The Role of Chemical Derivatives in Seeking New Markets for Fats

WALDO C. AULT, Eastern Regional Research Laboratory,[1] Philadelphia 18, Pennsylvania

WITHIN the past two decades the United States has changed from an importer to an exporter of fats. Numerous factors have contributed to the development of this situation. The more important appear to be the greatly increased production of soybeans, the greatly increased consumption of meat with corresponding increase in production of the by-product animal fats, both edible and inedible, and increasing domestic production of certain industrially used oils such as tung and castor. In addition, there is increased technical knowledge which permits the use of domestic oils in formulations that formerly required imported materials having unusual chemical composition.

Numerous facets of the domestic fat picture have helped to focus the major economic effects of this changing pattern directly on animal fats and oils, particularly inedible animal fats. The economic difficulties resulting from substantially increased production of inedible animal fats have been compounded by the simultaneous disappearance of a considerable portion of their principal outlet as soap.

Data in Table I on the production of animal fats, their use in soap, and the import-export tonnage demonstrate the magnitude of this changing picture.

TABLE I

Inedible Animal Fats
Production *vs.* Use in Soap and Exports

	Production	Consumption in soap	Percentage of production used in soap	Net imports (+) or exports (—)	Percentage of production exported
Year	*Million lbs.*	*Million lbs.*	*Percent*	*Million lbs.*	*Percentage*
1937-41	1,167	965	82.7	+2	......
1942-46	1,748	1,398	79.9	+25	......
1947-49	2,032	1,441	70.9	—195	9.6
1950	2,272	1,361	59.9	—534	23.5
1951	2,252	1,173	52.1	—530	23.5
1952	2,318	1,076	46.5	—747	32.3

Based on data from Fats and Oils Situation, 159, 1953, page 18.

Up to the present, despite the large increase in animal fat tonnage not used in domestic soap production, no large quantities of these fats have accumulated as surpluses; worldwide shortages of fats following World War II have facilitated their export. Last year about 750 million pounds, almost exactly one-third of our production, were exported. Dependence to such a degree upon export markets, beset as they are with so many difficulties and uncertainties, places the inedible fat rendering industry in an unenviable position. Moreover the relatively low returns from marketing these products in competition with fats produced abroad undoubtedly result in lower returns to the farmers who grow livestock.

The substantial excess of production of animal fats over domestic demand presents a challenge to agriculture and at the same time offers an opportunity to those who are in a position to give them consideration as a raw material. Available tonnages are of such magnitude as to encourage investigation of their use in some of the largest chemical outlets; in fact, one of the difficult aspects of the problem is the existence of such few potential outlets for quantities of material of the order of magnitude required.

One non-chemical field which offers an outlet for a substantial quantity of tallow and grease is animal feeds. As an example of the potential utilization in this field, it has been authoritatively estimated that the annual consumption of poultry feeds is about 30 million tons; simple calculation indicates that the addition of 1% of fat to these feeds would require 600 million pounds, nearly all our present exportable surplus.

Present information indicates that, in the field of animal feeds, fats will be in competition with other sources of calories, principally carbohydrates. Since the calorific value of fats is 2.25 times that of carbohydrates, they are competitive with many other farm feeds as a source of energy even at prices somewhat above their present levels. Further possible advantages of relatively minor additions of fats to certain animal feeds are indicated from research currently in progress. It therefore appears that research plans to investigate the use of fats as a raw material for the preparation of chemical intermediates and derivatives might well be based for the long pull on slightly higher prices for fats than those which have prevailed for the past two years. Consideration of all the factors involved however indicates that fats are a promising raw material for study by research investigators (1, 2, 3, 5, 9).

The price of fats is such that they cannot be considered as being competitive on a cents per pound basis with such raw materials as petroleum or coal. Fats cannot be subjected to the same types of processing, which are frequently relatively undirected and therefore result in undesirable by-products. The inedible animal fats however are relatively pure organic raw materials from which a substantial credit can nearly always be obtained by recovery of glycerine. It therefore follows that it is not desirable or necessary to base decisions regarding the value of fats as raw materials on a comparison of their unit weight costs with those of petroleum or coal. These latter materials moreover are used extensively by the chemical industry only after a variety of processing and purifying steps.

At present, most of the large volume of synthetic organic chemicals are derived from eight raw materials: ethylene, propylene, butylene, benzene, toluene, naphthalene, acetylene, and cellulose (5). Ethylene, propylene, butylene, benzene, and toluene are derived in part from petroleum and are worth about 4 to 5c per pound. Naphthalene from coal tar is presently priced at about 6c per pound whereas acetylene, a more reactive derivative from the same source, is worth approximately 12c per pound. The only agricultural raw material included, cellulose, is currently worth about 10c per pound.

