Steam (Physical) Refining Deodorizer for Malaysian Palm Oil

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ABSTRACT AND SUMMARY

The production of Malaysian palm oil is expected to increase 20% per year for the next 5 yr. Already planted are more than a million acres which will start to produce in the next few years. Recent plantings of new strains will produce 2400 to 3000 lb of palm oil per acre. Palmex Industries, Penang, Malaysia started in operation in August, 1975, a physical refining system to produce a deodorized palm oil with 0.03% free fatty acid (FFA) from crude palm oil containing 5.0% FFA. Production records confirm the feasibility of physical refining crude palm oil in Malaysia, exporting the oil to the United States, and producing a quality product with a minimum of additional processing.

INTRODUCTION

The domestic per capita consumption of food fats and oils is expected to increase from 55 lb in 1974/75 to 60 lb in 1979/80. To meet this demand, imports of palm, coconut, and palm kernel oils are expected to remain at 11 to 12% of domestic consumption.

High U.S. palm oil imports during the past 2 yr resulted from low U.S. fats and oil production and wide price spreads between palm and soybean oils. In 1975 the United States was the largest importer of palm oil (436 thousand metric tons) followed by West Germany (210 thousand) and the United Kingdom (206 thousand) (1).

Palm oil is produced in Malaysia, Indonesia, Zaire, Nigeria, Ivory Coast, Dahomey, and Cameroon. Malaysia is by far the largest single palm oil producer, accounting for nearly 50% of the world production.

Palm oil is derived from the fruit of the oil palm tree, which in appearance is rather like the date palm with a large head of pinnate feathery fronds growing from a sturdy trunk, the fruit grows in bunches weighing 40 to 50 lb with 400 to 1500 individual fruits. The fruit consists of the outer pulp which is the source of the crude palm oil, an inner shell which is used as a fuel, and a kernel which is the source of palm kernel oil and meal. The palm trees require about 3 yr to start bearing fruit; they reach peak production in 8-10 yr. Malaysian palm trees will produce 3000 lb of oil per acre (1).

At harvest crude palm oil contains ca. 0.5% free fatty acid (2). Within hours of harvesting it rises rapidly, especially if the fruit is bruised or damaged, due to enzyme action (3). A good grade of Malaysian crude palm oil contains 3 to 5% free fatty acid.

Harvesting is done by hand using either a chisel or a curved knife on a long pole depending on the height of the palm tree. The bunch is harvested from the palm tree by cutting through the bunch stem. The harvested bunch is then gathered together with any detached fruit and carried manually to road side to await transport to the oil mill. The fresh fruit bunches are loaded into trucks, transported to the oil mill where they are dumped and reloaded into sterilizer cages. The extraction of palm oil from fruit in Malaysia is in four stages. The first stage is sterilization in which the fresh fruit bunches are subjected to live steam under a pressure of 35 to 45 lb per square inch for 50 to 75 min. The purpose of sterilization is to deactivate the enzymes responsible for the breakdown of oil into free fatty acid and to loosen the fruit from the bunches so that the oil can be recovered later. Great care is taken during sterilization to exclude air which interferes with the sterilization efficiency and may cause oxidation of the oil.

In the second stage of processing, sterilized bunches of fresh fruit are fed continuously into a rotary drum threshing or stripping machine which strips and separates fruit from the bunches. The fruit passes along channel bars running longitudinally along the drum while the empty bunches are eventually discharged at the end of the drum for incineration. After stripping, the fruit is fed continuously into a digester. Digestion converts the fruit into a homogeneous oil mash suitable for pressing. The digested mash is then fed into a press for extraction of crude oil under pressure which is applied either hydraulically or by means of a worm screw.

The deoiled fibrous material is used as fuel for the steam boilers which in turn by operating steam turbines produce the electrical power required for the oil mill.

The nuts separated from the fruit pass through a polishing drum, the nuts are cracked and shells separated from the kernel in a hydroclone. The shells are mixed with the fibrous material for use as fuel. The kernels are then packed in sacks for transport to the palm kernel oil mill. The kernels are pressed or solvent extracted to produce palm kernel oil and meal. The fruit produces 20% palm oil and 6% palm kernel oil.

