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Trends in the Oilseed Industry[1]

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DEVELOPMENTS in our industry during the past year reflect the rising tempo of technical advancement. Some of the major trends at present are in reality a fulfillment of scientific achievements first reported to our Society not so many meetings ago and, at that time, considered rather distant or mere "straws in the wind." At our present sessions, as in years past, we plan to hear prepared papers and informal discussions that will portend the future course of oilseed technology.

The trends to be discussed right now are really those premonitions acquired at previous A.O.C.S. meetings which have come true. Some of them are due in part to economic ills, to an extent political, that have made oilseed processing a decidedly unprofitable business to all except perhaps the very efficient operators with the most modern of equipment.

Supply and Demand

The outstanding trend at present is the enormous increase in production and world supplies of fats, oils, and oilseeds which in 1951 set an all-time record and restored per capita supplies for the first time to prewar levels. Among the major increases were copra and coconut oil from the Philippines and Indonesia, soybeans exported in volume from Manchuria for the first time since the war, a bumper yield of olive oil in Southern Europe, and record production of lard and other animal fats.

The impact of such supplies on our markets is being felt more and more every day, and prices of crude soybean and cottonseed oils, as examples, are at the lowest points in many years. The prospect of continued abundant supplies makes any major price increases unlikely in the near future. It is interesting to recall that eight years ago, while addressing this group, Robert M. Walsh (12) summarized the probable postwar economic situation by predicting that world supplies probably would not catch up with demand sufficiently to depress prices until after 1950 but that, with gradual restoration in major production areas, an eventful return of surpluses appeared inevitable.

The supply situation with respect to protein meals, on the other hand, has encouraged higher prices, and ceilings have been imposed that, together with low oil prices and the high cost of raw materials, reduce the processing margin to such an extent that a great many mills have had to operate "in the red." In the soybean industry various expedients have been adopted to avoid the penalty resulting from these low ceiling prices. Among these are the sale of "mineralized supplements" and the "custom processing" of beans on a toll basis, but neither of these is a particularly profitable operation either.

In the soybean and cottonseed industries the low-margin situation is aggravated by a surplus of processing capacity due largely to the construction of many new solvent extraction plants. The less modern pressing plants have difficulty in meeting the competition of the more efficient solvent process, but some are able to continue in business nevertheless, even though losing money in many cases. With supplies of raw materials inadequate to keep all these plants running on a reasonably full-time basis, it is not surprising that oilseed prices have remained high in relation to the prices received by the oil millers for the products.

To summarize the economic condition of our industry, a lot of oil mills are for sale.

Switch to Solvent Extraction

The change from Expellers and screw presses to solvent extraction is essentially past history in the soybean industry, except for "mopping-up" operations. Only in isolated instances is it worthwhile to continue the operation of pressing equipment, and most of those who still run press plants wish they had done something several years ago about the installation of solvent equipment. The big rush to build extraction plants in the soybean industry seems to be over, at least for the present, because construction costs are very high and present margins provide no inducement for expanding processing capacity.

The linseed industry is in the midst of a change from pressing to solvent extraction. Some operators have extracted the seed without forepressing. As the technology has developed however, the trend appears more and more to be toward the combination of forepressing followed by solvent extraction. Two large mills in Minnesota have been running for several years with this process and have found it very satisfactory, and additional plants now are being built.

A similar trend of sensational proportions exists today in the cottonseed industry. Although considerable work and some commercial exploitation have resulted from experiments with such solvents as isopropanol, methanol, and hydrocarbon mixtures thereof, the preferred technique now appears to be scalping in forepresses followed by extraction, and new mills employing this method have sprung up all through the cotton belt. Coupled with this swing to extraction has been a decided westward shift of cottonseed processing, including a marked increase in California. The cottontonseed industry has undergone a change almost overnight, and old-timers can hardly recognize it in its new form.

Forepressing appears extremely well suited to cottonseed processing for it overcomes in one step many of the perplexing problems faced by those who attempted to conduct the extraction in one stage en-

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tirely by solvent. Any seed or seed meat containing a high percentage of oil, i.e., 30% or more, will disintegrate badly and present a severe dusting problem if the oil is extracted in one stage, for the resulting marc is too porous and fluffy. It has been found more economical and more practical from an operating standpoint to remove a large part of the oil by the use of moderate pressures, i.e., that part of the oil which is most easily removable. This is true for nearly all high-oil seeds, not just cottonseed. In the case of cottonseed however there appears to be an additional advantage resulting from the extreme extent to which the individual cells of the seed are ruptured, permitting more efficient removal or inactivation of toxic principles which must not remain in the finished meal.

