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Processing Of Fats And Oils

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PROCESSING OF FATS AND OILS[1]

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The production of fats and oils from domestic material in 1943 was in the neighborhood of 11 billion pounds compared with about 10.6 billion in 1942 and about 9.6 billion in 1941. With prices ranging from 8½c to 41½c (butter), it is realized that the business in domestic fats and oils is a large one although the total cost of all commodities amounts to only a little over one per cent of the figure for gross national production in 1943. It should be remembered that such cost covers only the fats and oils but not the raw material from which they have been produced.

Of all fats and oils consumed in this country in 1940, 67 per cent went into food products, 20 per cent into soap, 8 per cent into paints, varnishes, etc., and 5 per cent into miscellaneous products. Of the materials entering into food products, butter alone accounted for about 35 per cent, lard about 30 per cent and cottonseed oil about 20 per cent. The consumption of domestic fats and oils in 1940 constituted about 85 per cent of the total consumption of fats and oils. The remaining 15 per cent was of foreign origin. Since Pearl Harbor these percentages have been displaced as oils like coconut-, palm-, castor-, tung-, perilla oil and others have been partly or totally cut off from importation. In order to offset this curtailment of imports this country has greatly increased its acreage of linseed, soybeans and peanuts.

SOURCES OF FATS AND OILS

Fats and oils occur in many thousands of species of plants and animals. Frequently fats of quite different composition and appearance are obtainable from different parts of the same plant or animal. Only a few hundred fats, however, have been analyzed and of these only two or three dozen have attained commercial importance.

PRODUCTION OF FATS AND OILS

The *vegetable oil-bearing material* such as beans, nuts and seeds varies a great deal in its oil content. The latter may be as low as 16 to 23 per cent (soybeans) and as high as 62 to 70 per cent (copra, babassu). The material, as it arrives at the mill, has often been prepared, for various reasons, for immediate processing. Thus copra,

[1] Paper No. 57, Journal Series, General Mills, Inc., Research Department. This paper is a condensed report on the discourse, illustrated by slides, and given by the author at the Eleventh Annual Meeting of The Minnesota Academy of Science, April 24, 1943. The figures given at that time for the production and consumption of fats and oils have been modified to correspond with 1943. The present report differs from the original paper to the extent required by the absence of the slides.

which is the sun- or smoke-dried meat of the cocoanut, arrives from the Orient with a moisture content of 4 to 6 per cent. Palm- and babassu kernels are imported as such, that is, they have been removed from the shell. The common domestic material such as cottonseed, peanuts and soybeans receives such preparatory processing as de-linting, de-hulling or de-"skinning" at the mills where the pressing or extraction takes place.

In the mill the material is generally subjected to certain cleansing processes, prior to comminution, in order to remove foreign substances, dust, etc., and it also passes over traps and magnetic pulleys in order to be freed from stones and metals which, if they remained, might ruin the equipment and be a fire hazard.

The material is now comminuted by means of attrition mills, cracking- or flaking-rolls. It is then either heated or "cooked," depending upon the method chosen for subsequently obtaining the crude oil. The methods in use are: (1) The hydraulic batch process in which the material is subjected to pressures up to 6,000 lbs. per square inch. Types of presses used are the plate-, the box- and the cage-press. (2) The expeller- or screw-press in which the pressure is transmitted by means of motors and gears. This process is continuous. Localized pressures up to 18,000 lbs. are obtained and certain oil-bearing material, therefore, on account of the action of the equipment, does not have to be comminuted prior to the passage. (3) The extraction method by means of solvents such as hexane, trichloroethylene, benzene, etc., in which the process may be either batch or continuous. Several types of the continuous process have been adopted by the large-scale producers. In preparing the raw material for any of the three methods it is essential that substantially all oil cells are opened or ruptured. In the pressing operations it is, furthermore, important that the material receives a heat treatment in order to coagulate proteins and to promote such other chemical-physical changes as to make the material suitable for pressing without seeping through the presscloth or cage. Certain material, however, may be pressed "cold." In this connection it should also be mentioned that the moisture content is highly important in order to give the material the physical properties required for obtaining the best results from a particular operation.

