Review of Literature on Fats, Oils and Soaps. Fat Literature Review Committee*

Part 2

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Deterioration

The new investigations on methods of evaluating the stability of fats and of measuring deterioration mainly elaborated the limitations and significance of the known tests. Macarovici (*Bull. sect. sci. acad. roumaine 23,* 372) plotted the development of peroxides and aldehydes during autoxidation of 13 animal and vegetables fats. He found that the peroxide curves provided the more reliable criterion of stability. In similar work Sundberg and Hultberg (*Iva 1942,* 243) recorded acid number, saponification value, index of refraction, peroxide number, aldehydes and methyl ketones. In the dark at 37° the aldehydes became especially high after an induction period. In sunlight, decomposition products appeared quickly, peroxides being first detected. The oxygen uptake with butter was 2% instead of equivalent to the unsaturation; 58-86% of the oxygen could be accounted for in the aldehydes, peroxides and acids formed; the rest was believed to go into the formation of volatile products. In brown stoppered bottles the volume of gases evolved overbalanced that of the oxygen gas consumed. The author suspected that polymerization of butter was somewhat related to tallowiness for during the process there was an increase in molecular weight. The data of Viollier (*Mitt. Lebensm. Hyg. 34,* 318) showed no definite correlation between acidity and peroxide value during spoilage. The peroxide value was his choice as the most useful criterion. Guimaraes (*Anais assoc. quim. Brasil 2,* 202) in work on babassu oil also pointed out that peroxide formation was more evident than hydrolysis to free fat acids. Two methods for testing bacon for decomposition depended on determining acidity with pH indicator solutions (Schönberg—*Z. Fleisch- u. Milchhyg. 53,* 61, 91). Koblic (*Sbornik Ceskeslov. Akad. Zemedelske 17,* 162) believed that bacon with an acid number over 10 could be considered unfit for eating, but this should not apply to sausage, for the fat in some of the better type of salami showed an acid number greater than 10. Lauridsen's (*Kem. Maanedsblad 23,* 117) stability criterion for lard was defined as the number of days necessary for 50 c.c. of the fat in an Erlenmeyer flask at 50° and in the absence of light to develop a peroxide value of 3. French and Lundberg (*Oil & Soap 21,* 23) believed the new stability test which depends on the disappearance of chlorophyll fluorescence to be of doubtful value for some fats because of the absorption of light by the fats and the masking effect of natural fluorescence of the samples.

In a study of the mechanism of autoxidation Atherton and Hilditch (*J. Chem. Soc. 1944,* 105) oxidized methyl oleate in bright sunlight for 34.5 days at room temperature. The fall in the iodine value was greater than required for the exclusive formation of hyperoxide but only half that which would occur if the peroxides alone were produced by union at the double bond. The final product was fractionated by adsorption methods and the eluted fraction was analyzed by using permanganate oxidation followed by determination of the oxidation products. The results confirmed Farmer's view that oxidation of oleic acid at ordinary temperature involved conversion of the CH_2 group at the 8th or 11th carbon into hyperoxide; and that appreciable amounts of autoxidation products were formed by union of oxygen at the double bond. The oxidizing action at 120° appeared to proceed exclusively at the double bond and may be followed by secondary oxidation at other points in the acyl chain. In similar work, Paschke and Wheeler (*Oil & Soap 21,* 52) plotted peroxide formation at 100, 75, 55, 35 and 15°. Maximum peroxide development progressively increased as the temperature was lowered to 35°. The rate of decomposition or disappearance of peroxide at all temperatures investigated agreed best with that of a bimolecular reaction. The disappearance of peroxides and the changes in iodine number were discussed from the standpoint of such reactions as polymerization, formation of OH groups and development of volatile products.

The year's publications on the accelerating effect of copper on spoilage of fats originated from dairy products' research. The copper content of butter was correlated with development of fishiness (Hussong and Quam—*J. Dairy Sci. 27,* 45), with lack of stability (Schulz—*Deut. Molkerei-Ztg. 64,* 132), with production of peroxides and destruction of caro-

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tenoids (Gould *et al.—Mich. State Agr. Exper. Sta. Quart. Bull. 26,* No. 2) and in the loss of color (Hussong and Hammer—*Food Res. 9,* 289).

Nagy, Vibrans and Kraybill (*Oil & Soap 21,* 349), in investigations to test the efficiency of antioxidants, found results with the accelerated oxidizability equipment and with Barcroft-Warburg apparatus in good agreement with storage tests at room temperature on pure lard or lard stabilized with phosphatides. With lard stabilized with fat acid esters of *d*-isoascorbic acid the results with the Barcroft-Warburg apparatus agreed better with storage tests than did those with the accelerated oxidizability equipment. Banks' (*J. Soc. Chem. Ind. 63,* 8) new procedure for evaluating antioxidants made use of the Barcroft-Warburg apparatus and a substrate of linoleic acid in 2% starch solution. Hematin was used to increase the susceptibility of the linoleic acid to oxidation.

In most comparisons of antioxidants, the investigators used either a storage test or an accelerated method of oxidation. Lea's (*J. Soc. Chem. Ind. 63,* 107) data on antioxidants for butter from storage tests at 100° and at 37° proved that pyrogallol, quinol, 1,5-dihydroxynaphthalene, pyrogallol-acetone condensation product, gallic acid and its esters, pyrocatechol and hematoxylin were most powerful, and proline, protocatechuic acid, tannic acid, guaiacum resin, tocopherol concentrates, 6-hydroxy-2,2,5,7,8-pentamethylchroman and several other substances were weaker. Similar tests at 94° with ethyl esters of unsaturated fat acids were made by Diemair and coworkers (*Fette u. Seifen 50,* 349) who investigated only biological material as antioxidants. Vitamin D and lecithin were strong antioxidants; xanthophyll had a weak effect; vitamin E, cholesterol and alanine were in effective; while vitamin B_1, phytosterol, chlorophyll, choline and β-carotene were proöxidants. The comparison of antioxidants by Higgins and Black (*Oil & Soap 21,* 277) was increased in significance by including tests on the stability of goods baked with the protected fat. Gum guaiac and nordihydroguaiaretic acid were effective antioxidants for lard and the stability carried into the baked products. However, the latter sometimes imparted a disagreeable metallic flavor to lard on standing. Propyl gallate, tocopherols and wheat germ oil extracts had protective influences of various degrees, but this protection was not imparted to baked goods. Mattil, Filer and Longenecker's (*Ibid.* 160) comparison of 21 antioxidants for edible fats indicated that gallic acid was the most effective single compound of those investigated although nordihydroguaiaretic acid, ascorbic acid and its fat acid esters each about doubled the keeping time of fats. The protective effect of nordihydroguaiaretic acid was improved with either citric or phosphoric acid. The same authors (*Ibid.* 289) recorded that gallic and ascorbic acids, when used as antioxidants for cottonseed oil, disappeared gradually during the induction period. Mattil and Filer (*Ind. Eng. Chem., Anal. Ed. 16,* 427) also devised a spectrographic and a colorimetric method for the determination of gallic acid in fats. Riemenschneider *et al.* (*Oil & Soap 21,* 307) reported on the effect of deodorization on stabilized lard. Nordihydroguaiaretic acid was more effective as an antioxidant than tocopherol and it was not affected by deodorizing the lard prior to addition. The stabilizing effect of tocopherols with synergists on lard was improved by a prior deodorization of the lard. Lovern (*J. Soc. Chem. Ind. 63,* 13) and Williams *et al.* (*Oil & Soap 21,* 161) evaluated the relative protective capacities of the common antioxidants specifically for preserving carotene in oil solutions. Lea (*J. Soc. Chem. Ind. 63,* 55) found ethyl gallate, 1,5-dihydroxynaphthalene and guaiacum resin most useful in retarding the development of "off" flavors in dried pork. Work by Williamson (*Food Res. 9,* 298) demonstrated that antioxidants which normally protect fat alone will also protect the fat in dried milk.

Many of the communications on antioxidants described the capacity of individual natural materials for this purpose. Lunberg, Halvorson and Burr (*Oil & Soap 21,* 33) described the properties of nordihydroguaiaretic acid. It was very effective in fats and finished baked products, and the effectiveness was improved with added ascorbic acid. Riemenschneider, Turer and Ault (*Ibid.* 98) evaluated the amount of improvement obtained in lard by the additions of 1-10% of various vegetable oils. The separation of antioxidant fractions from hydrogenated cottonseed oil by molecular distillation was described by Singleton and Bailey (*Ibid.* 157). The mixture of tocopherols in the most potent fractions was more effective than α-tocopherol but less effective than γ-tocopherol. The same investigators with Oliver (*Ibid.* 188) did similar work on peanut oil. In both investigations evidence indicated the presence of substances capable of inhibiting the action of tocopherols. Thompson and Steenbock (*Arch. Biochem. 4,* 15) found that β-carotene would promote oxidation in some fats and that α-tocopherol counteracted this proöxidant effect. According to Swift, Mann and Fisher (*Oil & Soap 21,* 317) during oxidation the decomposition of γ-tocopherol in a fat resulted in the formation of a red compound, chroman-5,6-quinone. It possessed relatively little antioxidant activity. Hanson *et al.* (*J. Biol. Chem. 156,* 673) confirmed some of their earlier work by demonstrating that the keeping qualities of animal body fats could be improved by addition of tocopherols to the diet, but that ascorbic acid, lecithin, hydroquinone, α-naphthol, etc. did not increase the stability of the body fats. The antioxidant work of Hove and Hove (*Ibid.* 601, 611, 623) included a method of determining α-tocopherol in mixtures, an approximate determination of total tocopherol and data on the effect of temperature on the activity of the tocopherols. The approximate determination was based on the protection of carotene against preformed fat peroxides. At low temperatures the tocopherols were about equally active; at high temperatures the γ-form was several times more active than the α-form. In the same communications gossypol was reported to be equal to the tocopherols at 35°. In a later paper Hove (*Ibid.* 633) demonstrated that pure gossypol, anilinogossypol and cottonseed oil meal were good preservatives for the carotene fed with lard to experimental rats. The products were slightly inferior to α-tocopherol but were equal to wheat germ. Tracy *et al.* (*J. Dairy Sci. 27,* 311) recommended preserving dairy products with 0.2% wheat germ oil, based on the weight of fat. At higher levels the flavor of the oil was sometimes detectable. Täufel and coworkers (*Biochem. Z. 315,* 381; *Fette u. Seifen 50,* 434) described the methods that could be used to concentrate the antioxidant from oatmeal. They believed the action of this material to be due to a peroxidase

reaction. Olcott (*Science 100,* 226) reported good antioxidant properties for cottonseed phospholipids. According to Bailey and Feuge (*Oil & Soap 21,* 286) phospholipids and phosphoric acid were effective stabilizers for fats whether added before or after deodorization.

A mechanism for the enhancing or synergistic effect of ascorbic acid with quinone was proposed by Calkins and Mattill (*J. Am. Chem. Soc. 66,* 239). They believed the effect was due to the catalytic action of quinone and offered substantial data in support of their theory. Quinone seemed to act by being reduced to a semiquinone which was reoxidized to quinone by the active fat peroxides. The lowering of the active oxygen level protected the substrate. Quinone seemed to serve as an intermediary agent in the ascorbic acid fat system by lowering the free energy of formation of the activated complex such that it doubled the number of particles of ascorbic acid possessing sufficient energy of reaction. Riemenschneider *et al.* (*Oil & Soap 21,* 47) pointed out means of obtaining optimum effects from ascorbic acid antioxidants by combining them with other materials which yielded a synergistic effect. In the application of these to refined oils, all traces of soaps or alkalies should be removed. An analytical method for ascorbic acid derivatives in fats by Turer and Speck (*Ind. Eng. Chem., Anal. Ed. 16,* 464) depended on titration with a 2,6-dichlorophenol-indophenol reagent.

Some investigators recorded the antioxidant efficiency of certain pure organic compounds. These were sulphydryl compounds (György *et al.—Science 98,* 518), N,N-dimethylaminoazobenzene or butter yellow (György *et al.—J. Biol. Chem. 154,* 317), maleic acid (Glimm and Nowack—*Fette u. Seifen 50,* 217) and maleic and fumaric acids (Kaufmann and Wolf—*Ibid.* 218).

Some of the recently patented methods for preserving fats made use of the following antioxidants: hematoxylin (Banks and Lovern — *Brit. 552,809*), reaction products of fat acids and betaine (Shappirio—*U. S. 2,352,229*), tannin compounds (Verbeck —*U. S. 2,354,719*), oil deodorization sludge (Jakobsen —*U. S. 2,363,672*; Hickman—*U. S. 2,349,274*), extracts of non-pathogenic bacteria (Shappirio—*U. S. 2,338,207*), hydrogenated refined soybean or sesame oils (Phelps and Black—*U. S. 2,357,543*), special extracts from corn or oats (Musher—*U. S. 2,355,097-8*), special extracts from molasses (Musher—*U. S. 2,342,-162*), acetyl methyl carbinol (Simons and Buxton— *U. S. 2,331,432*), tomato pulp (Buxton—*U. S. 2,347,-462*) and special extracts from seed meals and oils (Buxton and coworkers—*U. S. 2,345,571, 2,345,576-80; Brit. 550,983*). Phosphoric acid incorporation in wrapping paper was a suitable means of inhibiting the rancidity of oils later absorbed (Mitchell—*U. S. 2,344,470*). The reaction product of phosphorus chloride with an organic ester of lactic acid (Prutton *et al.*—*U. S. 2,365,291*) and the aldehydic oxidation product of the tertiary butyl ether of *o*-tertiary butyl *p*-cresol (Smith and Wilson—*U. S. 2,358,833*) were 2 antioxidants patented for use in technical oils.

