SOLVENT EXTRACTION OF VEGETABLE OILS**By Glenn H. Pickard, Chicago, Ill.**

In order to bring the time required to present this paper to within a reasonable limit, there will be discussed only the fundamentals of solvent extraction.

Raw Materials:

The raw materials available to a plant producing vegetable oils by solvent extraction divide themselves into three heads.

1. Natural oil bearing products from the vegetable kingdom, of which cottonseed, linseed, copra, palm kernels, corn germs, soya beans and the like are typical.

2. The cake or meal resulting from the application of pressure by means of the hydraulic press or expeller to the materials mentioned above or similar oil bearing bodies.

3. The by-products from refining, filtering or otherwise handling vegetable oils obtained by any process, among which are fullers earth, filter cloth, filter paper and rags saturated with oil.

The preparation of the first two classes of raw material mentioned offers the first important problem to the operator of an extraction plant. In order to secure efficient extraction, if is necessary to subdivide the raw material to an extent which will give to the solvent free access to the oil bearing cell. Obviously, if the solvent cannot enter and leave all oily portions freely the extraction will not be complete. Therefore a maximum particle size must be determined and maintained for each material, since they vary greatly in denseness.

Similarly the presence of an excess of very fine material reduces the efficiency of an extraction plant because the flow of solvent and steam is retarded by the compactness of the mass brought about by the filling of the interstices between the larger particles with those of small dimension. The extent to which raw materials can be subdivided depends upon their physical structure. Those which are fibrous or stringy and do not easily form fine masses, slimy when wet, can be ground more finely than those which do pack and mat.

If flaxseed, for instance, is ground too finely, the flow of solvent and steam are so slow that several times the usual period is required to complete the operation. When finished the meal will be a solid, rubbery mass that will break with difficulty. Essentially what is required is sufficient grinding to afford access for the solvent and yet to cause the minimum of pulverization. The optimum condition must be determined for each raw material.

The economical requirements of an extraction plant are that it shall handle the maximum amount of raw material per unit of time, that the meal and oil shall be of the best quality available from the raw material furnished, and that the operation shall be conducted at the lowest cost. Plant capacity, a variable, is an important factor in this as in all manufacturing operations. It varies, however, to a greater extent as a result of equipment design and raw materials handled than do most operations in the same class.

Elements of design which are functions of capacity are:

1. Pipe sizes for conveying liquids and vapor. All pipes should be of such dimensions that rapid transfer can be maintained.

2. Proper extractor size, in order that the extraction and steaming periods may not be unduly prolonged. With many materials when the mass becomes too large, the time required for a cycle is so great that it overcomes the advantage of the greater weight of material comprising a charge. If a plant

is designed to handle but one material, the physical properties of that body should be given consideration, while if various products are to be treated an average dimension is the best.

3. The ratio of the strainer surface and its construction are vital points in extractor design, for on them depends the rate of flow of the solvent and oil mixture from the extractor. If the area is too small, obviously the operation will be slowed up. Again, if it is of such a nature that when sufficiently fine to retain the solid matter it fills up and prevents free flow of the liquid, trouble results. It can be readily understood that the design and construction of the strainer must depend upon the nature of the solid matter to be retained by it, so that no rule can be laid down to be followed in all cases. Usually the whole bottom area becomes the strainer bed in the vertical extractor, while a sector of varying area is employed in the horizontal type. Burlap is the straining medium most generally employed.

4. The amount of oil in the raw material is a function of plant capacity because it controls the number of washes required to reduce the oil content of the meal to the desired minimum. The richer the material in oil, the larger the volume of solvent which must pass through it to wash the oil out. The number of washes depends upon the ratio by weight or volume of the solvent in each wash to that of the charge. The extremes of oil content found between the cakes and the natural products from which they are made can usually be handled in two or three extra washes. Practically all extractable bodies require two washes for economical handling, while it is very seldom that five washes or less will not completely extract them.

5. Still and condenser capacity must be sufficient to handle the work they are designed to do at such a rate that the operation of extraction will not be retarded. The capacity of these two units varies somewhat, because the amount of solvent required to extract a ton of material varies with the oil content of it. The less oil there is in the oil solvent mixture fed to the still, the greater the capacity that unit must have. In addition to the amount of vapors to be condensed, the average temperature of the condenser water must be borne in mind when condensing area is figured out.

