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LIGHT A FACTOR IN SUGAR PRODUCTION.¹

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THE fact that the United States is one of the greatest sugar-consuming nations of the world, and that about nine-tenths of the sugar consumed is imported at an annual cost of about \$100,000,000, have given rise, from time to time, to attempts in the direction of a greater home production of sugar than is possible from the long-established sugar-cane industry of the Gulf States.

Owing to the geographical location of this country, only such sugar-producing plants could form the basis of these attempts, as were adapted to cultivation in the temperate zone. Of these plants only two need be mentioned here; namely, sorghum and the sugar-beet.

As is well known the early efforts at sugar production from beets in this country were absolute failures. Various causes contributed to this result, prominent among which was the antipathy of the American farmer to accommodate himself to the cultivation of beets, which is much more irksome than the cultivation of ordinary agricultural crops, to which he had been accustomed, and which at that time brought him satisfactory returns for his labor. The country was not ripe for the establishment of the new industry.

In the late seventies and early eighties the experiments in making sugar from sorghum were at their height. This crop can be grown like corn, and its cultivation is much more in keeping with the taste and practices of the American farmer, than that of the sugar-beet. Wherever sorghum sugar factories were established there was no difficulty whatever in securing an abundant supply of the cane delivered in proper shape at the mills. For a time the prospects of the sorghum sugar industry were bright. The sugar produced found a ready sale at remunerative prices, but, unfortunately for those who had embarked in the new enterprise, and fortunately for those who

¹ Read at the Boston Meeting of the American Association for the Advancement of Science.

were about to invest on a larger scale, the sorghum sugar industry, before it was fairly upon its feet, was confronted by a falling market, due to the overproduction of sugar in Europe and especially in Germany. This unexpected interference with the sugar market of the world, gradually brought the price of sugar and molasses down to a point where the manufacture of sugar from sorghum was no longer profitable, and the new industry which had excited general attention for three or four years had to succumb with all its investments, a total loss. It may be said in passing, that the sorghum sugar industry is dead for all time to come. The good old times for the manufacture of sugar, when yellow C sugar sold for eight cents per pound cash in car-load lots, are gone nevermore to return.

These fruitless attempts at the establishment of a sugar industry in this country have been thus briefly referred to, for the reason that they are still of importance to us for the lessons which they have taught.

The Department of Agriculture at Washington, under the able direction of Dr. Wiley, has for many years made valuable investigations in connection with the sugar industry; but with the advent of the present Secretary of Agriculture, a general interest in the subject of a home production of sugar has been renewed. The efforts of Secretary Wilson found the farmers throughout our country in a responsive mood, owing to the universal depression in agriculture for a number of years preceding his administration, and consequently during the past year in almost every county of many of the states, experimental plots of sugar-beets were grown.

Whether the establishment of this new agricultural industry in our country is advisable from an economic point of view or not, is a question foreign to this paper. This phase of the subject was ably discussed by Mr. Edward Atkinson in the *Forum* of November, 1897, in an article which deserves the earnest consideration of all who are interested in the public welfare.

If, however, the efforts put forward should result in the establishment of a beet-sugar industry in this country capable of producing our home demand for sugar, it should be borne in mind that this object must be accomplished in the face of an overproduction of sugar in the world, a condition which twenty

years ago would not have been considered possible. This over-production of sugar has come to stay. The margin of profit will necessarily be low. Of our vast domain the insignificant area of 2,000,000 acres of land subjected to beet culture will suffice for the production of our home demand for sugar. Taking all these facts into consideration it is evident that the successful sugar factories will necessarily exist only in the most favorable localities, and in the course of a very short time factories blindly started in unfavorable localities will be crushed.

There are various conditions, which must be supplied for the production of a sugar-producing plant rich enough in sugar to meet the competition at present existing in the manufacture of this article of food, as well as certain facilities for operating a factory after the plants are grown. Prominent among the former conditions is the matter of light. The leaves are the laboratory in which the sugar is directly or indirectly synthesized and light is the agent.