The *animal fats,* such as lard, tallow, fish body, and liver oils, whale oil, etc. are generally obtained by melting the fat-containing tissue in open or closed tanks or steam-jacketed screw conveyors, by direct or indirect steam treatment and at atmospheric, sub- or superatmospheric pressure. The fat may then be skimmed off after settling of the water and solid matters and then clarified by centrifugation or by means of filterpresses. In the plants which produce sardine oil the fish is cooked, then passed continuously through a screw press of a construction similar to the aforementioned expeller whereby water and oil are separated from the solids. The oil and water are separated by settling and skimming or by means of centrifuges. The rendering of the vitamin bearing and highly important and valuable liver oils may be done by heating the livers to some extent and with or without addition of chemicals. Fat-solvents may also be used, or the oil may be obtained by seepage from the deteriorated tissues. Thus it is seen that the rendering of animal fats and oils is much more simple with regard to equipment used than that of vegetable fats and oils.

TABLE I.

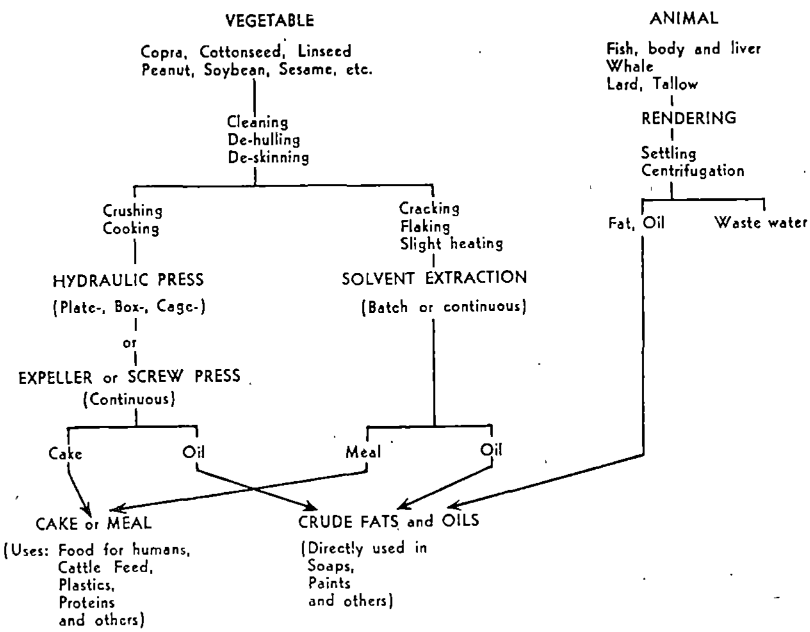


Table 1 shows a diagrammatic flow sheet of the principal steps applied in the production of crude oils. It is, by necessity, very sketchy. It is logical, on this flow sheet, to stop at the "crude oils," not only on account of the fact that milling and refining operations are, in most cases, carried out in separate buildings or even at different locations, but evidently also because we, at that point, are stepping over the threshold between mechanical and chemical processing.

CRUDE FATS AND OILS

Most crude *vegetable oils* are subjected to some kind of processing before being used for various purposes. Although certain fats and oils are used directly for the manufacture of soaps and paints, they are often subjected to a clarifying and bleaching operation before such use. Before being used for edible purposes they must, with the exception of olive oil, undergo a thorough refining process consisting of, mainly, such steps as alkali refining (removal of the free fatty acids), washing, bleaching and deodorization. Prior to the deodorization they may have been hydrogenated and such material may then be subjected to a rapid chilling process whereby it acquires desirable physical properties such as are known from various shortenings.

Hydrogenation, which is generally carried out on the neutralized (alkali refined) oils, also provides very large quantities of material for technical or inedible purposes (soap, compounding of rubber, metal soaps). The hydrogenation may be partial or complete, that is, the melting point of the hydrogenated product may vary between 30° C. and 67° C. The latter product is so hard and brittle that it may be pulverized or it may be cooled as a thin film on a revolving, internally cooled steel drum from which it is scraped off as flakes which may then be shipped in sacks.

For technical purposes the crude fats and oils may be "split" into their component fatty acids and glycerin by subjecting them to the Twitchell or similar process, by the action of lipolytic ferments, by autoclaving or, continuously, by means of water at high temperatures and pressures up to 500 lbs. per sq. inch. The hydrolysis is 95-97% complete. The liberated fatty acids can now be (fractionally) distilled while the glycerin solution must be purified and concentrated before distillation.

The crude *animal fats and oils* receive different processing depending upon their origin and future use.

