Cis* configuration. The Latin prefixes *Cis* and *Trans* indicate the orientation of the hydrogen atoms with respect to the double bond. *Cis* means **on the same side** and *Trans* means **across** or **on the other side**. The Food and Drug Administration in the United States defines TFA as unsaturated fatty acids that contain one or more isolated (i.e. non-conjugated) double bonds in a trans configuration (FDA, 2003). As such conjugated linoleic acid (CLA) is not covered by this definition, but vaccenic acid is not.

- Confectionery *(including biscuits and cakes)*
- Bakery Products *(including breads)*
- Savoury Snacks *(including crackers, crisps and children's savoury snacks)*
- Margarine & Spreads *(including dairy fat, vegetable fat margarine& spreads)*
- Milk & Milk Products *(including butter & cheese)*
- Fresh Meat, Poultry & Fish
- Meat, Poultry & Fish Products *(including eggs, processed meat, poultry & fish products)*
- Sauces *(including fresh, jarred, frozen or canned sauces)*
- Dried Food *(including soups, gravies, sauces and dried ready meals)*
- Miscellaneous Foods *(including eggs, cereal bars, spreads, fresh/frozen ready meals)*

1.3 What are the Health Concerns?

The European Food Safety Authority (EFSA) has indicated that evidence from many controlled human intervention studies has shown that consumption of diets containing TFA, like diets containing mixtures of SAT fatty acids, consistently result in increased serum low density lipoprotein cholesterol (LDL-C), compared with consumption of diets containing cis-MUFA or cis-PUFA fatty acids (EFSA, 2004; IFST 2007; Upritchard et. al. 2005). The effect shows a linear dose response with serum LDL-C indicating that effects are proportional to amounts of TFA consumed (EFSA, 2004).

Elevated LDL-C has been causally linked to coronary heart disease; thus, higher intakes of TFA may increase risk for coronary heart disease (CHD). However, the available evidence does not provide a definitive answer to the question of whether TFA have a different effect on LDL-C than SAT fatty acids on a gram-for-gram basis (EFSA, 2004). Recently published research has indicated that high habitual intakes of SAT and TFA are independently associated with increased sub clinical atherosclerosis (Merchant et. al. 2008). The research indicates that for every 10-g/day increase in SAT fat intake, mean carotid artery intimal medial thickness (IMT) was 0.03 mm higher (P = 0.01) after multivariate adjustment. A 1-g/d higher intake of TFA was associated with a 0.03-mm higher IMT (P= 0.02) after multivariate adjustment (Merchant et. al. 2008). The Irish Heart Foundation has indicated that a reduction in intakes of SAT fat to < 10% of dietary energy and TFA to < 2% of total energy would provide for a large public health gain in Ireland (Irish Heart Foundation, 2007).

It's not clear if TFA that occur naturally *(e.g. in ruminant animal products)* have the same effect on LDL-C and CHD as industrial TFA (Huth, 2007). Ruminant animal products contain trans-11-vaccenic acid in greater concentrations than hydrogenated vegetable oils whereas hydrogenated vegetable oils contain greater concentrations of trans-9-elaidic acid (Mossoba *et al.*, 2003; Kodali, 2005). Trans-11-vaccenic acid is a metabolic precursor and is converted to rumenic acid in ruminant animals as well as humans. In addition, ruminant fats contain significant amounts of conjugated linoleic acid (CLA) *(i.e. predominantly 9 cis, 11 trans-18:2, also called rumenic acid)*, whereas hydrogenated vegetable oils are typically low in CLA. As such there may be a basis for potential metabolic differences between industrial TFA and ruminant TFA that may be related to

specific TFA isomers, their levels and differences in how they are metabolised in the body (Stanton & Donnelly, 2007). However, it is not yet clear how specific TFA isomers vary in their biological activity and mechanisms of action. There is evidence of health benefits on some of the endpoints that have been studied for some animal TFA isomers, such as CLA, but these are not a major source of TFA in the diet (Gebauer et. al., 2007).

A number of epidemiological studies (Willet et al., 1993; Ascherio et al., 1993 & 1994; Bolton Smith et al., 1996; Pietinen et al., 1997; Gillman et al., 1997; Oomen et. al. 2001) have indicated an association between the consumption of TFA and the risk of CHD. In three studies (Willet et al., 1993; Ascherio et al., 1994; Pietinen et al., 1997) this risk of CHD was primarily associated with industrial TFA with one study (Pietinen et al., 1997) indicating an inverse association between ruminant TFA and the risk of CHD (Mozaffarian et. al. 2006; Jakobsen et. al. 2007). A more recent study has also suggested that intake of ruminant TFA is not associated with a higher risk of CHD (Jakobsen et. al. 2007).

In 2004 the EFSA indicated that limited clinical evidence was available on the effect of natural sources of TFA coming from milk fat, dairy products and ruminant meat on surrogate biomarkers of CHD risk such as LDL-C and HDL-C (EFSA, 2004). In most human intervention studies at that time, monounsaturated TFA from hydrogenated vegetable oil were evaluated. The EFSA indicated that no human intervention studies had been carried out to evaluate the effects of TFA from ruminant fat, and indeed such studies were not practicable (EFSA, 2004). Thus it was not possible to determine whether there were differences between TFA from ruminant fat and industrial TFA from hydrogenated vegetable oils in their effects on metabolic risk parameters such as LDL-C or HDL-C (EFSA, 2004).

In 2008 two studies by Chardigny et al., 2008 and Bélanger et al., 2008 became the first controlled feeding studies to directly compare industrial with naturally occurring TFA. The study by Chardigny et al., 2008 indicates that TFA from industrially and natural sources have different effects on cardiovascular risk factors in women. The HDL cholesterol–lowering property of TFA seems to be specific to industrial sources. However, the study found it difficult to draw a conclusion about the effect of TFA from either source on absolute CVD risk in the test subjects and the mechanism underlying the observed differences on cardiovascular risk factors due to subjects sex (Chardigny et al., 2008).

The study by Bélanger et al., 2008 suggests that, whereas a high dietary intake of TFA from ruminants may adversely affect cholesterol homeostasis, moderate intakes of TFA from natural ruminant sources that are well above the upper limit of current human consumption have neutral effects on plasma lipids and other cardiovascular disease risk factors (Bélanger et al., 2008). However, it has been suggested that the interpretation of both studies (Chardigny et al., 2008; Bélanger et al., 2008) is limited because the durations of each diet used in the studies was only 3-4 weeks, the diets also contained different amounts of some specific saturated

fatty acids, and statistical power to detect some differences may have been limited (Willett & Mozaffarian, 2008). In addition, participants were selected to be leaner, younger men and women, whereas those at risk of heart disease typically are overweight persons who are middle-aged or older (Willett & Mozaffarian, 2008). Furthermore as both of the present studies acknowledge (Chardigny et al., 2008; Bélanger et al., 2008), the amount of TFA from dairy sources used in the studies greatly exceeded the intake of ruminant TFA in usual diets (Willett & Mozaffarian, 2008).

1.4 What are the Consumption Levels?

There is convincing evidence that a high intake of energy dense foods promotes weight gain (National Taskforce on Obesity, 2005). Energy dense foods tend to be high in fat, sugars or starch (WHO, 2003). The greatest contributors to fat intake in the Irish diet are meats (23%), spreads such as butter and margarine (17%), cakes and biscuits (9%) and milk and yoghurt (9%) (IUNA, 2001).

Data from 14 European countries (excluding Ireland) on vegetable fat spreads collected during 1995-96 indicated that vegetable fat spreads had TFA contents ranging from < 1% to 17% of total fat with mean daily intakes of TFA ranging from 1.2 to 6.7 grams/day (Hulshof et. al. 1999). However, the use of hydrogenated oil (HO) in vegetable spreads, margarines and shortenings has decreased since the mid 1990s in Europe, as several scientific publications have highlighted adverse effects, particularly cardiovascular risk factors (Mensink & Katan 1990; Zock & Katan 1992; Willet et. al. 1993; Willet & Ascherio 1994; Ascherio et. al. 1994; Zock & Mensink 1996; van de Vijver et al. 2000).

