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COMMERCIAL UTILIZATION OF GRAPE POMACE AND STEMS FROM THE GRAPE-JUICE INDUSTRY.[1]

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CONTENTS.

THE CONSERVATION OF FRUIT-PRODUCT WASTES.

FOR MANY YEARS the cultivation of grapes for the production of grape juice has been an industry of large and growing proportions, and with the increasing popularity of the juice as a beverage the industry has received added impetus. In the process of preparing the juice for market large quantities of stems and pomace result, which at present are practically waste material.

In several publications of the United States Department of Agriculture (13, 14, 15, 16)[2] it has been shown that in preparing products for market from such fruits as cherries, raisins, peaches, apricots, and tomatoes the waste resulting from the various processes is capa-

[1] The writers wish to express their thanks to Mr. J. D. McIntyre, Chemical Laboratorian of the Office of Drug, Poisonous, and Oil Plant Investigations, for valuable assistance rendered during the course of this investigation.

[2] The serial numbers in parentheses refer to "Literature cited" at the end of this bulletin.

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ble of being converted into products of considerable value. The waste resulting from the grape-juice industry offers like possibilities.

ACCUMULATION AND PRESENT DISPOSAL OF GRAPE WASTE.

In the manufacture of grape juice the grapes are first passed through a so-called stemmer, which removes the stems and discharges them to a conveyor or chute, which in turn carries them to the dump heap as waste (fig. 1). Immediately following this operation, the grapes, more or less crushed, are heated to about 140° or 145° F., thoroughly agitated to insure homogeneity of the mass, then wrapped in heavy press cloths and placed in hydraulic presses between wooden racks. After the juice has been pressed out the pomace which remains

FIG. 1.—Waste grape stems.

in the cloths is approximately 1 inch in thickness and 4 feet square. This pomace, stripped of the cloths, is discharged to conveyors, which usually carry it also to the dump heap (fig. 2).

The pomace has been used in a small way for fertilizer purposes and to a limited extent by vinegar manufacturers. It has been used by some to make a second or low grade grape juice by soaking with water and pressing again and has also been fermented into wine. The water extract of the pomace has been used to flavor jelly.

Commercial interests in the United States have given some attention to the disposal of grape waste with a view to its profitable utilization, but thus far no complete utilization of both stems and pomace has resulted from the attempts made, and the disposal of this waste is at present an item of expense rather than one of profit.

In some other countries considerable attention has been given to the utilization of grape residues resulting from the wine industry. In 1907 Semichon (18) called attention to the feeding value of dried grape marc based on its protein, fat, and carbohydrate content. In the same year Bertainchand (2, 19) reported on the utilization of grape marc for the feeding of farm animals. He condemned its use as a fertilizer, because of its value when mixed with molasses as a feeding stuff for cattle and sheep. Paris (12) has investigated grape residues in Italy, stating that if the seeds contained in the marc were utilized for oil an annual production of 18,000 liters could be obtained. The fresh marc is said to contain 25 to 30 per cent stems, 50 to 60 per cent fibrous tissue, and 15 to 20 per cent seeds. Grape-seed cake was stated by Fuchs (6) to contain 12 per cent protein, 5

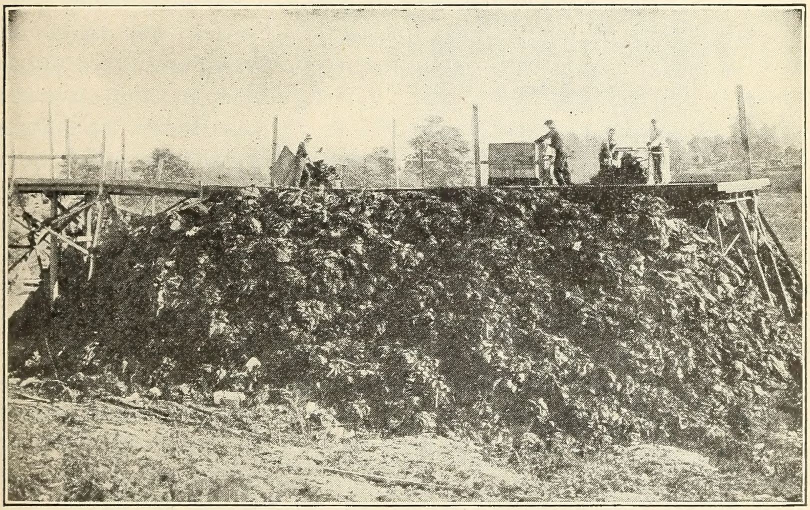

FIG. 2.—Waste grape pomace.

per cent fat, and 33 per cent nitrogen-free extract; but because of the great quantity of crude fiber its value as a stock food is diminished. Daza (4) and Disdier (5) patented processes in 1914 for treating grape marc for the production of various useful products, such as oil, alcohol, tannin, and potassium bitartrate. Further work of similar nature on the utilization of grape residues is mentioned by De Saporta (17) and Matignon (8).

During the war Kling (7), in a report on new feeding stuffs used in Germany, stated that grape pips, containing 10 per cent protein, 7 per cent fat, 29.5 per cent fiber, and 35.1 per cent nitrogen-free extract, have a nutritive value corresponding to that of medium-quality meadow hay.

In 1916 Monti (10) reported a process for extracting grape pomace. During the same year a statement was made (11) to the effect that grape seed can be used as a fodder, but apparently only for sheep. It is also noted that the Austrian Ministry of Commerce (1) called attention to the use of grape seed as a raw material for the production of oil, oil cake, and meal, the latter to be used as a stock food.

In 1917 Matignon and Marchal (9), in addition to investigating grape pulp for fertilizer and food value, called attention to the possible fuel value of this waste, which, from the wine industry of France, would be equivalent to 160,000 tons of coal. In 1918 Ventre (20) further called attention to the utilization of grape seeds in France for the extraction of edible oil. In 1915 Dawson (3) reported on the manufacture of oil from grape seeds in Argentina.

AVAILABLE QUANTITY OF GRAPE WASTE.

In order to estimate the available quantity of waste resulting from the manufacture of grape juice, questionnaires were sent to manufacturers in the grape belt, extending from Michigan across upper Ohio and into central New York. The figures submitted gave the tonnage of grapes crushed from 1914 to 1918, inclusive, and from these an average has been taken to represent the quantity which may be expected annually.

