particularly attractive. Indicate what trips you wish to make when you register.

6. Entertainment—The ladies' committee is arranging a program of entertainment for the ladies. Announcement of the completed plans will be posted on the bulletin board near the registration desk.

Bowling Tournament—The annual bowling tournament will be held in the Bensinger alleys, 235 S. Wabash Avenue, under the management of A. E. King. The events will be five-men team matches, singles and doubles. Send your entry to Mr. King, care Swift & Co., Chemical Laboratory, Chicago, promptly.

Football—Tickets for the Chicago-Indiana and the Northwestern-Purdue games will be secured by the local committee for those desiring to attend either game. It will not be necessary to make reservations before the first day of the meeting.

Golf—If the weather is suitable arrangements will be made for those who care to play golf. If enough interest is shown a golf tournament will be arranged.

Registration—Registration will take place between 9:30 and 10:00 a. m., Thursday morning, October 20. There will be the usual nominal registration fee of $1.00 to take care of the incidental expenses of the convention.

Exhibits—Another complete exhibit of chemical equipment, supplies and machinery will be shown in the Florentine Room of the Congress Hotel.

President N. C. Hamner of Dallas, Texas, will be in general charge of the meeting. The first day's program will be devoted very largely to papers on soap and Mr. Archibald Campbell will preside.

The second day will be taken up with papers on oils and fats, and President Hamner will take charge.

Mrs. J. P. Harris, Chairman of the Ladies' Committee, is arranging a very attractive entertainment for visiting and local ladies.

In addition to the bowling, if the weather permits, arrangements will be made for those who care to play golf, and there are also two football games in Chicago on Saturday, October 22—Chicago vs. Indiana and Northwestern vs. Purdue.

Last year the chemical exhibits at our convention were the best presented at any scientific meeting for many years. This year the list of exhibitors includes not only most of those who exhibited last year, but some new ones. A complete list to date is given below. (Corrected since September issue.)

Booth No.	1.	Skelly Oil Company
"	2.	Daigger, A., & Company
"	3.	Proportioneers, Inc.
"	6.	Precision Scientific Co.
"	7.	Cleveland-Cliffs Company
"	8.	Welch, W. M., & Co.
"	9.	Industrial Chemical Sales Co.
"	10.	Central Scientific Co.
"	14.	Gillette Publishing Co.
"	12.	Purina Mills
"	13.	American Oil Chemists' Society
"	14.	Merck & Company
"	15.	Sargent, E. H., & Company

The Technology of Palm Oil

By H. P. TREVITHICK and M. F. LAURO

THE usual palm oil on the market is derived from the fruit of the palm tree, *Elaeis Guineensis,* and comes chiefly from the West Coast district of Africa, from Gambia to St. Paul de Loanda. There are cultivated species in South America (Brazil), the West Indies, Java, North Burma, and Sumatra (*Elaeis melanocca*). In Sumatra particularly, there are large Government controlled plantations, and the importations of this Sumatra oil have been quite extensive in recent years.

The oil is obtained from the outside fleshy portions of the fruit, the nuts (or seeds) giving the well-known "PK" or palm kernel oil. This

oil is distinctly different from palm oil both physically and chemically, and resembles coconut oil very closely.

In the older methods of preparation, holes were dug in the ground and filled with the fruit, which was allowed to stand and ferment for one or two weeks. Then barefoot natives trod the fruit, causing the oil to rise to the surface, where it could be skimmed off. This method of preparation of the oil for the market resulted not only in the loss of considerable of the oil, but in leaving a considerable amount of impurities (both accidental and intentional) in the oil; darkened its color, emphasized its peculiar odor and increased the free fatty acid content (with consequent loss of glycerine). The more modern methods of quick handling, boiling of the fresh fruits and removal of the oil before fermentation sets in, produces a softer and sweeter product, with far better color, and very low acidity.

According to its source and its preparation, the color of palm oil ranges from pale orange yellow for Sumatra, or deep carrot red for West African fresh fruit oil to a dirty dark red for Congo oil. The odor similarly varies from one described as suggestive of wood violets or Florentine orris, to a sharp and rancid odor, peculiar and characteristic, but not easily definable. The consistency ranges from that of soft butter (almost liquid) in the fresh oil to that of tallow, producing grades known as softs," "semis" and "hards," the higher fatty acid content oils being the harder. Fresh fruit oil may have an acid content as low as 2 per cent, while the inferior varieties may run over 60 per cent or even as high as 90 per cent.

