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SUGAR PRICES FOR MONTH ENDING MAY 9, 1908.

	Centrifugals.	Beets.	Parity.
April 10	4.43¢	11s 6d	4.47¢
" 11	4.43¢	11s 8¼d	4.47¢
" 13	4.43¢	11s 9d	4.49¢
" 14	4.46¢	11s 9¾d	4.50¢
" 15	4.36¢	11s 9d	4.49¢
" 16	4.36¢	11s 9d	4.49¢
" 17	4.36¢	11s 9d	4.49¢
" 18	4.36¢	11s 9d	4.49¢
" 20	4.36¢	11s 9d	4.49¢
" 21	4.445¢	11s 9¾d	4.50¢
" 22	4.445¢	11s 10½d	4.51¢
" 23	4.455¢	11s 9d	4.49¢
" 24	4.455¢	12s	4.54¢
" 25	4.455¢	11s 11¼d	4.53¢
" 27	4.455¢	12s	4.54¢
" 28	4.455¢	11s 11¼d	4.53¢
" 29	4.455¢	11s 10½d	4.51¢
" 30	4.42¢	11s 9d	4.49¢
May 1	4.42¢	11s 9d	4.49¢
" 2	4.42¢	11s 9d	4.49¢
" 4	4.42¢	11s 9d	4.49¢
" 5	4.42¢	11s 9d	4.49¢
" 6	4.42¢	11s 8¼d	4.47¢
" 7	4.36¢	11s 8¼d	4.47¢
" 8	4.36¢	11s 9d	4.49¢
" 9	4.36¢	11s 7½d	4.46¢

Messrs. Willett & Gray in their "Weekly Statistical' 'of April 23, state:

Raws.—Nearly all sugar news received from the Easter holidays has been favorable to further improvement in the market, the latest transactions showing an advance for the week of .06c. per 100 lbs. spot value, to 4.42c. per lb. 96° test Centrifugals.

The basis for the advance was the Cuba news showing that 27 Centrals stopped grinding and that the weather news continues unfavorable for the growing crops. The European market was immediately affected, as well as our own, and beet sugar advanced to the highest point yet of the campaign, say to 11s. 10½d. per cwt., f. o. b. Hamburg.

Also the weather in Europe is unfavorable for the beet crop.

The business of the week consisted mainly of Cuba Centrifugals for April and May shipment, of which some 200,000 bags were taken by the refiners at 3c. c. & f. and 3⅛c. c. & f. for 96° test, and 3 1-16c. c. & f. for 95° test.

At the close the offerings are more free at 3 3-16c. c. & f., 96° test, for April-May shipment, with buyers at 3⅛c. c. & f., or its equivalent, 4.49c. landed.

Beet sugars are quoted a little off from the highest point, now 11s. 9¾d. for May, the new crop at 10s. 6¾d. for October-December, being affected by the low offerings of Russian Crystals (at 11s. 3d. for Danzig) for delivery after September 1st.

Beet for shipment to the U. S. is offered at 12s. 2¼d. c. & f., being the parity of 4.49c for Centrifugals.

A new feature is the offerings of Java sugars for shipment here from the United Kingdom at 13c. c. & f., equal to 4.51c. landed, duty paid, 96° basis.

June-July shipment from Java direct are held at 12s. 3d. c. & f. equal to 4.41c. landed.

Later shipments for July-August are held at 11s. 10½d. c. & f., equal to 4.33c. per lb. landed.

The final sales reported are 32,000 bags Cuba Centrifugals, 96° test, at 3⅛c. c. & f., April-May clearance, and 8,000 bags Porto Ricos on the spot at 4.42c.

The tone and tendency is to continued steadiness and gradual improvement.

