BY-PRODUCTS OF THE SUGAR BEET AND THEIR USES.

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INTRODUCTION.

The primary object in growing sugar beets is the production of refined sugar. Any other materials, therefore, that remain or are produced in the manufacture of refined sugar from beets should be classed as by-products. These consist chiefly of beet tops (leaves and crowns), pulp, waste molasses, and lime cake. From these original by-products other by-products are often made that are of much greater commercial value than are the original by-products; for example, alcohol made from waste molasses and commercial fertilizer made from refuse slop. The first mill for the utilization of sugar beets, built more than one hundred years ago, made alcohol as one of the chief products, while sugar was looked upon as a by-product or at least as a product of secondary importance. In recent years both the quantity and the quality of sugar produced from beets have placed the material in the highest rank as a commercial product. The total quantity of sugar produced annually from beets is approximately the same as that produced from cane, whether considered from the standpoint of sugar production in the United States or from the standpoint of the world’s output, and the sugar is just as satisfactory for all purposes, including the preparation of jellies, jams, and preserves, so far as the Department of Agriculture and several of the State experiment stations have been able to determine.

A careful consideration of the present uses in general of the by-products of the sugar beet brings one to the conclusion that much of their real value is being lost to the farmer and to the sugar company. This paper is written with the hope that a more general interest may be taken in the proper utilization of the sugar beet, and especially of the by-products.

TOPS.

The first by-product of the sugar beet is the tops, composed of leaves and crowns, which are removed by the grower in preparing the beets for the factory at harvest time. Although the sugar is made in the leaves, only a small percentage remains in them, as it is con-
stantly passing into the root, where it is stored. The crown also contains a comparatively small quantity of sugar, while both leaves and crowns contain a comparatively high percentage of mineral matter, or ash. The percentage of ash in the leaves is usually about three times as great as the percentage in the untopped beet, while the percentage of ash in the crown is more than six times as great as the percentage in the whole beet. On account of the low sugar content and the high percentage of ash in the leaves and crowns they are discarded so far as sugar making is concerned, and therefore become a secondary product or by-product.

The leaves and crowns may be utilized either as a fertilizer or as a stock food. As a fertilizer they may be plowed under in the fall while still green or they may remain on the ground and be plowed under in the spring after more or less decomposition has taken place, or when fed to stock they may enter into and form a part of the stable manure, and in this manner be returned to the soil. If left in the field and plowed under, they will add a small amount of humus to the soil and a comparatively large amount of mineral matter. They should therefore be spread over the ground as uniformly as possible if they are to be plowed under.

The weight of leaves and crowns produced per acre varies greatly in different parts of the country, as well as from season to season, depending upon soil and climatic conditions. An average of 4 tons of tops per acre is a conservative estimate. This means an annual yield of about 1 1/4 million tons of this by-product. Of this quantity about one-fourth, or 1 ton per acre, is crowns and the remaining 3 tons per acre are leaves. The crowns contain about 5.6 per cent of mineral matter, or ash, which is equal to about 112 pounds per acre, while the leaves contain about 2.2 per cent of ash, yielding for the 6,000 pounds about 132 pounds of mineral matter per acre. Crowns and leaves together give a total average yield of 244 pounds of mineral matter per acre. This mineral matter consists for the most part of potash, soda, lime, magnesia, chlorin, sulphuric acid, silica, and phosphoric acid, which are mainly necessary plant foods, so that the value of this by-product as a fertilizer should not be overlooked.

If the leaves and crowns are to be fed to stock, they may be utilized in the fresh state, dried, or siloed. The best method of disposing of this by-product must depend upon local conditions and upon the object sought; that is, whether it is advisable to get the most out of this material from the feeding standpoint or to get it into the form of a fertilizer as soon as possible.

