Minor Oil-Producing Crops of the United States

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In view of present international relations and disturbed economic conditions, it is well to consider more carefully our own resources of certain crops and commodities that are of a minor or auxiliary character. In this paper we propose to deal with the subject of lesser known and little used vegetable oils, which may or may not be byproducts of crops grown in considerable abundance. Some of them are not being produced at all for lack of a market or a price return that will justify collection, processing and refining; others are in production in small quantities but not to the potential limit of the supply of oil-bearing material.

It is a fact that oil prices in general have risen sharply in the last year due to our own increased needs, lend-lease arrangements, and lowered imports. The situation is, of course, an unusual and artificial one but it is also true that decisive and permanent changes in trade and commerce will result from the present state of flux. Domestic producers will receive benefit by absorbing markets which in times past have gone to foreign competitors. Byproduct industries will receive the impetus which previously was denied and profits will accrue from former waste materials. A war-torn world will be succeeded by one impoverished of the very essentials of simple living for its inhabitants.

Processing residues of fruits and vegetables and unmarketable grades of such commodities are the first materials to which it is logical to turn in search of vegetable oils, for at least a part of such wastes embraces seeds which are oil-bearing. Pits from the dried fruit industries, tomato waste and citrus waste from canneries and byproduct plants are rich sources of easily obtained and readily refined edible oils. Raisin seeds and seeds from grape pomace fall in this category. Then there is rice bran which is not only a source of vitamin B_1 but also of an easily recovered oil. Cull and frost-damaged avocados can be processed for oil similar in its glyceride constituents to olive oil, which is now selling at fabulous prices. Cull Persian or English walnuts have little value but can be made to yield a superior drying oil.

The oils just referred to may be grouped conveniently as:

1. Pit and Nut Oils
2. Fruit Pulp Oils
3. Seed Oils

The first and third classes are both seed oils, to be sure; nevertheless, there is a natural distinction between them in that fruit pits are characterized by their size with relation to the fruit and their tough woody shells, which necessitate somewhat different treatment in an oil-recovery plant. As the various available oils are considered in turn, production statistics will be cited wherever possible as well as potential supplies residing in the wastes from processing plants. The latter are limiting figures only and need not be construed necessarily as a practical goal because of economic factors such as decentralization, or lack of sufficient material in the smaller plants to justify either recovery equipment or haulage to a custom-pressing establishment.

Pit and Nut Oils

The pit oils of the apricot, prune, peach, and cherry bear a striking resemblance to each other in composition and indeed are with difficulty distinguishable one from the other. They are like sweet almond oil for which they are often substituted (1). A rising demand for pit oils is indicated by the Department of Commerce figures (2) which list imports of peach and apricot kernel oils amounting to 47 tons in 1938, 67 tons in 1939 and 83 tons in 1940. Sweet almond oil imports were 43, 53 and 43 tons, respectively, showing no definite trend. The specialty oils are usually handled by essential oil brokers.

Almonds—Within the past year, one company in the Los Angeles area has started to produce almond oil in substantial quantities from domestically grown nuts. Ungraded, shelled nuts, principally of the Nonpareil variety, containing about 50 per cent oil, are dried, coarsely ground and cold-pressed. About 75 per cent of the oil is removed at 450-lb. pressure. The oil is low enough in free fatty acids that it may be refined to a high-grade salable product by the use of bleaching agents alone. American almond oil has an iodine value of about 103 which is slightly higher than U.S.P. specifications. Nevertheless, it is commonly accepted by the trade.

The meal, containing about 20 per cent oil, is edible but slightly bitter because of the skins. It is ground, sieved to various sizes and sold to the cosmetic and baking trades. The current season (1941) has yielded an abnormally low almond crop, 6,500 tons, which is resulting in an increased price for the nuts and oil. The average annual crop for the five-year period, 1936-40, was 14,400 tons.