The waste consists of stems and pomace, the latter being made up of the skins and seeds. The stems are calculated as 3 per cent of the original grapes and the pomace as 20 per cent. The skins constitute about 75 per cent of the wet pomace (containing 50 per cent of moisture) and the seed 25 per cent. From these calculations the following figures were obtained, which may be taken as representing the approximate quantities of the waste materials which result annually from the grape-juice industry in the grape belt under consideration:

	Tons.
Total quantity of grapes crushed	22,000
Stems (3 per cent of the grapes)	660
Wet pomace (20 per cent of the grapes)	4,400
Skins (75 per cent of the wet pomace)	3,300
Seed (25 per cent of the wet pomace)	1,100

COMMERCIAL PRODUCTS OBTAINABLE FROM GRAPE WASTE.

The stems, which occur as the first by-product, contain cream of tartar and tannin, both of which may be obtained in the same operation.

The pomace, which constitutes the second and larger portion of the waste, consists of skins and seeds in about equal parts when dry. From the skins, which contain much flavor, color, and pectin, a palatable jelly can be made. From the seeds can be obtained oil, meal, and tannin extract, the most important of which is perhaps the oil, the meal and tannin extract being of secondary importance in point of actual value. The diagram (fig. 3) illustrates the reduction of this waste material to the various commercial products mentioned.

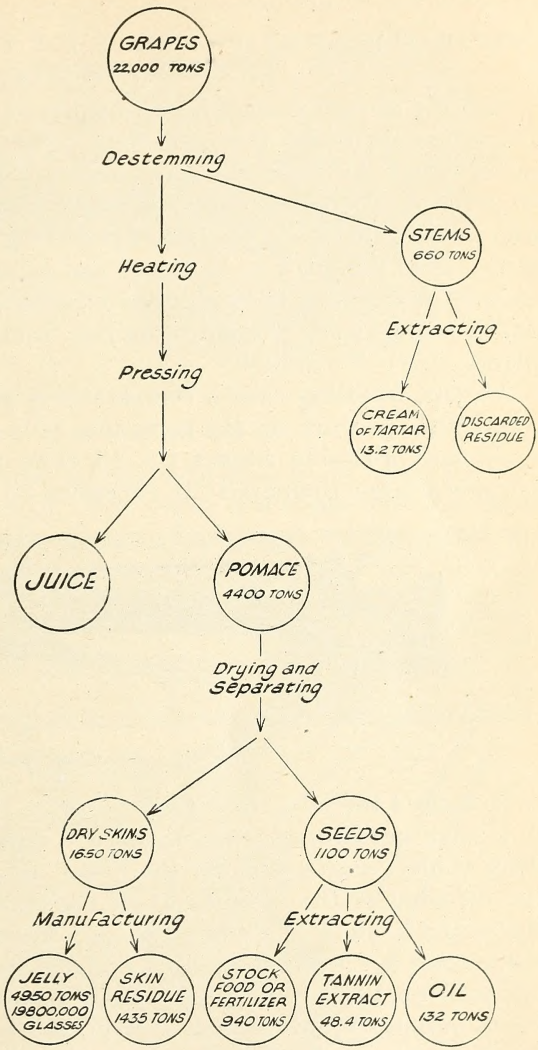

Fig. 3.—Diagram showing the products obtainable from grape waste.

CREAM OF TARTAR FROM GRAPE STEMS.

The method of extracting the cream of tartar from the stems consisted in boiling the ground stems with an excess of water, running off the water extract, and concentrating it at atmospheric pressure or by means of a vacuum pan to the consistency of a thin sirup. When allowed to stand, this extract deposited crystals of cream of tartar, which were thrown on a force filter or into a centrifuge and washed with cold water, in which the crystals are only slightly soluble. In this manner about 2 per cent of crude cream of tartar was obtained. The washed crystals were readily purified by recrystallization from a hot-water solution.

The total quantity of wet stems (660 tons) would yield, therefore, about 13.2 tons of crude cream of tartar, which, at 40 cents a pound (a conservative figure for the crude crystals), would bring a gross revenue of $10,560.[3]

[3] All estimates and prices quoted hereinafter, unless otherwise specified, are based on prices obtaining in the winter of 1919–20.

The tannin content in the mother liquid from which the cream of tartar was crystallized was found to be too low to be considered as a commercial product.

PREPARATION OF GRAPE POMACE FOR THE MANUFACTURE OF JELLY AND OIL.

Scarcely enough pomace is produced at any one factory to pay the individual plant for the immediate utilization of both skins and seeds. Since, however, the pomace as it is produced contains about 50 per cent of moisture, which is conducive to rapid spoilage, attention was directed along the line of preparing this wet pomace in such a way as to permit it to be stored and manufactured later into the various products or to be shipped to some central utilization plant which could handle the entire output from the several grape-juice plants.

A plant handling even a comparatively small tonnage of grapes could perhaps work up the skins into jelly at a good profit, but it could not profitably extract the oil from the seed, since for this purpose a large, comparatively expensive oil mill would be required.

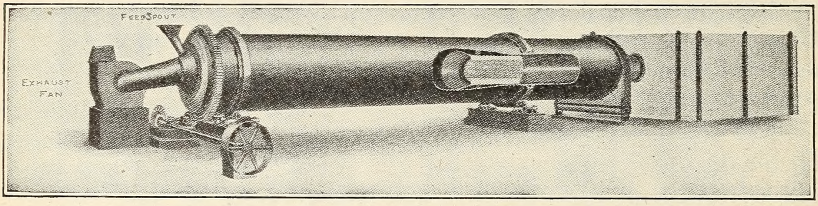

FIG. 4.—A direct-heat drier.

To extract the jelly stock from the skins they must first be boiled in a small quantity of water and then pressed in hydraulic presses. This would necessitate either the installing of additional presses or the reducing of the quantity of grapes handled; in the latter case the output of juice would be curtailed. Experiment has proved that the pomace can be satisfactorily dried, the seeds and skins separated, and each worked up as desired. There would thus be no curtailment of the output of juice because of reduction in the quantity of grapes handled, nor would there be any added expense incurred for installing additional presses.

