THE WINTERIZING OF COTTONSEED OIL

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Abstract

A brief historical summary of methods used in the production of salad oil from cottonseed oil with general description of a recently developed method employing direct expansion of liquified gaseous refrigerant in the coils of the winterizing vessels, eliminating the use of intermediate cooling media such as brine or water.

EARLY in the history of utilization of cottonseed and its products the chief use of the oil was in soap manufacture. Although the oil as hot-pressed from the seed was wine-red or darker in color most of the red tint could be eliminated by the succession of washes in the soap kettle, and cottonseed oil thus became at least a tolerable ingredient in common yellow laundry soap.

Discovery of soda refining methods led to use of the new oil in soaps of lighter color and likewise paved the way for the acceptance of cottonseed oil in its true field, that of a valuable food product.

The primary edible use of cottonseed oil was for cooking purposes, chiefly in the beginning as a mixed ingredient in lard and lard compounds.

For such uses, as well as for direct use unblended in cooking, the high titer of cottonseed oil in comparison with other liquid oils, due to its relatively large content of glycerides of solid fatty acids, proved to be an advantage. The oil blended readily, in large percentages, with lard, without excessive softening of the latter product as a result of the blend.

In the early days of cottonseed oil refining great quantities of oil were used for edible purposes after no further treatment than caustic refining and filtration, with or without bleaching clay. That such oil could be so used is attributable to several underlying causes. Firstly, flavor standards were undoubtedly much lower than those current today. Secondly, pressing methods being but little developed, the yield of crude oil was lower and the average quality equal to, if not superior to that of today. Thirdly, such off oils as were produced found a ready market in the soap kettle and their conversion into edible products was seldom attempted.

In the development of uses for this new product it was natural that it be used as a salad oil, furnishing active domestic competition for olive oil, then almost entirely an imported product. As long as cottonseed oil was used only in Southern climates it made a satisfactory salad oil, but as soon as its use spread to cooler districts, the separation of a white cloud of so-called "stearine" rendered the material undesirable, if not unsuitable, for use as a salad oil. Since in the early days of cottonseed oil refining, much salad oil was marketed in bottles and so displayed on grocers' shelves, the stearine deposit in cottonseed oil was particularly objectionable. The earliest attempts at winterizing for removal of the "stearine" consisted simply of storing the oil in barrels in the refinery yard during cold weather. Provided no extended period of weather below 32° F. was encountered, this method proved quite satisfactory and after some days of exposure, the clear winter oil could be decanted from the barrels, leaving the stearine. The percentage of "stearine" to be removed from Cottonseed Oil of United States origin varies from 16%-25%, and it is reported (in some rare cases) even to 33%.

The vagaries of weather, however, were such that means were soon sought to accomplish the desired result by artificial methods which would be independent of climate. Several methods have been developed, but all are based upon the general principles of slow artificial cooling of the oil for crystallization of the stearine, fol-