Apricot pits—Nearly all of the apricot industry is located in certain well defined areas of California such as the Santa Clara, Sacramento, and San Joaquin Valleys, and a few of the southern counties. The average crop for the past four years was about 237,000 tons (3) of which the bulk, 84 to 93 per cent, was dried or canned. Many of the larger growers dry their own fruit from which the pits are removed and are able to sell the latter at prices ranging from $30 to $45 per ton, which is sometimes in excess of the price received for fresh fruit. Four plants in California buy and shell apricot pits in amounts as high as 14,000 tons per year if the crop is good. Apricot kernels are in demand as a substitute for almonds in bakery goods, though it is necessary to process them first in a way that will remove the bitter taste and liberate the hydrogen cyanide, such as by heating the ground meats in a current of steam (4). The bulk of this product formerly was exported to Europe but the domestic market is now the only one available. There is no market for broken meats that result incidentally from the shelling operation, and to minimize the loss that would otherwise be sustained these are pressed for oil, which is sold to the cosmetic and drug trades at the now very good price of 40 to 48 cents a pound. The present market, however, is a distinctly limited one, probably not in excess of 150 tons. The 14,000 tons of pits previously mentioned would yield, if all were pressed for oil, about a thousand tons in round figures.

At present there are two companies in California engaged in pressing pit oils, of which apricot is the chief. The cracking, separation of shells from meats, and pressing present no difficulties. If the meats are floated from the shell in brine, they must be promptly washed and dried to prevent hydrolysis of amygdalin and consequent release of "oil of bitter almonds" into the fixed oil. Refining losses can be held to a low figure. The oil bleaches easily and it is sufficiently bland that no deodorization is required. It is an excellent cooking and salad oil. The meal is nitrogenous and is sold for lawn fertilizer.

Prune pits—No prune-pit oil is produced at present although a little has been pressed in years past. It is similar to apricot- and peach-pit oils. The prune industry differs somewhat from the apricot industry in that the bulk of the crop is dried without being pitted. Some prune products are now put out minus the pit but these are of small volume. Ninety per cent of the United States prune crop of over 200,000 tons is produced in California (5-year average) (5), the balance coming principally from Washington and Oregon.

Prune pits average 12.5 per cent by weight of the fruit (6). They yield about 7 per cent of oil. An outside figure for the oil from prune pits for the entire annual crop is about 2,000 tons. This amount, however, could never be realized unless present marketing practices were to change in favor of pitted prunes.

Morgan of the Home Economics Division, University of California, College of Agriculture, found that prune-pit oil is relatively rich in vitamins A and E (7).

Peach pits—Peaches bear a certain similarity to apricots in the disposition of the crop, especially in the western states, which account for about 50 per cent of the national total. Here we find the bulk of the crop dried and canned, whereas in the East only minor quantities are thus processed. Pits separated from the fruits in these operations represent the only practical sources of oil.

A four-year average of the tonnages of both clingstone and freestone peaches dried and canned (3) is summarized as follows:

	Tons canned	Tons dried
Clingstones	305,000	23,400
Freestones	23,580	102,660

The total of these figures is 454,640 tons, which is equivalent to about 1,100 tons of oil. Pits at the present time can be had at a nominal price from companies in California, because at present there is no demand for peach kernels. A few tons of peach-kernel oil are being pressed by one or two small plants in California. Like the closely related apricot oil it can be refined and bleached to a sparkling light-colored bland oil ideal for a general cooking and salad oil. It is in small demand by the cosmetic trade.

The peach kernel represents only about eight per cent by weight of the pit whereas apricot kernels run close to 25 per cent. In considering utilization of both kinds of kernels, a profitable return on the shells is highly desirable. No particularly exclusive uses are known for the shells. Some shells have been ground for use as dynamite base, carbonized to make absorbent chars, and blended with carburizing compounds; some have been applied in the coarse form as a loose surfacing material for drives and parking areas. Whole peach pits are ground and briquetted for fuel by one western plant.

It might prove profitable to remove the volatile oil of bitter almonds from the meal by steam distillation. Finely ground, light colored meal has been used in beauty packs for its rubefacient properties.

Cherry pits—In 1930 Jamieson and Gertler (8) pointed out the excellent qualities of cherry kernel oil for the exacting requirements of the pharmaceutical and cosmetic trades. Since then the cherry crop has expanded appreciably until now we have annual yields as high as 96,000 tons of sour cherries which comprise the bulk of our canned pitted cherries. When the output of No. 2 cans is considered in terms of fresh fruit, the pack is estimated to be about 45,000 tons, or almost one-half the crop.

Cherry pits represent 12 to 15 per cent by weight of the fruit and contain about 11.2 per cent of oil. Thus, if all the pits from the cherries canned in factories were made available for oil, about 600 tons of oil could be obtained.

The oil has a somewhat higher iodine value than apricot and peach pit oils but not sufficiently high to place it in the drying class. It has good keeping qualities.

