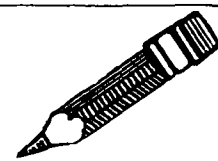


Technical News Feature



Odor Control in Edible Oil Processing

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ABSTRACT

The problems with odor around a typical edible oil deodorizer are discussed in detail, and a three-step solution to eliminate these problems is presented. The three steps are a distillate recovery system which recovers most of the fatty acid in the deodorizer vapor discharge as a valuable byproduct, a closed loop barometric cooling water system which keeps the fat-laden hotwell water out of the cooling tower by recirculating it back to the vacuum system after cooling with tower water in a heat exchanger, and a vapor scrubbing system to eliminate volatile organic compounds which are not removed in the previous two steps.

INTRODUCTION

Identifying the source of the odor and the low threshold of odor of many contaminants makes odor control one of the most difficult of all air pollution control problems. These problems can be solved, however, in certain applications where the source of the odors is well known. As an example, a chemical reactor may produce hydrogen sulfide as a byproduct. In this case, the nature of the odor-causing contaminant is well understood and the treatment equipment is specifically selected for that contaminant. The problem becomes more confused as the complexity of the odor-causing emission increases. In pulp digestion systems used in the paper industry, reduced sulfur compounds as well as hydrogen sulfide are produced. While the nature of these compounds will vary with the wood being digested and the process conditions, the odor emissions still fall into a known class of compounds, and quantitative methods can be applied to solve the odor problems.

As the number of contaminants and their nature diversifies, the measurement of these contaminants becomes impossible. Unfortunately, the emissions from a typical edible oil deodorization system would fall into this category. Deodorization is the last major refining step in the processing of most edible oils. Although various commercial schemes are available, all deodorization systems involve the basic principles of steam stripping the oil under high vacuum and temperatures to drive off various volatile compounds. These compounds, which include free fatty acids, aldehydes, and other trace components, all contribute to "off-flavor" oils. Even if methods could be developed to identify all of these components, the ones actually present and their concentration would change for each different oil, different source of the oilseeds, growing conditions of the seeds, and operating variations in caustic refining, bleaching, hydrogenation, or other processing steps which precede the oil deodorization.

The other problem is the low concentrations for threshold of odor of many of these compounds. Many can be detected at the very low parts per million and some even at parts per billion concentration levels. No analytical device has been developed to date which can quantify odor values. The best sensing device is still the nose; and noses can vary in their sensitivity.

The organic material discharging from an edible oil deodorizer can be divided into three component groups. The first group involves condensables, the components that will condense between the deodorization and their solidification temperatures; the second group includes those that are condensed and which solidify when cooled to a lower temperature by contact with the vacuum system condensing water; and the final category includes those which remain volatile even at this lower temperature. Control of the odor problems in the vicinity of the deodorization system caused by all three categories requires different approaches. Each group will be discussed below with particular emphasis on the third, noncondensable portion, which often proves the most difficult to control.

THE DISTILLATE RECOVERY SYSTEM

The condensable organic components, usually called distillate, have been recovered in distillate recovery systems for almost 20 years. In the case of soybean and other unsaturated oils, these distillate recovery systems not only reduce the contaminants in the deodorizer discharge but also provide a valuable byproduct for sale. As recently as February 1977, one company has advertised their need for this material and has even offered technical assistance in selecting the recovery method (1). A second user is also known to be actively seeking this material (W.R. Vicars, Tennessee Eastman Co., personal communication, May 1977).

