UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 769

Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief

Washington, D. C. ▼ February 10, 1919

THE PRODUCTION AND CONSERVATION OF FATS AND OILS IN THE UNITED STATES

By

HERBERT S. BAILEY, Chemist in Charge, Oil, Fat, and Wax Laboratory, in Collaboration with B. E. REUTER, Chief, Fats and Oils Division, U. S. Food Administration

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ERRATA.

Table 1. The figures for the production of linseed oil in 1912, 1914, 1916, and 1917 should be 461,000,656, 507,422,111, 531,586,115, and 482,-198,766, respectively.

Table 7. The production of edible soy bean oil for January should be 2,960,194 pounds. The production of red oil for January should be 1,614,710, and for February 1,740,978 pounds.

The figures given in this bulletin are corrected only up to July 1, 1918, and are, therefore, subject to revision.

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THE PRODUCTION AND CONSERVATION OF FATS AND OILS IN THE UNITED STATES.[1]

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CONTENTS.

IMPORTANCE OF FATS AND OILS.

Not only are fats and oils a necessary part of our food supply, but they also occupy an important place in the manufacture of certain munitions, in the lubrication of aircraft engines, and in the mixing of paints, varnishes, waterproofings, and like compounds. Nowadays when a nation goes to war, one of its first resources to feel the effect of the abnormal conditions is the stock of fats and oils. Because the sum total of the world's supply of these substances is less than that of either of the other two basic food constituents, carbohydrates and proteins, a sudden drain, even though comparatively small, is quickly noticed. A great war soon creates such a drain, largely because of the imperative need for an enormous amount of nitroglycerin, one of the component parts of which is glycerin, obtained as a by-product in the manufacture of soap from certain oils and fats. When it is considered that 10 tons of fat are required to yield 1 ton of glycerin, and that but 1 part of glycerin to every 9 parts of fatty acids, or soap, is produced from the oils and fats, it is not surprising that the price of glycerin in England soared from $250 to $1,250 a ton within a very short time after that country entered the Great War.

[1] The authors wish to express their appreciation to Mr. J. E. Wrenn, of the U. S. Food Administration, for his valuable assistance in the collection and compilation of the data which they have used, and to Miss K. A. Smith, Bureau of Chemistry, for her efficient services in editing this work.

A comparison of the data in Tables 1 to 7 indicates that, as a people, we are rapidly increasing our use of vegetable oils. This is due partly to the recent advances in our processes of making hardened fats from oil by hydrogenation (page 10), and partly to the increased consumption of oleomargarine and vegetable margarine. Not only have our domsetic requirements for fats and oils increased, but during the past four years the allies, especially England, were to a large extent cut off from their usual sources of supply, the colonies in Africa and Asia.

Fortunately we did not reach the position in which Germany found herself at the outbreak of the Great War—almost entirely dependent upon foreign countries for vegetable oils. For many years Germany had been mobilizing her resources, while preparing industrially and agriculturally for war. She had, however, permitted a very serious lapse in her scheme for making herself self-sustaining, in failing to provide for an adequate supply of fats and oils for food and technical needs. The advice of some of the foremost German scientists that those crops which would yield enough oil to supply the country's needs be developed was disregarded, and potatoes, grains, and sugar beets were planted, to the exclusion of the oil-producing crops. From the beginning of the war, therefore, Germany was forced to depend almost entirely on other nations for the important vegetable fats and oils. Although possessing numerous oil mills, the materials which they pressed necessarily came from the overseas colonies, or from foreign countries.

In addition to the oils obtained from her own mills, Germany, before the war, imported a great deal from France, England, and the United States. So when the war cut off these supplies, the Germans were forced to fall back upon animal fats and oils. These might have proved sufficient to furnish the oil necessary for the proper nourishment of the people and for the production of glycerin for the armies, had it not been for the unfortunate lack of feed for the maintenance of the herds of swine, cattle, and sheep. To supplement the potatoes, hay, and grain fed to the stock, the accustomed concentrates derived from the oil mills were needed. Since the supply of raw materials for these mills was not forthcoming, it became necessary to slaughter large numbers of hogs and other animals because of the lack of concentrates to feed them. For a time this compensated, to a certain extent, for the lack of vegetable oils previously imported, but soon Germany found herself very seriously embarrassed by a shortage of fats and oils. This situation makes it quite evident that a well-rounded agriculture should include oil-producing crops.

DOMESTIC PRODUCTION AND IMPORTATION.

In normal times the United States produces nearly 4,000,000,000 pounds of fats and oils, exclusive of butter fat, imports over 300,000,000, exports about 1,000,000,000, and consumes nearly 3,500,000,000 pounds. Including the fat in the butter and cheese made in this country, the total production is about 6,000,000,000 pounds, or 30,000,000 tons. The data upon which these summaries are based are derived from figures compiled by the Fats and Oils Division of the Food Administration and various other Government agencies, and are given in detail in Tables 1 to 7.[1]

Table 1.—*Production of vegetable oils in the United States.*

Oil.	1912	1914	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Castor	5,145,000	5,449,000	9,302,000	6,188,000
Coconut	31,729,000	38,272,000	104,727,000	188,488,000
Coquito			803,000	
Corn	72,832,000	91,810,000	109,963,000	118,021,000
Cottonseed	1,435,401,000	1,789,777,000	1,492,430,000	1,343,674,000
Grape seed	320,000	435,000	752,000	667,000
Linseed	364,625,000	406,669,000	464,595,000	400,266,000
Mustard seed	360,000	306,000	729,000	1,098,000
Olive	966,000	1,128,000	1,461,000	963,000
Palm kernel	3,200,000	402,000	8,619,000	6,453,000
Peanut	454,000	1,006,000	28,534,000	50,287,000
Rapeseed	90,000	19,000	223,000	232,000
Sesame		30,000	129,000	304,000
Shea nut			3,974,000	81,000
Soy bean		2,764,000	9,920,000	42,074,000
Sunflower seed				5,000
All other vegetable oils	41,000	118,000	346,000	534,000
Total	1,966,613,000	2,338,185,000	2,236,507,000	2,159,335,000

Table 2.—*Production of animal and fish fats and oils in the United States.*

Product.	1912	1914	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Bone grease	29,267,000	41,926,000	34,061,000	30,668,000
Cod and cod liver oil	372,000	394,000	366,000	439,000
Garbage grease	29,812,000	39,935,000	49,873,000	56,229,000
Herring oil	1,888,000	1,512,000	1,476,000	1,637,000
Lard	731,164,000	890,765,000	1,091,967,000	873,798,000
Menhaden oil	40,787,000	17,966,000	20,810,000	19,627,000
Miscellaneous oils	2,639,000	2,037,000	3,260,000	2,575,000
Neat's foot oil	5,201,000	5,184,000	7,268,000	8,345,000
Neutral lard	51,414,000	51,303,000	76,163,000	52,712,000
Oleo stock	122,568,000	143,247,000	152,476,000	153,188,000
Packers' and renderers' greases	122,312,000	167,403,000	172,693,000	162,707,000
Sperm oil	3,832,000	1,934,000	3,906,000	3,285,000
Tallow	201,334,000	221,073,000	265,424,000	259,509,000
Whale oil	931,000	632,000	1,691,000	1,193,000
Wool grease and recovered grease	7,481,000	9,723,000	14,630,000	7,702,000
All other fish oils	815,000	1,123,000	1,709,000	2,837,000
Total	1,351,867,000	1,596,157,000	1,898,774,000	1,636,451,000

Table 3.—*Total production of fats and oils in the United States.*

Product.	1912	1914	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Vegetable oils	1,966,613,000	2,338,185,000	2,236,507,000	2,159,335,000
Animal fats	1,351,867,000	1,596,157,000	1,898,774,000	1,636,451,000
Total	3,318,480,000	3,934,342,000	4,135,281,000	3,795,786,000
Butter[2] (farm)	1,660,000,000	1,613,736,000	879,610,000	733,222,000
Butter[2] (factory)	[3] 581,000,000	652,382,000	609,398,000	636,278,000
Total	2,241,000,000	2,266,118,000	1,489,008,000	1,369,500,000
Grand total	**5,559,480,000**	**6,200,460,000**	**5,624,289,000**	**5,165,286,000**

[1] The figures given in these and subsequent tables were compiled by the Fats and Oils Division of the United States Food Administration, from a careful survey made during 1917 and 1918.

[2] These figures represent the average butter fat content of butter, or 83 per cent of the total butter produced.

[3] Estimated.

TABLE 4.—*Importation of fats and oils into the United States.*

Product.	1912	1914	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Chinese nut oil	42,787,000	30,139,000	57,649,000	41,190,000
Coconut oil	46,720,000	58,012,000	64,349,000	163,091,000
Cottonseed oil	2,160,000	16,016,000	16,598,000	13,826,000
Linseed oil	2,135,000	4,350,000	711,000	633,000
Olive oil, edible	43,460,000	50,857,000	55,435,000	51,055,000
Olive oil, inedible	5,694,000	5,609,000	6,334,000	4,476,000
Palm oil	52,771,000	49,092,000	29,270,000	34,257,000
Palm kernel oil	27,681,000	21,089,000	4,324,000	306
Peanut oil	7,626,000	7,365,000	15,674,000	27,405,000
Rapeseed oil	10,266,000	11,172,000	20,181,000	10,132,000
Soy bean oil	24,959,000	12,555,000	145,409,000	264,926,000
Oleostearin	9,178,000	4,030,000	649,000	5,555,000
Cod and cod liver oil	21,727,000	14,198,000	10,973,000	16,618,000
All other fish oils	....	1,459,000	3,117,000	3,124,000
Total	297,164,000	285,943,000	430,673,000	636,288,306

TABLE 5.—*Exportation of fats and oils from the United States.*

Product.	1912	1914	1916	1917
Vegetable oils:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Chinese nut (tung)	80,000	106,000	132,000	244,000
Coconut	358,000	506,000	478,000	1,830,000
Corn	22,870,000	16,204,000	9,119,000	4,709,000
Cottonseed	356,288,000	216,410,000	188,214,000	124,843,000
Linseed	3,151,000	1,994,000	6,180,000	10,724,000
Olive, edible	59,000	52,000	392,000	436,000
Palm	112,000	133,000	57,000	31,000
Palm kernel	75,000	358,000	5,000	167,000
Peanut	7,000	96,000	171,000	145,000
Soy bean	184,000	3,000	2,063,000	3,977,000
Animal and fish products:				
Fish oils (except whale)	9,375,000	1,490,000	954,000	895,000
Lard	495,093,000	438,016,000	426,660,000	373,349,000
Lard, neutral	57,556,000	21,798,000	27,265,000	9,395,000
Lard oil	1,224,000	767,000	2,279,000	1,911,000
Oleo oil	95,345,000	85,145,000	83,892,000	33,403,000
Stearin (animal)	1,524,000	3,239,000	13,217,000	8,375,000
Tallow	28,989,000	9,980,000	15,338,000	7,506,000
All other fish and animal oils	10,729,000	4,793,000	4,207,000	2,314,000
Total	1,082,019,000	802,100,000	780,623,000	584,254,000

TABLE 6.—*Comparison of production with importation and exportation of fats and oils in 1917.*

Product.	Produced.	Imported.	Exported.
Vegetable oils:	*Pounds.*	*Pounds.*	*Pounds.*
Chinese nut	....	41,091,000	244,000
Coconut	188,488,000	163,091,000	1,830,000
Corn	118,021,000	....	4,709,000
Cottonseed	1,343,674,000	13,826,000	124,843,000
Linseed	400,266,000	633,000	10,724,000
Olive, edible	965,000	51,055,000	436,000
Olive, inedible	....	4,476,000	....
Palm	....	34,257,000	31,000
Palm kernel	6,453,000	306	167,000
Peanut	50,287,000	27,405,000	145,000
Rapeseed	232,000	10,132,000	....
Soy bean	42,074,000	264,926,000	3,977,000
Animal and fish products:			
Cod and cod liver oil	439,000	16,618,000	....
Fish oil (except whale)	24,101,000	....	895,000
Lard	873,798,000	....	373,349,000
Lard, neutral	52,712,000	....	9,395,000
Lard oil	37,930,000	....	1,911,000
Oleo oil	143,086,000	....	33,403,000
Oleostearin	74,342,000	5,555,000	[2] 8,375,000
Tallow	259,509,000	....	7,506,000
All other fish and animal oils	....	3,124,000	2,314,000
Total	[1] 3,616,379,000	636,288,306	584,254,000

[1] This figure does not represent the total United States production, as commodities on which neither export nor import figures are obtainable are not included, and some derivatives are given (p. 43).
[2] Reported as stearin (animal).