Messrs. Czarnikow, Macdougall & Co. report under date of April 24, as follows:

The market reopened after the holidays with small offerings at last week's prices. When these offerings had been absorbed, refiners found that further supplies could only be obtained by the payment of higher prices, and ultimately large transactions took place at 3.125c. c. f., basis 96°, for Cubas for shipment, an advance of .0625c. over last week's sales. This made spot sugars worth 4.49c. delivered, but refiners refused to pay over 4.42c. for sugars in this position, and that price had to be accepted for 10,000 bags Porto Ricos in port. As spot sugars had sold at 4.36c. in the beginning of the week, the last mentioned sale also marks an advance of .0625c., although it is below the parity of the business done in sugars for shipment.

The transactions referred to are estimated to amount to at least 30,000 tons, and they, for the time being, cleared the market of all offerings; but sellers subsequently put forward about 15,000 to 20,000 tons Cubas at 3,125c., basis 95°, or 3.1875c., basis 96°. This further advance has not yet been paid, but as every day brings refiners nearer increased melting requirements for their summer trade, with less and less nearby supplies to meet them, there is every prospect that the further advance asked for by sellers will soon be secured. This could hardly be the case so long as Beets were obtainable at a somewhat lower parity, as was the case during part of the week, when, it is believed, purchases were made at a parity of 3.14c. c. f. for 96° Cubas. These Beet purchases are estimated to aggregate 20,000 tons, and are probably the cause of today's advance of that market to the parity of 3.19c. c. f. for Cubas, thus bringing both markets to the same level.

The European beet market opened at slightly higher prices than those ruling before the holidays and it closes very firm at an advance for the week of 3d. per cwt. on present crop for all deliveries and of 2¼d. on next crop. Today's f. o. b. quotations are: April, 11s. 11¼d.; May, 11s. 11¼d.; August, 11s. 11¾d. Next Crop (October-December) 10s. 6¾d.

In connection with the beet market, it must be said that it is difficult to reconcile the relatively low price of next crop (October-December) with the forecast of reduced sowings. Making every allowance for large quantities of beets coming on the market as soon as the reaping of new crop begins, it is hard to account for that crop being at a discount of 1s. 4½d. per cwt. as compared with today's price of present crop. Nor is it explained by the fact that between 1st of September, 1908, and 31st of August, 1909, Russia may export up to 300,000 tons sugar to Convention countries hitherto closed to her. This quantity is hardly likely to be dumped on European markets in one lump, and if spread over the year its effect on prices should only be moderate. Further, no increase of cane supplies is in sight for 1908-09, and even were such in prospect, the natural increase of consumption must be provided for. The solution of the problem must, therefore, be left to time.

NOTES.

Crop Conditions.—From all reports it would seem that the present crop, now being harvested, will produce at least 450,000 short tons of sugar, and will possibly overrun this amount. The juices thus far appear to be much better than for the crop of 1907, in many instances the sucrose content of the canes harvested for this crop averaging 1% to 1.49% higher than for the crop of 1907. Nearly all the plantations report the cane as looking well, and the season up to within a few weeks ago, was very favorable for the harvesting of the crop; the recent rains may delay operations somewhat, but are too late to materially affect the quality of the juice.

The transportation facilities this season have been remarkably good. The American-Hawaiian Steamship Company has kept right up to its schedule and the sugars have gone out in quicker time and in much better condition than during the previous crop.

This year there will be little enforced storage of sugars for any long period, and consequently there will be comparatively little loss from deterioration due to this cause such as was experienced last year.

With favorable prices for their product and a large crop to be harvested, the Hawaiian planters face a good year.

Mexican Sugar Industry.—The "Hacendado Mexicano" has issued its annual sugar report for 1907-1908, containing interesting statistical matter, as well as information relating particularly to the sugar industry of Mexico.

The production of sugar in Mexico during the past season has been better than was anticipated, the amount in excess of the estimate being 4000 tons. The estimated production for the year 1907-1908 is 115,000 tons.

The sugar industry in Mexico is gradually increasing every year. New large sugar factories are being erected and a greater area of cane planted to supply them with the raw material.