All sugar-producing plants are equipped by nature with an abundant leaf surface, and when these plants are rescued from their unfavorable surroundings in wild vegetation and subjected to cultivation, their leafy organs are capable of elaborating and storing much more sugar than is necessary for the perpetuation of the species. This excess of production is utilized by man for the manufacture of sugar.

It would seem evident therefore that, other things being equal, the more light one of these plants could get during its period of vegetation, the higher its content of sugar would be. The truth of this proposition has been confirmed by numerous observations made upon sugar-producing plants.

Sugar-producing plants may be divided into two categories : (1) Those having a long period of vegetation, as the different varieties of southern cane, and (2) those having a short period of vegetation as sorghum and the sugar-beet. The former group of plants when cultivated in tropical regions grow luxuriantly for a period of eighteen months and at the end of this time the content of sugar in the juice reaches eighteen to twenty per cent. The crop of sugar-cane is, however, usually taken off after a period of twelve months, when the content of sugar in the juice is only fourteen to fifteen per cent.

The increase in amount of sugar in the longer period of vegetation is due to the greater amount of sunlight, to which the growing plants have been exposed. Owing to this long period of vegetation, southern cane is not so much affected by climatic conditions and suitable locations as is the case with sugar plants of a short period of vegetation.

The latter group of sugar-producing plants, in which the present territory of this country is directly interested, are affected in many ways by the amount of light available during the period of vegetation, which on account of the present competition in the manufacture of sugar may mark prospective enterprise with success or failure as the case may be.

1. Climatic conditions must be taken into consideration in the location of sugar factories. Localities in which the seasons vary greatly in the amount of clear weather are not so well adapted to the growing of rich sugar plants as those in which clear weather during the growing season predominates every year. As an example illustrating this fact may be mentioned the experience of the writer in the investigation of sorghum as a sugar-producing plant.

The years 1880, 1881, and 1882 in the locality of Champaign, Illinois, were typical sugar seasons. During the summer months clear weather prevailed. The cane-sugar in the juice of the best varieties of sorghum reached thirteen to fourteen per cent. The coefficient of purity of the juice was high, and with proper precautions in treating the juice, sugar could readily be made even with crude apparatus. The years following were less favorable in this respect. In 1883, for example, cloudy weather with rain prevailed almost daily during the summer months. As a consequence the content of cane-sugar in the juice of the better varieties of sorghum only reached eight to ten per cent. The purity of the juice was correspondingly low, and the manufacture of sugar extremely difficult.

Four sorghum sugar factories were erected in consequence of the favorable results obtained in the preliminary experiments of 1880 and 1881 at Champaign, Illinois, conducted by Professor M. A. Scovell and the writer. It is safe to say, that if the weather of these two seasons had been similar to that of 1883, the factories would not have been started and the capital and labor invested in them lost.

The ideal localities in this respect are the arid plains of the western states, where the necessary soil moisture can be supplied by irrigation. Here, for a given degree of latitude, the maximum amount of light is available for the growing crop, and poor sugar seasons cannot occur.

2. The higher latitudes are more favorable, other things being equal, than the lower ones, owing to the greater length of the days and the longer duration of twilight.

The sorghum sugar industry again can furnish data illustrating this point. Among the numerous visitors from all parts of this country and from many foreign countries to the factory at Champaign, Illinois, was a party from Tennessee, who claimed that the "Sunny South" was the place for raising sorghum. Capital was raised, a factory erected at Franklin, Tennessee, and about 700 acres of sorghum were grown. The yield of the crop was heavy; but the sugar content of the juice was very disappointing, it being about four per cent. lower than that of sorghum grown in central Illinois, although the season was an ordinary one for that section of the country.

The plant from which the sugar-beet has been derived is indigenous along the shores of the Mediterranean Sea, but it has been developed into one of the most important sugar-producing plants in the latitudes of northern Germany and France.

The writer does not wish to be understood as claiming that a higher latitude is under all circumstances better than a lower latitude. The climatic conditions already mentioned, and other conditions to be considered further on, may more than compensate for the increase of light obtainable through a more northerly location.

