VEGETABLE FATS AND OILS

BY

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GENERAL INTRODUCTION

American Chemical Society's Series of Chemical Monographs

By arrangement with the Interallied Conference of Pure and Applied Chemistry, which met in London and Brussels in July, 1919, the American Chemical Society was to undertake the production and publication of Scientific and Technologic Monographs on chemical subjects. At the same time it was agreed that the National Research Council, in cooperation with the American Chemical Society and the American Physical Society, should undertake the production and publication of Critical Tables of Chemical and Physical Constants. The American Chemical Society and the National Research Council mutually agreed to care for these two fields of chemical progress. The American Chemical Society named as Trustees, to make the necessary arrangements of the publication of the Monographs, Charles L. Parsons, secretary of the Society, Washington, D. C.; the late John E. Teeple, then treasurer of the Society, New York; and the late Professor Gellert Alleman of Swarthmore College. The Trustees arranged for the publication of the ACS Series of (a) Scientific and (b) Technological Monographs by the Chemical Catalog Company, Inc. (Reinhold Publishing Corporation, successor) of New York.

The Council of the American Chemical Society, acting through its Committee on National Policy, appointed editors (the present list of whom appears at the close of this sketch) to select authors of competent authority in their respective fields and to consider critically the manuscripts submitted.

The first Monograph of the Series appeared in 1921. After twenty-three years of experience certain modifications of general policy were indicated. In the beginning there still remained from the preceding five decades a distinct though arbitrary differentiation between so-called "pure science" publications and technologic or applied science literature. By 1944 this differentiation was fast becoming nebulous. Research in private enterprise had grown apace and not a little of it was pursued on the frontiers of knowledge. Furthermore, most workers in the sciences were coming to see the artificiality of the separation. The methods of both groups of workers are the same. They employ the same instrumentalities, and frankly recognize that their objectives are common, namely, the search for new knowledge for the service of man. The officers of the Society therefore combined the two editorial Boards in a single Board of twelve representative members.

Also in the beginning of the Series, it seemed expedient to construe rather broadly the definition of a Monograph. Needs of workers had to be recognized. Consequently among the first hundred Monographs appeared works in the form of treatises covering in some instances rather broad areas. Because such necessary works do not now want for publishers, it is considered advisable to hew more strictly to the line of the Monograph character, which means more complete and critical treatment of relatively restricted areas, and, where a broader field needs coverage, to subdivide it into logical subareas. The prodigious expansion of new knowledge makes such a change desirable.

These Monographs are intended to serve two principal purposes: first, to make available to chemists a thorough treatment of a selected area in form usable by persons working in more or less unrelated fields to the end that they may correlate their own work with a larger area of physical science discipline; second, to stimulate further research in the specific field treated. To implement this purpose the authors of Monographs are expected to give extended references to the literature. Where the literature is of such volume that a complete bibliography is impracticable, the authors are expected to append a list of references critically selected on the basis of their relative importance and significance.

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PREFACE

This book bears the same title as No. 58 in the A.C.S. Monograph Series, now out of print, written by George S. Jamieson. The aim in its preparation has been to meet some of the same needs that have created a continuing demand for its predecessor. The book is newly written, entirely, and the present author bears the responsibility for its arrangement and content.

The principal feature of the predecessor volume has been retained in this one, namely, the provision of a descriptive catalog of nearly all of the vegetable fats and oils concerning which much scientific information has been published. This part occupies the greater number of pages; it begins with Chapter 8 and continues to the end of the book.

The order in which the individual fats and oils are described is new. The grouping into nondrying fats and oils, semidrying oils, and drying oils has been eliminated. That method of classification, although it has been used in many books, always was an arbitrary one, requiring such absurdities as the placing of almond oil and peach kernel oil in different groups because their average iodine values happen to fall on either side of a dividing line. Further than this, the developments of recent years in the formulation of paints, varnishes, and kindred products have tended to shift or erase the boundaries between the old drying, semidrying, and nondrying groups, so that now many oils formerly classed as semidrying or even nondrying are good materials for use in the "drying oil industries."

The placing of any individual fat in the book has been determined entirely according to the botanical classification of the plant from which the fat is obtained, regardless of its iodine value or melting point. This puts each fat near those which are most closely related to it botanically and facilitates comparisons among fats belonging to the same genera and families. In the opinion of the present author, the interest that is gained by making comparisons easy among fats that are near relatives outweighs any loss caused by the elimination of other groupings. Comparisons are facilitated further by the liberal use of tables containing data for more than one fat.

