Some Industrial Outlets for Seed Flax

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The flax plants from which we get fibers are tall, little-branched, and early maturing. Their seeds are small, and the fibers in the stems are long.

On the other hand, seed-flax plants are short and branched. They are selected for high yield of seed. Processed by conventional methods, they produce short fibers of little value for making cloth.

The seed of the fiber-flax plant yields an oil of good quality. Seed not required for replanting therefore is usually sold in the oilseed market.

Nearly 5 million acres of seed flax is grown each year in the United States. Our acreage of fiber flax has varied from 4 thousand to 18 thousand since 1940. Most of the fiber-flax acreage is in Europe.

How long seed flax will continue to be used almost exclusively for oil is problematical. Considerable research has been done with the object of making satisfactory cloth from the fiber of seed flax.

A continuous process for producing yarn from the straw of ripe seed flax was announced by the University of Minnesota in 1948. The straw is separated into fibers 12 to 18 inches long by chemical and mechanical means instead of by the traditional retting, which depends on fermentation and produces, from seed-flax straw, short fibers of little value. A continuous method of roving, followed by wet spinning, yields a yarn that can be woven into cloth. Linen crash woven from this yarn is said to have the same properties as linen crash made from fiber flax. Commercial success of the process should greatly increase the value of the seed-flax crop.

THE FIRST STEP in utilization of linseed oil is its isolation from flaxseed. Traditionally, this has been accomplished by squeezing the oil from the ground seed (meal) in presses. In early presses, the meal was placed between plates, which were then forced together by driven wedges. Later, screws and finally hydraulic forces came into use for applying pressure to the plates. The most modern method employs screw presses, which operate continuously.

Now, the solvent-extraction process, which has been so successful for soybeans, is not satisfactory for flaxseed. In that process, the seed is rolled into flakes (linseed flakes), which are treated with a petroleum hydrocarbon solvent, such as hexane, to dissolve the oil (linseed oil). But when flaxseed is flaked, and then extracted, the solvent tends to dissolve the connective material that holds the flakes together. Linseed flakes, therefore, tend to distintegrate, become powdery, and cake. The solvent can then run through cracks in the caked material, and the efficiency of the process is lost.

Success has been achieved by utilizing a combination of pressing and solvent extraction. Linseed meal is pressed to an oil content of 10 to 15 percent. The residual oil in the cake is then extracted with solvents. The pressing operation imparts a more rigid structure, which withstands the action of the solvent. The first plant to use this process was built near Minneapolis and put into operation in 1949. It has a capacity of 12,000 bushels a day.

Another possibility, which is being investigated by a commercial processor, is solvent extraction of linseed meal directly in a slow-speed centrifuge. Although the meal still tends to disintegrate under those conditions, the centrifugal action effects separation of the fine particles from the solution of oil obtained.

The continuous screw-press method works thus: Upon receipt at the mill, the flaxseed is cleaned of weed seeds, dirt, particles of metal, and other undesirable materials. It is then crushed or ground to a suitable particle size, after which it is passed through cookers. In the cooker, which is operated continuously, the meal is exposed to heat and live steam. The temperature is gradually raised, as the meal approaches the bottom of the cooker, to 190° to 200° F. The temperature and moisture content of the meal are carefully regulated at this point to assure economical recovery of the oil. The preliminary grinding and cooking operations destroy in part the cellular structure of the seed, so that removal of the oil is easier and more complete.

From the cooker, the meal passes to the continuous screw press, which is essentially a hardened steel block with a tapered bore. By means of an arrangement of screws, meal is forced through the bore, resulting in compression of the meal. The oil released in this operation passes out through fine grooves and perforations in the press. The meal emerging through the outlet of the press contains about 4 percent of oil. After further grinding to a suitable size, the meal is sold as feed for animals.

The freshly expressed oil is warm—170° to 180° F. In that state it is filtered to remove any fine particles of meal. It is then stored until cool. During cooling, waxes and phosphatides separate and are removed by a second filtration to leave the ordinary double-filtered raw linseed oil of commerce.

For certain uses further refining is required. The refining agent may be acid or alkali. Acid refining is conducted by treating the oil with sulfuric acid in a lead tank. The strong acid chars many of the undesired contaminants in the oil and produces a precipitate, which is removed by filtration. Excess acid is eliminated by washing the refined oil with water. Acid-refined oils are used in grinding pigments, for example, in preparing white lead pastes and in making paints of a high content of lead.

In the alkali-refining process, a sludge of impurities is formed by heating the oil at 60° F. with a small amount of caustic soda solution. After the sludge is removed, the oil is washed, dried, and heated with bleaching clay to remove undesirable color. Alkali-refined oils are important because of their low free acidity. They are used in making varnishes, enamel vehicles (particularly for light-colored enamels), and printing inks.