TABLE 7.—*Monthly production of fats and oils and their derivatives in the United States, January–June, 1918.*

Product.	January.	February.	March.	April.	May.	June.
VEGETABLE OILS.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Castor	1,443,772	677,638	599,113	579,770	440,673	677,000
Coconut, edible	6,719,350	9,923,637	11,338,237	8,459,148	9,993,897	6,088,000
Coconut, inedible	20,770,528	16,480,296	15,742,276	18,629,678	19,731,904	14,064,000
Corn, edible	7,150,985	6,000,259	7,834,048	9,977,630	6,396,056	5,696,000
Corn, inedible	1,053,126	2,385,196	2,695,421	2,754,240	2,293,607	2,270,000
Cottonseed, crude	89,463,523	79,712,799	58,139,702	56,646,750	24,226,883	14,151,000
Cottonseed, refined	115,551,172	128,984,340	114,200,549	128,768,474	78,536,484	45,105,950
Linseed	29,123,502	26,704,069	33,266,033	26,351,907	34,542,889	35,359,000
Mustard seed	51,315	99,793	86,884	84,203	139,959	134,000
Olive	86,250	122,545	12,550	490	4,500	637
Palm kernel, edible	569,423	47,390	....	27,760	....	....
Palm kernel, inedible	198,690	603,173	137,475	....	548,960	93,000
Peanut, edible	11,644,371	6,033,237	6,995,593	6,200,264	5,001,446	2,273,000
Peanut, inedible	1,490,036	1,183,631	620,245	891,126	627,329	....
Raisin seed	....	....	....	36,795	13,665	35,481
Rapeseed	....	....	6,000	....	....	9,000
Soy bean, edible	12,960,194	4,564,739	3,971,687	4,970,523	6,088,737	2,468,000
Soy bean, inedible	144,360	161,382	266,500	106,818	....	16,000
All other vegetable oils	7,792	26,707	46,641	....	....	....
Vegetable stearin	56,634	2,418,749	4,559,404	3,146,639	2,563,304	7,953,000
ANIMAL FATS AND OILS.						
Bone grease	2,979,619	3,103,739	1,947,424	2,174,495	1,729,610	1,745,000
Cod and cod liver oil	1,950	....	....	....	....	....
Garbage grease	4,000,519	4,465,523	4,153,072	4,505,999	5,467,644	4,818,378
Herring oil	11,250	....	....	....	1,875	56,000
Horse oil	7,676	11,008	60,476	79,378	13,950	....
Lard, edible	78,962,590	79,477,832	80,337,257	92,699,313	83,725,853	70,803,000
Lard, inedible	2,699,938	2,912,562	2,780,711	2,140,804	456,139	505,000
Lard, neutral	5,000,224	9,280,458	8,640,417	5,808,963	6,233,545	6,636,000
Menhaden oil	....	3,375	9,750	30,004	391,525	2,553,000
Miscellaneous animal oils	....	38,787	16,420	384,396	6,375	4,156
Miscellaneous fish oils	61,610	61,875	5,323	1,920	2,721	80
Neat's foot oil and stock	699,346	701,675	577,495	577,943	682,846	749,000
Oleo stock	10,922,707	8,987,167	11,812,495	12,725,623	10,106,161	8,103,000
Sperm oil	....	....	....	....	....	22
Tallow, edible	3,792,503	4,094,420	3,505,225	2,638,381	2,032,463	2,290,000
Tallow, inedible	19,308,145	17,902,662	18,209,310	20,149,658	16,778,122	17,459,000
Wool grease and recovered grease	961,025	785,279	887,096	1,205,465	1,279,145	1,099,619
DERIVATIVES.						
Acidulated soap stock	3,670,609	3,408,528	3,527,718	3,872,388	1,377,676	1,776,000
Cottonseed foots	11,549,560	10,703,653	12,080,603	12,492,580	7,850,512	6,943,000
Cottonseed foots (distilled)	2,316,655	3,558,083	4,483,993	5,131,430	3,252,285	2,163,000
Fatty acids	2,522,639	5,805,178	6,008,332	6,738,115	6,774,469	5,674,000
Fatty acids (distilled)	1,791,792	1,986,564	1,315,381	3,365,586	2,935,817	3,267,000
Greases:						
Brown	195,539	114,598	981,854	1,315,440	1,319,356	1,170,047
Curriers	11,500	54,023	18,120	25,194	87,538	19,000
Sewer	....	1,606	29,569	39,464	43,965	56,000
Tankage	7,556,620	8,527,756	5,115,303	5,563,400	4,092,380	4,293,000
White	405,925	1,465,780	3,746,116	4,134,256	3,163,110	2,882,000
Yellow	504,040	527,193	2,252,941	3,120,373	2,243,476	2,448,000
Miscellaneous	102,710	265,432	990,034	188,563	1,209,053	1,293,065
Lard oil	5,258,719	2,921,371	3,648,001	1,755,847	2,482,669	2,195,000
Lard stearin	242,161	334,588	871,828	724,711	674,967	334,000
Mutton oil	4,620	24,865	41,617	25,157	15,747	9,000
Oleo oil, edible	11,307,556	11,027,811	10,625,367	16,892,620	13,019,724	11,851,000
Oleo oil, inedible	621,559	....	....	45,214	1,420	200,000
Red oil	319,426	153,830	2,797,104	3,488,362	3,956,889	3,439,000
Other soap stock	1,510,216	2,564,317	2,947,033	210,288	66,110	198,260
Stearic acid	299,187	701,199	2,325,774	2,194,996	2,003,169	1,752,000
Tallow and oleo stearin, edible	6,371,110	5,855,167	5,819,072	9,437,245	4,487,541	6,646,000
Tallow and oleostearin, inedible	584,308	532,540	1,268,765	993,432	5,193,206	426,000
Tallow oil	....	516,676	93,730	139,982	116,230	70,600
All other foots	30,203	206,340	836,662	1,676,150	633,340	985,000
All other stearin	271,993	....	1,060	....	....	....

Unfortunately the statistics on the fat and oil situation in the United States in recent years are not entirely complete, so that it was necessary to make some assumptions in the compilation of these tables. In Tables 1 and 2 the productions given are those reported to the Food Administration by a large number of oil manufacturers, but it has been difficult to secure proper returns in some cases, and undoubtedly many of the smaller oil mills and slaughter houses have been overlooked. It is felt, however, that these figures are at least 95 per cent correct.

In Tables 4 and 5 the weight in pounds of some of the vegetable oils is calculated from the amount in gallons, as reported by the Customs Service, assuming the trade weight of a gallon of all oils except olive to be 7.5 pounds, and that of olive oil to be 7.56 pounds. The total fat and oil produced in the United States as given in Table 3 includes the butter fat in factory and farm butter. As the average fat content of butter was assumed to be about 83 per cent, the figures in this table represent only 83 per cent of the total butter production as reported by the Dairy Division of the U. S. Department of Agriculture. It is obvious that these grand totals do not include nearly all of the fat or oil in this country, as in milk alone an immense quantity of butter fat is consumed. Cheeses also are rich in this fat, containing from 30 to 35 per cent, and olives, some grains, nuts, and especially meats add very largely to the supply of food fats. From a technical point of view, however, when we have covered the pure fats and oils and butter we have included all products used primarily as fats or oils in the dietary and for manufacturing purposes.

It is very difficult to compare our domestic production of fats and oils with the available data on exports and imports, as there is sometimes a wide variation between the meaning of a term applied to some of our imports in this country and its meaning in the country of origin. For example, according to our use of the term "foots," olive oil foots should be a soap containing some free oil obtained as a by-product in refining the oil, but it is really olive oil extracted by a solvent from the waste pomace left after the virgin oil has been expressed. It therefore falls into the class of primary products, and is not a derivative substance, or secondary product.

To account for the entire exportation of fats from this country we must consider the quantity of butter and lard substitutes which are shipped, and perhaps also soaps, lubricating greases, and other manufactured articles. A statement of our importations of fats and oils should include the quantity of oil-bearing materials, such as flaxseed, copra, soy beans, and peanuts. While these are discussed in the sections dealing with the particular oils, it is difficult in many instances to determine just how much of the material imported is used for oil production and how much goes into other channels. This is especially true of coconuts and peanuts.

Nevertheless, some rather interesting broad generalizations may be based on the foregoing tables.

1. The United States normally produces about six times as much fat as is exported, even if the quantity of fats and oils combined in other foods, such as condensed milk, meats, and grains, and in technical products are not considered. Although butter is not included in Table 3, as it is reported by the Department of Commerce under "Butter and Butter Substitutes," the total of these products exported in 1916 was only 26,561,302 pounds, and therefore does not affect this rough comparison.

2. While in the prewar years we exported over three times as much as we imported, in 1917 our imports were larger than our exports.

3. The production of the animal fats, exclusive of butter fat, equal to but 70 per cent of the vegetable oil output of the United States in 1912, rose in 1917 to nearly 80 per cent. Including butter, in 1912 the quantity of animal fats was approximately twice as great as that of vegetable oils, while in 1917 the production of the two classes of fats and oils was nearly the same.

4. Among the vegetable oils, that made from cotton seed stands in a class by itself with respect to its production in this country. In 1912 it constituted 73 per cent, and in 1917, when the cotton crop was unusually short, 61 per cent of the total production. Next in importance in this class of oils is linseed, which in this country is used entirely for technical purposes. Before the war, in 1912, and in 1917, after this country had begun to feel the effects of the war on its foreign commerce, linseed oil constituted about 19 per cent of the total vegetable oil production. It will be noticed that the quantities of coconut oil, corn oil, peanut oil, and soy bean oil have increased very rapidly during the last five years. The amount of coconut oil made in 1917 was six times as much as that manufactured in 1912; the amount of corn oil was somewhat less than twice as great; and the peanut oil made in 1917 was over 100 times as much as that produced in 1912. Probably little or no soy bean oil was made in the United States in 1912, but in 1917 our oil mills turned out more than 42,000,000 pounds, and we imported almost 265,000,000 pounds, as against the 25,000,000 pounds imported in 1912.

5. Very little animal fat has been imported. Even when the fish oils and butter substitutes are included, the total annual importation in prewar years was only about 28,000,000 pounds, or a little less than 9 per cent of the amount consumed. After the war began the

annual importation increased about 2,000,000 pounds. While our importation of animal fats has not increased greatly during the last six years, the amount of some of the vegetable oils being imported has shown a remarkable increase. For instance, the importation of soy bean oil in 1917 was over ten times as great as in 1912, and now exceeds 265,000,000 pounds, more than twice as much as our cottonseed oil exports. Similarly, in spite of the enormous increase in domestic production, the importation of peanut oil rose from 7,626,000 pounds, in 1912, to 27,405,000, in 1917.

TERMINOLOGY AND TECHNOLOGY OF THE OIL TRADE.

Before discussing the raw materials from which our fats and oils are derived and the methods used in extracting and refining them, it may be well to define a few of the terms peculiar to the oil industry.

In the first place, there is, strictly speaking, no distinct difference between a fat and an oil. Both are mixtures of various fatty acids combined with glycerin to form what the chemist calls glycerids. Those combinations of glycerids which happen to be liquid at ordinary temperatures we term "oils," while those which are solid are popularly known as "fats." Although most of the so-called oils are obtained from the fruit or seeds of plants, as, for example, olive, peanut, and cottonseed oil, not all the vegetable glycerids are oils. Some are solid fats, or "butters," as cacao butter, the fat contained in chocolate, nutmeg butter, obtained from the nutmeg, and palm kernel and coconut oils, which, although liquid in the tropical countries whence they come, are fairly solid in the temperate zones. On the other hand, animals, as a rule, produce fats which are hard at ordinary temperatures, for example, lard and suet. There are, however, a few exceptions to this generalization, for lard oil, bone oil, and the fish and whale oils are not solid.

Nearly all fats and oils contain some glycerids which solidify more readily than the rest of the product. These are called stearin, while the more liquid portion is known as olein. When a fat cools slowly, the stearin part of it separates as a fine, whitish precipitate, and settles out. This phenomenon may be observed when a kettle of lard which has been used for deep frying is allowed to stand in a warm place for several days. The fat does not regain its original smooth consistency, but separates into a solid (stearin) and a liquid (olein) layer. In the same way, many oils if chilled become cloudy, and show the presence of a sediment in the bottom of the receptacles containing them. As many housewives consider this sediment to be an impurity, it is customary in this country to cool salad oils until part of the stearin crystallizes out, and then filter them before they are placed on the market. This is called wintering the oil. To secure a fat with a high melting point, tallow is subjected to a similar process, which in this case is called graining. The hard oleostearin thus obtained is employed in making lard substitutes, while the liquid or semisolid oleo oil goes into oleomargarine. When a fat or oil decomposes, some of the glycerids break up, thus liberating the free fatty acids which are partially responsible for the characteristic burning taste of rancid oils. Aldehydes and probably other compounds occur in rancid oils, and to these more than to the fatty acids are due their disagreeable odor and flavor.

To obtain pure animal fats, the tissues in which they exist are usually minced or chopped fine and then rendered, that is, heated until the melted fat separates out. After the free, separated fat has been drawn off, the cracklings, or cooked tissues, usually are pressed to recover as much as possible of the fat. Instead of heating them dry in steam-jacketed kettles, many lard makers cook the hog fats under pressure with live steam blown directly into the covered tanks. This gives what is known in the trade as steam lard, in contradistinction to kettle-rendered lard.

Vegetable oils are commonly pressed from the seeds or fruit containing them by means of heavy hydraulic presses or continuous expellers. They may also be extracted by volatile solvents, such as gasoline or carbon bisulphid. Some fruits, like the olive, which give up their oil readily, can be pressed cold after they have been properly ground. Most of the oil seeds, however, yield so little oil when cold pressed that they must be cooked and pressed hot. As a rule, oils pressed cold do not require any subsequent treatment to make them edible. Such oils are known to the trade as virgin oils. On the other hand, hot pressed and extracted oils contain coloring and flavoring matter which must be removed by refining before the oil can be used for food, or even, in many cases, for technical purposes. Refining is the chemical treatment of the oil by which undesirable flavors or coloring substances are removed. Various acids and alkalies, as well as numerous salts, like borax, water glass, potassium bichromate, and potassium permanganate, have been used for this purpose. The present commercial method, however, consists simply in treating the warm oil with a solution of caustic soda, thus neutralizing the free fatty acids present, and destroying, or precipitating, much of the coloring matter. The alkali combines with the free acids and some of the oil to form a soap which gradually settles to the bottom of the refining kettle. In the United States this semisolid mass of soap is termed soap stock, or foots, and is used by soap manufacturers.

After they have been refined, many oils are also bleached. This is accomplished by mixing the hot refined oil with a small quantity of fuller's earth, which takes up a large part of the remaining color not removed by the caustic soda, or other alkali. The fuller's earth, with the color which it has absorbed, is then filtered out from the oil by forcing the mixture through a filter press.

In making lard substitutes it is desirable to use a very bland oil, that is, one possessing but little odor or flavor. To produce such an oil, the refined and bleached oil must be subjected to a third process, that of deodorizing. As a rule, this consists merely in blowing superheated steam through the oil which is heated in a vacuum kettle. Recently hydrogen has been substituted for steam, and by its use it is now practicable to deodorize even the fish oils.