In 2004 the EFSA indicated that the intake of TFA varies between EU countries, with lowest intakes found in the Mediterranean countries (EFSA, 2004). TFA isomers account for about 4.5 % and 3% of total fatty acids in sheep and goat milks respectively, commonly consumed in Mediterranean countries. While the contribution of these two milks is low in most EU countries, in Greece sheep and goats milk fat can contribute up to 45% of the daily consumption of trans-11-vaccenic acid (Wolff, 1995). There is no specific data on the intake of TFA in Ireland (Irish Heart Foundation, 2007). However, one research study estimated the mean daily TFA intake at 5.4 g with margarine spreads providing the majority of TFA consumed (Cantwell et al., 2005). Recent dietary surveys have indicated that intake of TFA has decreased in a number of EU countries, mainly due to reformulation of food products, to reduce their TFA content (EFSA, 2004).

In 2002, the Panel on Macronutrients of the U.S. National Academies of Science, Institute of Medicine, recommended that TFA consumption be as low as possible while ensuring a nutritionally adequate diet. The Panel did not set a safe upper limit because the evidence suggested that any rise in TFA intake increased CHD risk (IM, 2002). Subsequently, in 2003, the World Health Organisation (WHO) recommended that TFA intake be limited to <1% of overall energy intake, a limit regarded by that body as a practical level of intake consistent with public health goals (WHO, 2003).

1.5 What's the Legal Situation?

In the EU, it is not mandatory for the presence or concentration of TFA to be mentioned on the labelling of food products (Directive 2000/13/EC). However, the law does state that all pre-packaged foods must have their ingredients listed on the packaging. If partially hydrogenated oil or hydrogenated oil (HO) is listed in the ingredients, this may suggest the presence of TFA. Also, ingredients are listed in decreasing amount; therefore TFA concentrations are likely to be higher in a product where partially hydrogenated oil or HO is listed as the first ingredient than a product where it is listed as the last ingredient (FSAI, 2007).

Regulation (EC) No 1924/2006 on nutrition and health claims indicates that a claim that a food is low in SAT fat, and any claim likely to have the same meaning for the consumer, may only be made if the sum of SAT fatty acids and TFA in the product does not exceed 1.5g per/100g for solids or 0.75g per/100 ml for liquids and in either case the sum of SAT fatty acids and TFA must not provide more than 10% of energy. A claim that a food is SAT fat free, and any claim likely to have the same meaning for the consumer, may only be made where the sum of SAT fat and TFA does not exceed 0.1 g of SAT fat per/100 g or 100 ml (Regulation EC No 1924/2006). Claims specifically related to TFA in products are not permitted under the current Regulation (Regulation EC No 1924/2006).

Commission Directive 96/4/EC on infant formulae and follow-on formulae, states that TFA shall not exceed 4% of total fat content and eurcic acid content shall not exceed 1% of total fat content in baby foods (Directive 96/4/EC). From January 1st 2008 Commission Directive 2006/141/EC reduced these concentrations to 3% and 1% respectively (Directive 2006/141/EC).

There is no legislation governing tolerance values for nutritional labelling under current EU legislation. However, the issue of tolerance values for nutrition labelling is currently being discussed at EU level along with other nutrition labelling issues.

In June 2003, Denmark became the first European country to introduce national legislation concerning TFA in food (Danish Government, 2003). Under this legislation, the level of industrially produced TFA either alone or as an ingredient in foodstuffs, must not exceed 2g per/100g of fats or oil in the product *(e.g. if a product has 10% fat the maximum TFA level allowed is 0.2% which equates to 2% of the fat content or 2g per/100g)* as sold to the final consumer (EFSA, 2004) [vi]. In products which are claimed to be "free from trans fatty acids", the content of trans fatty acids in the finished product shall be less than 1g per/100g of the individual oil or fat (Danish

[vi] The Danish legislation applies to oils and fats, including emulsions with fat as the continuous phase which, either alone or as part of processed foodstuffs, are intended, or are likely, to be consumed by humans. The legislation does not apply to the naturally occurring content of trans fatty acids in animal fats or products governed under other legislation (Danish Government, 2003; Stender & Dyerberg, 2003).

Government, 2003; Stender & Dyerberg, 2003). In 2005, Canada became the first country to regulate the mandatory labelling of TFA on pre-packaged foods (CFIA, 2003). In 2006, the United States introduced the mandatory declaration of TFA in foods containing ≥ 0.5g TFA per serving (FDA, 2003).

1.6 Can TFA be removed from Foods?

There are five broad technologies available which have the ability to minimise or remove industrial TFA in processed foods (Kodali, 2005). These technologies use formulation, modification, hydrogenation, fractionation and interesterification individually or in combination with each other to achieve a low or TFA free food product. More detail on these technologies is given in Appendix 1. The minimisation or elimination of TFA which occur naturally in foods is a more difficult process.

1.7 What's the FSAI Doing About TFA?

The EU is currently reviewing Council Directive 2000/13/EC that governs the content and format of nutrition labels on foods. The Food Safety Authority of Ireland (FSAI) believes that the mandatory labeling of the TFA and SAT content of foods would enable consumers to make healthier food choices that could lower LDL-C and reduce the risk of CHD and obesity. In light of further evidence becoming available the FSAI is establishing data on concentrations of TFAs in foods. A small preliminary survey of 100 retail foods has been completed and the results of this survey are now presented. A further survey of TFA in fast-foods is planned for 2008. The FSAI will send the results of these surveys to the European Commission for consideration during negotiations of the labelling legislation.

2. Methods of Analysis

2.1 Total Fat by Acid Hydrolysis

Samples were hydrolysed with dilute hydrochloric acid to liberate fat that may be bound to protein. The digested sample was then filtered, washed, dried and extracted with petroleum ether and the total fat calculated.

2.2 Fatty Acid Profile

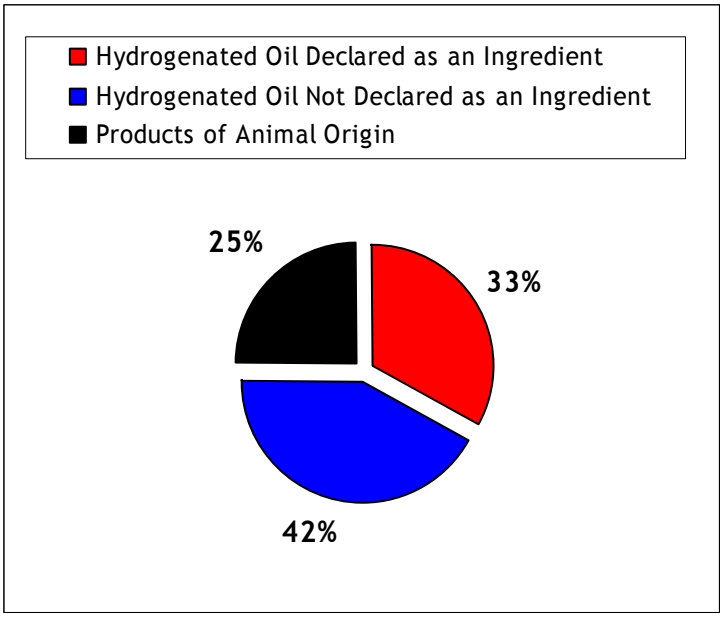
The fat extracted from the sample was transesterified to the methyl ester of the fatty acid. The methyl esters formed, were separated on a highly polar capillary gas chromatography column. Individual fatty acids were then identified by comparison of retention times to known standards. The fatty acid profile for each sample was calculated by area percentage normalisation of the individual fatty acid methyl esters found. Individual fatty acids were detected at a concentration of 0.1% in the extracted fat, equating to a limit of quantification of 0.1g/100g.

3. Results and Discussion

3.1 General Results

One hundred retail food products were analysed for total fat content and fatty acid profile including TFA. The samples comprised a randomly selected cross-section of products which would be expected to naturally contain TFA *(e.g. cheese, lamb)*, and those which may industrial TFA as a result of the manufacturing process *(e.g. fried food)* or ingredients *(e.g. hydrogenated oil)*. Products making a claim as regards TFA or the absence of HO were also sampled in the survey (Figure 1).