The typical distillate recovery system is shown in Figure 1. It consists of a tower located between the deodorizer and the first water condensing stage of the vacuum system. In the tower, deodorizer effluent is cooled by direct contact with a stream of circulating distillate, which causes 90-95% of the condensable organic material to condense. The circulating distillate is then cooled to remove the heat of condensation before returning to the tower. Excess distillate is sent to storage so the level in the tower remains constant, and the temperature of the circulating distillate is

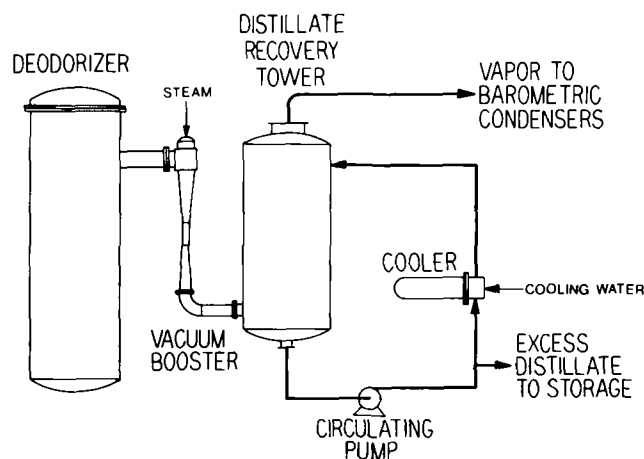


FIG. 1. Deodorizer distillate recovery system.

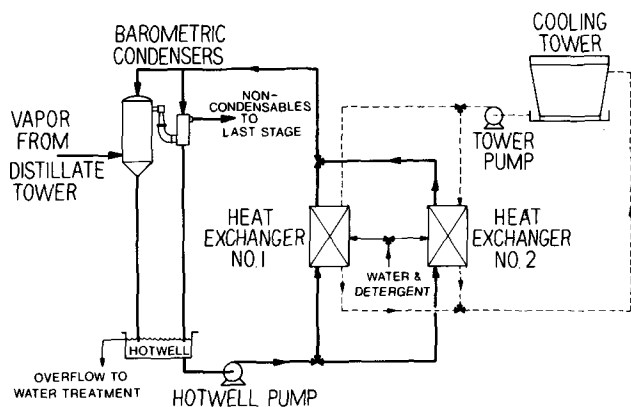


FIG. 2. Condenser water recycling system.

TABLE I

Typical Volatile Substances in Soybean Oil Deodorization^a
(Partial List)

Component	Odor description
Acetaldehyde	Fruit odor, pungent
Dimethyl sulfide	Disagreeable odor
Ethyl acetate	Fragrant
2-Butanone	Acetone-like
Diacetyl	Strong
Acetic acid	Pungent
N-Hexanal	Aldehyde-like
Acetoin	Aroma carrier
5-Methyl-2-hexanone	Pleasant
Butyric acid	Penetrating and obnoxious
2-Heptanone	---

^aFrom Reference 2.

also carefully controlled to recover as much of the condensables as possible, to prevent any components of the circulating stream from solidifying, and to prevent condensation of the vacuum system steam.

THE CONDENSER WATER RECYCLING SYSTEM

The organic material exiting the distillate tower, because it will not condense at the tower operating conditions or is entrained in the exit vapor, flows to the first condensing stage of the vacuum system. The portion of this material that will condense and solidify when in contact with the condensing water has been one of the oil processors biggest headaches with deodorizing systems. Typically, many of these deodorizers have used closed circuit water systems where the hotwell water is reused in the vacuum system condensers after being cooled in a cooling tower. Although the discharge of the distillate tower contains only a small amount of organic material, it has tended to accumulate both in the hotwell and in the cooling tower causing both pollution and maintenance problems. Initially, high efficiency packed cooling towers were used in these systems; however, many of these had to be abandoned as the organic material would build up on the packing substantially reducing the tower efficiency and causing a serious odor problem around the tower. Therefore, many current installations use unfilled, higher cost towers in an attempt to solve this problem. Although these towers do reduce the maintenance required, there is still an odor problem as some of the components of the organic material become volatile when sprayed into the tower. Particularly in populated areas, or in those states which rigidly enforce odor emission standards, a method of eliminating this problem must be found.