Forepressing followed by extraction is not new to the American oilseed industry. Castor beans and corn germ from wet milling operations have been processed in this manner for many years. The art of forepressing received its greatest prewar development however in Germany and other European countries, and it is interesting to compare the methods and equipment used there with those now being used in this country. In Germany, perfecting of the screw press as a means for removing oil from seeds was comparatively slow as compared with solvent extraction. The reverse was true in this country, where Expellers and screw presses of extremely rugged construction were developed for the soybean and other oilseed industries. In contrast to the German counterparts, these machines are able to press to an oil content of 4% and less. In Germany, as the need for a scalping press to precede extraction became apparent, efforts were made to design equipment for this specific purpose. The object was to remove only the portion of the oil which is very readily recovered by pressing and to strike an economic balance between the yield to be obtained by pressing and that to be obtained in the final extraction. The result was a continuous press having a stepwise construction in the barrel and screw. This design is considered in Europe to be particularly suitable for the type of operation in which a tremendous volume reduction occurs, as in the case of high-oil seeds from which most of the oil is being squeezed under pressure. The European practice therefore has been to forepress only to about 16 or 18% oil and to use extraction for the remainder.

In the United States the screw press became so highly developed as a tool for complete removal of oil, even from high-oil materials, that the combination of equipment for scalping and subsequent extraction seems to have been tailored more or less to conform with current screw press design. It is not surprising therefore to find that most operators of linseed and cottonseed extraction plants are forepressing to an oil content of about 9%. Indeed there may be good technical justification, for a recent patent by Dunning (2) is based on such a treatment and covers a forepressing operation in which the oil is reduced to approximately one-fourth the protein content. It is claimed that more durable flakes which can be extracted more rapidly are obtained under these conditions. In the case of cottonseed moreover, one of the advantages of forepressing seems to be the rupturing of the seed cell structure, resulting in rather effective removal of the free gossypol. Forepressing to these lower oil contents should result in more complete breakage of the cell structures.

New Solvent Extraction Equipment

Aside from the large-scale change in this country to combined forepressing and solvent extraction, the interesting developments in the solvent extraction field concern new types of equipment. Of these, two European extractors have gained widespread attention. They represent efforts of equipment fabricators in Europe to recapture markets lost to them during World War II and embody features typical of recent European progress in oilseed technology.

The Depmer-Lurgi extractor is very similar to the Hansa-Mühle equipment, but it embodies several improvements in the design of the baskets, the method of introducing flakes, and the utilization of steam. In most basket-type extractors the flakes are introduced in discreet batches, one basketful each. With each surge of flakes entering, a simultaneous surge of air and solvent vapor is forced out through the vent system. The rapidity of this surge mitigates against complete condensation or other removal of the condensibles from the air.

In the Depmer-Lurgi extractor there is a continuous flow of flakes into the baskets so that the corresponding escape of vented gas is non-pulsating. The result is claimed to be more complete solvent recovery from the vented non-condensible gases by use of comparatively small equipment. Another interesting feature of this equipment is the re-use of mixed steam and solvent vapors from the Schnecken, or meal desolventizers. These vapors are scrubbed with a hot water spray and used for sparging in the initial portion of the oil stripping column. Then, finally, they are condensed by heating the first stage of the pre-evaporators. Direct steam is used only in the final section of the oil stripping column and in the third stage of pre-evaporation. The steam economy is said to result in an overall usage of only 600 pounds per ton of soybeans.

Another extractor being installed in a number of mills is that of DeSmet and is of Belgian origin. It employs a horizontal conveyor belt composed of perforated metal sections upon which prepared seeds ride in a thick layer. As they progress, they are alternately sprinkled with solvent and allowed to drain. Underneath each drainage section is a sump from which a pump recirculates the solvent into the corresponding sprinkling section directly overhead. Fresh solvent is sprayed at the discharge end and, after percolating through the flakes, is pumped from the sump and recirculated in the same zone. The same type of recirculation from sump to sprinkling zone overhead is employed throughout the length of the extraction belt. Countercurrent flow is achieved by stepwise installation of the sumps so that excess solvent flows by gravity from one to the other, with the concentrated miscella leaving at the seed entrance of the belt.

The DeSmet extractor is a self-filtering type, and sludge from the final miscella sump is pumped to the seed bed instead of being carried out with the miscella. It is being installed in this country now in at least two different plants.