A very interesting method for converting liquid oils into solid fats which has recently come into rather general use is known as hydrogenation. In this hardening process reduced nickel is employed to effect the combination of hydrogen gas and the liquid glycerids. The hydrogen unites with the oleins of the oil, changing them into stearins, which are solid at ordinary temperatures. The nickel does not combine with the oil, or at least not permanently, and at the end of the process can be removed by filtration and used again. A substance that acts in this way, simply to collect, as it were, one chemical substance and pass it along, and force its acceptance upon another substance, is termed a catalyst.

HOW TO SAFEGUARD OUR OIL AND FAT SUPPLY.

So much for a brief description of the general processes used in the production of our fats and oils. Now let us consider the possibilities for increasing our supplies of the various food and technical oils. How can we develop new sources of these most important substances? In what ways can we improve upon our present methods of manufacture? How can we substitute the more abundant oils for those which are scarce, and how conserve for the purposes to which they are peculiarly adapted those oils, which, like castor oil as a lubricant for aeroplane engines, can not easily be replaced by other oils?

VEGETABLE OILS.

COTTONSEED OIL.

From the data in Tables 1 and 2 it is apparent that the United States produces more cottonseed oil than any other single oil—nearly 1,344,000,000 pounds during the calendar year 1917. We likewise consume more of this oil than of all other vegetable oils combined. This is due not only to its suitability for both table and cooking purposes, but also to the fact that it forms the bulk of the lard substitutes, and that large amounts are employed in the manufacture of oleomargarine, as well as in soap and other technical industries.

DOMESTIC COTTON SUPPLY.

The 1917 cotton crop fell a little short of that of 1916, and neither was more than about three-fourths of the average for the five-year period, 1911 to 1916. The 1918 crop was about 11,700,000 bales, or about 3½ per cent more than was produced in 1917. To insure a sufficient supply of good seed, the United States Department of Agriculture recommended that cotton growers save double the quantity needed for the first planting. Through the Government committee on seed stocks and the various State seed committees arrangements were made whereby farmers who carried over more seed than they needed could dispose of it in other sections where a third or fourth planting was required.

In 1917 the price of fertilizers in many places was so high that undoubtedly some plantations did not receive a sufficiently heavy treatment. Through the Department of Agriculture approximately 100,000 tons of Chili saltpeter were imported under the provision of the food control act, and sold to the farmers at cost in 1918. This helped to solve the nitrate fertilizer problem, and, incidentally, release for commercial purposes a large amount of cottonseed meal which would otherwise be needed for fertilizing.

PRESSING THE SEED.

The method of pressing American cottonseed oil is typical of the way hot-pressed oils are made, and the machinery and processes used in the production of this oil in the United States are superior to those of any other country. Plants of American design and construction are in operation in Europe, Asia Minor, India, and China.

Preparation for the press.—At the crude-oil mill the cotton seed is first run through revolving screens which separate out the larger pieces of trash mixed with it, then passed over shaking sieves and magnets, and through cyclone cleaners, to get rid of the sand, nails, and dust. Next the seeds are fed into the delinters, where the little short cotton hairs which the gins failed to remove are taken off, compacted into a felt, and rolled out like cotton batting, ready for the mattress maker or gun-cotton manufacturer. From the last of these delinters the seed goes to the hullers, which break the hard outer coat or hull and liberate the soft oil-containing meats. To separate the hulls and meats as thoroughly as possible, the material as it comes from the hullers is run over shaking screens. The hulls are passed through a second and sometimes a third huller, and then through additional separators until they come out practically free from any of the valuable oil-bearing interior portion. The meats when nearly freed from the hulls are ground through a series of three or more heavy steel rolls, and finally carried into storage bins over the pressroom.

In expressing most of the edible oils abroad several grades are frequently made by a repressing of the same batch of raw material. Cotton seed, however, in the United States, at least, is pressed only once, and when hydraulic presses are used it is always heated or cooked before pressing. The cooking is done in a shallow, steam-jacketed pan equipped with a mechanical stirrer, which, as it revolves, mixes the meats thoroughly and prevents uneven cooking. In many mills a second pan, called a subheater, similar to the cooker, and installed just below it, serves to hold the cooked batch until the presses are ready for it.

Hydraulic press.—The type of press most commonly used in this country in the production of cottonseed oil is the steel box-frame hydraulic. It consists of a series of horizontal steel plates set one above the other, and provided with closely fitting steel sides so that the whole machine is really a series of steel boxes without ends, piled one upon the other, the lowest box resting upon a hydraulic piston. One after another all the boxes are charged with cooked meats wrapped in heavy press cloths until the press is filled. The compressed air is then turned on, and the oil as it is squeezed out flows down over the sides of the press and through troughs to the settling cistern. As it comes from the press the dark-red crude oil contains some fine meal. Before being pumped or shipped to the refinery, therefore, it is held in settling tanks or cisterns until most of the finer particles have settled out.

Expeller press.—An increasing amount of crude cottonseed oil is made in mills equipped with a type of continuous-working press known as the expeller. The expeller is built somewhat on the principle of the ordinary meat grinder, and is simply an interrupted screw revolving inside a slotted steel barrel. The ground seed enters through a hopper at one end of the barrel, is pressed along toward the opposite end, and finally discharged around a cone, which can be set in or out of the outlet orifice, to give any desired pressure. Squeezed from the seeds by the pressure of the screw, the oil runs out through the small slits in the barrel, and after settling or, better, filtering through a filter press, is ready for shipment to the refinery.

As the yield of oil by either process is only about 45 gallons per ton, or less than 17 per cent of the weight of seed handled, and as a large part of the ground cake and hulls can be used as feed or fertilizer by the local farmers, the crude-oil mills often are located in the smaller towns throughout the cotton-growing sections. From these the oil is shipped in steel tank cars to more centrally situated refineries or to the packing houses and cooking compound manufacturers of the North. It is invariably refined before being used for food, as the crude oil has a very dark-red color, and contains substances which rapidly develop a disagreeable flavor and produce rancidity in a comparatively short time.

HOW TO INCREASE THE OUTPUT.

After the farmer has made his contribution toward increasing the supply of cottonseed oil, by raising more cotton and offering only good seed, the responsibility for greater production passes on to the operators of the gins, crude mills, and refineries. The cotton ginner and the oil manufacturer now very generally recognize the fact that not all seed can be made to yield a good oil. The annual loss of oil from neglect in the proper cleaning and storing of cotton seed is enormous. Partly because of the keen competition between buyers of the seed and partly because seed consisting largely of water and trash commands nearly the same price as good seed, little attention has been given to developing methods for the effective removal of impurities at the gins, or for keeping the seed dry until pressed. Dirty seed has a tendency to hold more moisture than clean seed, and wet seed heats rapidly, causing the oil contained in it to become rancid, which makes it fit only for use as soap stock.

Some idea of the total annual loss of edible cottonseed oil may be gained from the reports of the Bureau of the Census. During the 1916 crushing season, the 10-months' period ending April 20, 1917, 1,161,591,332 pounds of crude cottonseed oil were refined. From this 1,080,636,014 pounds of refined oil were produced, a refining loss of over 7½ per cent. By decreasing this loss even 1 per cent, on the basis of crude oil handled, over 10,000,000 pounds of oil would have been saved, or nearly eight times as much as the total amount of olive oil produced in the United States during the same period. It is not fair, however, to assume that the difference between the amount of crude oil entering a refinery and the finished product represents a total loss, for the by-product, known as soap stock, is used in making soap, and yields a small amount of glycerin.

Naturally a great deal of attention has been given to the elimination of losses in both the crude-oil mills and the refineries. It is still possible, however, to increase the amount of oil obtainable from cotton seed at several points in the process. For instance, in the hydraulic mills the cakes used to fill the boxes in the press are sometimes so long that the ends are not properly pressed. This reduces the yield of oil unless the soft ends are cut off and re-pressed. Again, an excessive amount of meal is allowed to run into the storage tanks with the oil. After such meal has collected for a time it becomes rancid, and makes the oil sour. In the refineries many attempts have been made to decrease the "refining loss," that is, the amount of oil absorbed in the soap stock, or "foots," but much yet remains to be done. Recently methods which make it possible to press the soap stock or put it through a centrifugal, thus effecting the recovery of a part of the oil absorbed by it, have been suggested.

The bleaching of cottonseed oil with fuller's earth causes a loss, and probably does not materially improve the quality of the oil. If the trade did not demand a white cooking compound, it would be possible to dispense with this operation. As it appears necessary, however, that bleached oil be supplied, the practice of extracting the spent fuller's earth with gasoline, to recover as much as possible of the oil, might be in more general use.

MANUFACTURE OF "COMPOUNDS."

As already stated, a large part of American cottonseed oil is used in the manufacture of lard substitutes. This fact is substantiated by the data in Table 8, compiled from reports made to the Fats and Oils Division of the Food Administration, which, while not absolutely accurate, are approximately correct. In 1917 nearly 1,174,000,000 pounds of lard substitute were produced, and in its manufacture about 1,070,000,000 pounds of refined cottonseed oil were used. This refined oil, figured back to the crude, allowing an average refining loss of 8 per cent, represents over 1,163,000,000 pounds, or practically 87 per cent of our total production of crude cottonseed oil. The 13,800,000 pounds of cottonseed oil imported is such a small proportion—less than 1 per cent of what is used in the United States—that in these comparisons it need not be considered. During the three years immediately preceding the war, our average annual exportation of lard substitutes was nearly 68,000,000 pounds, but since then the volume of the exports has fallen somewhat, the figures for 1917 being only about 50,300,000 pounds. This decrease is proportionately about the same as that which has occurred in our exports of lard, and probably is due to the same causes—the difficulties in trans-Atlantic shipping, and the lessened demand in foreign countries for such products, attendant upon their increased prices.

Lard substitutes are variously known as "Lard Compound," "Vegetable Cooking Compound," "Compound Lard," or, more generally in the trade, simply as "Compound." Some of these are mixtures of lard or lard stearin with vegetable oils, while, instead of lard, others contain about 12 per cent of oleostearin. Recently a new class of substitutes containing no animal fats whatsoever has become very popular. These preparations are made either by the partial hydrogenation of a vegetable oil, or by mixing with the untreated oil a sufficient proportion of almost completely hydrogenated fat to produce a substance having the consistency of lard (p. 10).

TABLE 8.—*Lard substitute production.*

Product used.	1912	1914	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Cottonseed oil	866,696,000	1,053,141,000	919,447,000	1,069,214,000
Coconut oil				3,545,000
Corn oil			13,105,000	4,166,000
Peanut oil	1,687,000	2,144,000	17,869,000	12,209,000
Soy bean oil		1,585,000	14,247,000	34,351,000
Vegetable stearin		239,000	2,694,000	15,342,000
Cottonseed oil stearin	180,000	372,000	1,313,000	1,798,000
All other vegetable oils	6,418,000	5,464,000	13,421,000	12,742,000
Hydrogenated oil		83,000	778,000	833,000
Lard, edible	480,000	350,000	369,000	412,000
Tallow, edible	10,814,000	13,921,000	9,835,000	9,938,000
Oleo stock	20,000	24,000	17,000	15,000
Pork fat	720,000	940,000	700,000	592,000
Stearin	57,644,000	64,926,000	49,493,000	54,959,000
Total	944,659,000	1,143,189,000	1,043,288,000	1,224,916,000
Lard substitute	876,927,000	1,136,522,000	1,027,133,000	1,173,446,000

The older types of lard compounds, those that contain animal fats, are made by mixing with the heated vegetable oil the proper amount of melted fat, usually oleostearin, and running the homogenous mixture in a thin layer on large "chill rolls," huge revolving drums kept cold by refrigerated brine circulating within them. Thus the compound solidifies so quickly that there is no time for the solid fat to separate from the liquid oil. As rapidly as it is chilled the product is automatically scraped from the roll and dropped into an open screw conveyor leading to the pumps, which force it directly through the filling pipes into the shipping packages. The screw of the conveyor consists of a series of small paddles which turn so rapidly that the compound is beaten up violently, and retains some 14 per cent of its volume of air when put in the cans. This incorporation of small bubbles of air gives it the beautiful pearly white luster of natural lard.

The introduction of the hydrogenation process has made it possible to replace 12 per cent of oleostearin in lard compounds with about 5 per cent of hardened cottonseed or other vegetable oil. The process of manufacture is practically the same as that of the first type, when completely hardened oil is mixed with untreated oil, but a better texture is secured for the product when the entire batch of oil used is partially hardened. The chilling and beating are, however, essential; otherwise the product does not possess the proper appearance.

It may be well to mention here the fact that this new device of hydrogenation, which is still shrouded in secrecy and complicated with patent litigation, makes it possible not only to produce hard fats from liquid oils, but also to convert oils formerly considered inedible into sweet, white, perfectly wholesome products. For example, in certain parts of the world, whale oil, and even some of the fish oils, are now being refined, deodorized, and hardened, and a lard substitute made from fresh herring oil is already on the market in the West Coast States.

OLIVE OIL.

DOMESTIC SUPPLY.

Replies to a questionnaire sent to a majority of the olive pressers of this country by the Bureau of the Census, in June, 1917, indicate that in 1916 we made some 1,300,000 pounds of olive oil. A later request mailed to all oil producers by the Food Administration brings this figure up to 1,461,000 pounds. This is only about 2 per cent of our consumption of olive oil, and less than 0.1 per cent of our total domestic production of vegetable oils, during the period. In 1917 our production apparently decreased to a little over 963,000 pounds. The United States imports, largely from Italy, France, and Spain, about 50,000,000 pounds of edible and 5,000,000 pounds of inedible olive oil annually. The exact amounts, taken from the reports of the Bureau of Foreign and Domestic Commerce, are given in Table 4.

PRESSING OLIVES.

