Initial Quality of Frying Oil

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Fried food has grown in popularity despite the low-fat/no-fat health trend. For example, between 1979 and 1988, the snack food industry in the United States increased by about 88%.

Fat or oil used for frying often determines the acceptability of food prepared with them. Although frying oil serves primarily as a heat exchange medium, oil often makes up a significant portion of the final food product, as much as 45% of the total product. Oil varies widely in eating quality, functionality, and rate of deterioration depending on source, processing, or formulation.

Quality in the Edible Oil Refinery

Traditionally, two terms have been used to describe how quality is monitored in processing facilities: quality control and quality assurance. Quality control is a process function with evaluations at each step of the process with specifications set at each step. Interpretation of results followed by process adjustments ensure that the final product meets product specifications.

The function of quality assurance encompasses all aspects of oil processing including specifications, packaging, shipping, receiving, purchasing, sales, service, storage, and sanitation. In today's environment, there is a "partnering" between oil processor (supplier) and user (customer). Partnering implies that both are in business together and have a stake in the outcome. Since the early 1980s, quality assurance in processing industries has been referred to as a "total quality movement." No longer is quality concerned only with controlling the process to meet minimum product specifications. Quality is now assured through all aspects of production from management to shipping to product characteristics. Terms frequently used to describe today's quality programs are select supplier programs, ISO 9000, statistical process control (SPC), good manufacturing practices (GMP), and total quality management (TQM).

Frying Oil Specifications

Specifications are prepared for oil to ensure that quality is acceptable. Specifications may originate from the producer or be part of buyers' specifications. Specifications are guidelines for the oil processor to purchase raw materials, process intermediates, and formulate products. A typical production specification at the oil refinery is shown in table 1.

Table 1
Typical Specifications for Winterized Soybean Oil[a]

Specification		Specifications
Color (5 1/4" Lovibond)	1.0 max	Iodine value (Wijs) 108–112
Free fatty acid (% as oleic)	0.05 max	Drop point (ºF)
Peroxide value (meg/kg)	0.5 max	SFI[b] 50ºF
Flavor/odor	7 min	70ºF
Filter test	6	80ºF
Moisture (%)	0.05 max	92ºF
Appearance	clear	104ºF
Chlorophyll (ppb)	75 max	AOM[c]
Cold Test (h)	10 min	Linolenic acid (%) 3.0 max

[a] Composition: ingredients, winterized SB–110W 100%; additives, none.
[b] SFI = Solid Fat Index.
[c] AOM = Active Oxygen Method.

Crude Oil Processing

Edible fats and oils are derived from several plants (soybean, corn, sunflower, rapeseed, or canola) and animal sources (tallow, lard, fish, and butterfat). They are differentiated by source, fatty acid chain length, and physical form. Each has a unique fatty acid composition that influences its suitability for various applications. In addition to the identity of oil, geographical origin or the method of recovery may be identified.

Crude oil refers to any oil in its native state. Components that adversely impact flavor, odor, appearance of finished product, or performance of an oil during use are removed during processing. The composition of crude soybean oil is shown in table 2.

In addition to the undesirable flavor, odor, and color, the presence of free fatty acids (FFA), partial glycerides, and phospholipids make the crude oil unsuitable for deep-frying use.

Table 2
Average Compositions for Crude and Refined Soybean Oil

	Crude Oil	Refined Oil
Triglycerides %	95–97	>99
Phosphatides %	1.5–2.5	0.00–0.045
Unsaponifiable matter %	1.6	0.3
Plant sterols %	1.6	0.13
Tocopherols %	0.15–0.21	0.11–0.18
Hydrocarbons (squalene) %	0.014	0.01
Free fatty acids %	0.3–0.7	<0.05
Trace metals		
Iron ppm	1–3	0.1–0.3
Copper ppm	0.03–0.05	0.02–0.06

The common steps of oil processing include: i) filtration and degumming, ii) alkaline or physical refining, iii) bleaching, iv) hydrogenation, v) winterization or fractionation, vi) deodorization, and vii) packaging. The objectives of oil refining are to isolate, in a commercially practical sense, pure triglycerides from crude oil. The triglycerides may then be modified or combined with additives to obtain desirable performance and packaged in a usable form.

Objectives of Processing Steps

Filtration and Degumming

This step removes small amounts of nontriglyceride components, such as residual meal, metal fragments, dirt and gums (hydrated phospholipids), and other insolubles from crude oil. A filter aid, such as diatomaceous earth (DE), is slurried with the crude oil prior to filtration to assist the flow of oil through the filter.