Two investigations dealt with production and handling to preserve stability. Twisselmann (*Fette u. Seifen 50,* 38) reported that fresh undamaged raw beef tallow contained antioxidants which under mild and careful rendering procedures, yielded stabilized premier jus. The work of Krukovsky *et al.* (*J. Dairy Sci. 27,* 249) led to several recommendations for storing milk fat. It could be stored for several months even at 60° without loss of vitamin A or carotene provided the fat was degassified, then placed in lightproof containers filled to the top and tightly sealed. Rapid cooling also aided in retarding deterioration.

The interchange of oils for food uses is limited by the tendency of some deodorized oils to revert to their characteristic flavor. Soybean and linseed oils are examples which exhibit this fault. Recent investigations by Lemon (*Can. J. Res. 22F,* 191) on partially hydrogenated linseed oil led him to suggest that the unpleasant flavor was due to isomeric linoleic acid. He believed that complete hydrogenation would eliminate the reversion. Armstrong and McFarlane (*Oil & Soap 21,* 322) also attributed the cause to a derivative of linoleic acid that was formed during hydrogenation. But they believed this derivative decomposed to form volatile products directly responsible for the reverted flavor and odor. They suggested oxidation before hydrogenation, special selective hydrogenation procedures, deodorization steps and use of antioxidants as possible means of improving shortening made from linseed oil, but reversion could not be entirely eliminated thereby. A method of predicting the flavor stability of soybean oil by Sanders (*Ibid.* 357) depended on the residual color after standard bleaching and it was only successful on about 66% of the samples. Two methods for stabilizing oils against reversion were patented. One group of patents claimed success by treating the oils with active free halogen elements (J. R. Short Milling Co. —*U. S. 2,349,377-8*; *Brit. 549,703, 549,731*). For the same purpose Royce (*U. S. 2,349,381*) heated the oils to 240-300° out of contact with air and in the presence of zinc, magnesium or tin.

Deterioration in fats as effected by biochemical influences interested only a small number of investigators. Süllmann (*Helv. Chim. Acta 26,* 1114; *27,* 789) listed the various inhibitors for oxygen uptake by unsaturated acids in presence of soybean lipoxidase in the following order of decreasing effectiveness: pyrocatechol, hydroguinone, α- and β-naphthol, *p*-aminophenol, adrenaline and tocopherols. Phloroglucinol and ascorbic acid were weaker in hindering deterioration and with some fat acids they accelerated the process. He also discussed the mechanism of enzymic oxidation. Mundt and Fabian (*J. Bact. 48,* 1) in tests on 32 cultures of soil bacteria discovered that 25 of them increased and 6 decreased the oxygen uptake of corn oil. A review on the effect of fermentation organisms on the storage of fat was prepared by Niethammer (*Fette u. Seifen 50,* 309).

In a comparison of the relative usefulness of palm and hydrogenated cottonseed oil in tin plating baths, stability of oil was the principal criterion (Bauer and Gastinel—*Oil & Soap 21,* 36). In the presence of zinc and ferric salts hydrogenated cottonseed oil was more stable than palm oil. The metallic contaminants which had a marked effect on the rate of increase in viscosity in palm oil had no effect in cottonseed oil.

Fat losses occurring during doughnut drying were studied by Arenson and Heyl (*Oil & Soap 21,* 60). About 0.09% volatilized material based on total fats was recovered by absorption. The total volatile material and polymers formed were 0.27%.

Reviews on spoilage of fats giving general information on causes, prevention, etc. were written by

Hilditch (*Chem. & Industry 63,* 67), Bryant (*Food in Can. 3,* No. 10, 11; No. 11, 11; No. 12, 10; *4,* No. 1, 7), Bergel (*Chem. & Industry 63,* 127), Riemenschneider and Ault (*Food Industries 16,* 892, 936), Boehm and Williams (*Pharm. J. 151,* 163) and Nergaard and Jakobsen (*Tids. Hermetikind. 29,* 54).

Physiology and Biochemistry

For this portion of the field of lipids, Smedley-MacLean provided a much needed compilation of the most significant results of investigations in the metabolism of fats. This book, published by Methuen & Co., is a welcome contribution because there is very little organized material relating to this specialized subject. A very brief review was prepared by Bloor (*Nutr. Rev. 2,* 289). Two reviews, one on fat metabolism (Barnes and MacKay—*Ann. Rev. Biochem. 13,* 211) and one on fat-soluble vitamins (Russell—*Ibid.* 411) treated the work of the previous year. Longenecker (*J. Am. Dietetic Assoc. 20,* 83) dealt with the dietary aspects of the subject.

Investigations comparing the nutritive values of butter, butter substitutes and other fats have continued with the contribution of interesting new data. Deuel and coworkers (*J. Nutr. 27,* 107, 335, 339, 509) fed rats mineralized skim milk, vitamin supplement and fat to compare the nutritive values of butter, corn oil, cottonseed, olive and peanut oils and margarine. No differences in the effects of the fats were detected from the standpoints of growth, tibia length, efficiency of conversion of the various fats to body tissue, composition of the carcass, fertility of males or females and lactation. The experiments apparently refuted the idea that butter fat contained certain saturated fat acids not present in other fats, and which are essential for growth. However, the rats preferred the diets containing butter and this was associated with flavor because the rats ate fats to which butter flavor was added in preference to unflavored fats. In similar work, Boutwell *et al.* (*Proc. Soc. Exptl. Biol. Med. 55,* 153) recorded that with *ad libitum* feeding and with lactose as the sole carbohydrate, the growth and appearance of rats fed butter fat were superior to those of animals fed corn oil. In like tests with glucose as the sole carbohydrate there were no differences in growth rate or appearance. Westerlund (*Lantbruks-Högskolons Ann. 10,* 74) found that calcium metabolism was unaltered whether the fat in the diet was butter or margarine. The analytical results of Hilditch and Meara (*Biochem. J. 38,* 29) revealed that human milk fat more nearly resembled a typical margarine blend than butter fat. Human milk fat differed, in general, from butter fat by the absence of butyric acid or of acids below decanoic, and by a higher content of unsaturated C_{18}, C_{20} and C_{22} acids.

The nutritive value of several other fats was investigated. Fachini (*Olii minerali olii e grassi, colori e vernici 22,* No. 3, 13; No. 4/5, 21), in a report on nutritive value of seed oils, favored olive oil, stating that he believed it was most easily digested and absorbed. Some work purported to show that there was no difference in the metabolism of synthetic fats versus natural fats. Flössner (*Ernährung 8,* 89) confirmed earlier observations in which synthetic fat as prepared in Germany by hydrogenation of carbon monoxide and esterifying with glycerol had no ill effects on human subjects. According to Kraut *et al.* (*Biochem. Z. 316,* 96) the synthetic fats containing odd carbon chain acids were as susceptible to lipase as those of the even carbon acids having one more or less carbon. Dihydroxy fat acid glycerides, when replacing hydrogenated fats in control diets, already presumed to be adequate, exerted a favorable effect upon the growth and development of rats (Harris *et al.*—*Arch. Biochem 5,* 63). Trihydroxy acid glyceride had little influence on growth. Dienoic fat acids of 19 and 20 carbon atoms and 9,11-octadecadienoic acid could not replace linolenic acid according to Karrer and Koenig (*Helv. Chim. Acta 26,* 619); since the 19 carbon acid was ineffective, they believed that the rat was unable to convert the acid to linolenic by β-oxidation.

A communication under the title "Fried Food for Children" (Richardson—*J. Pediatrics 24,* 199) contained a review of the literature and of the opinions of leading nutritionists and pediatricians who were consulted regarding the suitability of fried foods for children. In general, the belief held by all was that frying was harmful, yet no scientific support was found for this prejudice. In opposition the scientific literature contained one article which demonstrated that fried potatoes were more easily digested than boiled potatoes.

A miscellaneous group of investigations on fat nutrition yielded data which were of interest both in practice and in theory. Fraps (*Texas Agr. Exper. Sta. Bull. No. 632*) showed that in actual experiments on rats and chickens fatty oils had an energy value 1.8 times that of carbohydrate instead of the usually accepted figure of 2.25. Dogs could utilize only 12-13 g. of olive oil per kg. of body weight (Strack and Friedrich—*Ber. Verhandl. sacks Akad. Wiss. Leipzig Math. phys. Klasse 93,* 115). Therefore, investigators should know the maximum capacity for fat utilization of the animals used in fat tests. Basal diets for fat digestibility studies were standardized by Barnes, Primrose and Burr (*J. Nutr. 27,* 179) after they found that protein intake affected the digestibility of fat. The previous diet of the animals may also influence the test; rats utilize depot or stored fat much easier after a high fat diet than after carbohydrates (Roberts *et al.*—*Am. J. Physiol.140,* 639). Forbes and Swift's study (*Science 99,* 476; *J. Nutr. 27,* 453) on the dynamic effect of foods showed relationships of interest in the choice of food. For a desired decrease in food intake for hot weather, they recommended diminishing first carbohydrates, second the protein and last the fat of the diet. Shorland *et al.* (*Empire J. Exptl. Agr. 12,* 103) provided new experimental information on altering the iodine value of pig fat by different feeding conditions. White *et al.* (*Proc. Soc. Exptl. Biol. Med. 54, 301*) reported that mice were suitable laboratory animals for essential fat acid deficiency studies. Alimentary administration of quinine was found to decrease fat absorption (Roy and Sen—*Ann. Biochem. Exptl. Med. 3,* 9).

Individual steps in the processes of fat metabolism were investigated. The partition hypothesis of fat absorption according to which part is hydrolyzed and which part is absorbed as the glyceride was well supported by Frazer's work (*J. Physiol. 103,* 306, 329). A milky lacteal accompanied the absorption of neutral fat but not that of fat acids. The glycerides gave a systematic lipemia with little change in portal

blood, whereas fat acids caused portal lipemia with little change in the systemic blood. Neutral fat could be traced to fat depots and with moderate doses there was no marked deposition in the liver; the reverse occurred with fat acids. When the rats were fed neutral fat with added lipase the effect was the same as that associated with ingestion of fat acids. The fact that complete inhibition of lipolysis by sodium cetyl sulfate did not prevent triglyceride absorption suggested that lipolysis was not an essential step in fat absorption. Lipolysis was said to determine the fate of the absorbed fat and secondly to provide fat acids for soap and phospholipid formation. Favarger (*Arch. intern. pharmacodynamie 68,* 409) added support to a theory that fats were partly absorbed as cholesterol esters by demonstrating that such esterification could take place in the intestine. The theories of β-oxidation, multiple alternate oxidation and β-oxidation-condensation were tested by Weinhouse, Medes and Floyd (*J. Biol. Chem. 153,* 689; *155,* 143). The results of *in vitro* oxidation of stearic acid with liver slices agreed with those predicted by the β-oxidation-condensation theory; labeled carbon atoms which originally were principally in the carboxyl group appeared equally distributed between the carbonyl and the carboxyl carbon atoms of the acetoacetic acid formed. Only 20-25% of the stearic acid which disappeared was accounted for either by ketone body formation or by complete oxidation to carbon dioxide. Analytical data by Machlan (*Ibid. 152,* 391) on the blood lipids of fasted rats supported the view that there was no preferential or selective utilization of fats during fasting.

Labeled elements were also conveniently used in other metabolism studies. Using deuterium, Morehouse (*J. Biol. Chem. 155,* 33) found that ingested tributyrin was deposited in the tissue of rats but it disappeared completely after 36 hours. The tributyrin could be wholly accounted for by analyses, thus suggesting that it was not converted to long-chain fat acids. Bernhard and Bullet (*Helv. Chim. Acta 26,* 1185), who also made use of deuterium, showed that regeneration of deposited fat acids occurred in about 9 days on a carbohydrate rich diet. Radiophospholipids were used by Reinhardt *et al.* (*J. Biol. Chem. 152,* 79) to demonstrate that the phospholipids appearing in the blood stream were rapidly transferred to the thoracic duct lymph.

A formation of carbohydrate from fat in dogs was demonstrated by Edwards (*Science 100,* 268). The course of conversion was said to be from acetoacetic acid to citric acid and then to glucose.

New investigations have been attempted in an effort to elaborate the mechanism involving the adrenals in fat metabolism. According to Ingle (*J. Clin. Endocrinol. 3,* 603), adrenal cortical insufficiency diminished the rate of fat absorption and under conditions which cause fatty liver the amount of fat so deposited was less. In similar work Samuels and Conant (*J. Biol. Chem. 152,* 173) revealed that adrenalectomy decreased the rate of transport of fat from body stores to the liver of fasting rats.