Figure 1 Cross Section of 100 Products Surveyed [a]



[a] 9% of products surveyed made a claim in relation to TFA

As a basis for indicating high and low concentrations of TFA (Danish Government, 2003) and SAT fat (Adapted From: Regulation (EC) No 1924/2006) in the results the following classification is used:

- **Low TFA** = ≤ 2% of total fat in the product
- **High TFA** = ≥ 2% of total fat in the product
- **Low SAT** (i.e. SAT Fat + TFA) = ≤ 1.5% per/100g of product [vii]
- **High SAT** (i.e. SAT Fat + TFA) = ≥ 1.5% per/100g of product [v]

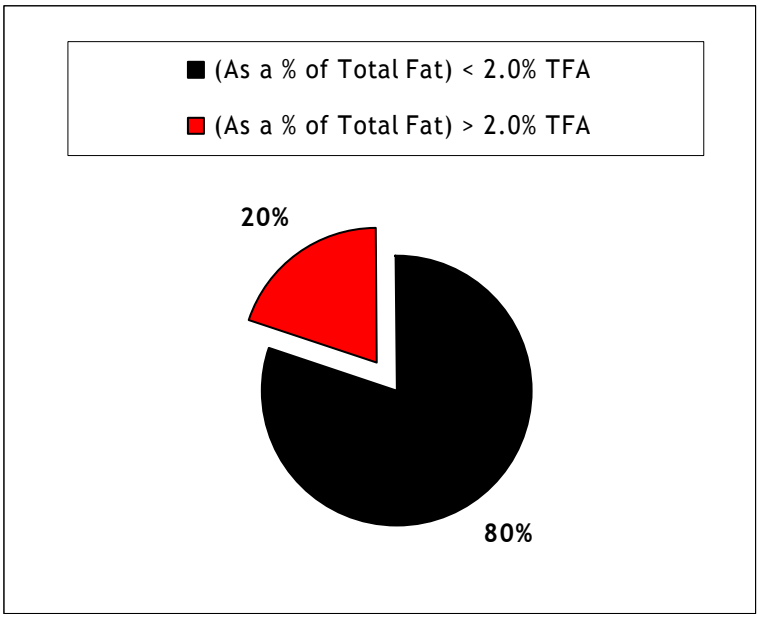
The natural presence of TFA in products of animal origin produced or prepared without HO was not the focus of the current survey. Therefore results for the survey are presented under the following headings:

[vii] It's not clear from the legislation if ≤ or ≥ 1.5% per/100g relates to 100g of product or 100g of oil/fat. However, it is assumed that it relates to 100g of product.

- Products Declaring HO on the Ingredients List
- Products Not Declaring HO on the Ingredients List
- Products of Animal Origin Not Declaring HO on the Ingredients List

Results indicate that in general concentrations of TFA in products surveyed are low *(i.e. ≤2% TFA as a percentage of total fat)*[viii]. Eighty percent of products surveyed contained ≤2% TFA (Figure 2). Twenty percent of products surveyed were high in TFA *(i.e. ≥2% TFA as a percentage of total fat)*.

Figure 2 General Levels of TFA in Products Surveyed [a]



[a] 57% of samples having ≤*2% TFA* were ≤0.1% TFA *(i.e. limit of detection)*

[viii] Concentrations of TFA in products surveyed should be read in conjunction with SAT fat when commenting on their effects on serum LDL-C and the perceived increased risk for CHD. SAT fat and TFA raise total cholesterol and LDL-C and are known to increase the risk of CHD, while dietary unsaturated fatty acids play important roles in maintaining cardiovascular health (Irish Heart Foundation, 2007).

3.2 Products Declaring HO on the Ingredients List

3.2.1 Study of TFA and SAT Fat Content

The primary reasons for hydrogenating oil are to improve its oxidative stability and increase the proportion of solid to liquid fats (EFSA, 2004; Jang et al. 2005; Kodali, 2005). Based on manufacturer's ingredient declarations[ix], 33 of the 100 samples surveyed contained HO *(Table 1)*. Eleven of these 33 products were high in TFA *(i.e. ≥ 2% total fat content)* and 22 were low in TFA (*i.e. ≤ 2% of total fat content*) where 16 of these 22 had ≤ 0.1% TFA *(Table 1)*. However, in 17 of the 33 products SAT fats level were ≥ 50% of the total fat content *(Table 1)*.

Dried gravy mixes, dried soup mixes followed by vegetable fat spreads contained the highest concentrations of TFA *(Table 1)*. The concentration of TFA in products which contained HO ranged from < 0.1% to 22.5% of total fat *(Table 1)*. This variance in TFA content perhaps reflects the differences in ingredients used and manufacturing processes applied to these products. Typically, it would be expected that standard hydrogenation techniques would lead to products which contain TFA. However, the current results suggest that this relationship is not consistent and the declared presence of HO doesn't necessarily relate to the presence of TFA in some products *(Table 1)*.

[ix] An "ingredient" is defined as any substance including additives, used in the manufacture or preparation of a foodstuff and still present in the finished product even if in an altered form (Directive 2000/13/EC).

Table 1 Fat Profile of Products Declaring HO on the Ingredients List [a]

(Code) Product	% Total Fat [c]	% TFA [b]	% SAT [b]	% MUFA [b]	% PUFA [b]
(1) Vegetable Fat Spread 70% [e]	67.9	7.2	19.4	49.3	19.4
(9) Vegetable Fat Spread 70% [e]	69	5.6	17.2	53.0	19.7
(18) Vegetable Fat Spread 70% [e]	68.9	5.5	23.1	47.9	19.0
(7) Reduced Fat Spread 59% [f]	59.1	10.4	13.4	52.9	18.8
(12) Frozen Cheese Pizza	10.7	< 0.1	63.4	24.0	8.1
(24) Frozen Cheese & Tomato Pizza	7.8	< 0.1	53.7	28.4	13.5
(13) Frozen Pepperoni Pizza	10.8	< 0.1	54.3	34.0	7.3
(23) Frozen Pepperoni Pizza	9.9	< 0.1	48.1	33.9	13.6
(33) Frozen Pepperoni Pizza	7	< 0.1	45.4	38.1	12.0
(35) Frozen Pepperoni Pizza	10.5	< 0.1	50.6	32.4	12.6
(55) Chocolate Sandwich Bar	28.4	< 0.1	58.3	31.8	5.5
(57) Chocolate Sandwich Bar	26.3	1.7	55.5	32.8	5.5
(58) Chocolate Sandwich Bar	22.9	0.1	57.2	31.3	6.9
(59) Chocolate Biscuit & Caramel Bar	20	< 0.1	53.4	34.6	7.6
(65) Wafer Biscuit	26.2	1.6	80.5	10.6	2.9
(68) Mince Pies	17.1	1.1	45.7	34.2	14.5
(79) Cereal & Milk Bar	10.9	< 0.1	86.3	7.5	1.8
(80) Cereal & Milk Bar	11.3	< 0.1	84.2	9.3	2.0
(99) Hazelnut Milk Chocolate Spread	33.4	2.3	13.2	50.2	29.8
(71) Dried Chicken Soup [d]	16.7	10.7	48.4	31.3	5.1
(74) Dried Chicken & Croutons Soup [d]	25.2	1.8	29.9	45.6	18.2
(75) Dried Chicken & Bacon Soup [d]	23.4	10.6	48.9	32.1	3.9
(72) Dried Beef & Vegetable Soup [d]	6.9	10.6	48.6	32.0	4.3
(73) Dried Tomato Soup [d]	8.4	10.7	50.9	32.7	1.3
(95) Dried Gravy [d]	15.5	< 0.1	62.2	28.0	5.4
(96) Dried Gravy [d]	19.6	22.5	50.5	21.1	1.4
(97) Dried Gravy [d]	13	18.6	54.8	21.1	1.1
(83) Dried Pasta & Mushroom Meal [d]	11.6	< 0.1	54.2	32.9	8.4
(84) Dried Pasta Carbonara Meal [d]	13.6	< 0.1	53.9	33.3	8.1
(51) White Burger Buns	3.8	< 0.1	13.4	47.8	35.4
(76) Tortillas	11.2	1.1	35.9	42.0	16.5
(77) Tortillas	11.2	1.3	35.8	41.4	16.9
(50) Processed Chicken in Crumb	8.3	< 0.1	17.4	24.0	54.1

TFA = Trans fatty acids; **SAT** = Saturated fatty acids; **MUFA** = Monounsaturated fatty acids; **PUFA** = Polyunsaturated fatty acids

[a] As stated in manufacturers list of ingredients

[b] As a percentage of total fat

[c] Grams per/100g of Product as sold

[d] As dry product sold

[e] Fat Spread X % = Products obtained from vegetable and/or animal fats with fat contents of <39%; 41-60% or 62-80%. Under Article 3:4 of Reg (EC) 2991/94 the term **"Vegetable"** can be used (Regulation (EC) No 2991/94).

