The Food & Drink Innovation Network

Opportunities for the oils and fats industry

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Agenda

- What are trans fatty acids?
- How are they formed?
- Hydrogenation
- Where are hydrogenated fats used?
- What are the options?
- Implications of replacing trans fatty acids

Fatty acids

- **Four main groupings:**
  - Saturated
  - cis-Monounsaturated
  - cis, cis, (cis)-Polyunsaturated
  - Trans
- **Unsaturated double bonds are either cis or trans**
- **In vegetable oils the ‘natural’ form is cis**

cis - trans

Cis - monounsaturated chain

Trans-monounsaturated chain

How are TFAs formed?

- **Microbial hydrogenation**
  - TFAs are present in animal fats (beef, lamb, butter, milk and other dairy products)
  - Produced by microbial hydrogenation of polyunsaturated fats in the animal's rumen
  - Levels are typically between 3% and 8%
  - So - we have been consuming TFAs from these sources for centuries!!

How are TFA's formed?

- **Subjection to excessive heat**
  - if fats are subjected to very high temperatures during, for example, refining the cis double bonds can start to transform to trans double bonds
  - this can be minimised (<1%) by using mild processing conditions
  - thus, this is not a major source of TFAs in the diet

How are TFAs formed?

- **Partial hydrogenation**
  - partial hydrogenation of vegetable oils is the most common way of introducing TFAs into the diet
  - this makes it the route coming under major scrutiny, debate and legislation.

What is hydrogenation?

- **A process in which an oil is reacted with hydrogen in the presence of a catalyst (usually nickel, sometimes platinum or palladium)**
- **There are two competing processes occur:**
  - saturation in which hydrogen is added across the double bonds forming a single bond
  - isomerisation in which cis double bonds isomerise to trans double bonds

Why use hydrogenation?

- To enable fats with a wide range of melting profiles and melting points to be produced from simple liquid oils
- To improve oxidative stability
- To give specific functional characteristics such as crystallisation rate, aeration properties, gloss retention etc.

Where are hydrogenated fats used?

- Dough fats and shortenings
- Margarines and spreads
- High stability frying oils
- Confectionery coatings and fillings
- Caramels and toffees

What are the options?

- **Firstly, identify why the hydrogenated fat is being used?**
  - Is it for ‘solidity’ i.e. to give a specific melting profile?
  - Is it for oxidative stability?
- **Then investigate what the options can be in terms of TFA-free fats**

Melting profile and solid fat contents

- Often a hydrogenated fat is used where a degree of solid fat is necessary for the application, e.g. confectionery coatings and fillings
- Even in other areas where perhaps a more liquid oil could be used, e.g. doughs, toffees, an inferior product would result from making such a change
- So - some solid fat is needed in the fat
- If this cannot be produced by hydrogenation, then oils must be used which have naturally occurring amounts of solid fat.

Solid fat contents at 20C

Sunflower oil	Liquid
Soyabean oil	Liquid
Groundnut oil	Liquid
Cottonseed oil	Liquid
Rapeseed oil	Liquid
Olive oil	Liquid
Coconut oil	38%
Palm kernel oil	43%
Palm oil	25%
Cocoa butter	76%

Process options

- **Fractionation**
  - take an oil which already contains some solid fat (e.g. palm, palm kernel, coconut) and fractionate to concentrate this solid fat to the required level
- **Complete hydrogenation**
  - Hydrogenating to complete saturation results in effectively zero TFA - **BUT**
    - the oil still must be declared as ‘hydrogenated’
    - apart from coconut oil it will have a melting point above mouth temperature and therefore will need to undergo one or both of the following process options to ensure palatibility

Process options

- **Interesterification**
  - Interesterification randomises the position of each fatty acid on the glycerol backbone.
  - It allows, for example, the rearrangement of the fatty acids in a fully saturated triglyceride (SSS) and a fully unsaturated triglyceride (UUU)
  - This produces a composition that can be mathematically predicted of SSS, SSU, SUS, UUS, USU and UUU triglycerides
  - Thus a blend of, for example, a fully hydrogenated oil and a non-hydrogenated liquid oil can be interesterified to produce an end product with an acceptable melting profile for use in food products

Process options

- **Blending**
  - The simplest of all process options but one which allows considerable flexibility
  - The components in the blend can be:
    - unfractionated, non-hydrogenated fats
    - fractionated, non-hydrogenated fats
    - fully hydrogenated fats
    - interesterified fats
  - All of which will allow a TFA-free declaration (although perhaps not a ‘non-hydrogenated’ declaration)

How to decide which option to use

- **It is not simply a matter of matching the melting profile of the hydrogenated fat being replaced**
- **Switching from a hydrogenated to a non-hydrogenated fat can have a number of implications:**
  - Interactions with other fats present in the product can be different
  - Processing conditions, particularly cooling and crystallisation conditions may need to be modified. It may be necessary to include a pre-crystallisation or even a tempering stage
  - Change in product characteristics on storage - hydrogenated fats often post-harden; TFA-free fats will show less of this
  - Stability
  - Price

