Handling of Fats and Fatty Acids

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THE subject of handling fats and fatty acids is so extensive that in one paper it can be discussed only briefly and in a general fashion in order to point out some of the problems involved. More specific discussions are given in other papers in this series.

Animal Fats

Most of the slaughtering of animals is done in either state or federally inspected establishments although some farm slaughtering is still done for local consumption. The packing house does some trimming of fats but sells a large part of the slaughtered animals partially cut up into sides, halves, or cured meats to wholesale jobbers. The wholesale jobbers cut the meat into still smaller cuts and sell to butchers, chain stores, hotels, restaurants, or large institutions. The latter recut and trim the meats for final consumption. Thus, there are animal fats available at several levels, from the meat packer, wholesaler or jobber, hotels, restaurants, institutions, and homes. These fats at the various levels are collected, sorted, rendered, and then sold by grade to the many users of rendered tallows and greases. There are many factors which affect the quality, yield, and value of the rendered tallows or greases.

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Since commercial grades of tallows and greases are sold on the basis of free fatty acid, titer, color, moisture and volatile matter, impurities, and unsaponifiable matter, some precautionary attention in the handling and rendering of fats will yield beneficial results.

Free Fatty Acid

To keep the free fatty acid in rendered fat as low as possible the following factors should be watched carefully:

1. Process all raw fats as quickly as possible,
2. wash all fats carefully,
3. keep cookers and rendering equipment in clean, good operating condition, and
4. store only clean, rendered, well-settled and dried stock for as short a period as possible. Only use heat to melt for loading.

Free fatty acids will react chemically with iron and bone fragments. This reaction will leave some soap dissolved in fat. In addition to iron soaps, traces of other soaps, such as calcium, magnesium, etc., are usually present in rendered animal fat.

Color

To insure best color of rendered fats:

1. Use care in heating of fats; do not overcook or scorch,
2. free fats to be rendered from intestinal or stomach residue, and
3. remove decayed or dirty raw fats.

Titer

The titer of the rendered fat will be determined by the raw materials. There is no way to change the titer by rendering. Care should be exercised to keep out certain items, such as vegetable oils, horse fat, chicken fat, etc., which might drop the titer to a point outside of the standard grades. Generally fats with titers outside the standard grades have to be sold at a discount.

Moisture and Volatile Matter

Any rendered tallows or greases containing excessive moisture and volatile matter will lose quality in storage. Since animal and vegetable fats are fatty acid glycerides, storage of the tallow with moisture may cause some decomposition, with loss of glycerine and darkening in color. The glycerine will be lost in the water layer drawn from the bottom of the storage tank.

Some factors resulting in high moisture and impurities are:

1. Leaking coils in storage or settling tanks,
2. undercooking, and
3. condensed steam from line blowouts.

Solvent extracted fat often contains residual solvent. This will show up and be reported with moisture and volatile matter. Furthermore the residual solvent can be a dangerous hazard.

Unsaponifiable Matter

Unsaponifiable matter is material soluble in pure fat, but it does not combine with caustic to make a soap. Ordinarily rendered fresh fat will contain less than 0.5% unsaponifiable matter. Sometimes decay of the raw material will cause a rise in unsaponifiable matter. Unclean fat, containing residual undigested feed from the stomach or intestines, will also tend to raise the unsaponifiable content of the fat.

Other sources for excessive unsaponifiable content of fats are:

1. Mixtures with household or salvage fat or garbage grease,
2. excessive lubricating oil leakage from oil lines or lubricators in rendering plants,
3. use of tank cars or tank wagons or pipe lines previously used for handling fuel or lubricating oils which have not been properly cleaned,
4. excessive use of denaturant by packing house. (Note: The U. S. Department of Agriculture insists on use of denaturant on certain grades of fats to insure that fat does not go into edible use.)