Marine animal oils are generally alkali refined and bleached before further processing which may consist of such steps as "bodying" by means of air-blowing or heating, hydrogenation for technical or edible purposes, molecular distillation for recovery of vitamins, "splitting" so as to obtain fatty acids which by fractional distillation yield products with high iodine numbers and sulphonation. The fats from land animals, such as lard and tallow, seldom receive any treatment beyond a bleaching or clarification with Fullers Earth or activated carbon or both, although lard may be alkali refined prior to hydrogenation. Both lard and tallow may be subjected to a cooling process and the crystallized, solid or semi-solid fat packed in canvas bags which are then transferred to a hydraulic press. The pressing causes a separation of the liquids (lard oil, oleo oil) from the solids (lard stearin, oleo stearin). These products are used for both technical and edible purposes. The crude tallow may also be hydrolyzed either by one of the previously mentioned methods or by adding a few per cent of concentrated sulfuric acid. The latter method, which causes almost 100% hydrolysis, also increases the content of solid acids by converting oleic acid to hydroxy-stearic which, however, during a subsequent distillation will split off water to give oleic- and iso-oleic acid. After the above acidification the mixture is boiled with water. The fatty acids may now be separated, before or after distillation, into liquids and solids by chilling and hydraulic pressing. The solids which form the product commercially known as stearin or stearic acid are used in candle making, compounding of rubber, polishes, etc. while the liquids known as "red oil" are used in textile soaps, wool oils, leather making, etc. "Turkey red oil" is, generally, sulphonated castor oil.

Table 2 is an attempt to draw a flow sheet showing the principal steps in the processing of crude fats and oils. It is to be understood that the steps thus shown do not apply to all kinds of fats, some of which may skip certain steps entirely. Due to the diverse properties of the fats and the various purposes for which they are used it would be impossible to present a detailed flow sheet which would cover the individual fats and still not exceed reasonable space limits.

At this point it seems advisable, briefly, to refer to the technological expressions used.

Degumming—precipitation of phosphatides by adding water or solutions of chemicals.

Alkali refining—neutralization of the free fatty acids and removal of the resulting soaps.

Soapstock (Foots)—the soaps from the alkali refining plus entrained neutral oil.

Acidulated Soapstock—the mixture of free fatty acids and neutral oil obtained by boiling the soapstock with dilute sulfuric acid and live steam.

Splitting—hydrolysis of glycerides by various methods.

Cold pressing—separation of solid from liquid acids by hydraulic pressing. The term may also be used for winterized oils.

Boiled-down soapstock—the product resulting from saponifying soapstock (generally cottonseed oil) with excess caustic soda, salting out the soap, settling and draining off the lower aqueous solution containing the coloring matters. Repeated processing and final evaporation of water yields a light colored soap base with up to 80-85% total fatty acids.

Washing—spraying or mixing with water.