Thus we see that the capacity of an extraction plant varies not only with the cubical capacity of the extractors, but also with the raw material, the manner in which that raw material is prepared for extraction, the detail of plant design and also with the skill of the operator. Therefore, in asking estimates upon an extraction plant, the buyer should state upon what material or group of materials the equipment is to be operated, in order that the maker can design a plant which will be of the proper size.

The cost of operation of an extraction plant in addition to the fixed charges, depends upon three main factors—the solvent, the fuel, and the labor consumed. The solvent cost is dependent upon its purchase price, the amount that is lost and the amount that is required per ton of material to properly operate the plant. Obviously, the lower the purchase price, the lower the total solvent cost.

No requirement in the design of an extraction plant is of greater importance than that the solvent be so handled that the loss of it will be at a minimum. Some of the factors influencing this are an extractor and a still which permit of complete removal of all vapors, the passage of the minimum amount of air in and out of the equipment, the centralization of all vents so that the solvent vapors can be removed as completely as possible from exit air, freedom from

leaks and the causing of any such to be inward by the use of a vacuum.

If the plant is properly designed and operated and the raw material well prepared, the solvent loss ought not to be greater than one per cent of the weight of material charged. This is a somewhat lower loss than it is generally understood prevails in plants now being operated, but the writer holds the opinion that it could be maintained if the requirements are properly controlled.

In a single unit plant, or a multiple unit one so designed that the percentage of oil in the solvent-oil mixture is low, the amount of solvent required to be used per unit of material extracted becomes unnecessarily large. This means money tied up in solvent, and in excess tank capacity for its storage.

The next important item is fuel consumed. Outside of an efficient boiler room, the design and operation of the extraction plant bear directly upon this item.

Obviously, radiation must be cut to the minimum by properly insulating all portions of the equipment in which heat is employed.

In discussing the solvent cost, mention was made of the amount that is distilled per unit of weight of material extracted as being a factor. This also affects the fuel cost, because heat is required to distill the solvent and consequently the more there is distilled the greater the amount of fuel consumed.

The extractor which is designed so that the solvent leaves the meal freely, and which requires the minimum of the sensible heat only of the steam, will require the least amount of fuel for its operation.

The ease of removal is dependent upon the distribution of the live steam and the physical condition of the charge. The live steam should be distributed over a wide area and the meal agitated so that the steam can pass through all portions of it without shingling or channelling, for when channels are not broken up, the steam, taking the course of least resistance, follows them and does not completely remove the solvent.

When live steam is led into meal at a temperature much below the boiling point of water, the steam condenses and must be removed during the steaming off process. This can be accomplished only by the use of the sensible heat of the steam and is therefore an expensive operation. To avoid this, the meal must be heated to as high a temperature as possible by the application of heat derived from both sensible and latent heat of the steam. This is done by coils in or jackets about the extractor or else by the passage of superheated solvent vapor into the meal after the liquid solvent has been drained off. By either operation, the minimum of steam is condensed only to be evaporated again, and the meal is darkened in color or otherwise changed in appearance to the least possible extent.

The still design also bears an important relation to the fuel cost. When a large amount of surface is afforded for the solvent to leave the oil, when the maximum amount of heat furnished is consumed in vaporizing the solvent, the fuel consumption will be lowest. Because of its greater efficiency, the column still is now being employed as the most economical means of removing solvent from oil.

The amount of labor required in an extraction plant depends upon the proportion of the material handling that can be accomplished by machinery. With feed bins over the extractors filled by conveyors, with self emptying extractors delivering directly to conveyers taking the material to bins from which it is bagged or otherwise disposed of the only labor left is the handling of the valves controlling the operation

and the preparation of the raw material. In comparison with an hydraulic mill of equal capacity, the labor required to operate an extraction plant is less, for press room labor is largely eliminated.

The steam required for power is low, for agitation by either method requires but a small horsepower. In addition to this, the conveying of the raw material and meal, the pumping of the liquids, and the vacuum pump complete the list of units requiring power.

Quality of Products:

The quality of the products of solvent extraction of oleaginous materials is a moot question. There exists a prejudice against extracted oil and meal due to the fact that some existing plants are either improperly designed or operated, or both, and also because in former years operators took the course of least resistance in marketing their products and sold them below the current prices of the same items obtained by hydraulic pressure.