Many beet growers turn their sheep or other stock into the beet fields after the roots have been hauled to the factory. This is the
most wasteful method of feeding beet tops, since much of the material is trampled upon and the stock will not eat it. One of the most satisfactory methods of feeding beet leaves and tops is to dry them. This requires extra labor, and if they are artificially dried special machinery is required, which means additional cost. Tops when fresh contain from 85 to 90 per cent of water and when dried from 10 to 12 per cent; that is, in drying there is a loss of about 75 per cent of the original weight of the material, so that the average yield of dried material per acre is about 1 ton, which is considered equal in feeding value to the same quantity of first-class hay. A very small part of this by-product is treated in this manner in this country at present. The cash value of the material as a stock food depends upon the demand and therefore varies with the section and the season.

In some localities, especially in dairy sections, beet tops are siloed with other material for winter and early spring feeding. These silos are filled with alternate layers of beet leaves and some dry material, like straw, which will take up the excess moisture from the leaves. The layers of leaves are, or should be, sprinkled with salt, using about 6 to 8 pounds per ton of leaves. This mixture, if properly siloed, will keep for several years and is considered very satisfactory by dairymen.

Estimating the value of beet tops as $6 per acre, which is at the rate of $1.50 per ton for the fresh material or $6 per ton for it when dried, the total value of this by-product in the United States exceeds $2,000,000. It is evident, therefore, that beet tops have not received the attention due them, either as a fertilizer or as a stock food.

**Pulp.**

The material that remains after the beets have been sliced and the sugar has been extracted is known as pulp. Fresh pulp constitutes about 80 per cent of the weight of the beets. In the process of extraction the beets lose nearly all their sugar, usually only a fraction of 1 per cent being left in the residue or pulp. They also lose a large part of the salts taken up in the process of growth, so that the residue after extraction consists of about 90 per cent water, from 1.5 to 3.5 per cent cellulose, a fraction of 1 per cent each of albuminoids and ash, and about 0.5 to 3.33 per cent extractive substances.

The crop of beets harvested in the United States in 1907 amounted to 3,767,871 tons, which yielded more than 2½ million tons of pulp. This material is disposed of in various ways by the different sugar companies. In some instances it is furnished the beet grower gratis, while in other cases it is sold at a nominal price, from 12½ cents to $1 per ton. At an average price of 50 cents per ton this by-product would represent a return to the sugar companies of more than 1½
million dollars. Its real value as a stock food has been estimated at from two to three times that amount, depending upon the kind of stock to which it is fed and the object sought; that is, increase in weight, energy, milk flow, butter production, etc.

Efforts have been made to utilize beet pulp in the manufacture of paper and also as a fertilizer. It seems to have a percentage of fiber too low to make it satisfactory in the manufacture of paper. As a fertilizer, it is useful in adding a certain amount of humus to the soil, thereby improving its physical condition. It contains also a small proportion of ash, a fraction of 1 per cent of the wet pulp, which amounts to considerable in the aggregate. Up to the present time its greatest use has been as a stock food. For this purpose it is fed either wet or dried. To be fed in the wet condition, it may be used as soon as it comes from the factory, or it may be left for some time in the factory silo or pit, or the stockman using it may haul it to his farm or ranch and pile it in some convenient place for feeding purposes. The layer of the pulp on the surface of the pile—that is, the part exposed to the air—undergoes certain fermentation changes and should be discarded; for this reason the pulp should be kept in piles as large as practicable, since the larger the diameter of the pile—that is, the greater the bulk of material—the smaller the proportionate loss from surface fermentation. To be fed in the dried condition, it may be dried by itself or it may be mixed with molasses or other edible material before drying. But whether it is to be fed in the wet or in the dried condition it should be mixed with other material before feeding.

It is customary in this country and in Europe to feed the pulp mixed with a given amount of grain or oil cake, together with a quantity of chopped hay, straw, dried beet leaves, or material of a similar nature, the proportion of pulp to other material depending upon the object sought. In some instances the grain or oil cake is omitted and only the pulp and roughage fed. According to good authority, the daily ration should amount to only about 6 to 10 per cent of the weight of the animal, so that an animal weighing 1,000 pounds would receive from 60 to 100 pounds of pulp, to which should be added roughage to the extent of 10 to 15 per cent of the weight of the pulp and when desired from 2 to 5 pounds of oil cake or grain per 100 pounds of pulp and roughage.