These basic products are all essentially pure compounds, which in most cases are used by the chemical industry as "building blocks" for the preparation of

[1] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Service, U. S. Department of Agriculture.

a wide variety of larger molecules. The animal fats or mixed fatty acids do not have the same degree of chemical purity and hence for some purposes are not strictly comparable with these intermediate products as raw materials for organic preparation or synthesis. Rather, for most purposes, such comparisons might better be made with relatively pure intermediates derived from fats such as stearic and oleic acid, their two principal components.

Such a comparison is far from discouraging to those who are considering the possibilities of research on fats and oils, particularly if consideration is given to the functionality of the materials and to the long, straight-chain structure of the fatty acids which make up about 92% of these fats. These long, straight-chain structures frequently present advantages and seldom pose serious disadvantages in such fields as plastics, rubber, synthetic fibers, surface-active agents, plasticizers, lubricants, and waxes. It is exceedingly fortunate for would-be users of tallow that these fields in which the basic chemical composition of fatty acids appears to give them certain advantages coincide to a considerable extent with the major fields for marketing organic chemical products. The only major chemical field in which fatty acids appear to offer little or no potentialities for use is that of solvents. For such a purpose their straight-chain paraffinic nature coupled with their relatively high molecular weights must be considered as a definite disadvantage.

Before drawing any final conclusions regarding the potential development of commercially valuable organic chemical products from fats, it may be well to evaluate very briefly their present position in each of the important markets mentioned above.

Plastics and resins. The use of fatty acids in plastics and resins has largely been confined to their incorporation as components in alkyd resins. Their function has been largely that of a modifier and extender, and most of the fatty acids used have been of the relatively unsaturated type.

Two current developments offer some hope for substantially increasing the use and improving the position of fats in this field. The first of these, reported to be in commercial operation, is the conversion of oleic acid to azelaic acid. This fat-derived compound can be used as a component of the primary base for polyester resins made by condensation reactions. The second development, only in the research stage at present, involves the use of such fat derivatives as vinyl stearate for copolymerization with other important commercial monomers. If it achieves commercial status, it will open the way to the use of the saturated fatty acids in this large and rapidly growing field.

Rubber. Considerable quantities of fats (up to 100 million pounds a year) have been used in the preparation of soaps that serve as emulsifiers in the manufacture of synthetic rubber. Also fatty acids are used as additives in nearly all rubber formulations. In recent years this application required about 20 million pounds of fatty acids, a quantity that represents only a minor additive by comparison with the tonnage of rubber used.

The scientific information available is not sufficient to permit appraisal of the possibility for using fatty acids as a component raw material for the rubber itself.

Plasticizers. Fats, oils, and many of their simple derivatives have most of the properties desirable in plasticizers, such as low vapor pressure, good color and color stability, and uniformity. Lack of compatibility with commercially important polymers however has restricted the use of fats for this purpose. A recently developed method for chemical modification of fatty compounds resulting from the epoxidation studies of Swern and coworkers (10) has served to stimulate interest in the use of fats for preparing plasticizers. The compatibility of fatty compounds with such important commercial plastic materials as polyvinyl chloride is increased substantially by the introduction of the three-membered epoxy or oxirane ring into the molecule (6). This work has already led to greatly increased use of fats in plasticizer manufacture, and in view of the widespread interest in this development further progress seems probable.

Surface-Active Agents. Fats formerly occupied a unique and dominant position in the field of surface-active agents, being the raw material used almost entirely for preparation of soaps. Moreover the first acid-stable wetting agents were developed from fats, chiefly for use in textile processing. Miller (8) reports that the textile industry in this country today is consuming materials derived from fats at the rate of several hundred million pounds per year. According to this authority, fat derivatives are used in wool scouring, rayon wet spinning, spinning lubricants, sizing compounds, wetting and rewetting agents, acid fulling, and dye leveling, and as finishing agents.

For about two decades surface-active agents derived from non-fatty materials have been used to serve an ever-increasing number of industrial needs. Since World War II these materials have found substantial acceptance for household laundering and dishwashing. At present the question seems to be whether it is possible for fats to regain some of their former position or even hold their present level as raw materials for use in manufacture of surface-active agents. In a recent analysis of available data on the production of surface-active agents McCutcheon (7) stated that dodecyl benzene sodium sulfonate continues to be the leading base material for detergents. Although the second largest base detergent material is alcohol sulfate derived from coconut and tallow fatty acids, he implies that use of these products has not shown the huge increase that might have been expected on the basis of low-priced tallow over the last year or so. It does seem probable however that for several years use of tallow for this purpose has increased considerably, at the expense of imported and more expensive coconut oil.

Several other acyclic-type products show consistent gains since 1942, and the low price of inedible animal fats is stimulating increased research aimed at the use of fats in production of surface-active agents.