The first seven chapters are general ones, containing information broadly applicable to the fats and oils. The nature of the material in these chapters is indicated in the chapter headings. In addition to this, much of the information given in the discussion of some of the more important individual fats and oils is more or less broadly applicable. By referring to the index, the reader may find information on particular subjects in which he is interested even though they are not covered in the general chapters.

The references cited had to be chosen from a much larger number, in order to keep the work within the bounds of one volume, and to avoid bewildering the reader with a multiplicity of citations. The principle followed was to give preference to (1) the reports which appeared to be the most reliable ones, (2) the more recently published reports and reviews, especially when they included leading references to older material, (3) reports in publications readily accessible in American libraries. Little space has been devoted to the history of the development of knowledge on particular subjects, and no attempt has been made to make the citations reflect any opinion concerning the credit due for individual achievements. If some readers feel that this policy has caused undue weight to be given to American publications, the answer is that this has occurred through no desire to slight the contributions and priorities of workers in other lands, but solely for the purpose of packing as much useful information as possible into one volume, on the assumption that the majority of those using the book will be more interested in finding what is known about the vegetable fats and oils than they will be in learning to whom they are indebted for it.

If more space were available, a general section covering milling, processing and utilization of the fats and oils might have been included. However, much of the material for such a section is included in the discussion of individual fats and oils and may be found by reference to the index. Any lack in this department is well supplied by other books recently published. The collaborative works on "Cottonseed and Cottonseed Products,"[1] edited by the late A. E. Bailey, and on "Soybeans and Soybean Products,"[2] edited by K. S. Markley, together with the book by A. E. Bailey, entitled "Industrial Oil and Fat Products,"[3] provide extensive and authoritative information on modern methods of handling oilseeds and processing and utilizing their products.

The many persons who have helped me by providing information and in other ways are too numerous to be mentioned individually. I hereby acknowledge my indebtedness and thank all those who have responded so generously to my requests for assistance. Among those who have done so repeatedly are the staffs of the Procter and Gamble Company Tech-

[1] Interscience Publishers, Inc., New York, 1948.
[2] Interscience Publishers, Inc., New York, Vol. I, 1950; Vol. II, 1951.
[3] Interscience Publishers, Inc., New York, 2nd Ed., 1951.

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nical Library, The Lloyd Library and Museum, and the Science and Industry Department of the Cincinnati Public Library.

Special thanks are due to Lawrence P. Miller for writing Chapter 6 and for reading some of the other chapters. My associates, R. O. Alderson and R. J. Woestman, have had much to do with the preparation of the book, including reading of the manuscript, finding and organizing data and information, and preliminary preparation of part of the text. The figures were drawn by R. J. Woestman. The typing of the manuscript is the minor part of the contribution made by Agnes V. Dardeen. Her help in preliminary tabulation of data, verification of references, detection of errors, and a variety of other ways has been indispensable.

I wish also to acknowledge the support and help of the editor. Finally, special acknowledgment is due to my wife, who endured patiently the disadvantages incurred when her husband undertook to write a book.

E. W. Eckey

Cincinnati 15, Ohio
January 15, 1954

CONTENTS

Chapter 1

INTRODUCTION

The fats make up one of the three classes of organic matter that are the main building materials of living organisms. Probably every live thing contains protein, carbohydrate, and fat, although in some the proportion of fat may be very small.

How fat is synthesized, and just what its function is in the living plant, do not appear to be known with any certainty, but its vital importance is evident from its presence in every cell, its concentration in reproductive organs such as pollen grains and seeds, and its intimate association with other substances known to influence life processes, such as the fat-soluble vitamins, sterols, and phospholipides.

To mankind, the vegetable fats are important first as food. They are a concentrated food material, having more than twice the net heat value of the same weight of carbohydrates or proteins. In addition, they serve as carriers of fat-soluble vitamins and they furnish the essential fatty acids without which the animal organism cannot thrive. Besides their direct nutritional value, they have the virtue of making other foods more appetizing. They are indispensable in practical cooking and baking, since many foods cannot be made fit to eat without fat.

