

DEEP FRYING

Harmful substances can be formed during deep frying due to the exposure of frying oils and fats to high temperatures over a long period of time.

What are the rules governing the safety and quality of frying oils including those for acrylamide and *trans* fatty acids? *Dr Rüdiger Weifshaar*

Fried food is popular worldwide, producing appetising food which has a good aroma, flavour, texture and mouthfeel.

Frying is also an efficient means of food preparation as it is fast, has excellent heat transfer, is lethal to microorganisms and is applicable in food service and street food.

In order to maintain the safety and quality of food, many national and international regulations have been enacted (see Figure 1, p19). As different as detailed national regulations are, there are a number of universal food law principles accepted in nearly every country, the main rule being that food should be safe for consumers. This means that food should not be harmful to consumers' health and should be fit for human consumption.

Safety of used frying oil

It is undisputed, that harmful substances can be formed during the lifetime of a frying oil, even if good manufacturing practices (GMP) are followed.

"There is no other kind of food which is exposed to harsher thermal conditions (high temperature for a long time of exposure) than deep frying oil," according to the conclusions of the 3rd International Symposium of Deep Fat Frying in March 2000. "Myriads of complex heat and/or oxygen induced reactions take place during the usage life of a deep frying fat, provoking drastic changes in the sensory, physical, chemical and nutritional properties of the oil.

"A number of clinical symptoms are described for the long term consumption of high levels of highly oxidised fats such as diarrhoea, anorexia, anaemia, reduced growing and myocardial inflammation."

In the EU, Regulation EC No 178/2002 states that in determining whether any food is injurious to health, regard should be paid to:

- a) the probable immediate and/or short-term and/or long-term effects of that food on the health of a person



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consuming it, and on subsequent generations;

- b) the probable cumulative toxic effects;
- c) the particular health sensitivities of a specific category of consumers where the food is intended for that category of consumers.

"Despite all possible hypothetical health risks, there is a general agreement in research that moderate consumption of used frying oils, used at normal frying conditions is not injurious to human health", the 3rd Deep Fat Frying Symposium concluded.

Even the occasional consumption of moderately deteriorated frying oils and fried food is not rated as harmful to human health.

This is a point of considerable legal importance because the marketing of food which is injurious to human health is classified as a criminal offence in most countries, with serious punishments.

Assessment criteria

From the first moment of use, frying oils undergo steadily growing changes in sensory properties, chemical composition and physical characteristics.

The crucial question for fryer operators and food inspectors is how extensive the changes can be for the quality of the used frying oil and fried food to be still acceptable for consumers.

The 3rd Deep Fat Frying Symposium concluded that the principle quality index for deep fat frying should be the sensory parameters of the food being fried. Two tests should be used to confirm abuse, analysing:

- Total Polar Materials (TPM) < 24%
- Polymeric Triglycerides (PTG) < 12%

Over the last 20 years, many countries have established guidelines or regulations for fryer operators and official food control agencies on abused frying fats and oils. In most cases, TPM is the critical parameter with limits from 24% to 27%. (see Table 1, p19).

If the sensory properties of a used frying oil are not acceptable and at least one of the recommended or regulated limits is exceeded, the oil is undisputedly not suitable for human consumption.

A food item takes up a significant amount of frying oil so that the oil itself becomes an ingredient of the fried food item. If any ingredient of a foodstuff is



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unsafe, the whole foodstuff is rated as unsafe. This is a basic principle of food law all over the world.

Therefore, food which is prepared in abused frying oil or frying fat is unsafe and not suitable for human consumption.

The best parameter for the assessment of extracted frying fat is the amount of PTGs. However, the limits for chemical parameters cannot be simply transferred to fat extracted from fried food because values can be changed as a result of the extraction procedure.

It should also be noted that a frying oil is not automatically acceptable if its values are in line with the limits.

There are some frying applications, where the sensory quality of the frying oil may become unacceptable long before TPM and PTG limits are reached. This is the case with frying oils with high amounts of linolenic acid like rapeseed oil; frying oils with E900 (dimethylpolysiloxane) as an antifoaming agent; and the frying of bakery products like doughnuts where the oil bath has an unfavourable surface to volume ratio.

