

A range of regulations govern deep frying to safeguard consumer health, covering the quality of fresh and used cooking oil, as well as additives, allergens, *trans* fatty acids, genetically modified oils and compounds such as acrylamide, 3-MCPDEs and glycidyl fatty acid esters

Bertrand Matthäus



Photo: Adobe Stock

Regulatory update

A range of regulations around the world govern deep frying to safeguard consumer safety. They cover compounds such as acrylamide, allergens, *trans* fatty acids (TFAs), free and bound 3-monochloropropanediol (3-MCPD) and glycidyl fatty acid esters (GEs), which are of health concern, as well as food additives and the quality of fresh and used frying oil.

Regulations are important to address product quality, as well as health and environmental issues.

Employees must be protected from volatile reactive degradation products in fumes, and there must be safeguards against smells and gaseous effluents in the environment.

Frying oils must be consistent in smell and taste and offer storage stability. There must be mitigation of heat-induced contaminants such as acrylamide, as well as other contaminants such as TFAs, 3-MCPDEs and GEs. Steps must also be taken to minimise degradation products in the oil and fried food, such as free fatty acids, polymer triacylglycerols, polar materials and oxidised fatty acids.

Increasing amounts of degradation products impair oil quality. While the nutritional effect from used cooking oils on mono- and diacylglycerols free fatty acids are harmless – along with di- and oligomer triacylglycerols and dimeric fatty acids because of their very low resorption rate – mono- and dimeric acids, oxidised cyclic fatty acids and other polar compounds have a negative nutritional effect.

Symptoms from the consumption of

highly oxidised oils include diarrhoea; myocardial inflammation; enlargement of the liver and kidney; anaemia; accumulation of peroxides in fat-containing tissue; and the lack of vitamin E and selenium.

Used frying oils

There is general agreement that harmful compounds are formed during frying but research shows that moderate consumption of used frying oils, based on good manufacturing practice (GMP), is not injurious. Nevertheless, quality control of the frying process is very important.

Codex Alimentarius sets out standards for food and residue limits, with code of practices, guidelines and recommendations.

Codex's voluntary rules govern food hygiene; pesticide residues; labelling and presentation; methods of analysis and sampling; inspection and certification; food additives; and contaminants.

There is a Codex Standard for Named Vegetable Oils (CODEX STAN 210-1999) which sets out quality standards for edible oils including data on fatty acids, tocopherols and phytosterols; and quality criteria on chemical and physical parameters such as density, refractive index and peroxide value.

In the EU, Regulation EC No 178/2002 lays down the general principles and requirements of food law. Complete traceability of products in the production chain is mandatory, and operators must apply the legislation at all stages of the food chain, from production, processing,

transport and distribution through to the supply of food.

No food can be placed on the market if it is unsafe, with food deemed unsafe if it is considered to be injurious to health and unfit for human consumption.

Frying oils are regarded as food in the EU as they are taken up by a food item during frying. A long-term used frying medium should not be suitable for human consumption but there are no legal regulations for heated oils and fats at the EU level.

Very few countries have adopted legislation on used frying oils but if regulations or standards are available, they are often based on the recommendations of the Germany Society for Fat Research (DGF) from 1973, which deem that used frying fats and oils are deteriorated if:

- On sensory assessment, the taste or flavour is unacceptable
- Polymer triacylglycerols levels are >2%
- Polar compounds are >24%
- The acid value is $\geq 2.0\text{g}/100\text{g}$
- Petroleum ether insoluble oxidised fatty acids are above 0.75%
- The smoke point is $\geq 170^\circ\text{C}$
- The smoke point difference is $>50^\circ\text{C}$
- Oxidised fatty acids are above 1%

Frying oils or fat extracted from fried food that exceed these limits are not suitable for human consumption. The 3rd International Symposium on Deep-Fat Frying in 2000 also recommended that:

- The principal quality index for deep fat frying should be the sensory quality of

DEEP FRYING



Waste cooking oil can be defined as used cooking oil (UCO) originating from food manufacturers, restaurants and industrial kitchens; and oil that has been dumped in sewers

- ▶ the food being fried.
- Analysis of total polar compounds and polymeric materials (polymerised triacylglycerols) should be utilised to confirm suspect/abused frying fats and oils.
- The use of rapid tests for monitoring oil quality is recommended.
- Filtration is one of the basic tools to ensure food and oil quality.
- Used, but not abused, frying oils may be topped up or diluted with fresh oil with no adverse effects on quality.