New Solvent Extraction Processes

Every oilseed presents its specific problems to the oil miller, especially when processed by solvent extraction. The technical literature abounds with intriguing proposals for conducting extraction by non-conventional methods, such as microbiological digestion, extraction with normally gaseous hydrocarbons under high pressure, etc. One of the newest of these shows real merit although it still is in an early stage of development. It has been found at the Southern Regional Research Laboratory that cottonseed, when properly cooked and then re-rolled, are changed greatly in their physical properties and that the oil becomes very easily extractable and can be removed by washing on a continuous vacuum filter. The preferred method (5) consists in passing the seeds through a stack cooker at moisture contents of 12 to 14% and at temperatures ranging from about 150 to 225°F. The seeds are re-rolled and then are slurried with solvent and sucked dry on a continuous rotary filter. During their passage around the filtration drum they are alternately washed and allowed to drain several times, and the final marc is discharged with an oil content of about 0.6%. The miscella moreover is highly concentrated and contains approximately 30% oil because the washing is accomplished in a stepwise countercurrent manner.

Another interesting development in the solvent extraction of cottonseed is the one employing isopropanol, as developed at the Cottonseed Products Laboratory, Texas A. & M. College (10). The solvent is less flammable than hexane and also appears to remove or inactivate free gossypol effectively. It is not completely miscible with the oil. Extraction is conducted with warm solvent, and cooling the miscella then causes the oil and alcohol to separate. The solvent is recirculated to the extractor, and the oil phase is purified by stripping it with hexane, some water being introduced countercurrently. Impurities concentrate in the isopropanol-water phase, from which the solvent is recovered by evaporation.

Technology of Protein Meal

Another important trend in our industry is the increased care being exercised to produce protein meals of highest nutritive value and wide utility for feeding livestock and poultry. A useful tool in this connection is the type of desolventizer in which essentially all solvent removal is accomplished by the application of direct steam. One version of this equipment is a stack cooker into which live steam is blown at the bottom. Condensation of this steam on the relatively cool marc results in evaporation of the solvent, and it requires only about one-seventh of a pound of condensing steam for removing one pound of hexane, the usual solvent. The chief advantage of this method, as contrasted with that employing indirect heat, as in jacketed screw conveyors, is that the moisture condenses directly in the pores of the material and thereby comes into very intimate contact with all the protein, carbohydrate, and other constituents. An extremely efficient heat-and-moisture treatment is thereby obtained, and the result is a meal of very fine color, excellent flavor, and high nutritive value.

The direct steaming of meal in the case of soybean extraction was common practice in Europe practically from the inception of the soybean processing business there. In that case though, batch extractors of the multiple contact, countercurrent type were commonly employed, and these utilized direct steam blown in at the bottom for the solvent removal. It may be that this highly efficient moisture treatment during desolventization accounts in some measure for the fact that European technologists originally were not faced with the problem of toasting soybean meal in order to inactivate certain inhibitors which, if present, would detract from the nutritive value.

Coupled with improved processing practices has been an everincreasing effort by oil millers to produce meals of uniform quality and optimum nutritive value. The roles played by various inhibitors and toxic principles have been studied intensively, and methods have been perfected for eliminating those which detract from the nutritional characteristics of the meal. The science of feeding has grown with great rapidity, and the buyers of meal have become very quality-conscious. Supplementation with antibiotics to compensate for deficiencies and achieve utmost utilization of all constituents of the meal has completely changed feed formulation practices.

In the case of cottonseed enormous strides have been made toward eliminating free gossypol while, at the same time, preserving optimum nutritive value of the protein. It was found at the Southern Regional Research Laboratory (3), for example, that screw pressing of cottonseed will yield a meal of high protein solubility, low gossypol content, and excellent nutritive value if the process is preceded by cooking at relatively low temperatures and low moisture contents. Under these conditions much of the gossypol appears to be removed with the oil and is eliminated therefrom in subsequent refining steps.

Trichloroethylene Extraction of Soybeans

In the American oilseed industry there always has been quite an incentive to conduct small-scale operations on a local basis close to the source of the raw material so that the meal could be consumed nearby in livestock or poultry feeds. Substantial freight savings on both the oilseeds and the finished meal are afforded, and an efficient mill operating in this manner can prove quite profitable even under adverse price conditions. Because of the inefficiency of pressing methods however, there has long been a demand for a small solvent extraction plant suitable for processing soybeans close to the point of production, serving a limited area.