[f] Under Article 5 of Reg (EC) 2991/94 the term **"Reduced-Fat"** can be used with products having 41% fat but not greater than 62% (Regulation (EC) No 2991/94)

The food industry has developed a number of technologies to minimise the formation of industrial TFA in products which contain HO. These technologies include re-formulation of oils *(e.g. reformulation has a number of variations but commonly it involves blending partially hydrogenated oils with high oleic acid vegetable oils such as canola, peanut and palm oils)*, manipulation of hydrogenation techniques *(e.g. increasing pressure, catalyst concentration and agitation during hydrogenation to decrease TFA formation)* and the use of specialised hydrogenation techniques such as supercritical fluid state hydrogenation (Jang et. al. 2005).

It is unclear whether any of the above TFA reduction technologies have been employed by the manufacturers of products surveyed which contain HO. However, the use of these technologies maybe a contributing factor to the low TFA concentrations (i.e. ≤ 0.1%) seen in 16 samples declaring HO as an ingredient *(Table 1)*. Alternatively there may also be issues in relation to inaccuracies in ingredient declarations on product labels which could impact on levels of TFA. Further detail on TFA reduction technologies is outlined in Appendix 1.

Also impacting on the perceived concentration of TFA in a product, is the position of the HO ingredient in the product's ingredient declaration. Manufacturers are required to list ingredients in order of the descending quantity/concentration (Council Directive 2000/13/EC). As such the presence of HO at the start of an ingredient declaration may indicate a higher concentration than if it is at the end of the declaration. However, some samples such as frozen pizza had < 0.1% TFA even when listing HO as an ingredient *(Table 1) (i.e. Samples 12-13, 23-24, 33 and 35).* The low levels of TFA in frozen pizza maybe explained by the fact that the HO ingredient was a component of added vegetable oil and was not presented at the start of the ingredient listing. This suggests the concentrations of HO were low which may have resulted in the low TFA levels *(Table 1)*.

Of the 33 of the 100 samples surveyed contained HO *(Table 1)* 29 products were high in SAT fat *(i.e. SAT Fat + TFA ≥ 1.5% per/100g) (Table 2)*. Some products such as cereal and milk bars *(i.e. Samples 79-80)* had SAT fat concentrations of greater than 84% of their total fat content *(Table 1)* or 9.4 and 9.5g respectively of SAT fat per/100g of product. Based on a 20g portion size for these products *(i.e. Samples 79-80)*, this represents approximately 1.9g of SAT fat per portion *(Table 2)* or approximately 6%/10% respectively of an adult male/females guideline daily amount (GDA) [x] *(i.e. as per manufacturers labelling)*.

[x] Some foods provide data about the GDA which is derived from the estimated mean requirements for energy for men/women (2500 & 2000kcal respectively), aged 19-50, of normal weight and fitness. GDA are intended to guide consumers in understanding the recommended daily consumption of energy, fat and saturates and a base against which the content of individual foods can be compared.

Table 2 TFA and SAT Fat per Serving of Products Declaring HO on the Ingredients List [a]

(Code) Product	Serving Size (g) [b]	Total Fat (g) [c]	TFA (g) [c]	SAT (g) [c]	TFA + SAT (g)
(1) Vegetable Fat Spread 70%	10	6.79	0.49	1.32	1.81
(9) Vegetable Fat Spread 70%	10	6.90	0.39	1.19	1.57
(18) Vegetable Fat Spread 70%	10	6.89	0.38	1.59	1.97
(7) Reduced Fat Spread 59%	10	5.91	0.61	0.79	1.41
(12) Frozen Cheese Pizza	200	21.40	0	13.57	13.57
(24) Frozen Cheese & Tomato Pizza	200	10.06	0	5.40	5.40
(13) Frozen Pepperoni Pizza	141	21.60	0	11.73	11.73
(23) Frozen Pepperoni Pizza	129	13.96	0	6.71	6.71
(33) Frozen Pepperoni Pizza	172	12.04	0	5.47	5.47
(35) Frozen Pepperoni Pizza	235	24.68	0	12.49	12.49
(55) Chocolate Sandwich Bar	26	7.38	0	4.30	4.30
(57) Chocolate Sandwich Bar	28	7.36	0.13	4.09	4.21
(58) Chocolate Sandwich Bar	24	5.50	0.01	3.14	3.15
(59) Chocolate Biscuit & Caramel Bar	25	5.00	0	2.67	2.67
(65) Wafer Biscuit	7.3	1.91	0.03	1.54	1.57
(68) Mince Pies	53	9.06	0.10	4.14	4.24
(79) Cereal & Milk Bar	20	2.18	0	1.88	1.88
(80) Cereal & Milk Bar	20	2.26	0	1.90	1.90
(99) Hazelnut Milk Chocolate Spread	15	5.01	0.12	0.66	0.78
(71) Dried Chicken Soup	50	8.35	0.89	4.04	4.93
(74) Dried Chicken & Croutons Soup	68	5.54	0.10	1.66	1.76
(75) Dried Chicken & Bacon Soup	68	5.85	0.62	2.86	3.48
(72) Dried Beef & Vegetable Soup	22	4.69	0.50	2.28	2.78
(73) Dried Tomato Soup	25	5.71	0.61	2.91	3.52
(95) Dried Gravy	28	4.34	0	2.70	2.70
(96) Dried Gravy	28	5.49	1.23	2.77	4.01
(97) Dried Gravy	56	7.28	1.35	3.99	5.34
(83) Dried Pasta & Mushroom Meal	87	10.09	0	5.47	5.47
(84) Dried Pasta Carbonara Meal	87	11.83	0	6.38	6.38
(51) White Burger Buns	20	0.76	0	0.10	0.10
(76) Tortillas	58	6.50	0.07	2.33	2.40
(77) Tortillas	41	4.59	0.06	1.64	1.70
(50) Processed Chicken in Crumb	100	8.30	0	1.44	1.44

[a] As stated in manufacturers list of ingredients

[b] Manufacturers suggested serving/portion size in grams. No Suggested Serving Size: **(7, 9 & 18)** taken as 10g; **(50)** taken as 100g; **(51)** N/S taken as 20g; **(71-75)** taken per dry portion; **(76-77)** taken as one Tortilla; **(95-96)** taken per dry portion as 2 heaped tablespoons of 14g each as per manufacturers instruction for making up gravy; **(97)** taken per dry portion as 4 heaped tablespoons of 14g each as per manufacturers instruction for making up gravy

[c] Based on results shown in Table 1

However, there are currently no GDA values for children. Three samples of frozen pizza *(i.e. 12, 13 & 35)* provided over 11g of SAT fat per portion *(Table 2)* or approximately 43%/68% respectively of adult male/females GDA for SAT fat.

[xii] The natural presence of TFA in these products (including fish products) was not the focus of the current survey.

3.2.2 Study of TFA Isomers

The EFSA has indicated that there is no method which permits naturally occurring TFA to be distinguished from industrial TFA (EFSA, 2004). This is because of the overlap in TFA profiles of ruminant fats and hydrogenated oils and the varying proportions of TFA isomers among different hydrogenated fats (EFSA, 2004).