The quality of oil and meal from any raw material depends upon the solvent used and upon the design and operation of the plant. In the case of both oil and meal, the best solvent is the one which is more easily removed and which dissolves the least of the raw material other than oil. The most generally employed solvents are gasoline, benzol, tri-chlor ethylene, carbon tetrachloride and carbon bisulphide.

The one most widely used is gasoline. It is almost universally conceded that when gasoline of the proper distillation range is available that it is the most generally satisfactory solvent to employ because it has a lower solvent power for materials other than oil, because it has, with the possible exception of castor oil, as great a solvent power for the oil and because it can be as completely removed from oil and meal as any other. The low limit of the boiling point range that is permissible depends to some extent upon temperature of the condenser water. It should not be so low that condensation could not be easily accomplished. A maximum temperature of about 300° Fahrenheit will indicate gasoline which can all be removed.

Benzol is coming more and more into use because of its price. It has the advantage of having a constant boiling point. On the other hand it is a more active solvent for certain materials of some oleaginous bodies, which, when present in the oil, detract from its value. This is particularly true of cottonseed, for there are in the hull of that material resinous-like bodies soluble in benzol but insoluble in gasoline, which deepen the color of the oil and cause a higher refining loss. In the case of castor oil extraction it is an advantageous solvent because it is miscible in all proportions with that oil, while gasoline is not. Benzol, however, is hard to remove from the meal and oil and frequently, leaves an unpleasant odor and flavor.

Carbon bisulphide is used in Europe to some extent, particularly in the olive oil industry, but in this country it is not employed. Tri-chlor ethylene has been employed to some extent abroad but is unknown here. Recently its cost has prevented the use of it. The fact if its non-inflammability made it attractive.

Carbon tetrachloride has been used because it is non-inflammable. This solvent can be satisfactorily employed only in specially designed equipment, because when in the presence of moisture hydrochloric acid is formed which attacks iron and darkens the oil. There is little doubt, however, but that equipment can be constructed in which carbon tetrachloride can be used as a solvent. The particular advantage of it

lies in the inflammability, which would permit of the construction of an extraction plant within the buildings or confines of a large plant without disturbing the insurance rate.

The operating conditions which have the greatest bearing upon meal quality are the time required for passing steam through the meal, for, the shorter the time the less the effect. Second, the temperature to which the mass must be heated to remove all the solvent — the lower the better — and, third, the amount of water that is permitted to condense and must subsequently be vaporized.

The ideal conditions would be to have the meal heated to above 212° Fahrenheit in a manner which precluded local heating and consequent darkening of the meal and then to pass dry steam through it to remove the last traces of solvent vapor. When a solvent of proper distillation range is available the use of superheated solvent vapor comes close to the ideal condition described.

The writer offers, as evidence of the fact that satisfactory meal can be produced by solvent extraction, the statement that during a four year connection with a plant operating on this principle that not a single complaint was registered on meal because of foreign odors. All the meal made was consumed in this country or abroad as stock food. Recently the English have been studying the use of meals made by solvent processes and have arrived at the conclusion that they are satisfactory when compared with those made by hydraulic pressure. The quality of oil made by solvent extraction depends upon the solvent employed and the design and operation of the still.

That solvent which will take the least material from the solid matter into the oil and is most easily removed from the oil is the most satisfactory. The nature and amount of extractable bodies, other than oil in a raw material, are the deciding factors as to what solvents are available when judged from that angle.

Obviously, if a solvent leaves odors or flavors which cannot be removed it would be excluded from the list of those available for the manufacture of high grade oil, for many users employing the oil for manufacturing purpose will not stand for off odors. The elements in still operation which make for oil quality are the total time under heat, the maximum temperature and the average temperature. The best still removes the solvent in the shortest possible time under heat and at the lowest average and maximum temperature.

The reason is that when any oil is heated for a short time at a high temperature or for a longer time at lower temperature the color of the oil is deepened and set. Consequently the bleaching is more difficult, if indeed possible, and the refining loss is higher.

The usual still design has been a tank in horizontal position with closed and live steam coils in the bottom or a vertical type with coil or calandria in the bottom. Neither of these is the best type because the mass of and through coils employed is controlled so that the fore, the maximum time and temperature are required.