Among the obstacles to be overcome in developing a process of this type is the extreme flammability of hydrocarbon solvents, and study has been devoted to trichloroethylene as a substitute. It is a non-flammable chlorinated hydrocarbon and has found wide usage in the degreasing field. The major part of the developmental work was performed by Iowa State College (9), and several versions of extraction equipment owe their origin to the studies undertaken there.

The Detrex extractor was one of the first, and two small installations of this equipment were made during the war in Danville, Indiana, and Springfield, Ohio. Other similar plants were built elsewhere, and the Crown Iron Works, Minneapolis, Minnesota, has been active in the design and construction of these extractors for the past five or six years. The more recent installations are well engineered and operate very efficiently.

Some concern has been expressed from time to time about an article by Stockman (7) in England, who reported in 1916 that widespread cattle deaths had occurred in Southern Scotland and showed that they were caused by feeding soybean oil meal produced by trichloroethylene extraction ("trimeal"). In retrospect, it now is apparent that greater credence should have been accorded the Stockman report, but a certain amount of experimental work performed more recently in this country was construed as casting doubt on the accuracy of his conclusions or, at least, indicating that toxicity would not be encountered with present-day solvent and methods.

Although quite a few trichloroethylene extraction plants have been built in the soybean industry, perhaps eight to ten in all, they are small, and their combined capacity is probably less than 2% of that of the entire industry. During the past two years however there have been numerous outbreaks of cattle deaths, and the symptoms were the same as those reported by Stockman, i.e., an extreme reduction in the white blood cell count, a high temperature, eventual bleeding at body openings, and severe internal hemorrhaging throughout the body tissues, resulting finally in death. As veterinarians and State Experiment Station people investigated case after case, enormous circumstantial evidence was developed to incriminate the meal being turned out by certain of these trichloroethylene extraction plants. The work performed by the veterinarians and by the Minnesota and Iowa Experiment Stations to identify the disease and take steps to prevent it is most commendable.

Soybean oil meal ordinarily is produced by pressing or extraction with hydrocarbons and has been found, through years of most successful application in all branches of livestock and poultry feeding, to be one of our most valuable and versatile protein concentrates. "Trimeal," on the other hand, is relatively new in this country, has not received the enormous amount of nutritional and practical feeding study accorded to regular soybean oil meal, and should not be confused with the product made by conventional methods to which the trade has become accustomed.

The alarm spread in the trade because of the reported cattle deaths attributed to "trimeal" caused the Soybean Research Council to undertake a literature survey in cooperation with other groups interested in the problem. It was known that the same disease occurred in Germany and neighboring countries in 1924, but only a few references describing the outbreak there had been cited in technical papers appearing in this country. The literature search revealed however an enormous quantity of published material in German, French, Dutch, and other languages, and a study of this reveals the great extent to which "trimeal" caused cattle deaths during the 20's. Practically all of it came from one large mill which ceased using this solvent after the effects became known. It is unfortunate that this vast literature was not surveyed earlier and called to the attention of those contemplating the use of trichloroethylene for extracting soybean oil in this country.

Still more recently, the same type of cattle deaths have been reported on a large scale in Japan, Italy, and Hawaii. The Japanese epidemic appears due to rather recent use of trichloroethylene on a large scale for extracting soybeans in that country, and a similar operation caused the deaths of stock reported in Italy (4). The Hawaiian outbreak has been traced tentatively to "trimeal" originating from one of the mills employing trichloroethylene in this country.

The affliction caused by feeding "trimeal" to cattle is known in Europe as the "Duren disease," after the German province in which it first appeared on the Continent, although it also is described in the literature sometimes as "Brabant disease," and its exact cause still is obscure. The problem is an extremely complex and intriguing one and now is the object of intense study. Stockman first presumed that residual trichloroethylene might be the cause but was unable to reproduce the ailment or observe toxic effects when he added quantities of the solvent to normal meal, even when the concentration was many times that remaining after extraction and the feeding was continued for long periods. Stang (6) observed about the same lack of toxicity in the solvent itself. Both investigators did induce the sickness in many instances however by feeding the implicated meal at moderately high levels. Stockman hypothesized that the solvent may react in some manner with the meal to yield a poisonous material, that the trichloroethylene itself may form a poisonous substance, or that the solvent may have contained a toxic impurity.

At about the same time as he worked on the "trimeal" problem, Stockman (8) also studied the Bracken Disease, which occurs when cattle eat green ferns of a certain type and whose symptoms resemble those of the Duren disease. He showed indeed that the two illnesses are indistinguishable and concluded that the toxic material or other causative agent must be the same in both cases. To this day veterinarians find it impossible to diagnose one from the other except by tracing the diets of the afflicted cattle.