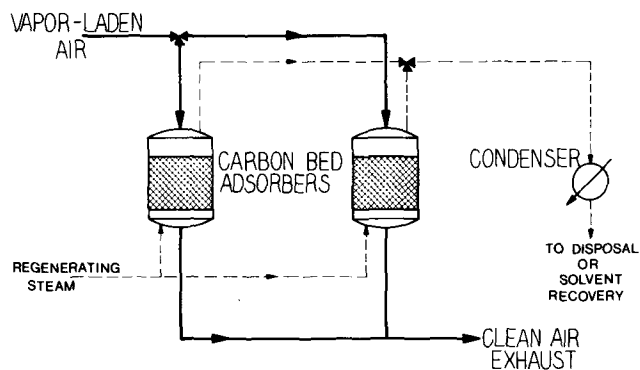


FIG. 3. Carbon bed adsorption.

Figure 2 shows a closed loop system, in which the tower operates only with clean water that has been introduced in several locations. In this system, the hotwell water is not pumped to the cooling tower but to a heat exchanger, where it is cooled with tower water before returning to the vacuum system. There is no direct contact between the water streams so the tower water remains clean, and high efficiency, lower cost packed towers can be used in new installations, or packing installed in existing towers for increased cooling capacity. In anticipation of heat exchanger fouling because of the dirty hotwell water, two units are provided. When fouling begins, the flows are switched to the clean exchanger and the dirty unit is cleaned by back flushing with hot water which may contain a detergent. The entire system, including the cleaning cycle, can be put on automatic control relieving the operator of any additional duties.

ODOR CONTROL OF NONCONDENSABLES

The distillate recovery and condensing water recycling systems remove most of the odor-causing compounds in the deodorizer effluent but do not effect volatile compounds which pass through these systems and into the atmosphere. In a typical deodorizer installation they exit in the final, noncondensing stage of the vacuum system which is usually discharged into the hotwell just below the water surface. Table I lists some of these components that have been identified for soybean oil deodorization. They are believed to be a significant contributor to the odor around the deodorizing system.

The three techniques that are used for odor control of noncondensable materials in industrial process applications are wet scrubbers, carbon bed systems, and thermal incineration. A typical carbon bed system is shown in Figure 3. It relies on the adsorption of the organic contaminant on the surface of activated carbon particles. Once the bed is loaded with organic material, it is regenerated by steam stripping the organics off of the bed. This process is particularly useful for solvent systems since the solvents can be condensed and recovered during the regeneration cycle.

Carbon beds have not been applied successfully to edible oil processing because of two major problems. The first problem is the heat load in the steam being discharged from the deodorizer vacuum system. A carbon bed system cannot accept high temperature gases since high temperatures reduce the bed's capacity for organic material. The final vacuum stage discharge would first have to be cooled to a temperature of ca. 38 C in a separate condensing system to allow the effective use of carbon adsorption.

Most carbon systems have two towers; one is on-stream while the second is being regenerated. It is during regeneration that the second problem develops in using carbon systems for odor control in edible oil processing. In most

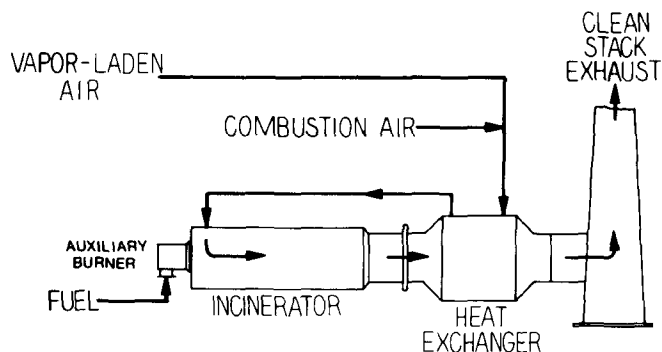


FIG. 4. Thermal incineration with heat recovery (3).

installations the regeneration of the bed is accomplished by steam stripping the organics from the carbon followed by condensing of the steam and organics. However, in this case, the odor-causing compounds are volatile, would not condense, and therefore further treatment would be required. For treating extremely large air volumes, such a system is possible. For example, carbon can be used to remove odor from large ventilation systems. The quantity of steam that is used for regeneration is much less than the air flow, and secondary treatment of the condensed regenerating stream is economical. This is a special case and does not apply to the smaller volumes treated in edible oil deodorization.