The meal contains 30 per cent or more of proteins and an amygdalin similar to that present in peach and apricot meals.

One company in Wisconsin is known to have produced cherry-pit oil in amounts less than 50 tons per year but is no longer operating. In quite recent years, another middle western company has produced natural cherry flavor by steam distillation of the ground meats but did not recover the fixed oil.

English walnuts—Walnut oil is distinctly different from the pit oils. It is a drying oil comparable to linseed oil.

About 90 per cent of the English walnuts grown in the United States are produced in California (5). The crop is divided almost equally between northern and southern counties (9, 10). The majority of the growers are members of an association which manages the disposal of the crop. Market saturation for walnuts is about 30,000 tons (11). Including culls and blow-offs domestic production is usually well above this figure, and it is necessary to provide some outlets for surplus to avoid depressing market prices. Surplus walnuts have been exported or shelled and the lowered returns to the grower have been partly compensated for by diversion payments.

It is now regular practice to press the inedible portion of culls for oil which is done largely in the Los Angeles area. There has been general acceptance of this oil by the paint industry at a price somewhat less than that of linseed. Output has been small, the six-year average for the period 1933 to 1938 being 454 tons. This figure represents only about 13.4 per cent of that portion of the 1939 crop graded as culls, which amounted to 15,000 tons (11).

Walnut oil is said to be free from after-yellowing effects when used as the drying oil constituent of interior white paints. It can also be refined to a satisfactory edible oil.

TABLE I
Pit and Nut Oils

Kind	Pit in fruit	Kernel in pit	Oil in kernel	I. V.	Composition of fatty acids			Unsap.
					Oleic acid	Linoleic acid	Sat. acids	
	Pct.	Pct.	Pct.		Pct.	Pct.	Pct.	Pct.
Almond	—	40-60	50	95-103	77	19.9	3.1	—
Apricot	5.6	25	40-45	100-108	63.34	31.15	3.7	0.7
Peach	7.5-12	5-8	40-45	96-110	57.5-62.7	15.7-20.9	—	—
Prune	12.5	21	33-34	—	—	—	—	—
Cherry	12-15	28	32-40	115.8-118.7	49.0	42.0	8.1	—
English Walnut	—	27-42	60-70	158-161	17.6 Linolenic 3.2	73.0	5.34	

Fruit Pulp Oils

The oils to be considered under this heading are those from avocado and olive. They are of importance because of their similarity and because of the acute shortage of olive oil in this country due to stoppage of imports from the Mediterranean basin.

Avocado—The culture of avocados in the United States is confined to Florida and California, the latter state accounting for 82 per cent of the total production (9,400 tons, 5-year average) (19). In addition, about half this quantity is imported from Cuba during the summer months.

The avocado is a luxury fruit. The edible portion or flesh is the oil-bearing part, a fact which limits the processing of avocados for oil to cull or inedible grades. Heavy freezes, such as occurred in 1937, result in considerable quantities of damaged fruit for which the industry would like to find an outlet. A few tons of frost-damaged avocados have been successfully pressed for oil. At least one company in the Los Angeles area presses avocado oil, which is distributed entirely to the cosmetic trade.

The oil content of avocados ranges from three to 21 per cent. The normal range is nine to 15 per cent. The oil content is a criterion of the grade of the fruit, being highest in fruits considered best for table use.

Avocado oil is similar to olive oil in its high oleic acid content and in odor and flavor. The mushy character of the fruit presents some problems in oil recovery. The fruit has a tendency to yield a dark, unbleachable oil of high acid content if it is partially dried before pressing.

Avocado oil has been reported to have a definitely favorable effect on skin disorders, such as eczema (26). There is definite interest on the part of avocado growers in California in the possibility of increasing utilization of cull fruit for specialty oil. The current market price of the oil is 75 to 85 cents per pound.

Olive—The olive industry, localized in the West, has in times past supplied only five per cent of our olive oil requirements. The principal varieties produced here are the Mission, Manzanillo, and Sevillano (27). About half the acreage is planted to Mission which is a fairly good variety for oil. In normal times olives crushed for oil have never yielded the domestic grower as high a price as those sold for canning, which means that the amounts crushed were determined largely by the supply in excess of the demand for canning.

For the five-year period ending 1940 (28), the domestic production of olive oil averaged 2,225 tons. The shortage of imported oil, however, and the consequent increased price will doubtless encourage larger diversions of olives to oil production.