A typical analysis for crude Malaysian palm oil is: FFA (palmitic), 3.5%; moist, 0.1%; iodine valve, 45-56; color (1 in. Lovibond) 25 red.

In August 1975, Palmex Industries, Penang, Malaysia put into operation a physical refining system designed to produce refined palm oil for the export market. This system involved two steps, acid pretreatment and steam refining deodorizing, to produce a refined oil that would not lose quality during 2 to 3 mo transit time and upon receipt could be bleached and deodorized to eliminate any off flavors or odors picked up during transit or unloading.

PRE-TREATMENT PROCESS

Figure 1 illustrates the flowsheet for the acid pretreatment process, which is designed to continuously acid-treat the crude oil to remove impurities that are not removable by steam stripping or that would be degraded by heat treatment. These include, in varying amounts, materials such as

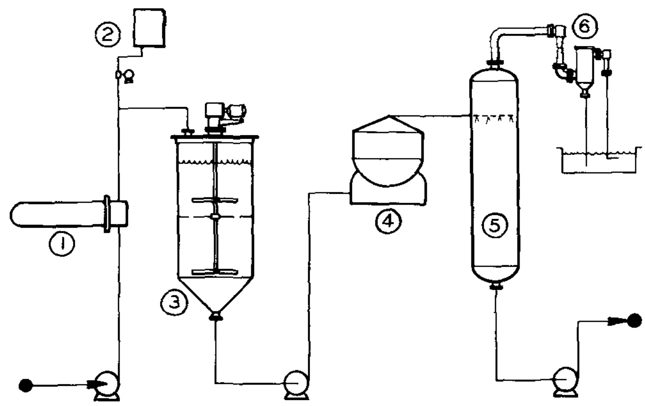


FIG. 1. Acid pretreatment process.

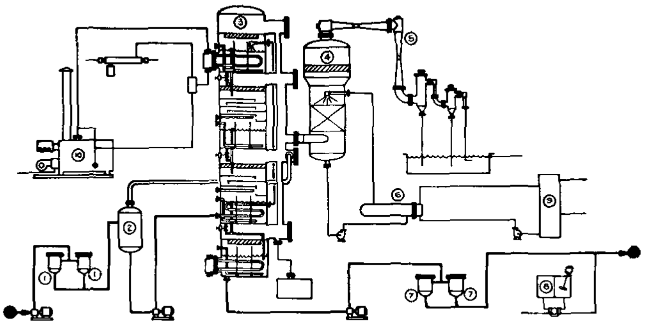


FIG. 2. Steam refining and deodorizing process.

phospholipids and trace metals.

Crude palm oil is continuously pumped under automatic control, through the crude oil heater [1] where it is heated to 190 F. Metering pumps feed concentrated phosphoric acid and demineralized hot water [2] at controlled rates into a pipeline where they combine to form a dilute phosphoric acid solution.

The heated crude palm oil and dilute phosphoric acid are combined in a pipeline and delivered to the treat tank [3] for thorough mixing.

The acid water serves to react with the trace metals and inactivate them and also hydrate the phosphatides forming a second phase.