Thermal incineration is another technique which is used for odor control. Where all of the compounds can be incinerated and recovery is not warranted, this technique eliminates a discharge of any kind.

A thermal incineration system, shown in Figure 4, relies on natural gas or oil as a fuel. Typically, the exit gas from the process must be heated to 704-816 C and retained at that temperature for ca. .3 to .4 sec. Some of the energy can be recovered through a fuel gas to combustion air-exchanger on the discharge, but efficiency of such units is only ca. 50%. Thermal incineration is particularly suited to systems that involve ventilation flows containing a high percentage of organics. This reduces the fuel quantities required to a minimum as the organics are available to the system as fuel.

The cost and availability of energy make thermal incineration a very doubtful technique for control of odor compounds from the vacuum deodorization. Since incineration is an energy-consuming process, its use must be limited to systems where a high percentage of the fuel is available from the process itself. It is also a very sensitive process where misadjustment can partially oxidize the exit products rather than burn them completely. For example, partial oxidation of an aldehyde could convert it to an organic acid which may have a lower threshold of odor.

Wet scrubbers offer the best solution for eliminating noncondensable odor compounds coming from edible oil deodorization. A wet scrubber is a device where a liquid is used to contact the gas and absorb the soluble components or capture any solid particles. Scrubbers normally consist of two components; the first section is a contacting zone where the vapor or particle is captured, and the second section is a disengaging zone where the liquid is eliminated from the cleaned gas. Almost all scrubbers have these two sections in some arrangement. Scrubbers can also be used to cool the gas and are extremely flexible when installed as they can be adjusted as process conditions change.

The design of wet scrubbing systems involves the determination of the scrubbing liquid and selection of the proper sized unit to assure sufficient contact time between the liquid and gas for the required removal efficiency. As noted earlier, it is difficult to quantify the exit contami-

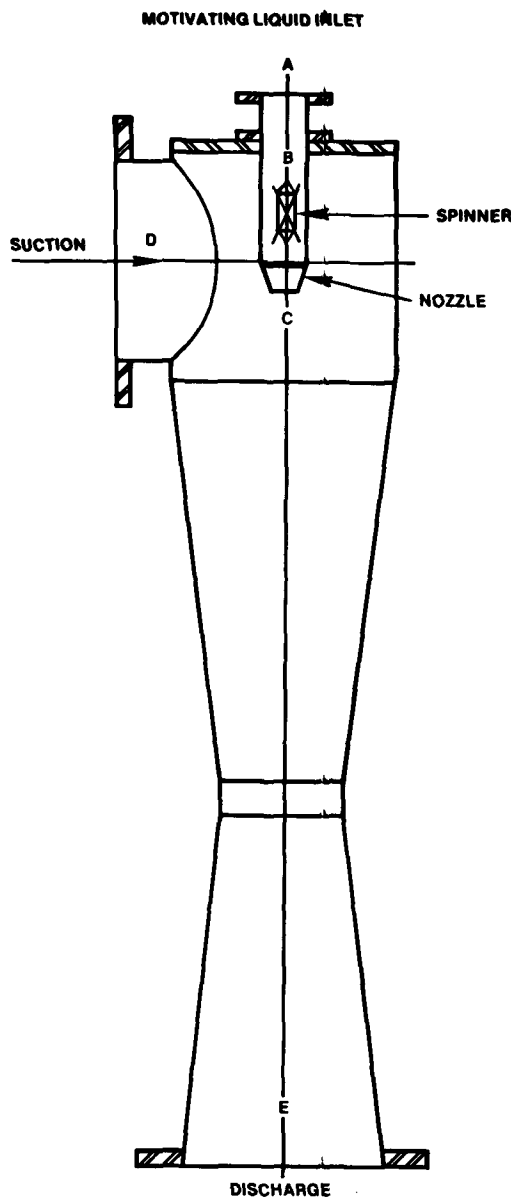


FIG. 5. Jet Venturi wet scrubber.

nants or determine the percentage removal required to control odor. The only assured way of eliminating the odor is by pilot testing or examination of similar commercial installations.