Lubricants and Lubricant Additives. Although fats and oils were undoubtedly the earliest lubricants used by man, they have surrendered dominance in this field to those derived from petroleum. Nevertheless it has been reported recently by Zisman and coworkers (4) that dibasic acids such as azelaic acid, which is derived from fats, serve as a basis for synthesizing excellent greases and lubricating oils.

The field of additives to lubricants is also a growing one; lubricants frequently contain 5 to 10% additive or even more. Purposes for which additives are used include accentuation of "oiliness," modification of viscosity, improvement of viscosity index, detergent action, lowering of pour point, and inhibition of corrosion and oxidation. The paraffinic nature of fatty acids modified only by the presence of a terminal carboxyl group tends to make them ideal raw materials for the synthesis of specific compounds required to fill these needs.

Synthetic Fibers. The function of fats and fat derivatives in the manufacture of synthetic fibers is almost entirely peripheral in that only minor amounts are incorporated in the structure of the fiber molecules. Such use as they enjoy in production and processing of synthetic fibers is largely that of surface-active agents. It is not possible to make predictions regarding the future use of fats in this field. It does seem reasonable to assume however that any substantial use of fats will depend upon the development of relatively simple secondary derivatives capable of entering into the polymerization reactions generally used in the preparation of synthetic fibers.

Waxes. Nearly all the valuable natural waxes are complex chemical mixtures consisting largely of compounds which have long paraffinic chains, frequently modified by hydroxyl groups. It is not surprising therefore that a great many of the "synthetic waxes" are prepared from fats which because of their paraffinic structure appear to be ideal starting materials.

A number of additional fields offer considerable promise as outlets for fat derivatives. Although their discussion is beyond the scope of this paper, a few offer such promise as to merit mention. These include steel processing (hot-dip tinning, rolling mill and drawing lubricants), adhesives, flotation agents, and hydraulic fluids. In conclusion, the following summarizing statements may be made: a) Inedible fats and oils are available in sufficient quantities to serve as raw materials for chemical derivatives having large outlets. b) Indications are that inedible animal fats will be available at prices which permit their consideration for use as organic raw materials. c) The greatest opportunities for development of chemical uses for fats are in those fields where their paraffinic chain, already modified by terminal carboxylation, gives them some potential advantages. Fortunately such fields include many which have been shown to possess great growth potential. d) The basic chemical and physical information necessary for the practical development from fats of new derivatives that will serve a variety of industrial needs is rapidly becoming available.

REFERENCES

1. Ault, W. C., Chemurg. Digest, *10*, No. 9, 4 (1951).
2. Ault, W. C., Proceed. of Third Research Conf., Am. Meat Institute, 87, 1951.
3. Ault, W. C., Proceed. of Fifth Research Conf., Am. Meat Institute, 18, 1953.
4. Bried, E. M., Kidder, H. F., Murphy, C. M., and Zisman, W. A., Ind. Eng. Chem., *39*, 484 (1947); Atkins, D. C. Jr., Baker, H. R., Murphy, C. M., and Zisman, W. A., *ibid.*, *39*, 491 (1947); Hain, G. M., Jones, D. T., Merker, R. L., and Zisman, W. A., *ibid.*, *39*, 500 (1947).
5. Ewell, R. H., J. Ag. and Food Chem., *1*, 552 (1953).
6. Greenspan, F. P., and Gall, R. J., Ind. Eng. Chem., *45*, 2722 (1953).
7. McCutcheon, J. W., Soap and Sanit. Chem., *29*, No. 8, 97 (1953).
8. Miller, L. M., Am. Dyestuff Reptr., *42*, Proceedings, 435 (1953).
9. Swern, D., Ault, W. C., and Stirton, A. J., Yearbook of Agriculture, 538, 1950-1951.
10. Swern, D., Findley, T. W., and Scanlan, J. T., J. Am. Chem. Soc., *66*, 1925 (1944); Findley, T. W., Swern, Daniel, and Scanlan, J. T., *ibid.*, *67*, 412 (1945).

[Received October 12, 1953]

(Editor's Note: *This article was presented as the introductory paper before the session on Fatty Acid Derivatives at the 27th fall meeting of the American Oil Chemists' Society, Nov. 3, 1953, in Chicago, Ill.*)

Sees Great Expansion

The organic chemical industry sees at least 100,000 new jobs created during the next 10 years according to Cary R. Wagner, president of the Synthetic Organic Chemical Manufacturers Association. This expansion in employment is due to the fact that the organic chemical industry is growing at a rate four times faster than all U. S. industry.

Speaking before the students and faculty at Wooster College, Dr. Wagner said "in the best judgment of those of us in the organic chemical industry, we have just begun to grow. Even the most conservative of us talk and think in superlatives—not boastfully, but merely in terms of the foreseeable expansion in employment, plants, and the thousands of ways in which chemicals will be used in the future."

