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SUGAR BEETS

FORT COLLINS, COLORADO.

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The Agricultural Experiment Station.

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SUGAR BEETS.

The beet (*Beta vulgaris*), a plant of the order *Chenopodiaceæ*, has long been cultivated for food. It is a native of Egypt and the Mediterranean border, where it is found growing in its wild state. Under cultivation, we find several well-marked varieties, which differ in their quality, color, sweetness, etc. The beet is a lover of a sandy, quick soil, in which the roots can easily penetrate; and as an aid to this, good, deep plowing and a finely pulverized seed bed are essentials to success. The climate also has quite an influence on the final result. The spring should be warm and dry, with plenty of moisture as the season progresses, and not too much heat. In Colorado, where irrigation is practiced, the two conditions above named are perhaps more nearly realized than elsewhere.

In Spon's Encyclopedia, Vol. V., 1882, it is stated that the beets are usually sown about sixteen inches apart, on land that has not received fresh fertilizers or manures, as these cause the plants to take up too much nitrogen, and thus the sugar content is much reduced. It is thus much better to manure a preceding crop well, and, preparing the soil thoroughly, use no fertilizers for the beets. In this State, it is easy to raise very large crops of beets. Not only is the total yield heavy, but the single specimens often grow to wonderful size.

In the countries of Continental Europe, the effort is to grow beets that shall weigh from two and one-half to four pounds, as by experiment, these give the greater per cent. of sugar. The same authority also states that the formation of sugar is favored by dry weather and unclouded sky in autumn. Here again is a condition which is found in perfection in Colorado, and should give us a high per cent. of sugar in our beets, provided all other conditions and circumstances are carefully noted. In general for Colorado :

1. Prepare a deep and well-pulverized seed bed.
2. Sow in drills about eighteen to twenty inches apart, so as to admit of horse culture between the rows, using from seven to eight pounds of good seed per acre.
3. Irrigate judiciously and keep clear of weeds. Cultivate thoroughly during their early growth.
4. When well up, thin so that there shall be one thrifty plant every six or eight inches (some say ten to twelve), and take care not to injure the plants in this process.
5. In cultivation take care to preserve the leaves and to throw some earth to the plants each time. The portion of the beet which grows above ground does not contain much sugar.
6. Harvest when ripe, and preserve free from frost.

Every person who secures a good stand should have no difficulty in producing at the rate of twenty-five tons per acre. (The average for Europe is said to be twenty-three tons). Indeed, the effort must be to produce twenty-five rather than forty tons.

In practice, sugar has been extracted in various ways :

First—By means of pressure to extract the juice after crushing, slicing or grating the beets.

Second—By means of maceration in hot water until all the saccharine matter is extracted.

Third—By the process of diffusion, which is a modification of the second, and an excellent means of breaking up the cell walls and extracting the sugar.

This process is sure to revolutionize the method of sugar production from cane and sorghum, as well as with beets. Our sister State Kansas (see Report State Board of Agriculture, January, 1890) has published the results of beet sugar production at Medicine Lodge, in that State; 4.7 acres were raised, which produced 60.23 tons cleaned beets, from which were manufactured 10,158 pounds of sugar and 380 gallons of syrup. The production was more than one ton of sugar per acre, and not under the most favorable circumstances. A skilled expert from Germany was engaged to look after the culture and manufacture of the crop. The appliances not being the best, he claims that the best results were not obtained.

Where sorghum can be raised, the same company can manufacture sorghum into sugar until the heavy frosts come, when the beet crop can be worked with the same diffusion plant, as most of the machinery can be used for both.

The sugar sold readily at the factory for six cents per pound, and the demand exceeded the supply.

What has been accomplished in Kansas can also be performed in Colorado and Nebraska; and near Grand Island, in the Platte Valley of the latter State, a large area of sugar beets will be raised this year (1890), and a large and costly plant will work the crop for sugar.

The experience in Kansas has taught them that there should be an expert chemist with every diffusion plant, in order to insure good results; that there must be a beet-sugar expert to take charge of the work, for while such a person can easily make sugar from sorghum, a sorghum or cane sugar worker will have great difficulty in getting good results with beets, on account of the particular treatment they require. Prof. Cowgill, State Sugar Inspector to the Kansas State Board of Agriculture, recommends the following conditions, which are as valuable for us in Colorado as for the farmers in Kansas:

“Select carefully the location as to ability to supply good cane or beets, and an abundance of good water.

“Provide sufficient ready capital.

“Contract with a thoroughly competent and responsible machinery company.

