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FEDIOL Code of Practice on vegetable oil and fat refining for food purposes

The Code developed by FEDIOL, in cooperation with its members, is a non-binding recommendation developed for the use of members and non-members.

Introduction

The purpose of refining vegetable oils and fats for edible purposes is to produce a bland, odourless, fit-for-purpose product that meets food safety, customer, and quality requirements.

Crude vegetable oils and fats, which are obtained by expelling or extraction, contain substances and trace components, which are undesirable for taste, stability, and appearance or further processing. These substances and trace components may include seed particles, impurities, phosphatides, carbohydrates, proteins, and traces of metals, pigments, waxes, oxidation products of fatty acids, contaminants and pesticide residues.

Refining has become increasingly critical for the removal of volatile and non-volatile compounds and contaminants such as polycyclic aromatic hydrocarbons, dioxins, aflatoxins, or pesticides residues.

The present FEDIOL Code aims at describing the main steps of the refining process and what chemical and physical refining entails.

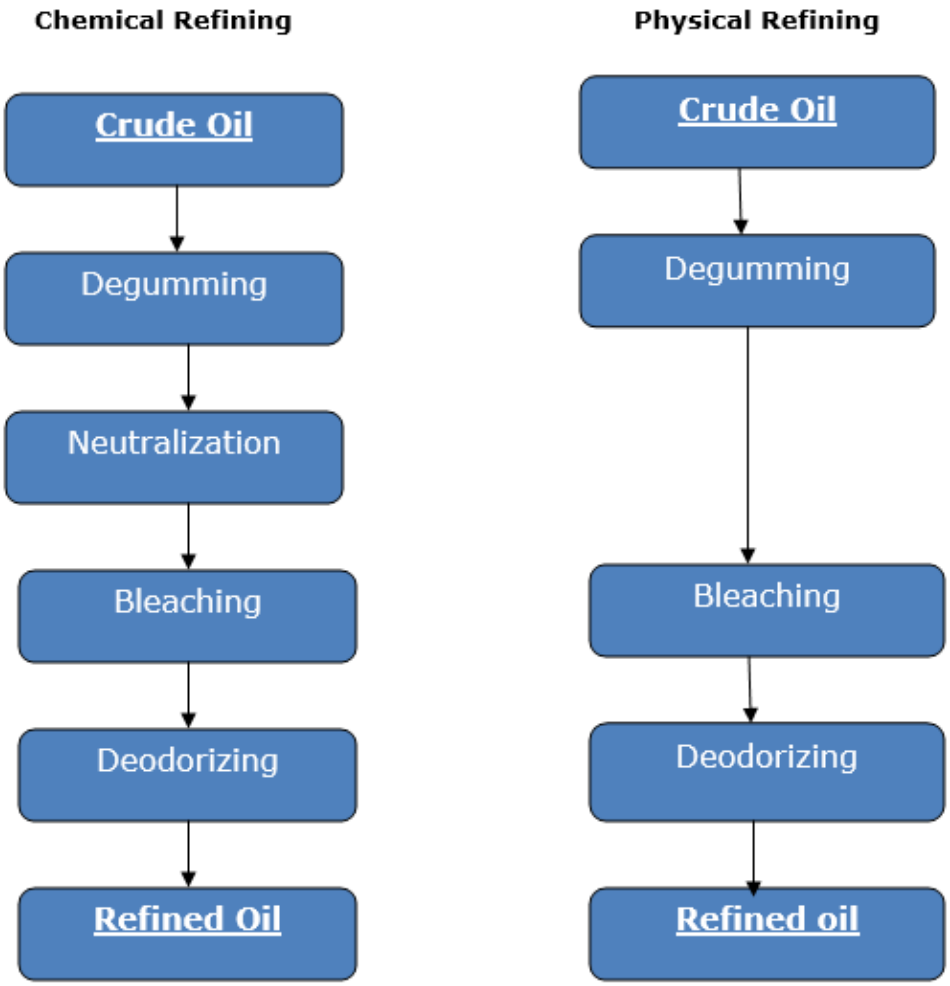
It should not be interpreted as being exhaustive, as other parameters can be described in specific FEDIOL Codes of Practice (e.g. FEDIOL Code of Practice on bleaching earth[1], FEDIOL Code of Practice on mineral oil[2]) or in internationally agreed Codes of Practice (e.g. Codex Alimentarius Code of Practice for the reduction of 3-MCPDE and GE in refined oils and food products made with refined oils[3]). Each step described below should not be seen in isolation but should be looked at in a comprehensive manner, as the way each step is conducted may have influences on the quality of the refined oils and fats and on some undesirable substances (e.g. 3-MCPDE and GE).