The organic chemical industry has become a vital and vigorous part of our national economy, Dr. Wagner said, and its products have become indispensable to all of American industry, to our armed services, and to the every-day living of all our citizens. To illustrate his point Dr. Wagner said that 256 chemicals are used in the manufacture of an automobile. Without chemicals, he added, there would be no steel or light-weight metals, no TV sets or telephones, no synthetic rubber, no sulfa drugs and many other essential products.

"There are no limits to our opportunities," said Dr. Wagner. "For example, it's a good guess that better than half our production of chemicals 20 years from now will be in products unknown to us today."

A two-color illustrated brochure showing the features and advantages of the single beam Model 12-C Infrared Spectrometer is available from the Perkin-Elmer Corporation, Norwalk, Conn. Three versions of the Model 12-C are described.

A 12-page booklet entitled "X-ray Methods of Possible Use in Clinical Laboratories" is available from the Research and Control Instruments Division, North American Philips Company Inc., 750 South Fulton avenue, Mount Vernon, N. Y. The publication discusses crystallography and X-ray diffraction, identification of compounds, X-ray spectroscopy, and microradiography.

New Members

Active

Charles M. Bodach, research chemist, Dearborn Chemical Company, Chicago, Ill.

Garth Stanley Chalmers, manager, fats and oils, Burns and Company Ltd., Winnipeg, Manitoba, Canada.

Abner Eisner, chemist, Eastern Regional Research Laboratory, Philadelphia, Pa.

Oliver J. Goldstein, chief chemist, Moreland Chemical Company, Spartanburg, S. C.

Jerome J. Hargarten, technical representative, E. I. du Pont de Nemours and Company, Wilmington, Del.

Stanley C. Mikszta, chemical engineer, Kraft Foods Company, Glenview, Ill.

Lewis C. Wallace, plant manager, Celulosa Nacional, S. A. Rio Bravo, Tamaulipas, Mexico.

David Aelony, research chemist, General Mills Inc., Minneapolis, Minn.

Vincent Ashford, chief chemist, Hydrol Company Inc., Bladensburg, Md.

H. E. P. Barta, director, Centrifugas Ltd., Nassau, Bahamas.

T. Roger Bresnahan, chief chemist, Darling and Company, Chicago, Ill.

Robert T. Haefeli, chief chemist, de Roll S. A., Zurich, Switzerland.

Charles W. E. Jane, sales engineer, Centrifugas Ltd. Nassau, Bahamas.

Gordon Scott Moss, chief chemist, J. M. Schneider Ltd., Kitchener, Ontario, Canada.

Robert J. O'Connor, research chemist, Colgate-Palmolive Company, Jersey City, N. J.

Frank R. Reitter, analytical chemist, Colgate-Palmolive Company, Jersey City, N. J.

Hachiro John Togashi, chemist, U. S. Army, Quartermaster Food and Container Institute, Chicago, Ill.

John Yensco Jr., senior project chemist, Colgate-Palmolive Company, Jersey City, N. J.

A. S. Armstrong, technical service-catalysts, Harshaw Chemical Company, Cleveland, Ohio.

John Kenneth Darch, plant manager, S. F. Lawrason and Company Ltd., London, Ontario, Canada.

Frank H. David, production supervisor, Baker Caster Oil Company, Bayonne, N. J.

R. M. Dillard, chief chemist, Texas Testing Laboratories Inc., Dallas, Tex.

Leo Lichtenberg, secretary-treasurer, Chicago Sanitary Products Company, Chicago, Ill.

James E. Malone, research chemist, Wilson and Company, Chicago, Ill.

Frank P. O'Connell, production supervisor, Baker Caster Oil Company, Bayonne, N. J.

William F. Phillips, process engineer, Anderson, Clayton and Company, Houston, Tex.

Olavo Romanus, chemist, Institute de Biolog. e Pesq. Technologicas, Curitiba-Parana-Brazil.

Heinz Stuermer, Boonton, N. J.

Sven Young, chemist, Canada Packers Ltd., Toronto, Ontario, Canada.

Else Schildknecht, chemist, Blendax-Werke Mainz, Mainz/Rh., West Germany.

Individual Associate

G. F. Des Autels, research chemist, Kalamazoo Vegetable Parchment Company, Kalamazoo, Mich.

Guy W. LaLone, director, production and engineering, General Mills Inc., Minneapolis, Minn.

Edward G. Smith, production manager, Hardesty Industries Inc., Philadelphia, Pa.

Corporation Associate

Maxton Oil and Fertilizer Company, Maxton, N. C.

The American Society for Testing Materials, Philadelphia, Pa., has announced the appointment of F. F. Van Atta, as special assistant on the headquarters staff. He will coordinate and extend the A.S.T.M. developmental and promotional activities.