Broadly speaking the current survey results would confirm the above assessment by EFSA. Using the ratio of trans-9-elaidic acid to trans-11-vaccenic acid to differentiate between industrial TFA *(i.e. hydrogenation)* and natural TFA from ruminant animals *(i.e. biohydrogenation)* is not always reliable. The TFA content and type of TFA isomer identified in surveyed products containing HO varied considerably *(Table 3)*. Trans-9-elaidic acid *(i.e. the trans isomer of oleic acid [18:1 trans-9])* is a major TFA associated with hydrogenated vegetabale oils and also occurs naturally in small amounts in runinant milk and meat products (Alonso et.al. 1999; MAFF 1998).

Sample 1 *(i.e. 70% vegetable fat spread)* contained trans-9-elaidic acid and trans-11-vaccenic acid *(Table 3)*. The ratio of trans-9-elaidic acid to trans-11-vaccenic acid was approximately 2.6:1 *(Table 3)* of total TFA *(Table 1)* contributed by the HO and buttermilk used as ingredients in the product. Sample 7 *(i.e. 59% reduced Fat Spread)* contained < 0.1% trans-9-elaidic acid and 91.67% trans-11-vaccenic acid which was unexpected as the only product of ruminant origin in sample 7 was reconstituted skimmed milk powder *(Table 3)*.

Overall, there was not necessarily a correlation between the presence of ruminant derived ingredients in products and the presence or increased concentration of trans-11-vaccenic acid. Sample 57 for example contained whole milk powder, whey powder, skimmed milk powder, milk fat and HO. However, the TFA isomer trans-9-elaidic acid made up 100% of the total TFA identified in sample 57 *(Table 3)*. Likewise there was no observed correlation between the presence of HO oil ingredients in a product and the presence and increased concentration of trans-9-elaidic acid. For example, samples 7, 9, 12 & 13 which listed HO as an ingredient contained < 0.1% trans-9-elaidic acid *(Table 3)*.

Table 3 TFA Isomers in Products Declaring HO on the Ingredients List

(Code) Product	% Trans-Palmitoleic Acid [a]	% Petroselenic Acid [a]	% Elaidic Acid [a]	% Vaccenic Acid [a]	% Linolelaidic Acid [a]
(1) 70% Vegetable Fat Spread	< 0.1	< 0.1	72.22	27.78	< 0.1
(7) 59% Reduced Fat Spread	< 0.1	< 0.1	< 0.1	91.67	8.33
(9) 70% Vegetable Fat Spread	< 0.1	< 0.1	< 0.1	91.38	8.62
(12) Frozen Cheese Pizza	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(13) Frozen Pepperoni Pizza	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(18) 70% Vegetable Fat Spread	< 0.1	< 0.1	70.18	24.56	5.26
(23) Frozen Pepperoni Pizza	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(24) Frozen Cheese/Tomato Pizza	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(33) Frozen Pepperoni Pizza	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(35) Frozen Pepperoni Pizza	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(50) Popcorn Style Chicken	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(51) Burger Bread Buns	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(55) Chocolate Sandwich Bar	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(57) Chocolate Sandwich Bar	< 0.1	< 0.1	100	< 0.1	< 0.1
(58) Chocolate Sandwich Bar	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(59) Chocolate Biscuit/Caramel Bar	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(65) Wafer Biscuit	< 0.1	< 0.1	69.90	29.12	< 0.1
(68) Mince Pies	< 0.1	< 0.1	75.00	25.00	< 0.1
(71) Dried Cream Of Chicken Soup	< 0.1	< 0.1	66.36	29.91	3.74
(72) Dried Beef & Vegetable Soup	< 0.1	< 0.1	62.16	34.23	3.60
(73) Dried Cream Of Tomato Soup	< 0.1	< 0.1	92.86	< 0.1	7.14
(74) Dried Cream Of Chicken/Croutons Soup	< 0.1	< 0.1	73.68	26.32	< 0.1
(75) Dried Creamy Chicken/Bacon Soup	< 0.1	< 0.1	68.47	31.53	< 0.1
(76) Tortillas	< 0.1	< 0.1	66.67	33.33	< 0.1
(77) Tortillas	< 0.1	< 0.1	64.29	35.71	< 0.1
(79) Cereal & Milk Bar	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(80) Cereal & Milk Bar	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(83) Dried Pasta Mushroom Meal	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(84) Dried Pasta Carbonara Meal	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(95) Dried Gravy	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
(96) Dried Gravy	< 0.1	61.02	22.03	12.29	4.66
(97) Dried Gravy	< 0.1	< 0.1	70.10	29.90	< 0.1
(99) Hazelnut Milk Chocolate Spread	< 0.1	< 0.1	66.67	33.33	< 0.1

a As a percentage of total TFA (Table 1)

Sample 96 contained beef fat unlike samples 95 or 97, this would be assumed to contribute towards the level of TFA and the type of the TFA isomers found *(Table 1 and 3)*. However, analysis of the TFA isomers in sample 96 indicated that only 12.29% of the total TFA was trans-11-vaccenic acid, which was lower than sample 97 (29.90%), which listed no ingredients of animal origin *(Table 3)*.

Dried soup samples *(i.e. 71-75)* had the highest percentage trans-9-elaidic acid with sample 73 having the highest overall with 92.9% of total TFA been trans-9-elaidic acid *(Tables 2-3)*. The presence of high concentrations of trans-9-elaidic acid was expected in these dried soup samples based on the presence of HO

and its position at or near the start of all of these products ingredient declarations.

3.2.3 Labelling Declarations

The descriptors hydrogenated and partially hydrogenated on food labels are often used interchangeably on food ingredient labels, but both indicate the possible presence of TFA in a food product. However, the means by which oil and fat ingredients was listed in ingredient declarations of products surveyed differed markedly between samples *(Table 4)*. In particular the declaration to designate the presence of HO or fats was confusing with many different descriptors been used *[e.g. Hydrogenated Vegetable Oil, Partially Hydrogenated Vegetable Oil, Refined Vegetable Oil & Partially Hydrogenated Animal Oil, Vegetable Oil (Including Hydrogenated Vegetable Oil), Hydrogenated Vegetable Oil (Including Vegetable Oil)]*.

Many products also had combinations of ingredients such as HO, partially hydrogenated oil, animal fats, vegetable fats and vegetable oils containing hydrogenated or partially hydrogenated oil ingredients. This makes the interpretation of labelling for the presence of HO difficult for the consumer *(Table 4)*.

Technically, oil that has been fully hydrogenated will contain no TFA. Thus oils/fats which are partially hydrogenated should have variable amounts of TFA depending on the extent of hydrogenation. It would appear based on ingredient declarations and analyse results that sample 95 perhaps contained fully HO *(i.e. % TFA = <0.1%)* and samples 96-97 contained partially HO of different degrees of hydrogenation *(Table 4)*. The SAT fat content of sample 95 *(i.e. 62.2%)* was higher than 96 *(i.e. 50.5%)* and 97 *(i.e. 54.8%)* respectively which would support this hypothesis *(Table 1)*.