Although the Duren disease was studied very intensively by veterinarians and other research workers in Germany and elsewhere on the Continent, no clear-cut solution ever was published with adequate substantiation. A host of theories appeared, including avitaminosis, the removal of lecithin and related materials by the solvent, the removal of urease, etc. Trichloroethylene, incidentally, is a far more powerful solvent for lipids than is naphtha. Many of the theories in the literature appear somewhat absurd in the light of present-day knowledge. The situation was obscured considerably also by efforts to conceal the true nature of the disease or the source of the feeds causing it.

Another apparent enigma is the fact that a mill in England converted from naphtha to trichloroethylene early in World War II and has continued to operate until this day, and no symptoms of the disease have been reported. An investigation reveals however that no soybeans were processed by this plant until the last three years and that even then the volume was comparatively small. Still more important however is the fact that the operators determined by careful testing that the meal is safe for use at very low levels, particularly when fed in combination with other protein meals. That is the way it has been used in England, i.e., fed at an average rate of about ⅙th pound per animal per day or less, when fed at all, and never more than ½ pound per day. It is not surprising that the disease did not develop there in recent years for the numerous cases described earlier in Southern Scotland, later in Germany and the Low Countries, and still more recently in the U.S.A., have occurred at relatively high levels of protein intake, 2 or 3 pounds per day or often much higher, and usually when the meal is "top-fed" rather than incorporated in mixed feeds.

The sickness has been reproduced many times experimentally (11, 1). Studies as to the nature of the toxicity however are extremely costly and time-consuming because no reliable method has been developed for experimenting with small animals. It still is necessary to use cattle, and it requires one to six months of feeding for the symptoms to develop. Recoveries moreover are rather rare. In all the experimental studies, the results have indicated conclusively that no such toxicity exists in other types of soybean oil meal, i.e., those resulting from pressing or from extraction with hydrocarbons. The phenomenon appears to be associated with the combination: trichloroethylene, soybeans, and cattle.

Competition from Animal Fats

The story of competition between lard and vegetable shortenings is a familiar and interesting one. Good hydrogenation and deodorizing practices, coupled with perfected plasticizing technology and the application of emulsifiers, enabled vegetable shortenings to capture a large part of the market once enjoyed by lard. This trend occurred largely in the 30's. There were other reasons for the change however, and among them was the fact that lard occurs in nature with a peculiar fatty acid distribution. It appears to contain higher proportions of low-melting and high-melting constituents and less of the intermediate melting ones than do hydrogenated vegetable fats. When chilled and plasticized therefore, lard tends to develop large grainy crystals, whereas it is easy to produce very fine crystals in the vegetable shortenings. These latter placticize better and result in a texture and plastic range considerably superior to those in ordinary plasticized lard.

Many of the earlier shortcomings of lard have been overcome by hydrogenation, deodorization, stabilization with antioxidants, etc., but for some purposes even these products have proved inferior to good vegetable shortenings. Some proof of this situation is evidenced in the comparative prices of the two products, for most types of lards sell at considerably lower prices than the vegetable counterparts.

It has been known for some years that the physical properties of lard can be altered considerably by effecting a molecular rearrangement. Treatment at the proper temperatures with a catalyst, such as alkali or sodium methylate, changes the fatty acid distribution and the crystallization behavior of the product. Products that have been so treated have been on the market for several years, but remarkable advances have been made during the past year in the technology of conducting this operation. Much of this information undoubtedly is still unpublished and unpatented, but the progress is clearly evidenced by the startling results now obtainable with lards processed in this manner. The properties of these "rearranged" lards and the results obtained with them represent so vast an improvement over other lards that vegetable shortenings appear certain to encounter increasing competition. It is likely indeed that processes similar to those now being developed for lard eventually will be found necessary by the producers of vegetable shortenings in order to effect further improvements in their products.

Conclusions

It is hardly feasible to mention here a host of additional trends now apparent in our industry. Neither is it possible to foresee with sufficient clarity the importance that will be attached one year or ten years hence to those trends which we have just discussed. By a thorough study of these however, including the economic situation responsible for them and the effects they will have on the oilseed and oil markets, we can formulate some insight into the course of the oilseed industry in the years ahead. We hope that this discussion, when viewed in retrospect next year or at a future date, will prove to have been accurate in at least some respects as an indicator of future developments.

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