Additives

Additives such as antioxidants and anti-foams can be added to frying oils to control foaming during frying and to extend the lifespan of the oil.

Additives are defined as ingredients of food not normally consumed as food themselves. All additives in the EU must be authorised and listed with conditions of use in the EU's positive list based on a safety assessment and technological need, with an assurance that the use of the additives will not mislead consumers. These rules are set out in Annex II of EU Regulation (EC) No 1333/2008.

In the USA, regulations for food additives and colour additives are listed in 21 Code of Federal Regulations (CFR),

Parts 172 and 173, and Parts 73, 74, respectively. 'Generally Recognized as Safe' (GRAS) substances such as alpha-tocopherol, beta-carotene and citric acid – which are added to frying oils to improve their oxidative stability – are listed in 21 CFR Parts 182 and 184.

HACCP

Hazard Analysis and Critical Control Point (HACCP) is a concept to identify, access and control danger regarding food safety:

- Analysing possible danger (biological, chemical and physical).
- Identifying points where danger could occur.
- Deciding which points are critical (a point is only 'critical' if danger can be avoided by appropriate action).
- Defining safety measures.
- Verifying the introduced concept.

The HACCP concept in relation to frying oil is set out in Table 1 (*below*).

Trans fatty acids

Industrial *trans* fatty acids (iTFAs) – as opposed to naturally-occurring TFAs from the meat and milk fat of ruminant animals – are formed during partial hydrogenation of oils to turn them into semi-solid or solid fats, which have increased resistance to

oxidation and a long shelf-life.

Various clinical studies have shown that TFAs raise low density lipoprotein ('bad') cholesterol in blood, and lower high density lipoprotein ('good') cholesterol, increasing the risk of heart disease.

According to a World Health Organization (WHO) news release in January 2023, *trans* fat intake "is responsible for up to 500,000 premature deaths from coronary heart disease each year around the world".

The WHO recommends that no more than 1% of our daily energy intake in kilojoules should come from TFAs.

In the EU, an amendment to Annex III of Regulation (EC) No 1925/2006 states that the content of *trans* fat – other than naturally-occurring *trans* fat of animal origin – in food intended for the final consumer and food intended for supply to retail, should not exceed 2g/100g of fat.

In addition, food business operators supplying other food business operators with food not intended for the final consumer or not intended for supply to retail shall ensure that food business operators are provided with information on the amount of *trans* fat, (other than *trans* fat naturally occurring in animal origin fat), where that amount exceeds 2g/100g of fat.

The formation of TFAs during the frying process is negligible, if frying conditions are in line with GMPs and recommended temperatures are not exceeded.

TFAs are regulated in different ways around the world, with some countries mandating TFA labelling.

Acrylamide

Acrylamide is a chemical that naturally forms in carbohydrate-rich food products during high-temperature cooking and is mainly formed from reducing sugars like glucose or fructose, and amino acids, particularly asparagine.

The European Scientific Committee on Food evaluated acrylamide in 1991 as a "genotoxic carcinogen" while the International Agency for Research on Cancer stated in 1994 that acrylamide is "probably carcinogenic to humans".

According to the European Commission's Joint Research Centre, acrylamide is a "non-threshold carcinogen", and it is recommended that human exposure to the chemical be restricted as much as possible, applying the As Low As Reasonable Achievable (ALARA) principle.

However, epidemiological studies have not shown any correlation between acrylamide in food and the occurrence of different types of cancer.

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

Source: 11th Deep Frying Symposium, 27-29 March 2023, Hamburg, Germany

Table 1: HACCP in relation to frying oils

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

In EU regulation 2017/2058, there is a benchmark maximum level of 500µg/kg established for ready-to-eat French fries, while the maximum benchmark level for potato crisps and crackers is 750µg/kg. If benchmark values are exceeded, food business operators must apply mitigation measures. In addition, EU regulation defines a maximum temperature of:

- 160-175°C when frying french fries and other cut deep-fried or oven-fried potato products; and 180-220°C when using an oven.
- 168°C at the exit of the fryer for sliced potato crisps.

3-MCPD and GEs

EU Regulation 202/1322 sets out maximum levels of 3-MCPD, 3-MCPD fatty acid esters and GEs in certain foods.

For GE, expressed as glycidol, the level is 1ppm. For 3-MCPD and 3-MCPD esters, the level is 1.25ppm for coconut, maize, rapeseed, sunflower, soyabean, palm kernel and olive oils.