There are two main types of refining, depending on and influenced by the type of oil seed, oil bean or nut to refine, i.e.: physical refining and chemical refining. Some oils,

[1] http://www.fediol.be/data/1483955074 16COD137%20FEDIOL%20Code%20of%20Practice%20on%20the%20purchase%20conditions%20of%20FBE%20and%20filter%20aids%20-%209%20January%202017.pdf
[2] http://www.fediol.be/data/151938092114COD341Rev1_CoP%20for%20the%20management%20of%20MOH%20presence%20in%20vegetable%20oils_14Feb2018_FINAL.pdf
[3] http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXC%2B79-2019%252FCXC_079e.pdf

e.g. fruit oils, can be refined in simplified physical way i.e. dry degumming, bleaching and deodorization.

The two refining processes can be summed-up in the following flowcharts:



Each step of the refining is undertaken in line with HACCP principles, so as to achieve at the end a refined vegetable oil/fat meeting EU law requirements, which is either delivered directly to consumers through bottled oils or enters the composition of other food products.

The refining as described below ensures that no more than 2% *trans fatty acid* (TFA) on fat basis is formed during the refining for refined vegetable oils and fats, incl. bottled oils. At the same time, the fatty acid distribution within the triglycerols remains substantially unchanged.

1. Chemical Refining

Degumming
The first step of chemical refining is degumming. Its main purpose is to remove seed particles and impurities, together with partial removal of phosphatides, carbohydrates, proteins and traces of metals.

The crude oil is treated with food grade processing aids (acids) and/or water, which leads to hydration of the main part of the phosphatides, proteins, carbohydrates and traces of metals. The concentration of the processing aids depends on the quality of the crude vegetable oil. The hydrated gums are removed by centrifugal force from the oil.

Neutralisation
Alkali neutralisation reduces the following components among other: free fatty acids, oxidation products of free fatty acids, residual proteins, phosphatides, carbohydrates, traces of metals and some of the pigments.

The treatment consists in the reaction with an alkali-solution. By this treatment, a second phase is formed (soap stock), in which the undesired substances are dissolved. This phase is separated and removed by centrifugal force, followed by washing or filtration treatment to eliminate residual phosphatides, soap and precursor molecules as well. This process is mainly used for seed oils and is not common for tropical oils.

Bleaching
The purpose of bleaching is to reduce the levels of pigments such as carotenoids and chlorophyll, but also residues of phosphatides, soaps, traces of metals and oxidation products. These trace components can have a negative effect on the course of further processing and on the quality of the final product.

These substances are removed by adsorption with activated clay and silica under vacuum and at temperatures of around 100°C.

Fresh bleaching earth and filter aids are processing aids used during the refining process of vegetable oils/fats.

When selecting bleaching earth, care should be taken to avoid bleaching clays that contain significant amounts of chlorine-containing compounds/activated by hydrochloric acid. From 3-MCPD mitigation point of view, consider using pH-neutral clays. However, on the other hand, to mitigate GE acid activated (sulphuric acid or citric acid) is preferred.

Dosage of these adsorption agents should be adapted to ensure the removal of the specific substances.

If polycyclic aromatic hydrocarbons ((PAH) are present up to a certain level, activated carbon is used for their removal.

The bleaching clay containing all these substances is separated by filtration. If activated carbon was used, it is disposed of in a suitable way outside the food and feed sector[4].

[4] see FEDIOL Declaration on the safety of Used Bleaching Earth and Used Filter Aids in meal feed and expellers 13SAF195 for further details

Deodorization
The purpose of deodorization is to reduce the level of free fatty acids and to remove odours, off-flavours and other volatile components such as pesticides or light polycyclic aromatic hydrocarbons by use of a stripping media. Careful execution of this process will also improve the stability and the colour of the oil, whilst preserving the nutritional value and retaining, or only minimally changing, the original triglyceride composition.