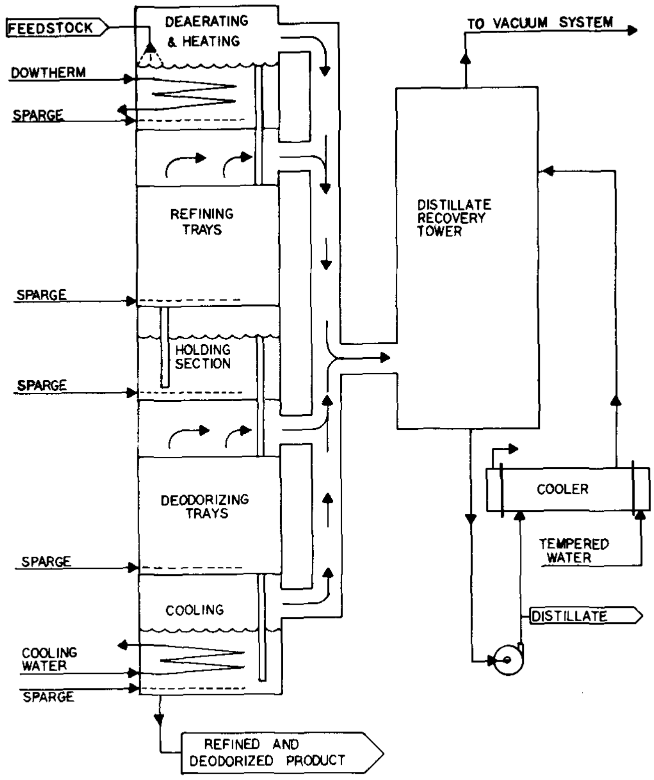
The oil-acid mixture is pumped to the centrifuge [4] where the hydrated gums are separated from the oil by centrifugal force and discharged into the waste water trap. The degummed oil passes to the oil dryer [5] where dissolved moisture is removed under vacuum [6]. The degummed crude palm oil is now ready for physical refining. Crude palm oil pretreatment data is: max. flow rate, 17,000 lb/hr; normal flow rate 16,000 lb/hr; 85% phosphoric acid, 0.20-0.25%; water 2.0-2.5%; retention time 20-30 min.

STEAM REFINING AND DEODORIZING PROCESS

In this process the pretreated oil is purified by three operations conducted under high vacuum at high temperature. First, the free fatty acids are removed by multistage countercurrent contact with steam. Then, the pigments are converted to a colorless form by retention of the hot oil for the required reaction time. Finally the oil is deodorized by additional multistage countercurrent contact with steam (Figure 2).

In order to achieve the full potential of the steam refining deodorizer the process was designed with the following objectives in mind: (a) reduction of the free fatty acid from 5.0% to 0.03% or less; (b) production of a fully deodorized product; (c) operation without substantially higher utilities consumption than a normal deodorizer; (d) recovery of the fatty acids from the sparge steam. A fifth objective implicit in the preceding is that the steam refining deodorizer should also be suitable for normal deodorization of the usual salad oils, shortening stocks, and margarine oils without sacrifice of product quality or operation efficiency.

As shown in figure 2, the pretreated oil feedstock is continuously pumped through a Filter [1] and sprayed into the Deaerator [2] under vacuum to remove entrained and dissolved air. The deaerated oil is pumped to the Refining Deodorizer [3] in which it passes through coils in the heat recovery section and up into the heating section in the top of the Deodorizer. In this section the oil is heated to the required processing temperature by coils, which are heated by vapor from Dowtherm Vaporizer [10] or other suitable heating media. The oil then flows down to the refining section in which it passes over a series of trays countercurrent to the flow of stripping steam which is injected below the bottom tray.



UTILITIES REQUIREMENTS PER 1000 LBS. OF FEEDSTOCK		
DEODORIZER	REFINING	NORMAL
STEAM 150 PSIG	300 LBS.	250 LBS
WATER 85° F	4500 GAL.	3800 GAL.
FUEL GAS 1000 BTU/SCF	380 SCF	380 SCF
ELECTRICAL POWER	1.5 KWH.	1.5 KWH.

FIG. 3. Utilities requirements for steam refining.

The refined oil flows down to the holding section which provides the retention time required for heat bleaching of the oil after which it flows down to the deodorizing section. In this section the oil again passes over a series of trays countercurrent to the ascending stream of stripping steam. The completely deodorized oil flows down through the heat recovery section to transfer its heat to the feedstock, and then flows down to the cooling section. In this section the oil is cooled to the required discharge temperature and is pumped out through a Polishing Filter [7]. Metered quantities of solution from the Antioxidant Tank [8] and nitrogen are injected as the oil is discharged to produce storage.

The vapors from the Refining Deodorizer, consisting of distillate (fatty acids and volatile impurities) and steam, flow into the bottom of the Distillate Recovery Tower [4] and up through a grid packing countercurrent to the descending spray of cooled liquid distillate. The distillate vapor condenses and combines with the liquid distillate, flows out of the bottom of the Tower, and is pumped through a Distillate Cooler [6] and recycled back to the top of the Tower. The quantity of distillate recirculating in the system is maintained constant, and the recovered distillate is automatically discharged to storage. The temperature of the Distillate Cooler is controlled by circulation of water from Water Tank [9] which is automatically maintained at a temperature somewhat higher than the freezing point of the distillate. The steam from the top of the Distillate Recovery Tower flows to the Multistage Vacuum System [5] which maintains the entire Deodorizing System under vacuum.