“Secure the best business management.

“Secure competent, skilled operatives.

“Contract with reliable, careful farmers.

“Secure carefully selected seed of known purity.

“Observe the above requirements, and you have gone a long way on the road to success. The absence of any one of these conditions will entail loss, and probable failure.”

The single success and several failures prove the truth of the above position.

C. L. INGERSOLL,

Director.

Chemical Section.

The subject of sugar from sugar beets was continued from the year 1888; the result of the work of that year being embodied in Bulletin No. 7.

In 1889, it was proposed to grow beets on poor (unfertilized) soil and on rich (fertilized) soil, and to note the difference, if any, in the substances present in the ash; to compare the specific gravity of the expressed juice, and the per cent. of sugar present.

It was expected to determine the relation of the sugar content in the beet to weight of top, and the feeding value of the top as well as that of the roots.

The early frost killed the tops, and thus prevented the completion of that part of the experiment.

In order to study the amount of material removed from the soil by the different kinds of beets—both when the beets were grown upon rich soil and poor soil—analyses have been made of the ash of the beets, as shown in the following table:

COMPOSITION OF ASH.

	Silician on Poor Soil. Per Cent.	Silician on Rich Soil. Per Cent.	Imperial on Poor Soil. Per Cent.	Imperial on Rich Soil. Per Cent.
Total ash.....	1.08.....	1.28.....	.801.....	1.234.....
Silica, Si O ₂	1.59.....	2.24.....	2.49	2.60
Carbon, C.....	4.75.....	4.42.....	6.44	5.05
Iron and Alumina, Fe ₂ O ₃ -I- Al ₂ O ₃	5.85.....	.27.....	2.43	2.06
Calcium, Ca O.....	2.60.....	1.92.....	2.78	2.30
Magnesia, Mg O.....	2.84.....	3.49.....	3.94	3.55
Potash, K ₂ O.....	31.48.....	32.76.....	30.10	32.62
Soda, Na ₂ O.....	13.54.....	12.45.....	10.42	10.80
Phosphoric Acid, P ₂ O ₅	7.64.....	4.82.....	8.25	7.80
Sulphuric acid, SO ₃	3.49.....	4.12.....	4.47	4.29
Carbonic acid, CO ₂	22.27.....	26.00.....	24.50	23.70
Chlorine, Cl.....	3.28.....	7.60.....	4.56	5.60
Total.....	99.33.....	100.09.....	100.38	100.37

It will be noticed that the amount of ash was greater in the beets raised on rich soil, while the amount of iron and alumina, calcium and phosphoric acid was the greatest in those raised on the poor soil.

Of course, the farmer must return the mineral substances used up by the beets and found in the ash, in order to obtain the best results in successive crops, and prevent impoverishing the soil.

There may come some misunderstanding between the manufacturer and grower of sugar beets. It would be unfair to both, to buy and sell according to weight. A better way would be to take an average sample and have the juice extracted. An increased density, other things being equal, would indicate an increase of sugar. In many places it has been customary to take a specific gravity of 1.055 (7.27° Baume) as to the standard.

The Societe Centrale de l'Agriculture, du Pas-de-Calais, have agreed upon the following standard :

Specific gravity	1.045	yields	8	per cent.	sugar.
"	"	1.050	"	9	" " "
"	"	1.055	"	10	" " "
"	"	1.060	"	11	" " "
"	"	1.065	"	12	" " "

This standard must be unfair, as the yield of sugar is increased disproportionately in rich juice ; on the other hand, the juice may be high in other salts and poor in sugar.

The highest specific gravity as given by Dr. Wiley in the analyses of ten samples of the best California sugar beets is 1.075 White Imperial, and it corresponds to 15.19 per cent. of sugar ; while there is one sample, White Silician, having specific gravity 1.074, which gives 15.85 per cent. of sugar ; and another, White Imperial, specific gravity 1.067, which gives 15.19 per cent. of sugar. For the reason above given, the specific gravity is not always a correct index of the per cent. of sugar, as the following analyses of varieties raised on the College garden will show :

NAME.	Loss on Dressing, in Grams.	Weight taken, in Grams.	C. C. Juice obtained.	Sp. Gr. of Juice.	Per Cent. of Juice.	Total Sugar, Per Cent.
Silician on poor soil.....	.25	820	550	1.055	70.7	9.66
Silician on rich soil.....	.26	1550	1025	1.050	70	10.47
Imperial on poor soil.....	.23	755	550	1.059	77	10.44
Imperial on rich soil.....	.40	1705	1100	1.049	70	9.07
Velmorin18	1696	1275	1.050	78.8	8.11

The classical researches of Scharcht, Walkhoff, Champagnon, Pellet, Bretschneider and Decaisne have shown that in a cross section of the beet the inner zone is the richest in sugar. The neck, above the ground, is usually filled with crystals. Those in the samples analyzed resembled crystals of potash. Below the ground the crystals gradually disappear. If the sugar beet contained nothing but a solution of sugar, the operation of sugar making would be quite simple.