In these cases, the use of additional parameters such as anisidine value, acid value or smoking point may be helpful.



Figure 1: Countries controlling the quality of frying oil

Country	Polar material	FFA	Smoke point	PTG	Heat limit	Others
Austria	27%	1.25%	170°C	12%	180°C	Oxidised FA<1% Linolenic acid<2% Oxidised FA<0.7% No silicone additives Carbonyl value <50 Smoking/colour
Belgium	25%	1.25%	170°C	10%	180°C	
France	25%			14%	180°C	
Germany	24%	1.00%	170°C	12%	170°C	
Hungary	25%				180°C	
Italy	25%				180°C	
Netherlands	27%	2.25%		16%	180°C	
Portugal	25%				180°C	
Spain	25%					
Switzerland	27%		170°C			
Chile	25%	1.00%	170°C			
Japan		1.25%	170°C			
USA		2.00%				

Table 1: Regulations for used frying oils

Relevant danger	Formation of substances in toxicological relevant amounts
CCP	Yes
Limit	Oligomer triglycerols <12%; total polar amounts <24%
Control	Quick test
Measure	Removal and exchange of frying oil
Documentation	Documentation of the values with date and time
Responsibility	Chef de cuisine

Table 2: Exemplary HACCP protocol for frying operations

Another tool for assessment of these oils can be a statistically verified combination of various parameters. For example, a combination of TPM and acid value.

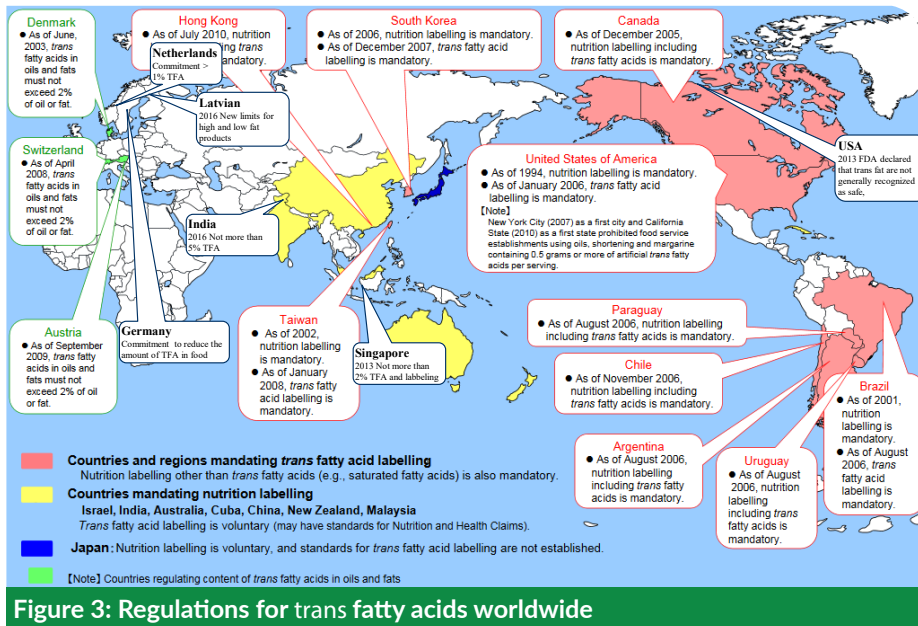
Acrylamide regulations

Acrylamide is a neurotoxin classified by the International Agency for Research on Cancer (IARC) as a Group 2A probable carcinogen. Binding limits for acrylamide in fried food do not exist but different governments and NGOs have a number

of regulations and guidelines to mitigate acrylamide levels.

In the EU, there are benchmark levels and a catalogue of mitigation measures for different food groups. French fries have a maximum acrylamide limit of 500 µg/kg while potato crisps and crackers have a maximum level of 750 µg/kg. Mitigation measures are obligatory if benchmark values are exceeded

The most important measure to minimise acrylamide formation is temperature control.



Source: Consumer Affairs Agency, Food Labelling Division, Japan

Different lists of threshold values for different allergens are in preparation worldwide.

The compromise labels of “may contain [allergen]” or “processed in a facility that also processes [allergen]” are often used although these advisory labellings should not be used to conceal defects in GMP.