Table 4 Ingredient Declarations on Products Declaring HO on the List of Ingredients

(Code) Product	PHVO/F	RVO & PHAO	AF	VO/F with HVO/F	HVO/F	HVO/F with VO/F
(1) 70% Vegetable Fat Spread	ND	ND	**D**	ND	**D**	ND
(7) 59% Reduced Fat Spread	ND	ND	ND	ND	**D**	ND
(9) 70% Vegetable Fat Spread	ND	ND	**D**	ND	**D**	ND
(12) Frozen Cheese Pizza	ND	ND	ND	**D**	ND	ND
(13) Frozen Pepperoni Pizza	ND	ND	**D**	**D**	ND	ND
(18) 70% Vegetable Fat Spread	ND	ND	**D**	ND	**D**	ND
(23) Frozen Pepperoni Pizza	ND	ND	**D**	ND	**D**	ND
(24) Frozen Cheese/Tomato Pizza	ND	ND	**D**	ND	**D**	ND
(33) Frozen Pepperoni Pizza	ND	ND	**D**	ND	**D**	ND
(35) Frozen Pepperoni Pizza	**D**	ND	**D**	ND	ND	ND
(50) Popcorn Style Chicken	ND	ND	ND	ND	**D**	ND
(51) Burger Bread Buns	ND	ND	ND	ND	**D**	ND
(55) Chocolate Sandwich Bar	ND	ND	ND	ND	**D**	ND
(57) Chocolate Sandwich Bar	ND	ND	ND	**D**	ND	ND
(58) Chocolate Sandwich Bar	D	ND	ND	**D**	ND	ND
(59) Chocolate Biscuit/Caramel Bar	ND	ND	ND	ND	**D**	ND
(65) Wafer Biscuit	ND	ND	ND	**D**	ND	ND
(68) Mince Pies	ND	**D**	ND	**D**	ND	**D**
(71) Dried Cream Of Chicken Soup	ND	ND	ND	ND	**D**	ND
(72) Dried Beef & Vegetable Soup	ND	ND	ND	ND	**D**	ND
(73) Dried Cream Of Tomato Soup	ND	ND	ND	ND	**D**	ND
(74) Dried Cream Of Chicken/Croutons Soup	ND	ND	ND	ND	**D**	ND
(75) Dried Creamy Chicken/Bacon Soup	ND	ND	ND	ND	**D**	ND
(76) Tortillas	**D**	ND	ND	ND	ND	ND
(77) Tortillas	**D**	ND	ND	ND	ND	ND
(79) Cereal & Milk Bar	ND	ND	**D**	ND	**D**	ND
(80) Cereal & Milk Bar	ND	ND	**D**	ND	**D**	ND
(83) Dried Pasta Mushroom Meal	ND	ND	ND	ND	**D**	ND
(84) Dried Pasta Carbonara Meal	ND	ND	ND	ND	**D**	ND
(95) Dried Gravy	ND	ND	ND	ND	**D**	ND
(96) Dried Gravy	ND	ND	**D**	ND	**D**	ND
(97) Dried Gravy	ND	ND	ND	ND	**D**	ND
(99) Hazelnut Milk Chocolate Spread	**D**	ND	ND	ND	ND	ND

D = Declared as an Ingredient; **ND** = Not Declared as an Ingredient; **PHVO** = Partially Hydrogenated Vegetable Oil or Fat; **PHAO** = Partially Hydrogenated Animal Oil; **RVO** = Refined Vegetable Oil; **VO/F** = Vegetable Oil or Fat; **VF** = Vegetable Fat; **AF** = Animal Fat; **HVO/F** = Hydrogenated Vegetable Oil or Fat; **HVF** = Hydrogenated Vegetable Fat

3.3 Products Not Declaring HO on the Ingredients List

Based on manufacturer's ingredient declarations, 42 of the 100 samples surveyed contained no HO *(Table 5)*. Fourteen products contained TFA at concentrations ≥ 0.1% total fat with only one of these having a high *(i.e. ≥ 2% total fat)* TFA level *(Table 5)*. However, overall concentrations of TFA were significantly lower in products not declaring HO on the ingredient list *(Table 5)* than those containing HO *(Table 1)*. Concentrations of SAT fats in products were high *(Table 5)*. In ten of 42 products produced or prepared without HO *(Table 5)* concentrations of SAT fats was > 50% of total fat content.

The current results indicate that only 4 out 12 vegetable spread samples surveyed contained HO. Of the vegetable spread samples not containing HO *(Table 5)* all products except sample 2, had a TFA concentration equal to or lower than 0.5%. In sample 2 the ratio of trans-9-elaidic acid to trans-11-vaccenic acid was approximately 2.67:1 *(Table 3)* of total TFA. However, the high concentration of trans-9-elaidic acid would not be expected with this product as it contains reconstituted buttermilk and butter but no HO. The results suggest TFA, in particular trans-9-elaidic acid is the result of other ingredients or the processing they have received or perhaps inaccurate ingredient declarations on the product label.

Samples 3-5, 8 and 41-42 while containing no HO, also contain small concentrations of TFA *(Table 5)*. Small concentrations of TFA in sample 4, 5 and 8 may be the result of specific ingredients used in the products. For example, in sample 4, fish oils and non-fat milk solids were ingredients while in sample 5, cream was an ingredient and reconstituted buttermilk (9%) was an ingredient in sample 8. These ingredients are also a source of natural trans fats. The fatty acid profile of the samples 4-5, and 8 indicated that the predominate TFA isomer was trans-11-vaccenic acid in all samples. Trans-9-elaidic acid was < 0.1% in all samples *(Table 5)*. Samples 41-42 contained buttermilk powder as an ingredient but the predominat TFA isomer was trans-9-elaidic acid.

The results for samples 41-42 suggest that the low concentrations of TFA are the result of other ingredients and/or the processing that the product or its ingredients have received *(Table 5)*. In both samples 41 and 42 vegetable oils of varying types were present. Sample 60 had a low concentration of TFA *(i.e. 0.4%)* but listed no ingredients of animal origin or HO. However, as the sample contained vegetable oil it is possible that minor amounts of industrial TFA were formed during the refining of that oil *(e.g. deodorisation of vegetable oil)*. Industrial TFA are also formed in small amounts during the heating and frying of oils at high temperatures (EFSA, 2004; IFST, 2007). However, it is unclear whether vegetable oils used in samples 41-42 and 60 were refined or heated and as such contributed to the TFA content of these samples *(Table 5)*.

Table 5 Fat Profile of Products Not Declaring HO on the Ingredient List

(Code) Product	% Total Fat [a]	% TFA [b]	% SAT [b]	% MUFA [b]	% PUFA [b]
(2) Reduced Fat Blend 59%	59.7	6.6 [c]	20.1	49.4	19.3
(3) Reduced Fat Blend 59%	58.9	0.2	23.5	54.3	17.5
(4) Low Fat Spread 38% *(With Omega 3)*	40.4	0.5	24.2	50.2	20.7
(5) Blended Spread 73%	68.2	0.25	41.2	41.1	12.9
(6) Vegetable Fat Spread 59%	60.9	< 0.1	17.9	23.4	54.2
(8) Vegetable Fat Spread 59%	54.0	0.5	25.9	49.0	20.1
(41) Vegetable Fat Spread 59%	54.2	0.3	19.8	25.7	49.8
(42) Reduced Fat Spread 55% *(added plant sterols)*	60.8	0.3	20.0	53.6	21.7
(34) Frozen Pizza	4.8	< 0.1	47.3	35.6	12.6
(36) Cheese, Chicken & Crackers Snack	17.6	< 0.1	52.5	34.4	8.7
(37) Cheese, Ham, & Crackers Snack	17.0	< 0.1	53.1	33.8	8.7
(38) Cheese, Ham, & Tortilla Snack	8.2	< 0.1	50.4	34.7	10.5
(39) Cheese & Cracker Snack	11.6	< 0.1	55.2	32.9	7.4
(40) Cheese & Breadstick Snack	8.7	< 0.1	72.8	18.0	4.7
(52) White Burger Buns	8.3	< 0.1	17.4	24.0	54.1
(53) Fig Filled Biscuits	5.2	< 0.1	44.6	36.9	14.1
(54) Fig Filled Biscuits	7.6	< 0.1	47.5	36.5	11.5
(56) Chocolate & Wafer Bar	23.3	0.15	65.8	26.3	3.3
(60) Cream Crackers	14.2	0.4	47.2	35.1	12.9
(61) Cream Crackers	14.2	< 0.1	46.7	35.9	13.0
(62) Crackers	21.9	< 0.1	54.3	31.1	10.1
(63) Crackers	27.9	< 0.1	76.6	13.9	5.1
(64) Cheese Flavoured Crackers	25.2	0.15	49.0	36.1	10.4
(66) Mince Pies	16.8	< 0.1	45.9	38.3	11.4
(67) Mince Pies	14.5	< 0.1	39.4	40.0	16.2
(69) Mince Pies	22.1	0.2	37.7	42.6	15.1
(70) Mince Pies	15.8	< 0.1	32.1	45.3	18.2
(78) Tortillas	7.0	< 0.1	86.3	7.5	1.8
(81) Dried Pasta Meal [d]	8.3	< 0.1	47.8	37.9	9.9
(82) Dried Pasta Meal [d]	6.2	< 0.1	48.2	37.4	9.9
(85) Cheese & Onion Crisps	28.3	< 0.1	10.5	21.3	63.8
(86) Cheese & Onion Crisps	32.5	< 0.1	10.4	21.9	63.2
(87) Cheese & Onion Crisps	31.2	< 0.1	6.8	82.7	6.1
(88) Sour Cream & Onion Crisps	31.9	0.3	28.1	34.4	32.8
(89) Cheese Flavour Corn Chips	27.2	< 0.1	43.5	38.8	13.2
(90) Jarred Curry Sauce	6.9	< 0.1	28.6	24.2	42.8
(91) Jarred Curry Sauce	6.8	0.4	23.8	49.5	21.8
(92) Jarred Curry Sauce	8.2	< 0.1	61.2	15.5	18.9
(93) Jarred Curry Sauce	4.7	< 0.1	44.9	37.3	13.5
(94) Jarred Curry Sauce	11.2	< 0.1	38.3	36.7	20.5
(98) Hazelnut Chocolate Spread	28.8	< 0.1	31.5	52.3	11.8
(100) Chocolate Spread	35.4	0.2	22.2	52.2	21.0