Study of the factors involved in the accumulation of excess fat in the liver helped to elucidate a step in fat metabolism. The literature on this subject was thoroughly reviewed by McHenry and Patterson (*Physiol. Revs. 24,* 128). The sources of extra liver fat in various types of fatty livers were listed by Stetten and Salcedo (*J. Biol. Chem. 156,* 27) as follows: choline deficiency resulted in impaired transportation of fat acids from liver to depots; feeding of cystine increased the rate of fat acid synthesis in the livers and the injection of anterior pituitary substance resulted in excessive mobilization of depot fat and migration to the liver. Beveridge (*Science 99,* 539) recorded that lipotropic factors were affected differently in presence of so-called "essential fat acid." For example, corn oil increased the action of choline and obliterated that of inositol. The same investigator with coworkers (*J. Biol. Chem. 154,* 9) pointed out that the nature and level of protein and amino acid intake caused variations in the rate of fat accumulation in the liver. The results were said to indicate the reason for discrepancies in some recent experiments on lipotropic substances. Supplementing this type of work, Treadwell *et al.* (*Ibid. 156,* 237) determined the lipotropic action of different amounts of methionine. According to Roberts and Eckstein (*Ibid. 154,* 367) inorganic sulfides and such organic sulfides as dimethyl sulfide, dimethyl disulfide, S-methylisothiourea and methylxanthogenate could be used intraperitoneally to exert a lipotropic effect on rats fed a diet which produced fatty livers. Fishman and Artom (*Ibid. 109,* 117) also tested several materials and combinations of substances for reducing fatty livers. Ethanolamine, *dl*-methionine, *dl*-serine and glycine could not duplicate the action of choline although ethanolamine alone and in combination with methionine had a slight effect. Their data on the action of choline, vitamins, amino acids and combinations of these were developed in an attempt to elucidate the role of these compounds in the formation of liver phospholipids. Forbes (*Endocrinology 35,* 126) recorded that thyroxine exerted a lipotropic effect, but this effect was evident only in the presence of choline. According to two South American writers (Topelberg and Honorato—*Rev. Soc. Argentina biol. 19,* 409) caffeine prevented an increase in liver fat. Entenman *et al.* (*Am. J. Physiol 141,* 221) believed that the Dragstedt lipocaic preparation from pancreas was a poor anti-fatty liver factor in tests on depancreatized dogs maintained with insulin. The investigations of Boxer and Stetten (*J. Biol. Chem. 153,* 617) yielded the relative turnover rate of liver phosphatides normally and under conditions favoring fatty liver formation. In the first case the daily replacement of choline in the liver phosphatides was 3.9 mg. per rat; when no choline was fed the daily replacement decreased to 1.3 mg. Patterson and coworkers (*Ibid.* 489; *156,* 265) studied choline deficiency from the standpoint of prevention of hemorrhagic kidneys in rats. Choline deficiency caused a diminished concentration of phospholipids in the liver and kidneys and they believed that the damage to the latter organs was the consequence of an inadequate supply of phospholipids.

Among the studies on fat metabolism were investigations on leanness and obesity. New theories on these pathological conditions proposed by Shapiro (*Med. Woman's J. 51,* No. 2, 23; No. 7, 17) were linked with dysfunction of the liver. In obesity and leanness of the "essential" type, impairment of the fat-metabolizing functions of the liver was believed to be the primary cause; the "glandular" type was said to arise indirectly through the unbalanced effect of the diseased endocrine gland on the liver. She diag-

nosed the types of obesity and leanness by the extent and direction of the shift in the iodine value of blood and plasma fat with different ingested fats. Feinblatt (*Am. J. Digestive Dis. 11,* 260) found no differences in the efficiency of fat digestion in thin and obese individuals. A more prominent rise in blood cholesterol occurred in the obese individual after fat digestion, suggesting that cholesterol was used in an intermediate stage of fat metabolism and was not a waste product of the process. In investigations on congenitally obese mice, Salcedo and Stetten (*J. Biol. Chem. 151,* 413) attributed the condition to retarded catabolism of the depot fat acids.

The study of the relation of diet constituents to work and to fat storage showed some progress. Earlier investigators reported greater weight loss on high-fat as compared to high-carbohydrate reducing diets of equal calorific values. However, Anderson (*Quart. J. Med. 13,* 27) attributed the difference to a higher salt content of the latter leading to retention of water and salt. When the salt contents were made equal the weight losses were the same on both diets. In work on poultry by Fraps (*Poultry Sci. 22,* 421) the substitution of cottonseed oil for corn meal in a standard ration produced chicks with a higher fat content but a lower live weight. The effect of a high fat diet on the composition of the body and skin of rats was an increase in fat and a decrease in moisture and protein (Wynor and Haldi—*Am. J. Physiol. 142,* 508). In similar research on rats Hajdu (*Arch. ges. Physiol, Pflugers 245,* 556) introduced work as another factor. Inhibition of growth and loss in weight as a result of excessive work was greatest on a diet which consisted calorically of 64% fat and 36% protein. Maximum growth and weight were attained on a diet containing 69% carbohydrate, 8% fat and 23% protein. In general, work capacity was least on the highest fat diets.

Several investigators delved into the essential nature of fat in the diet of animals. Lucas *et al.* (*Cornell U. Agr. Exper. Sta. Memoir 251*) obtained an increase in milk and butter fat production with dairy rations containing 5.9% fat in the grain mixture as compared to a ration with 2.5% fat. In like tests with grain mixtures containing 4.89 and 2.69% fat, Monroe and Krauss (*Ohio Agr. Exper. Sta. Bull. No. 644; Ohio Agr. Exper. Sta. Bimo. Bull. 29,* 15) were unable to detect significant differences. These latter results were also substantiated by Fountaine and Bolin (*J. Dairy Sci. 27,* 155). Reduction of the fat content of poultry mash and scratch feed so that the whole ration furnished only 1.56% fat was not deleterious to the performance of laying and breeding flocks of chickens (Taylor *et al.—Poultry Sci. 23,* 155). With rats, Loosli *et al.* (*J. Nutr. 28,* 81) found that on a fat free diet corn oil could supply the fat constituents necessary in the diet for lactation; hydrogenated coconut oil or ethyl linoleate did not improve the lactation response. Hansen *et al.* (*Fed. Proc. 3,* 94) described the course of improvements in dogs on addition of various amounts of lard to fat free diets. The above author with a coworker (*Proc. Soc. Exptl. Biol. Med. 56,* 244) also reported that dogs on low-fat diets were able to synthesize sufficient fat to maintain a normal lipid level in both cells and plasma but were unable to synthesize the highly unsaturated acids necessary to maintain the degree of unsaturation normally present in both these portions.

The fat content of the diet was also investigated from the standpoint of its effect on vitamins. According to Ellis and Madsen (*J. Nutr. 27,* 253), when thiamine was fed to pigs depleted of their stores of it, the response in appetite, growth and general health was usually greatest in pigs fed a high fat diet followed in order by animals on intermediate and low fat. Reinhold *et al.* (*Ibid. 28,* 51) however, maintained that there was no evidence of the so-called "thiamine-sparing action" by fats. They believed the amount of carbohydrate in the diet was the important factor in determining the daily requirements for thiamine. The decrease in fat content of rats on thiamine-deficient diet was interpreted by Boxer and Stetten (*J. Biol. Chem. 153,* 607) to be caused chiefly by lower food intake. Like results had previously been interpreted to indicate that thiamine was involved in the synthesis of fat acids from carbohydrates. Mannering *et al.* (*J. Nutr. 28,* 141) recorded that riboflavin deficient rats survived for shorter periods of time when fed a high fat ration than when maintained on a high carbohydrate diet. Dam (*Ibid. 27,* 193) reported that high fat diets intensified some of the pathological conditions that develop in chicks on vitamin deficient diets. Fitzhugh *et al.* (*Proc. Soc. Exptl. Biol. Med. 56,* 129) attributed similar results to rancidity in the fats.

Several publications on fat soluble vitamins were of interest to fat and oil chemists. The role of these vitamins in nutrition was reviewed by Buckstein (*Am. J. Digestive Dis. 11,* 147, 292, 326). Analytical data on the potency of certain fish liver fats were published (Rapson *et al.—J. Soc. Chem. Ind. 63,* 18, 21; Springer and French—*Ind. Eng. Chem. 36,* 190; Morton—*Prog. Repts. Pacific Coast Sta., Canada No. 61,* 6). Poe and Fehlman (*Food Res. 9,* 500) tabulated the vitamin A content of samples of palm oils from many geographical sources. Munin (*Fette u. Seifen 50,* 288) described feeding practices for increasing the vitamin A content of winter butter. Analytical activities included a colorimetric method for determining vitamin D (Petersen and Harvey—*Ind. Eng. Chem., Anal. Ed. 16,* 495), a spectroscopic method for vitamin A (Zscheile and Henry—*Ibid.* 437), a comparison of spectrophotometry with filter photometry in determination of vitamin A in butter (Zscheile *et al.—Ibid.* 83), a procedure for vitamin A in margarine (Neal and Luckmann—*Ibid.* 358), a method of separating the alcohol and ester forms of vitamin A chromatographically (Reed *et al—Ibid.* 509) and 2 procedures for tocopherols using the iron-dipyridine reagent (Kaunitz and Beaver (*J. Biol. Chem. 156,* 653, 661; Rawlings—*Oil & Soap 21,* 257). Scharf and Slanetz (*Proc. Soc. Exptl. Biol. Med. 57,* 159) reported that an unknown factor in soybean lecithin improved the utilization of fat-soluble vitamins. Jensen *et al.* (*Ibid. 54,* 294) identified this factor as tocopherols.

Some adverse effects of dietary fats were recorded. High-fat diets produced fatty degeneration of heart muscle in rabbits (Govan—*J. Path. Bact. 35,* 351). Hog liver fat acids were toxic to chicks fed a vitamin E deficient diet (Dam—*J. Nutr. 28,* 297). Under pathological conditions where tumors were present, high fat diets accelerated their growth (Lavik and Bauman—*Cancer Res. 3,* 749; Opie—*J. Exptl. Med. 80,* 219; Rusch—*Physiol, Revs. 24,* 177). Highly heated lard was said to produce multiple mesenteric

Oil or Fat Source	% Oil or Fat	Specific Gravity	Refr. Index	Acid No. or (% free fat acids)	Sapon. No.	Iodine No.	(SCN) No.	Acetyl No. or (OH No.)	R-M No.	Polenske No.	% Unsapon.	Melting Point	Solidification Point	Hexabromide No.
Alfalfa seed[1] *Medicago sativa*				(1.4)	187.5	161.4								
Alliaria officinalis seed[2]		$0.9133^{20/4}$	1.4675^{20}		167	99					0.39		2.6	
Anda-assu seed[3] *Joahanesia princeps*	22			0.30		142								
Apple seed[4]	19-23	0.923^{20}	1.486^{20}	(1.3)	197	122		9			0.89			
Babassu[5]				(2.85)	251.5	16.1						24		
Balanites roxburghi kernels[6]	43		1.4623^{40}	0.58	195.2	88.3		31.75			2.92			
Beechnuts[7]	45.6	0.9202^{15}	58.5 (Butyro)	10.1	187.4	110.9	77.7		0.33	0.3	0.55			
Bombax malabaricum seed[8]	26	0.9362^{25}	1.4611^{40}	(32.58)	196.3	68.11					1.76	34	30	
Cephalocroton cordofanus seed[9]	42	$0.963^{15.5}$	1.4700^{40}	1.75	184.5	91.4	89				0.88		−4	
Corn cockle seed[10] *Agrostemma githago*	7.18			2.1-3.5	184-192	131-139					1.74-3.55			
Euphorbia calycina seed[12]	20.8		1.4759^{40}		189	192.3	121.0							50.3
Euphorbia erythraeae seed[12]	33.0		1.4735^{40}		190	179.2	105.7							35.7
Fanweed seed[13] *Thlaspi arvense*	33-35	$0.9168^{15/15}$	1.4652^{45}	0.8	177.8	117.3		8.3	0.25	0.0	1.34			
Favela tree seed[14]	30	0.9161^{25}	1.4729^{25}	1.6	195.1	108.6		12.3			0.96			
Fish[16] Herring of Iceland					183	140.0					1.3			
Fish[17] Snoek liver	1.3-19.4					119-176					2.25-14.05			
Snoek viscera	3.2-15.1					158-185					4.07-32.3			
Fish[18] Stonebass liver	8.5-25					98-187					5.1-38.5			
Stonebass viscera	1.8-9.1										6.76-16.63			
Grape (wine type) seed[19]	12-22				188-194	122-131					0.3-1.21			
Linden tree seed[21] *Tilia sylvestris*				(0.85)	165	116								
Tilia argentia				(1.20)	164	117								
Locusts[22]			1.684^{37}	150.4	216.3	75.3	35.3	7.3						
Malabar-tallow seed[23] *Vateria indica*	20	$0.8989^{40.3}$	1.4578^{40}	2.88	191.1	36.72					0.59			
Martynia diandra fruit[24]	20	0.9528^{23}	1.4720^{23}	15.4	195.3	75.6		10.8	3.88	0.78	0.86			
Mbokaya or coco of Paraguay fruit[25] *Acrocomia totai*	12-20				204.8-213.4	5.3-84.4					1.14			
Mexican-poppy seed[26] *Argemone mexicana*	38	$0.9247^{15.5/15.5}$	1.4742^{20}	10.3	192.1	119.1					1.6			
Milk Camel[27]	3.4-4.4		1.4588^{40}		217				1.1			43.5-44.7	34-35	
Moringa concanensis seed[32]			1.4624^{40}	2.61	189.3	79.25		23.1	0.57	0.26	1.1			
Mould grown on soybean lecithin[1]					220	54.2								
Nettle leaf[1]					207	103	91.3							
Niam seed kernel[33] *Lophira alata*	40			(9.7)	192	73.4					1.4			
Niger seed[1] *Guizotia abyssinica*				(0.5)	191.5	138.7					0.9			
Ocimum kilimandscharicum seed[12]	16.2		1.4767^{40}		193	195.6	122.5							54.0
Orange seed[34]		0.9203^{20}	1.4666^{25}	1.25	191.2	103.5	61.27	5.8	0.52	0.45	0.45			1.67
Orange (Valencia) seed[35]		0.9153^{25}	1.4686^{25}		197.5	101.7					0.95			
Oyster nuts or koeme seed kernel[1] *Telfairia pedata*	58			(0.4)	205	82.6					0.4			
Physic nut kernel[20] *Jatropha curcas*	46.3	0.9849^{20}	1.4669^{30}	26.27	196.1	90.84					0.2			
Physic nut kernel[36] *Jatropha curcas*	53	0.918^{15}	1.4689^{20}	6.8	190	99								
Prinsepia utilis seed[38]		0.9215^{20}	1.4625^{20}	23.1	200.2	109.8		12.3			0.5			
Rye germ[39]	10.7	0.9324^{15}	1.4793^{20}	8.7-9.4	171.8	139.5-142.2		51.54	0.29	0.13				
Rye germ[40]		0.8841-$0.9301^{20/4}$	1.4736-1.4787^{20}	5.5-82.0	175.0-192.2	126.3-140.3	50.5-81.2	(10.2-32.2)			2.0-4.6			
Seal blubber[41]				(1.5)	190	135.8					0.7			
Soybean[42]				0.14-16.39		99.6-147.6					0.59-2.68			
Star-anise seed kernel[44]	55	0.9128^{25}	1.4677^{25}	11.65	194.5	88.36		8.37	0.75	0.29	0.59			