COMMERCIAL INSTALLATIONS OF WET SCRUBBERS

Two types of scrubbers have been used for odor control in edible oil deodorization systems, and these have been compared on the basis of actual results.

The Jet Venturi type fume scrubber (Fig. 5) has been employed in several commercial applications and consists of a spray nozzle which creates a hollow, cone-shaped liquid spray at the vapor inlet. The liquid and gas then enter the throat in a very turbulent state creating a further scrubbing action. For removing condensable fatty acids in a distillate recovery system, this type of scrubber has been very successful. Several installations were accomplished, and the results generally indicate a good removal of fatty acids and removal of some of the readily absorbed volatile components such as acetic acid. The odor at the discharge from the system was greatly reduced, but there was still a distinctive smell to the exit vapor. It appears that for low or moderately soluble

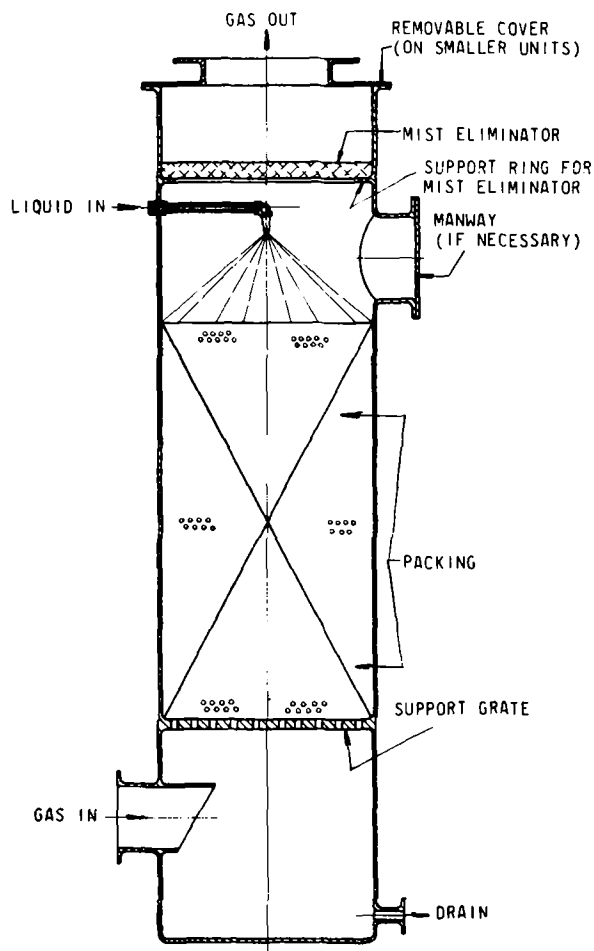


FIG. 6. Typical packed tower.

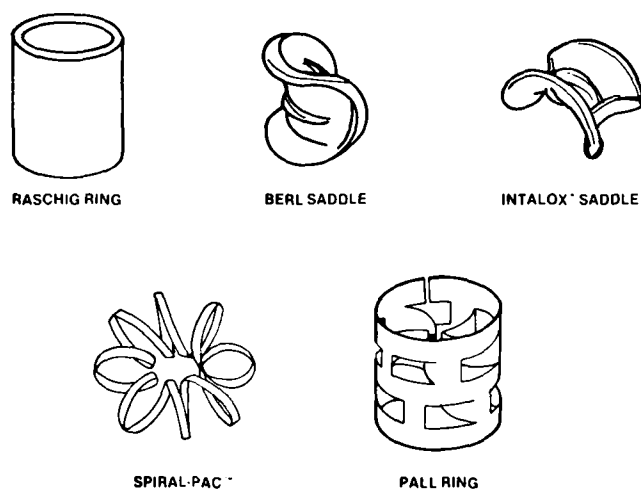


FIG. 7. Commercial types of tower packing.