The dried pulp, according to various analyses, consists of from 8 to 12 per cent of water, 4 to 8 per cent of ash, 7 to 8 per cent of raw protein, 18 to 20 per cent of crude fiber, and from 50 to 60 per cent of nitrogen-free extract. In drying the pulp it is first passed through a press which removes from 10 to 15 per cent of the water, and the remaining wet pulp is then transferred to kilns, where the moisture
is reduced to from 8 to 12 per cent, a process which requires from thirty to forty minutes. Other methods may be used in drying the pulp, but whatever the method the purpose is to remove a large part of the water without burning or otherwise changing the composition of the solid matter. In the dried condition the pulp will keep almost indefinitely if stored in a dry place, and it is easily transported. It commands a selling price varying from $12 to $25 per ton, depending upon locality and condition. Good results seem to have been obtained by feeding a mixture of dried pulp (with or without molasses), chopped hay, and oil cake or grain. The total quantity fed must depend, as in the case of the tops, upon the kind of stock and the object sought. While the use of pulp as a stock food has increased rapidly during the last few years, there are still some localities where its value has not yet been recognized.

WASTE MOLASSES.

Waste molasses is the by-product that remains after the crystallizable sugar has been separated from the concentrated beet juice, or molasses. This by-product contains nearly 50 per cent of sugar which can not be separated from the nonsugars by the ordinary methods, owing to the presence of various salts that have been taken up by the beet from the soil in the process of growth. These salts being soluble are extracted from the beet with the sugar and remain in the molasses. In addition to the sugar and salts in the molasses, there are some organic substances which, with the salts, may be classed as nonsugars. As a rule the larger the proportion of nonsugars present the smaller the quantity of sugar that can be separated, a fact which shows the importance of the purity coefficient. The purity coefficient is the number which shows the relation of the sugar in the juice to the total solids in the juice and is determined by dividing the weight of the sugar in a given quantity of juice by the weight of the total solids (combined weight of sugar and nonsugar) in the same quantity of juice.

In addition to the effect of these salts upon the separation of the sugar, they with the organic matter give to the molasses a disagreeable flavor which prevents it from being used for table purposes. The presence of a large proportion of nonsugars, especially of mineral salt, makes the waste molasses a valuable fertilizer, but it could not be used economically for this purpose owing to the great loss of sugar that would result. However, the nonsugars do not prevent the molasses from being used as a stock food provided too large a quantity is not fed at one time or in one day. Feeding molasses to stock has been practiced in Europe for nearly one hundred years, and yet large quantities of so-called refuse molasses have been wasted in this country because stockmen who might have utilized it did not realize
its value. In those sections where it is used as a stock food it is fed to cattle, horses, hogs, sheep, and poultry. It may be dried with beet pulp, alfalfa, or other material for feeding purposes, or it may be used by simply diluting it with about twice its volume of water, in which condition it is fed by itself, or it is sprinkled upon dry hay or other dry fodder. The quantity of molasses used per day depends upon the kind of stock to which it is fed and varies from one-half pound to 6 pounds per thousand weight of the animal. In beginning the use of molasses as a part of the daily ration, it is advisable to start with about one-fourth of the desired quantity and gradually increase the amount from day to day until the full ration is fed. The greatest direct value of the molasses as a stock food is in the sugar, but the nonsugars undoubtedly aid and stimulate digestion and are therefore of great value indirectly if not fed in too large quantities.