Sterculia parviflora fruit coat[1]	35				200	74.4					0.6				
Sterculia tomentosa seed[13]	33.0		1.4637[40]		193	84.8	66.3								
Sunflower (Argentina) seed[45]		0.9243[15]	1.4686[40]	0.6	191	131.6	75.5	(2.0)			0.56				
Tobacco-seed[46] *Nicotiana tobacum*	28	0.9405[36.3]	1.460[37]	0.7	191.2	112.2					2.0				
Trichilia emetica seed[12]	59.5		1.4599[40]		199	49.2	42.1								
White top seed[49] *Lepidium draba*	9.2-10.8	0.9129[15]	1.4750[25]	2.05	180.9	136.1			1.22	0.39	2.4				

FAT ACID COMPOSITION

Oil or Fat Source	Common Saturated Acids			Common Unsaturated Acids			Other Fat Acids
	Myristic	Palmitic	Stearic	Oleic	Linoleic	Linolenic	
Alfalfa seed[1] *Medicago sativa*		9.5	4.7	11.2	43.1	31.5	
Alliaria officinalis seed[2]		0.4		5.0	8.1	9.0	C_{22} (−2H) 77.4
Babassu[5]	15.4	8.5	2.7	16.1	1.4		C_6 0.2, C_8 4.8, C_{10} 6.6, C_{12} 44.1, C_{20} 0.2
Cephalocroton-cordofanus seed[9]*		2		56	6		Ricinoleic 31
Coffee[11]*							
Raw		38.81		27.52	22.62		
Roasted		35.10		26.94	23.81		
Grounds		39.35		24.96	23.85		
Fanweed seed[13] *Thlaspi arvense*	trace	1.5		12.5	33.0	0.5	C_{22} (−2H) 49.0, C_{24} 3.5
Fish[15] Dog (*Squalus catulus*) liver	3.2	15.7	2.0	25.4	14.1		C_{20} (−2H) 2.3, C_{14} (−2H) 1.7, C_{15} (−2H) 12.6, C_{18} (−8H) 0.8, C_{20} (−4H) 2.3, C_{20} (−6H) 2.2, C_{20} (−8H) 2.7, C_{20} (−10H) 1.2, C_{22} (−10H) 10.9, C_{22} (−12H) 2.9
Ruffe (*Perca cernua*)	5.2	11.3		13.6	19.4	7.9	C_{20} (−2H) 1.0, C_{14} (−2H) 2.6, C_{15} (−2H) 16.4, C_{20} (−4H) 5.4, C_{20} (−6H) 2.9, C_{20} (−8H) 5.0, C_{22} (−8H) 6.2, C_{22} (−10H) 2.8
Fish[16] Herring of Iceland	7.0	11.7	0.8		19.6 (−3.5H)		C_{20} 0.1, C_{14} (−2H) 1.2, C_{16} (−2.4H) 11.8, C_{20} (−5.2H) 25.9, C_{22} (−4.3H) 21.6, C_{24} (−3.8H) 0.1
Malabar-tallow seed[23] *Vateria indica*	0.7	13	43.1	42.5	0.1		C_{20} 0.4
Martynia diandra fruit[24]		10.5	8.5	74.5	6.2		
Milk							
Cow colostrum[28]	9.5	31.7	11.8	28.5	2.5	0.4	C_4 2.6, C_6 1.6, C_8 0.5, C_{10} 1.6, C_{12} 3.2, C_{20} 0.6, C_{10} (−2H) 0.1, C_{12} (−2H) 0.2, C_{14} (−2H) 0.7, C_{16} (−2H) 2.7, C_{20} (−4H) 1.1, C_{20} (−8H) 0.7
Human (mature)[29]	8.5	23.2	6.9	36.5	7.8	0.4	C_4 0.4, C_6 0.1, C_8 0.3, C_{10} 2.2, C_{12} 5.5, C_{20} 1.1, C_{10} (−2H) 0.1, C_{12} (−2H) 0.1, C_{14} (−2H) 0.6, C_{16} (−2H) 3.0, C_{20} (−4H) 0.9, C_{20} (−8H) 2.4
Human (1st and 2nd day)[29]	2.8	24.6	9.9	36	7.5	0.3	C_4 0.2, C_6 0.1, C_8 0.8, C_{10} 3.5, C_{12} 0.9, C_{20} 4.9, C_{10} (−2H) 0.2, C_{12} (−2H) 0.1, C_{14} (−2H) 0.1, C_{16} (−2H) 1.8, C_{20} (−4H) 4.6, C_{20} (−8H) 1.8
Human (early lactation)[30]	8.1	22.5	8.3	36.4	7.9		C_{10} 2.7, C_{12} 5.1, C_{20} 1.0, C_{10} (−2H) tr., C_{12} (−2H) 0.1, C_{14} (−2H) 1.3, C_{16} (−2H) 3.1, $C_{20\text{-}22}$ (unsatd.) 3.5
Human (late lactation)[30]	13.9	24.1	9.6	30.2	5.5	5.4	C_{10} 0.5, C_{12} 7.0, C_{10} (−2H) tr., C_{12} (−2H) 0.1, C_{14} (−2H) 0.9, C_{16} (−2H) 2.8, $C_{20\text{-}22}$ (unsatd.) 5.4
Sows[31]**	1.8	28.3	6.1	35.0	14.0		Volatile fat acids 2.4, C_{16} (−2H) 8.8, $C_{20\text{-}22}$ 3.6
Mould grown on soybean lecithin[1]	3.5	40.5	7.9	19.0	20.1		C_{20} 1.1, C_{16} (−2H) 7.9
Niam seed kernel[33] *Lophira alata*	1.9	27.1		14.5	33.3		C_{22} 14.2, C_{24} 2.3, C_{14} (-2H) 0.3, C_{16} (−2H) 1.2, C_{22} (-2H) 5.0, C_{24} (−2H) 0.2
Niger seed[1] *Guizotia abyssinica*	1.7	5.0	2.1	38.9	51.6		C_{20} 0.2
Orange (Valencia) seed[35]		20.7	4.7	36.6	36.5	0.6	C_{20} 0.9
Oyster nuts or koeme seed[1] *Telfairia pedata*	0.6	32.5	14.2	13.8	35.5	3.4	
Physic nut[20] *Jatropha curcas*	1.37	15.61	9.69	40.90	32.08		C_{20} 0.35
Pig back fat[37]	2.3	27.7	10.6		52.3 (−2.1H)		C_{10} tr., C_{12} 0.3, C_{12} (−2H) tr., C_{14} (−2H) 0.2, C_{16} (−2H) 5.2, C_{20} (−3H) 1.4
Prinsepia utilis[38]	1.8	15.2	4.5	32.6	43.6		C_{24} 0.9
Seal blubber[41]	5.1	10.7	1.3		39.6 (−2.4H)		C_{12} 0.1, C_{20} 0.5, C_{22} 0.1, C_{14} (−2H) 1.8, C_{16} (−2.1H) 10.5, C_{20} (−5.6H) 17.6, C_{22} (−0.3H) 10.6, C_{24} (−10H) 2.1
Soybean lecithin[43]		15.77	6.30	12.98	62.92	2.02	
Star-anise seed kernel[44]	4.43		7.93	63.24	24.4		
Sterculia parviflora fruit coat[1]	2.3	27.6	9.0	37.6	22.2		C_{20} 1.3
Tobacco-seed[46] *Nicotiana tobacum*	1.8	7.8	5.6	30.2	54.6		
Tumbling mustard seed[47] *Sysimbrium altissimum*		14.1		5.2	19.0	34.9	C_{10} (−2H) 1.0, C_{22} (−2H) 25.3
Vateria indica seed[48]	0.7	13	45.1	42.5	0.1		C_{20} 0.4, low mol. wt. acids 0.2

* Data based on total oil.
** Data in mol. %.

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sarcomas in rats (Peacock and Beck—*Brit. J. Exptl. Path. 24,* 143). Davis (*Am. J. Physiol. 142,* 213) produced anemia in dogs by feeding a large amount of fat and choline. The fat was said to furnish hemolytic agents, *i.e.,* soap and fat acids, which increased red blood cell destruction. However, Johnson *et al.* (*J. Am. Med. Assoc. 124,* 1250) found that a high fat diet in normal animals did not cause sufficiently great increase in daily erythrocyte destruction to produce anemia.

Characteristics and Composition

The descriptive information on fats and oils has been recorded for many purposes; some of it has, therefore, been given in other parts of the review. For example, references giving certain characteristics of a new oil to show its suitability in place of one commonly used appears in the first section; and where a reference also deals with nutritional phases it is found in the section on biochemistry and physiology. The principal new information on composition and characteristics has been appended to this section in tabular form. In addition, several analytical reports were available to the writer only by reference. These surveyed Albanian olive oils (Lorenzola and Greco—*Chim. ind. agr. biol. 18,* 45), variety differences in sunflower oils (Dublyanskaya — *Sci. Res. Inst. Oil Culture U.S.S.R. of 1939, 1940,* 379; Dieterle—*Seifensieder-Ztg. 69,* 316), glycerides of safflower oil (Lagawankar *et al.*—*J. Univ. Bombay 12A,* Pt. 3, 71), castor bean oil from seed grown in Oklahoma (Webster *et al.*—*Proc. Oklahoma Acad. Sci. 23,* 69), variety differences in rape oils (Andre and Kogane-Charles—*Compt. rend. 214,* 636) and second and third grade Ceylon copra (Child and Nathanael—*Trop. Agr. Ceylon 99,* 203).

Analysts have furnished some data for scientists in other fields. Rewald's (*Oil & Soap 21,* 50, 93) analyses showed that petals and stamens of tulips, poppies, dandelions, daffodils and roses contain 0.523 to 2.97% phosphatides; data on oil content were included. Phospholipid and fat contents of dried grass were also recorded. The information may be important to the biologist who studies the composition and function of the fats in plants and it may be important from the standpoint of its role in the nutrition of grazing livestock. The analyses of various grasses and hay by Brouwer and van Albada (*Rec. trav. chim. 62,* 380) were correlated with the character of butter from cows fed the materials. The oil contents of grasses and hay, respectively, were 3.5-6.9 and 2.2-2.8%, and their iodine values were 180-190 and 120-145. The iodine values of butters from cows fed fresh grass or clover were higher than those of hay-fed cattle. The monthly variations of the oil content of the head, body and viscera of the horse mackerel were recorded by Kallir *et al.* (*J. Soc. Chem. Ind. 63,* 57), as suitable material for inclusion in the documentation of the physiology of this fish. The variations in the properties of oils with changes in the physiological condition of fish and the fatty deposit were also evident in the analytical data on 6 varieties of fish by Aenlle (*Inst. espan. oceanograf., Notas y resumenes Ser. II, No. 115*). Stansbury *et al.* (*Oil & Soap 21,* 239) analyzed peanut kernels for oil, and the oil for free fat acids and iodine value in relation to U. S. standards for the different varieties of farmers' stock peanuts. From comparative work on sour and normal rapeseed by Anderson and Aitken (*Can. Grain Res. Lab. Winnipeg Ann. Rept. 17,* 53) the condition of the sample had no effect on oil content or iodine value, but the free fat acids were definitely higher in the sour samples. Rusoff and French (*Fla. Acad. Sci. Proc. 5,* 133) tabulated the specific gravity, refractive index, cold test, free acids, unsaponifiable matter, saponification value and iodine value of the liver oils of sand, lemon and dusky sharks in connection with the work on standardizing the oils from sharks caught in Florida waters.