The pomace may be dried by means of driers of the direct-heat type (fig. 4) or the steam type (fig. 5). In either case the wet pomace should be disintegrated and conveyed into the machine in a continuous stream. Both driers rotate on a horizontal axis. The material enters the driers at one end in a continuous stream and passes out at the other end in a dry condition. The heated air current enters at the discharge end and leaves at the entering end, thus working on the counter-current principle. The two types of driers differ only in the sources and method of application of the heat. Both are continuous in operation. Such procedure in

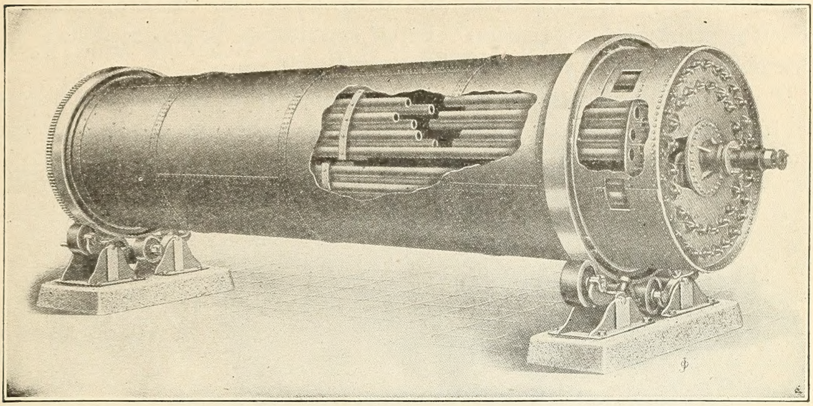

FIG. 5.—A steam-type drier.

all cases can be carried out by the individual plant, since the outlay is comparatively small. The skins and seeds may be separated and bagged for storing immediately upon issuing from the

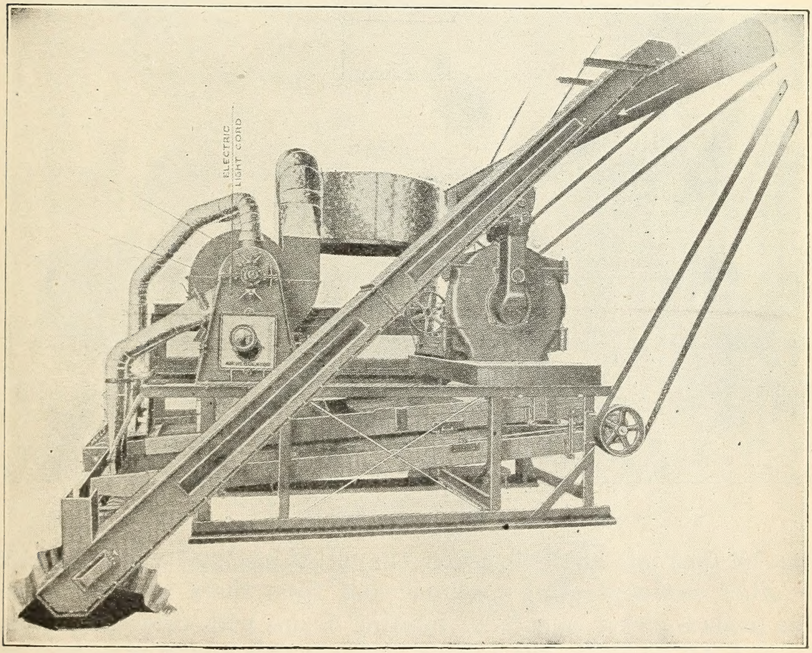

FIG. 6.—A hulling and separating machine.

drier. A hulling and separating system which consists essentially of an elevator, grinder, shaking sieves, and blower, as shown in figure 6, is well adapted for this purpose. The masses of seeds and skins from the driers are conveyed to the elevator of the hulling and separating system, thence to the grinder, where the seeds and skins are thoroughly disintegrated and drop upon the shaking screens, effecting a partial separation. Final separation is accomplished by means of the blower attachment.

If it should be desired to separate the seed from the pomace before drying, the wet pomace passes through an ordinary pomace picker

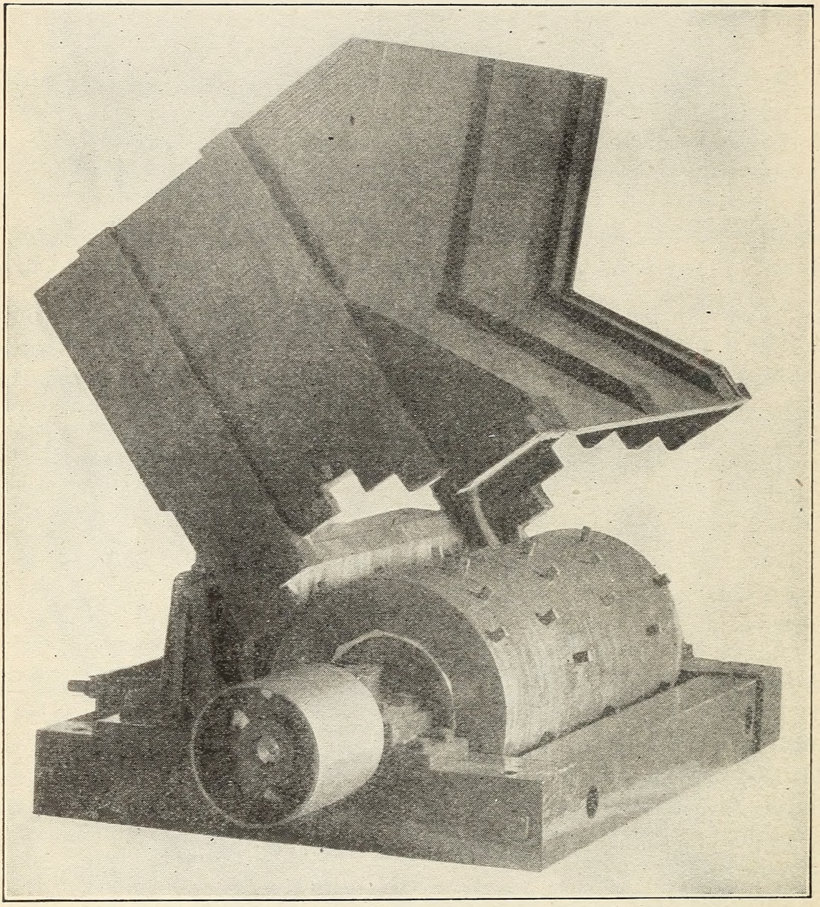

FIG. 7.—A pomace picker.

