Finished Product Storage and Handling

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ABSTRACT

The previous speakers have addressed the needs of producing high quality products from meat fats. It is of equal concern to the refiner that these products be properly stored and transported to maintain their integrity and performance up to the point of use, whether in the home kitchen, the restaurant, or food processing plant.

INTRODUCTION

Care should be exercised in selecting and maintaining warehousing facilities for shortening. Warehouses should be suitable for food products and have good sanitation standards. Good practice dictates that each facility have a formal, written sanitation program administered by a responsible person. This program should include attention to grounds and surroundings as well as to the immediate building. Pest control should be professionally organized to ensure its effectiveness and proper control of pesticides.

Shortenings should not be stored or transported with non-food products, and their proximity to any controlled substance must be meticulously avoided.

Fats are totally bland and have the ability to absorb odors and flavors from other foods. Therefore, they should not be transported with or stored in the same area as spices, onions, pickles, smoked meats, fruits or other aromatic foods.

Temperature control is the most important single factor in maintaining the quality of shortening and margarine during distribution. The exact temperature conditions and precautions which are required will depend upon the formulation and end use of a particular product.

Household shortenings and commercial all-purpose or cake and icing shortenings are commonly made from formulations which provide a stable crystal configuration, wide plastic range and good creaming properties. Recommended temperatures for distribution and use usually are 70 to 80 F. When properly formulated, plasticized and tempered they do have some tolerance to variations in temperature and typically may be useable in the range of 60 to 90 F. Within limits, such shortenings when cooled or heated can be brought back to original consistency and performance by holding for a sufficient time at 70 to 80 F. Long term storage at temperatures above 90 F may adversely affect the performance of cake and icing shortening, presumably because of changes in crystal structure.

Because fats are poor heat conductors, a long time is required to return a shortening to the desired temperature. For example, a single 50-pound cube at 45 F will require five days to reach 70 F. Obviously, a pallet load of 36 cubes will take considerably longer.

LARD AND PIE SHORTENINGS

Lard is a preferred fat for the manufacture of pies. Its particular physical properties are unmatched by any other fats for the production of flaky and tender pie crusts. Therefore, special pie lards and pie shortenings consisting predominantly of lard are manufactured.

These shortenings must be carefully formulated, plasticized and tempered to achieve the precise crystalline characteristics necessary for the pie crust. Unfortunately, these products are highly unstable and tend to undergo crystal changes. As a result, very close temperature control must be exercised from plasticizing to the point of use to avoid temperature variations which will promote crystal changes.

Usually, these products are put through a precise temperature-time cycle after filling and brought to the exact temperature required by the user before shipment. Products are then shipped in temperature controlled trucks or rail cars to maintain this temperature.

The temperature conditions needed may differ with different formulations and customers. But the basic principle of completely removing the heat of crystallization and achieving and maintaining a uniform low temperature must be observed. Failure to observe proper care results in nonuniform or grainy texture or other defects which interfere with proper pie crust mixing.

MEAT FAT MARGARINE

Sizeable quantities of margarine are made from meat fats. Typically, margarines are stored and transported under refrigeration at 45 F. This is required because margarines contain an aqueous phase and are susceptible to microbiological growth, especially surface mold.

A very common meat fat formulation is primarily lightly hydrogenated lard. This is packed both in one-pound prints and cubes. In common with most lard products, this has a tendency for crystal change to the Beta form and to become mushy if subjected to temperature changes. This is prevented by properly cooling the product after packaging to ensure complete removal of the heat of crystallization. Cubes of this margarine filled at 55 F typically would be held in the cooler at 45 F for 72 hr before shipment, and then shipped in a Thermo-King unit set at 45 F.

Other meat fat margarines made for food service, bakery or food processor use from formulas contain edible tallow as a major ingredient. These may be of a general purpose type or specially formulated with wide plastic range for Danish or puff pastry use. Such products have stable crystal characteristics and hold up well under normal storage and handling.

BULK HANDLING

Perhaps the greatest volume of edible meat fats is shipped in tank trucks or tank cars to large commercial users. Such products must be handled properly in loading and transit as well as in the customers' tanks to ensure quality integrity at the time of use.