For other vegetable oils – including olive pomace, fish and marine organism oils – and mixtures of oils and fats in this category, the level is 2.5ppm.

For mixtures of oils and fats from the two categories, the level is 2.5ppm.

Allergens

Both the EU and USA have allergen regulations.

EU Regulation No 1169/2011, Article 9(c), Annex II defines allergens as “substances causing allergies or intolerances”, which includes milk and milk products; egg; fish; crustaceans; nuts (almonds, hazelnuts, walnuts, cashew); cereals containing gluten; peanuts and their products; and soyabeans except fully refined soyabean oil; and celery, mustard, sesame, sulphites, lupin and molluscs.

The US Food Allergen Labelling and Consumer Protection Act (FALCPA) defines major food allergens as products which protein derived from milk, egg, fish crustacean shellfish, tree nuts, wheat, peanuts and soyabeans.

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

A typical example of an allergenic contaminant are 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.

However, this may change with proposals for a Voluntary Incidental Trace Allergen Labelling (VITAL) system in Australia, New Zealand and Switzerland.

GM frying oils

An increasing proportion of edible oils – such as soyabean, corn, rapeseed and cottonseed oils – are produced from genetically modified (GM) plants.

The use of GM organisms (GMOs) for food and feed must be approved by national or international food authorities. The labelling of GM food is required in Europe, Australia, Brazil, China, India, Japan, New Zealand, South Korea and the USA.

Fully refined oils and food served in restaurants and fast-food outlets have to be labelled as “genetically modified” or “bio-engineered” 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.

Waste cooking oil

Waste cooking oil can be defined as used cooking oil (UCO) originating from food manufacturers, restaurants, and industrial kitchens; and oil that has been dumped in sewers.

The EU defines all waste food, including UCO, as originating from restaurants, catering facilities and kitchens, including central kitchens and household kitchens.

Health risks related to UCO include:

- Undesirable levels of contaminants such as polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs) and dioxins.
- Some toxicity (such as triacylglycerol dimers, trimers and other polymers, cyclic monomers and compounds derived from the oxidation of cholesterol) as a result of oil degradation during frying and cooking.
- Risks for animal health due to the use of UCO in animal feed and, as a result of bio-accumulation, for consumer health as well.

The heat treatment of UCO during processing leads to oxidation and degradation products, and oil soluble components from processed products.

Sewer oil can contain mixtures of vegetable and animal oils, together with oil soluble and solid components obtained from fat separators, and its treatment can result in oxidation and degradable products, oil soluble components, and an undefined mixture of other compounds.

In the EU, there is no direct legal

regulation regarding the use of waste cooking oils in nutrition.

However, regulation EC No 1774/20023 lays down health rules concerning animal by-products not intended for human consumption, and catering waste is not allowed in animal nutrition as the traceability of these products cannot be guaranteed.

No foodstuff dangerous to health and/or unfit for consumption may be placed on the market, but oils from manufacturing premises are felt to be identifiable, traceable and to contain no specified deleterious or prohibited contaminants.

EU regulation allows the use of waste oils from the food industry (other than catering facilities) where a credible system of traceability and quality control can be ensured.

The recycling of UCO into technical products for pure industrial uses – such as production of soaps, biodegradable lubricants or biofuels – is allowed.

Conclusion

Frying is a complex process that leads to the deterioration of the frying medium with progressive frying time, depending on the frying conditions.

During frying, part of the frying medium is absorbed by the fried food, so that the frying medium becomes part of the fried food. Therefore, a number of regulations and recommendations are available to ensure that the quality of the fried food is not negatively affected by the frying medium and that the safety of the food remains assured.

There is no specific regulation for used frying oil but EU regulation 178/202, other regulations in the world, along with different recommendations that describe quality parameters for used frying oils, provide the framework for assessment.

In addition, for contaminants such as acrylamide, 3-MCPDEs, glycidyl esters and *trans* fatty acids, different regulations ensure that a risk to consumers can be ruled out.

All these regulations and recommendations cannot prevent the formation of undesirable substances and a decrease in oil quality during frying, but they do ensure that the frying process and the food produced from it are safe for the consumer if the specifications are fulfilled.

Even if the specifications of used frying oils differ to some extent from country to country, the general aim of ensuring the safety and quality of fried food is always the same in each country. ●

Bertrand Matthäus is the head of the Department for Safety and Quality of Cereals at the Max Rubner-Institut, Germany