Since last year two American concerns have started making sugar, The Rio Tamasopo Sugar Co., Dr. H. B. Tanner, President. This factory is located on the Mexican Central Line between San Luis Potosi and Tampico at 206 Kilmeters from the latter point; capacity 3000 tons cane daily. The Mexican National Sugar Refining Company, situated at Potrero, between Cordoba and Atoyac on the Mexican Railway and at 90 kilometers from the port of Veracruz. The President of this company is Mr. H. P. Pope, of the Carnegie Steel Company. It has a capacity of 800 tons of cane daily, is equipped with an up-to-date refinery turning out the same quality of refined sugars as in the United States.

New machinery has been installed in several old sugar houses, bringing their capacity and quality of their production up to the standard of new and modern sugar factories.

The stock of last year's sugar was almost exhausted when the grinding season began this year, and with the raising of the duty on imported sugar from 2½ cents per kilo to 5 cents, a general rise has occurred in the price on the local markets over the price of last year.

The want of rain at proper time has caused a shortage of cane in a few districts, whereas on the Coast there appears to be an excess over last crop.

Organ for Publication of Agricultural Research.—When one considers the vast number of scientific publications in the nature of bulletins and circulars, treating of agricultural matters, and the variety of subjects dealt with, the following from the "Experiment Station Record" will be appreciated:

The question of suitable provision for publishing reports of the more scientific investigations carried on at the experiment stations, especially those under the Adams fund, is already attracting attention and will soon become an important one. It is generally recognized that these will not in their entirety or original form be suited to the regular series of bulletins. While the result of work of this character will ultimately prove of very great benefit to agriculture, its details will ordinarily have little interest for farmers or the general public. At the same time, in order to satisfy the proper demands of the scientific world and to give our agricultural investigators and students the information they should have regarding these researches, it will be highly desirable to have them published in as much detail and with as complete illustration as is usually done in the case of work of the same order in other branches of science.

Referring to this matter, the report of the Director of this Office, just issued, points out that this will mean the providing of a different class of publications from the ordinary station bulletins and reports. Either the individual stations must establish with the aid of State funds a technical series of publications, which, though limited in editions, will be relatively elaborate and expensive, or Congress must make provision for the grouping together of the scientific work of the stations in a general series of special publications to be issued under the authority of the National Government.

To the world at large the latter course would undoubtedly be the most satisfactory, since this would bring the research work of the stations together and establish a regular and permanent medium for its publication, thus making it readily accessible to scientists and students the world over. Foreign critics of our experiment station system have often expressed the view that under present conditions the national character of our system of agricultural research was obscured and the scientific value of much of the work of our stations was lost sight of because of the miscellaneous character of the station publications, and the multiplicity of the sources from which they emanated. There is little doubt that our stations would have a much better standing in the scientific world if their more scientific publications were differentiated from their popular ones and issued through a single regular channel.

The report suggests the possibility of establishing an editorial board through the Association of American Agricultural Colleges and Experiment Stations to represent the interests of the stations in this matter, and that this board might act in coöperation with this office in the preparation for the press of reports submitted by the individual stations. There is ample time for the elaboration of this or some other satisfactory plan for securing the suitable publication of the scientific work of the stations, but it is felt that this problem should be carefully considered with a view to reaching a satisfactory solution in the near future.

PHILIPPINES.—All Ohioans at the head of the Nation's affairs are apparently not of the same mind. Witness the statements of Hon. Isaac R. Sherwood in the House of Representatives, speaking on the subject of Army Appropriations:

"Look at the criminal exploitation of militarism and imperialism in the Philippines. * * * Eight hundred millions of our hard earned tax money wasted, and worse than wasted, in the Philippines, is not too high an estimate.