Implications of replacing trans fats

- **Some of the potential processes also involve hydrogenation**
  - What does the consumer want – no trans or no hydrogenation
- **What do you replace the trans with – more saturates or cis-unsaturates?**

Chocolate-flavoured compound coatings

	Hydrogenated coating fat	Cocoa butter and CBEs	Palm kernel fraction
Saturates	34%	62%	91%
Cis-monounsaturates	13%	35%	8%
Cis-polyunsaturates	<1%	3%	1%
Trans	53%	<1%	<1%

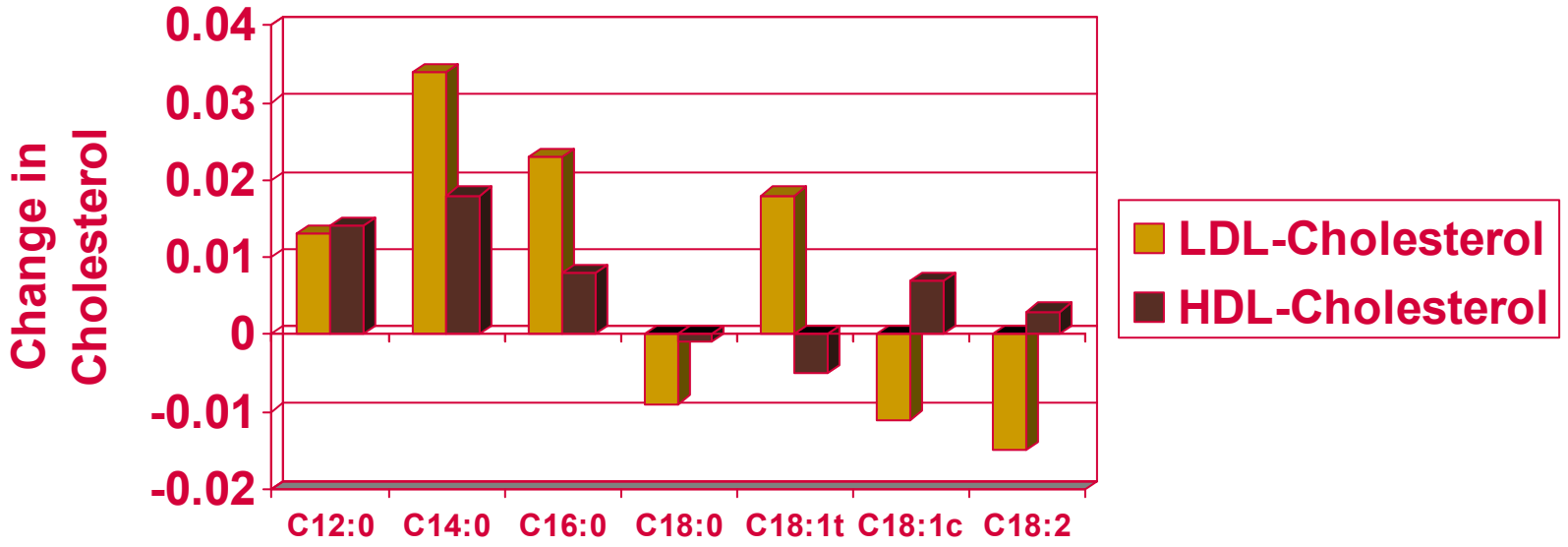
Biscuits and Bakery products

- Biscuits can, in theory, be made from fully liquid oils – but
- Such biscuits suffer from high levels of oil exudation
- By replacing partially hydrogenated dough fats with, for example, palm fractions it is possible to replace trans fatty acids by about an equal amount of saturates

Frying oils

	Partially-hydrogenated high-stability vegetable oil	Rapeseed oil	Palm fraction
Stability (Rancimat time at 120C)	>35 hours	<2 hours	>10 hours
Saturates	12%	8%	38%
Cis-monounsaturates	30%	62%	47%
Cis-polyunsaturates	<1%	30%	15%
Trans	58%	<1%	<1%

Effects of Fatty Acids on LDL/HDL Cholesterol



From Katan, Zock and Mensink – Am. J. Clin. Nut. (1994) 60 (Suppl.) 986S-990S

FEDIOL Position

- **Favours the decrease of trans fatty acids as long as the sum of trans and saturates does not increase**
- **No distinction should exist between trans fatty acids of vegetable and animal origin**
  - No scientific substantiation that the effect of trans fatty acids from vegetable origin have any different effect on LDL cholesterol than those from animal origin
  - Analytical methods cannot accurately differentiate between trans from vegetable origin and trans from animal origin
  - More than 50% of the trans intake in Europe is from animal origin

Summary

- **There are opportunities for the oils and fats industry to reduce or eliminate trans fatty acids from products - but**
- **There are then other implications either in terms of:**
  - labeling,
  - nutritional balance between the remaining fatty acids,
  - functional characteristics such as structural and oxidative stability

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