Very little inedible olive oil is produced in this country. One small solvent extraction plant is operated in the San Joaquin Valley. Our imports of inedible grades are about one-fifth of those of the edible grades.

TABLE II
Distribution of Olives for Oil and Canning and Growers' Prices. Period 1935-1939 (27)

Year	Tons	Canned ripe	Crushed for oil		Total production
		Growers' average price	*Tons*	*Growers' average price*	*Tons*
1935	7,800	$72.60	17,300	$31.00	32,000
1936	13,800	80.50	11,000	42.00	27,000
1937	11,500	93.00	12,300	46.00	28,000
1938	6,900	99.30	24,500	29.00	44,000
1939	12,200	93.40	6,100	42.00	23,000
Average	10,440	87.76	14,200	38.00	30,800

A process is now being publicized and practiced (29) which may relieve the acute shortage of olive oil, and enable the meager supply of domestic oil to be vastly extended. It consists, in brief, of macerating about five parts of pickled olive paste with about 95 parts of a cheaper oil such as corn oil and expressing the oil from the mass. An olive-flavored oil is said to result which has a greater stability than the original oil. The question of properly distinguishing this olive-infused oil from genuine olive oil by a name or other description has naturally arisen and is not yet settled.

TABLE III
Fruit Pulp Oils

Kind	Oil	I. V.	Composition of fatty acids		
			Oleic acid	Linoleic acid	Sat. acids
	Pct.		Pct.	Pct.	Pct.
Avocado	3-21	94	77.4	10.75	7.2
Olive	15-60	74-94	69.1-84.4	3.9-12.0	9.3-17.2

Seed Oils

Oil-bearing seeds from various agricultural products are numerous. Large quantities of citrus fruit, grapes and tomatoes are processed in centralized plants where the seeds form a considerable portion of the waste products and are separable with little difficulty. Edible oils may be expressed from them by conventional methods and provide an additional source of income from the parent crop, although returns to individual growers whose interests are pooled in gigantic concerns would not be large in most cases. Rice bran accumulates in large tonnage at mills in the South and far West, and is a more prolific source of oil than any other material herein described.

Tomato seeds—Tomato production for manufactured products in 1939 was 1,925,500 tons. If it is assumed that on the average the seeds contain 20.5 per cent of oil and represent 0.55 per cent of the whole tomato (12), the total potential supply of tomato seed oil from the 1939 crop was 2,170 tons (slightly less would have been recoverable by expression methods). The press cake from tomato seed is quite rich in protein and would be a valuable stock feed.

In years past the Department of Agriculture has investigated tomato seed as a source of fixed oils and the general problem of the utilization of tomato waste. These studies included the important factors incidental to the subject, such as handling and sorting tomato waste, cleaning of the seed, extraction and refining of the oil, cost analysis and possible returns (13). At the time of this investigation only 400 tons of tomato seed oil were potentially available; since then, as already indicated, the available quantity has risen considerably and the general economic picture has changed.

There is no production of tomato seed oil in the United States at the present time. One solvent extraction plant was put in operation in Los Angeles a few years ago but was not successful, perhaps because of faulty design.

Freshly expressed tomato-seed oil is brownish to reddish in color and has a strong odor. When the crude oil is refined by caustic soda, bleached and deodorized, a pale yellow product is obtained which is entirely suitable for culinary purposes. In Italy the crude oil is chiefly used in soap making.

The tomato processing industry is widespread. Canneries are located in all parts of the country. Disposal of tomato waste is frequently a problem to canners when it becomes a nuisance as in stream pollution. This is solved in isolated instances by drying the whole waste in rotary kilns and selling the ground product for stock feed. Separation of the seed and recovery of the oil would enhance profits from this material provided plant capacity were sufficiently great to warrant installation of equipment.

Citrus seeds—The phenomenal increase of the United States pack of fruit juices from less than 3,000,000 cases in 1929 to over 30,000,000 cases in 1940 (14) is noteworthy, as it has made available a large potential quantity of byproducts. A large portion of this increase is attributable to citrus fruits. In the years 1937 to 1940, 25 per cent of the California Valencia orange crop was culled or used for byproducts because of increased production and generally lower price levels.

Production of citrus fruits in the United States is divided approximately as follows: 59 per cent oranges, 33 per cent grapefruit, and eight per cent lemons (15). Of the total orange acreage, 40 per cent has not yet reached full bearing.