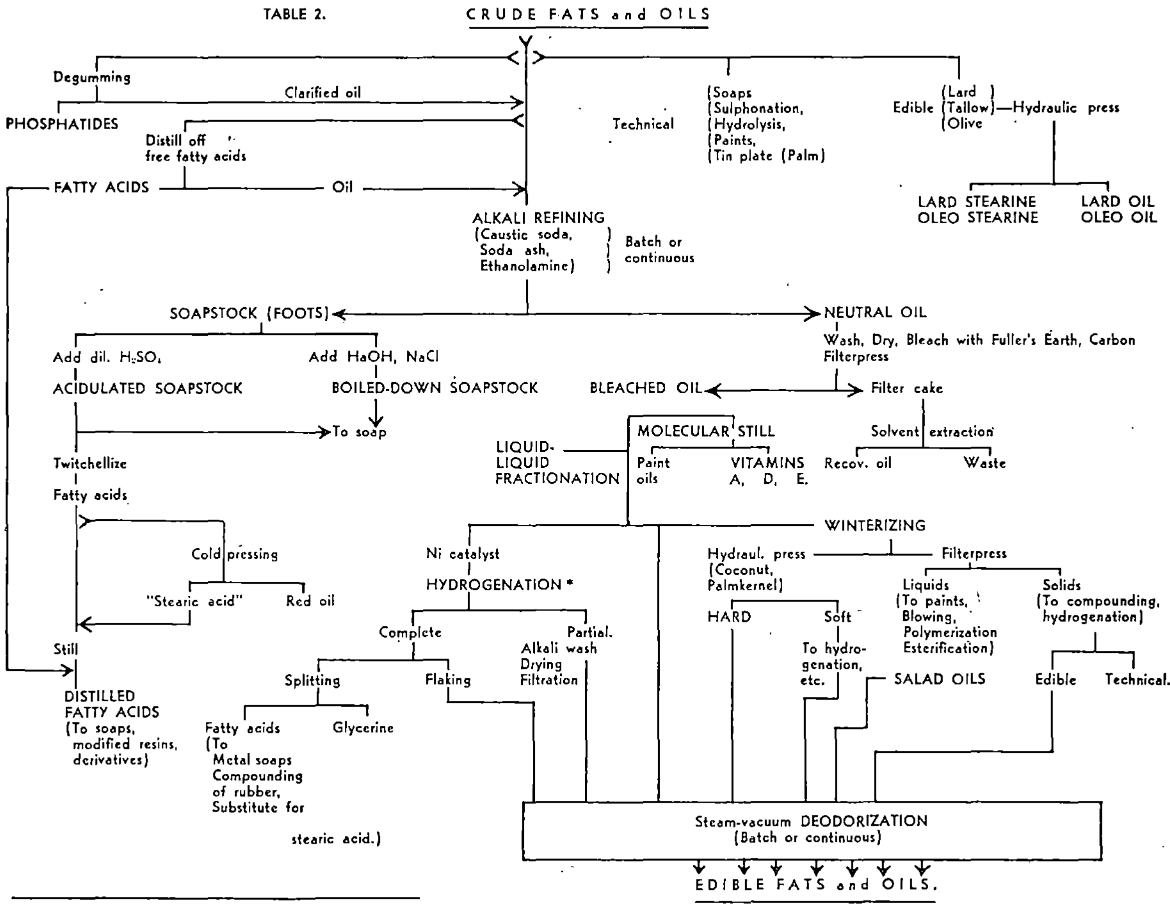
Bleaching—generally done with Fullers Earth, activated earths (clays) and carbon.

Liquid—liquid fractionating—the partial separation, by means of solvents, of glycerides with higher and lower iodine numbers.

Winterizing—the partial separation, by chilling and crystallization, of glycerides with a higher melting point from those with a lower melting point. Salad oils must not show a precipitate above 32° F.

Hydrogenation—generally carried out at not over 70 lbs. pressure and temperatures up to 220° C. Conditions may be varied to promote selective or non-selective hydrogenation. Different cata-

TABLE 2.



(For Shortenings, Margarine, Cooking and Salad Oils, Confectionary and others)

* High press. hydrogenation (fats to alcohols) not considered.

lysts may be applied for similar reasons. The catalyst used commercially is reduced nickel or copper-nickel produced by heating the formate or, on a carrier, by hydrogen-reduction of the basic carbonates precipitated on diatomaceous earth or carbon. Raney nickel may also be used. Hydrogenation may also be carried out continuously, using a stationary catalyst. The hydrogen used may be produced electrolytically or by the shaft and other processes. It must be free from catalyst poisons.

Deodorization—the process of blowing live steam through the oil at temperatures up to 225° C. and under a vacuum of 5 to 50 mm. The odoriferous matters are carried off by the steam.

Shortening—made by subjecting fats to a rapid cooling either in a thin film on a revolving, internally cooled steel drum from which the semi-solid material is scraped off and homogenized (texturated), or by passing through an externally cooled cylinder under agitation and pressure. The material emerges through an extrusion valve whereby homogenization is accomplished. In both cases a certain amount of air or nitrogen is incorporated for the purpose of improving texture, plasticity and color.

NIGHT VISION

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Dark adaptation is the ability of the eye to adjust or adapt its visual mechanism to darkness. The phenomenon may be observed when passing from the street, with noonday illumination, into the movie theater. At first nothing is seen in the darkened room, but as the eye adapts itself, the benches, chairs and walls begin to be discerned. As time goes on, objects become clearer and more definite, and the eyes become adjusted or adapted to the environmental illumination. In turn, in passing from the darkened surroundings of the theater to the brightly illuminated street, the eyes must become *light*-adapted. One often experiences the effects of glare and the symptoms of photophobia. Hence, the most adaptable eyes and those of superior quality in military science, such as night flying, possess *tolerance* for strong illumination and retinal *sensitivity* to low illuminations.

PHYSIOLOGY OF DARK ADAPTATION

The retinas of most vertebrates contain two different types of receptors—cones and rods. Hence the retina of the vertebrate may be considered as a dual rather than a single sense organ. Structurally, the center of the human eye, the fovea centralis, is occu-