"Look at our pension list, resulting from the death and disabilities of soldiers in this cruel conquest, amounting higher every year on account of the deadly Philippine climate. Up to 1907 it amounted to within a fraction of $19,000,000. And what is our gain commercially? A mere fraction. According to official estimates, of the total of Philippine imports, amounting to $28,785,855 in 1906, there is credited to the United States only $5,155,359, leaving to the credit of other countries $23,630,496. Thus it will be seen the imports from the United States into the Philippines amount only to about 18 per cent. of the total. In respect of the exports the figures show that the total of $33,713,-357, there must be credited to foreign countries $21,634,143, so that of the products exported from the Philippines the United States consumes nearly 40 per cent. Of the $30,000,000 worth of imports into the Philippine Islands probably 65 per cent. is of a class produced in the United States, over 50 per cent. being manufactures and 38 per cent. articles of food and animals, rice, being, however, included in the last mentioned class. The market available in the Philippine Islands for products of the United States appears to be, therefore, at the present time, about $20,000,-

000, and of this the United States now supplies about $5,500,000, leaving to our rivals—chiefly the United Kingdom, Germany, Spain and Australia—the remainder of the field. Of this Philippine market of over $30,000,000 worth of merchandise the United States supplies but 18 3/5 per cent., while in the Hawaiian Islands she supplies about 80 per cent., and in Porto Rico 90 per cent. of the total merchandise entering those Islands. These figures prove that the United States is policing these islands for the benefit of foreign countries, which supply the largest proportion of the imports into the Philippines."

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*THE AMERICAN BEET SUGAR INDUSTRY.**

HISTORY.

No other industry has been established in the United States in the face of so long a list of failures as the production of beet sugar.

The first experiment was made in 1830, over three-quarters of a century ago. A small factory was erected in Philadelphia, a few hundred pounds of sugar was produced, but from lack of knowledge of the culture of the roots and extraction of sugar, did not succeed, and a second trial has never been made in the State of Pennsylvania.

The next attempt in beet cultivation was made in Massachusetts in 1838-9. The experiment resulted in producing 1300 pounds of sugar at an estimated cost of 11 cents a pound, only 6% of sugar being obtained from the beets. No further attempt was made to produce beet sugar in New England until 1879, when the Franklyn Sugar Refining Company was organized at Franklyn, Mass., with $75,000.00 capital and failed in a very short time. The Legislature of Massachusetts, in 1870, exempted from taxation for ten years all capital and property invested in the beet industry, but this was not sufficient encouragement to revive it, and no further attempts have been made at beet culture in the Old Bay State.

In 1876 the Legislature of the State of Maine offered a bounty of 1 cent per pound for the manufacture of sugar from beets grown in that State for a term of ten years, not to exceed $7,000 in any one year. A number of experiments were made, with better results than were obtained in Massachusetts. A plant was erected at Portland and operated for a few years, but afterwards

* NOTE.—Extracts from paper on The American Beet Sugar Industry, written by Elmer E. Paxton.

abandoned in 1879 for lack of beet supply. This failure ended the attempts to produce sugar in New England.

The first experiment of any great magnitude was begun in 1863 at Chatsworth, Ill., by the Germania Beet Sugar Company, under the management of Genert Brothers, experts from Germany. One thousand acres were put in cultivation, machinery was imported from Europe, at a high rate of dutv, but the best extraction ever obtained was 5½% of sugar. Excessive rains one year, protracted drought the next, and lack of labor led to failure and the loss of $300,000 in the enterprise. The machinery was afterwards removed to Freeport, Ill., and a second attempt made likewise ending in failure. No further efforts were made to produce beet sugar in the State of Illinois until within the last few years.

At the same time the experiment was made in Illinois a company with $12,000 capital was started at Fon du Lac, Wisconsin, by two German experts, Messrs. Bonsteel and Otto, who succeeded for a time on a small scale, but afterwards moved to California. It was not until within the last fifteen years that the industry was resumed in the State of Wisconsin.