Grapefruit seeds—A small plant is regularly producing grapefruit seed oil in Florida at the rate of about 45 tons a year. The various steps used in recovering this oil have been described in a paper by Nolte and von Loesecke (16), who indicate the potential supply of grapefruit seed oil as almost 2,000 tons per season from the seeded varieties used by Florida canners. The seed represented by this quantity of oil amounts to more than 15,000 tons.

The grapefruit situation as a whole can best be illustrated by a statistical picture as follows:

TABLE IV
Grapefruit 1938-39

	Production	Used in canning
	Tons	*Tons*
Florida	944,000	377,560
Texas	626,800	221,240
California	54,720	15,000 (California and Arizona)
Arizona	81,000	
Total	1,706,520	613,800

Distribution of trees

	Seeded	Seedless
	Thousands	*Thousands*
Florida	3,500	2,000
Texas	585	4,470
California	137 (California and Arizona)	1,369
Arizona		1,159

These figures show that 35.4 per cent of the Texas crop is canned, whereas only 11.6 per cent of the acreage is planted to seeded varieties, so it must be concluded that the bulk of the fruit canned in Texas is seedless. The acreage of seeded fruit in California and Arizona is smaller than that in Texas. Potential grapefruit oil production of these three states, therefore, cannot be large.

Two patents have appeared on the use of grapefruit seed oil in treating textile fabrics (17) and leather (18). In the former case its value as a lubricant and softener for fibers is attributed in the specifications to the sulfonated *raw* oil, the bitter principle of which is said to be a stabilizer.

Orange seeds—It is difficult to develop an accurate estimate of the quantity of raw material potentially available each year for the production of orange-seed oil. An approach to this problem may be made through the calculation of the tonnage of fruit utilized in the manufacture of juice, juice concentrate, canned segments, etc. Approximately 100,200 tons of seeded oranges were processed in 1939 for the production of these products. In 1940 this figure rose to about 188,300 tons. These estimates are admittedly open to question because they fail to include the fruit processed for other products not among those mentioned, such as essential oil. Moreover, the annual production of canned juice is still rising at a truly remarkable rate.

An estimate of the fruit potentially available for seed oil production would include all the harvested seeded fruit not marketed as fresh fruit. It has been calculated that in 1939 this was about 550,000 tons and in 1940 about 501,000 tons.

Seeded varieties of oranges contain up to three per cent of their weight of wet seeds. For present purposes one per cent is the factor that has been used in the estimates. The dry weight of the seeds is about 40 per cent of their wet weight. The oil content of the dry seeds is in the neighborhood of 35 per cent.

Thus the seed oil corresponding to the 1939 and 1940 canned products alone would have been about 140 and 264 tons, respectively. The total quantities of harvested fruit not sold as fresh fruit in the same years raise these figures to 770 and 700 tons, respectively.

A broad picture of the United States production of seeded and seedless varieties, the portion of the seeded crop not sold as fresh fruit, and the potential supply of oil follows:

TABLE V
Orange Production—Total California and Florida (19)

Year	Seedless and Miscellaneous	Seeded	Total
	Tons	*Tons*	*Tons*
1937	687,300	1,921,190	2,608,490
1938	779,765	2,306,055	3,085,820
1939	720,200	2,099,500	2,819,700
Average	729,088	2,108,915	2,838,003

1938 California Valencia (seeded) crop	Tons
Total harvest	813,575
Not marketed as fresh fruit	194,040

Only seeded varieties are canned. If we assume the same ratio of fresh market sales to the total harvest for all seeded varieties, then the total tonnage of seeded oranges not marketed as fresh fruit would be 502,976, of which the oil equivalent is 704 tons.

From initial tests at the Western Regional Research Laboratory at Albany, California, it has been found that the expressed oil, refined, bleached and deodorized, has a pleasing bland taste and is useful for foods and other purposes.

Lemon seeds—Lemons, unlike oranges, are not a seasonal crop. Fruit may be found on a given tree in all stages of ripeness. Seed content of lemons is an exceedingly variable quantity, depending on the climatic conditions during ripening. It is an interesting fact that a cold snap or freeze will be followed, after a fixed time interval, by a crop of lemons having an abnormally high seed content.

Lemon seeds cannot be counted on as a plentiful source of oil. One of the large cooperatives has stated that 127,478 tons of lemons from the 1938-39 crop year were consigned to byproducts. At ten pounds of wet seed per ton this quantity of fruit would represent about 112 tons of oil.