TABLE I

Physically Refined Palm Oil

	Specification	Production
1. Free fatty acid	0.1% max.	0.03-0.05%
2. Color (5¼ in. Lovibond)	6-8 red	4.4-6.0 red
3. Peroxide value	0.5 max.	0.0-0.25

TABLE II

Bleaching Effect Physical Refining

	Crude FFA	Product color
1. Low acid crude	2% max.	2-3 red
2. Quality crude	2-3%	3-4 red
3. Crude	3-5%	4-8 red
	(5¼ in. Lovibond)	

In the table of utilities requirements Figure 3, it can be seen that the refining deodorizer uses only ca. 20% more steam and water than the normal deodorizer. This somewhat higher consumption is caused by the distillate recovery system, which must handle ca. 50 times more distillate than from a normal deodorizer.

Typical steam refining operating data is: max. flow rate 17,000 lb/hr; normal flow rate 15,000 lb/hr; deodorizer oil temp. 500-550 F; vacuum 3 mm. Hg. abs.; residence time 1 hr.

This refining deodorizer design achieves the objectives originally set forth. (a) It removes the FFA from high acid oils by means of additional stripping trays without increasing sparge steam, in accordance with well-known and proven design principles. (b) It produces a fully deodorized product and is also suitable for the deodorization of normal feedstocks because it is based on a deodorizer of proven performance to begin with. (c) It operates with only a moderate increase in utilities consumption. (d) It recovers the distillate without further processing (4).

Table I contains typical analytical data for physically refined palm oil.

A synergist is added to the palm oil to sequester the trace metals before steam refining. An antioxidant is added to the deodorized oil and the deodorized oil is thoroughly saturated with nitrogen to protect its quality.

The physical refining deodorizer will substantially reduce the red color of the crude oil by heat bleaching at 500 F (Table II).

This oil can be shipped to the United States or Europe and after being in transit for 60 to 90 days; the oil can be bleached with acid activated bleach clay to reduce the yellow and red color. In 5¼ in. Lovibond tube, the original oil was 70/5.2, 0.5% bleach clay = 30/2.2, 1.0%. Bleach clay 22/2.0, and 2.0% bleach clay = 18/1.4 Lovibond.

An acid treating vacuum bleaching process, Figure 4, can be substituted for the centrifugal process to produce a refined palm oil that does not require additional bleaching.

The function of the pretreatment process is to remove impurities that are not removable by stream stripping or that would be degraded by the heat treatment. These include, in varying amounts in different oils, materials such as phospholipids, B-Carotene, heat-sensitive color bodies, and trace metals. The process consists of an acid treatment followed by an activated clay treatment under vacuum.

As shown in the flow diagram in Fig. 4, the crude oil is fed continuously at a regulated rate into the Treat Tank [1] along with a metered amount of phosphoric acid from the Acid Tank [2]. The mixture is thoroughly agitated in two stages to obtain complete treatment, after which it is pumped to the Slurry Tank [3]. Activated clay and filter aid are continuously fed from the Clay Bin [4] into the Slurry Tank [3] at a controlled rate adjusted to suit the characteristics of the oil. The slurry of oil, clay, and filter aid is pumped continuously to the Vacuum Bleacher [5] and sprayed into the head space to obtain complete deaeration prior to heating.

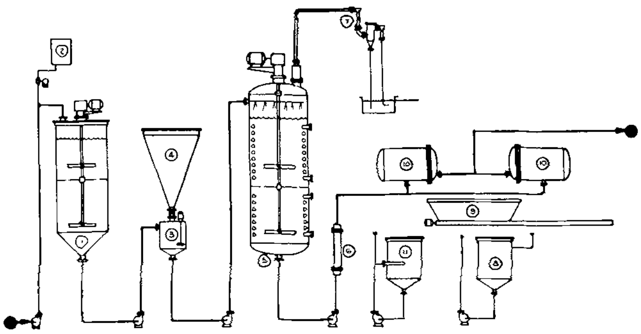


FIG. 4. Acid treatment vacuum bleaching process.