In 1870 the State of New Jersey exempted from taxation for ten years all capital and property employed in beet culture; a few experiments were made on a small scale, but without any permanent results. In 1879 a beet sugar plant was established in Hartford, Maryland, but afterwards abandoned.

With the single exception of a 600-ton factory at Lyons, N. Y., the production of beet sugar up to the present time has resulted in failure east of the Alleghany Mountains.

CAUSES OF FAILURE.

These failures were largely due to lack of knowledge in cultivation of the beet and the extraction of the sugar, and the further fact that the first localities selected are today regarded as the least favorable. This is often the case when a new product is introduced, and was true of the cane industry of the Hawaiian Islands.

It is doubtful if New England soil and climate could ever be made to produce beets at a profit even with the present improved methods. With the development of the great West, beet sugar enterprise looked in that direction for more favorable conditions until it found its first permanent home in California.

FIRST SUCCESSFUL FACTORIES.

The first successful beet sugar factory started in the United States was at Alvarado, California.

The first attempt was made by the German experts from Fon du Lac, Wisconsin, Messrs. Bonesteel and Otto, above referred to, at Alvarado in 1869, who with others organized the California

Beet Sugar Company, with a capital of $250,000. The factory was built in 1870 on the farm of E. H. Dyer, twenty-four miles from San Francisco, near Alameda. After running a few years it proved a financial failure. The machinery was removed to Santa Cruz County, where a new plant was established and likewise failed. In 1879, Mr. Dyer bought the buildings and land of the old company in Alvarado and organized a company under the name of the Standard Sugar Refinery, which company made a success of the business from the start, and in 1884 produced about one thousand tons of refined sugar. The company was reorganized and supplied with new machinery and is now known as the Alameda Sugar Company, with a present capacity of eight hundred tons of beets a day.

In 1880, Mr. Henry T. Oxnard organized the Oxnard Beet Sugar Company of Grand Island, Nebraska, and erected a factory with a capacity of three hundred and fifty tons of beets, which has been operated to the present time without increase of capacity. A factory was also established at Norfolk, but the same has lately been moved to Colorado. With the exception of a small plant at Leavitt, no further permanent factories have been established in the State of Nebraska.

STATUS OF INDUSTRY AT CLOSE OF 1890.

In 1890 there were only three factories in operation, one at Alvarado, one at Watsonville and the one at Grand Island, Nebraska, altogether producing an output of only eight hundred tons of beets per day or ten thousand tons of sugar per annum. This was sixty years after the first attempt was made near Philadelphia. The record of the beet sugar industry in America for that long period is one of failure and disaster up to its successful inception in the State of California.

The record is a poor one compared with that of France for the same period, where the production increased from 5,000 tons to 770,000 tons, per annum, under the fostering care and bounties paid by that government.

FAILURE OF STATE BOUNTIES.

Nearly every State in which beet factories have been started, has, at some stage of the industry, made provision for bounties to be paid on the amount of sugar produced. The history of the attempts to evade the payment of bounty claims would furnish an interesting chapter, and illustrates the lack of reliance to be placed on State legislatures and courts. In Nebraska, three different legislatures passed acts providing for beet sugar bounty, but in each case the following legislature either repealed the act, or failed to make an appropriation for the payment of the bounty. Michigan passed a bounty law in the early 90's and was the main cause of the starting of several factories in that State, but when the claims for bounty were presented, the Auditor refused to pay them and his action was sustained by the Supreme Court of the State on the ground of unconstitutionality. A similar action is now pending in the Idaho courts. Minnesota paid bounties for two years, 1898 and 1899, and then declared the law unconstitutional.

Bounty laws have in the past been enacted in Kansas, Iowa, South Dakota, Indiana, Illinois, Maine and some other States. In a few cases bounties have been paid, but the practice is almost obsolete, New York only paying a bounty at the present time of one-half cent per pound.

UNITED STATES TARIFF PROTECTION.

The following resume of the tariffs on sugar published by Willett & Gray some years ago, may be useful for reference.