[a] Grams per/100g

[b] As a percentage of total fat

[c] Equivalent to 3.9% TFA per/100g of product

[d] As dry product sold

3.4 Products of Animal Origin Not Declaring HO on the Ingredients List [xii]

Based on manufacturers' ingredient declarations, 25 of the 100 samples surveyed were of animal origin and contained no HO *(Table 6)*. Twelve products contained TFA at concentrations ≥ 0.1% total fat with eight having a high *(i.e. ≥ 2% total fat)* TFA level *(Table 6)*.

Table 6 Fat Profile of Products of Animal Origin Not Declaring HO on the Ingredient List

(Code) Product [a]	% Total Fat [c]	% TFA [d]	% SAT [d]	% MUFA [d]	% PUFA [d]
(10) Irish Butter [e]	83.2	4.7	60.9	27.5	2.4
(11) Irish Butter [e]	84.7	2.1	66.2	24.3	2.1
(28) Irish Cheddar	29.0	4.1	65.9	23.5	2.1
(29) Irish Cheddar	30.6	5.5	65.6	22.1	2.2
(30) Irish Cheddar	31.5	6.9	69.6	16.5	2.4
(31) Irish Cheddar	32.5	6.3	61.3	25.2	2.6
(32) English Cheddar	30.6	5.2	65.8	22.3	2.3
(19) Fresh Chicken Breast	0.90	< 0.1	27.9	48.5	19.2
(20) Fresh Boneless Pork Chops	18.6	< 0.1	37.3	44.1	14.2
(21) Fresh Striploin Beef Steak	5.5	1.9	45.2	45.3	3.2
(22) Fresh Lamb Gigot Chops	19.2	9.0	49.1	43.7	3.7
(14) Frozen Cod in Crumb	9.2	< 0.1	9.4	36.7	49.5
(15) Frozen Cod in Crumb	9.4	< 0.1	9.1	26.0	60.5
(16) Frozen Cod in Crumb	10.0	< 0.1	9.4	25.5	60.9
(48) Frozen Cod in Crumb	7.4	< 0.1	10.4	26.3	58.8
(27) Frozen Skinless Cod [b]	<0.1	< 0.1	< 0.1	< 0.1	< 0.1
(43) Pork Sausages	19.4	< 0.1	36.8	44.5	14.3
(44) Pork Sausages	24.6	1.4	35.6	43.2	15.3
(45) Pork Sausages	26.1	< 0.1	37.8	39.3	18.4
(46) Pork Sausages	29.5	0.7	37.3	41.4	16.1
(47) Pork Sausages	25.9	0.8	36.6	40.5	17.7
(17) Processed Chicken in Crumb	18.2	< 0.1	15.8	51.8	28.0
(25) Processed Chicken in Crumb	16.3	< 0.1	11.5	56.1	27.9
(26) Processed Chicken in Crumb	9.4	< 0.1	18.0	29.2	48.4
(49) Processed Chicken in Crumb	14.9	< 0.1	15.7	34.8	45.1

[a] Sample 50 (Table 1) was also a processed chicken in crumb product. However, this product included HO as an ingredient and is therefore not included in Table 6

[b] Sample 27 was chosen as a control which contains no TFA and < 0.1% total fat (MAFF, 1998)

[c] Grams per/100g

[d] As a percentage of total fat

[e] Mean values for total TFA in Danish butter from one study were 4.8% (as a percentage of total fat). However levels of TFA were 29% greater during the outdoors pasture-feeding season than during the indoors feeding season (Jakobsen et al. 2006)

Concentrations of TFA, while similar to products declaring HO on the ingredients list *(Table 1)* and higher in some cases than non-animal origin products with no declared HO on their ingredients lists *(Table 5),* may have a different significance to public health (Mossoba *et al.,* 2003; EFSA, 2004; Kodali, 2005; IFST, 2007). Concentrations of SAT fats in products were high *(Table 6)*. In seven of 25 products of animal origin produced or prepared without HO *(Table 6)* concentrations of SAT fats was > 50% of total fat content.

Natural sources of TFA are ruminant lipids supplied in the diet by milk, dairy products and ruminant meat *(e.g. beef, lamb)* and are characterised by different TFA isomeric distributions and contents than industrial TFA (Mossoba et. al. 2003). As expected the ratio of trans-11-vaccenic acid was higher than trans-9-elaidic acid in samples of ruminant origin *(Table 7)*.

Table 7 TFA Isomers of Products of Animal Origin Not Declaring HO on the Ingredient List

(Code) Product	% Trans Palmitoleic Acid [a]	% Trans Petroselenic Acid [a]	% Trans Elaidic Acid [a]	% Trans Vaccenic Acid [a]	% Trans Linolelaidic Acid [a]
(10) Irish Butter	<0.1	<0.1	0.5	3.1	1.2
(11) Irish Butter	<0.1	<0.1	0.3	1.3	0.6
(28) Irish Cheddar	<0.1	<0.1	0.5	3.5	0.5
(29) Irish Cheddar	<0.1	<0.1	0.2	1.3	0.2
(30) Irish Cheddar	<0.1	<0.1	0.2	1.6	0.4
(31) Irish Cheddar	<0.1	<0.1	0.2	1.4	0.4
(32) English Cheddar	<0.1	<0.1	0.5	3.5	0.9
(19) Chicken Breast	<0.1	<0.1	<0.1	<0.1	<0.1
(20) Boneless Pork Chops	<0.1	<0.1	<0.1	<0.1	<0.1
(21) Striploin Beef Steak	<0.1	<0.1	0.1	<0.1	<0.1
(22) Lamb Gigot Chops	<0.1	<0.1	0.1	1.6	<0.1
(14) Frozen Cod in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(15) Frozen Cod in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(16) Frozen Cod in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(48) Frozen Cod in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(27) Frozen Skinless Cod	<0.1	<0.1	<0.1	<0.1	<0.1
(43) Pork Sausages	<0.1	<0.1	<0.1	<0.1	<0.1
(44) Pork Sausages	<0.1	<0.1	<0.1	<0.1	0.4
(45) Pork Sausages	<0.1	<0.1	<0.1	<0.1	<0.1
(46) Pork Sausages	<0.1	<0.1	<0.1	<0.1	0.2
(47) Pork Sausages	<0.1	<0.1	<0.1	<0.1	0.2
(17) Processed Chicken in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(25) Processed Chicken in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(26) Processed Chicken in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(49) Processed Chicken in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1
(50) Processed Chicken in Crumb	<0.1	<0.1	<0.1	<0.1	<0.1

[a] As a percentage of total TFA (Table 6)

However, trans-9-elaidic acid was still present in 7 of the samples at concentrations of ≥ 0.1%. The public health significance of this difference is not yet quantifiable.