TECHNICAL CONSIDERATIONS

There are three primary considerations in maintaining the quality of fats and oils. Any bulk handling system must be designed and operated with these in mind:

—Avoid contamination.
—Avoid overheating.
—Minimize exposure to air.

CONTAMINATION

Edible fats and oils are processed at high temperatures and are completely dry; thus, they do not support microbiological growth. Reasonable precautions should be taken to prevent introducing water and other foreign materials into the fat. Water may promote hydrolysis of the fat and development of free fatty acid, especially in lauric-based fats or fats containing emulsifiers. Wet oil, when charged to a deep fat fryer, constitutes a safety hazard due to explosive vaporization at high temperature in the fryer. Water with organic materials such as sugar or flour can settle to the bottom and provide a substrate for microbiological growth. Keep in mind that water is virtually insoluble in oil, and anything over 0.1% will be present as a separate phase.

Metallic contaminants such as copper and iron are strong pro-oxidants at very low concentrations, less than .1 ppm in the case of copper. Copper should be scrupulously avoided in any equipment in contact with oil. Because copper and brass are so widely used in valves and other fittings for steam and water, it is not uncommon for a mechanic to use these fittings in an oil system.

Iron and steel equipment is completely satisfactory as a material of construction for bulk oil tanks and pipe lines, as long as precautions are taken to prevent pickup of iron by the oil. It is most important to prevent rust formation. The thin film of rust which rapidly develops on a thoroughly cleaned steel surface seems particularly likely to be picked up by the oil. After cleaning, the equipment should be refilled immediately with oil or a film of oil wiped on to protect against rust.

OVERHEATING

Most bulk fats and oils are handled with some degree of heating. It is axiomatic that oils should not be heated any more than absolutely necessary. The rate of oxidation of oils is increased approximately three times for each increase in temperature of 20 F. The minimum temperature required generally is about 10 F above the melting point of the fat to avoid any cloudiness or precipitation of high melting fractions.

EXPOSURE TO AIR

Exposure to air results in oxidation of oil, which ultimately can lead to low stability and poor flavor. While air can be completely excluded by maintaining a nitrogen atmosphere at all stages after deodorization, it generally is not necessary to go to this extent.

The condition of oil in storage is easily monitored by the peroxide value. This simple test can be performed in less than 10 min using inexpensive equipment. It gives a quantitative measure of the degree of oxidation of the oil. Deodorized oil will have a peroxide value of 0 out of the deodorizer. In good quality oil, peroxide value will rise slowly, the rate of rise depending upon a number of factors. These include temperature, exposure to air, contamination and type of oil. Under typical commercial conditions, tank truck deliveries should not exceed 1.0 peroxide value at the time of delivery. Tank car deliveries usually will not exceed 1.0, but some allowance should be made if the car is in transit for several days, especially in very hot weather, or if it must be reheated for unloading. Under adverse conditions a peroxide level will continue to increase slowly in storage tanks, and flavor development will parallel peroxide increase.

In products where flavor is critical, flavor studies can be made and correlated with the time oil is in storage and peroxide development. If indicated, nitrogen protection may be considered.

The simplest form of nitrogen protection consists of sparging enough nitrogen into a stream of oil to completely saturate the oil with nitrogen, plus an excess. This excess is then released when the oil goes into the holding tank and displaces air in the headspace of the tank. This practice requires about 5 cu ft of nitrogen per 1000 lbs of oil. The alternative of maintaining a nitrogen atmosphere in the tank at all times requires about 25 cu ft per 1000 lbs of oil.

TANK CARS AND TANK TRUCKS

It is important that transport equipment be of the proper type, in good mechanical condition and properly cleaned.

The most economical form of transportation generally is in jumbo tank cars holding 150,000 lbs. Smaller tank cars of 60,000 or 30,000 lbs are available at somewhat higher freight rates. Tank car shipments are best suited to the very high volume user, because they require a railroad siding, steam heating facilities and large plant storage tanks. Since tank cars are subject to the variability of rail traffic, a considerable lead time on orders may be necessary. There are some special problems relating to tank car shipments which require particular attention by both the shipper and receiver. Cleaning is somewhat difficult because of the ordinary steel construction and heating coils which tend to become coated with oxidized oil. Overheating can occur or unmelted product can be left in the car if unloading practices are not good. Coils may freeze and break if not properly drained of condensate.