Where the renderer, whether packer or private rendering concern, can help himself and the consumer is to follow certain basic rules:

1. Handle fats very quickly,
2. sort fats,
3. clean and wash fats,
4. render; do not under- or over-cook,
5. see that the fat is released as quickly as possible to the consumer,
6. ship rendered tallow or grease as quickly as possible to consumer,
7. if necessary to store, be sure that moisture is as low as possible,
8. do not heat stored fat unless necessary, and then only enough to insure flowability,
9. keep pumping and pipe lines clean, and
10. use stainless steel wherever possible, where in contact with fat or rendered products. For temperatures to 300° F., use type 304 stainless steel.

Tallow and greases are usually produced by any one of three methods, steam rendering, dry rendering, and solvent-extraction.

Steam Rendering. This process is sometimes called wet rendering. It consists of heating, directly with live steam, the fresh fats contained in closed, cone-bottomed, usually uninsulated steel tanks. The tanks are made in various sizes, usually so that the depth is about twice the diameter. The tanks are equipped with a charging door, a vent line and safety valve on top, draw-off cocks on the side, steam inlets in the lower part of the cone, and a quick opening gate valve on the bottom of the cone for dumping the tankage and tank water.

Dry Rendering. After the steam-jacketed tank had been put in use in packing houses and vacuum equipment became available, the two were combined and applied to the rendering of animal fats. The tank used for making dry rendered lard and tallow is known as a "dry melter." It consists usually of an insulated horizontal steam-jacketed cooking tank with charging door and sampling device. It is also equipped with a mechanical arm agitator, extending the length of the tank to stir the material while it is being cooked.

One of the most critical and difficult phases in dry rendering is the determination of the proper end-point of the cook. Even the most experienced operator may misjudge the correct end-point. The temperature within the cooker remains almost constant until most of the water is driven off, then suddenly starts to rise, at increasing rates, until the product is dry.

The correct end-point is just before the product is dry and while it still contains some moisture. If cooked less than this, the cracklings will be too soft and difficult to press and will usually show a high fat content. If cooked past this point, some dehydration of the protein takes place and some of the color passes into the tallow, causing dark color and loss of bleachability.

Solvent Extraction. Some tallow and greases are produced by grinding fat and mixing with solvent. Subsequent heating will release the fat molecules, which dissolve in the solvent. Stripping of the solvent leaves the solvent-free fat.

Inedible Vegetable Fats and Oils

Some whole vegetable fats and oils are used in the inedible industry, such as soap, synthetic detergents, fatty acids, paints, etc., but, as a rule, whole oils are used only when economics justify doing so or when they are needed for specialty purposes. Some of the common vegetable fats and oils used are coconut, palm, palm kernel, babassu, cottonseed, castor, peanut, soya, corn, and linseed.

Oil seed, nut or bean, can be processed to separate the oil from the high protein meats by several processing methods. In the hydraulic method of processing the meats are crushed in vertical rolls, cooked to coagulate the protein and obtain the proper moisture and temperature, and then pressed under hydraulic pressure.

In the continuous mechanical press process the meats are sometimes crushed or cracked, and sometimes fed directly to the presses. Most material is also heated or dried, and then fed to the continuous press.

The solvent extraction method involves the mixing of crushed oil seeds with solvent, with subsequent stripping of the solvent from the oil.

Proper selection and storage of seed are essential if the products are to be of high quality. Proper cleaning of the seed may make the difference between operation uninterrupted for many weeks and operation plagued by minor shut-downs. Since warm, moist protein quickly forms hard masses, which plug equipment and conveyors, one shut-down generally causes several more. Not only does down-time reduce production, but it is during periods of irregular operation that plants using hydrocarbon solvents are hazardous. Excessive rain, drought, improper storage of seeds or beans will affect the quality of the vegetable oils and the yields of refined oil and soapstock.

All crude vegetable oils contain non-glyceride constituents commonly known to be "impurities." Some of these impurities are: free fatty acids, sterols, carbohydrates, mucilaginous matter, odor bodies, and color bodies. To make the oil palatable for human consumption, the oil must be processed by refining.