3.5 Nutritional Labelling Issues

In addition to the labelling issues discussed in Section 2.1.3 there are also issues pertaining to nutritional labelling and health claims. In the EU nutritional labelling is voluntary but becomes compulsory if a nutritional claim is made on the label of a product *(e.g. Six samples (i.e. 10, 19-22 & 46) in the current survey had no nutritional information displayed on pack labels, four of which where fresh meat samples)* (FSAI, 2007). Furthermore, if product labels carry nutritional information, even when not required, they must comply with the current legislation (Directive 90/496/EEC).

Sixteen samples had Group 1 nutritional information only (FSAI, 2007). Three of these sixteen samples were incorrectly labelled by also providing fiber and sodium values in addition to group 1 requirements and not the remaining Group 2 requirements (FSAI, 2007). Seventy-eight samples had Group 2 nutritional information. One further sample *(i.e. sample 55)* was incorrectly labelled giving only nutritional data for energy, protein, carbohydrate and sugars but had no data to fat content.

Foods or certain categories of foods must comply with specific nutrient profiles in order to bear nutrition or health claims. This is because claims are used to present products as having an additional health or nutritional benefit. In most cases, consumers perceive products carrying certain claims to be better for their health and wellbeing. However, currently a food which is high in fat, salt and/or sugar, can still use claims such as “rich in vitamin C” or “high in fibre” to attract consumers, even if the overall health and nutritional benefits of the product are low (FSAI, 2007). The Nutrition and Health Claims Regulation aims to prevent consumers from being misled in this way, by tying the use of health or nutrition claims to certain conditions related to the nutrient profiles *(i.e. level of fat, sugar, salt etc)* of foods (Regulation EC No 1924/2006). These nutrient profiles are to be established by the Commission by 19th January 2009 at the latest and will be based on the scientific opinion of the EFSA (FSAI, 2007).

Of the 100 products analysed, five *(i.e. 2-3, 6, 8 & 42),* all of which were vegetable or dairy spreads, made a specific claim “Virtually Trans Fat Free” in relation to the presence or absence of TFA. All of these samples had appropriate nutritional information on the labels. A further four samples *(i.e. 4, 53-54 & 93)* whilst not directly making a claim in relation to TFA, listed TFA in nutritional labelling on the product packaging.

Under Article 8 of the current regulation nutrition claims shall only be permitted if they are listed in the Annex and are in conformity with the conditions set out in the Regulation (Regulation EC No 1924/2006). The claim “Virtually Trans Fat Free” in relation to the presence or absence of TFA as used by some products, sampled

in the current survey is not listed in the annex to the current Regulation (Regulation EC No 1924/2006).

Of the nine products making claims in relation to TFA or listing TFA in nutritional labelling, seven had TFA value greater than or equal to the stated nutritional value. One sample *(i.e. sample 2)* however, exceeded its stated nutritional claim for TFA. The product *(i.e. sample 2)*, a blended reduced fat spread made a claim of "Virtually Trans Fat Free" with a nutritional declaration of < 0.5% TFA per/100g of product. However, analysis indicated the product contained 3.9% TFA per/100g of product *(Table 5)*. The ingredient declaration for this product *(i.e. sample 2)* didn't list HO as an ingredient but the product did contain butter and reconstituted buttermilk as ingredients.

3.5.1 Tolerances for Nutrient Declaration

The Nutrition Labelling Directive (Directive 90/496/EEC) stipulates that the definition of tolerable margins between values declared on labelling and those obtained by official controls should be determined following the Standing Committee procedure (Directive 90/496/EEC). However, tolerances for nutrient declaration are not defined at European Community level, either via legislation (Directive 90/496/EEC) or guidelines except in the case of the declaration of fat content in spreadable fats (Regulation (EC) No 445/2007) [xiii]. Some Member States have national guidelines in place for the declaration of vitamin and mineral content *(i.e. Denmark, Finland)* as well as for macro-nutrients *(i.e. United Kingdom)* (European Commission, 2006). Ireland currently has no national guidelines on tolerances for nutrient declarations.

Fourteen samples exceeded a ±20% tolerance for declared fat content. This tolerance is hypothetical and has no basis in food law. Of these five and nine respectively had a higher or lower fat content than that declared on the product labelling. The largest difference for a product with a higher than declared fat content was 58.99% in a mince pie sample *(i.e. sample 69)*. While the largest difference for a product with lower than declared fat content was 73.33% in a white bread burger bun *(i.e. sample 52)*. Results of analysis indicated that 62% and 29% of samples respectively had a lower or higher total fat content than that which was on the label. Seven samples had no details of fat content while 2 were the same as that labelled. In relation to SAT fat 60% and 17% of samples respectively had a lower or higher SAT fat content than that which was on the label. 22 samples displayed no data on SAT fat while one sample was had the same SAT fat content as that labelled. One sample of mince pie *(i.e. sample 66)* had an analytical SAT fat content of 7.7g per/100g while the labelled SAT fat

[xiii] The indication of the fat content as provided for in Article 3(1)(b) of Regulation (EC) No 2991/94 shall comply with the following rules: (a) the average fat content shall be declared without the use of decimals; (b) the average fat content may not differ by more than one percentage point from the percentage declared. Individual samples may not differ by more than two percentage points from the percentage declared; (c) in all cases, the average fat content must comply with the limits laid down in the Annex to Regulation (EC) No 2991/94.

content was 2.3g per/100g. However, the analytical total fat content and labelled fat content of this sample *(i.e. sample 66)* was similar *(i.e. 16.8 and 17 g/100g respectively)*.

Current legislation allows manufacturers to use analysis results, calculations from know or actual value of ingredients or use of generally established and accepted data *(i.e. food composition tables)* to derive nutrient declarations for labelling purposes (Directive 90/496/EEC). However, the use of some of these methods or combinations can influence the accuracy of the derived nutrient declarations used for labelling purposes and can mislead consumers unnecessarily.

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Appendix 1 TFA Reduction Technologies

Hydrogenation

The primary reasons for hydrogenating oil are to improve its oxidative stability and increase the proportion of solid fats in the product (Kodali, 2005; EFSA, 2004; Jang et al. 2005). Typically the hydrogenation process will lead to products which contain moderate to high concentrations of TFA. However, manipulation of hydrogenation techniques and conditions can minimise the formation of TFA in products.

- TFA formation increases with hydrogenation temperature, use of hydrogen starvation during hydrogenation and use of reused or poisoned catalysts. However, TFA formation decreases with increasing pressure, catalyst concentration and agitation
- Use of specialised hydrogenation techniques to produce low TFA products (Kodali, 2005) including electrocatalytic hydrogenation, precious catalyst hydrogenation, and supercritical fluid state hydrogenation (Jang et. al. 2005).

Formulation

Perhaps the easiest method to reduce or eliminate TFA in processed foods is the formulation of oils. This methodology can involve a number of techniques (Kodali, 2005):

- Blending partially hydrogenated oils with high oleic acid oils *(e.g. Canola, Peanut and Palm oils)*
- Adding antioxidants *(e.g. natural and/or synthetic)* to provide oxidative stability ad improve shelf-life
- Use of palm oil fractions and/or animal fats to achieve a desired solid fat content without using hydrogenated oils. However, these techniques can increase the SAT fat and cholesterol content of the prepared oil
- Entrapment technologies where liquid oils are trapped inside solid oils *(e.g. a small quantity of completely hydrogenated soybean oil has the capacity to entrap a large amount of liquid oils)*

Modification

The genetics of plants producing vegetable oils can be modified using traditional plant breeding or genetic engineering techniques (Kodali, 2005).

Fractionation

This is a process of crystallisation and separation of low melting liquid and high melting solid portions of a fat *(e.g. palm oil)* with or without the use of solvents such as acetone or hexane (Kodali, 2005).

Interesterification

In vegetable oils and fats the fatty acid distribution on the glycerol backbone is not random (Kodali, 2005). Interesterification modifies the distribution of the fatty acids on this glycerol backbone and as such modifies the properties of the fat or oil usually by increasing the hardness of the oil. Interesterification is done under chemical or enzymatic conditions (Kodali, 2005).