The epidermic tissue is composed mostly of cellulose. The beet contains tannin, and this tannin combines with the albuminoids to form an insoluble compound that is a valuable thing for the sugar makers.

Payen has shown that the sugar beet contains malates of potash, lime, soda and ammonia; also the oxalates of potash, soda and ammonia, and several other compounds in small quantities. These compounds are mostly found in the neck of the beet, and it is now an accepted statement that the amount of sugar varies indirectly proportional to these salts. The formation of sugar in the beet seems to be mainly due to the leaves. The amount of sugar present is greatly influenced by the weather, fertilizers, size, soil and the variety grown. The sugar increases from the top to the bottom, as shown by the following analyses. The sections were made across the beet, one inch apart, and are numbered from the top down :

PER CENT. OF SUGAR IN SECTIONS OF THE BEET.

SECTION.	Silician on Poor Soil.			Silician on Rich Soil.			Imperial on Poor Soil.			Imperial on Rich Soil.		
	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.
1....	.02	7.40	7.42	.019	9.10	9.11	.019	9.10	9.11	.080	7.96	8.04
2....	.033	10.5	10.52	.024	10.30	10.32	.017	10.50	10.52	.096	8.02	8.12
3....	.035	10.9	10.93	.026	11.00	11.02	.023	11.20	11.22	.071	7.82	7.40
4....	.065	11	11.06	.015	11.30	11.31	.030	11.60	11.63	.080	9.48	9.56
5....	.060	11.1	11.16	.034	11.40	11.43	.030	11.70	11.73	.069	10.86	10.93
6....				.023	11.45	11.47				.066	11.80	11.87
7....				.027	11.70	11.72						
Av			9.66			10.74			10.44			9.08

FEEDING VALUE.

In connection with the per cent. of sugar, the feeding value of the beet has been estimated. The amount of water in any article of food must diminish its value, for two reasons: First, a large per cent. of water means a small per cent. of dry matter in the food; second, in the winter season, when root crops are usually fed, this water must be raised from the freezing point to the temperature of the animal. There has been found a certain relation between the amount of dry food and water consumed by animals. In Bulletin No. 8, page 18, it is given for steers as about four parts of water to one of dry food. Where the experiments have been conducted with sheep, they require only two parts of water to one of dry food. These facts show that root crops, like beets, would be better for food for cattle than for sheep. The following table gives the feeding value of the roots:

NAME.	Moisture.	Crude Ash.	Fat.	Alb'minoid Nitrogen or Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.
Silician, poor soil.....	87.17	1.08	.24	.925	.830	9.75
Silician, rich soil.....	86.31	1.28	.27	1.77	.68	9.69
Imperial, poor soil.....	87.88	.801	.14	.808	.587	9.78
Imperial, rich soil.....	89.80	1.234	.18	1.44	.433	6.91
Velmorin	88.69	1.131	.175	1.159	.618	8.22

The large per cent. of water reduces the feeding value of beets very much, there being only about twelve per cent. of dry matter in the beets. The method of analysis for feeding value was that described by the Association of Official Agricultural Chemists. The amount of sugar present was determined by Scheibler's polariscope, which we have found to be one of the best in the market.

CONCLUSIONS.

1. It is found that there is a greater per cent. of ash present in beets grown on rich soil than in those grown on poor soil.

2. The per cent of iron, aluminum, calcium and phosphoric acid present in the ash was greatest in beets from poor soil.

3. The specific gravity of the expressed juice of the beet is not a correct index to the per cent. of sugar present, as various salts in solution, and often accidentally present, produce increased specific gravity when there is no corresponding increase of sugar.

4. An examination of the beet by horizontal sections shows a somewhat regular increase in sugar content from the top downward.

5. The average per cent. of sugar present in the crop of 1889 (9.98 per cent.) was but little less than that of 1888 (10.45 per cent), but the greater yield of beets per acre, in 1889, more than compensated for the less per cent. of sugar present.

DAVID O'BRINE, *Chemist.*