Olive oil is probably the most widely known of the virgin oils. It is obtained by grinding nearly ripe olives, usually pits and all, in a suitable mill, and pressing the resulting pulp in large fruit presses very similar to those used in making cider or grape juice. To press the pulp it is wrapped in a coarse cloth to form so-called "cheeses," which are then stacked in piles, each cheese being separated from the one above by a lattice grating of wooden slats, and pressure applied. As the pressure applied to the olives is comparatively light, the oil obtained need only be washed and filtered to yield the pure virgin oil of commerce. The pomace left from the first pressing is reground, and, after the addition of a little hot water, again pressed to form lower grades of olive oil. Finally, a very low grade of oil may be obtained from the last cake by extraction with some volatile solvent, such as ordinary gasoline, or, abroad, carbon bisulphid, the solvent, of course, being later boiled off from the oil.

CAN WE INCREASE OUR PRODUCTION?

Most of the American olives are grown for pickling, and, as none of the oil is lost in the processing and canning of the ripe or green olives, there would be no real gain in using more of the olive crop for oil and less for pickling. At the present time probably nearly all of the cull olives fit for making oil are being utilized in this way, since the price of olive oil is so high that it pays the grower to ship culls to the oil mills, which formerly would not bear the freight charges. As an olive tree does not yield fruit in commercial quantities until it is 5 years old, there is no possibility of an immediate increase in the quantity of olives available for oil, except in so far as the young orchards, already planted, come into bearing during the next year or two.

Although olive oil as a food and medicinal oil can be replaced very largely by other vegetable oils, there are one or two technical uses, wool spinning, for instance, for which no entirely satisfactory substitute has yet been found. The grade of oil, however, required by these trades is such that an extracted oil can be employed, and this country ought to be using more generally a solvent process on the spent olive oil pomace which is now wasted. The custom of extracting the final press cake with carbon bisulphid or other solvent, as practiced in Italy and France, has not been deemed commercially profitable in the United States. The oil obtained by a carbon bisulphid extraction is dark green, due to the presence of chlorophyl, the green coloring matter of plants, dissolved from the pomace by the solvent, and has a rank, disagreeable odor and flavor. Such oil, imported under the name "olive oil foots" or "sulphured olive oil," is used in making Castile soap, and is said to be satisfactory for other technical purposes.

With our improved processes of refining, it is even possible to make a low-grade edible oil from extracted oils, although they are nearly tasteless. As there is no market for this sort of oil, it has been customary in foreign countries to mix with it a highly flavored oil to form a blend which very closely resembles, in both taste and color, a virgin oil. While this substitution of a blended refined oil for a virgin product can not be commended, oil which is now wasted in the pomace from the olive oil mills should be saved. Where the press cake from an oil mill is used as food for man or animals the 5 to 8 per cent of oil it contains is, of course, not lost, but oil mill wastes, such as spent olive pomace, which are not fed to stock, should be extracted whenever possible.

PEANUT OIL.

RAPID RISE IN FAVOR.

Although American peanut oil was an almost unknown product before the Great War, in 1917 it ranked third in the vegetable oils made from home-grown products, coconut oil being produced exclusively from imported copra. Until recently most of the imported oil came from France and Holland, but these countries now have scarcely enough to supply their own needs. China, however, has come into the market, and is shipping us large quantities of a rather poor grade of peanut oil.

Even with the marked increase in the importation of peanut oil, from a little over 7,600,000 pounds in 1912 to 27,400,000 pounds in

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1917, the South to-day is making more of this delicious food oil than ever before. The 1917 crop of peanuts was about 60,900,000 bushels. In 1917 we manufactured over 50,000,000 pounds of peanut oil, some of which, however, was made from imported peanuts. Reports for the first six months of 1918 show an output of about 43,000,000 pounds of peanut oil.

PRESSING PEANUTS.

Peanut oil, like olive oil, can be obtained by cold pressing, and when so made from sound, sweet nuts it need not be refined. Such cold-pressed oils possess a characteristic flavor which, in the opinion of many consumers, makes them superior, especially for salad purposes, to the oils that are hot pressed and refined. Cooking the peanuts and subjecting them while hot to a very high pressure, however, gives a larger yield of oil than cold pressing. It is customary, therefore, when a virgin, or cold-pressed, oil is made to regrind and heat the cake, which is then pressed a second time, to extract as much oil as possible.

In France, where the crushing of peanuts was an important industry long before any peanut oil was produced in the United States, the almost universal practice is to make virgin oil from all the fresh sweet peanuts. The cold-press cake and rancid nuts are then hot pressed, and the lower grade oils thus obtained refined. Unfortunately, so far very little virgin peanut oil has been made in this country, but a number of mills are now producing it, and already it is appearing on the market. The American practice has resulted in an appreciable loss in our production of edible peanut oil. Not that the hot-pressed oils can not be made entirely satisfactory for both table and cooking purposes, by refining, but in the refining process a part of the oil is converted into soap stock, thus going to the soap kettle instead of to the kitchen.

Large as this loss is, and it probably means at least 150,000 pounds on the crush of 1917, an additional and greater waste has occurred because of the fact that most American mills are pressing part of the shells with the peanut kernels. These shells contain less than 0.5 per cent of oil, but they readily absorb it from the kernels when pressed with them, and come out from the presses with from 5 to 7 per cent of oil. The Spanish varieties of peanuts, the kind usually pressed for oil, contain an average of 25 per cent of shell, or 500 pounds to the ton. As the average press cake contains 6 per cent of oil, the shells in the cake from a ton of nuts will absorb 27½ pounds of oil, in addition to the 2½ pounds they originally contained. Based on a price of 15 cents per pound for oil, this failure to remove the shells represents a financial loss of some $80,000 on the 1917 crush.

A further economic loss occurs when peanuts are pressed with the shells left on, in that the press cake containing shells can not be used for human food. When blanched kernels from which the shells have been removed are employed in making oil, the cake, which may contain 7 per cent of oil, can be ground into meal and used with wheat, corn, and similar starchy flours to form very palatable and highly nutritious cakes, gems, and hot breads.

COCONUT OIL.

RECENT INCREASE IN IMPORTATION AND MANUFACTURE.

For many years we, as a nation, have been using coconut oil in the manufacture of the so-called marine soaps, that is, those which form a lather in alkali and salt waters, to make pharmaceutical preparations, cosmetics, and, to a smaller extent, confectionery and cakes. It is only within the last five or six years that this oil has received the attention which it deserves as a food product.

The rapid increase in coconut oil importations, from 46,720,000 pounds for the year 1912 to 163,091,000 pounds during 1917, is due partly to the fact that larger amounts of this oil are now used in the soap industry than ever before. Coconut oil yields a higher percentage of glycerin than any of the other soap fats, and it can be substituted to some extent for tallows the price of which was abnormally high during 1917. Reports from the soap trade (Table 9) indicate a consumption of coconut oil during 1917 of 168,602,000 pounds, which is 5,500,000 pounds more than the total imports for the same period. To furnish the additional oil used by the manufacturers of vegetable butter substitutes and other industries at least 10 copra-crushing mills are now operating in the United States. The 1917 output of the crushers was nearly 188,500,000 pounds, which is about 26,400,000 pounds greater than the amount of coconut oil imported. To supply these mills it was necessary to bring in from the Orient and the West Indies, in 1917, 366,700,000 pounds of dried coconut meat, known commercially as copra. During 1912 the importations of copra were only 62,168,000 pounds, about one-sixth of the amount imported in 1917, in spite of the difficulties experienced in getting sufficient ships for our overseas trade. In the fiscal year 1913 we brought in a little over 1,000,000 pounds of coconut oil from the Philippines, and in 1916 over 30,000,000, nearly half of our entire importation for that period.

The absence of German buyers from the foreign copra markets caused an increase in the amount of coconut oil produced in the United States, during the past five years. Although the difficulty in obtaining ships to bring the copra from the tropics has resulted in lowering the price of this product in the countries where it is produced, the domestic price for coconut oil has increased. At present a comparatively small amount of the world's supply of copra is going to Germany, England, and Holland, very large importers before the war began, and much of it has been diverted to American manufacturers. This, to some extent, has helped to keep the price of coconut oil from reaching the high figure it might otherwise have attained because of our greatly increased domestic consumption.

MANUFACTURE AND USE.

The coconut oil produced in tropical countries where the coconuts grow is often made by very crude methods. Nevertheless, much of it reaches the American market in as good condition as that pressed at home. This is due to the fact that since we raise no coconuts in the continental United States, the raw material used in our oil mills is imported from overseas. Copra is dried in the sun or over smoky fires, largely by native labor. Such methods, of course, offer every opportunity for the oil to become rancid before the meats are properly cured. Moreover, copra is often shipped by slow sailing-vessels, and, being a comparatively cheap cargo, it is stowed in damp holes where it sweats and still further decomposes. A number of modern plants for both drying and pressing coconuts have recently been put into operation in the Philippines, and the product from these mills reaches this country in a much better condition than that produced by the natives.

TABLE 9.—*Consumption of fats and oils by the soap industry in 1917.*

	Pounds.
VEGETABLE FATS AND OILS.	
Chinese vegetable tallow	6,417,000
Chinese nut oil	115,000
Coconut oil	168,602,000
Corn oil	15,997,000
Cottonseed oil	126,390,000
Linseed oil	1,006,000
Olive oil	1,731,000
Palm kernel oil	4,762,000
Palm oil	27,345,000
Peanut oil	15,126,000
Rapeseed oil	5,972,000
Sesame oil	5,000
Shea nut oil	2,487,000
Soy bean oil	124,058,000
All other vegetable oils	9,692,000
Total	509,705,000
ANIMAL AND FISH FATS AND OILS.	
Bone grease	37,032,000
Garbage grease	63,118,000
Herring oil	4,104,000
Lard	7,481,000
Lard, neutral	166
Menhaden oil	2,279,000
Neat's foot oil and stock	118,000
Recovered grease	12,680,000
Sperm oil	17,000
Tallow	362,297,000
Tankage grease	15,475,000
Whale oil	5,732,000
Wool grease	233,000
All other fish and animal oils	9,257,000
Total	519,823,166
SECONDARY FATS AND OILS.	
Acidulated soap stock	25,086,000
Cottonseed foots	67,369,000
Cottonseed foots (distilled)	8,872,000
Fatty acids	35,050,000
Fatty acids (distilled)	39,465,000
Grease stearin	19,146,000
Lard oil	1,436,000
Oleo oil	108,000
Olive oil foots	4,761,000
Red oil	12,812,000
Nonclassified[1] totals	25,000,000
Total	239,105,000
Grand total	1,268,633,166

[1] Firms under this head failed to classify consumption of fats and oils.

As copra contains a higher percentage of oil (63 to 70 per cent) than any of the other products usually pressed for oil in the United States, it has been found advantageous to press the raw material twice, although neither pressing is done cold or with the idea of producing a virgin oil. A number of our coconut oil mills press once in expellers, then regrind the cake, and, after heating, make a second pressing in hydraulics. Both the first- and second-pressing oils are refined. Refining processes similar to those used in the refining of other vegetable oils are employed to eliminate the free fatty acids. Owing to the fact that coconut oil contains glycerids of the lower fatty acids, which are more easily decomposed than those of seed oils, greater care is necessary in its refining to prevent an abnormally high loss due to the conversion of a large portion of the oil into soap.

A number of plants separate the portion of the oil which melts at a lower temperature from that which is solid at a higher temperature, the liquid portion being sold as coconut olein for use as a cooking oil, while the stearin is used as a substitute for, or an adulterant of, cacao butter in the confectionery trade and in sweet fillings for certain cookies or wafers and in vegetable margarines. The by-products from the refining of coconut oil, of course, are used largely in the manufacture of soaps, and the press cake from the oil mill is a valuable stock and concentrated dairy feed.

One of the most important uses of refined coconut oil is in the production of vegetable margarines, sometimes called "nut margarines." In making these butter substitutes approximately 50 parts of coconut oil, 25 parts of peanut or other vegetable oil, and 25 parts of ripened milk are mixed thoroughly by churning, and then quickly chilled. The cooling of the mixture must be done in such a way that the fat particles when collected and worked will yield a smooth butter-like product. This is usually accomplished by either spraying the batch into a large tank of cold water or running it from the churn in a thin sheet under an ice-water spray. After the batch has congealed into a mass of fine wax-like particles it usually is collected in large trucks and placed in a tempering room, where it is allowed to ripen and develop a buttery flavor. In a day or two, when properly ripened, it is taken to the workers, the requisite amount of salt added, and the excess of moisture squeezed out. It is then ready to be put in packages for the market.

POSSIBLE ADDITIONS TO THE PRESENT SUPPLY.

The same economies that have already been suggested with reference to other vegetable oils would effect some increase in the yield of coconut oil made in the American mills. Abroad, however, the copra cake is highly prized as a dairy feed, because of the belief that the coconut oil left in the cake resembles milk fat more than any other oil, and is therefore easily converted into cream by the cows. If this is true, although it seems a questionable theory, then, of course, the 6 or 8 per cent of oil in the cake is more valuable as a dairy feed than when it is extracted and used for soap making.

As already intimated, the world's copra trade was entirely upset by the war, and it is impossible to predict what will happen when shipping conditions are again normal. It would seem probable, however, that our coconut oil mills will experience more difficulty in getting copra when England, Holland, and especially Germany, are again in the market. Fortunately, the seeds of several varieties of palms in Mexico, and in Central and South America contain oils so similar to coconut that they are for all practical purposes identical. Among these are the babussa, the cohune, and coquito. While none of these have as yet become of any great commercial importance, some are being imported in small quantities, and if the problem of cracking their hard, thick shells is satisfactorily solved they will undoubtedly come into competition with the coconut.

PALM KERNEL OIL.

Palm kernel oil, both chemically and physically very similar to coconut oil, is obtained from the palm nut or kernel, the hard, interior seed of the fruit of a species of palm which grows in western Africa and other tropical countries. These nuts, being much harder than the copra, bear transportation better, so that the loss in refining palm kernel oil is usually much less than that from refining coconut oil. Palm kernel oil is used interchangeably with coconut oil in making vegetable margarines and other food products, but as yet comparatively small quantities of this oil are produced in the United States.