Another important use for the waste molasses is in the manufacture of alcohol, including that for denaturing purposes. One gallon of beet molasses, containing about 50 per cent of sugar, weighs approximately 12 pounds and will yield about 3 pints of 95 per cent alcohol; therefore a 50-gallon barrel of waste molasses will produce about 19 gallons of 95 per cent alcohol. Besides alcohol, the distilleries produce as a by-product fusel oil, and the remaining slop or refuse is of great value. Fusel oil finds commercial value in the manufacture of lacquers. Waste molasses is also utilized to some extent in the manufacture of vinegar of a very satisfactory quality. Certain medicinal preparations have been separated from this slop, such as betaine. The slop or refuse of a distillery contains the salts and organic matter that were present in the molasses. From the concentration of this slop, potash salts are obtained and nitrogen compounds are prepared in Germany and other foreign countries that are used as fertilizers. In this country this waste product known as slop is usually dried and ground up with fish scraps or other material and placed on the market as a commercial fertilizer. When these methods of disposing of the waste molasses are practiced, approximately all the material extracted from the beet is utilized.

Formerly waste molasses was used in Europe in the manufacture of soap, three grades of which were produced, namely, hard, medium, and soft. Efforts are being made by the Office of Public Roads to determine the practicability of utilizing waste molasses in combination with other material in constructing blocks for street-paving purposes. Whether or not these blocks will be sufficiently durable for practical purposes can be determined only by a prolonged test, which is now under way.

When the value of denatured alcohol is better understood it will undoubtedly come into more general use, and it is probable that
waste molasses will form an important source of this product. In some countries a portion of the waste molasses is utilized in the manufacture of briquettes by mixing coal dust with molasses, pressing, and drying. It is probable that other uses of a more or less important nature will be found for this by-product from time to time, but even with our present knowledge of the value of this important material not one pound of residuary molasses should be allowed to go to waste.

LIME CAKE.

As already stated, there are certain nonsugars in the beet juice that prevent immediate crystallization of the sugar. In order to remove some of these substances the juice is treated with milk of lime. The amount of lime used in the preparation of the milk of lime is generally about 2 to 6 per cent of the weight of the beets sliced; that is, a factory slicing 500 tons of beets a day will require from 10 to 30 tons of lime daily. The amount needed, therefore, for a 100-day run would average about 2,000 tons, making a total for all the factories in the country of nearly 200,000 tons. After the lime has combined with certain substances in the beet juice, the liquid containing the sugar is pressed through filter cloths and the lime cake remains behind. Comparatively little use has been made of this by-product in this country, while in Europe it is in general use as a fertilizer. So far as we have tested lime cake as a fertilizer it has given satisfactory results in nearly all cases. It is to be especially recommended in the case of acid soils and hard soils that need some material to make them more friable. It is certainly an enormous waste of valuable material to wash the lime cake into the sewers and gullies, as is done in the great majority of American factories at the present time. The difficulty in handling this material and spreading it uniformly over the land is a serious hindrance to its use as a fertilizer. The cost of transportation is also an important consideration in this connection. In a few irrigated sections the lime cake is washed out over the fields with the waste water, under which condition it is spread more or less uniformly and appears to be very beneficial to alfalfa and other field crops. If it could be passed through some process or mixed with some material that would render its handling easier, it would undoubtedly come into more general use as a fertilizer.

Numerous efforts have been made to utilize the lime cake in the manufacture of cement in this country, but, so far as can be ascertained, the tests made have not yet been entirely satisfactory. In Germany this industry has reached commercial importance. That lime cake will eventually be used for some such purpose there can be
no doubt. A small amount of waste lime from beet-sugar factories is now being used in the manufacture of a wall board, the principal ingredients of which are coal tar and waste lime. It has been used in the construction of pavements, roofing, etc., by drying, pulverizing, and mixing with asphaltum.

SEED BEETS.

As the beet-seed industry develops in this country, several additional by-products of the sugar beet will deserve attention, namely, the seed beets after they have gone to seed, seed stalks, and refuse seed. The seed beets increase in size during the second year, often attaining a weight from two to four times as great as the beets had at the end of the first season. The sugar content also deserves considerable attention, often varying from 10 to 14 per cent after the seed has been harvested at the end of the second season. These roots, therefore, represent considerable material per acre, usually from 8 to 10 tons of roots, which, owing to their woody, fibrous nature, are not readily workable in the sugar mill. If passed through a chopper they may be utilized as a stock food, or, considering the large quantity of sugar present, they may be employed in the manufacture of alcohol. At the present time less than 300 acres of beet seed are grown in this country, so that the loss from the nonutilization of these roots is less than in the case of any of the by-products previously mentioned. As the beet-seed industry develops, however, this by-product will become of greater importance. Future possibilities along this line may be realized when we remember that the present needs of this industry call for the total seed production of 5,000 acres and that the industry may be increased fivefold. When this stage of development is reached there will be at least 250,000 tons of seed beets to be utilized in some manner each year.