Stainless steel-insulated tank trucks provide a more convenient form of delivery. Normally, these tankers will carry approximately 45,000 lbs, which is dictated by highway weight limits. In a properly insulated tank truck, the fat is held at a constant temperature and delivered ready for unloading. Normally, the truck carries unloading hoses and a power-take-off pump which is hooked up and operated by the driver.

Tank cars and trucks should be cleaned and inspected thoroughly on each turnaround. Tanks must be completely clean and dry. Outlet valves of trucks should be disassembled for inspection. On tank cars the foot valves must be closed and coils tested. Hose and pumps on trucks must be clean and dry and protected against dirt and water during travel.

Tanks should be sealed, both on the top manhole and drain valve, to protect load against tampering. In the case of meat fat products, shipped between plants with meat inspection, U.S.D.A. seals will be used. When the receiver is uninspected, commercial seals are used.

BULK OIL HOLDING SYSTEMS

Holding tanks may be of any convenient configuration. Rectangular tanks provide the greatest storage capacity for a given space within a building, but usually require that they be constructed in place. Where space is available and accessible, either vertical or horizontal cylindrical tanks usually are preferred, and these may be fully or partially shop fabricated, depending on size. If the tank is to be pressurized to provide a complete nitrogen blanket, it must be of appropriate code construction.

Tank bottoms should be dish, cone or sufficiently sloped to provide complete drainage. There should be no "pockets" or "dead spots" in the system where oil can accumulate and not drain. Even a few pounds of oil in such a pocket can over a period of time become highly rancid and promote rancidity in subsequent batches of oil.

Fill pipes should discharge near the bottom of the tank to minimize aeration. To avoid syphoning of oil from the tank, a syphon breaker consisting of a half-inch pipe with a check valve should be installed between the high point of the fill line and the head space of the tank.

Tanks should be provided with adequate venting so that air or nitrogen can escape while filling and enter when emptying. If pressurized, a vacuum breaker and pressure relief valve should be provided, both set within the design limits of the tanks. This may seem like a very elementary precaution, but collapsing of improperly vented tanks has occurred several times in my personal experience.

MATERIAL OF CONSTRUCTION

Most bulk fat and oil systems are constructed of ordinary mild steel. This is economical and completely acceptable as long as precautions against rusting, previously mentioned, are followed. Stainless steel is completely satisfactory, although the added cost is not normally justified.

Certain fibre glass reinforced plastics may be used but generally are not a material of choice. Manufacturers' recommendations and guarantees should be carefully checked to ensure suitability for the service.

HEATING

Heating may be accomplished with a coil using low pressure steam or circulating hot water. A fail-safe temperature regulator should be provided to prevent overheating. Heat should be turned off when the level drops to where coils are exposed. Otherwise, the film of oil on the coils will be severely overheated and oxidized.

Tanks may be insulated or not, depending on location and heat conservation considerations. Enclosure of the tanks in a heated room is a viable alternative.

Pipelines must be traced with steam or electric tapes and insulated to keep them from freezing up with higher melting fats. As an alternative, pipes may be drained between use. Traced pipelines should be thermostatically controlled to prevent overheating. In no case should heat be left on when the lines are empty.

AGITATION

Mechanical agitation is desirable but not mandatory on storage tanks. It serves to keep temperatures equalized and prevents precipitation of high melting fat fractions on cold spots. Agitators should not be run continuously and never when the level is so low that they create a vortex or splashing which increases contact between oil and air. An alternate means of agitation is recirculation.

PUMPING

Oils may be pumped satisfactorily with either positive displacement or centrifugal pumps. Rotary positive displacement pumps generally are very satisfactory, as the oil is a good lubricant providing long life, and they give constant delivery rates regardless of the head. Pumps may be of cast iron, and mechanical seals are preferred to packing. Overpressure protection should be provided.