The proportion of fat in natural foodstuffs varies greatly. In white potatoes the lipide content is about 0.5 per cent of the dry weight; in English walnuts it is about 69 per cent. Much of the fat consumed by men is taken with the natural foodstuffs without ever having been separated from the other plant material in which it occurs, but the fats with which this book will be more concerned are those isolated in relatively pure form before use. Even of this portion of the total vegetable fat utilized, much the larger part goes into food. The most important part of fat technology, therefore, consists in the isolation of fats and the refining and processing needed to make them palatable and suited to various culinary requirements. The nonfood uses on the other hand, have long been important ones and are becoming relatively more so. Especially, the expanding use of fats as chemical raw materials for the synthesis of a great variety of improved and new products has been a feature of the chemical developments of recent years.

Nomenclature

In common usage, the noun "fat" refers to the material insoluble in water and having a characteristic oily or greasy feel and consistency, that can be separated from plant and animal tissues. The word "oil" is more ambiguous. When used together with the word fat, in the expression "fats and oils," it is understood to mean the same kind of material as fat, except that it is completely liquid instead of partly solid at ordinary temperatures. This kind of oil differs fundamentally from various other liquids which are also called oils, and is sometimes called fatty oil or fixed oil to distinguish it from such entirely different substances as mineral oil and essential oil.

Among chemists, the use of the word "fat" to include both fats and fatty oils is becoming common, so that in the chemical sense, cottonseed oil and cocoa butter both are fats. Also, in chemical usage, the word is restricted to exclude various materials which resemble fats in solubility and other properties but differ in their chemical make-up. To a chemist, therefore, the word "fat" means a substance which consists mainly of the esters of fatty acids and glycerol, but which may contain minor proportions of other esters and nonester material naturally associated with the fatty esters.

The broader term, which includes fat and other ether-soluble materials extractable from plant and animal matter, is lipide.* In the United States, the terminology proposed by Bloor[4] is accepted rather generally. His classification, somewhat modified and abbreviated, is as follows:†

Simple lipides. Esters of fatty acids with various alcohols.

Fats. Esters of fatty acids with glycerol.

Waxes. Esters of fatty acids with alcohols other than glycerol.

Compound lipides. Compounds of the fatty acids with alcohols, containing other groups also.

Phospholipides (phosphatides). Esters containing both fatty acid and phosphoric acid, and usually a nitrogenous group.

Cerebrosides (glycolipides). Compounds of the fatty acids with

* The spelling *lipid* for this word is preferred by some and is found often in the publications of biochemists. The spelling *lipide* is used in this book in conformity with the opinion of the leading American authority on chemical nomenclature, who says,[12] "It is not hard to show that the -ide spelling is the one legitimate one in English for such words as chloride, sulfide, amide, anilide, glucide, lipide, and what have you. . . . Examination shows that authors who write 'lipid' usually spell peptide, glucoside, phosphatide, and similar terms in the usual -ide way. Will they not help us make the -ide spelling unanimous? . . . Pronounce -ide, by the way, as in ride, not as in rid."

† For a more detailed classification, see ref. 5.

carbohydrate and a nitrogen compound, but containing no phosphoric acid.

Other compound lipides.

Derived lipides. Substances derived from the preceding group and having the general properties of the lipides.

Fatty acids.

Alcohols. Mostly normal chain higher alcohols and sterols.

In Britain, until very recently, the lipides were more commonly termed *lipoids*, and the compound lipides were comprised in the term *lipins*, but now the trend appears to be toward uniform usage in the English-speaking world.[9]

Classification of Fats

Various schemes of classification of fats have been used, based on biological origin, physical characteristics, composition or use, or combinations of these factors. Thus, it is usual first to put the fats into two groups, vegetable fats and oils and animal fats and oils. The vegetable fats and oils sometimes have been grouped, on the basis of their suitability for use in paints, into drying oils, semidrying oils, and nondrying oils. Besides overemphasizing one of the uses of fats, this distinction has never been a very precise one, and is becoming less so as oils formerly classed as semidrying, such as soybean oil, are being used more and more in paints, varnishes, and other products that dry in a highly satisfactory way. Another method is to group the fats according to the kind of fatty acid which distinctively characterizes or predominates in the fat. Thus, coconut oil and similar oils would be in the lauric acid group, castor oil in the hydroxy acid group, tung oil in the conjugated acid group, rapeseed oil in the erucic group, and so on to any degree of distinction desired. Although this method of classification is instructive, a difficulty is that the acid which distinguishes one fat from another often is not the one which is present in the largest proportion, and many cases of doubt as to where to classify a given fat occur.