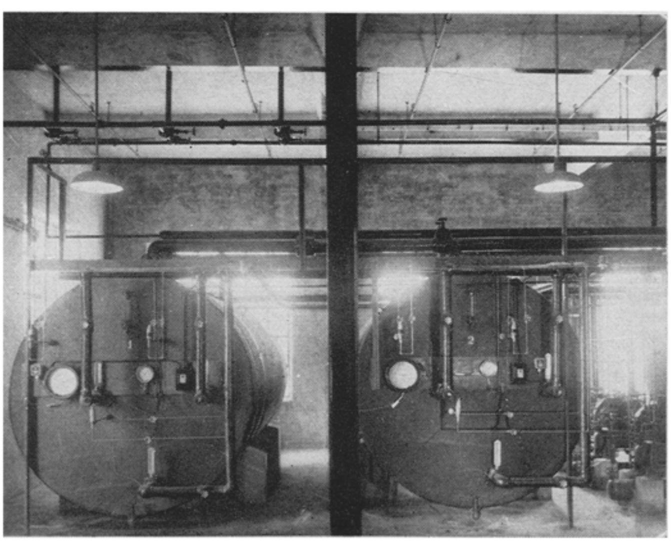

Fig. I
Front View of Two Winterizing Vessels

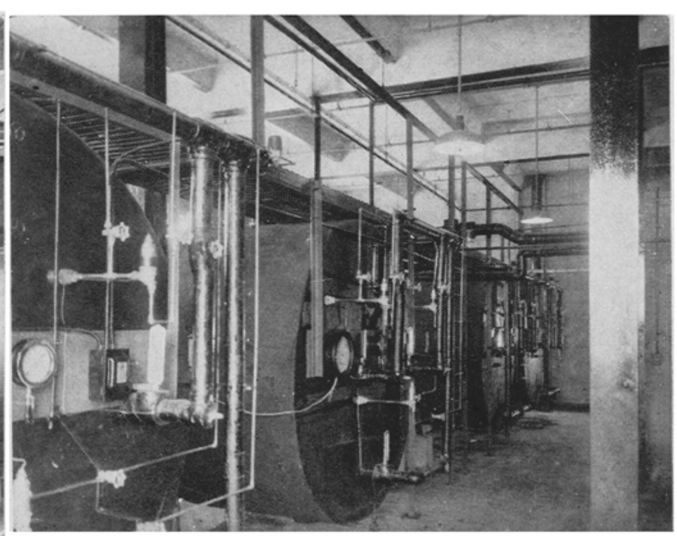

Fig. II
Refrigeration Piping

lowed by filtration to separate the stearine from the clear winter oil.

One of the earliest winterizing methods, which method is understood to be still in use by some of the larger refiners of cottonseed oil, consists of simply storing large bodies of oil in outdoor storage tanks during the winter season. If a large tank is left undisturbed throughout the winter at a location where the climate is moderately cold only, by early spring a large percentage of standard salad oil can be decanted from the tank by means of a swinging suction pipe.

Another early system of winterizing was based upon refrigeration of the summer oil in deep, narrow rectangular tanks, followed by gravity filtration for removal of the stearine. This system depended upon atmospheric air as a medium for refrigeration transfer between the refrigeration machine and the oil chilling tanks. A number of tanks, which were generally about 16′ long by 18″ or 2′ wide, by 14′ deep, were suspended vertically in an insulated room which was cooled by brine or ammonia coils. A fan was frequently used to promote cold air circulation about the tanks. Crystallization of the stearine usually required about a week, at the end of which time the oil was allowed to flow by gravity through filter presses which were placed either in the same room below the tanks or, preferably, in another insulated refrigerated room below the tank room.

Results of such winterizing procedure were excellent. Drawbacks were the length of time required for the stearine crystallization, the slow rate of gravity filtration and the comparatively low efficiency of air as a cooling medium.

A second winterizing method, which has been applied with excellent success for over thirty years, employs refrigerated water as the heat transfer medium. The oil to be winterized is charged into cylindrical pressure tanks, which are immersed in a basin of water. Arrangement is provided for circulation of water from the basin through some means of refrigeration heat-exchange and back to the basin. The refrigeration exchanger may be a shell and tube heat exchanger, a Bandelot cooler, or an open tank containing coils. The actual refrigeration of the water is accomplished by circulation of brine through the heat exchange equipment, or by the direct expansion of liquid refrigerant therein.

When the crystallization of the stearine is completed compressed air is admitted to the crystallizing tank and the oil is forced by pressure of the air through filter pressess installed in an insulated refrigerated room. The stearine separated from the oil in the filter presses is generally cleaned by manual labor from the filter presses, conveyed to a receiving tank equipped with a steam heating coil, melted therein and thence pumped to storage.

This cooling-by-water system of winterizing cottonseed oil has proven very successful in practice. The crystallization time is not excessive, insulation of the winterizing vessels is not required, the refrigerating medium is inexpensive and its temperature easily controlled.

Weakness of this system include inflexibility of the cooling time, difficulty of suitably varying refrigerant temperatures between various chilling vessels in a battery and radiation losses from the water basins, which may be built of concrete or steel, to suit the conditions of each individual installation. In general terms, the water-cooling system can be considered successful and efficient.