TABLE III

Acid Treated, Bleached, Steam Refined, Deodorized Palm Oil

	Specification	Production
1. Free fatty acid	0.1% max.	0.03-0.05%
2. Color (5¼ in. Lovibond)	25/2.5	18-20/1.8-2.2
3. Peroxide value	0.5 max.	0.0-0.25

TABLE IV

Bleachability of Acid Treated, Bleached, Steam Refined Palm Oil

	Color
1. Oil as received	1.8-2.2 red
2. 60/40 Mix soy oil No bleach-after deodorizing	1.75 red
3. 100% Palm 0.5% Bleach-after deodorizing	1.8 red

The deaerated slurry is heated to the desired bleaching temperature under automatic temperature control by internal steam coils; and the Bleacher is maintained under vacuum by a Steam Jet Ejector System [7]. The Vacuum Bleacher is compartmented to provide two stages of mixing for intimate contact and adequate time. The slurry is pumped from the Vacuum Bleacher through a Cooler [6] and into one of the two Filters [10], which are provided for alternate use. The filtered pretreated oil is discharged continuously to the Steam Refining Deodorizing Process or to intermediate storage.

When a Filter reaches its cake capacity, the slurry flow is diverted to the other Filter. The oil is discharged from the out-of-service Filter; and the cake is blown with steam, emptied into the Cake Chute [9], and conveyed to the discharge point. The Filter then is precoated, using the Precoat Tank [11] and Pump, in preparation for the next filter cycle. Steamings from the Filter are collected in the Steamings Tank [8] and reworked into the Slurry Tank [3].

The pretreatment process can also be used to prepare other oils such as coconut, palm kernel, soybean and corn oil for physical refining. Table III shows typical data for acid treatment bleached and steam refined deodorized palm oil.

STORAGE AND SHIPMENT

The rate of oxidation of crude palm oil during storage and shipment is markedly accelerated by heat and by the presence of pro-oxidants such as traces of metals librated and absorbed through the action of free fatty acids on extraction machinery, pipes, and tanks (5).

The trace metals have been inactivated, the fatty acids removed, and antioxidants added to the oil as produced by Palmex Industries, to eliminate the causes of oxidation during storage.

To protect the oil quality, the deodorized palm oil is trucked to the bulking terminal where the shore tanks are epoxy lined and nitrogen blanketed. The oil is loaded into ship's deep tanks in such a manner that aeration is avoided.

The oil is not heated on board ship until the ship is 10 days from port, by which time the temperature has dropped to 25 C. The temperature is gradually raised to a maximum of 50 C by the time the ship arrives at port. Proper intransit handling of the deodorized palm oil minimizes deterioration in product quality.

DOMESTIC PROCESSING OF PALM OIL

Crude palm oil received in the states is normally caustic refined, bleached, hydrogenated, blended with other oils and deodorized. The caustic refining process produces a large quantity of soapstock which requires acidulation and associated pollution problems, to produce a saleable product.

The physical refining process reduces the neutral oil loss normally associated with the caustic refining process by 50-60%, operating costs by 30%, and capital costs by 20%. Overall it is more economical to physically refine the crude oil in Malaysia, ship it to the United States, bleach and deodorize it in the Unites States, than it is to ship crude palm oil to the United States and caustic refine.

The physically refined palm oil does not develop color during transit, the antioxidant and nitrogen blanket prevents the development of peroxides; however, flavor changes, (boat odor) results in lowering flavor socre from 8.9 (10 point organoleptic scale) to 4-6 during transit.

After unloading, the physically refined palm oil is bleached, formulated by hydrogenation or blending with other oils according to the desired finished product specifications, and given a normal deodorization. Table IV shows typical bleach colors for acid treated, bleached, physically refined palm oil.

REFERENCES

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2. Guan, H.S., JAOCS 49:322A (1972).
3. Malaysian Palm Oil Producers Association, "Malaysian Palm Oil," Technical Bulletin No. 1, Kuala Lumpur, Malaysia, 1973. p. 11.
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150 attend Processing Clinic

Research efforts on soybeans, cottonseed, and peanuts were among topics discussed during the 26th Oilseed Processing Clinic that attracted 150 persons Feb. 14-15 in New Orleans.