Crude palm oil has the following general characteristics:

	Normal values	*Outside limits*
Color	Light orange to dark red	
Odor	Violets (except when rancid, etc.)	
Consistency	Pastry to very hard	
Specific Gravity at 30° C.	0.903-0.917	
Specific Gravity at 99° C.	0.849-0.859	
Iodine value (Wijs)	52-56%	51-57%
Saponification value	195-200	193-205
Titre	43.0-45.5° C.	41-46° C.
Unsaponifiable matter	0.20-0.60	0.20-0.90
Melting point (Open Capillary)	25° C.-42° C.	
Flash point (Cleveland open cup)	445° F.-500° F.	
Fire point (Cleveland open cup)	500° F.-600° F.	
Color (1 inch cell-Lovibond)	70 Yellow-20 to 100 Red	
Color (air bleached) ditto	35 Yellow-4 to 20 Red	
Color-refined deodorized (5½ inch cell)	35 Yellow-3 to 11 Red	

During the past fifteen years, due to the increased care in the preparation and handling of the oil, there has been a steady decrease in the content of free fatty acids, moisture, dirt, and unsaponifiable matter. Formerly, the average moisture and dirt content was between 2 per cent and 3 per cent, but of late years this average has decreased materially. All of the oil was formerly sold on a 2 per cent moisture and dirt basis, but now the best grades are sold on a 100 per cent oil basis, and the analyses of these grades will show less than 0.5 per cent moisture and dirt; frequently less than 0.1 per cent.

In general, the lower the free fatty acid content, the softer the oil. Plantation oils (both the true plantation and also the African oils prepared under modern conditions from fresh fruits), show acidities varying from 2 to 10 per cent or 12 per cent, with light color, soft body, sweet and pleasant odor, attractive clean appearance, etc. The colors on a 1 inch cell (Lovibond) range from about 35 yellow-20 red to 35 yellow-60 red, and will bleach with air and heat to 35 yellow-3 red or 35 yellow-4 red. The unsaponifiable matter is very low, sometimes as low as 0.17 per cent and never over 0.40 per cent.

An extracted *Sumatra* oil gave the following values: unsaponifiable matter 0.55 per cent, free fatty acid content as palmitic of 8.87 per cent, titre of 45.0° C., flash point (Cleveland open cup) of 446° F. and fire point of 505° F. *Lagos* type oils show acidities from 8 to 20 per cent or even 25 per cent, melting points of about 30° C., rather darker colors than the plantation oils, varying from light to dark orange, and are generally rather soft bodied. *Niger* type oil is quite hard, with still darker colors, some being quite red, with acidities from 20 to 60 per cent, and with a somewhat higher unsaponifiable mat-

ter content. *Congo* oils are very red and sometimes soft bodied although with rather high acidity, such as 35 to 70 per cent. The titre on a few of these samples was quite low, being 40.7 and 41.1° C.

A sample of *West Indian* palm oil was very soft and had the following characteristics:

Specific Gravity at 15.5° C.	0.9378
Iodine value (Wijs)	86.1
Saponification value	194.1
Free fatty acids (as palmitic)	9.5%
Index of refraction at 60° C.	1.4537
Melting point (capillary)	5° C.

The refining of this oil presents no especial difficulties. The refined oil is still yellow, however special treatment being needed to produce the white grades. Below are given some results which may be considered typical:

Type of Oil	*Acidity* Per Cent	*Loss* Per Cent	*Caustic Used*	
Plantation	3	18.3	10%	16° Be
"	10	32.6	18%	16° Be
"	5.82	12.7	22.5%	16° Be
"	7.12	18.1	8%	16° Be
"	4.50	9.5	7.6%	16° Be
Bonny Old Calabar	11.73	23.5	13.4%	18° Be
Lagos	18.0	49	19.2%	20° Be
Opobo	13.90	32	19.8%	16° Be
"	10.98	23.5	14.1%	18° Be
Lagos	17.8	47.5	21.4%	18° Be

The refined and bleached edible oils are of two grades, the white and the yellow. The color of the white is less than 4 red, Lovibond scale on a 5¼ inch cell, and of the yellow oil about 8 to 12 red. Age and exposure not only causes rancidity with increased acidity, but bleach out the characteristic reddish color to a pale dirty yellow or even cream white. Certain chemical changes are also effected, especially with respect to iodine value and titre, which will be dealt with later.