In the present work, no attempt at comprehensive classification of the vegetable fats and oils as such will be made. The order in which they will be treated in the part dealing with the individual fats and oils, will be based on the botanical classification of the plants from which they are obtained. In other words that part of the book is arranged according to the kind of plant from which the fat is obtained.

Naming of Plant Source

Since common names of plants often vary according to locality, and the same name often applies to more than one plant, it is desirable to use the system of naming used by botanists in designating the source of a vegetable fat. The scientific designation of any plant is in terms of a Latin binomial which names the genus and species to which the plant belongs. The species is the unit in plant classification, and in general may be taken to denote any organism which shows recognizable and constant differences in structure from all other organisms. A genus is a group of species which show closer resemblance to each other than they do to any other species. On similar principles, botanists have grouped genera into families, families into orders, orders into classes, and classes into the few broad divisions of the plant kingdom.

In the conventional usage, the generic name is a Latin substantive, written with a capital letter, and the species name is adjectival. Thus the plant from which linseed oil is obtained is *Linum usitatissimum*. Families of plants in general have names ending in -aceae, and orders usually have names ending in -ales. Thus *Linum usitatissimum* belongs to the flax family, Linaceae, which with related families constitutes the order Geraniales. Carrying the grouping up to the higher categories, the Geraniales fall in the subclass Archichlamydeae which is in the class Dicotyledonae of the subdivision Angiospermae of the division Spermatophyta, or seed-bearing plants.

Broad Outline of the Vegetable Kingdom

An outline of the main divisions, subdivisions, and classes into which the vegetable kingdom may be organized is given in Table 1-1. This outline, in general, follows the system of Engler and Prandtl which is the one most generally used in manuals and textbooks of botany. The sequence in which the different categories are placed in the outline is, roughly, the order of evolutionary development of the plants, with the simpler more primitive plants put at the beginning and the more highly developed organisms at the end.

If Table 1-1 were expanded to show all the known orders, families, genera, and species of plants, it would comprise about 300,000 species,[10] the majority of which would be in the division Spermatophyta, which has been estimated to include about 200,000 species belonging to nearly 300 families.

Probably all plants contain some fat, although many have less than one per cent of ether-soluble material. The most interesting ones, from the standpoint of fat content, are those which contain a large enough proportion of fat in some part of the plant to make its extraction economically practical, or in which the fat is an important nutrient when the plant is consumed as food or feed, or which contain fats with some distinctive property of special scientific or medical interest.

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TABLE 1-1. ABBREVIATED OUTLINE OF THE PLANT KINGDOM[1,13,14]

Divisions / Subdivisions / Classes	Characterization and Familiar Examples
Thallophyta, The Thallophytes	Simple plants without true roots, stems, leaves, flowers or seeds.
Algae	Generally able to manufacture food by means of chlorophyll.
Cyanophyceae	Blue-green algae.
Chlorophyceae	Green algae, including "pond scums."
Phaeophyceae	Brown algae. Brown seaweeds and kelps.
Rhodophyceae	Red algae. Marine plants, including the one from which agar is obtained.
Fungi[22]	Thallophytes that lack chlorophyll. Live as parasites or saprophytes.
Schizomycetes[3]	Bacteria.
Myxomycetes	Slime fungi.
Phycomycetes	Alga-like fungi, including water molds, white rusts, blights.
Ascomycetes	Sac fungi, including yeasts, blue molds, powdery mildews, morels, ergot.
Basidiomycetes	Club fungi, including rusts, smuts, mushrooms, puffballs.
Lichens	Composite plants, consisting of alga and fungus growing together.
Bryophyta, The Bryophytes	Small plants without wood, flowers or seeds. Some have simple stems and leaves.
Hepaticae	Liverworts.
Musci	Mosses.
Pteridophyta, The Pteridophytes	Green plants without flowers or seeds, but with true roots and usually stems and leaves clearly differentiated.
Filicineae	Ferns.
Equisetineae	Horsetails or scouring rushes.
Lycopodineae	Club mosses.
Spermatophyta, The Spermatophytes	Seed-bearing plants. Constitute the greater part of the vegetation of the earth.
Gymnospermae	Woody plants, bearing naked seeds, not enclosed in a pod. Pine, fir, ginkgo, sequoia, cypress.
Angiospermae	Flowering plants. Largest group of modern plants.
Monocotyledonae	One seed-leaf or cotyledon; stems have scattered vascular bundles; leaves have parallel veins. Examples: palms, grasses, lilies.
Dicotyledonae	Two or more cotyledons; stems have single cylinder of vascular bundles with a functioning cambium; leaves have netted veins. Examples: beans, olive, flax.