After filtration, the oil is mixed with small quantities of softened water. Hydratable components are allowed to hydrate; then the oil–water mixture is centrifuged to remove the higher density wet gums from the less dense oil. Properly filtered and degummed oil is clear and brilliant with less than 20 ppm phosphorus. The adequacy of filtration and degumming are determined by clarity or filter tests and residual phosphorus analysis.

Alkali or Physical Refining

This step is utilized to remove FFA from oil. Alkali refining consists of the reaction of dilute sodium or potassium hydroxide with the FFA to form water-soluble soaps. The amount of alkali or caustic to be added is optimized to remove only FFA and prevent further hydrolysis of triglycerides. The reaction of the alkali with FFA forms a thick stable emulsion, called soapstock, consisting of soaps, triglycerides, and water. The emulsion is passed through a refining centrifuge to separate the high-density soapstock and water mixture from oil. Final soap contents are normally less than 50 ppm, and FFA is near zero.

Physical refining does not involve caustic addition. Oil is steam sparged under a 4- to 6-mm Hg vacuum at more than 200°C. All volatile components, including FFA, are stripped from oil. Free fatty acids in soybean oil, for example, are reduced from about 1.5% in crude oil to less than 0.05% in finished oil.

Bleaching

Bleaching removes color bodies, residual soaps, and phosphatides from refined oil. Bleaching is an adsorption process. The adsorbents, referred to as bleaching clays, consist of calcium montmorillonite, natural hydrated alumina silicate, silicon dioxide, or activated carbon. Bleaching consists of adding adsorbents to oil followed by heating under a vacuum. The adsorbents are then filtered from the oil. Filter tests ensure complete removal of clay adsorbents.

Hydrogenation

This is the process of chemically reacting an oil with hydrogen gas in the presence of a catalyst. The catalyst is generally reduced metallic nickel. The hydrogen reacts at the unsaturated double bonds of fatty acids as these bonds are the most reactive groups in the triglyceride. Hydrogenation reduces the degree of unsaturation. This dramatically changes the chemical and physical attributes of fat or oil. Both oxidative and thermal stability of oil are increased with increased hydrogenation. Oil may be physically converted from a liquid oil to semisolid or solid fat during hydrogenation.

When the desired degree of hydrogenation is achieved, as represented by iodine value (IV), the oil is slurried with DE and passed through a filter to remove the catalyst. Citric acid may be added to chelate and remove any residual nickel catalyst or acid-activated clay.

The extent of hydrogenation is readily determined by IV, which is defined as the grams of iodine that combine with 100 g of oil. A lightly hydrogenated soybean oil has an IV of 110 and is a cloudy fluid at room temperature. Continued hydrogenation of oil to less than 90 IV produces a semisolid fat. Oil with less than 70 IV has a hard-to-brittle consistency.

Winterization or Fractionation

This step is the removal of high-melting triglycerides from lower-melting components. For example, a lightly hydrogenated 110 IV soybean oil is cloudy at room temperature because of the presence of high-melting triglycerides. In winterization, oil is slowly cooled to force crystallization of higher-melting glycerides. The crystallized components are then removed by filtration, producing a clear fluid oil at room temperature. Soybean oil hydrogenated to less than 95 IV, then winterized, produces a high-stability frying shortening that is fluid at room temperature. Palm oil is generally fractionated into low-melting olein and high-melting stearin components. Winterized oil is tested for resistance to crystallization at ice water temperatures. A minimum number of hours, such as 10, is commonly used for hydrogenated, winterized soybean oil.

Deodorization

Deodorizing oil removes the final traces of volatile components, primarily those that contribute to flavor and odor. The goal of deodorization is to produce a nearly flavorless, odorless oil with a light color. Deodorization consists of steam-sparging the oil under high vacuum (< 10 mm Hg) at high temperatures (> 200°C). After deodorization and cooling of the oil, a chelating agent, such as citric acid, may be added to deactivate trace metals. Antioxidants may also be added to enhance stability.

Packaging

Packaging oil may include additional processing steps. For bulk storage of frying oil, vertical tanks are preferred. Agitation or circulation and nitrogen blanketing prevents stratification and contact of oil with air during storage. Maintaining oil temperatures above the melting point is necessary to prevent solidification. Stainless steel storage tanks are preferred to prevent contact of oil with iron or other proxidant metals.

Oil for packaging is nitrogen flushed to prevent air contact. Saturating the oil with nitrogen also prevents partial collapse of plastic containers upon cooling of the oil in the container. Specially formulated frying oils, such as liquid frying shortening, require a positive nitrogen headspace. Votated plastic shortening in cartons contains 10–15% nitrogen gas to improve handling and appearance.

In summary, the initial quality of a frying oil may have a significant impact on the quality of fried food prepared with it. The initial quality of oil, as well as its durability during frying, is influenced by all steps involved in processing the oil.

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