The older and still current uses of palm oil are in the making of axle grease, lubricants, soaps; in oleomargarine and butter as a coloring matter to simulate the natural butter color, in the rubber industry, and in tin-plating. Today the partially or wholly bleached oil finds its way more and more into edible oil channels. This is particularly true of margarine, where the oil gives a better texture to the product, and a greater resemblance to butter in not melting immediately when warmed but being pasty over a considerable range. The addition of this oil, however, if still colored, to margarine is considered an artificial coloring and the product is taxed as such by the Federal authorities.

In the past, to detect such additions, certain color reactions claimed peculiar to palm oil, were employed. Among them was the Crampton and Simons test, which was later shown by A. H. Gill to be unreliable in that the test was really for carotin, the coloring principle of palm oil but also of many other oils, some of which like sesame oil and butter fat are possible ingredients of margarine. Carotin is to be found mostly in the unsaponifiable matter of the palm oil and is composed of the *alpha-* and *beta-* varieties. After extraction of the palm-oil soap with ether, the yellow component remains in the soap solution, and the red variety is found in the unsaponifiable residue (after evaporation of the ether).

Certain earths, and even heat alone above 220° C., will bleach the usual red color to a butter yellow. Bleaching with air, by bubbling it through the hot oil (heated to above 150° C.) converts it to a practically white fat (yellow in the liquid state). The usual methods of bleaching this oil, such as the use of air at elevated temperatures, the use of air and steam, the use of the usual chemical bleaching agents, or of fullers' earths, activited earths or carbons, do not affect the chemical characteristics of the oil noticeably. Slow bleaching caused by exposure to air and light over long periods of time has a marked effect on the oil, however, the iodine value in particular being greatly reduced and the titre being considerably increased. This change has been investigated and discussed by the authors previously (see *Cotton Oil Press,* of March, 1924). They found that these chemical changes occurred, in addition to the usual physical changes in odor, color, and consistency. The resulting product resembled tallow very closely in color, appearance, consistency, titre, and iodine value.

Some samples of palm oils were exposed partially, in jars, to light and air for some months, portions of the jars being covered to protect the material from the light effects. The covered portions of the oils were unchanged, retaining

the original color, appearance, etc., but the exposed portions bleached to a white or creamy color, became considerably harder, etc. The changed and unchanged oils were separated, and analyzed with the following results:

	Unchanged Oil		*Bleached Oil*	
Sample	Iodine Value	Titre	Iodine Value	Titre
No. 1.....	53.4	45.5° C.	48.4	46.5
No. 2.....	50.3	46.4° C.	49.1 (cream)	47.2
			30.8 (white)	49.5
No. 3.....	53.4	45.5° C.	48.4	46.5
No. 4.....	53.4	45.5° C.	48.4	46.5
No. 5.....	53.4	45.5° C.	47.7	46.0

A number of samples of other shipments of oil were received which had bleached naturally, but on which we did not have samples of the original unchanged oil. These gave the following results:

Iodine Value	Titre
53.6	45.0
44.4	48.8
49.1	47.2
50.3	46.4
30.8	49.5
39.8	46.7
50.6	46.0
42.3	46.9
47.5	45.5
49.5	44.4
49.1	47.0

Some of these oils had not bleached completely, the iodine value decreasing as the color decreased, but the rate of change is not necessarily the same. Also, the palm oil may be white, or yellow when melted, but the acids are generally red.

Danger of Setting by Heating

Heat also will bleach the oil, particularly where water is present. However, it may damage the oil by "setting" the color. On bulk shipments, it is necessary to heat the ship's tanks containing the palm oil, and this is done either by keeping a little steam in the heating coils during the whole voyage, or else by putting the steam in the coils while at sea, a few days before arrival in port. This facilitates the discharge of the cargo, as liquid oil. Excessive localized heat (even though possibly below the boiling point of water), if applied for a considerable period of time, will tend to bleach the oil and to "set" the color, even if bleached; it also may possibly introduce "bloom" (aside from fuel oil contamination through leakage) through its effect on the impurities (particularly fibrous material) which are always present to a greater or less extent in the oil.