TABLE 1-2. SOME OF THE ORDERS AND FAMILIES OF FLOWERING PLANTS

Order	Family	English Name of Family	Representative Plants, and Fats They Yield	
			MONOCOTYLEDONAE	
Glumiflorae (Graminales)	Gramineae	Grass	*Zea mays*, Corn	Corn Oil
Principes	Palmae	Palm	*Cocos nucifera*, Coconut Palm	Coconut Oil
			Elaeis guineensis, Oil Palm	Palm Oil (from fruit coat)
				Palm Kernel Oil
			DICOTYLEDONAE	
Myricales	Myricaceae	Sweet Gale	*Myrica cerifera*, Wax Myrtle	Bayberry Tallow
Juglandales	Juglandaceae	Walnut	*Juglans regia*, Persian or English Walnut	Walnut Oil
Fagales	Betulaceae	Birch	*Corylus avellana*, Hazelnut Tree	Hazelnut (Filbert) Oil
	Fagaceae	Beech	*Quercus rubra*, Oak Tree	Acorn Oil
Urticales	Ulmaceae	Elm	*Ulmus americana*, Elm Tree	Elm Seed Oil
	Moraceae	Mulberry	*Cannabis sativa*, Hemp	Hemp Seed Oil
Proteales	Proteaceae	Protea	*Macadamia ternifolia*, Macadamia Tree	Macadamia Nut Oil
Santalales	Santalaceae	Sandalwood	*Santalum album*, Sandalwood Tree	Sandalwood Seed Oil
Ranales	Myristicaceae	Nutmeg	*Myristica fragrans*, Nutmeg Tree	Nutmeg Butter
	Lauraceae	Laurel	*Persea gratissima*, Avocado	Avocado Oil
Rhoeadales	Papaveraceae	Poppy	*Papaver somniferum*, Poppy	Poppy Seed Oil
	Moringaceae		*Moringa oleifera*, Ben Tree	Ben Seed Oil
	Cruciferae	Mustard	*Brassica campestris*, Rape	Rapeseed Oil, Colza Oil
Rosales	Rosaceae	Rose	*Licania rigida*, Oiticica Tree	Oiticica Oil
	Leguminosae	Pea	*Soja max*, Soybean	Soybean Oil
			Arachis hypogaea, Peanut	Peanut Oil
Geraniales	Linaceae	Flax	*Linum usitatissimum*, Flax	Linseed Oil
	Rutaceae	Rue	*Citrus grandis*, Grapefruit	Grapefruit Seed Oil
	Simarubaceae	Quassia	*Irvingia gabonensis*	Dika Fat
	Meliaceae	Mahogany	*Azadirachta indica*, Mahogany Tree	Neem Oil
	Euphorbiaceae	Spurge	*Aleurites fordii*, Tung Tree	Tung Oil, China Wood Oil

TABLE 1-2. SOME OF THE ORDERS AND FAMILIES OF FLOWERING PLANTS.—(Continued)