In the column still the flowing of the oil in thin films and the dripping of it from section to section offers an immense surface and thus greatly facilitates the removal of solvent. Further, the heavier portions of the solvent traveling up through the still impart some of their excess heat to the lighter fractions, thus vaporizing them. This keeps the average temperature down and lowers the temperature of the vapors going to the condenser. Again, the amount of steam, both live and through coils, employed is controlled so that the solvent is just removed. Obviously, the oil is at the

maximum temperature only during its passage through the lower portions of the still.

Further, the operation of a still of this type is continuous and can be regulated to handle the oil-solvent mixture at a constant rate. This eliminates heat losses due to intermittent operation. With this type of still as a part of otherwise well designed equipment oil is being made in Europe which is consumed for edible purposes. We are firmly of the opinion that before long extracted oil will be consumed by the people of the United States in large amounts.

There are three types of extractors — the vertical without agitation, the vertical with internal agitation, and the horizontal rotary.

Of the unagitated type none are today being constructed for use in vegetable oil manufacture, and, in our opinion, rightly so, for extraction and solvent removal are not as efficient as when the charge can be moved. The trend in this country seems to be toward the rotary type largely because less power is claimed for it as well as lower labor. As between the rotary and internally stirred, the writer fails to see the advantage of the rotary for, obviously, the charging of each will require the same labor if both be provided with overhead bins filled by conveyors. Again, in unloading, the stirrer arm of the internally stirred type will force the meal out of a door as fast as any normal sized conveyor will take it away. The rotary can do no more in this respect.

The power item is, in our opinion, an exaggerated one, for it is applied for but a portion of the operating cycle. The consumption of power by the stationary type extractor is not as high as commonly supposed.

Recently an extractor eight feet in diameter operating on a ground press cake was found to consume at a maximum but twelve horsepower, and that for but a short portion of the steaming period.

On the other hand, we believe the application of the counter-current principle of extraction to be an important element in cost reduction, because it reduces the amount of solvent necessary to distil and because it reduces the handling of solvent since one pump of a gravity feed system will force the liquid from one unit to another. The small unit lends itself readily to the application of the countercurrent principle and the internally stirred, stationary type extractors can be built of smaller size more cheaply than can the rotary type.

The agitation in a stationary percolator prevents the movements of the mass as a whole, which takes place in some of the rotary machines. Particularly, in the case of plants of such a capacity that they do not require several extractors of the size usually employed by builders of the rotary machines, we believe the internally agitated to be most adaptable to what we consider the most economical arrangement. With regard to the relative cost of operation between the hydraulic system and that of extraction for the manufacture of vegetable oils much has been said.

Using as the basis for the calculation the operating cost of a solvent extraction plant and of pressure plants working simultaneously upon flaxseed, the writer computed the net return on the basis of raw material costs and product value to be about \$1.50 per ton more in the case of the extraction plant than with the pressure plants. The period covered was one of five normal years before the war. This is in spite of the fact that the extraction plant was inefficient because of a very poor power plant, because of antiquated design and poor state of repair, causing high labor and fuel costs and an excessive solvent loss.

After years of experience in the operation of both processes, after a thorough study of the quality of the products and of the efficiency of the two systems, the

writer is firmly of the opinion that the future of the vegetable oil industry lies in the adoption of the extraction process. We agree with those who predict the relegating of the hydraulic press for oil manufacture to innocuous desuetude, but dare not set the time that it will take to accomplish the change.

NOTES ON COCOANUT OIL COLOR

By P. W. Tompkins, of Curtis & Tompkins,
San Francisco

Almost as much misunderstanding has resulted from attempting to read many crude cocoanut oils appearing on the market according to New York Produce Exchange and Interstate Cottonseed Crushers' Assn. classification of basis 30 yellow, as there formerly was in reading soya bean oil basis 35 yellow. Cocoanut oils of the Manila type are frequently read by some in actual tints as well as basis 30 yellow, which creates confusion in the minds of many, as well as being misleading and inaccurate in the latter case. While basis 30 yellow is adequate for such oils as are referred to in these rules with 3 to 5 red, it does not in any way satisfy the needs with such crude oils as range 8 to 20 red, and yellow between 50 and 100. Reference to this subject was made at the end of an article, "Cocoanut Oil and Its Ally," in the February, 1920, number of THE COTTON OIL PRESS.