A more recently developed system of winterizing cottonseed oil, which is widely used, employs all the principles of the water-cooling method, the chief variation being that the oil-cooling refrigeration medium, which may be water or brine, is circulated through coils immersed in the winterizing vessels, which latter are, of course, fully encased in some type of low-temperature insulating material.

This method, which may be described as the coil-cooling system, while enjoying considerable favor among refiners, is subject to the same disadvantages as is the water-cooling method and to additional weaknesses in the presence of coils in the body of oil in the winterizing vessel, and in the lower efficiency of thermal insulation compared with a blanket of water in preventing heat infiltration to the oil during winterizing.

Over a period of years many inventors have sought means of continuously winterizing cottonseed oil, pursuing the hope of eliminating the labor of cleaning filter

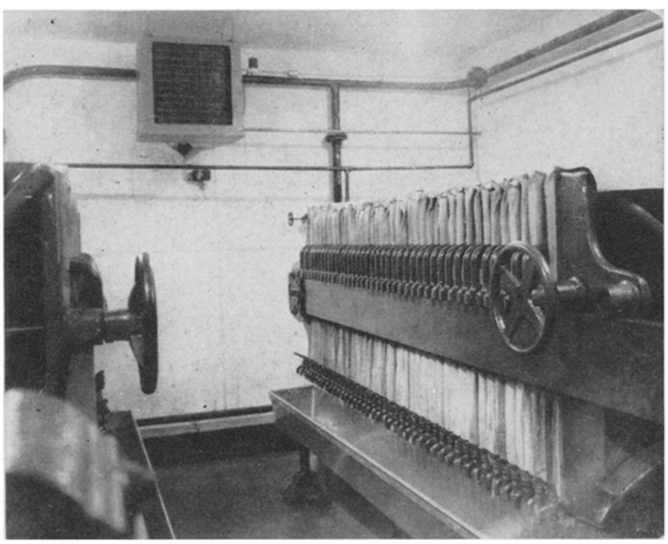

Fig. III
Filter Presses in Refrigerated Room

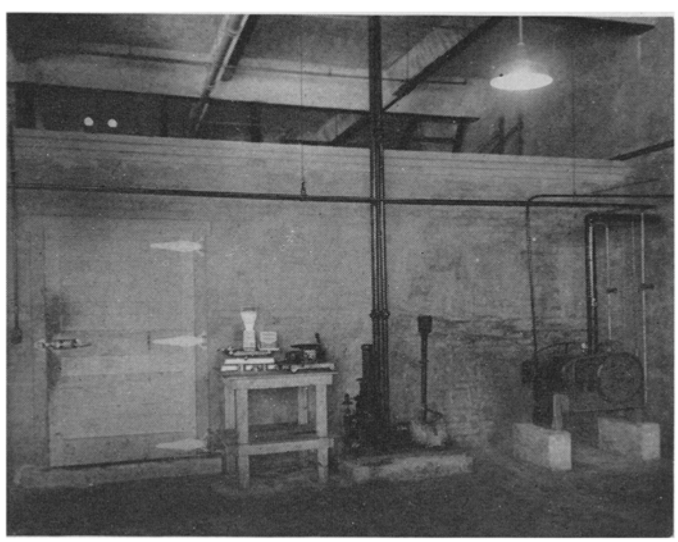

Fig. IV
Exterior View of Refrigerated Room with its Compressor

presses by hand. Most of the ideas brought forward have been based upon some sort of heat exchanger type of apparatus with countercurrent flow of oil and refrigerating medium.

No record is at hand of successful operation of any such scheme to date. The barriers to successful operation of such a method are to be found in the facts that cottonseed oil when chilled in motion will not crystallize suitably for removal of the stearine by filtration and that all available continuous filtering equipment has been found unsuitable for this operation.

Recently, particular attention has been directed to the application of direct expansion of liquified gaseous refrigerant in the cooling coils of winterizing vessels. The advantages of such a system are obvious, as it means elimination of brine or water tanks or tempering apparatus and of considerable auxiliary equipment as well as power economy in avoidance of the intermediate heat exchange between the brine or water and the gaseous refrigerant. A further power saving is accomplished by elimination of the pump required for circulation of brine or water.