One shipment we have analyzed was yellowish brown in color, rather than the usual red, having been partially bleached in transit. Samples were taken from the lot before shipping and after arrival (the lot being in two deep tanks) and were analyzed with the following results:

SAMPLE "A"

	Shipment	*Delivery*
Color (as received—1 inch cell).....	35 Yellow-47 Red	50 Yellow-6.7 Red
Color (air bleached)	35 Yellow-4.2 Red	35 Yellow-4.8 Red
Free Fatty Acids (palmitic).....	21.26%	23.51%
Unsaponifiable matter		0.27%
Fluorescence	None	None
Contamination	None	None

SAMPLE "B"

Color (as received—1 inch cell).....	35 Yellow-52 Red	50 Yellow-8.2 Red
Color (after air bleaching).....	35 Yellow-5.2 Red	35 Yellow-7.6 Red
Free Fatty Acids (palmitic).....	21.26%	22.70%
Unsaponifiable matter.....		0.32%
Fluorescence	None	None
Contamination	None	None

These results, particularly in the case of Sample "B", indicate fixation of the color by heat, since the bleaching with air failed to produce as

light a color on the delivery sample as on the shipment one, and in fact was not able to lighten the color to any appreciable extent, although the oil in transit already had become much lighter than when shipped. It may be noted that the acidity increased during transit, and that, since the unsaponifiable matter is normal in amount and no "bloom" or fluorescence is exhibited by the oil, contamination with mineral oil may be considered absent. Since much of the value of palm oils lies in their ability to bleach white and thus produce white soaps, such fixation of color by heat materially depreciates the value of the oil, because obviously the mere bleaching of the palm oil in transit would not detract from its value.

Contamination with fuel oil, even in slight amounts, frequently causes serious loss and damage to the oil. Unless the amount is considerable, the percentage of unsaponifiable content is of no value in determining this question, as 0.01 per cent of dark fuel oil will be shown up unmistakably in fluorescence. It is also a fact that mineral oil contamination will give a grayish cast to the finished soap.

Contamination is determined by various tests. Sometimes the air-bleached sample will exhibit a decided fluorescence. The petroleum ether or ethyl extract of the unsaponifiable (particularly the portion extracted with the first portion of the solvent) will often show a decidedly dark color and fluorescence, when contamination is present. Comparison of the samples of the oil taken before loading and those discharged will often throw light upon the problem. These may be air bleached, refined with lye and then bleached, and comparison made of the colors of the treated oils prepared from each sample.

Two samples of oil with acidities of 10.7 per cent and 10.76 per cent, respectively, and identical titres of 45.1° C. gave unsaponifiable values of only 0.49 per cent and 0.35 per cent, and yet they were contaminated unquestionably, as shown by the fluorescence and other characteristics of appearance. Conclusive proof was given by the fact that lumps of hard material were found in the tanks after discharge was completed, these lumps consisting of fuel oil and scale.

In tin-plating, the hot sheets from the tin bath are drawn through melted palm oil, to give a smooth finish to the plate. This process tends to char and burn the oil, producing finally a black pitchy mass. Some of this material gave the following results:

Specific Gravity at 99° C.	0.8859
Iodine value (Wijs)	54.8
Saponification value	120
Free Fatty Acids (palmitic)	42.7%
Titre	36° C.
Moisture and volatile matter	23.72%
Insoluble impurities	1.40%
Unsaponifiable matter	5.43%

Production and Trade in Glycerin First Half 1932

United States production and stocks of glycerin during the first half of 1932 are shown in the following table in comparison with the same period of the previous year:

Production

	1931 *Pounds*	1932 *Pounds*
Glycerin, crude—		
80 a/c basis	70,361,387	71,027,324
—dynamite	21,099,829	18,105,160
—chemically pure.	37,438,713	33,270,286

Stocks in hands of producers on June 30

	1931 *Pounds*	1932 *Pounds*
Glycerin, crude—		
80 a/c basis	13,183,235	20,200,388
—dynamite	11,685,623	15,156,098
—chemically pure.	10,778,964	13,565,980

Imports during the first half of 1932 were: Crude, 2,273,220 pounds, and refined 757,506 pounds, as compared with 5,803,859 pounds and 665,150 pounds, respectively, for the first 6 months of 1931.

Exports of glycerin (all grades) were 128,426 in the first half of 1932 and 165,420 in the corresponding months in 1931.