A basket strainer should be installed on the intake of the pump to prevent damage from the tramp metal. A filter on the pump discharge is desirable to remove extraneous material. A cartridge or bag type filter with a porosity of 25 microns will remove visible particles. A bypass should be provided in the event it is necessary to pump partially solidified fat.

PIPING

Piping required will vary considerably in different installations. In a plant with many points of use or with several types of oil, the system can become quite complex. Careful consideration should be given to piping design to minimize the danger of commingling different oils. Obviously, this can be a very costly error. Unnecessary cross connections should be avoided. Blind flanges may be used in place of valves where connections are used infrequently. Ball valves or rising stem gate valves are preferred, because it is easy to see at a glance whether they are opened or closed. Double valving should be considered in critical areas. In some cases, totally separate piping systems may be warranted.

FLUID FLOW AND HEAT TRANSFER

Pump performance curves, hydraulic data and heat exchange data are commonly available in convenient tables based on water. It is easy to overlook the differences between water and edible fats and oils and design piping, heat exchangers or select pumps based on these tables or previous experience with water. While this might not be critical in simple systems, it can lead to costly errors in more complex installations.

Consideration must be given to viscosity and density of oils. These properties will vary with temperature as well as type of oil. Figure 1 shows the viscosity of lard, tallow and soy oil.

Note the viscosity increases with the degree of saturation, also that the scales are logarithmic, not linear, and that viscosity increases very rapidly with reduced temperature. As a result, design must provide sufficient velocity to produce turbulent flow for low pressure drops and high film coefficients in heat exchangers. Baffles or other features to increase turbulence may be required.

In addition, as temperature approaches the melting point of a fat, there is a tendency for high melting fractions to solidify on the cooling surface. To prevent this, it may be necessary to limit the temperature differential between the coolant and fat.

Specific gravity of fats is about .9. This affects both static head requirements and centrifugal pump performance.

MEASUREMENT OF OIL

It is necessary to measure oil for inventory control and formulation. The simplest method is simply to calibrate the tank and measure liquid level. To convert to pounds with a high degree of accuracy, the density figure used must be accurate. Density will differ for different types of oil as well as by temperature, as shown in Figure 2.

Batching scales or meters can be used to measure oil to process. Positive displacement type meters probably are the most satisfactory for this service and may be temperature compensated for accuracy. They may require frequent calibration because of wear if a high degree of absolute accuracy is needed. Where there are several points of use the oil can be circulated at a constant rate and measured into each batch with an automatic timer. Sophisticated continuous proportioning systems are used in some industries.

QUALITY ASSURANCE

Quality assurance procedures for bulk oil receipts will be somewhat different from those used for packaged products. Once unloaded, bulk deliveries cannot be readily segregated or removed from the production plant if found to be defective. Tank trucks must be unloaded within one or two hours after receipt to avoid demurrage, and where the distance is short, as little as two or three hours may elapse between loading and unloading. Somewhat more leeway is available with tank cars, but even here the factors of demurrage, heating time, railroad switching schedules and plant production requirements limit the time available for pre-testing. In some cases, additional time may be gained by receiving each load into a separate tank, but this practice adds to investment and inventory costs.

The best assurance of quality is the reliability of the supplier. Good rapport between the technical departments of the customer and supplier is highly desirable. There should be a clear understanding of specifications, the testing procedures to be used at each point, and provision for