(fig. 7), then into an apple grater (fig. 8), thence into a fanning mill or other seed-separating machine, and from there into the drier. The pomace picker consists of rotating drums with projecting teeth. These teeth break up the pomace, but not sufficiently to release all of the seed. For this reason the pomace is put into the apple grater, which reduces it to smaller pieces and thus releases more of the seed. The seed and skins may then be effectively separated either by passing the disintegrated pomace into a shaking and fanning mill, such as is ordinarily used in cleaning grain and seed, or into a rotary separator similar to a sand cleaner, but provided with a quarter-inch mesh, that the seeds may fall through. The seeds are conducted

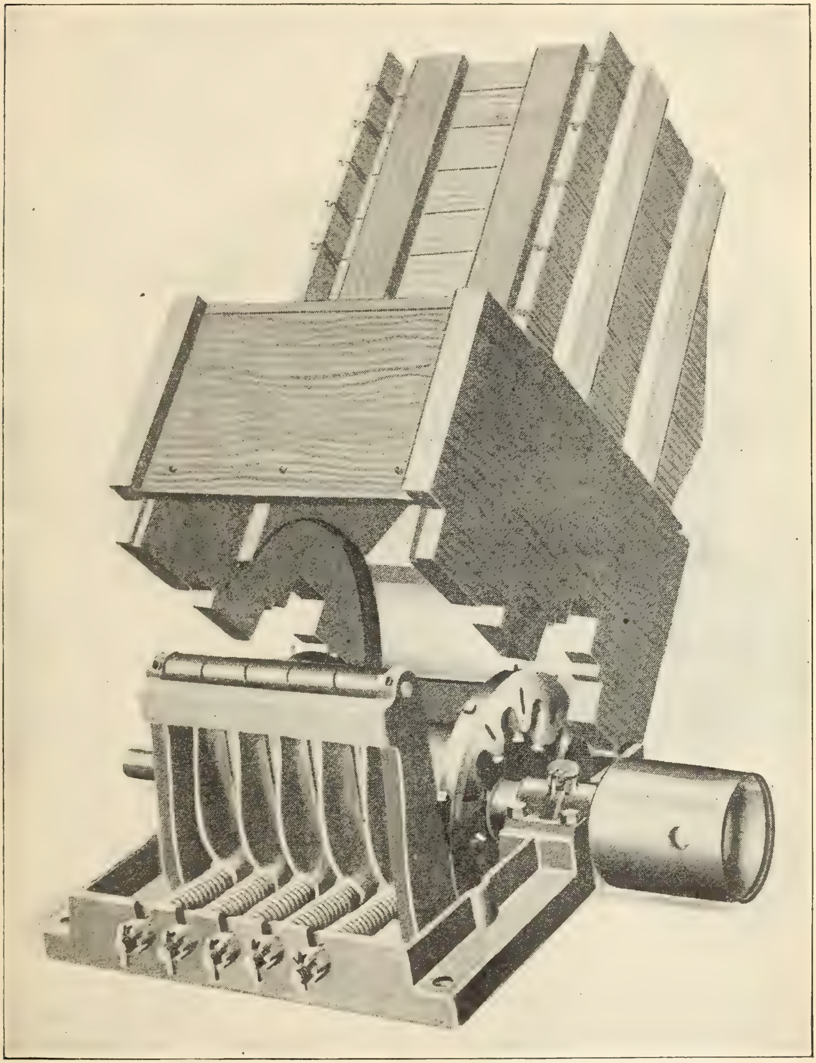

FIG. 8.—An apple grater.

out just as is the gravel in cleaning sand. In either machine, however, about 7 to 10 per cent of the total quantity of seed originally in the pomace is lost. Since the seed contains more than 13 per cent of moisture, it must be dried before storing or shipping; otherwise it would mold and spoil. In this connection it is of interest to note that in separating the seed from the wet pomace, particularly when it is effected in a fan separator, about 3 to 5 per cent of moisture (calculated on the total weight of the pomace) is removed, due to the aeration of the fanning operation.

A much better separation of the skins and seeds can be effected, however, after the pomace is dried, and it is therefore not considered advisable to make the separation before drying unless the wet pomace is to be worked up immediately, which can be done only where the plant producing it has all the facilities necessary for the purpose or where some plant engaged in utilizing such products is near enough to receive the pomace promptly. In the latter case the profitableness would be determined by the cost of hauling, giving due recognition to the fact that the fresh pomace contains 50 per cent of moisture, which would bear its proportionate cost of transportation.

In handling the pomace as it is produced from the presses the method outlined insures a minimum charge for labor and supervision. It is evident that by means of conveyors no handling of the pomace is involved after it is stripped of the press cloths until it is discharged from the driers. Bagging machines and conveyors would contribute to the continuity of the operation, but it is questionable whether the quantity of material handled would pay for the additional equipment necessary. A thermometer could be attached to the steam drier, so that there would be no risk of burning, but in case the boiler capacity of a plant were bearing its full load during the grape-pressing season there would not be sufficient steam available to operate the steam drier. In that event it would be necessary to resort to the direct-heat drier, requiring rather careful supervision.

MAKING JELLY FROM GRAPE SKINS.

To make jelly from the waste grape skins they are placed in a large wooden tank, in the bottom of which is an open steam pipe shaped like a cross. Enough water is added to cover the pipes, and the steam is turned on until the mass boils violently. The boiling should not be continued longer than 15 minutes, preferably about 10 minutes, depending, however, upon the quantity of material and the ease with which it can be handled. If boiled too long the jellifying property is destroyed, and if boiled too short a time the result is an insufficient solution of the jellifying property (pectin). If boiled too slowly some parts of the mass are overheated and others underheated, causing a low yield. The mass is then pressed in ordinary hydraulic presses, similar to those used in pressing out grape juice or in making cider. If the jelly is made by the plant which produces the pomace, the same presses can be used that were earlier used for making the grape juice.

In the manufacture of jelly it is absolutely necessary that the jellifying strength of a given juice be fairly accurately known, on account of the interdependence of the percentage content of the pectin, sugar, acid, and water. Varying the quantity of any one of these may cause the difference between good and poor jelly from the standpoints of texture and taste. It should always be recognized that it is impossible to determine the character of the resulting jelly until it has cooled under ordinary atmospheric conditions. Usually the results of a given procedure are not known until the following day.

The pectin is controlled by varying the quantity of juice used. The sugar should be increased or decreased as is found necessary for the given quantity of juice. Too little sugar produces tough, rubbery jelly, while too much produces soft jelly. To ascertain the best proportion of sugar to use to a given quantity of juice, it is recommended that a known weight of the pomace be cooked with the same relative quantity of water that is regularly used in the process of jelly manufacture. Add dissolved tartaric acid to the juice in the proportion of 1 ounce of acid to 1 gallon of juice. Divide this juice into equal portions of 1 pint each. For each pint use, respectively, one-fourth, one-half, three-fourths, and 1 pound of sugar. Cook to 224° F., pour into jelly glasses, and set aside undisturbed until the next day. The boiling should be done over a good flame and in a vessel large enough to take care of the excessive foaming.

These samples should be concentrated within 20 minutes, since long, slow boiling destroys the jellifying qualities. The jelly that presents the best texture is the one to adopt as the standard. However, the relative quantities of sugar and juice should be confirmed by making a larger batch, since results obtained from small quantities are not always the same when applied to large commercial runs.