The crude oil can be refined by the batch method, where the alkali solution is mixed with the crude oil in a kettle, agitated, heated, and allowed to separate into a top oil layer and a bottom soapstock layer.

The crude oil can also be refined continuously by mixing the oil and caustic, under controlled conditions, and then feeding to centrifuges, where the refined oil and soapstock are separated continuously. The amount of soapstock produced will vary with the quality of the crude oil. The refined oil can then be further processed to convert it into edible products by bleaching, hydrogenation, and deodorization.

The soapstock contains most of the impurities origally present in the crude vegetable oil, plus some alkali soap, some free oil, and water. Large quantities of this soapstock are sold as such to soap makers and fatty acid producers. This soapstock tends to deteriorate and ferment when held warm for extended periods of time. Sometimes formaldehyde or similar substances are added in very small quantities to prevent deterioration. This soapstock is difficult to handle, and one experience heating it with closed steam coils is all that is necessary to remember to keep the soapstock moist for handling.

Since the soapstock contains almost 50% water, there is no justification for paying long freight hauls on the water. Most refineries have acidulation equipment to remove it. The soapstock is pumped into the acidulation kettle, which can be of wood, lead, or Monel. Strong sulfuric acid is added while boiling, until a sample tested shows that the desired point has been reached. Too often some refiners are interested only in selling as many pounds as they can, rather than quality, so that they stop the acidulation just short of a good job, leaving it up to the consumer of the acidulated soapstock further to clean it up.

If the refiner keeps each type of soapstock separate, the composition of fatty acids in the acidulated soapstock will be about the same as the composition in the crude oil from which the soapstock is derived. Too often, for one reason or another, there is contamination. In the long run the care exercised should yield beneficial results. Some important items that can be watched by refiners are:

1. Keep lubricating greases or oils out of crude oils and soapstock,
2. do not sulfonate during acidulation; watch acid strength,
3. really acidulate to give good acidulated soapstock,
4. keep each type of soapstock separate,
5. keep out deodorizer hot well skimmings,
6. keep out extracted fat from bleaching process; this fat may show high oxy acids, and
7. do not overheat soapstock.

It is extremely important to the ultimate user of the soapstocks or acidulated soapstocks that they be as uniform as possible.

The fatty acid producer is called upon by manufacturers of resins and alkyds to produce a fatty acid as high in iodine number as possible. It is readily seen that mixing with soya either peanut or cottonseed soapstocks, or coconut for that matter, will certainly depreciate the soya to the point where it cannot be used in the manufacture of high grade alkyd or resin soya fatty acids. High oxy acids or oxidized acids in the soapstock are also deleterious to the use of the material for high quality fatty acids. The oxy or oxidized fatty acids usually end up as a still residue with very little value. The low yield of good fatty acids obtained, of course, is then high priced.

Handling of Fatty Acids

Commercial fatty acids are those produced by the hydrolysis of natural fats and oils, and subsequent separation and purification. They include various combinations of the straight-chain, monobasic carboxylic acids through the range of 6 to 24 carbon atoms. In addition, certain isomers, and dibasic acids fall into the same industrial grouping. Improved methods of handling and shipping fatty acids have made these products as simple to handle as fats and oils. The advantages of fatty acids now are no longer confined to the large plant with elaborate facilities but may now be utilized by all consumers who can profit by the use of these materials.

For most uses, fatty acids can be handled in conventional equipment. Although frequently discussed as a class, fatty acids vary widely in their characteristics so that methods of handling must be matched to the particular acid used. Methods of handling also differ substantially from those applicable to the oils from which they are derived, or which they may replace in application. The sensitivity of the end-product to quality factors, such as color, also strongly affects handling requirements.