Linseed oil often is subjected to still further processing. One common operation is polymerization, or heat bodying. Polymerization is accomplished by heating the oil at high temperatures in order to thicken it. By control of time and temperature the body, or viscosity, of the oil can be varied. Polymerized oil is frequently referred to as boiled oil.

Another common treatment of linseed oil is blowing. In that process, air is blown through the heated oil. As a result, the oil is thickened and its acidity is increased. Blown oils generally improve the leveling properties of paint and increase the ability of a paint oil to wet the pigment.

Sometimes linseed oil is heated with excess caustic to form a soap. Acidification of the soap liberates the linseed fatty acids, which are used in the manufacture of resins and various synthetic drying oils.

THE LARGEST SINGLE USE of linseed oil is in paint, varnish, enamel, and similar products. That accounts for about 70 percent of all linseed oil used in the United States.

Any paint is essentially a suspension

of a pigment in a liquid, the vehicle. Its properties depend in a complicated fashion on the kind of materials selected for pigment and vehicle. Most properties can be varied by changes in pigment, in vehicle, or in both—a factor that greatly complicates paint research and tends to prolong the period of testing before new paint formulations are placed on the market.

For many years people believed that the best exterior white paint should consist of white lead and pure linseed oil. Modern research has shown this idea to be wrong. Pigments other than white lead have been found to impart superior weathering properties with freedom from cracking and checking and with controlled chalking, which leave the surface in excellent condition to receive future coats of paint. One excellent pigment in use today is a mixture of titanium dioxide, asbestine, and leaded zinc oxide. Some satisfactory formulations contain no lead in any form.

Linseed oil, basically the best available oil for the vehicle, is seldom used in unmodified form. The modern vehicle consists of a mixture of linseed oil and heat-bodied linseed oil with enough thinner to make the final thickness about the same as that of linseed oil itself. Its use makes a paint that contains a smaller proportion of oil but that has, nevertheless, better leveling, brushing, and flowing properties, better gloss, and better resistance to penetration on new work. That vehicle was originally proposed and used during the Second World War as a replacement oil to conserve stocks of linseed oil.

THE MANUFACTURE of a paint requires two steps.

The first is to grind the pigment into a paste with a small amount of oil. The oil may be the same as the one to be used as vehicle for the paint. It is often advantageous, however, to use a special grinding oil. Such an oil usually contains free fatty acid, which helps the oil wet the dry powdered pigment.

The second step is to dilute, or reduce, the paste with the vehicle to the desired consistency. Driers (soluble compounds of cobalt, lead, or manganese) are also added to promote combination of the vehicle with atmospheric oxygen, to form the dry paint film.

A varnish is a solution of a resinous material in heat-bodied oil, diluted with thinner to the proper viscosity. An enamel is simply a pigmented varnish—a varnish to which pigment has been added to make it opaque and to provide color. Varnishes are prepared by heating oil and resin together at a high temperature until the desired thickening has occurred. Thinners and driers are added when the mixture has cooled. Varnishes are described in terms of their oil length, a quantity indicating the number of gallons of oil employed to 100 pounds of resin. The performance of a long-oil-length varnish (more than 30 gallons of oil) depends mainly on the properties of the oil; a short-oil-length varnish (less than 15 gallons) reflects the qualities of the resin. Films of some short-oil-length varnishes may justifiably be regarded as films of resin plasticized, or made flexible, by the oil present. Most commercial varnishes are of medium (15- to 30-gallon) oil length.

Oil-modified alkyd resins, another variety of coating material, are compounds of glycerin, phthalic anhydride, and fatty acids. They are made with a wide range of properties to serve specific purposes. Some dry to tough films when exposed to air; others do not. Certain forms contain relatively less oil than others and are employed as the resinous components of varnishes and enamels. Still another type contains enough oil to function as the sole vehicle in an enamel. Fatty acids of linseed oil are employed in alkyd resins of the drying type. Alkyd resins are generally used in finishes that must withstand severe abrasion and wear, such as automotive finishes, machinery enamels, and floor and deck enamels.

Linseed oil for many years has been

the preferred oil for use in paints, varnishes, and enamels because it brings to the coating material generally satisfactory performance in drying time, durability, dirt collection, resistance to water and alkalies, and the like. Other oils may perform better in one way or another, but this superior performance is usually offset by some serious weakness. Thus, tung oil dries more rapidly than linseed oil, but its films are too hard and brittle to endure out-of-door exposure. Soybean-oil films are flexible and more durable than those from linseed oil, but they take too long to dry. Certain formulations tend to pick up dirt. Furthermore, blends of oils do not always perform as satisfactorily as might be expected, and therefore are not adequate replacements for versatile linseed oil. An additional factor is that the cost of linseed oil is normally moderate. In general, manufacturers use linseed oil in preference to other oils unless special requirements must be met.