Any kind of sugar, whether cane, beet, or one of the corn sugars, such as glucose and the like, may be used.

All jelly should possess more or less acidity. Jelly of the best quality possesses an acidity of approximately 0.75 per cent (expressed as tartaric acid). Too little acidity results in soft jelly; too great an acidity also produces soft jelly, because it destroys the jellifying properties of the juice during the boiling operation. Since most of the acid in the grapes is removed with the juice, it is necessary to add tartaric acid to restore the acidity sufficiently to establish the proper ratio for satisfactory jelly. In all cases the acid should be dissolved in the smallest possible quantity of water and added to the boiling mass; otherwise it may not readily go into solution.

The water content, of course, is regulated by the extent to which the mass is evaporated and is best determined by the boiling temperature, the optimum temperature for good commercial jelly being 222° to 224° F. The housewife usually produces thinner jelly with a materially lower boiling point. In view of these facts it is apparent that it is not advisable to add too much water because of the prolonged boiling which is necessary to remove it.

Grape jelly foams exceedingly when it nears the jelly point, and ample accommodations should be left to take care of the volume of foam. This is most readily accomplished by using a low-jacketed kettle and insuring ample steam pressure.

Attention is also called to the fact that it is preferable to make the jelly in small quantities of 10 to 25 gallons rather than in quantities of 50 to 150 gallons, the common American practice. It is generally recognized that a product of higher grade can thus be obtained, since a smaller quantity means a greater percentage of heating area to the volume than is the case with larger quantities. This is due to the fact that as the quantity of liquid in a hemispherical kettle is increased the volume increases as the cube of the radius, while the surface exposed to the heat increases only as the square of the radius. Thus, there is a greater concentration of heat per unit of volume in the smaller quantity, with attendant quicker boiling.

It may be of general interest to point out that it is perfectly feasible to make good jelly by substituting some of the popular glucose sirups for granulated sugar. Such jelly, of course, is not as sweet as that made with the sugar, but this can be obviated by decreasing the quantity of tartaric acid added in the earlier stages or by using a mixture of equal parts of cane or beet sugar and glucose. It should be remembered, however, that commercial glucose contains approximately 30 per cent of water, and therefore a proportionately greater quantity by weight should be used than of sugar.

The phenomenon of crystallization attendant upon making grape jelly is one with which all housewives and jelly technologists are familiar. This is due to the slow precipitation of crystals of cream of tartar in the jelly during long standing, because of the insolubility of the crystals. Various means are used in the grape-jelly industry to obviate this. Some add alkali to the juice in order to convert the cream of tartar into potassium tartrate, which is more soluble in the jelly than the cream of tartar, and consequently there is much less tendency to crystallization. Others make jelly stock by boiling the grapes in a small quantity of water and canning the concentrated product for future use. Upon standing, the crystals of cream of tartar slowly settle to the bottom, and when the time comes to make the jelly the juice can be poured off from the settlings (argols). By this means crystallization in the jelly is reduced to a minimum.

Jelly made from grape skins contains only a minimum quantity of cream of tartar, since most of this has been removed with the juice; consequently, there is less tendency to granulation than in jelly made from the whole grapes. Jellies which were made in the laboratory from grape skins in the fall of 1919 were still free from crystals in the summer of 1920.

Ash determinations, which bear strongly on this point, showed 0.15 per cent of ash in the jelly made from grape skins, while that made from the whole grapes from the same section of the country showed 0.31 per cent. This is another indication that the cream of tartar content in the case of jelly from grape skins is lower than in that from the whole grapes.

Those who would not care to make jelly from the refuse skins could can the jelly stock and sell it to jelly manufacturers or to housewives. However, it is thought that this stock, upon standing, might become gradually weaker in its power of gelatinization, a fact recognized by jelly technologists as occurring in apple-jelly stock.

That a good grade of jelly can be made from grape skins is nothing new in itself. Many housewives make good jelly from the pomace resulting from homemade grape juice, and field experiences in the summer of 1919 disclosed the fact that in New Jersey many persons were securing the pomace from grape-juice manufacturers for this purpose.

QUANTITY AND VALUE OF JELLY AND RESIDUE.

As previously estimated, 4,400 tons of wet pomace result annually from the grape-juice industry, of which 3,300 tons are wet skins. The results of the experiments conducted, indicate that at least three 8-ounce glasses of jelly can be made from each pound of wet skins. Calculating on this basis, there could be manufactured from the total available annual supply of wet skins about 19,800,000 8-ounce glasses of jelly.

Grape jelly now appears on the market in three forms: (1) Pure grape jelly, made from the whole grapes; (2) apple-base grape jelly, made from a mixture of grape juice and apple juice; and (3) grape apple-pectin jelly, made from jelly stock strengthened in its jellifying properties by the addition of commercial apple-pectin stock. The prices of these products vary greatly. Pure grape jelly sold at wholesale in January, 1921, for $2.70 a dozen 8-ounce glasses, and some of it retailed for 30 cents a glass. Apple-base grape jelly and pectin grape jelly sold at wholesale for about $1.40 a dozen glasses, retailing at about 15 cents a glass.

As a basis for a comparison of prices, it may be stated that in January, 1921, apple jelly sold at wholesale for about $1.40 a dozen

8-ounce glasses, retailing at about 15 cents a glass. The price of dry apple pomace in January, 1921, was 2½ cents a pound; on this basis grape pomace should cost about a cent less. Since the only other ingredient is sugar, it follows that the prices of the two finished products should be approximately the same.

There should be no difficulty in marketing this jelly, since grape jelly is well liked, and the reason it does not fill a greater place in the dietary is largely on account of the high price. If, therefore, grape skins are utilized for this purpose it is evident that the jelly could be sold about as cheaply as apple jelly and yet return a satisfactory profit. The wholesale value of the total quantity of jelly capable of being manufactured from the grape skins available annually (3,300 tons) would be more than $2,000,000.

The net profit in handling grape waste will vary according to the plan of utilization adopted. These plans may be stated as follows:

(1) To separate the seed from the wet pomace at each factory, sell the seed, and manufacture the jelly immediately from the wet skins.

(2) To dry the pomace, separate and sell the seed, and manufacture the jelly from the dry skins during the season when the presses would otherwise be idle.

(3) To dry the pomace, separate the seed and skins, and sell both.

Plan No. 1.—Since 1 dozen glasses of jelly can be made from about 4 pounds of wet skins, 1,000 tons of grapes (producing 150 tons of wet skins) would yield approximately 75,000 dozen 8-ounce glasses. At a selling price of $1.50 a dozen the gross returns would be $112,500. The cost to manufacture this quantity of jelly (which will be given in detail later) amounts to $87,000, leaving a net profit on the jelly of $25,500. A thousand tons of grapes produces about 50 tons of seed, which would bring approximately $500. The total profit, therefore, in plan No. 1 would be $26,000.