Obstacles to the development of such a direct expansion system hitherto have been found in the high pressures necessary for operation of an ammonia system at the relatively high temperatures of cottonseed oil winterizing and in the need of a wide range of temperature variations in the different winterizing vessels of a series employed for day to day production.

Recent development of new refrigerant gases such as methyl chloride, dichlormethane and dichlorodifluoromethane (Freon), has directed new attention to the possibility of using the direct expansion method for winterizing.

The requirements are comparatively simple, calling only for a gaseous refrigerant which will permit evaporator temperatures of the order of 35° to 80° F., without the generation of excessive pressures in the evaporating coil and which can be condensed without the expenditure of excessive power.

It appears that such a refrigerant has been formed in Freon (Dichlorodifluoromethane). This relatively new refrigerant medium can be used at the required temperatures of cottonseed oil winterizing with suction pressures varying from 30 to 60 p.s.i. and liquid line pressures not in excess of 125 p.s.i.

The horsepower requirements of Freon compressors are lower, also, than those of ammonia compressors, the Freon machine giving nearly a ton of refrigeration per horse power at 115 pounds head pressure and 15 pounds suction pressure and requiring even less power at higher suction pressures.

Freon gas has little odor, is noninflammable and non-explosive. It has been widely adopted for use in household refrigerators and in airconditioning installations.

A recent installation of cottonseed oil winterizing equipment is noteworthy for its use of direct expansion of Freon for refrigeration purposes. The plant comprises four winterizing vessels, each of 25,000 lbs. summer oil charging capacity and each connected to its individual Freon compressor. The use of an individual compressor for each vessel provides means for taking full advantage of the power economy obtainable from the reduction of load when the oil chilling cycle arrives at the point of crystallization, at which point the rate of cooling is usually sharply reduced.

Each winterizing vessel is equipped with three cooling coils (Freon evaporators) connected in parallel to the liquid and suction lines from the Freon compressor. Liquid refrigerant is admitted to each evaporator through a thermal expansion valve, controlled by a suction line feeler bulb. The amount of superheat in the gas leaving each evaporator through the suction line controls the input of liquid to that evaporator through its expansion valve.

The rate of cooling of the oil in each vessel is kept at a low level by the provision of ample evaporator coil surface.

The b.t.u. transfer per square foot per hour per degree mean temperature difference is maintained at less than 10 at all times.

Each vessel is equipped with indicating and recording thermometers, gauge glass and indicating pressure gauge, also with a thermostatic switch operating a solenoid valve which shuts off the refrigeration completely when the winterizing is completed.

In Figure I is shown a front view of two of the four vessels of the installation. The four individual Freon compressors are located centrally between each pair of winterizing vessels. Figure II shows the refrigeration piping on all four vessels. The thermal expansion valves and feeler bulb lines are visible.

When the stearine crystallization is completed in any vessel, compressed air is applied to that vessel and the mixture of oil and stearine is expelled through one of the two large recessed-plate filter presses installed in the refrigerated press room. The presses are dressed with heavy filter twill of special weave and the air pressure must be applied slowly to insure the building of a firm cake of stearine in the press.

The compressed air used for emptying the winterizing vessels and for blowing the filter presses for cleaning is passed through water and oil separators before being used to insure against contamination of the oil. A cutflight helical conveyor below each filter press receives the stearine as the press is cleaned and conveys it to a melting pan outside the press room.

The press room is constructed of insulating cork board supported by a light brick wall and plastered with cement plaster inside and out. A small individual Freon compressor connected to a fin-coil type unit room cooler maintains the desired low temperature in the filter press room. An aerostat-pressurestat combination controls the temperature of the room, starts and stops the compressor and defrosts the cooler unit coils when necessary. A single thermal expansion valve regulates the flow of liquid refrigerant to these coils.

Figure IV is an exterior view of the filter-press room, showing the refrigeration compressor and the winter oil pump for transfer of the filtered winter oil from the filter press troughs to the final storage tanks. The entire plant is installed in a one-story brick and concrete structure 45′ x 50′ x 16′ high with storage tanks for winter oil and stearine located on the roof.