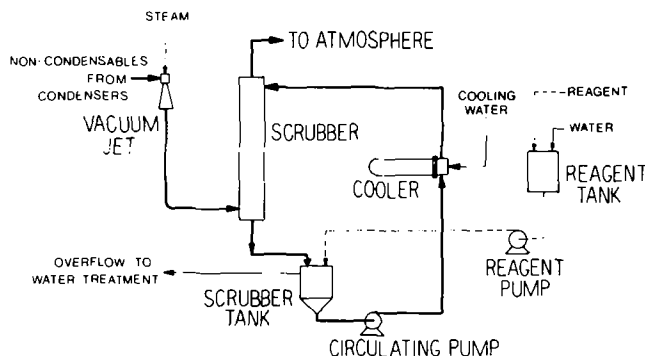


FIG. 8. Vapor scrubbing system.

organics there is insufficient contact time between the liquid and vapor to effect complete removal.

Packed towers provide this additional contact time and are particularly well suited to adsorption of small amounts of contaminants. In a typical packed tower (Fig. 6), the gas enters the bottom of the column and passes upward through a randomly filled bed of packing designed to provide a high surface area with high open space. The liquid is distributed over the surface of this packing and passes countercurrent to the gas. This allows the cleanest liquid to contact the most dilute gas and thus assures the highest possible efficiency. By increasing the height of the packed bed, the efficiency of the unit can be increased dramatically, however, pressure drop considerations limit most industrial applications to 3-10 feet of packing.

Figure 7 shows several common forms of packing. In the case of edible oil deodorization there is a potential for the presence of particles of fatty acid in the vapor, and, therefore, the spiral-pac packing is often used. Its open design allows the bed to handle a small amount of particulate without plugging.

Commercial installations of vapor scrubbing systems have shown that variations in the type of scrubbing solution used did effect the performance in most cases. Alkaline solutions, particularly caustic, are often used as the sodium hydroxide will neutralize acids to the sodium salts which, in many cases, have higher solubility in the scrubbing medium. Solutions containing oxidizing agents such as sodium or calcium hypochlorite or potassium permanganate are also used. The reaction in this case is a two-step operation. First, the contaminant must be absorbed into the solution; and second, it will be oxidized to a more soluble form or neutral form. For

example, a ketone can be oxidized to an acid which would be more readily soluble. In some cases, the advantages of both types of scrubbing liquid are employed. For example, sodium hypochlorite stabilized in an alkaline solution is an excellent scrubbing liquid because both the oxidization and neutralization reactions take place with the gas contaminants.

Wet scrubbers have high liquid-to-gas ratios, so a recycle system is necessary where treatment chemicals are employed.

A recent installation of a packed column to handle the noncondensable odor-causing compounds from the final stage of a deodorizer vacuum system involved a unit installed by EMI Corporation at PVO International in Richmond, CA, shown schematically in Figure 8. The bottom of the packed column serves as a hotwell to condense inlet steam vapors and also provides some gas absorption as the gas bubbles up through the liquid. The remainder of the vapor then passes through the actual packed bed section where it is contacted by a countercurrent liquid stream. The liquid collects in a small storage tank, is pumped through a heat exchanger for cooling, and then is recirculated back to the tower. The result has been good odor control.

The system was initially installed using water as the scrubbing medium, although fiberglass construction was used to allow for the future modification to other scrubbing liquids. After operation for approximately one-half day, the solution in the recirculating loop became saturated with contaminants as evidenced by a strong odor. At that time, calcium hypochlorite was introduced into the recirculating loop and eliminated the odor completely. Also, there was no evidence of odor exiting the top of the packed tower and discharging to the atmosphere.