From the standpoint of characterization, linseed oil received the most individual attention. Painter and coworkers (*Arch. Biochem. 5,* 337; *J. Am. Soc. Agron. 36,* 204; *N. D. Exper. Sta. Tech. Bull. No. 323; N. D. Agr. Exper. Sta. Bimonthly Bull. 5,* No. 6, 36) traced fat acid formation and oil deposition in flaxseed during several growing seasons. In 1942, the iodine value

increased rapidly from 135, 8 days after flowering, to a maximum of 198, 27 days after flowering. In 1941, the iodine value increased during early stages of growth, then dropped sharply long before all the oil accumulated in the seed. The percentage of oleic acid in the oils dropped sharply in the early part of the growing period, then leveled off to a nearly constant value. Linoleic acid remained nearly constant until the 14th day of growth, then decreased, until the 24th day. Saturated acids decreased throughout the period of oil formation. These results suggested that some of the unsaturated acids were formed by desaturation. Sallans and Sinclair (*Can. J. Res. 22F,* 132) correlated the iodine value with the fat acid composition of Canadian linseed oils from several seed varieties. Variety differences existed for all properties with the exception of saponifiable matter. Extensive analytical results were the basis for equations developed for predicting linolenic, linoleic and oleic acid content from the thiocyanogen and iodine values. The effects of artificial climatic conditions on the growth and oil production on the Punjab linseed variety were recorded by Tiver and Williams (*Australian J. Exptl. Biol. Med. Sci. 21,* 201).

Several analytical reports on fats described the discovery of new or unusual fat acids in certain oils. De la Mare and Shorland (*Analyst 69,* 337) recorded evidence indicating that pig back fat contained traces of highly unsaturated $C_{20\text{-}22}$ acids. Wikoff *et al.* (*J. Biol. Chem. 153,* 227) isolated caprylic and lauric acids from peanut oil for the first time. Several unusual fat acids were found in the lipids of tubercle bacilli (Anderson and coworkers—*Ibid. 154,* 497, 569, 581, 587; *156,* 443, 453). The structure *d-* and *l*-10-methylstearic acid was proposed for previously discovered tuberculostearic acid. The fatty material of the bacilli contained no glycerol but consisted of fat acid esters of the disaccharide trehalose. A separation of the acids yielded fractions corresponding to C_{24}, C_{25}, C_{26} and C_{27} acids. The properties of the acid having the formula $C_{26}H_{52}O_2$ agreed with those of the previously named "phthioic acid." The same group of investigators (*Ibid. 152,* 523, 533) isolated a liquid fat acid having a probable empirical composition of $C_{20}H_{40}O_2$ from *Phytomonas tumefaciens* fat, and named it phytomonic acid. The low melting point of this acid and the absence of unsaturation indicated a branched-chain structure.

Constituents of fats other than the glycerides have been investigated. Fat-soluble vitamin activity has been mentioned in the previous section of this review. The unsaponifiable content of sleeper shark, ratfish, monkfish and marbled sculpin liver oils was determined by Morton (*Prog. Repts. Pacific Biol. Sta., Canada, No. 58,* 13). The cholesterol content of the unsaponifiable varied from 0.6 to 80.9%. These unsaponifiables were adsorbed on alumina and the proportions eluted with the following successive solvents were recorded: light petroleum, benzene, ethyl ether and methyl alcohol. Work on coffee oil unsaponifiable by Paula (*Anais assoc. quim. Brasil 2,* 57) showed the presence of sitosterol, another sterol melting at 128-30°, tocopherols, carotenoids, calciferol, hydrocarbons, resins and a residue which had an estrogenic action on castrated guinea pigs. Like records were prepared by Ruiz (*Anales real acad. farm. 3,* 201) for the unsaponifiable fraction from ergot, peanut oil, grapeseed oil and herring oil. In a similar careful analysis of cacao husk fat unsaponifiable, Ruppol (*J. pharm. Belg. 2,* 26) recorded the presence of 2 petroleum ether insoluble materials, $C_{44}H_{84}NO_6$ and $C_{50}H_{84}N_3O_2$, sitosterol, stigmasterol, ergosterol, sterol C of Lobert, ceryl alcohol, nonacosane and a terpene. Boatner *et al.* (*Ind. Eng. Chem., Anal. Ed. 16,* 566; *Oil & Soap 21,* 10) developed a spectrometric procedure for determining gossypol in cottonseed products. The oxidation of gossypol was found to produce a red pigment. The name "gossypurpurine" was given to a blue pigment also found in cottonseed products.

Work on methods of fat analysis aimed at improving rapidity, adjusting the procedures for specific materials or comparing the accuracy of common methods. A procedure for vegetable material in which a preliminary drying was not required comprised extraction with acetone, evaporation and reëxtracting the residue with petroleum ether (Nielsen and Bohart —*Ind. Eng. Chem., Anal. Ed. 16,* 701). A quick extraction method for fish products which also aimed at recovering all the vitamin A with the oil comprised pepsin or alkali digestion followed by ether extraction (Rapson *et al.*—*J. Soc. Chem. Ind. 62,* 221). In similar procedures described for milk, caustic was the digestion agent in one (Boyer *et al.*—*Ind. Eng. Chem., Anal. Ed. 16,* 101) and a mixture of calcium chloride and caustic was used in the other (Heuser and Krapohl—*Z. Untersuch. Lebensm. 82,* 145). A method designed for cocoa and chocolate products eliminated oven drying before extraction by mixing the samples with an equal amount of anhydrous sodium sulfate (Achermann—*Mitt. Lebensm. Hyg. 32,* 12). Grossfeld and Schroeder (*Z. Untersuch. Lebensm. 85,* 225) improved the efficiency of analytical fat extraction from foods by first extracting with a 1:1 alcohol:benzene mixture, evaporating and extracting the moistened residue with petroleum ether. Popp (*Deut. Lebensm.-Rundschau 1942,* 129) recommended using trichloroethylene as the extraction solvent where acid hydrolysis was required before extraction. Katsin (*Zavodskaya Lab. 10,* 217) designed a funnel for fat analysis which permitted the removal of an upper solvent layer without disturbing the lower layer. Analytical data by Krober and Collins (*Oil & Soap 21,* 1) demonstrated that atmospheric humidity had a significant influence on the amount of lipids that could be extracted from soybeans. Moisture levels of 4.73 to 8.65 had practically no effect on amount of material extracted. At humidities of 75-80% soybean meals of relatively high moisture content could be extracted. Paleni (*Ann. chim. applicata 33,* 23) fostered the use of the refractometer for fat analyses and for determining the composition of binary mixtures of fat acids.

The dairy literature contained many reports on fat analysis of dairy products. Several communications were on butyrometric methods. Schulz and Senf (*Deut. Molkerei- u. Fettwirt. 1,* 71) cautioned that the sulfuric acid used must be as free of nitric acid as possible. Weighing instead of measuring the sample and solution temperature of 70-5° were precautions listed by Reidel and Kotterer (*Ibid.* 100) for using this method on cream samples. Swick-Siebenlist (*Deut. Molkerei-Ztg. 64,* 160) developed details for using the method on cheese; and Schloemer (*Ibid. 63,* 420) and Roeder (*Molkerei Ztg. 56,* 536), respectively, modified the test bottle and the ratio of

reagents used to adapt the method for analyses of butter samples. Mohr *et al.* (*Deut. Molkerei-Ztg. 63,* 742, 755, 771, 784; *64,* 8), in investigating dairy processes for determining manufacturing methods yielding the least losses, found butyrometric analyses too inaccurate for the purpose. The Röse-Gottlieb method was preferred for control of the whole milk, skim milk, buttermilk and butter. Herroid and Whitman (*J. Dairy Sci. 27,* 147) reported that the Mojonnier method for determining fat in milk and cream gave an accuracy of 0.02 to 0.3% milk fat in 86 and 94%, respectively, when calculated as the mean of duplicate samples. According to Babel and Nelson (*Natl. Butter & Cheese J. 35,* No. 9, 18), the Mojonnier method was inaccurate on blue cheese samples for this product contains free acids which were converted to unextractable ammonium soaps by the procedure. A rapid simple control procedure for high fat dairy products such as cream and butter comprised evaporation of the moisture and simple extraction with petroleum ether (Mohr *et al.—Deut. Molkerei-Ztg. 63,* 546, 602). When phosphatide determinations are required in dairy products, extraction of the fats and phosphatides should be according to the Röse-Gottlieb method (Mulder—*Versl. Landb. Onderzoek. C No. 48,* 709). However, Grossfeld and Zeisset (*Z. Untersuch. Lebensm. 85,* 321) found that ethyl or isopropyl alcohol and benzene mixtures best extracted the phospholipids.

Many improvements have been made in physical methods of investigating fats and oils and many data have been recorded. A method for determining the air in fats comprised melting it in ethylene glycol under a funnel with a graduated stem (Mohr and Eysank—*Fette u. Seifen 50,* 143). An immersion turbidimeter for testing oils depended on evaluating transparency with a photoelectric cell (Katzman—*U. S. 2,324,304*). Mehlenbacher *et al.* (*Ind. Eng. Chem., Anal Ed. 16,* 145) described the relationship between the individual color standards of the American Oil Chemists' Society. A method of identifying virgin olive oils or detecting refining by Ciusa (*Chimica e industria 24,* 233) depended on the intensity of the blue fluorescence in filtered ultra-violet light.

Many physical chemical data on fats and fat acids were determined to serve as the basis for analysis or fractionation. Vapor pressure data on the common fat acid methyl esters as prepared by Althouse and Triebold (*Ind. Eng. Chem., Anal. Ed. 16,* 605) indicated the suitable pressures and boiling temperatures required in fractionation to prevent decomposition. Mattil and Longenecker (*Oil & Soap 21,* 16) showed how the refractometer could be used on fat acid ester fractions to indicate the composition of the fractions. For a similar purpose and to determine purity of acids, Grondal and Rogers (*Ibid.* 303) prepared melting point curves of binary fat acid mixtures of the C_6 to C_{12} fat acids. In investigations on arylated fat acids Kimura (*J. Soc. Chem. Ind. Japan 44B,* 101) found greater differences existing in the boiling points of the individual esters than in the nonarylated fats and therefore recommended that analyses by vacuum distillation be performed on tolylated or xylylated samples of oil. Cowan, Falkenburg and Teeter (*Ind. Eng. Chem., Anal. Ed. 16,* 90) designed a still and a method for laboratory fractionation of polymeric fat acid methyl esters. The relative amounts of monomer, dimer and higher polymers were calculated from a plot of the index of refraction with the percent distilled.

Solubility data can serve as a basis for devising methods of fractionating fats or fat derivatives. Foreman and Brown (*Oil & Soap 21,* 183) recorded the solubilities of many common fat acids in acetone, methanol and "Skelly Solve B" at various temperatures to as low as —70°. These data suggested that saturated and unsaturated acids could be more readily separated by crystallization from the various solvents than by the usual lead-soap-alcohol or ether methods. According to Brode *et al.* (*Ind. Eng. Chem., Anal. Ed. 16,* 77) another advantage of this type of procedure was that the products were free from conjugation. This was demonstrated by absorption spectrum analyses. Henderson and Jack (*Oil & Soap 21,* 90) fractionated milk fat by crystallization from "Skelly Solve A" at various temperatures between —7 and —53° to yield less complex portions for detailed study of composition. Millican and Brown (*J. Biol. Chem. 154,* 437) used distillation of the methyl esters followed by crystallization from organic solvents to isolate the octadecenoic acids from several animal and vegetable oils. The acid isolated from chicken fat or from peanut, cottonseed, corn or linseed oils appeared identical with the oleic acid of olive oil. The octadecanoic acids of lard, tallow, beef adrenal phosphatides, pork liver lipids, human fat and to a lesser extent of some vegetable oils were mixtures of oleic acid and its isomers, the former being the principal component. Solubility data useful for analysis and processing were also recorded by Ralston and coworkers (*J. Org. Chem. 9,* 259, 267, 329). The fat derivatives investigated were C_7 to C_{14} saturated acids, various fat acid tertiary amines and fat alcohols; and the solvents used included chlorinated hydrocarbons, simple esters, lower alcohols and nitroethane.

Adsorption methods for fractionating fat acids are complicated because constituents are about the same in color; and color, therefore, cannot be used to indicate a possible separation that may be taking place. A partial solution was presented by Dutton (*J. Phys. Chem. 48,* 179) who employed a highly sensitive refractometer for measuring changes of percolates from adsorption columns. This led to the development of a method of separating stearic and oleic acid by adsorption technic.

Spectral absorption technic was also useful in determining composition of fat acid mixtures. Halden and Schauenstein (*Fette u. Seifen 50,* 78) studied the presence of linoleic acid and its relation to the phosphatide content of rye products by means of spectrographic absorption. The linoleic content of germ was 4 times that of grain; the lowest amounts were found in bread. The spectral absorption values of several unsaturated fat acids were determined by Barnes *et al.* (*Ind. Eng. Chem., Anal. Ed. 16,* 385) and Beadle and Kraybill (*J. Am. Chem. Soc. 66,* 1232). The data were intended as bases for analytical work on fats. Van den Hende and Fonteyne's (*Natuurw. Tijdschr. 25,* 24) results from measurements of the Raman spectra of C_3 to C_{18} saturated fat acids indicated that the unsaturated fat acids higher than C_{11} could not be distinguished by this means.