Partly because England controls practically the entire world supply of palm kernels and needs the oil herself, but largely due to lack of transportation facilities between the United States and Africa, our importation of palm kernels has almost ceased. In 1917 we made about 6,450,000 pounds of this oil, but it was largely from kernels imported the year before. During the summer of 1918 there was an embargo on palm kernels, and consequently no oil was made in this country at that time. During 1912 we imported 27,681,000 pounds, but in 1917 we received less than 1,000 pounds of palm kernel oil. This deficiency was only partially compensated for by our importation of coconut oil, although the oil in the copra brought in leaves a large balance in favor of our domestic consumption.

PALM OIL.

The fruit from which the palm kernels are obtained is one of a comparatively few that yield a commercial oil from both the rind, or fleshy portion, and the seeds. Just as the pulp of the olive gives up its oil, the fleshy part of the palm fruits, the color of which is, when ripe, an orange or yellowish brown, yields palm oil. This portion of the fruit can not be, or at least never has been, dried and exported, so that the United States is entirely dependent upon foreign lands for its supply of palm oil. While there was a decrease in our imports of this oil from over 52,700,000 pounds in 1912 to less than 30,000,000 in 1916, during the year 1917 we obtained 34,257,000 pounds in spite of the difficulties of trans-Atlantic shipping.

PREPARATION.

The natives crush the soft palm oil from the fruit, often by treading it with their bare feet, after which the kernels are removed. The crushed pulp is then allowed to ferment in pits, and the oil, as it gradually separates and rises to the top, is scooped off into gourds or other crude containers, and sold to the local factories. Before being exported it is sometimes remelted and strained. For their own use as a food oil, the Africans crush and boil with a little water some of the best fruit to get what is called "chop" oil. This, however, is seldom exported.

USES.

In the United States the yellow unbleached palm oil is used very largely in the tin-plate industry. So far it is almost the only substance which has been found satisfactory as a flux on the discharge side of the pots of melted tin through which the sheet-iron plates are passed to receive their coats of tin. Recent experiments with hydrogenated cottonseed oil, however, indicate that our tin-plate industry will be independent of this foreign controlled oil.

Palm oil can be bleached almost white, in which state it is used in combination with other oil in the production of palm oil soaps.

CORN OIL.

INCREASING IMPORTANCE.

Corn oil, which, so far as is known, is made only in this country and Canada, has within the last decade come into prominence as both a food and technical oil. No reliable figures are obtainable on the production of this oil previous to 1912, when nearly 73,000,000 pounds were made in 16 mills. Our export of corn oil has decreased steadily from 1912, when we shipped nearly 23,000,000 pounds, to 1917, when only a little over 4,700,000 pounds were exported. This decrease probably was due to competition with new oils in the foreign markets, and also, to some extent, at least, to an increased domestic demand for corn oil. It is only within the past few years that the refining processes have been so perfected that this oil could be used for general household purposes and for the manufacture of lard and butter substitutes.

Corn oil, or, as it is sometimes called, maize oil, is obtained from the small germ portion of our common Indian corn. Although the germ itself is about half oil, only from 3 to 6.5 per cent of the entire kernel is oil. Were it not for the fact that in the preparation of hominy feed, cornstarch, and brewers' grits, and sometimes in the making of corn meal and other corn products, the germ is more or less completely separated from the rest of the grain, corn oil doubtless would be a mere curiosity, as it would not pay to extract it.

On the basis of the 1917 output of corn oil, which was approximately 118,000,000 pounds, if we assume that the germs from a bushel of corn will yield 1 pound of oil, 118,000,000 bushels of corn were used in those plants that produce corn germs as a by-product. The hominy feed plants, which use the dry process, obtain from 2 to 2.5 pounds of germ per bushel of corn. As this germ is mixed with a good deal of meal, however, the oil yield is only about 0.4 pound per bushel of corn. The starch works, employing the wet process, obtain about 3.25 pounds of germ, containing 40 per cent of oil, from a bushel of corn, or 1.4 pounds of oil per bushel. Many of the distilleries, although they separate a low-grade oil germ, secure a larger yield of oil per bushel than the hominy works, as it is necessary for them to remove the germ almost completely from the rest of the corn.

MANUFACTURE AND USES.

In degerminating corn, two distinctly different processes are now in use in the United States. In the older one, called the wet process, the corn is soaked in dilute sulphurous acid for some time and the germ then separated from the rest of the grain. This yields a germ in which the oil is already rancid when extracted. In the newer process, usually known as the dry process, the germs are removed by mechanical means without the addition of water. If the corn is sound, this oil can be used for food purposes with little or no refining. The germs, after being separated, are cured until tough and leathery. They are then run through a series of flaking rolls which flatten them and break the oil cells but do not grind the material into a flour, which would be hard to hold in the oil presses. While hydraulic presses could be used, as in the cottonseed oil mills, the general practice in the United States is to run the germs directly from the flaking rolls into expellers similar to those already described in connection with the production of cottonseed oil (p. 12).[1]

Like cottonseed and hot-pressed peanut oil, corn oil is refined before being marketed for food purposes, but the crude oil can be used in making soap, paint, linoleum, and similar technical products.

[1] U. S. Dept. Agr. Yearbook (1916) Separate 691 gives a detailed description of the manufacture of corn oil.

An appreciable part of the germs used for making corn oil is derived from the manufacture of brewers' grits. With the decrease in the consumption of brewers' grits, the amount of corn oil made in the United States would materially decrease were it not for the growth in glucose, starch, and degerminated corn meal production.

SOY BEAN OIL.

GROWING IMPORTANCE.

Soy bean oil to-day stands at the head of our list of imports of foreign fats and oils. During the twelve months ending December 30, 1912, we imported a little less than 25,000,000 pounds, valued at about $1,000,000, but in the calendar year 1917 nearly 265,000,000 pounds, at a cost of about $27,000,000, an increase of approximately 1,100 per cent in quantity and more than 2,700 per cent in value. Besides the crude oil imported in 1917, some 34,000,000 pounds of the dry beans were brought here from eastern Asia. The major portion was sold to oil mills, a small quantity being used for canning and other purposes. The domestic production of soy bean oil in 1917 is reported to the United States Food Administration as 42,000,000 pounds.

It is estimated that 750,000 acres of soy beans were planted in the United States in 1917, which is about three times the acreage of 1916. Only a small portion of the planting was allowed to seed, however, most of it being cut for hay. Very few, if any, of the domestic beans were crushed by the oil mills, which used as raw material the Manchurian beans, as being cheaper and in less demand by bean canners than those grown in this country. In 1915, however, some 100,000 bushels of American soy beans were pressed, and the cake and oil from them were consumed in this country.

GROWING SOY BEANS.

Of the more than 500 known varieties of the soy bean which have been grown on the Government testing farms, at present only about 15 are handled commercially by seed men. The Mammoth (yellow), the standard late variety, is probably more extensively grown than any other. It is most important that the variety best suited to the locality where it is to be cultivated be selected. Also where the beans are to be used for oil those varieties which will yield the maximum amount of oil per acre should, of course, be planted, if they will mature a good crop.

The oil content of soy beans varies from 14 to as high as 21 per cent, in a few varieties, the average being about 17 per cent. Tests made by the Ohio Experiment Station with 25 varieties, planted for five successive years, but not on the same plot each year, gave yields of from 14 to 36.5 bushels per acre, the average being 30 bushels. Similar experiments in Connecticut with 13 different varieties produced from 15 to 32.5 bushels per acre. The yield of oil from an acre will average 250 pounds (about 35 gallons), or, based upon the dry shelled beans, 1 ton will produce from 28 to 30 gallons of oil and 1,600 pounds of meal. While, with the proper selection of varieties, soy beans may be grown in practically all parts of the United States, the yields in the Southwest have been rather light, and the greater portion of our crop is produced and pressed in the Carolinas.

EXPRESSING THE OIL AND ITS USES.

The cottonseed oil mills can handle soy beans with little or no change in their present equipment. As soy beans may be stored with less danger of deterioration than cotton seed, it is possible to press these after the regular cotton crushing season is over. Soy bean oil does not need to be refined for paint and other technical uses. Its flavor is distinctly beany, however, so before it can be used in food products it must be refined and deodorized like cottonseed oil. Even the cold-pressed oil is not edible as it comes from the presses, in which respect the peanut has an advantage over the soy bean.

Belonging to the group of drying oils, soy bean oil more closely resembles in its physical properties linseed and the other drying oils than peanut, cottonseed, and similar semidrying oils. It has, therefore, been used largely as a substitute for linseed oil in the making of paints, linoleums, and like products. As already mentioned, however, it is perfectly wholesome, and in China and other parts of Asia forms the staple food oil of large classes of the people. When properly refined it becomes quite bland, and can be used in lard substitutes, oleomargarines, and even, perhaps, as a table oil.

INCREASING OUR OUTPUT.

The soy bean and the peanut constitute the two most promising possibilities for a large increase in our fat resources. Both of these are fairly sure annual crops. The oil mills already established have a crushing capacity sufficient to handle almost any amount of the raw materials that the American farmers produce. Moreover, a good market for the oil is assured.

There is a double reason for increasing our crush of soy beans and peanuts. Not only will they furnish the United States with oils, but, what is perhaps still more important, they will greatly augment the protein supply. The soy bean press cake, that is, the residue after most of the oil has been expressed, need merely be ground to produce a most valuable flour. As these beans contain little starch, the flour they yield, from a nutritional point of view, is not a wheat substitute but a meat or milk substitute. While it is true that peanut and soy bean meals are first-class stock feeds, they are, if properly made, a valuable addition to the available food supply of the American home.

LINSEED OIL.

UNITED STATES LINSEED OIL TRADE.

Although linseed oil, which, by the way, is made from flax seed, is a staple food in some of the European countries, especially Russia, it has so far been used only for technical purposes in the United States. This is due partly to the fact that nearly all of our American oil is hot pressed, but more especially because it is much more valuable to the paint, linoleum, and printing ink manufacturers than to the food oil producer.

The United States produces and uses more linseed oil than it does of all other purely technical oils combined. The figures given in Tables 1, 4, and 5 show that in 1917 this country produced 400,266,000 pounds of oil, imported 633,000 pounds, and exported 10,724,000, leaving a consumable balance of 390,175,000 pounds. In 1914, before our foreign trade had been seriously affected by the war, we produced 406,669,000 pounds, imported 4,350,000 pounds, and exported 1,994,000 pounds, which would indicate a domestic consumption of 409,025,000 pounds. Similar summaries for 1912 and 1916 can be obtained from the other figures in the tables, and will show that the war had little effect on our domestic consumption of linseed oil. This country's foreign trade in linseed oil, which in normal times was only one or two per cent of the domestic business, however, does show a marked change after the beginning of the war. Referring again to the import and export trade figures, it appears that in 1917 we brought in only about one-seventh as much linseed oil as in 1914 and sent out five times the quantity previously exported. These figures do not tell the entire story of our foreign linseed oil trade, as the flax seed from which the oil is produced must be taken into consideration. In 1912 the United States crushed about 1,406,349,000 pounds of flax seed, of which 438,658,000 pounds, or 31 per cent, were imported. In 1917 our crush was 1,592,245,000 pounds, 526,080,000 pounds, or 33 per cent, of which came from foreign countries. At the present time, we are raising about 75 per cent of the flax seed crushed in this country, and importing the remainder, largely from South America.

MANUFACTURE.

Practically all of the linseed oil made in America is pressed in open plate hydraulic presses, although there are one or two expeller mills in operation. Abroad a good deal of this oil is made by the so-called "new process," in which the ground seed is extracted with benzol or other volatile solvents. Fire destroyed the last plant of this kind in the United States two or three years ago, and so far as known all the linseed oil we now produce is either hydraulic or expeller, sometimes called "cold-pressed," oil.

Flax seed averages about 35 per cent oil, the press cake usually containing between 6 and 8 per cent of oil, with some loss in milling and cooking. The average American yield is about 16 pounds of oil and 36 pounds of cake per bushel of seed, or an oil production of approximately 27 per cent. As already stated, linseed oil is not looked upon in the United States as a food oil, but since it can be made palatable by the proper refining and deodorizing treatment, we might fall back upon it in case of a serious food oil shortage.

HOW TO INCREASE THE SUPPLY.

The opportunities mentioned in connection with cotton seed crushing exist for increasing the yield of oil from flax seed. "New process" mills might be built or gasoline extraction plants established at the existing hydraulic mills to extract the press cake and recover the residual oil contained in it. This country could produce a larger supply of linseed oil by raising more flax, and efforts have been made by the Department of Agriculture and the experiment stations in flax-growing States to supply proper seed and have a greater acreage planted. As the 1918 crop in North America fell short of our requirements, owing to dry weather in June and July, it is fortunate that a few years ago when the price of linseed oil was abnormally high, the paint manufacturers and the Department of Agriculture made an investigation of possible substitutes for this product.

SUBSTITUTES.

In addition to corn, soy bean, perilla and fish oils, tung, China wood, or Chinese nut oil, as it is variously known, can be used in place of linseed oil in paints, varnishes, and other manufactured products. With the exception of tung and probably perilla oils, none of these apparently dry with the tough skin that is essential for a good, lasting paint oil, and they do not make varnishes that are at all satisfactory. Corn oil, however, makes perhaps a better rubber substitute than linseed, and in linoleums it and fish oil have been used to some extent. For certain kinds of rosin varnishes, those that are not affected by water, tung oil has been claimed to be even superior to linseed oil (p. 31).

CASTOR OIL.

DOMESTIC AND FOREIGN CASTOR BEAN PRODUCTION.