The unit employed had a very high residence time in the packed bed. The initial condensing of the steam in the

lower section increased the efficiency of the tower since the total vapor flow in the packed section was reduced, thereby, increasing the residence time.

To prevent buildup of the reaction products, fresh water was added continuously to the scrubber tank to force a small amount of the circulating solution to the water treatment system. Although the rate of this overflow stream was not measured, it is believed to be less than 5% of the total contribution of the deodorizing system to the water treatment load. Changing from calcium to sodium hypochlorite is also being considered, particularly if continued operation indicates that the calcium in the system causes sufficient increase in water hardness to effect the operation of the water treatment plant or to cause scaling in the tower or piping.

REFERENCES

1. General Mills advertisement, JAOCS 54:53A (1977).
2. Brandt, P.E., and B. Hornstrup-Jensen, *Ibid.* 52:278 (1975).
3. Ross, R.P., CEP 68(8):59 (1972).

[Received June 8, 1977]

ACIDS in thousand pounds		FINISHED GOODS INVENTORIES (FI)		PRODUCTION (AI)		RECEIPTS (RI)		DISPOSITION:				TOTAL DISPOSITION		FINISHED GOODS INVENTORIES (FI)	
Month	Year	June 1979	August 23, 1979	June 1979	August 23, 1979	June 1979	August 23, 1979	Export (E)	Domestic Shipments (D)	Inter-Industry Shipments (DI)	Shipments to Export (EI)	June 1979	August 23, 1979	June 1979	August 23, 1979
NUMBER OF MANUFACTURERS REPORTING		16		16		16						620		620	

Saturated		SP - Single Pressed; DP - Double Pressed; TP - Triple Pressed													
HYDROGENATED ANIMAL & VEGETABLE ACIDS	STEARIC ACID (80-90% Stearic Content) (1)	7,542	10,815	1,548	4,063	582	5,519	3,083	60	100	12,497	7,498			
	60 C maximum titer & minimum I.V. 5 (2a)	4,903	9,385	—	—	8,119	—	—	—	157	8,276	6,012			
	57 C minimum titer & maximum I.V. under 5 (2b)	3,595	13,005	2,240	6,675	7,792	41	180	14,680	4,232					
	Minimum Stearic Content of 70% (2c)	1,471	2,418	56	886	1,743	58	19	2,706	1,242					
	HIGH PALMITIC (Over 80% palmitic I.V. maximum 12) (3)	799	655	152	311	421	—	—	—	732	898				
	HYDROGENATED FISH & MARINE MAMMAL fatty acids (4)	462	342	—	100	419	—	—	—	—	519	285			
FRACTIONATED FATTY ACIDS	LAURIC TYPE ACIDS (I.V. minimum 50-55% including coconut, palm kernel, babassu) (5)	5,217	7,364	56	2,713	3,132	2,252	14	8,111	4,526					
	C18 or lower, including capric (6a)	676	1,366	2	185	757	120	2	1,064	980					
	Lauric and/or myristic content of 55% or more (6b)	2,291	1,547	55	955	611	58	—	1,624	2,289					
	TOTAL SATURATED FATTY ACIDS	26,948	46,978	4,111	15,888	31,178	2,580	472	50,127	27,910					