Plan No. 2.—As in plan No. 1, the yield of jelly from 1,000 tons of grapes would be approximately 75,000 dozen glasses and the gross returns the same, $112,500. To the cost for manufacturing the jelly ($87,000) must be added that for drying and bagging the pomace (200 tons), which is approximately $1,800, making the total cost $88,000. The net profit on the jelly in this case would therefore be $23,700. Here again the seed would bring approximately $500, making a total profit in plan No. 2 of $24,200.

Although plan No. 2 is not quite as profitable as plan No. 1, it is far more practicable, since it utilizes the presses during the winter months when otherwise they would be idle.

Plan No. 3.—Here the pomace is dried and both seed and skins are sold, so that no cost for manufacture is involved. The dry skins, delivered at a utilization center (jelly factory), would bring about $24 a ton. This includes $9 a ton for drying and $5 a ton for hauling, leaving a net profit of $10 a ton, which on 75 tons of dried skins (150 tons of wet skins) would equal $750. To this must be added the value of the seed ($500), making the total profit in plan No. 3 $1,250.

If the seed were all assembled at a central cooperative plant and manufactured into oil a greater profit could be realized by the producers.

The residue remaining from the manufacture of the jelly was investigated for its possible value as a stock food. After drying and reducing to meal it was found to have approximately the following composition, indicating excellent stock-feeding qualities:

	Per cent.
Protein	11.06
Ether extract	7.87
Nitrogen-free extract	59.92
Crude fiber	21.24

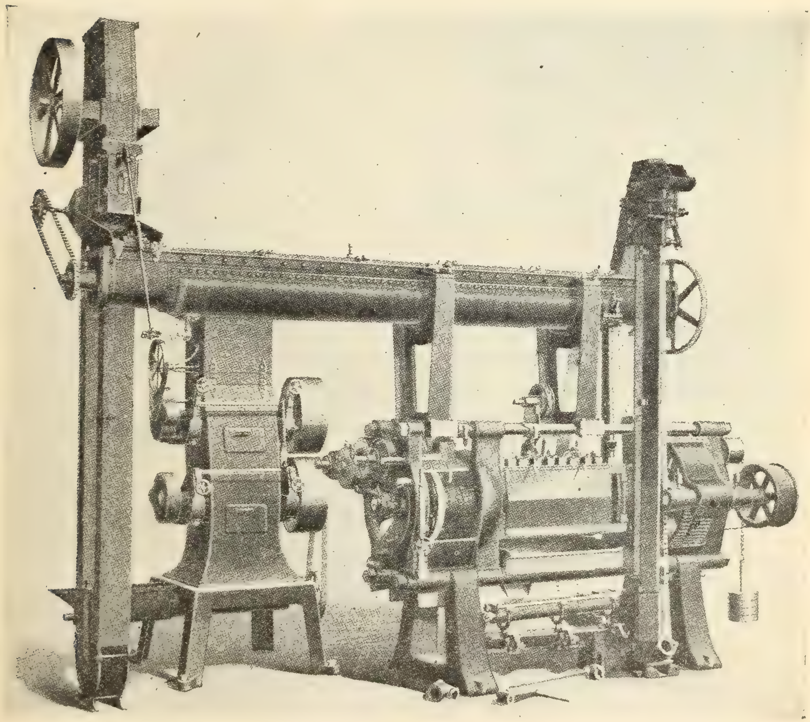

FIG. 9.—A 1-expeller type of press.

The total quantity of dry residue would be approximately 1,435 tons, which, valued at $17 a ton, would bring a gross return of $24,395.

MANUFACTURE OF OIL FROM GRAPE SEEDS.

Two methods of oil recovery are employed in extracting the oil from grape seeds: (1) The pressure method and (2) the solvent-extraction method.

The most economical pressure method is by means of the expeller type of press (fig. 9). The ground seed is fed continuously into the hopper, where a horizontal rotating screw carries the charge forward and subjects it to great pressure by discharging it over a cone in the throat of the horizontal barrel containing the charge and screw. The oil drips from openings in the barrel and the cake or chips are discharged from the throat.

Owing to the comparatively low oil content of the seed (13 per cent) and also to the very hard seed coat, which tends to cause excessive wear on the expeller, it is desirable that the seed be first decorticated. Thus, a large part of the hard hulls may be removed and the oil content of the kernels be more readily obtained. The resulting cake has also a much lower fiber content than if the whole seeds were passed through the expeller.

In the laboratory a successful decortication was effected by passing the seed through a vertical-plate mill set for medium to coarse grinding. The ground mass of seeds was then passed through a rotary sifter (of the flour-sifter type) fitted with No. 20 wire mesh. This produced a separation of the coarser particles of the shells or hulls from the finer meaty portion of the seeds. The hulls were found to constitute 44 per cent of the seeds and the kernels with some of the finer particles of shells 56 per cent. The hulls showed an oil content of 4.07 per cent and the kernels 19.9 per cent.

The kernels were now in condition to permit the oil to be readily extracted, and the shells were in such small quantity as to have only a minimum wearing effect upon the expeller. The yield of oil obtained from the kernels was about 14.5 per cent. This oil was of a dark-green color and had a strong nutlike odor and taste. After being refined it was straw colored with a slight greenish tint and pleasant bland taste and smell.

Solvent extraction of any oleaginous material depends upon the solubility of the oil in some volatile solvent, such as benzol. When dry ground grape seeds are treated with a warm benzol solution the latter dissolves the oil, which is then separated from the solution by distillation of the solvent. The recovery of the solvent from the solution is thus effected, enabling it to be used repeatedly. The extracted residue is treated with steam to remove the traces of benzol. By this method from 11 to 12 per cent of oil may be obtained. Such a solvent-extraction plant is shown in figure 10.

The crude grape-seed oil which was obtained by this method was refined and yielded an oil equal in quality to that obtained by pressure.

It will readily be recognized that each of these methods has both advantages and disadvantages. The solvent-extraction method produces a greater total yield of oil than the pressure method, but the oil cake resulting from the pressure method possesses valuable stock-feeding qualities which would enable it to be sold to better advantage than the resulting meal from the solvent extraction. The latter contains a large percentage of fiber, which practically precludes its use as a feeding material, and it could be used only as a fertilizer.

EXTRACTING TANNIN FROM THE HULLS.

The astringency of grape seeds is well known. This is due to the tannin in the hulls, which is present to such an extent as to affect unfavorably the stock-feeding value.