To most of us the term castor oil at once brings to mind a nauseous medicine. Few are aware that it is at present almost an absolute necessity for our high-speed airplane motors. And where to get enough of this oil for the airplane squadrons we were equipping, to say nothing of the ordinary domestic requirements, has been a serious problem. At one time the castor bean was an important crop in certain sections of Oklahoma, Kansas, Missouri, and Illinois. In recent years, however, we have been able to import from India all the beans we required more cheaply than we could raise them, and very few have been grown on a commercial scale by American growers, until 1918. The imports for the year ending June 30, 1916, amounting to 1,071,963 bushels, in the next fiscal year dropped to 766,857 bushels, in spite of the increase in price. Our normal requirements are about 1,000,000 bushels. The domestic production of castor oil from 1912 to 1917, inclusive, is given in Table 1, and, as we neither exported nor imported appreciable quantities, these figures may be considered as our prewar consumption.

Early in 1917, foreseeing the approaching shortage in the domestic supply of castor oil, the Federal Government purchased all the available stocks on hand, and also placed an embargo on the exportation of any except the lowest grades of this oil, which could not be used for lubricating purposes. The Signal Corps made contracts with southern farmers, guaranteeing to buy at a fixed price all the beans that could be grown on about 100,000 acres. The seeds for this planting were secured from India, by agreement with England which had placed an embargo on the Indian crop. It was also arranged that any excess of beans above the amount needed by the Army and Navy should be crushed to supply our technical industries requiring this oil.

METHODS OF OBTAINING CASTOR OIL AND ITS USES.

So far as is known all but one of the few American mills which crush castor beans use the hydraulic process similar to that of the cottonseed oil mill. A large portion of the beans raised in 1918 will be pressed in expellers, which recent experiments have shown to be well suited for this work. Abroad large quantities of castor oil are extracted from the ground beans by the use of volatile solvents, but this oil is inferior to the expressed oil. Although it has been believed that only No. 1 cold-pressed oil is satisfactory for high-speed motors, some hope seems to exist that a second or even third grade can be refined to form a good lubricant. Besides its medicinal and lubricating uses, castor oil is used in making certain varieties of soap, in the preparation of sticky fly papers, imitation leathers, and for many other commercial purposes. The press cake from castor beans contains a poisonous principle, which makes it dangerous as a cattle feed, although it has value as a fertilizer.

MISCELLANEOUS VEGETABLE FATS AND OILS.

In addition to the principal vegetable oils already discussed, a number of oils less important commercially are produced in or imported into the United States, in comparatively small quantities.

Taken all together, they constitute some 7,000,000 pounds, or 0.2 per cent of our total fat resources, exclusive of butter. While it would perhaps be impossible to develop any of these in a short time to the point where they would add materially to our oil supply, it may be well to mention here some of the more common of these oils.

Our importation of *rape* or *colza oil* dropped from about 20,000,000 pounds in 1916 to only a little over 10,000,000 pounds in 1917. This oil is used very largely for lubricating purposes, but, like nearly all vegetable oils, it can be refined to form a fairly palatable food oil. The soap industry uses very appreciable quantities (Table 9).

Closely related to rape oil is the oil obtained from mustard seeds, of which there are several varieties. *Mustard oil,* not the pungent-smelling, volatile oil, but the bland, fixed oil, can be used in foods, particularly in salad dressing. Undoubtedly a large part of the mustard oil produced in this country goes into our condimental dressings. A part of this oil is obtained as a by-product in the manufacture of mustard flour and prepared mustards, being expressed from the mustard seeds before they can be properly ground and bolted. In the grain elevators of the great Northwest, many hundred tons of wild oil seeds, principally brown mustard and charlock, are obtained in the screenings. One or two firms dealing in such miscellaneous products press these, and mix and market the oil under the label "Vegetable Oil." This is sold to manufacturers of soap or other technical products.

Sesame oil, one of the staple food oils of southeastern Europe and also produced to some extent in Mexico, is apparently coming into more common use in the United States. Recently a few hundred tons of sesame seed, known in Mexico as "Ajonjoli," have been pressed by southern oil mills, and a project is under way to import greater quantities as conditions in Mexico become more settled. Sesame would grow as far north as Ohio and Kansas. The harvesting of the seeds, however, requires a good deal of hand labor, for the little pods holding the seeds are readily shattered as soon as they are ripe, and, unless picked at exactly the right time and carefully handled, much loss occurs, because of the scattering of the seeds.

Sunflower seed oil, which constitutes from 45 to 50 per cent of the seed of the large cultivated sunflower, has a pale yellow color, a mild taste, and a pleasant odor. In Russia, where large quantities of this oil are produced, the cold-drawn grade is used for culinary purposes and in making butter substitutes, while that which is hot pressed is employed in making soaps and Russian varnishes. The Russian peasants also use it as a burning oil. In 1911, more than 500 mills in the Caucasus were engaged in pressing sunflower seeds, and part of the oil thus obtained was exported to English refineries. Although, so far, no appreciable quantity of sunflower seed oil has been made in the United States, in time the sunflower may be numbered among our oil-producing plants, since it is possible to use its oil to good advantage for both food and technical purposes.

Cacao butter is practically the only naturally hard vegetable fat produced in this country. It is obtained as a by-product in the manufacture of beverage cocoa. To make chocolate, the cacao bean is roasted, ground, and degerminated in the grinding process. Cocoa is obtained by pressing the chocolate and extracting part of the oil in hydraulic or screw presses. Before the war, the demand for cacao butter in this country was so great that it could not be supplied by our domestic manufacturers. Our average annual imports of cacao butter and its substitutes for the three prewar years of over 4,000,000 pounds dropped in 1917 to 166,000 pounds, and in that year we exported 551,000 pounds. Cacao butter is used largely in making confectionery. It owes its importance in this industry to the fact that it is necessary to add a certain amount of this fat to chocolate before the sugar in sweetened chocolate will dissolve freely. Since the scarcity of sugar has increased the price and decreased the production of confectionery, much less cacao butter is needed now than a few years ago. Consequently, cacao butter, formerly the most important article made by the cacao manufacturer, has become a by-product, and is one of the very few fats which have not materially increased in price. Cacao butter is also an important ingredient in certain pharmaceutical preparations, as salves, and attempts have been made to use it in the manufacture of margarines.

The United States is as yet dependent upon the Orient for its supply of *tung oil,* known here as *Chinese nut oil* or *China wood oil,* which is pressed by rather crude methods from the tung nut, *Aleurites cordata.* A few experimental plantings of this tree have been made in the far South, but they have not as yet yielded any commercial quantity of oil. Although the importation of tung oil into this country is nothing new, the quantity we bring in has been steadily increasing, until in 1916 nearly 57,650,000 pounds were received, as compared with the average 1912–1914 importations of 42,000,000 pounds annually. In 1917 the imports dropped off to 41,190,000 pounds. Since this oil is more important than ever just now, on account of the increased demand for rosin varnishes, some steps must be taken to increase our supply. Tung oil is poisonous, or at least so strongly laxative that it is not used in foods, and so far as is now known it can not be sufficiently refined to form an edible product. It is the best substitute we have for linseed oil in paints and especially varnishes. In fact, when rosin is used instead of the foreign varnish "gums," the tung oil is superior to linseed oil. The so-called "spar varnishes," which do not discolor when wet, are largely tung oil rosin preparations. For the waterproofing of our concrete ships enormous quantities of this Chinese wood oil may be required.

Candle nut oil, which is obtained from the *Aleurites moluccana*, a plant closely related to the tung nut, is somewhat similar to tung oil, but so far has not been imported in appreciable quantities, as it is not a good drying oil. Another member of this same family, the *Aleurites trisperma*, now under investigation by the Department of Agriculture, is still of only academic interest.

Shea nut oil, a semisolid fat, resembling somewhat coconut oil, is used very largely in the soap industry. It is derived from the fruit kernel of an African tree, and by the natives of the tropics is used for food. Small quantities of the oil are made in a crude fashion by the Africans for export, but practically all that is consumed in the United States is extracted from the imported nuts. This oil was a rarity in America previous to 1916, when one or two mills brought in and pressed several cargoes of shea nut. The total production was about 4,000,000 pounds in 1916, while in 1917 we made only 81,000 pounds, and in 1918, due to the embargo, only a few bags of the nuts came in. The soap industry used almost 2,500,000 pounds of shea nut oil in 1917, which was undoubtedly largely that reported as produced the year before.

ANIMAL FATS AND OILS.

LARD.

PRESENT SITUATION.

Lard occupies the most important place among America's fats, with the possible exception of butter. Butter, however, contains only about 83 per cent of fat, and when the amount of water and salt in it is deducted from the figures reported for the annual production of butter, lard stands first in the list of our output of animal fats and oils. Table 2 indicates that our normal production of lard is about 1,000,000,000 pounds, but this does not include the large amount made by small butchers and on the farms, which is perhaps 1,000,000,000 pounds more. At present lard is exported in greater bulk than all the other fats taken together, and even before the beginning of the European war it formed nearly 50 per cent of our total fat and oil exports.

MODERN METHOD OF PRODUCTION.

Probably from 85 to 90 per cent of the entire output of lard from the big packing plants, which produce about one-half of the domestic lard, is of the grade known on the boards of trade as prime steam lard. The rest is the so-called kettle-rendered lard or neutral lard. The smaller packers, local butchers, and hog raisers, who make the other half, usually produce only the kettle-rendered grade.

The distinction between steam and kettle-rendered lard is not entirely one of process, as, in the packing houses, at least, only the leaf and back fat are kettle rendered, all the other fats going into steam lard.

In making kettle-rendered lard the leaf fat is pulled from the carcasses while they are still warm and immediately chilled. When thoroughly cooled, the fat tissue is hashed fine and heated in steam-jacketed kettles until the clear fat, in the form of a light yellow oil at this temperature (250° F.), separates from the tissues. It is then salted and allowed to stand until the fine particles of the fat membranes separate out. Finally, after one or two more settlings, it is drawn off hot into the shipping packages and placed at once in a freezer. The cracklings left in the rendering kettle are either pressed to obtain the residual lard or put into the steam lard tanks. This rendering of lard in steam-jacketed kettles is merely a safe and convenient modification of the old home method of making lard by cooking the hog fat in a big pan over an open fire. The kettle-rendered product, therefore, has that characteristic lard flavor so highly prized by those who do not like the new type of lard substitutes.

Neutral lard, or simply neutral, as the packers call it, is made from the first grades of leaf fat by cooking in much the same manner as the kettle-rendered lard. It is, however, cooked at a lower temperature, from 126° to 128° F., so that it retains practically no hog flavor. It is used almost exclusively in the manufacture of oleomargarine.

Steam lard, as its name implies, is rendered by means of live steam. The chopped fats are charged into large steel tanks, and after the cover has been fastened down live steam is turned in through pipes at the bottom of the tanks. When the cooking has proceeded to the point where the melted lard separates from the fat membranes, the steam is turned off and the water and solids allowed to settle, after which the lard is drawn off from the top and the water and tankage dumped out at the bottom. As some darkening of the lard occurs during cooking and its flavor is often too strong, it is customary to bleach and deodorize it by the processes already described.

Lard oil, which is used as an illuminant in signal lights and miners' lamps and as a lubricant in machine shops, is made by chilling lard, and sometimes other fats, such as horse oil, and pressing out the liquid olein from the higher-melting stearin. The olein constitutes the lard oil. The remaining stearin is often mixed with whole lard to make it firmer in warm weather and is also used in making compound lard.

INCREASING THE YIELD.

The production of lard depends upon the weight of hogs slaughtered. As ways and means for increasing hog production in this country have been fully covered in another publication of the Department of Agriculture,[1] only such points as have a direct bearing upon the increase in our supply of lard will be mentioned here. It is estimated that the number of hogs slaughtered in 1917 was about 1,000,000 less than during the preceding year. Allowing 14 pounds of lard per hog butchered, this would mean that 14,000,000 pounds less lard were produced in 1917 than in 1916. Actual returns made to the Food Administration by the packing houses show that 218,170,000 pounds less lard (not including neutral) were made in 1917 than in 1916. Such a situation is, of course, very serious, especially under existing conditions. The United States Department of Agriculture, in conference with many of the State agricultural institutions and farmers, however, set 15 per cent as the minimum average increase in the production of hogs for 1918, and there is no reason why we should not secure this increase. Probably very little lard is wasted in the packing houses, where every effort is made to obtain as large a yield as possible. It is true, however, that if commercial conditions were different and the boards of trade recognized any grade of lard except prime steam more of the output of the packing houses might be converted into kettle-rendered lard. While this would not increase the total production appreciably, it would give us more of the better product and the value of the by-products, cracklings, and tankage would lower the expense of making the lard.

We must look then to the small butcher and the farmer for more pounds of lard per pound of hogs slaughtered. Just the little extra effort required to press the cracklings from the rendering kettle in a simple hand press would insure a greater saving of the pure fat from the various parts of the hog. The housewife in her own home can play an important part in decreasing the consumption of lard by saving the trimmings from ham and fresh pork, trying them out, pouring off the clear grease, and grinding up the cracklings, for use in place of the straight lard in making corn bread, muffins, and other hot breads.

TALLOW.

PRODUCTION AND EXPORTATION.

According to the best available figures, the United States in 1917 produced some 259,500,000 pounds of tallows, as the fats from sheep and cattle are called. Although this figure includes mutton tallow, the greater portion represents beef tallow, for many more cattle than sheep were killed in 1917, and the yield of fat from a steer is, on an average, 50 pounds as against 1 pound from a sheep or goat. According to data recently submitted to Congress by the Federal Trade Commission, the rate of slaughter of cattle has increased 30 per cent

[1] U. S. Dept. Agr., Office of the Secretary Circular 84.

during the five-year period 1913–1917, 12,000,000 cattle having been killed in 1913 and 15,600,000 in 1917, a very rapid increase. It is stated also that the slaughter of calves increased proportionately.