Unsaturated		ND - Not distilled; SD - Single distilled; MD - Multiple distilled													
FRACTIONATED FATTY ACIDS	OLEIC ACID (red oil) (7)	14,658	14,272	726	7,240	3,772	5,273	2,945	158	983	16,882	12,774			
	ANIMAL FATTY ACIDS other than oleic (I.V. 38 to 80) (8)	2,204	11,112	284	1,928	7,328	439	—	—	2	9,697	3,913			
	VEGETABLE OR MARINE FATTY ACIDS (I.V. maximum 115) (9)	3	—	43	43	—	—	—	—	—	43	3			
	UNSATURATED FATTY ACIDS (I.V. 116 to 130) (10)	5,303	6,219	—	626	3,934	—	—	—	2,245	6,805	4,717			
	UNSATURATED FATTY ACIDS (I.V. over 130) (11)	1,858	2,134	—	—	1,753	—	—	—	298	2,051	2,041			
	TOTAL UNSATURATED FATTY ACIDS	24,126	33,737	1,063	9,837	21,516	587	3,528	35,478	23,448					
TOTAL ALL FATTY ACIDS SATURATED & UNSATURATED	51,074	80,715	5,174	25,725	52,694	3,186	4,000	85,605	51,358						

JUNE 1979						
Tall Oil Fatty Acids & Statistics						
IN THOUSAND POUNDS	2% & OVER ROSIN CONTENT			LESS THAN 2% ROSIN CONTENT		
	JUNE	Percent change from MAY 1979		JUNE	Percent change from MAY 1979	
Stock on Hand JUNE 1, 1979	20,184	+	13.0	9,800	+	21.6
Production	19,507	+	4.5	20,881	—	3.5
Purchases & Receipts	1,416	+	373.6	—	—	0
Disposition	15,061	+	21.1	15,282	-	3.8
Export	4,894	+	16.2	1,446	-	48.4
Total Disposition	19,955	+	19.9	17,828	-	18.4
Net Disposition*	18,540	+	13.4	17,828	-	18.4
Total Stock JUNE 30, 1979	21,151	+	4.9	12,854	++	31.2

* Net - Less purchases & receipts.
 Definition: Fatty acids fractionated from crude tall oil having a minimum of 90% fatty acids, not including rosin acid. Primary fractions containing less than 90% fatty acids are classified as distilled tall oils.



Committee Spotlights

Flavor Nomenclature and Standards Subcommittee

A report was given on the collaborative study run this past year that compared the flavor results of four samples each of three sets of oils which had been light and temperature abused. The evaluations were made by five GLC procedures from four laboratories and the flavor panels of eight laboratories. The results indicated that the GLC methods were all more precise than any of the individual panels or the combination of all flavor panels. Only one of the GLC procedures (H. Dupuy) properly ranked samples according to abuse, but the two procedures used by Best Foods confused only one of the 12 samples which the flavor panels did not rank as significantly different. The remaining two GLC procedures mis-ranked samples that the flavor panels found to be significantly different. However, the values calculated from correlation equations for even the poorer GLC systems provided data well within the precision of the flavor panels.

The data proved that to obtain flavor panel scores from the GLC results, separate correlation equations must be developed for each type of oil, each abuse, each degree of hydrogenation or blending or manner of storage of the samples. Thus, a flavor panel would be needed to establish a reference point in each study. Since this would be too restrictive, it is the committee's decision that the GLC systems will be divorced from the flavor panel evaluations, and a means of reporting "GLC Flavor Quality" will be established such as ppm of total flavor volatiles.

The work of the committee for this year will center around a detailed comparison of the six available GC procedures as to their cost, speed, precision, etc. A single or two-method recommendation for future study should be ready for next year's meeting.

The compilation of the GLC method parameters once narrowed to a single or dual procedure will establish the collaborative study program for 1980. Since all participating laboratories would then have to assay by the proposed procedure, this procedure will have to use readily available equipment.

A similar evaluation is planned of the flavor panel score and characterization terminology so a method can be drawn as an AOCS procedure for flavor panels.

The following list is the current membership of the Subcommittee:

- | | | |
|------------------------|--------------------|---------------|
| A.E. Walting, Chairman | S.S. Chang | J. Covey |
| H.P. Dupuy | B. Eder | R.G. Gallant |
| E.G. Hammond | G. Hoffmann | H. Jackson |
| G.A. Jacobson | R.G. Krishnamurthy | S. Lin |
| E.R. Lowrey | R.G. Manning | W.A. May |
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