It would appear that too much is being borrowed from cottonseed oil color standards to be practical for many cocoanut oils, and is a case quite as impractical as developed in reading soya bean oil colors. In the 1919 standard for soya bean oils, the impossible color basis of 35 yellow was used, whereas the revised rules call for basis 70 to 100 yellow, which is more in keeping with the needs, and a similar provision for cocoanut oil is an equal necessity.

If one stops to compare the basis of 30 yellow with 3 to 5 red, and then considers oils being reported on the same basis (30 yellow) where the red may range from 8 to 20, it can be better understood that 30 yellow has outlived its usefulness as a basis for reading some cocoanut oils. Existing standards need not be altered, but some adequate provision should be inserted for reading oils that do not in any way represent the types enumerated.

A single illustration is sufficient to demonstrate this discrepancy, taking for example a cocoanut oil type not represented in the rules, as follows:

Actual	—Yellow.....	90.0
	Red.....	18.0
Basis	—Yellow.....	30.0
	Red.....	15.5
Difference—	Yellow.....	00.0 Less
	Red.....	2.5 Less

On the basis of 30 yellow, the reading does not adequately reflect the color of the oil, since 60 yellow and 2.5 red is eliminated from the color on paper, but not from the oil, thus causing a false impression of what the color reading is intended to show. With such oils as are enumerated in the rules, this distortion of color value does not occur, when reading basis 30 yellow.

It is not necessary to alter grades satisfactorily established, but to provide suitable means for reading oils that cannot be adequately represented by 30 yellow, or when the oil is far from the color for which 30 yellow was provided. In the absence of a more rational system for reading colors than is now officially adopted, it would serve a useful purpose if some such provision in effect as follows, was added to the rules:

"Any crude cocoanut oil exceeding 7 red on the

basis 30 yellow, should be read and reported on the basis of 50 yellow; any crude cocoanut oil exceeding 11 red on the basis of 50 yellow should be read and reported on the basis of 70 yellow; and any crude cocoanut oil exceeding 15 red on the basis of 70 yellow, should be read and reported on the basis of 30 yellow.

It is quite certain that no two operators will agree, if cocoanut oils of 10 to 20 red are determined on the basis of 30 yellow, as the imagination of necessity plays too important a part in such cases. If we must still endure the present system, an insertion in the rules which will provide some relief can hardly be anything but beneficial.

BLEACH TEST AND FULLER'S EARTH COMMITTEE REPORT FOR 1921

By R. C. Hatter, Louisville Food Products Co.,
Louisville, Ky.

The committee on the Bleaching Test and Fuller's Earth makes the following report: The regular method of the society was again checked up as to temperatures and quantity of earth used and we agree with last year's committee that no change should be made.

The previous committee recommended that we study various methods of stirring during bleaching. Various shaped containers were used and various methods of agitation both mechanical and hand were experimented with.

The differences in the color readings, if any, in the case of mechanical agitation were so slight that they could be called negligible.

Where hand agitation with an ordinary soup spoon was used we found that the round bottom sand bath used as the container gave slightly better results. The reason seems to be that the falling earth descending to the lowest part of the dish came in contact with the spoon at every motion, thus causing all the earth to be in a state of agitation for the full period.

This method gave slightly better results than methods using other containers, but when compared with the mechanical experiments the results were about the same.

We do not recommend any one shaped container or any one method of agitation inasmuch as the differences of our color did not warrant it.

In regard to the fuller's earth used in our bleach test, Interstate rules bind us to the English earth until we prove to ourselves that we have a domestic earth which is just as good, or better.

The experiences of most of us prove that the domestic earths which are good decolorizers are not uniform but are light, bulky and have high retention values and the earths which compare favorably with English earth in regard to these qualities do not bleach as well.

In view of the fact that we are all looking for a good domestic earth and a large number of the geologists have the same thing on their mind, it is possible that in the near future we will discover a domestic earth which will give us the results required. Until such discovery is made we should not consider the changing of our standard earth.

N. B.—The Committee's report was accepted and a motion passed to the effect that no changes be made this year in the Bleach Test.—Editor.

The Kenwood Products Co., Utica, N. Y. \$10,000 capital, has been chartered for manufacture of soaps. M. A. Payne G. H. Donah and L. A. Jones are incorporators.