The seed stalks also represent a large amount of waste material. In Europe efforts have been made to utilize the seed stalks by chopping them up and mixing them with some of the waste molasses for stock food, but owing to their dry, fibrous condition they do not seem to be satisfactory for this purpose. Whether or not any practical use can be found for them remains to be determined.

It sometimes happens that the seed, because of its age or for some other reason, is not satisfactory for planting. It is then best utilized by transforming it into a meal by grinding, when it may be used as a stock food, thereby preventing it from becoming a total loss. Ground beet seed is composed of from 10 to 12 per cent water, 13 to 17 per cent protein, 4 to 8 per cent fat, 32 to 45 per cent nitrogen-free extractive, 13 to 18 per cent crude fiber, and 5 to 13 per cent ash. The ash contains from 20 to 25 per cent potash, 4 to 22 per cent lime, and from 14 to 46 per cent phosphoric acid. It is evident, therefore,
that ground beet seed is valuable for cattle feeding and makes an im-
portant addition to the stable manure. In this connection it should 
be added that under ordinary conditions beet seed will retain its 
vitality for several years, so that there is little probability under 
existing circumstances of being obliged to utilize the seed for other 
 purposes than planting.

OTHER WASTE MATERIAL.

In addition to the by-products mentioned, there are several kinds of 
refuse in sugar factories that should be noted in this connection, 
namely, waste water, old filter cloth, rubber belting, and gunny sacks.

A 500-ton factory requires about 2½ million gallons of water daily 
during the time the factory is in operation. This is used in washing 
the beets, extracting the sugar from the cossettes, in the production 
of steam, etc. A greater part, however, of the water is used in wash-
ing the beets and is allowed to flow off as waste material after it has 
served its purpose in the factory. In only a few cases is this waste 
water utilized, but when practicable it has been found very useful for 
washing alkali out of the soil, for irrigation purposes, or for washing 
the pulp and lime cake away from the factory.

The old filter cloth is sometimes sold to nurserymen, who use it for 
wrapping material, or to tomato growers, who use it to protect their 
plants from late frosts.

Rubber belting when discarded finds ready sale for brake-block lin-
ing and for rubber recovery. The large quantities of cloth and belting 
used in sugar factories make these items of considerable impor-
tance as waste material.

A sugar factory utilizing the raw material from 5,000 acres will 
have not less than a thousand gunny sacks each year that were used 
in transporting the seed to the factory. If the seed were grown in 
this country the sacks could be used over and over, but it would 
not be economy to ship them back to Europe to be refilled. For this 
reason the factories have large numbers of these sacks on hand, many 
of which are utilized about the mills in various ways, while others 
are disposed of to farmers and other buyers at a low price, but 
amounting to a considerable sum in the aggregate. These sacks are 
useful in handling potatoes and other vegetables, in covering seed 
beets and other roots that are to be kept through the winter for seed 
production, and in many other ways about the farm and garden.

CONCLUSION.

It is apparent from the foregoing statements that several impor-
tant uses are already known for most of the by-products of the sugar 
beet. If these by-products should be utilized to the greatest advan-
tage in each of the localities where sugar beets are grown, millions
of dollars would be added directly or indirectly to the annual returns which the farmers and factories now receive from the sugar beet. It is also evident that the greatest money value of a given by-product may be realized when that by-product is utilized in one way in one locality and in an entirely different way in another locality. It is important, therefore, that each by-product be studied in its relation to the conditions and circumstances which exist in the location where the by-products are produced.