In order to determine the quantity of tannin obtainable from the hulls the ground hulls were macerated with water at 35° to 40° C. for

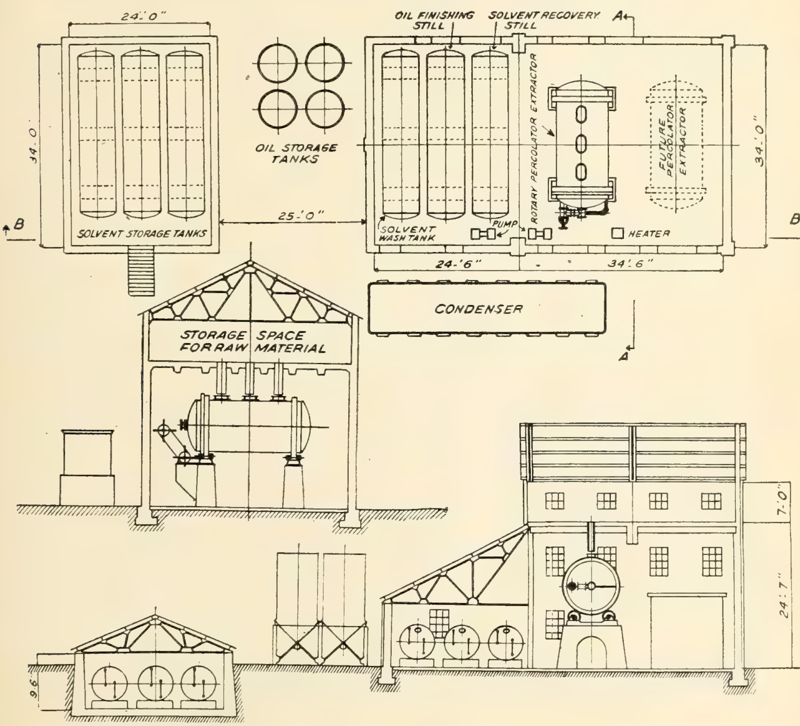

FIG. 10.—Oil-extraction plant, with rotary percolator extractors.

12 hours, then percolated, and the extract concentrated in vacuo. By this means 10 per cent of a soft extract was obtained, which showed 47.5 per cent total solids, 45.2 per cent soluble acids, 2 to 3 per cent insolubles, 15.5 per cent tannin, and 29.7 per cent nontannin.

This extract was submitted to a large tannery for testing, and the results of the test on leather showed good tannage with excellent color.

In view of the present need for tannin extracts, it appears probable that the hulls resulting from the decortication of grape seeds could be thus utilized. The total quantity of hulls available would be about 484 tons, which would yield 48.4 tons of tannin extract, or 96,800 pounds. Based on the analysis and behavior of the extract in tanning, a value of 3 cents a pound may be considered a conservative figure. The gross returns of this extract, therefore, would be $2,904.

QUANTITY, USES, AND VALUE OF THE OIL, OIL CAKE, AND TANNIN EXTRACT FROM GRAPE SEEDS.

Grape-seed oil is semidrying in character and possesses qualities similar to those of soy-bean and cottonseed oils. In commerce it should find ready application as an edible oil, or as a soap, paint, or varnish oil. Based on these facts, it should have an equal value with these oils. The pressed oil should bring about 17 cents a pound (the price of soy-bean oil in December, 1919). Extracted oil usually brings 1 or 2 cents less a pound.

The press cake from the decorticated seed contains 4.48 per cent fat, 14 per cent protein, 29.7 per cent nitrogen-free extract, and 43.2 per cent crude fiber, and should find use as an excellent stock food, comparing favorably with such feeding stuffs as sunflower seeds, cottonseed, coconut cake, palm-nut cake, timothy hay, and alfalfa hay. Based on the value of these common feeding stuffs, the value of the press cake can conservatively be figured at $30 a ton.

The undecorticated meal from the solvent-extraction process contains a much higher content of fiber and tannin and a much lower content of fat and could probably not be figured at more than $12 a ton. If the seed were decorticated, as in the expeller operation, the meal should bring about $25 a ton.

The quantities and gross value of the expeller oil, oil cake, and tannin extract, or the solvent oil and meal, capable of being manufactured from the total annual output of grape seeds are presented in Table I.

TABLE I.—*Quantities and gross value of products capable of being manufactured from grape seeds by the expeller and solvent processes.*

Process and product.	Quantity (tons).	Value.
Expeller process:		
Seeds available	1,100	
Kernels (56 per cent of seeds)	616	
Oil (14.5 per cent yield, at 17 cents a pound)	89.3	$30,362
Oil cake (at $30 a ton)	526.7	15,801
Hulls (44 per cent of seeds)	484	
Tannin extract (10 per cent) from hulls, at 3 cents a pound	48.4	2,904
Total value		49,067
Solvent process:		
Seeds available	1,100	
Oil (12 per cent yield, at 15 cents a pound)	132	39,600
Meal (at $12 a ton)	968	11,616
Total value		51,216

Since it was deemed more practicable to assemble the waste material at some utilization center and there work it up into merchantable products, several widely separated points were selected which would represent the maximum range of ready-assembling stations, and also their importance from the standpoint of working up waste materials from other industries. Table II gives the estimated cost of assembling the waste at several selected points. The freight rates represent car lots wherever possible and are given for shipping the whole pomace and the seed alone.

TABLE II.—*Estimated cost of assembling the dry grape pomace or the seed alone at various selected points for utilization centers.*

Waste, and shipping State.	Quantity (tons).	Cost of shipment to—			
		Chicago, Ill.	Indianapolis, Ind.	Philadelphia, Pa.	Westfield, N. Y.
Pomace:					
Michigan	750	$2,583.00	$3,092.00	$6,914.00	$3,870.00
New York	1,160	6,912.00	6,784.00	6,060.00	1,781.00
Ohio	290	1,390.00	1,325.00	1,903.00	1,110.00
Total	2,200	10,885.00	11,201.00	14,877.00	6,761.00
Average per ton		4.95	5.09	6.76	3.08
Seed:					
Michigan	374	1,292.00	1,546.00	3,457.00	1,936.00
New York	580	3,498.00	3,433.00	3,060.00	929.00
Ohio	145	713.00	668.00	949.00	581.00
Total	1,100	5,503.00	5,647.00	7,466.00	3,446.00
Average per ton		5.00	5.14	6.79	3.13

The operating costs may be divided into two general groups: (1) Those pertaining to drying the pomace, with the separation and bagging of the seed, and (2) those concerned with working up the material into the finished products.