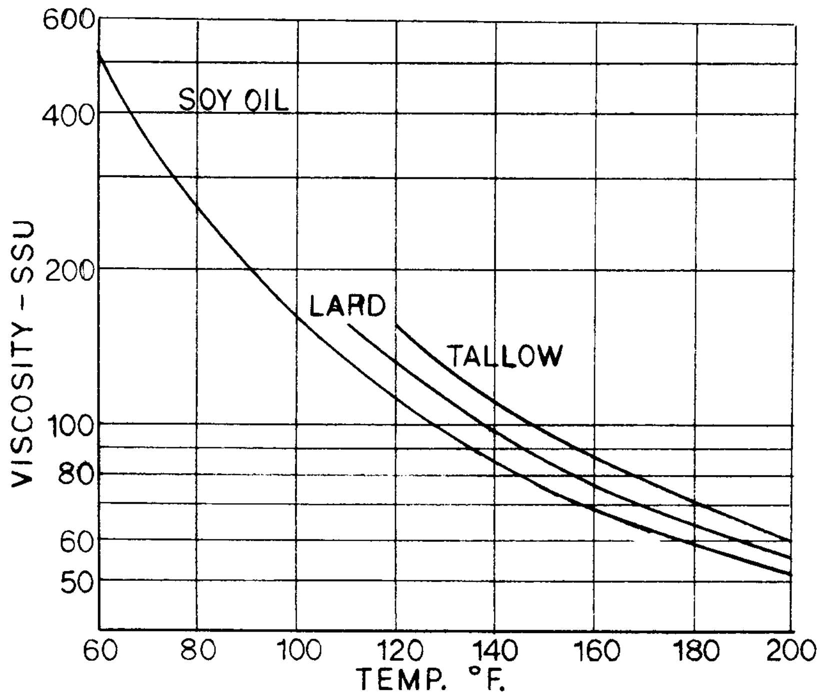

FIG. 1. The viscosity of lard, tallow and soy oil. Note the viscosity increases with the degree of saturation and with reduced temperature.

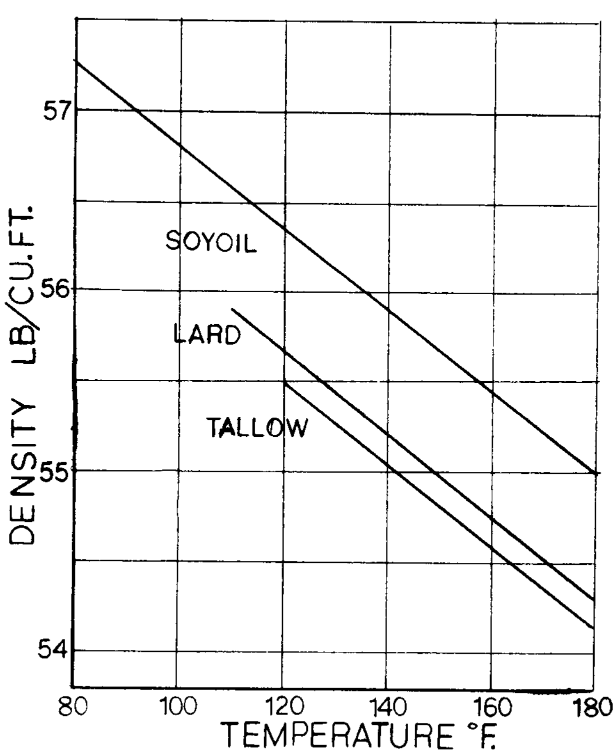

FIG. 2. The density of oils differs, as does the density of oil at different temperatures.

prompt communication of results.

Quality assurance procedures must be oriented to the time frame of the delivery. The supplier may forward copies of his out-turn analysis and/or samples with the tank truck, or on tank cars, may use wire, phone, or mail so that information is available before unloading. Consideration may be given to accelerated testing methods to replace longer standard or official methods.

PROCESSING FOR USE

In some uses such as deep fat frying or bread baking, or even spraying applications, fat is used in liquid form, and no in-plant processing beyond possibly some temperature control is required. In other uses, such as pies, cakes, icings, prepared mixes, biscuits and crackers, the fats may have to be chilled and plasticized to get the desired mixing characteristics. The most common device for this is the shortening votator or some other variation of the scraped wall heat exchanger.

Shortening processed through this system is not immediately equivalent to a plasticized shortening because this requires an additional tempering step of about 48 hr to permit crystal growth and transformation to the desired crystal form. As a result, changes may be necessary in mixing techniques or actual shortening formulation to compensate for the differences. For example, in cakes, specialized emulsifiers may be used to compensate for the lack of creaming properties of untempered shortening. The ramifications of adapting bulk shortening to some of these uses may be quite complex and entail substantial investment and research to make the process practical.