Order	Family	English Name of Family	Representative Plants, and Fats They Yield	
			DICOTYLEDONAE	
Sapindales	Buxaceae	Buxus	*Simmondsia californica*, Jojoba	Jojoba Oil*
	Anacardiaceae	Sumac	*Rhus succedanea*, Sumac Tree	Japan Wax*
Rhamnales	Vitaceae	Grape	*Vitis vinifera*, Grapes	Grape Seed Oil
Malvales	Malvaceae	Mallow	*Gossypium hirsutum*, Cotton	Cottonseed Oil
	Sterculiaceae	Cacao	*Theobroma Cacao*, Cacao Tree	Cacao Butter, Cocoa Butter
	Bombacaceae	Bombax	*Ceiba pentandra*, Kapok Tree	Kapok Oil
Parietales	Theaceae (Ternstroemiaceae)	Tea	*Thea chinensis*, Tea	Teaseed Oil
	Guttiferae	Garcinia	*Garcinia indica*	Kokum Butter
	Flacourtiaceae	Flacourtia	*Hydnocarpus wightiana*	Chaulmoogra Oil
Myrtiflorae	Myrtaceae	Myrtle	*Bertholletia excelsa*, Brazil Nut Tree	Brazil Nut Oil
Umbelliflorae	Umbelliferae	Parsley	*Petroselinum sativum*, Parsley	Parsley Seed Oil
	Araliaceae	Ginseng	*Hedera helix*, Ivy	Ivy Seed Oil
Ebenales	Ebenaceae	Ebony	*Diospyros virgineana*, Persimmon Tree	Persimmon Seed Oil
	Sapotaceae	Sapodilla	*Butyrospermum Parkii*	Shea Butter
Contortae	Oleaceae	Olive	*Olea europea*, Olive Tree	Olive Oil
(Gentianales)	Asclepiadaceae	Milkweed	*Asclepias syriaca*, Milkweed	Milkweed Seed Oil
Tubiflorae	Labiatae	Mint	*Perilla frutescens*, Perilla	Perilla Oil
	Solanaceae	Nightshade	*Lycopersicum esculentum*, Tomato	Tomato Seed Oil
	Pedaliaceae	Pedalium	*Sesamum indicum*, Sesame	Sesame Oil
Rubiales	Rubiaceae	Madder	*Coffea arabica*, Coffee Tree	Coffee Oil
	Caprifoliaceae	Honeysuckle	*Sambucus canadensis*, Elderberry	Elderberry Seed Oil
Campanulales	Cucurbitaceae	Gourd	*Cucurbita pepo*, Pumpkin	Pumpkin Seed Oil
	Compositae	Composite	*Helianthus annus*, Sunflower	Sunflower Oil

* Chemically, Jojoba Oil is not a fatty oil, but a liquid wax containing no glycerides. Japan Wax, on the other hand, is a fat, not a wax.

Generally speaking, the fats in the more primitive plants falling in the first three divisions, the Thallophytes, Bryophytes and Pteridophytes, are of more scientific than practical interest. As far as this writer is aware, none of these plants at present serves as a commercial source of fat, although numerous attempts have been made, especially during wartime shortages, to develop practical methods for using certain strains of molds and yeasts as generators of fat. Fat contents as high as 50 per cent of the dry weight of the mycelium have been achieved. The process of growing selected fungi on a cheap nutrient like sulfite liquor may become an economical source of fat and protein.[7]

Most of the fats which are described in detail in this book are derived from the Spermatophytes or seed-bearing plants, since this division accounts for most of the vegetable fat that is useful to mankind. This is not only because the seed-bearing plants constitute the greater part of the vegetation of the earth, but also because reserve fats so often are concentrated in the seed or in the seed and fruit.

Orders and Families of Flowering Plants

Some of the families of flowering plants that include species whose names occur frequently in the literature on fats and oils are listed in Table 1-2, together with the name of a representative species belonging to each family, and the name of the fat which it yields. Some of the plants named are important sources of commercial supplies of fat and some are not. The list illustrates some of the relationships which will become apparent in more detail in the part of this book covering the individual fats.

The botanical relationships shown among the various plants whose fats are described are generally consistent with the synopses given in L. H. Bailey's "Standard Cyclopedia of Horticulture"[2] and "Gray's Manual of Botany," Eighth Edition.[6]

Fats Produced in Largest Tonnages

Of the thousands of species of oil-bearing plants, less than a score account for more than nine-tenths of the tonnage of vegetable fat used in the world. The oil crops produced in the greatest volume are as shown on page 9.[8]

To this list may be added corn and cacao, which are not grown primarily as oil crops but which yield important tonnages of fat from the portion of the crop which is extracted.