The charges against drying the pomace and separating and bagging the seed may be itemized as follows:

Depreciation on equipment, 10 per cent	$600
Power, 5 tons coal at $6 for 20 days	600
Labor, 2 laborers at 40 cents an hour, for 20 days of 24 hours each	384
Bags, 1,000 at 20 cents each	200
Total cost for drying and bagging	1,784

These figures cover the cost for handling the pomace of a plant crushing 1,000 tons of grapes for a season of 20 days and represent the charge on 200 tons of wet pomace dried to 100 tons containing 20 per cent of moisture. One ton of dried and bagged pomace costs, therefore, approximately $18.

The cost for making and packing 1 dozen glasses of jelly has been estimated as follows:

Labor, power, depreciation	$0.10
Glasses and labels	.25
Pomace (cost of drying)	.03
Sugar (at 12 cents a pound)	.53
Boxes	.15
Overhead	.10
Total	1.16

Since the skins from 1,000 tons of grapes produce 75,000 dozen glasses of jelly, the total cost for making and packing this quantity of jelly would be $87,000.

Inasmuch as this investigation is concerned with utilizing a material which has heretofore been discarded as waste, it follows that the same plant, management, and selling force which handles the main line (grape juice) could take over the jelly manufacture with comparatively little extra expense for overhead charges. Consequently, this item is low. Approved accounting would, of course, demand that this product assume its share of the general manufacturing expense. But since such cost distribution would result in a greater profit from the grape-juice end and would thus be certain to appear on the books sooner or later, it is, for the sake of ready comparison, credited to the utilization of the waste.

An oil-extraction plant which could handle 25 tons of seed in a 24-hour day would cost approximately $25,000, not including the building. The total charge against this would be about $10 a ton, including the charges for depreciation, labor, power, and management. Only about 33 days would be consumed in working up this seed; hence, it would be necessary to work up other products during the remainder of the year in order to have these prices obtain. If the seed were extracted in a larger plant which was engaged at times in the extraction of other material, the cost would be considerably reduced. The cost to expel the oil would be about $13 a ton, figured on the same tonnage as the above.

GROSS RETURNS AND NET PROFITS FROM THE UNDERTAKING.

In order to show approximately the gross returns and net profits which may be expected from the manufacture of grape waste into commercial products, Table III has been compiled.

From these figures two totals are obtained, depending upon the method used for extracting the oil from the seeds. Solvent extraction produces oil and meal, whereas extraction by pressure produces oil, oil cake, and tannin extract. From the solvent method the total gross returns are $2,559,138 and from the pressure method $2,557,005.

TABLE III.—*Approximate values and estimated gross returns obtainable from the manufacture of various products from grape waste by different methods.*

Material used and product obtained.	Quantities obtained.		Approximate values.	
	Solvent method.	Pressure method.	Solvent method.	Pressure method.
Skins:				
Jelly	*Glasses.* 19,800,000	*Glasses.* 19,800,000	$2,475,000	$2,475,000
	Tons.	*Tons.*		
Jelly residue	1,435	1,435	24,378	24,378
Stems:				
Cream of tartar	13.2	13.2	8,560	8,560
Seeds:				
Oil	132	89.3	39,600	30,362
Meal	968		11,600	
Oil cake		526.7		15,801
Tannin extract		484		2,904
Total gross returns			2,559,138	2,557,005

Process or product.	Unit of estimate.	Cost per unit.	Total cost.	
			Solvent method.	Pressure method.
Extracting cream of tartar (13.2 tons) from stems	Ton	$30.00	$396	$396
Pomace (4,400 tons), local price	do	2.50	11,000	11,000
Drying and bagging pomace (4,400 tons)	do	9.00	39,600	39,600
Hauling dried pomace (2,200 tons)	do	5.00	11,000	11,000
Sparating seed (1,100 tons) from pomace	do	3.00	3,300	3,300
Manufacturing jelly (1,650,000 dozen glasses) from the skins	Dozen	1.16	1,914,000	1,914,000
Drying and grinding jelly residue (1,435 tons)	Ton	3.00	4,305	4,305
Extracting oil from seeds (1,100 tons)	do	10.00	11,000	
Decorticating seeds (1,100 tons)	do	4.00	4,400	4,400
Pressing oil from kernels (616 tons)	do	13.00		8,008
Extractlng tannin from hulls (484 tons)	do	3.00		1,452
Total cost for manufacture			1,999,001	1,997,461
Net profits			560,153	559,544

Against the gross returns must be charged the cost of making the various products. In order to ascertain the costs involved in a rational utilization of the waste, all successive operations involved from the accumulation of the pomace to the finished products are included in the estimates. No charge is allowed for the cost of the raw material, since there is no way to estimate what this should be except as the value of the finished products is compared with the cost of producing them. Table III shows the cost per ton and the total cost of the various operations from the purchasing of the pomace to the products resulting from the waste. It will be seen that if the solvent method is employed the approximate total cost will be $1,999,001, while by the pressure method the total cost is $1,997,461, making the approximate net profits from the two methods $560,153 and $559,544, respectively.

In these calculations it is assumed that the waste is utilized at some central point and that all the products are manufactured from the waste. Only in this way is a minimum expense involved, since much of the necessary machinery can be utilized for the several operations, thus reducing the cost of equipment and labor charge as well. If only a few of the products are manufactured, the profits would necessarily be reduced, since the cost of preparing the material would be distributed over a smaller number of products.

Complete utilization of grape waste for its full market value would be possible only when done at one point, since increased costs would mitigate against the success of the undertaking if attempted at several points with only a fraction of the total quantity of material available for reduction.

SUMMARY.

Since this investigation has shown that the waste which accumulates annually in large quantities at the various grape-juice plants can be made to yield a number of commercially valuable products, the utilization of this material should command the serious attention of manufacturers.

The possibilities have been pointed out and attention has been called to the proper and most economical methods for handling the waste. The procedure and methods of treating the stems, seeds, and skins for the production of cream of tartar, oil, oil cake, tannin extract, and jelly are most important from the standpoint of successful exploitation.

A careful study of the cost of the various operations involved in handling the waste and in manufacturing the products shows, by comparison with the returns, that profitable utilization is entirely possible.

It should be understood that all costs and returns, unless otherwise specified, were calculated on prices prevalent during the winter of 1919–20. Therefore fluctuations in prices and costs of freight, labor, machinery, and products must be given due consideration in the interpretation of the returns possible from an undertaking of this character.

With the growth of the grape-juice industry an increase in the quantity of waste will result. The more urgently, therefore, should be emphasized the necessity for utilizing this waste, both as an adjunct to the mother industry and as a reclamation project of agricultural and industrial importance.

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