The conference session was dedicated to Leo Goldblatt and Henry L.E. Vix, two AOCS members who have retired from the USDA's Southern Regional Research Center. The Center and the Mississippi Valley Oilseed Processors Association, Inc., sponsored the meeting.

T.A. Hieronymus of the University of Illinois' Department of Agricultural Economics presented a talk to the opening session on "Survival in a Fluctuating Market: Hedging."

Program sessions followed Hieronymous' talk with the initial session consisting of reports by William H. Tallent, director of the Northern Regional Research Center, on "Recent Developments in Soybean Research" at that center, and one by Laurence W. Mazzeno on "Status and Potential of Oilseed Research" at the Southern Regional Research Center (SRRC).

Tallent said studies on hydrogenation of soybean oil with copper catalysts have suggested ways to improve the process economics without sacrificing the advantage of providing hydrogenated oil of improved quality. Other research projects include studying what happens to exported beans while in transit, searching for feasible ways to upgrade oil from field damaged beans, and continuing work to remove flavor deterrents to use of soy protein for human food.

Mazzeno, substituting for Homer K. Gardner of the SRRC's engineering and development lab, outlined work to produce light-colored cottonseed concentrates and isolates and to study biochemical and functional properties. Peanut protein studies include seeking a practical solvent extraction process to produce white peanut meals and flours of high protein solubility with no raw taste, and a commercially feasible process for converting peanut oil into an acceptable salad oil. Other work includes methodology for determining aflatoxin in cottonseed and peanut products as well as in mixed feeds.

Talks during the second session included Dan Hicks, executive vice president of Ninety Six Manufacturing Co. of Ninety Six, SC, who spoke on "Shelling and Processing Peanuts on Cottonseed Equipment."

Harold P. Dupuy, a research leader at the SRRC, described a direct gas chromatographic technique for eluting and resolving flavor-related volatiles in oilseed products. Some of the volatiles were characterized by gas chromatography-mass spectrometry-computer system.

F.J. Schroeder of Anderson Clayton's Oilseed Processing Division in Phoenix, AZ, discussed factors in "Conservation of Energy in Oil Mills."

"Solving Lint Room Problems" was the subject of a panel discussion that included James C. Orr of Murray-Carver Inc. of Dallas, TX; R.A. Denman of Southern Soya Corp. of Estille, SC; and R.D. Sanders with W.C. Cantrelle Co. of Fort Worth, TX.

Delbert C. Hess for ACCO Seed in Plainview, TX, said that new gossypol-free, or glandless, cotton varieties have been developed that have lint yields of 98 to 111 percent of glanded varieties used as standards in yield tests. While there is reluctance to use the glandless types on large acreages because of possibility of insect damage, the release of the improved types coupled with a premium to grower could encourage enough acreage to provide good quantities for feed and food industries within the next few years, Hess said.

A.C. Griffin Jr. of the U.S. Cotton Ginning Research Laboratory in Stoneville, MS, reported that 1,000-lb. batches of cottonseed of varying moisture contents were treated with propionic acid to determine the acid's effectiveness in controlling development of free fatty acids in cottonseed stored for 180 days. Batches with initial moisture content of 16.6 and 19.1 percent stayed below 2 percent FFA. The acid did not protect a batch with an initial moisture content of 24.9 percent Griffin said.

R.J. Kohel, of the USDA and Department of Soil and Crop Sciences at Texas A&M, reviewed literature and described current research on "The Effect of the Environment on Cottonseed Development."

Reprints of talks may be requested from the Reprint Office, Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179.

Emery to market new fatty acids

Emery Industries, Inc., of Cincinnati has signed an agreement with Liquichimica Italiana S.p.A. of Milan, Italy, to market a new family of fatty acids synthesized from selected petrochemical feedstocks.