Our exports of tallow, as such, have decreased from an annual pre-war average of 28,600,000 pounds to a little more than 7,500,000 in 1917, and the exportation of oleo oil shows a corresponding decrease. It is interesting to compare the exports of straight tallows with those of tallow derivatives (Table 5). Such a comparison brings out the fact that foreign countries do not demand as much hard tallow and the harder oleostearin as they do the semisolid portion of the tallow—the oleo oil. This country produces practically one-fourth as much tallow as lard, and the 259,509,000 pounds of tallow constitute a little less than 16 per cent of our total animal and fish fat and oil output. Considering the tallow production, oleo stock must also be taken into account, as this is really only a high grade of edible tallow derived from cattle and is used primarily for the manufacture of oleo oil and stearin. If we include the 153,188,000 pounds of this fat reported in 1917 with the tallow, we have a total of 412,697,000 pounds. This places the tallows third in the domestic production of all fats and oils.

PREPARATION OF TALLOW AND TALLOW DERIVATIVES.

The modern packing-house method of handling beef fat is similar to that used in the preparation of hog fats. A larger portion of lard than of tallow, however, is made in open kettles. In the smaller packing houses, which are not under Federal inspection, practically the entire output of tallow is either sold as such, or mixed with cottonseed or some other vegetable oil to form a compound. On the other hand, the big packers convert a great deal of their edible beef fat into oleo oil and stearin. These are separated by a process known as "graining," which is similar to "wintering" as applied to vegetable oils, to separate the stearin and produce oils that will not become cloudy in cold weather. The graining process consists in running the melted oleo stock into large truck tanks, which are then wheeled into the graining room, where the stock is allowed to stand undisturbed at the crystallizing temperature of the stearin for a day or longer. When the stearin has separated from the oil, the batch is sent to the press room, also kept at a constant temperature, and the semisolid mass of stock is pressed in hydraulic or lever presses. As it runs from the presses the oleo oil is pumped into storage tanks, and later barreled either for the export trade or for use in domestic margarine manufacture. The solid cakes of stearin are stripped from the press cloths, melted, and stored in barrels for use in making lard substitutes.

USES OF BEEF TALLOW AND ITS DERIVATIVES.

Practically all of the oleo oil is used either here or abroad in making oleomargarine. The quantity consumed in this country, together with the amounts of other ingredients used in the margarine trade, is shown in Table 10. Neither butter nor lard substitutes are mentioned in Table 1, as they are not primary fats; that is, they are manufactured products made from the oils and fats, statistics for which are given in Table 11.

TABLE 10.—*Consumption of fats and oils by the oleomargarine industry.*

Product.	1912	1914	1916	1917
Vegetable oils:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Coconut	473,000	509,000	563,000	20,220,000
Corn			147,000	859,000
Cottonseed	17,837,000	21,205,000	49,960,000	63,652,000
Mustard seed	197,000	373,000	169,000	46,000
Peanut	2,453,000	3,137,000	5,335,000	10,498,000
Soy bean	708,000	486,000	2,123,000	6,614,000
Animal fats and oils:				
Butter	645,000	600,000	2,152,000	3,303,000
Lard and neutral lard	14,794,000	19,439,000	33,445,000	42,401,000
Lard stearin				7,000
Oleo oil	28,145,000	46,445,000	68,989,000	96,250,000
Oleostearin	906,000	2,620,000	2,036,000	2,494,000
Oleo stock	108,000	489,000	397,000	3,535,000
Total fats and oils	66,266,000	95,303,000	165,316,000	249,879,000
Other ingredients:				
Coloring	54,000	3,000	4,000	4,000
Milk	12,468,000	14,639,000	23,921,000	26,646,000
Salt	2,096,000	2,537,000	4,088,000	6,115,000
Oleomargarine produced	95,397,000	123,843,000	184,889,000	271,874,000

The Bureau of Internal Revenue collects a tax on every pound of oleomargarine, under which heading are included all butter substitutes. We have, therefore, exact figures on the production of this class of foodstuffs. In 1914 the output of oleomargarine was about 123,000,000 pounds; in 1916 it rose to nearly 185,000,000 pounds; while in 1917 it was over 271,000,000 pounds. Our average annual exportation during the three prewar years was a little over 3,000,000 pounds, about 2 per cent of the amount manufactured. Until 1915 the oleomargarine exports from this country had for several years shown a gradual decrease, but with the beginning of the war they doubled, and in the fiscal year 1915 we sent to foreign countries 5,250,000 pounds.

The butter substitutes now on the American market are of two classes—the true oleomargarine, which contains oleo oil and neutral lard, and the vegetable margarines, which contain no animal fats. The vegetable margarines are quite commonly called "nut margarine," being composed largely of coconut and peanut oils. Both types of margarines show a wide variety of composition. Not only has each manufacturer his own secret formula, but even the ingredients in the same brand may vary with the different seasons and with the fluctuations in the market price of the fats and oils used. In the highest grade of oleomargarine sometimes as much as 20 per cent of butter is used, and the vegetable oils may be entirely omitted.

The same general process, however, is employed for all of them. This consists in ripening whole milk, or skim milk, usually with a pure "starter," as is done in creamery butter making, adding the animal or vegetable oils, or both, and then churning, graining, salting, and working, as described in greater detail under coconut oil (page 21).

Aside from the use of tallows in lard and butter substitutes, and, to a less extent, in sausage, suet puddings, mincemeat, and similar foods, large quantities of the inedible grades are required by the soap maker and the manufacturer of leather dressings and of lubricating greases, as well as in other technical industries. The introduction of the hydrogenation process for hardening oils has made it possible to produce hard soaps from vegetable oils without the addition of as much tallow as was formerly required if the soap maker desired anything but a soft soap. This has probably brought about some decrease in the amount of tallow employed in the soap trade. As a people, however, we are demanding each year more soap, so the total quantity of animal fats going into our soap kettles is greater rather than less than it was five years ago.

HOW TO INCREASE OUR TALLOW PRODUCTION.

The amount of tallow which can be produced in the United States depends very largely upon the number of animals slaughtered. Perhaps the dressed carcasses might be more closely trimmed for fat than is now the custom. In that case, however, the housewife who buys the meat would be deprived of the fat, in the form of scraps and drippings, which she now uses for food purposes, and which is probably quite as valuable to her as fat in the form of oleomargarine would be. Every butcher whose plant is subject to Federal inspection makes two grades of tallow—edible and inedible. The inedible fat is made from animals unfit for human consumption or parts of diseased animals. The greater the number of tuberculous cattle coming to the packing house, the greater the amount of fat turned in to the "tank house," as that part of the plant where condemned animals are rendered is called.

The stockman has it in his power to augment the supply of edible fats in the United States in two ways: (1) By keeping his cattle healthy; (2) by properly fattening his animals before marketing them. It is not as easy to fatten a steer as a hog. The lean range steer, however, which in the stockyard is classed as a "canner," can be made into a fat steer if fed a suitable ration.

BUTTER AND CHEESE.

AMOUNT OF FAT AVAILABLE IN THE FORM OF DAIRY PRODUCTS.

Of all the fats and oils, the one most universally and extensively produced is milk fat, in its various forms of butter, cheese, and their modifications. No exact figures for the total production are available, but it is estimated that from 1,630,000,000 to 2,000,000,000 pounds are produced annually. The lower figure represents about 40 per cent of the entire milk production, which, based upon an average of 3,716 pounds of milk from each of our 22,768,000 dairy cows, is 84,605,888,000 pounds. In other words, since it takes 21 pounds of milk to make 1 pound of butter, it is necessary to churn 34,650,000,000 pounds of milk to form 1,650,000,000 pounds of butter. We must not lose sight of the fact, however, that this butter is not all fat, the legal requirements being that butter shall contain less than 16 per cent of water. The actual fat in all the butter produced annually in the United States is between 1,300,000,000 and 1,400,000,000 pounds.

The fat which occurs in cheese is practically identical with that in butter. Since we produced in 1917 about 476,000,000 pounds of cheese, containing on an average 35 per cent of fat, it is perhaps no more than common justice to our good friend the cow to credit her with an average annual production of an additional 166,000,000 pounds of butter fat. To give the dairy industry full allowance for its share in supplying the Nation with fats, attention should also be directed to the fact that the 1,416,000,000 pounds of butter fat which in 1917 went into our butter and cheese constituted only 50 per cent of the total milk produced. Thus it is seen that from this industry we have in one year derived over 2,832,000,000 pounds of one of the very best food fats known to man.

The Department of Commerce figures show that the exports of butter from the United States have increased very rapidly during the past six years, and that the foreign demand for this product in 1917 greatly exceeded the average for the first three years of the war. This can be accounted for by the fact that England and France formerly depended to a great extent upon Holland, Belgium, and Switzerland for their supply of butter and cheese.

FISH OILS.

PRODUCTION AND USES.

Although our fish oil industry may be said to occupy a minor position in the general oil market, the approximately 30,000,000 pounds which we produce annually, and the 20,000,000 pounds which we import, make fish oil worthy of some consideration. Our imports of fish oil, including cod and cod liver oils, were about 5 per cent of the aggregate of the oils and fats which we imported from foreign countries in 1914. In 1917 they formed only 3 per cent, due not to any falling off in fish oil imports, but to greatly increased imports of soy bean and coconut oils. A number of varieties of fish are used for oil, and many more yield a small quantity of oil as a by-product from plants where they are canned or dried. Strictly speaking, sperm and other whale oils, as well as the dolphin and porpoise oils, do not belong in the same class with menhaden and the related drying fish oils. The production, importation, and exportation of these oils are shown in Tables 2, 4, 5, and 7. Straight fish oil and fish liver oil are reported together as there is only a very small amount of pure liver oil made in this country. Recently a refining process in which hydrogen instead of steam is used to blow the oil has been developed. It appears that it is now possible to remove the disagreeable odor and flavor from some kinds of fish oils and render them suitable for food. For several years whale and possibly some fish oils have been hardened by hydrogenation in Norway and Germany, and within the last six months a lard substitute made in this way from Pacific coast herring oil has appeared on the American market. At present, however, fish oils are classed as technical oils, and are used chiefly in the manufacture of leather dressings, soap, and, to some extent, in making cheap paints.

HOW TO INCREASE THE SUPPLY.

The older methods for obtaining fish oils, which fortunately are now falling into disuse, consisted merely in permitting fish and scrap to rot, or, at best, in cooking the partly decomposed material in open kettles and skimming off the oil as it rose to the top. If care is taken to render with steam the fish before they have begun to decay and to press the fish scrap and residue from the rendering tanks, larger yields of a greatly superior oil are possible. There is no well-established market for fish oils other than the menhaden, herring, cod and cod liver oils, and comparatively few of the fish packers are equipped to make a good grade of oil. The fishermen, therefore, throw away much of their catch which is not suitable for food purposes, and a great deal of the refuse from the canneries is used only as fertilizer, or dumped back into the water. Many firms are coming to realize that it is perfectly possible to create a good market for fish meal as a stock feed, and that it will be profitable for them to press their refuse material to obtain the oil and grind the pressed cake for feed.

This country uses, and produces in small quantities, a great many special oils from such marine animals as the whale, the porpoise, and the seal. Nearly all of these are manufactured to supply some specific demand. For instance, the best oil known for lubricating clocks, ships' chronometers, and other delicate instruments is obtained from the fat glands in the jaws or head of the porpoise. Very little of this oil is made, one firm producing practically the entire amount, but it is very valuable, bringing from $25 to $50 a gallon.

Seal oil is also considered superior as a lubricant for fine machinery, and it, too, is made in comparatively small quantities. Whale oil is of great importance in Norway, where there are no native vegetable oils. After hydrogenation this oil can be used in the manufacture of oleomargarine. The American catch is not large enough, however, nor do we import a sufficient amount to warrant any such use of whale oil in this country. A few experimental shipments of the hydrogenated oil were brought in before the Great War, and it is possible that at some future time this oil may enter into competition with our hydrogenated vegetable oils for making the various compounds and margarines.

MISCELLANEOUS ANIMAL FATS AND OILS.

Chicken fat is rendered and packed by a number of firms for sale to Hebrew trade for use instead of butter during certain seasons of the sacramental year. It has a sweet taste, a light color, and possesses some very desirable physical properties. This fat is also highly prized by some of our finest cooks in making certain kinds of hot breads and cakes. Since the necessity for economy in the beef, pork, and mutton consumption has become of such importance, it would seem inevitable that our supply of poultry should increase appreciably. The wise housewife will save all chicken fat for use as a substitute for butter or lard in cooking.

One of the most important of the less common animal oils is *horse oil*, which is produced from the carcasses of horses either killed for meat or ordered destroyed by public health officials. This oil is the basis of a large proportion of the commercial neat's foot oil, which is merely a wintered horse oil. In the manufacture of many lubricating greases, horse oil is considered an essential constituent, as it is claimed to be superior to any other fat for mixing with petroleum greases.

The various greases which are grouped together in Table 2 under the heading "Packers' and Renderers' Greases" comprise about 10 per cent of the entire animal and fish oil production, and are handled under numerous more or less loosely defined trade names. Much of the inedible fat of the packing houses goes on the market as white, yellow, or brown grease, being graded according to color and percentage of free fatty acid. These are largely hog fats, but may contain catch-basin skimming, some of the fat from the tankage, and the better grades, rancid lard and crackling greases.

REFUSE FATS AND TRADE WASTES.

Several important potential sources of recoverable fats and oils are still largely overlooked in this country. One of the most promising of these is city garbage. Some idea of the total amount of grease that might be recovered from our domestic wastes may be gained from the actual yield of 4,000,000 pounds from the reduction plant operated by the city of Chicago. Armour & Co. contracted to buy this quantity of grease from the city at a price of 11.57 cents a pound in 1918, and the Emery Candle Co. pays 13.5 cents for a similar grease obtained from Washington garbage. It has been stated by Mr. Bammann, of the United States Food Administration, an authority on the subject of garbage disposal, that 30,000,000 pounds, over $3,000,000 worth of grease, which could be converted into 4,400,000 pounds of nitroglycerin and almost 40,000,000 12-ounce cakes of soap, goes to waste in 24 of our larger cities alone. If this garbage from a combined population of 5,000,000 were properly utilized, we would get in addition to the grease 60,000 tons of fertilizer, sufficient to grow a 3,000,000-bushel wheat crop.