Storing Fatty Acids

Chemically, fatty acids are mild acids and react with certain metals, such as iron, to form metallic soaps. These soaps cause discoloration and, in addition, act as catalytic agents to accelerate oxidation, particularly in the case of highly unsaturated fatty acids. Effective control in the customer's plant is a simple matter in the case of drum stock, since the drums in which the acids are received are satisfactory for all ordinary storage periods, if they are not stored at temperatures materially above room temperature. Drums should not be allowed to stand open and, whenever possible, the holding of partially full drums should be avoided.

Bag stocks also may be stored as received, but, unless a cool, dry storage space is available, prolonged storage will result in some deterioration.

The fatty acid industry has, in the main, adopted substantially uniform containers for shipping various grades of materials. In general, it can be said that every effort has been made to insure the delivery of the finest fatty acids possible to fatty acid users. Hard fatty acids are produced in flake, bead, powdered, or cake form, depending upon the type of product and the practices of the individual manufacturer. In flake, bead or powdered form it is supplied in 50-lb. multi-wall paper bags. In cake form it is packed in 100-lb. paper cartons, or in bags containing 200 lbs. Hard fatty acids are also shipped in insulated 8,000 gal. (60,000 lb.) lined tank cars, equipped with melting-out coils.

Lined steel or aluminum tank cars of 8,000 gal. (60,000 lbs.) capacity have been used for several years by the fatty acid industry for the bulk shipment of fatty acids; and this is the trend in the fatty acid industry. In addition, local deliveries are made in various sizes of tank wagons, steel or lined steel.

Unloading Bulk Solid Acids

Low pressure steam should be turned on the coils gradually to heat slowly. All pumping lines should be equipped with steam tracers (usually copper tubing wound about the line or electric strip elements) and kept at an elevated temperature to prevent solidification and blockage of the line. Under these conditions stearic acid can be pumped as readily as any low-titer fatty acid. All pumping lines should be cleared after using by blowing out retained liquid, using nitrogen, carbon dioxide, or steam. Steam has the advantage of melting out any solidified material, but, of course, the blown-out product is water-contaminated and must be segregated. Air-blowing is not desirable.

Shipment of Semi-Solid and Liquid Fatty Acids

Where necessary, problems of iron contamination can be avoided by the transport of light-colored liquid and semi-liquid fatty acids in resin-lined steel or aluminum tank cars. Even low titer acids, such as oleic, will "titer-out" or seed out in cold weather so that the steaming procedure given above may be required.

Fatty acids in drums may be stored in outside areas, if necessary, but inside storage is much preferred. Outside storage will tend to obliterate drum markings and rust the drums. Drums should be kept out of the sun. The best practice is to store drums of fatty acids under conditions of reasonably constant temperature.

Most fatty acid products are mixtures of two or more individual fatty acids, and there is some tendency, even among normally liquid fatty acid mixtures, for a selective settling out of the higher melting point acids. For this reason, when the contents of drums are only partially used at a given time, it is essential that the fatty acids be completely liquefied and mixed prior to their usage to insure complete uniformity.

Users who purchase fatty acids in tank car quantities will find it advisable, if best results are to be obtained, to maintain special storage and handling equipment. In many cases existing steel tanks may be economically coated or lined for fatty acid storage.

When new storage tanks are to be erected, aluminum and stainless steel are preferred construction materials. Various types of stainless steel and stainless clad are available to meet special conditions. Type # 304 is suitable for general storage and will, in most installations, prove satisfactory. Wooden tanks can be used, but here, due to shrinkage of the staves, leakage is a serious problem. Wood should not be used for permanent installation. Copper and ordinary steel tanks are not recommended because of serious corrosion and discoloration of the fatty acids. Heating coils for storage tanks are a necessity except in cases where very low-melting fatty acids are to be stored. Correctly designed heating coils are extremely important since fatty acids are poor conductors of heat and tend to discolor rapidly when subjected to local over-heating. Automatic temperature controls are desirable and should be set to maintain the minimum temperature required to keep the fatty acids liquid.