UNITED STATES TARIFFS ON SUGARS SINCE 1846.

Tariff Act, July	30th, 1846	—All sugars 30% ad valorem.
" " March	2nd, 1861	—¾¢ per pound on raw. 2¢ per pound on refined.
" " July	14th, 1862	—Sugars not above 12 D. S. 2½¢ per pound. Sugars above 12 D. S. not above 15 D. S. 3¢ per pound. Sugars above 15 D. S. not above 20 D. S. 3½¢ per pound. All refined sugars 4¢ per pound.
" " April	29th, 1864	—Sugars not above 12 D. S. 2½¢ per pound plus 50% equals 3¾¢ per pound. Sugars above 12 D. S. and not above 15 D. S., 3%, plus 50% equals 4½¢ per pound. Sugars above 15 D. S. and not above 20 D. S., 3½¢ per pound plus 50% equals 5¼¢ per pound. All refined sugars 4¢ per pound plus 50% equals 6¢ per pound.
" " July	1st, 1864	—Sugars not above 12 D. S. 3¢ per pound. Sugars above 12 D. S. not above 15 D. S. 3½¢ per pound Sugars above 15 D. S. not above 20 D. S. 4¢ per pound. All refined sugars 5¢ per pound.

Tariff Act, July 14th, 1870—Sugars not above 7 D. S. 1¾¢ per pound.
Sugars above 7 D. S. not above 10 D. S. 2¢ per pound.
Sugars above 10 D. S. not above 13 D. S. 2¼¢ per pound.
Sugars above 13 D. S. not above 16 D. S. 2¾¢ per pound.
Sugars above 16 D. S. not above 20 D. S. 3¼¢ per pound.
All sugars above 20 D. S. and all refined 4¢ per pound.

" " March 3rd, 1875—Sugars not above 7 D. S. 1¾¢ per pound plus 25% equals 2.19¢ per pound.
Sugars above 7 D. S. not above 10 D. S. 2¢ per pound plus 25% equals 2.50¢.
Sugars above 10 D. S. not above 13 D. S. 2¼¢ plus 25% equals 2.81¢ per pound.
Sugars above 13 D. S. not above 16 D. S. 2¾¢ plus 25% equals 3.44¢ per pound.
Sugars above 16 D. S. not above 20 D. S. 3¼¢ plus 25% equals 4.06¢ per pound.
All sugars above 20 D. S. and all refined sugars 4¢ per pound plus 25% equals 5¢ per pound.

" " June 1st, 1883—Sugars not above No. 13 D. S. and not above 75 degree polarization 1.40¢ per degree and .04¢ per degree additional.
Sugars above 13 D. S. not above 16 D. S. 2.75¢.
Sugars above 20 D. S. 3½¢ per pound.

" " April 1st, 1891—Bounty on domestic production, sugars testing 80 to 90, 1¾¢ per pound.
Bounty on domestic production, sugars testing at least 90, 2¢ per pound.
All sugars not above 16 D. S. free.
All sugar above 16 D. S. duty ½¢ per pound.

Tariff Act, April	1st, 1891—	All sugar above 16 D. S. from bounty-paying countries, duty 6.10¢ per pound.
" " Aug.	28th, 1894—	Bounty on domestic production repealed. All sugars 40% advalorum. All sugars above 16 D. S. and all sugars discolored, 40% and ⅛¢ per pound. All sugars from bounty-paying countries, 1.10¢ per pound additional.
" " July	24th, 1897—	Raws not above 16 D. S. and not above 75 degree polarization .95¢ per pound. Each additional degree .035¢ per pound additional. Sugar above 16 D. S. and all refined 1.95¢. All sugars from bounty-paying countries countervailing duties equal to bounties, additional.

It will be seen from the above that domestic sugar has received continuous protection for over half a century, at varying rates of duty, the highest being for the few months between April and July, 1864, when the rate was 5¼ cents on 16 D. S. and 6 cents on refined.