Grape and raisin seeds—Almost 90 per cent of our grape crop is grown in California. The acreage devoted to grapes in that state is more than double that of oranges.

Statistics on grapes are broken down into raisin, table and wine grapes. The per cent of total acreage of each in California is summarized as follows (20):

	Per cent of total acreage
Table grapes	16.6
Raisin grapes	48.7
Wine grapes	34.7
	100.0

Raisin production is concentrated in California in the Fresno area. The seeds from one processing plant alone justify the operation of a byproducts plant which recovers high-proof spirits by fermentation of the adhering pulp, presses oil from the seeds, and combines the meal with ground raisin stems for stock feed. Although the drying of seeded varieties has dwindled as a result of the increased use and popularity of Thompson seedless grapes, the amount of seed has now reached a fairly constant figure of 2,500 tons per year in this area (22) of which the oil equivalent is about 250 to 300 tons.

The utilization of waste raisin seed was discussed quite thoroughly as long ago as 1913 by Rabak (21), who found the composition summarized in Table 4.

Raisin-seed oil has an iodine value of 120-130, which puts it in the semi-drying class. It is being used successfully in paint formulae by at least one company operating in San Francisco which is interested in obtaining further supplies.

Raisin-seed oil is bought back by the packers who furnished the seed for expression, to lubricate packaged raisins to make them free-flowing. Some is sold for cosmetic purposes both here and abroad, and for culinary uses.

The extensive wine interests in California are quite conscious of the desirability of using their pomaces for recovery of grape-seed oil. The chief difficulty here, in contrast to the raisin industry, is the lack of centralization of the industry. The report of one company (23) indicates that it annually processes about 35,000 tons of grapes, of which about 70 per cent are seed bearing varieties. It is estimated that the grapes used by this one company would yield by extraction methods about 90 tons of seed oil per year. In tests made by the company seeds were removed to the extent of about 85 per cent by discharging the twice-washed pomace upon rotating screens and drying to about 12 per cent moisture content. Seeds are high in silica and therefore hard on grinding equipment, expeller barrels and pressing clothes. It was concluded that grinding to about 40-mesh and solvent extraction would be the proper means of oil recovery.

The tonnage of wine grapes in California (average of 5 years) (5) is about 776,000, of which approximately 543,200 tons are seed bearing varieties, the seed equivalent being 16,296 tons. Estimated at 12 per cent the total recoverable oil is, therefore, about 2,000 tons.

Apple seeds—The annual apple harvest in the United States is about 3,500,000 tons (19). The eastern region of the country produces about 42 per cent of the total crop while the central and western regions contribute about 22 and 36 per cent, respectively.

The bulk of the crop is sold as fresh fruit but a significant quantity of cull fruit, which may average about 120,000 tons annually (24), is graded out at the packing plants. This cull fruit is a potential source of byproducts. The problem of what to do with the culls, however, is still far from solution and for obvious reasons only that part of the crop which is actually processed need be considered in estimating the oil that could be obtained from apple seeds.

Apple products industries use about 744,000 tons of fruit annually, distributed about as follows (24):

Product	Per cent of total apple production
Cider and vinegar	10
Dried apples	4
Canned apples	3
Canned apple sauce	1.2
Brandy	1.1
Total processed	19.3

If it is assumed that the dry weight of the seeds amounts to 0.25 per cent of the weight of the fresh fruit and that they contain 25 per cent of oil (25), 744,000 tons of apples would represent 465 tons of oil.

It is obvious that except for certain regions, such as the Pacific Northwest where apple production is concentrated in small areas, recovery and collection of the seeds would be especially difficult. Hence, until the larger problem of cull utilization is solved, apple seeds can hardly be regarded as a likely source of oil.

Vegetable seeds—Oil-bearing seeds from squash and pumpkin are present in the waste material from factory-canning of these vegetables. The seeds contain about 30 to 35 per cent of oil, which has an iodine value of 120-130. In Central and Southern Europe, pumpkin seed oil is used for edible purposes (12). No oil recovery from these seeds on a large scale has ever been attempted in this country.

Sunflower seeds—The small quantity of sunflower seed that is grown in the United States is utilized almost entirely in poultry feeds. Production has decreased from 8,000 tons in 1928 to about 1,500 tons in recent years (19). The oil in sunflower seeds is a good salad and cooking oil and is semi-drying. It is used as an edible oil in Russia.