The order in which the crops appear in this list may seem surprising, since some oils that are of relatively minor importance in the United States are high in the list. Peanuts, for example. are grown and used for

Oil Crop	Millions of Pounds of oil in the estimated average annual world production of the crop, 1934–1938	Principal Producing Localities
Coconuts	5,900	Indonesia, Philippines, India (including Burma), Ceylon, Malaya, Oceania.
Peanuts	5,200	India, China, French W. Africa, U.S.A., Nigeria.
Cottonseed	4,400	U.S.A., India, China, U.S.S.R., Brazil, Egypt.
Soybeans	4,000	China, Manchuria, U.S.A., Korea.
Rapeseed and Mustard seed	3,000	China, India, Europe, Japan.
Flaxseed (Linseed)	2,600	Argentina, U.S.A., U.S.S.R., India, Europe.
Olive	1,900	Spain, Italy, Greece, Portugal, Syria, Tunisia, Algeria, Lebanon.
Palm (fruit)	1,600	Africa, Indonesia, Malaya.
Sesame	1,500	China, India, Burma, East Africa.
Sunflower	1,300	U.S.S.R., Romania, Bulgaria, Argentina.
Palm kernels	700	Africa, Indonesia.
Castor	446	Brazil, India, U.S.S.R.
Hempseed	290	U.S.S.R., China and Manchuria, Europe.
Tung	170	China, U.S.A.
Babassu	26	Brazil.

oil production in much greater quantity in other parts of the world than in the United States. An estimate of the quantity of vegetable fats and oils actually produced as such is given in Table 1-3.

In volume of world trade, the list would fall into a different order. Coconuts would still head the list, because a large proportion of the total production of coconut oil is exported from the countries where it originates, either as oil or in the form of copra. Peanuts would stay in second place, but from there on the order would be quite different. Only a small proportion of the huge cottonseed crop is exported from the countries where it originates. India's rapeseed oil and mustard seed oil are consumed mostly within the country. The same is true of sesame in Burma and sunflower in the U.S.S.R. On the other hand, India's flaxseed crop goes largely to more industrialized countries where linseed oil is in demand by the drying oil industries. Palm oil and palm kernels rank high in world trade, being produced largely for export.

The vegetable fats currently most important in the United States from the standpoint of tonnage consumed, are listed in Table 1-4. The values given in the table do not stay the same from year to year. Besides the changes in total consumption caused by changes in population and economic conditions, there have been remarkable shifts in the usage of

TABLE 1-3. ESTIMATED WORLD PRODUCTION OF FATS AND OILS[a]
(In millions of pounds)

Commodity	Total in fat or oil equivalent				
	Average 1935–39	1948	1949	1950	1951[d]
Edible vegetable oils[b]					
Cottonseed	3,440	3,000	3,244	3,000	3,640
Peanut	3,320	3,750	3,860	3,880	3,930
Soybean	2,710	3,294	3,030	3,900	3,820
Sunflower	1,240	1,840	1,930	1,670	2,040
Olive	1,920	1,060	2,346	1,210	2,950
Sesame	1,440	1,440	1,550	1,550	1,530
Total	14,070	14,384	15,960	15,210	17,910
Palm oils[c]					
Coconut	4,260	2,860	3,840	3,980	4,570
Palm kernel	820	770	890	960	870
Palm	2,120	1,040	2,330	2,430	2,430
Babassu kernel	60	98	80	100	90
Total	7,260	4,768	7,140	7,470	7,960
Industrial oils[b]					
Linseed	2,290	2,548	2,440	2,292	2,150
Castor bean	400	460	440	460	450
Rapeseed	2,660	3,288	3,314	3,360	3,320
Oiticica	20	40	16	28	18
Tung	300	300	230	250	280
Perilla seed	130	10	10	10	12
Total	5,800	6,646	6,450	6,400	6,230
Animal fats					
Butter (fat)	7,960	5,912	6,500	6,660	6,800
Lard	5,500	5,000	5,560	5,940	6,500
Tallow and greases	3,180	4,120	4,320	4,530	4,470
Total	16,640	15,032	16,380	17,130	17,770
Marine oils					
Whale	1,090	770	840	850	860
Sperm whale	60		140	110	180
Fish (incl. liver)	1,000	520	620	750	790
Total	2,150	1,290	1,600	1,710	1,830
Estimated world total	45,920	42,120	47,530	47,920	51,700

[a] From Foreign Agriculture Circular FFO 3-51, March 16, 1951; FFO 3-52, March 24, 1952, Office of Foreign Agricultural Relations, U. S. Department of Agriculture, Washington, D. C.

[b] In the case of vegetable oilseeds, oil production has been estimated by assuming for each of the various crops that a certain proportion was crushed for oil. The years shown refer to the years in which the seed was produced and not necessarily when the oil was extracted.

[c] Estimated on the basis of exports and the limited information available on production and consumption in the various producing areas.

[d] Preliminary.

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