The x-ray was applied to fat investigations by Filer, Sidhu, Daubert and Longenecker (*J. Am. Chem. Soc. 66,* 1333) who determined the interplanar

spacings and relative intensities of diffraction lines for 1- and 2-monoglycerides of several fat acids. An empirical equation was derived to express the long-spacing values in terms of the number of effective carbon atoms. The authors believed that the data could be applied in identification of simple mixtures. The properties of synthetic 1-monoglycerides and simple linoleic and linolenic glycerides and methods for their preparation were developed by Daubert and Baldwin (*Ibid.* 997).

Some investigators drew attention to interesting analytical relationships discovered in the application of viscosity measurements on oils. Ravich (*Acta Physiochim. U.S.S.R. 17,* 55) reported that the viscosities of C_{18} fat acids were a linear function of the iodine value, the coefficient decreasing with increasing iodine value; he also proposed equations for the correlation of viscosity at different temperatures and described anomalies in the viscosity of natural, hydrogenated and polymerized fats. Wakeham and Magne (*Ind. Eng. Chem. 36,* 568; *Oil & Soap 21,* 347) also pointed out the parallel relationships between viscosity, density and other physical and chemical properties; and suggested that many physical properties of an oil could be inferred from the same properties of other oils of similar characteristics. The kinematic viscosity values of methyl esters of linoleic acid dimer as illustrated by Young and Biertuempfel (*J. Am. Chem. Soc. 66,* 843) were in a straight line relationship with temperatures when plotted on the viscosity-temperature chart of the American Society of Testing Materials. Cowan and Wheeler (*Ibid.* 84) prepared the superpolyesters from linoleic acid dimer with ethylene, decamethylene and hydrogenated dilinoleyl glycols and plotted their viscosity-molecular weight relationship. There appeared to be a straight line relationship between the log of the viscosity and the square root of the molecular weight up to 10,000. The charts should be of interest for the study of reactions occurring during the manufacture of these products and should aid in the control of processing.

Most interesting among the year's analytical work on fats was the development of some new thermal data. Gudheim's (*Oil & Soap 21,* 129) information on specific and latent heats of fusion was specifically developed as an aid for the design of heating, cooling and other processing equipment. The average specific heats of several vegetable oils were 0.53 and the latent heat of fusion averaged 45 to 52 calories. The data on cottonseed oil covered the temperatures between 21 and 100°. The specific heat of completely hardened fats was 0.28. The relation between heat content and iodine value was correlated and the data were also used to approximate the solid phase present in oils. Bailey and coworkers (*Ibid.* 293, 297, 300) did similar work in a more intensive and detailed manner. The calorimeter which they designed was suitable for measurements from —193 to 67°. Their data on hydrogenated and unhydrogenated cottonseed oil showed heat capacities of 0.278-0.344 and 0.475-0.513, respectively, for the solid and liquid oil. The respective latent heats of fusion, 20 and 27.4, were slightly less than half those of the preceding reference. The data served to approximate the liquid-solid composition. These in turn were correlated with consistency as measured by a micropenetration test that was designed in the same laboratory (*Ibid.* 78). The consistency tester, however, was intended for use in standardizing the evaluation of consistency and for use in the control of blending and hydrogenation of oils.

Bailey and Kraemer (*Oil & Soap 21,* 251, 254) also applied dilatometric technic to fats in conjunction with the above calorimetric work for investigating the solid-liquid phases. The volume change of completely saturated fats amounted to 11%. Temperature-expansion curves indicated the transition points of constituents by sharp breaks in a series of straight lines. Since each break corresponded to the disappearance of a distinct class of glycerides or complexes, they suggested developing the application of dilatometry for the analysis of fats.

A new apparatus and method proposed for determining the melting point of a fat by Gorchoff (*Proc. Sci. Sect. Toilet Goods Assoc. 1943-44,* No. 1, 18) were based on the temperature at which a disk of fat fused on a glass tray would slide off. Barnicoat (*Analyst 69,* 176) suggested the ball and ring procedure as used in bitumen product laboratories. Malo (*Rev. alimentar Rio de Janeiro 8,* No. 2, 7; No. 3, 7), after investigating 12 common methods, recommended the capillary tube procedure because of its simplicity and precision. Büchi and Oesch (*Hundert Jahre Schweiz. Apoth.-Ver. 1843-1943,* 333) discussed melting and solidification of fats from the standpoint of factors that influence results. He used cacao butter as an example and obtained melting points varying from 23.3 to 33.5 depending on the conditions of a previous solidifying operation, such as time of cooling and whether the sample was stirred during the process. Daubert and Clarke (*J. Am. Chem. Soc. 66,* 690) prepared cooling and warming curves of mono-oleyl-disaturated glycerides in work on determining transition-point data for the polymorphic forms. Ravich and Volnova (*Acta Physico-chim. U.S.S.R. 17,* 323) compared the behavior of palmitic-stearic acid and tristearin-tripalmitin system by means of data on melting point, hardness, micro-structure and viscosity. The transition and solubility behaviors were discussed from information derived from the data..

Many new improvement have been suggested for chemical characteristic analyses of fats. An indicator comprising a mixture of cresol red and thymol blue improved the titration for free fat acids (Kleinzeller and Trim—*Analyst 69,* 241). Ethylbis-2,4-dinitrophenylacetate, another indicator, was especially recommended for the titration carried out in the saponification equivalent determination (Fehnel and Amstutz—*Ind. Eng. Chem., Anal. Ed. 16,* 53). Another improvement in saponification value determination in the presence of large amounts of moisture comprised adding petroleum ether to the saponifying medium (Kiczales—*Soap 19,* No. 3, 57). One analyst designed apparatus and method for the semimicro-determination of saponification value (Trenite—*Verfkroniek 16,* 97). Norris and Buswell (*Ind. Eng. Chem., Anal. Ed. 16,* 417) recorded that a sample of Wijs iodine value solution in dark bottles could be stored for 505 days without change. According to MacLachlan (*J. Biol. Chem. 152,* 97) reliable iodine numbers could be obtained on phospholipids when chloroform:ether, 1:1, or moist ether were employed as the solvent. The use of pyridine sulfate dibromide in conjunction with mercuric acetate catalyst as a bromine addition reagent was suggested for the iodine value determination of tall oil (Rowe—*Ind. Eng.*

Chem., Anal. Ed. 16, 371). Painter (*Oil & Soap 21,* 343) and Scholfield and Bull (*Ibid.* 87) correlated relationships between the iodine value and the amount of individual fat acid present in linseed and soybean oils, respectively. A new characteristic for drying oils called the "oxidation iodine value" was an iodometric measurement of the oxidizing capacity of a sample after a standard oxidation with sodium dichromate catalyzed with trichloroacetic acid (Chen and Hu—*J. Chinese Chem. Soc. 10,* 173, 180).

Several notes on determination of adulteration were published. Sen-Gupta (*J. Indian Chem. Soc. Ind. & News Ed. 6,* 153) claimed that the Kirschner value could successfully detect as low as 10% adulteration of buffalo butterfat. Determination of horse meat in admixtures of pork and beef, based on detecting linoleic acid through a hexabromide method was not quantitative but in some cases constituted sufficient evidence that horse fat or meat was present (Crowell—*J. Assoc. Off. Agr. Chem. 27,* 448). Bömer and Hagemann (*Fette u. Seifen 50,* 1) suggested the substitution of zinc acetate for lead acetate in testing for hardened fats by the Twitchell method. Mingo and Romero (*Ion 3,* 329) determined the Bellier index of many common oils, oils from newly proposed sources and binary mixtures of these to serve as a basis for detecting adulteration. Heretofore, tung oil was usually adulterated with edible or semidrying oils. Since the present war, the situation in China has been reversed. A method of identification of tung oil adulteration of food fats depended on the amount of resins formed under controlled treatment with nitric acid (Suen and Wang—*Ind. Eng. Chem., Anal. Ed. 16,* 511). A method for detection of adulteration of the olive oil used in packing Maine sardines depended on differences between the Hanus iodine value and the refractive index at 25° (Voth—*J. Assoc. Off. Agr. Chem. 27,* 455).

New analytical information was published in the progress reports of committees within the American Oil Chemists' Society. The Uniform Methods and Cooperative Work Committee (*Oil & Soap 21,* 310) reviewed the work in progress. The Color Committee (*Ibid.* 360) evaluated the Lovibond color system and discussed visual observations in relation to Lovibond color. The Refining Committee (*Ibid.* 123) recommended that the official refining test for expeller oils be tentatively used on hydraulic oil and that the tentative test now used on extracted soybean oil be adopted as an official method. The Bleaching Methods Committee (*Ibid.* 196) added slight modifications for reporting color. The Analysis Committee (*Ibid.* 143; *Chem. Eng. News 22,* 606) suggested an increase in the amount of reagent used in the thiocyanogen value determination; they discussed the limitations of the Halphen test for cottonseed oil and developed collaborative data on the Swift Stability Test. The American Oil Chemists' Society method for analysis of soybeans for oil content was published with slight amplifications (*Oil & Soap 21,* 306).

Detergents

No spectacular developments occurred in ordinary soap manufacture. The writers and inventors revealed only minor improvements of processes already in operation or adjusted the procedures to make use of the raw materials on hand. Linder (*Fette u. Seifen 50,* 82) stimulated a little interest in old and almost forgotten methods of converting soap stock of highly unsaturated acids, C_{18} to C_{22}, to simple unsaturated C_{14} to C_{18} fat acids. These were known as the Varrentrapp and the Stiepel processes; they comprised respectively, high temperature caustic treatment and vigorous autoclaving. Information on using linseed and castor oils in the manufacture of potash soap by Kranich (*Soap 20,* No. 3, 27) contained notes on blending and perfuming for eliminating undesirable odors. A patented distillation process for converting low grade fatty material to good soap stock revealed a choice of temperatures and pressures used in collecting the improved fractions (Murphy—*U. S. 2,361,411*). Soap stock refining procedures were issued for the German soap makers as an aid in reducing fat losses (Singer—*Seifensieder-Ztg. 70,* 3, 20). Clayton (*U. S. 2,327,502*) refined soap stock containing excess alkali from alkali refining of oils by adding oil to react with the excess lye and heating the mixture to break down the odoriferous substances present.

Several improvements were made in the use of tall oil and rosin for soap stock. Solodkii (*Bumazhnaya Prom. 19,* No. 2, 18) started from the sulfated soap by-product of pulp manufacture, isolated the phytosterol with turpentine and treated the remaining sulfated soap with sulfuric acid to free the tall oil. A second process made use of alcohol to remove phytosterols. The latter method produced a less odorous tall oil soap stock but yielded smaller amounts of the phytosterol by-product. Woods and Johnston (*Soap 20,* No. 10, 37) encouraged the use of tall oil in soap manufacture because it accelerated saponification of the other fats and oils in the soap kettle. Objectionable odors and the tendency to crystallize were eliminated from hydrogenated rosin soaps by heating to about 375° until about 25% of the weight volatilized (Schantz—*U. S. 2,327,132*). A rosin soap in which ammonia was the saponifying agent was prepared specifically for use in paper manufacture (Arledter—*Ger. 729,115 Cl. 23e*). A composition containing 2 parts tallow soap, one resinate and one alkali soap builder mixture was made for use in salt water (Van Zile and Borglin—*Oil & Soap 21,* 164).

The literature revealed that adjustments were necessary in soap making procedures when synthetic fat acids were used. To improve salting out of these soaps, Kinzl (*Seifensieder-Ztg. 70,* 69) saponified with the half heat method and added 1% salt at the start. For the same purpose Widaly (*Ibid.* 35) tripled the amount of salt used ordinarily and used a double salting out process. Jenkins and Wilson (*U. S. 2,361,547*) improved synthetic fat acid soaps by treatment with mineral acids to release the weaker fat acids. A patented method of obtaining improved soaps from the synthetic raw materials comprised steam distillation to remove part of the unsaponifiable material by volatilization and removing the remaining unsaponifiable by commonly known methods (Märkische Seifen-Industrie—*Ger. 734,273 Cl. 23d*). Fractions of synthetic fat acids having 6 to 10 carbon atoms were selected especially for shaving soap manufacture (Neu—*Ger. 715,798 Cl. 23e*). A comparison of soaps from natural and synthetic raw materials in washing agents revealed no perceptible differences in efficiency or effect on the textiles (Opitz—*Deut. Textilwirt. 8,* No. 14, 12).

In the information on soap builders and fillers one review was of particular interest because it listed and described about 30 materials used for this purpose (Widaly—*Seifensieder-Ztg. 70,* 102). A mixing procedure for flaky washing soap comprised using soap with 11% moisture and adding a mixture of alkali persalt and disodium phosphate containing approximately 9% moisture. Stiepel (*Ger. 715,439 Cl. 23e*) used a soap manufacturing process to yield excess alkali soap and then added suitable phosphate builders to neutralize the excess alkali. Other patented soap fillers and builders were water soluble polymers of acrylates and methacrylates (Trommsdorff—*Ger. 729,200 Cl. 23e*), compounds of the polyglycol-polyglycerol series (I. G. Farbenind. A.-G.—*Ger. 737,308 Cl. 8i*), water soluble hydroxyalkyl cellulose (Kalle & Co. A.-G.—*Ger. 718,339 Cl. 8i*), unsaponifiable components obtained as by-products of paraffin oxidation (Mannes and Seiffert—*Ger. 735,-569 Cl. 22g*) and finely ground roasted coffee beans (Brown—*U. S. 2,353,686*). Several patents described manufacturing procedures and selection of ingredients for making mixtures containing alkali phosphate with other inorganic soap builders (Kepfer—*U. S. 2,326,949*; Treffler—*U. S. 2,351,559*; Hatch—*U. S. 2,365,190*; Rhodes—*U. S. 2,365,215*). The aim in these was the production of flaky or free flowing products for use alone as detergents or for addition to soap.