Emery has exclusive rights to market the products throughout the Western hemisphere except in Brazil. The Liquichimica plant at Saline, Italy, that will produce the materials is expected to begin production during the next three months and will have an annual rated capacity of 100,000 metric tons. The petrochemically derived fatty acids will be a mixture of linear and nonlinear acids, ranging initially from C_{12} to C_{19} in carbon chain length.

The new product line has unique physical, chemical, and performance properties not available in the market place, Emery said in announcing the agreement. Specific potential applications exist in lube oil additives, cosmetics, soaps and detergents, textiles, printing inks, natural and synthetic rubbers, paints, and a variety of chemical intermediates, the U.S. firm said. The synthetically derived acids will supplement Emery's line of naturally derived fatty acids. •

European cosmetic meeting set

The International Federation of Societies of Cosmetic Chemists will hold its 1977 Council Meeting on Sept. 18, 1977, in the Sheraton Hotel in Brussels, Belgium. The meeting will be followed on Sept. 20 with a one-day symposium on "The Many Faces of Cosmetic Research."

Further details are available from IFSCC, 56 Kingsway, London WC2B 6DX, England; or ABA, 49 Square Marie-Louise, B-1040 Bruxelles, Belgium. •

Esmark to finance academic programs

Esmark, Inc., and a subsidiary, Estech, Inc., have established a program to finance a visiting lecture series and a program of graduate scholarship support at the Department of Chemistry, University of California, San Diego. Scholarship funds will be used primarily for support of graduate students from outside California, the firms said. •

Toronto topics outlined

Three main subject areas have been announced for the World Conference on Future Sources of Organic Raw Materials to be held July 10-13, 1978, in Toronto, Canada.

In depth studies of the following topics are planned: (a) fossil hydrocarbons with emphasis on alternatives to petroleum; (b) renewable resources, including wood and other plant materials; (c) urban, agricultural, and industrial waste.

Persons seeking further information should write: The Chemical Institute of Canada, 906-151 Slater St., Ottawa, Ontario, Canada K1P 5H3. •

Grindsted forms new committee

AOCS members Richard Schoenfeld and Niels Krog have been named to the new three-member Operating Management Committee for Grindsted Products, Inc., of North Kansas City, MO. Schoenfeld is director of sales and marketing for the firm; Krog is director of technical sales and services.

Third member of the panel is Robert A. Thomas Jr., the firm's controller. Grindsted Products Inc. was formed in 1975 as a subsidiary of Grindstedvaerket A/S, Denmark, a food additive manufacturer. The new committee was formed to improve coordination between research and production in the United States and in Denmark. •

First Argentina national meeting April 22

The Argentine Fats and Oils Institute will hold its "First National Meeting on Fats and Oils Science and Technology" on April 22, 1977, in Buenos Aires.

Eight papers have been scheduled:

- "Oil extraction by means of ultrasounds" by A. Diner, technical director for the institute.
- "Present state of legislation relating to edible fats and oils," by Norah Carranza, National Institute of Pharmacology.
- "Babassu oil hydrogenation," by C. Pesin, of the technical department of Pulgar S.A.
- "Antioxidants: characteristics and properties" by N. Poliakoff, manager of Development Department, Productos Roche S.A.
- "Some problems related to the extraction of the grape seed oil," by H. Gatti, Industrial Department, ACA.
- "Use of bleaching earths in the fats industry," by B. Lorcovick, technical director of Carimar, S.A.
- "Effects of gamma radiations on lipids," by M. Ritacco, division of intense radiation sources, Radiosotopes and Radiations Department, National Atomic Energy Commission.
- "New vegetable oil sources," by S. Belart, chief of Food Research Center, Argentine Fats and Oils Institute.

Persons interested in attending should contact Dr. Alberto O. Diner, Argentine Fats and Oils Institute, Chile 1192; 1098, Buenos Aires, Argentina. •

'Nutrition and Work' conference

The third international symposium on "Nutrition and Work" will be held Sept. 28-30, 1977, in Nancy, France. Conference themes will be new technologies applied to protein sources; influence of technological treatments on nutritional values of protein; technological processes to maintain nutritional quality; new food conservation processes; and new foods from new technolgoies. Further information is available from the Department of Nutrition and Metabolic Disorders, University of Nancy, 40 rue Lionnois, 54000, Nancy, France. •