Rice bran—Until several years ago rice bran oil had received comparatively little attention in this country. The reason for this lack of interest on the part of the trade is traceable, in part at least, to the fact that earlier attempts to produce the oil had yielded a distinctly inferior type of product. It had been repeatedly stated that rice-bran oil is unstable and that it develops large quantities of free fatty acids even during short periods of storage. Of course, this property would render the oil unsalable except in the very low price field.

Japan has been producing and using rice-bran oil continuously for some time. In 1938 and 1939 a number of shipments were received from the Orient by California companies. Samples of their stocks had previously been submitted by Japanese traders and were tested by a number of firms. These samples contained only moderate quantities of free fatty acids and failed to show any marked tendency to further development of acid. When refined and deodorized the samples did not become rancid rapidly nor develop "off" odors or flavors. They contained relatively little stearine and hydrogenated readily. These findings indicated the oil was suitable for the manufacture of edible products such as salad oil, shortening and oleomargarine. The samples did not bleach quite as easily as some other oils, but as the original color of the samples was not excessive this was not considered a serious drawback.

Shipments of rice-bran oil received during 1938 proved disappointing, however, for like many oils produced in the Orient the quality of the samples varied greatly from that of the cargoes. Plant scale processing, moreover, resulted in high refining losses, difficulties in winterizing and bleaching and finally the bleached oil exhibited a tendency during processing to regain color. These unhappy circumstances have created a certain distrust of rice-bran oil in the trade. The experience of one company led to modifications in the treatment that overcame some of the difficulties and there is good reason to believe that most of the others could be eliminated by the development of suitable methods of handling the bran and extracting the oil.

The use of rice bran as a feed material is hampered by its tendency to undergo spoilage, which in turn is ascribed to the presence of lipases that act upon the oil. Removal of the oil obviates this difficulty and the exhausted meal is judged to be worth at least as much as the original bran.

West and Cruz (30) have reported that rice bran may be prepared for storage by heating to remove moisture and to destroy most of the enzymes. They recommend a temperature of 105° C. and state that the bran and the oil contained in it are darkened by higher temperatures. According to a Japanese patent the lipase in rice bran may be destroyed and the bran bleached by a combination treatment with sulfur dioxide or bleaching powder, exposure to sunlight and neutralization with lime (31). Oil produced from the treated bran is said to be of excellent quality.

Rice production in the United States in 1939 amounted to 1,208,745 tons. Of this quantity California produced 202,500 tons. For the United States and California, respectively, rice bran production in 1939 was about 103,350 tons and 15,190 tons. At 15 per cent oil content the nation's bran production in 1939 was equivalent to about 15,500 tons of oil. The California crop represented about 2,280 tons. The foregoing figures are derived from data collected from several sources (19, 32, 33, 34).

California figures are presented separately because there is a potential market on the Pacific Coast for a locally produced supplementary bulk oil. In the past a fair amount of sardine oil has been processed in that state for food. Of late this oil has enjoyed increasing use as a source of vitamins in animal feeds and this fact is beginning to raise the price of the crude oil. It seems probable that this trend will continue. It is felt by some, moreover, that production may fall off in the not far distant future either from depletion of the fisheries or restrictions imposed for purposes of conservation. Under these circumstances there is a possibility that rice oil may help to fill a growing need.

TABLE VI
Seed Oils

Kind	Seed in fruit	Kernel in seed	Oil in seed	I. V.	Composition of Acids			Unsap.
					Oleic acid	Linoleic acid	Sat. acids	
	Pct.	*Pct.*	*Pct.*		*Pct.*	*Pct.*	*Pct.*	*Pct.*
Tomato	0.5-0.6	—	18-23	107-125	45	34.2	18.3	0.7
Grape-fruit	4.7	77	28-35	101-106	—	—	—	—
Orange	0-3	62	35-45	98-104	—	—	—	—
Lemon	0.5-2	—	30-35	103-109	—	—	—	—
Grape and Raisin	10	—	12-15	118-131	34.5	54	8.8	0.8
Squash	—	—	36.6	121	36.6	43.3	18.9	—
Pump-kin	—	—	30-35	120-130	25	45	30	—
Sun-flower	—	—	22-32	120-136	33.4	57.5	7.1	1.2
Apple	<1	64.3	25.0	119.8	—	—	—	1.1-1.7
Rice Bran	—	—	15-17 (in bran)	100-105	39.2-41.0	35.1-36.7	14.3-15.3	4.6

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