Several patented soap ingredients were for special purposes. A mixture of inorganic peroxygen compounds and succinic acid anhydride gave the soap bleaching properties (Reichert, McNeight and Elston —*U. S. 2,362,401*). Sodium salt of α-chloropolyacrylic acid (Dittmar—*U. S. 2,327,302*), tripolyphosphates (Bornemann and Huber—*U. S. 2,342,786*) and water soluble alkali lignin (Schubert and Pierer—*U. S. 2,-352,021*) were ingredients patented for the purpose of inhibiting formation of lime soap during use of the soap in hard water. Special dihydroxytetrachlorodiphenyl compounds improved the germicidal properties of soap (Burton T. Bush, Inc.—*U. S. 2, 353,724, 2,353,735*). Another medicinal soap contained special polysulfides (Antropoff—*Ger. 689,373 Cl. 23e*). Mercaptopyrimidine compounds were patented as soap antioxidants (Ter Horst—*Can. 421,523*).

The literature on the mechanical phase of soap manufacture dealt principally with improvements of the continuous systems. Improvements in the system of the Sharples Corp. (*U. S. 2,348,855; Brit. 549,386-7*) comprised a cooling unit placed before the final centrifuging and other details which speeded up the soap making process. Colgate-Palmolive-Peet Co. (*U. S. 2,325,320, 2,328,892, 2,345,465*) designed electrical equipment to control proportioning the amount of alkali for saponification, developed a spray drying accessory and adapted the continous process for saponifying with sodium carbonate. A heating medium for transferring heat to conduits in a continuous system contained 40 sodium nitrite, 7 sodium nitrate and 53% potassium nitrate (Ward—*U. S. 2,362,734*). Clayton (*U. S. 2,343,829*) extruded plastic soap from the system at temperatures and pressures such that moisture was evaporated and the soap became porous. Kirschenbauer (*Oil & Soap 21,* 237) replaced gravity settling with centrifugal separation in a laboratory soap boiling test to increase the speed of the test.

A new soap manufacturing process intended for efficient recovery of glycerol was the subject of a patented improvement (Bradshaw and Meuly—*U. S. 2,360,844*). It was called a dry soap process and comprised ester interchange of the glycerol of the fat with alcohol; after the separation of glycerol the ethyl esters were used for soap making. During the latter process the alcohol was recovered for re-use in the system.

Some innovations in saponification were sufficiently novel for patent protection. Clayton and Edwards (*Brit. 553,679*) used special mixtures of fat acids and a mixture of lye and soda ash such that the final textile soap would have a pH of 7-9. A bar soap in which at least 50% of the fat acids were combined as potassium soaps was said to have the property of dispersing insoluble alkaline earth soaps (Houlton—*U. S. 2,358,976*). A nearly neutral liquid soap comprised a mixture of alkali soaps and triethanolamine salts of fat acids (Gollasch—*Ger. 731,241 Cl. 23c*).

Several patents dealt with finished soap products. For dedusting powdered products Maxwell and Atwood (*U. S. 2,351,351*) designed mechanical means; Soderberg (*U. S. 2,345,776*) added 0.10-20.0% of pine oil, kerosene, light mineral oil or other unsaponifiable material; and Lever Bros. & Unilever Ltd. (*Brit. 553,735*) used polyhydric alcohols, aliphatic phosphates, sulfonated oils or other hygroscopic material. New soap molds were invented by Burt (*U. S. 2,359,-403*) and Craig and Harber (*U. S. 2,354,000*). Warren (*U. S. 2,364,575*) designed a form and package for 100-lb. soap cakes; the cake was scored and package grooved in a manner to simplify cutting. A divisible soap bar was scored to allow easy splitting into 2 small bars (Egan—*U. S. 2,339,773*). Mabley (*U. S. 2,356,168*) mixed soap with methyl cellulose to produce a product in the form of a leaf or film.

Recent physical studies of phenomena which occur during soap cooling have been used as bases for improving soaps (Ferguson — *Oil & Soap 21,* 6). X-ray diffraction work has now established the occurrence of 4 forms of solid soap, which depended on fat, moisture and electrolytic composition. Rapid chilling induced an ω-phase while slow cooling increased the amount of β-soap. A conversion from β- to ω-phase reduced the lather power of the soap. The formation of a δ-phase was favored by rapid cooling, by extrusion at high moistures and by high molecular weight. The application of x-ray to the study of soap systems was presented in more detail by the above worker with Nordsieck (*Ind. Eng. Chem. 36,* 748). They believed that soap crystallized as a solid solution. Similar work by McBain and coworkers (*Oil & Soap 21,* 227; *Ind. Eng. Chem. 36,* 808) defined the limits and equilibria of kettle-wax soap phases for sodium laurate and stearate with salt and moisture. An x-ray study of transparent soap indicated that it was composed of fine ultramicroscopic crystallites, arranged at random and scattering light (McBain and Ross—*Oil & Soap 21,* 97). Gallay and Puddington (*Can. J. Res. 21B,* 202) prepared cooling curves and measured densities of soaps of stearic and oleic acids in work pointing out transition points of these soaps.

Several detergents were compounded for special purposes. The cleaners for aluminum and tin utensils were special mixtures of abrasives, inorganic salts and detergents (Comaschi—*U. S. 2,350,592*; McDonald—*U. S. 2,362,284*; Schwartz—*U. S. 2,359,587*). A foam suppressing bottle detergent contained lye, sodium metasilicate and sodium sulfate (Hill—*U. S.*

2,359,913). A preparation containing coal tar oil, monoethanolamine, oleic acid, ethylene glycol, ethyl silicate and phosphoric acid was designed for carbon removal (Bowman and Packer—*U. S. 2,356,747*). A granular rug cleaner contained hydrocarbon solvents, soap and wood flour (Edwards — *U. S. 2,364,608*). Several patents covered the use of soaps for dispersing pigments in paints, varnishes, inks and dyes (Morgan and Vaughn—*U. S. 2,346,041*; O'Neal—*U. S. 2,350,520-6*; Nuodex Products Co., Inc.—*Brit. 549,332*). A process for prevention of corrosion of metals comprised dipping in a solution containing ordinary soap and aluminum salts and then drying (Shoemaker—*U. S. 2,359,799*). A very small admixture of mahogany soap improved the dichloroether extraction process in the manufacture of lubricants (Robinson and Lowry—*U. S. 2,338,384*).

A miscellaneous group of publications involved the use of insignificant amounts of detergents in theoretical and applied research. Small amounts of sulfonated detergents improved mixing in bread making (Swanson and Johnson—*Cereal Chem. 21,* 222). King (*J. Phys. Chem. 48,* 141) produced foams on organic liquids with several commercial detergents. Potassium palmitate was one of the reagents used in a water analysis scheme prepared by Michaelis (*Vom Wasser 15,* 280). Vestling and Swerdlow (*Ind. Eng. Chem., Anal. Ed. 16,* 581) showed that several common detergents may be conveniently substituted for the more expensive saponin as a hemolytic agent in the van Slyke determination of oxygen capacity. The mechanism of precipitation and potential application of detergents for the preparation and separation of proteins was discussed (Putman and Neurath—*J. Am. Chem. Soc. 66,* 692). Detergent-albumin complexes were prepared in work on proving the layer structure of native egg albumin postulated by Pauling (Palmer —*J. Phys. Chem. 48,* 12). Sodium oleate inactivation of the virus of epidemic influenza was successfully used in the experimental preparation of antigens; 6 commercial non-soap detergents were ineffective for this purpose (Stock and Francis—*J. Immunol. 47,* 303). The property of sodium alkyl sulfate to inhibit pepsin and trypsin explained its use in the treatment of gastroduodenal ulcerative disease (Fogelson and Shoch — *Arch. Int. Med. 73,* 212; Block and Necheles — *Gastroenterology 3,* 106; Kirsner and Spitzer—*Ibid. 2,* 348; Kirsner and Wolff—*Ibid.* 270). As shown in earlier parts of this review this property of sodium alkyl sulfate was also used in fat metabolism studies. Whigham (*Lancet 1944,* 646) discussed the use of this detergent for inhibition of adhesions and as a thrombotic and sclerotic agent in varicose veins.

Details of several analytical procedures for soap products were published. A moisture and fat acid determination by Picozzi (*Ann. chim, applicata 32,* 51) was based on distilling off moisture with xylene in a Marcusson apparatus, hydrolyzing the residue with hydrochloric acid and extracting with ether. For filled soaps, Schützer (*Seifensieder-Ztg. 70,* 88) suggested Soxhlet extraction of soap with alcohol before hydrolysis and extraction of free acids with ether. Ankerst (*Fette u. Seifen 50,* 354) recommended that fillers be removed by means of porous stone filters before fat determination. Johnson and Ladyn (*Oil & Soap 21,* 141) adapted the dichromate method for factory control determination of glycerol in soap. A qualitative test for the bicarbonate ion in soap products was based upon the fact that bicarbonates liberate hypochlorous acid from hypochlorites (Blank and Utter—*Ibid.* 27). Optical technic, filtration, elutriation, sedimentation and settling were discussed as means for determining particle size of mineral soap fillers. A method for determination of tin was adapted for the approximation of the amount of tin antioxidant in soap (Compeau and Blank—*Ibid.* 275). A procedure for soap-synthetic detergent mixture analysis depended on separating the constituents with solvents (Berkowitz and Bernstein—*Ind. Eng. Chem., Anal Ed. 16,* 239). Analysis of fat acid-amide detergent was by hydrolysis followed by acid titration (Olsen—*Die Chemie 56,* 202). For the same purpose, Jones (*J. Assoc. Off. Agr. Chem. 27,* 309) extracted with hydrochloric acid, liberated amine with silver oxide, filtered and titrated with standard acid. An adsorption method for analysis of petroleum sulfonates was described (Koch—*Ind. Eng. Chem., Anal. Ed. 16,* 25).

Foam and foam stability are often used as criteria for characterizing soap. The methods reviewed and developed by Brady and Ross (*J. Am. Chem. Soc. 66,* 1348) were for lubricating oils, beers, etc. but were also applicable to soap solutions. His new apparatus for the purpose employed bubbling as a means of producing the foam. Miles and Ross (*J. Phys. Chem. 48,* 280) recorded the foam stabilities of the soaps of many pure fat acids and showed the effect of pH, temperature and concentration. They obtained better foams with mixtures. For each soap definite temperatures had to be exceeded before foam formed; the optimum pH was also evident from the data. In similar work by Merrill and Moffett (*Oil & Soap 21,* 170) the superiority of mixed soaps was confirmed by data from soaps of natural fats and oils, and from single fat acids. Maximum foam stability of tallow and palm oil soaps was at pH 10.6.

Methods of evaluating textile detergents by washing tests were written by Crowe (*Soap, Perfumery, Cosmetics 17,* 109), Jaag (*Tech.-Ind. schweiz. Chem.-Ztg. 25,* 331), Ringeissen (*Teintex 8,* 31), Woodhead *et al.* (*Oil & Soap 21,* 333), Holland and Petrea (*Am. Dyestuff Reptr. 32,* 534). The methods described compounding of soiling material, washing apparatus and methods of standardizing the tests. A method of evaluating dishwashing detergents was based on the photometric measurement of the decrease in transmission or transparency of glass plates due to formation of "hard water" films formed during test washing operations (Wilson and Mendenhall—*Ind. Eng. Chem., Anal Ed. 16,* 251, 253). Enzymic detergents could be evaluated by viscosity changes in a gelatin substrate (Vlcek—*Chem. Obzor 18,* 30).