LARGE QUANTITIES of linseed oil are consumed each year in the manufacture of linoleum and oilcloth.

The first step in the manufacture of linoleum is oxidizing and polymerizing linseed oil until a relatively dry, nontacky solid is produced. The solid is mixed with rosin and heated at a fairly high temperature until the desired degree of chemical reaction has occurred. The product, called cement, is mixed with ground cork, or similar material, and pigments and then pressed onto a backing of burlap or other coarse fabric. A final curing at moderately high temperature completes the process. A true linoleum is thus distinguished from the cheaper substitutes, which are made by impregnating felt with bitumen and applying one or more coats of enamel on the surface.

Oilcloth consists of a cloth base on which several coats of enamel have been applied. The enamel must be specially formulated for maximum flexibility. Oilcloth differs from oiled cloth, which is made by saturating fabric with a drying oil, usually linseed or fish oil, and allowing each application to dry thoroughly.

LINSEED OIL is put to a variety of miscellaneous uses.

Printing inks are heavily bodied, or polymerized, linseed oils, called lithographic varnishes in the trade, combined with pigments, thinners, driers, resins, and the like. Where the paper is very absorbent, as is newsprint, the drying oil is replaced by mineral oil. Drying occurs here merely by absorption of the mineral oil by the paper. The exact properties of a printing ink must be carefully adjusted for the type of press, kind of paper, and nature of the printing process involved.

Linseed oil is frequently valuable because of its binding properties when gelled. Core oils, of which linseed oil is an important ingredient, are used to bind sand together to form the core of hollow metal castings. In the process, sand is thoroughly wetted with the core oil, formed to the desired shape, and baked to gel the oil. The properties of a satisfactory core oil must be such as to impart strength to the core without interfering with subsequent breakage for removal from the casting. The tensile strength of a core should be about 200 pounds to the square inch, as measured in an ordinary cement tester.

Linseed oil is also suitable for binding asbestos fiber in brake blocks, shingles, and the like.

Small amounts of linseed oil go into soap. Oils valuable for other purposes ordinarily are not used in soap manufacture. However, linseed-oil soaps, particularly the soft potassium soap, are prized for cleaning automobiles, linoleum, and painted or varnished surfaces.

THE CHARACTERISTIC ODOR AND FLAVOR of linseed oil are unacceptable to most people, although considerable amounts of the oil are consumed as food in eastern Europe, particularly in Russia, Poland, and Hungary. The world-wide shortage of edible oils and fats during and after the Second World War stimulated research, particularly in Canada, on elimination of the objectionable odor and flavor of linseed.

Two lines of research have been followed: Hydrogenation and solvent segregation.

In the hydrogenation process, linseed oil and hydrogen are combined catalytically. Much of the oxidative instability of the oil is lost thereby and odor and flavor are improved. Hydrogenated oils are used in margarine and cooking fats. Moderate amounts of hydrogenated linseed oil may be included with other oils in the manufacture of these products with reasonably satisfactory results.

The purpose of solvent segregation is to separate linseed oil into two fractions, one that is easily oxidized and one that is less readily oxidized. The basis of the separation is the difference in solubility in the solvent of the two types of material. The easily oxidized fraction should be an excellent drying oil for use in paints and varnishes, while the less readily oxidized fraction should be more satisfactory than the original oil for edible purposes. Although excellent drying oils have been produced commercially by this process, edible oils acceptable to the American taste have not yet been made from linseed oil.

Because of the variety and the importance of its industrial uses, linseed oil is essential in our economy. This alone is sufficient justification for the research and effort that have been devoted to fostering domestic production of seed flax. How well the endeavors have succeeded is indicated by the fact that the United States now produces flaxseed in excess of its requirements, whereas previously we were dependent upon imports.

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CREATION of new industries often can be traced to a few adventurous individuals. One of the group responsible for developing the soybean crop in this country is William J. Morse, who retired from the Department of Agriculture in 1949, after 42 years of service.

His enthusiasm for soybeans as a farm crop for the United States developed during an extended trip to China, Manchuria, Korea, and Japan in 1929 to 1931, when he collected the hundreds of varieties that since have been used as the basis for our extensive soybean program. The increase in the agricultural wealth of our country that resulted from the introduction of the new crop, the subsequent work leading to the improvement in yields and higher oil content, and the development of suitable plant characteristics are a lasting tribute to the work of Morse and his associates. The growing and processing of soybeans is now our largest oilseed industry and involves hundreds of millions of dollars each year in the United States.

Besides an encyclopedic knowledge of soybean culture, Morse brought from the Far East an appreciation of soybeans as food and detailed information on many methods for their preparation.—*Allan K. Smith, Northern Regional Research Laboratory.*