Internal heating coils in fatty acid storage tanks are used, but, because of their tendency to cause local overheating, care has to be exercised. Proper temperatures may be conveniently maintained in fatty acid storage tanks by the use of outside heating coils, such as seamless copper tubing wound on the exterior surface of the tanks, or by a hot-water jacket around a tank with thermostatic controls. Magnesite block, or other suitable insulation, should be applied to prevent heat losses. Such an installation is economical to operate since only a minimum heat input is required to maintain the fatty acids in a liquid state. When other means of heating fatty acid storage tanks are not available, open steam coils may be employed but are not recommended. The water resulting from the condensation of the steam should be allowed to settle and then be drawn off from the bottom of the tank. However approximately one-half of 1% moisture will be retained in the fatty acids.

Bulk stocks of fatty acids are best maintained in the liquid phase rather than by remelting periodically as the fatty acids are used. There are no definite temperature limitations for fatty acids in storage, but best results against deterioration of quality are obtained by maintaining the fatty acids at the lowest temperatures at which they are completely liquid and which permit satisfactory handling for the user. Unsaturated fatty acids can generally be handled at maximum temperatures of 120° F.

Stainless steel and aluminum are the preferred materials of construction for pumping lines. Copper and its alloys should be completely avoided if color and odor stability are desired.

Light-weight type 304 stainless steel piping is satisfactory for transfer lines, but type 316 is recommended for process lines. Stainless steel tubing is also successfully employed. Aluminum (3-S) pipe may also be used. Steel or copper lines are not desirable.

Centrifugal pumps of type 316 stainless steel, or of such trade alloys as "Worthite" (Worthington Pump and Machinery Company), "Durimet 20" (Duriron Company), or "Ircomet" (Ingersoll-Rand) are used. Bronze or Monel pumps may be used where metal contamination is not objectionable. When pumping out a tank car or storage tank, it is desirable to instal a strainer ahead of the pump. Ni-Resist (International Nickel Company) and Causul Metal (Lunkenheimer Company) valves with stainless steel trim are very satisfactory for handling fatty acids at ordinary temperatures (up to 250° F.) For high temperature applications, valves should be of type 316 stainless steel, Worthite, etc.

No hard-and-fast rules can be set down for the selection of processing equipment for fatty acids since consideration must be given to the conditions under which the equipment will be used and to other factors which may be involved. Stainless steel, Inconel, nickel, aluminum, glass-lined Monel, ceramic ware, and other chemically resistant materials and coatings are all satisfactory under the proper conditions. Most equipment suppliers have corrosion data for various processing operations and can guide your choice of materials.

In conclusion, I would like to illustrate the need for proper storage and handling of fatty acids. For several years we had been shipping one drum at a time of white oleine (multi-distilled commercial oleic acid) to one of our customers. He purchased about one drum a month. There were no complaints. His business dropped off, and he did not buy any white oleine for six or seven months. After this period of time he sent us a sample, supposedly representing what was left in the drum. It was quite green and cloudy. He claimed that all of the white oleine left in the drum was like the sample. We were at a loss. White oleine is a stable product and is shipped in drums lined with acid resistant phenolic lining. We have kept test lots of white oleine in lined drums in our warehouse for two years with no off-developments. A careful check of the green sample showed copper in relatively large quantities. Well, to make a long story short, it developed that our customer had a brass spigot on the drum, and he had not withdrawn any oleine for several months. A coating of copper oleate developed on the brass spigot, which was washed out with the first fresh white oleine coming through the spigot. The removal of the spigot and a sample taken through the bung from the drum showed the remaining white oleine to be entirely satisfactory. In another case a tank car buyer of red oil (commercial oleic acid) stored the oil in his storage tank for almost 10 months, through the winter. He complained of the red oil darkening and having white spots. A check of the sample revealed heavy iron content and higher titer than the original material sent him. A study of his storage tank revealed it to be of iron, located outdoors and subject to cold weather, which would cause graining out of some solid acids.