It is reported on good authority that in one year the British Army collected from its camp kitchens wastes that yielded 1,800 tons of glycerin, which is equivalent to at least 40,000,000 pounds of fat.

We are told that in Germany systematic efforts have been made not only to save garbage grease, but also to recover the fatty matter from sewage. A comparatively small plant for the recovery of sewage grease has been in operation for some time on one of Boston's outfall sewers. As a result of these experiments, Dr. Sedgwick, of the Massachusetts Institute of Technology, who has been in charge of the plant, states that 25,780,000 tons of recoverable grease go to waste each year in the sewage of 97 American cities. Average sewage contains about 430 pounds of recoverable grease in each million gallons.

More concentrated forms of fatty wastes are derived from fish canning and packing plants, wool scouring establishments, tanneries, and similar manufacturing plants. Many of these wastes, already looked upon as a source of valuable by-products, are recovered, purified, and marketed. In a great number of the smaller plants, however, especially in the fish and canning industries, the aggregate loss of oils is still very large.

METHODS FOR RECOVERING REFUSE FATS.

The garbage and similar refuse fats are recovered either by using a volatile solvent extraction or by the pressure cooking process. The raw materials from which they are obtained are neither rich enough in fat nor do they as a rule contain a sufficient amount of fibrous substance to make it possible to press them. City garbage usually is cooked under pressure in large autoclaves, and the grease which separates from the disintegrated vegetable matter blown out with live steam through the strainers at the bottom of the tanks. The residue is often dried afterwards and extracted, to recover the remaining fats, and then sold as tankage. Fish scrap is sometimes boiled in open kettles, and the oil skimmed off. Better yields, however, are obtained when it is treated by the same method as the garbage. A comparatively new process, the Cobwell System, which depends upon the removal of the water from the garbage by heating with a volatile solvent, is being used in New York City. In this plant the wet garbage is charged into a closed vessel known as a reducer which is equipped with a stirrer and flooded with a volatile solvent, usually gasoline. This is then distilled off, carrying with it some of the water. This process is repeated until the garbage is practically dry. It is then extracted several times with solvent which, however, is now drawn off instead of being distilled, and the fat it has dissolved recovered by the usual distillation methods. The degreased tankage remaining in the reducer is freed from solvent by blowing it with live steam, after which it is discharged ready for use as fertilizer.

The refuse fats are, of course, suitable for industrial purposes only. They all contain from 7 to 10 per cent of glycerin, and many of them, especially garbage grease, which is high in animal fat, constitute a satisfactory soap stock. Fish heads, tails, fins, etc., yield a fair grade of fish oil, if the material has not been allowed to decompose too badly. Grease recovered from wool scouring forms the crude lanolin, or wool grease, which when properly refined makes one of the most expensive of our greases, the lanolin of the pharmaceutical trade, and the basis of many ointments and salves.

OILS FROM TRADE WASTES.

With the growing demand for fats and the resulting increase in their price, manufacturers are paying more attention to the recovery of fats and oils from the wastes of their factories. This is particularly true where the disposal of the waste entails an expense, as in the case of canning factories located in or near large towns. Tomato seed oil is an example of an oil which may be recovered from such wastes. In Italy it has been extracted with volatile solvents from the tomato seeds thrown out by the tomato-pulp plants. The tomato seed oils made in the Bureau of Chemistry of this department by cold pressing tomato seeds from pulp and catsup factories in different parts of the United States are greenish yellow, and are easily refined and bleached.

Pumpkin and squash seeds, now a total loss in the factories which can these vegetables, contain a dark-red oil somewhat similar in appearance to cottonseed oil. When refined this oil does not, however, become as light in color as cottonseed oil. Still it would be possible to use such an oil in soap making, and perhaps for some other technical purposes. These oils are now under observation by the experts of the Department of Agriculture.

Individually such oil-bearing wastes do not as a rule occur in sufficiently large amounts in any one place to make profitable there the operation of an oil mill. Nevertheless, if collected and pressed at a central point in the various canning sections, they would add their mite to our oil resources.

FAT AND OIL DERIVATIVES OR SECONDARY PRODUCTS.

Aside from the pure fats and oils produced in this country, there are a number of products that are either glycerids or by-products from the refining of glycerids, largely sodium soaps, mixed with more or less neutral oil. These have been grouped together, and, for want of a better term, called fat and oil derivatives. In 1917 we manufactured over 590,000,000 pounds of such secondary products (Table 11).

TABLE 11.—*Production of fat and oil derivatives in the United States.*

Product.	1912	1914	1916	1917
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Acidulated soap stock	32,702,000	32,411,000	26,199,000	16,151,000
Cottonseed foots	141,088,000	194,144,000	122,468,000	112,847,000
Cottonseed foots (distilled)	80,724,000	87,820,000	33,548,000	33,900,000
Fatty acids	15,618,000	23,563,000	20,431,000	25,531,000
Fatty acids (distilled)	28,476,000	32,436,000	50,016,000	55,373,000
Grease stearin	17,508,000	19,730,000	31,619,000	30,046,000
Lard oil	22,296,000	22,034,000	45,413,000	37,930,000
Mutton oil	573,000	687,000	430,000	405,000
Oleo oil	119,889,000	143,453,000	152,033,000	143,088,000
Other soap stocks	10,076,000	18,095,000	11,629,000	7,457,000
Red oil	27,494,000	38,109,000	38,300,000	40,160,000
Tallow and oleostearin	77,756,000	82,049,000	80,263,000	74,342,000
Tallow oil	5,010,000	8,103,000	6,702,000	3,761,000
Vegetable stearin			5,398,000	5,801,000
All other stearin	218,000	345,000	195,000	1,565,000
All other foots	383,000	1,258,000	2,210,000	2,402,000
Total	579,813,000	704,239,000	636,854,000	590,759,000

These derivatives fall into two classes. The first class comprises those which are obtained as by-products from refining oils, and are known in this country either as soap stock or "foots." Adding together the acidulated soap stocks and crude and distilled cottonseed foots produced in the United States in 1917, a total output of some 160,000,000 pounds of these by-products is obtained. As both fatty acids and distilled fatty acids are made largely from cottonseed oil, it is evident that by far the greater proportion of foots in this country come from cottonseed oil. Appreciable quantities of foots are derived also from the refining of peanut, coconut, soy bean, and other vegetable oils which are treated with caustic soda to make them suitable for food purposes. A detailed description of the methods by which these various products are obtained would involve more technical detail than properly belongs to a treatise of this kind. Suffice it to say that acidulated soap stock, or black grease, as it is often called, is made by neutralizing with sulphuric acid the caustic soda present in raw foots. If, after neutralizing with acid and separating the small amount of glycerin from the large quantity of sodium sulphate liquor formed during this process, the fatty acids are distilled, the resulting product is known as distilled fatty acids, or, sometimes, distilled cottonseed foots. These fatty acids may also be further treated by pressing them according to a method similar to that employed in obtaining oleostearin and the oil from oleo stock (page 35). The liquid acids manufactured in this way are known in the trade as red oil, and the solid acids usually as stearic acid. Properly speaking, these solid acids are by no means pure stearic acid, but a mixture of stearic, palmitic, and other saturated fatty acids. The red oil is very largely crude oleic acid, although it too may contain a certain amount of other unsaturated fatty acids and a small quantity of palmitic and stearic acids. To the second group of derivatives belong the stearins and oleo oils. The method of separating the higher from the lower melting portions of tallow, and the chilling out by the wintering process of the cottonseed stearin from cottonseed oil have already been described (page 8).

In figuring our production of fats and oils it is obviously incorrect to include these derivative products, which have already been reported in the production of the crude oils, tallows, greases, etc., from which they are obtained.

Vegetable stearin, a term properly applied only to the higher melting portion of vegetable oils separated by some chilling process, has recently been used as a synonym for hydrogenated oil. These hardened fats made by the hydrogenation process, however, should not be confused in this way with the natural vegetable stearins. The figures given in Table 11 for the production of vegetable stearins probably refer, to some extent at least, to hydrogenated oils, due to this unfortunate confusion of terms in modern trade practice.

SUMMARY.

During the recent Great War, the matter of maintaining an adequate supply of fats and oils became a very important factor. Although the allied nations were able to secure enough to meet their military and civil needs, Germany soon found herself seriously embarrassed by a lack of all fats. Had her Government heeded the advice of those experts who advocated the planting of oil-producing crops during the years of preparation for the war, such a situation probably would have been avoided. For vegetable oils are being used in ever-increasing amounts to supplement the animal fats and oils. Some, like cottonseed oil, make a satisfactory substitute for part at least of the animal fats in such products as lard, while some of the less well-known vegetable oils, like peanut and corn, are rapidly growing in public favor as substitutes for olive oil, which has recently been very difficult to obtain. It has also been found possible to conserve our supply of linseed oil by using tung and similar oils in making paint, varnishes, and other technical products. It is believed that the manufacturer of vegetable oils may practice many more economies than he now does, thus eliminating certain sources of waste.

The recently devised hydrogenation process has made it possible to secure a very satisfactory lard compound, in which a vegetable oil replaces all of the often more expensive animal fat. By means of this same process, various fish oils now employed only for technical purposes may be rendered edible.

Conservation in food materials is still essential. To this end the small butcher and farmer are urged to trim the animals they slaughter closely to obtain all the fat possible for rendering as lard or tallow. The housewife, too, should be as economical as possible in her use of animal fats.

The question of recovering fatty matter from garbage and trade wastes is receiving much attention at this time, and it is probable that effective methods for doing this will soon be worked out.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO FATS AND OILS.

PUBLICATIONS FOR FREE DISTRIBUTION.

Soy Beans: Utilization for Oil, Cake, and other Products. (Department Bulletin 439.)

Possibility of Commercial Production of Lemon-grass Oil in United States. (Department Bulletin 442.)

Effects of Cultural and Climatic Conditions on Yield and Quality of Peppermint Oil. (Department Bulletin 454.)

Studies of the Digestibility of Some Nut Oils. (Department Bulletin 630.)

Influence of the Linseed Oil of the Geographical Source and Variety of Flax. (Department Bulletin 655.)

Digestibility of Some Seed Oils. (Department Bulletin 687.)

The Production and Conservation of Fats and Oils in the United States. (Department Bulletin 769.)

Peanut Oil. (Farmers' Bulletin 751.)

Studies on Chicken Fat: 3, Influence of Temperature on Lipolysis of Esters; 4, Hydrolysis of Chicken Fat by Means of Lipase; 5, Occurrence of Catalase, Oxidases, and Reductases in Fat of Common Fowl, Gallus Domesticus. (Bureau of Chemistry Circular 103.)

Detection of Phytosterol in Mixtures of Animal and Vegetable Fats. (Bureau of Animal Industry Circular 212.)

Some American Vegetable Food Oils, Their Sources and Methods of Production. (Separate 691, from Year Book, 1916.)

The Soy-Bean Industry in the United States. (Separate 740, from Yearbook, 1917.)

The Peanut, a Great American Food. (Separate 746, from Yearbook, 1917.)

Present Status of the Peanut Industry. (Separate 748, from Yearbook, 1917.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Digestibility of Some Animal Fats. (Department Bulletin 310.) Price 5 cents.

Production of Sweet-Orange Oil, and New Machine for Peeling Citrus Fruits. (Department Bulletin 399.) Price 5 cents.

Fats and Their Economical Use in the Home. (Department Bulletin 469.) Price 5 cents.

Digestibility of Some Vegetable Fats. (Department Bulletin 505.) Price 5 cents.

Studies on Digestibility of Some Animal Fats. (Department Bulletin 507.) Price 5 cents.

Olive Oil and Its Substitutes. (Bureau of Chemistry Bulletin 77.) Price 10 cents.

Improvement of Knorr Fat Extraction Apparatus. (Bureau of Chemistry Circular 69.) Price 5 cents.

Studies on Chicken Fat: 1, Occurrence and Permanence of Lipase in Fat of Common Fowl, 2, Oxidation of Chicken Fat by Means of Hydrogen Peroxid. (Bureau of Chemistry Circular 75.) Price 5 cents.

Modification of Herzfeld-Bohme Method, for Detection of Mineral Oil in Other Oils. (Bureau of Chemistry Circular 85.) Price 5 cents.

Chemical Investigation of American Spearmint Oil. (Bureau of Chemistry Circular 92.) Price 5 cents.

Effects of Certain Pigments of Linseed Oil, with Note on Manganese Content of Raw Linseed Oil. (Bureau of Chemistry Circular 111.) Price 5 cents.

Studies Upon Keeping Qualities of Butter: 1, Canned Butter. (Bureau of Animal Industry Bulletin 57.) Price 5 cents.

Chemical and Physical Study of Large and Small Fat Globules in Cow's Milk. (Bureau of Animal Industry Bulletin 111.) Price 5 cents.

Manufacture of Butter for Storage. (Bureau of Animal Industry Bulletin 148.) Price 5 cents.

Normal Composition of American Creamery Butter. (Bureau of Animal Industry Bulletin 149.) Price 5 cents.

Practical Method for Detection of Beef Fat in Lard. (Bureau of Animal Industry Circular 132.) Price 5 cents.

New Method for Determining Fat and Salt in Butter, Especially Adapted for Use in Creameries. (Bureau of Animal Industry Circular 202.) Price 5 cents.

Wild Volatile-Oil Plants and Their Economic Importance. (Bureau of Plant Industry Bulletin 235.) Price 5 cents.

Utilization of Waste Raisin Seeds. (Bureau of Plant Industry Bulletin 276.) Price 5 cents.

Peanut Butter. (Bureau of Plant Industry Circular 98.) Price 5 cents.

Chinese Wood-Oil Tree. (Bureau of Plant Industry Circular 108.) Price 5 cents.

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