3. Proximity to large bodies of water is favorable to sugar production. This is due to the fact that near the shore of such bodies of water and extending for a considerable distance inland the location has the advantage of a more intense light, caused by the direct rays of the sun in addition to the light reflected from the surface of the water. The writer had an opportunity of investigating this point during the past season.

Sugar-beet seed of the Klein-Wanzleben variety was universally distributed over the State of Ohio by the Department of Agriculture at Washington, and also very generally planted for

experimental purposes. Samples of beets were obtained representing a section of the state from Lake Erie to the Ohio River. A sample consisted of four average beets of each field or plot from the largest size down to about one-half pound in weight. Each beet was wrapped in paper and the sample sent by express to our laboratory, to insure as slight a change as possible, and immediately analyzed. In addition, and in order that the results obtained might be strictly comparable, the percentage of juice was determined in each case.

Without going into details, the results of the investigation clearly indicate that the region of the state of Ohio bordering upon the lake has advantages in the raising of sugar-beets of high grade, which are not possessed by other portions of the state. The best samples of beets in the whole list were grown at Oak Harbor near Lake Erie. The smallest beet weighed twenty ounces and the largest twenty-nine ounces. The percentage of sugar in the juice was 16.3 and in the beets 15.68. The coefficient of purity was 81.71.

A sample grown at Locust Point on the lake exemplifies, in a high degree, the possibilities of the lake region in producing beets with a high content of sugar. The smallest beet of the sample weighed twenty-eight ounces and the largest 71.25 ounces or nearly four and five-tenths pounds. The percentage of sugar in the juice was 14.2 and in the beets 13.8 with a coefficient of purity of 81.42.

The same may be said of another sample grown at Locust Point. The smallest beet of this sample weighed 60.25 ounces and the largest 70.25 ounces. Even these enormous beets with an average weight of four pounds were found to be above the standard for content of sugar and purity of the juice, as generally accepted for the manufacture of sugar.

The remarkable richness of these overgrown beets becomes more apparent, when contrasted with a sample grown in Licking County in the central portion of the state. This beet weighed 40.75 ounces; the content of sugar was 8.47 per cent., and the purity 64.68 per cent.

Although some samples were obtained from other sections of the state, which were of good quality for the manufacture of sugar, yet other samples of the same sections fell below the

standard. The lake region alone produced beets, which were uniformly of a high grade, when all the requirements of a good beet were taken into account.

4. Topographical features of land are of importance in determining a suitable location for a sugar factory. It is well known that beets grown in the shade are worthless for the manufacture of sugar. In view of this fact it would seem almost superfluous to say that a partial obstruction of the direct rays of the sun daily would cause the production of a crop of beets of lower sugar content than would be the case if such obstruction did not occur. Consequently level tracts of land, where on clear days the plants are exposed to the direct rays of the sun from morning to night, must be better adapted to beet culture than deep valleys, especially if they are narrow and skirted by hills or mountains, and if in addition their general course is from north to south.

The writer is convinced that the variation in the composition of beets grown in the same sections of the country, having a diversified topography, is due in a great measure to the injudicious selection of the fields in this respect.

There are other factors which enter into the successful inauguration of the proposed new beet-sugar industry in this country, but, as a guide to the selection of the most favorable localities for its permanent establishment, the matter of light should receive due consideration.

COMMERCIAL IRON SILICIDES WITH A HIGH PERCENTAGE OF SILICON: THEIR PROPERTIES, MANUFACTURE, AND USES.

BY G. DE CHALMOT.

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IRON silicides containing about eleven to thirteen per cent. silicon have, for some years, been made in blast-furnaces, and have been successfully introduced in the manufacture of iron and steel. It has been found impracticable to much increase the amount of silicon by the blast-furnace process. This can, however, be successfully done by changing the process and making use of the great heat of the electric furnace. I have made, in the electric furnace, silicon-iron alloys containing from