Physical chemical studies on soap solutions were used as a basis for elaboration of cleansing action and to gain some practical information. Aickin (*J. Soc. Dyers Colourists 60,* 36) evaluated the effectiveness of several negative ions for reducing the interfacial tension of sodium *sec*-alkyl sulfate against paraffine hydrocarbons. In general the bivalent ions had more effect than univalent ions. The least hydrated ions lowered the interfacial tension most. In work of similar nature, McBain and Johnson (*J. Am. Chem. Soc. 66,* 9) studied the solubilization of water-insoluble dyes by 4 potassium soaps. Solubilization was so rapid that the investigators favored

the mechanism of incorporation between layers of lamellar micelles against the suggestion of solution in the hydrocarbon portion of the molecule. Electrolytes, such as potassium chloride, improved solubilizing power. The frequent failure of solutions of sodium oleate to obey Beer's law of absorption of ultraviolet light was attributed to the disorientation of colloidal micelles through the previous flow of the liquid (McBain—*J. Phys. Chem. 48,* 89). In a study of curves on the relationships of surface tension to concentration of pure alkyl sulfates, Miles and Shedlovsky (*Ibid.* 57) found that strictly pure compounds did not exhibit a minimum. The common presence of a minimum, in many investigations, was associated with the presence of mixed surface active material, of salt and possibly selective adsorption. Ekwall (*Kolloid-Z. 101,* 135) studied the relationships between conductivity and concentration of soap solutions. The deviations of the curves were correlated with effects of molecular weights of the fat acids, hydrolysis, carbon dioxide and excess fat acids. In a review on theories of cleansing action of soaps Baborovsky (*Chem. Listy 37,* 33) believed that interfacial tension behavior was sufficient evidence to indicate that cleansing was dependent principally on a lowering of interfacial tension. Treffler (*Soap 20,* No. 4, 29) investigated pure soaps and soap ingredients from the standpoint of their ability to affect the many usual tests associated with evaluation of the soaps. The ability of potassium soaps to emulsify oil began with the caprylate, increased to the palmitate and began to decrease with the stearate. Coconut oil soap emulsified oil less efficiently than the soaps from oils containing a greater predominance of higher fat acids. Dilute solutions of oleates were superior to C_4-C_{18} saturated acid soaps for dissolving insoluble organic compounds. At a temperature of 212° F. the descending order of detergent value of soaps was listed as follows: stearate, oleate, palmitate, myristate, linoleate, laurate and ricinoleate. Similar work on the sodium alcohol sulfates by Dreger *et al.* (*Ind. Eng. Chem. 36,* 610) showed that solubility decreased with increased molecular weight; surface tension was lowest when the $-OSO_3Na$ radical was at middle of the carbon chain and decreased with increased molecular weight; lowering the surface tension caused by added electrolytes was greater the higher the valence of the cation; foam properties were maximum at C_{15} and for the C_{15} compound foaming properties improved as the $-OSO_3Na$ was shifted toward the middle of the chain; wetting time by the canvas disk method was least when the $-OSO_3Na$ was in the middle of the chain and detergency was best the nearer the $-OSO_3Na$ was to the end of the chain.

Many publications on soap products were too general to appear in this review with a discussion and they are listed here under their subject matter:

Methods and materials: Dean—*Soap, Perfumery, Cosmetics 17,* 573; Vallance—*Ibid. 16,* 337, 528; *17,* 496; Weir—*Ibid. 16,* 692; Safrin—*Soap 20,* No. 9, 25, No. 10, 39. Types: Hoyt—*Am. Perfumer 46,* No. 3, 41. Transparent soaps. Leimdörfer—*Seifensieder-Ztg.* 70, 1, 18, 34, 49 *et seq.*

Soap stock: Tall oil. Treffler—*Soap 20,* No. 6, 29. Turkey red oil and castor oil. Serebryakov—*Tekstil Prom. 1943,* No. ½, 24. Dairy waste. Bolduan—*Deut. Molkerei-Ztg. 64,* 116.

Special cleaners: For carpets, rugs, etc. Lesser—*Soap 20,* No. 11, 33. Dry cleaning—Treffler—*Ibid.* No. 12, 36.

Analysis: Wigner—*Soap, Perfumery, Cosmetics 17,* 248, 252. Fischer—*Soap 20,* No. 1, 28.

Rancidity and discoloration: Henk—*Deut. Parfüm.-Ztg. 27,* 69. Sadgopal—*Soap, Perfumery, Cosmetics 17,* 176, 324.

Sulfonated products: Andel—*Chem. Weekblad 49,* 314; Widaly—*Seifensieder-Ztg. 69,* 176; Joag—*Schwiez.-Brau. Rundschau 53,* 43. Sulfonated peanut oil. Gallent—*Am. Dyestuff Reptr. 33,* 148. Sulfonation of blubber. Engel—*Sbornik Rabot Vsesoyuz. Tsentral. Nauch.-Issledovatel. Inst. Zhirov 1941,* 67. Sodium *sec*-alkyl sulfates. Anon.—*Chem. & Industry 63,* 327.

Detergent action: Tomlinson—*Manufg. Chemist 15,* 159. Wetting properties. Sadgopal—*Soap, Perfumery, Cosmetics 17,* 258. Detergency of amolytic enzymes and Na alkyl sulfates. Arent—*Univ. Microfilms Pub. No. 558.*

Fillers and substitutes: Uhl—*Seifensieder-Ztg. 69,* 281, 291, 300. Guillemonat and Piganiol—*Tech. moderne 34,* 102. Fleury-Larsonneau and Andre—*Chemie & industrie 47,* 333. Hojka—*Casopis Mydlar Vonavkar 21,* 28. Bo—*Kem. Maanedsblad 23,* 165. Henk—*Deut. Parfum.-Ztg. 27,* 106. Smith—*Am. Perfumer 45,* No. 10, 61. Foulon—*Seifensieder-Ztg. 69,* 23. Cellulose and pectin types. Bosurgi—*Rev. ital. essenze, profumi piante offic. 24,* 167. Clay type. Trautluft—*Fette u. Seifen 50,* 220. Alkali phosphates. Corey—*Soap 20,* No. 8, 32.

Miscellaneous soaps: Triethanolamine soaps. Hardy—*Teintex 6,* 186. Invert soap from petroleum. Profft—*Oel u. Kohle 39,* 189. Naphthenic acid soaps. Widaly—*Seifensieder-Ztg. 69,* 211.

Uses in: Medicine. Lesser—*Soap 20,* No. 7, 29; No. 10, 33. Leather cleaning. Lesser—*Ibid.* No. 9, 29. Dishwashing. Hadfield—*Ibid.* No. 8, 29. Paper making (as a size). Carter and Harrison—*World's Paper Trade Rev. 121,* TS9; Leffingwell—*Fibre Containers 28,* No. 12, 118. Textile industry. Leffingwell and Lesser—*Rayon Textile Monthly 25,* No. 4, 78. Drilling, mining and ore treatment. Leffingwell and Lesser—*Mining J. 28,* No. 4, 5. Fruit and vegetable peeling. Lankler and Morgan—*Food Industries 16,* 888. Leather processing. Leffingwell and Lesser—*Shoe Leather Reptr. 233,* No. 12, 13. Floor maintenance. Koss—*Seifensieder-Ztg. 69,* 235. New uses in industry. Lesser—*Soap 20,* No. 8, 25.

Germicidal soap: Taub—*Merck Rept. 53,* No. 3, 28. Council on Pharmacy and Chemistry—*J. Am. Med. Assoc. 124,* 1195.

Glycerol: Manufacture. Andsten—*Tek. Tid. 72,* No. 50, 89. Boyle—*Manufg. Chemist 14,* 313. From waste products. Du Puis—*Oil & Soap 21,* 76. Textile applications. Leffingwell—*Textile Res. 14,* 69.

The patents on nonsoap type detergents and methods for their manufacture are listed with only partial classification:

Those on methods of sulfonating and production were:

Colgate-Palmolive-Peet Co.—*Brit. 548,276.*

E. I. du Pont de Nemours & Co.—*U. S. 2,365,638, 2,366,027.*

Fraser and Fraser, Ltd.—*Brit. 553,598.*

Harvel Corp.—*U. S. 2,324,300.*

Houghton and Co.—*U. S. 2,352,698.*

Natl. Oil Products Co.—*U. S. 2,328,931, 2,344,154.*

Procter & Gamble Co.—*U. S. 2,356,903, 2,365,783.*

Pyzel—*U. S. 2,332,527.*

Socony-Vacuum Oil Co.—*U. S. 2,365,653.*

L. Sonneborn Sons, Inc.—*U. S. 2,358,773-4.*

Standard Oil Development Co. — *U. S. 2,354,577, 2,357,866.*

Stiepel—*Ger. 716,837.*

Those on sulfonated derivatives of fats or petroleum were:

Allied Chem. & Dye Corp.—*U. S. 2,340,654, 2,347,336, 2,364,767, 2,364,782.*

Am. Cyanamid Corp.—*U. S. 2,345,041, 2,345,307.*

Böhme Fettchemie-G.m.b.H.—*Ger. 736,400 Cl. 8o.*

Colgate-Palmolive-Peet Co.—*U. S. 2,345,061, U. S. Reissue 22,548 to 2,244,512.*

Deut. Hydrierwerke A.-G.—*Ger. 738,445 Cl. 8o.*

E. I. du Pont de Nemours & Co.—*U. S. 2,338,928-30, 2,346,568.*

J. R. Geigy A.-G.—*Ger. 737,762 Cl. 8o.*

Gen. Aniline & Film Corp.—*U. S. 2,337,924.*

Hercules Powder Co.—*U. S. 2,340,901, 2,362,882.*

I. G. Farbenind. A.-G.—*Ger. 729,892 Cl. 12o, 730,280 Cl. 12o.*

Lever Bros. & Unilever Ltd.—*Brit. 551,616.*

Monsanto Chem. Co.—*U. S. 2,355,592, 2,359,291, 2,359,326.*

Natl. Oil Products Co.—*U. S. 2,336,166, 2,341,060; Brit. 551,246.*

Oranienburger Chemische Fabrik A.-G.—*Ger. 714,973 Cl. 12s.*

Oswald Lütgens & Co.—*Ger. 728,237 Cl. 30i.*

Solvay Process Co.—*U. S. 2,336,387, 2,354,359.*

Some sulfonated detergents were made by sulfonating special amines or other nitrogen containing organic compounds:

Alien Property Custodian — *U. S. 2,345,121, 2,350,000.*

Am. Cyanamid Co.—*U. S. 2,345,539.*

E. I. du Pont de Nemours & Co.—*U. S. 2,346,569, 2,361,188, 2,362,886.*

Hercules Powder Co.—*U. S. 2,344,833, 2,362,882.*

Hydronaphthene Corp.—*U. S. 2,355,503.*

Johnson-Marsh Corp.—*U. S. 2,342,150.*

Kalle & Co. A.-G.—*Ger. 737,309 Cl. 8i.*

Natl. Oil Products Co.—*U. S. 2,340,112, 2,353,081.*

Oranienburger Chemische Fabrik A.-G.—*Ger. 734,337 Cl. 8o.*

Procter & Gamble Co.—*U. S. 2,342,562.*

Soc. Chem. Ind., Basle—*U. S. 2,338,477.*

Many amines, amides and quaternary ammonia derivatives were patented for use as wetting agents, detergents, etc.:

Alframine Corp.—*U. S. 2,357,598.*

Alien Property Custodian — *U. S. 2,335,466, 2,345,121.*

Am. Cyanamid Co. — *U. S. 2,324,712, 2,329,619, 2,350,453, 2,355,442.*

Arnold, Hoffmann & Co., Inc.—*U. S. 2,344,259.*

Böhme Fettchemie-G.m.b.H.—*Ger. 735,077 Cl. 8o.*

Commercial Solvents Corp.—*U. S. 2,346,454.*

Deut. Hydrierwerke A.-G.—*Ger. 736,671 Cl. 30h.*

E. I. du Pont de Nemours & Co.—*U. S. 2,327,160, 2,327,213, 2,359,862-4, 2,359,884.*

Emulsol Corp.—*U. S. 2,322,783, 2,362,894.*

J. R. Geigy A.-G.—*U. S. 2,343,071.*

Hercules Powder Co.—*U. S. 2,338,797.*

I. G. Farbenind. A.-G.—*Ger. 731,558 Cl. 8i.*

Monsanto Chem. Co.—*U. S. 2,347,633.*

Natl. Oil Products Co. — *U. S. 2,345,632; Can. 421,839.*

Procter & Gamble Co.—*U. S. 2,334,517.*

Soc. Chem. Ind., Brit.—*U. S. 2,365,871.*

Soc. pour l'ind. chim. a Bale—*Brit. 549,172.*

United Shoe Machinery Corp.—*U. S. 2,354,320.*

U. S. Rubber Co.—*U. S. 2,356,710.*

Winthrop Chem. Co.—*U. S. 2,336,179.*

Among miscellaneous detergents were special organic compounds or phosphates of organic compounds:

Am. Cyanamid Co.—*U. S. 2,341,846.*

Colgate-Palmolive-Peet Co.—*U. S. 2,345,006.*

Diversey Corp.—*U. S. 2,360,135.*

E. I. du Pont de Nemours & Co.—*U. S. 2,357,479.*

Eastman Kodak Co.—*U. S. 2,336,230, 2,364,348.*

Hercules Powder Co.—*U. S. 2,339,428.*

Solvay Process Co.—*U. S. 2,336,387.*

Very little information on glycerol was published. Govan (*Oil & Soap 21,* 271) recommended control of pH in acid treatment to reduce the amount of flocculating agent necessary. He described plant operations for glycerol recovery from spent soap-lyes. One German patent (Endres — *Ger. 736,885 Cl. 12o*) described purification and recovery of valuable constituents of glycerol still residues. Two patents (Batchelder and Peterson—*U. S. 2,363,494;* Farber *et al.*—*U. S. 2,351,413*) covered extraction processes for glycerol from fermented liquors. In studies on obtaining glycerol by catalytic hydrogenation of carbohydrates Natta *et al.* (*Chimica e industria Italy 24,* 419) hydrogenated several hundred carbohydrate preparations. The most active catalysts were nickel on kieselguhr and copper-nickel on kieselguhr; the presence of water gave optimum results with the first catalyst, whereas in the presence of alcohol copper catalysts were advantageous. The yields were 20 to 30% glycerol with 30 to 40% propylene glycol. Possibly many of the developments in glycerol manufacture are being held for future publication.