The deodorization process is carried out under vacuum (<5 mbar), at temperatures preferably between 180° - 230°C and using a stripping media. It is recommended to use a deeper vacuum to facilitate evaporation of volatile compounds.
Specific conditions (temperature, duration, combination of both) should be adapted within these ranges as appropriate depending on the type of vegetable oil/fat and the type of facilities so as to ensure the removal of the specific substances.

To remove volatile contaminants, a minimum of 225-230°C is proposed. On the other hand to reduce the formation of heat induced contaminants such as glycidyl esters or trans fatty acids, not more than 235-240 °C should be applied. For example, it is suggested to conduct deodorization at 190-230°C for vegetable oils to decrease formation of GE[5].

2. Physical Refining

There is a distinction between chemical and physical refining in the way that fatty acids are removed: in physical refining, fatty acids are removed by distillation whereas in chemical refining, chemicals are used which bind to the free fatty acids to facilitate their separation and removal from the oil.

Degumming
In physical refining degumming aims at removing phosphatides, solid impurities and traces of heavy metals.

The degumming has an increased importance in case of physical refining as phosphatides should be removed to the required level prior to bleaching.

Seed oils are typically degummed in two stages using centrifugal separation. For fruit oils, which typically contain no more than 20 mg/kg phosphatides, dry degumming or no degumming is applied.
Dry degumming includes mixing acid into the oil and combining this with a bleaching step without washing.

Bleaching
The same process as described under chemical refining applies. The same recommendations are valid:

When selecting bleaching earth, care should be taken to avoid bleaching clays that contain significant amounts of chlorine-containing compounds/activated by hydrochloric acid. From 3-MCPD mitigation point of view consider using pH-neutral clays. However, on the other hand, to mitigate GE acid activated (sulphuric acid or citric acid) is preferred.

Dosage of these adsorption agents should be adapted to ensure the removal of the specific substances.
The bleaching clay containing all these substances is separated by filtration. If activated carbon was used, it is disposed of in a suitable way outside the food and feed

[5] Ibidem footnote 3.

sector[6]. These processes are partly done under vacuum and at temperatures below 110°C.

Deodorization
The purpose of deodorization is to reduce the level of free fatty acids and to remove odours, off-flavours and other volatile components such as pesticides and light polycyclic aromatic hydrocarbons by use of a stripping media. Careful execution of this process will also improve the stability and the colour of the oil, whilst preserving the nutritional value.

Deodorization in case of physical refining consists in two steps: stripping and deodorization.
Stripping allows to remove free fatty acids and volatile contaminants at higher temperature (240-260°C, below 2 mbar) for shorter time.

The deodorization step is carried out under vacuum, at temperatures between 180° - 260°C and using a stripping medium. It is recommended to use a deeper vacuum to facilitate evaporation of volatile compounds.
Specific conditions (temperature, duration, combination of both) should be adapted within these ranges as appropriate depending on the type of vegetable oil/fat and the type of facilities so as to ensure the removal of the specific substances.

3. Additional step which can be included in the chemical and physical refining: Dewaxing

Some oils like sunflower oil contain waxes, which crystallise at low temperatures and give to the oil a turbid appearance. Wax treatment is implemented for optical reasons, as waxes do not impact taste or other quality elements.

To remove waxes, different procedures are applied. They all have in common the low temperatures at which the waxes crystallise (the process is called "winterisation").

The waxes can be eliminated either by wet or dry dewaxing processes. In dry dewaxing filter aids are usually applied. It is also possible to filter without filter aids to obtain a semisolid oil-wax product that can be used in the bakery sector.

Filter aids can be sub-divided into three categories: perlite (naturally occurring volcanic glass based on sodium potassium aluminium silicate), diatomite (originated from diatomaceous earth) and cellulose and other organic media (produced by the sulphite or sulphate processing of hard woods). Filter aids are typically used to remove waxes and other solid components from crude oil.

4. Post refining

Depending on the quality of the oil achieved after refining, additional post-refining steps can be applied to reduce occurrence of specific substances. This can include additional bleaching and deodorisation steps.

If this is undertaken, care should be taken in considering appropriate parameters (temperature, duration, combination of both). Post-treatment can be used if it is not possible beforehand to prevent the formation of some contaminants or reduce them to the desired level.

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[6] Ibidem footnote 4.