Food additives

Food additives must be approved by national food authorities with consideration to safety assessments; technological need; ensuring that the use of the additive will not deceive consumers and labelling requirements.

Labelling of GM frying oils

An increasing proportion of edible oils, such as soyabean, corn oil, rapeseed and cottonseed oils, is produced from genetically modified plants (GMO).

The use of GMOs for food and feed must be approved by national or international food authorities.

The labelling of GM food is required in Australia, Brazil, China, India, Japan, New Zealand, South Korea, the USA and the EU.

Fully refined oils and food served in restaurants and fast food outlets do not have to be labelled as “genetically modified” or “bioengineered” (USA) in most countries.

In the EU, all food (including processed food) or feed which contains more than 0.9% of approved GMOs must be labelled (even food served in restaurants and fully refined frying oil).

What can we expect in the future?

In the future, aspects other than consumer protection and food safety may possibly gain in importance in the field of deep frying. These include:

- The protection of fryer operators and ambient air from harmful volatile substances such as acrolein.
 - Sustainability and climate protection aspects such as climate-friendly production of frying fats and oils; energy efficiency of frying systems; and recycling of used frying oils as raw material for biogas and biofuel.
- The number of worldwide regulations will no doubt increase. ●

This article is based on a presentation made at the March 2020 10th International Symposium on Deep Frying in Hagen by Dr Rüdiger Weißhaar, who is a member of the scientific staff of Chemisches und Veterinäruntersuchungsamt (CVUS) Stuttgart, one of the four official food control and animal health laboratories of Baden-Württemberg state in southern Germany

▶ In the EU, French fries and other cut deep-fried or oven-fried potato products should have a temperature of 160-175°C when frying; or 180-220°C when using an oven. Sliced potato crisps should have a maximum temperature of 168°C at the exit of the fryer.

Due diligence and HACCP

Food business operators at every stage of the food chain have to ensure that their products are safe and fit for human consumption.

The Hazard Analysis and Critical Control Points (HACCP) system is a preventive approach to food safety that attempts to avoid hazards rather than attempting to inspect finished products. The use of HACCP in food business is mandatory in many countries. The system analyses possible biological, chemical and physical dangers; identifies where points of danger can occur; sets critical limits at danger points; establishes corrective actions; and outlines procedures to ensure HACCP is working.

The important critical points for frying operations are temperature and TPM or PTG (see Table 2, previous page).

Trans fatty acids

Industrial or artificial trans fatty acids (TFAs) can be found in baked, fried and snack foods and are formed when fats and oils are partially hydrogenated to improve their taste, texture and shelf-life. Industrial TFAs increase our risk of heart disease by increasing the ‘bad’ low density cholesterol in our blood, while also lowering the ‘good’ high density cholesterol.

In the EU the content of industrial TFAs in food intended for the final consumer

and food for supply to retail should not exceed 2g per 100g of fat.

The formation of TFAs during the frying process is negligible if frying conditions are in line with GMP, especially if recommended temperatures are not exceeded. TFA concentration can rise by the transition of fat from fried goods into the frying oil (see Table 2, previous page).

Labelling of allergens

Allergenic substances have to be labelled if they are ingredients of a foodstuff, for example, where doughnuts are fried in (hydrogenated) peanut oil, the use of peanut oil must be labelled.

In the USA, major food allergens are those which contain protein derived from milk, egg, fish, crustacean shellfish, tree nuts, wheat, peanuts and soyabeans.

The EU lists substances causing allergies or intolerances, which include milk and milk products; egg; fish; crustaceans; almond, hazelnut, walnut and cashew nuts; peanut and peanut products; and soyabeans except for fully refined soyabean oil.

A typical example of an allergenic contaminant is traces of seafood protein in frying oil, which is used alternately for shrimps and french fries.

The labelling of allergenic contaminants is not obligatory in most countries although this may change if the Voluntary Incidental Trace Allergen Labelling (VITAL) concept is adopted in Australia, New Zealand, Switzerland and the EU.

In the VITAL concept, allergenic substances which are not basic ingredients of a food item have to be labelled if a specific threshold or judgement value is exceeded.