OTHER FACTORS OF SUCCESS.

The industry would no doubt have been abandoned in its earlier stages if it had not been for several influences which have continually lent encouragement to the enterprise.

The first of these factors is the constant example of success set by Europe. From a few thousand tons at the beginning of the last century, European production has constantly gone on until it now reaches the enormous aggregate of nearly 7,000,000 (long) tons. In 1855 beet sugar represented only 13% of the world's production. By 1882, beets furnished half of the world's sugar supply, and in 1900 during the Cuban war with Spain, 64%. Since Cuban production has become normal beet and cane are almost equal, the world's production for last year in long tons being:

Cane	7,161,446
Beets (including U. S.)	7,144,377
	14,305,823

European experts had their attention constantly directed towards the boundless resources of land in America and continued their efforts to establish the industry until it was first successfully installed by Bonesteel & Otto at Alvarado. In the meantime, Claus Spreckels had begun the study of beet culture and the manufacture of beet sugar in Europe, which laid the foundation for his success in California, where he has established the largest ~~plant in the world, with one exception.~~

IMPROVEMENT OF THE SUGAR BEET.

It is an undisputed fact that the sugar beet is the most scientifically bred vegetable in the world. It is due to this fact, more than anything else, that beet sugar has gained so immeasurably upon the cane product. The saccharine content of sugar cane has been increased but very little over the indigenous plant and not until recently has any scientific effort been made to produce new varieties of sugar cane with a higher sucrose content. A century ago the sugar beet in Germany weighed from 4 to 5 ounces and contained from 5 to 6% of sugar. Today the average size factory beet weighs over two pounds, carries 15 to 20% of sugar from which there is extracted on an average of about 12% of the weight of the beet, or say five ounces of sugar per beet. *In other words, there is today extracted as much pure sugar from each beet as the entire beet weighed a century ago.*

The early failures in the eastern part of the country were largely due to the poor quality of beets as compared with the product of today and the crude methods of extracting even the small amount of sugar which the beets then contained.

IRRIGATION INTRODUCED IN BEET CULTURE.

In 1891 a discovery was made in California in connection with beet culture which more than anything else has been the direct cause of the development of the industry in this country since that year.

Up to that time it was believed that beets grown by irrigation would be larger but less in sugar content or purity. All of the beet sugar in Europe had been grown under rainfall, and the experts who came from the old country were naturally inclined to follow home methods.

In 1891 a beet sugar factory was erected in a region of California where crops are raised both with and without irrigation. The farmers who put in beets were instructed to grow them without irrigation for the reasons above stated; learning that some of the farmers were disregarding these instructions the factories issued a printed notice that they would refuse to receive beets which had been irrigated; nevertheless, some of the farmers continued *sub-rosa* to irrigate their beets and secured a greatly increased tonnage of the highest grade product. The facts leaked out, a factory in Utah was located the same year, and thus was laid the foundation for beet culture in arid America, this section contributing last year 71% of the total American production.

STATUS OF INDUSTRY IN 1900.

By 1900—ten years after the bounty was voted by Congress and ten years after irrigation was begun in California—the industry had made rapid progress, and had reached a firm footing. The three factories in 1890 had increased to thirty; to the States of California and Nebraska, had been added Colorado, Michigan, Minnesota, New Mexico, New York, Oregon, Utah and Washington; twenty millions of capital had been invested in factories, and the output had reached 82,000 tons.

PRESENT STATUS OF INDUSTRY.

There were operating during the campaign of 1906-7 sixty-three factories, as compared with fifty-three the previous year. Fifteen states and one territory were represented of which four, Minnesota, Montana, Kansas and Arizona Territory were added during the past year. The total yield was 483,612 tons, an increased production over last year of 54½%, and an increase of 491% over that of 1899-1900.

ACREAGE AND YIELD—CROP 1906-7.

	Acres.
The total area planted for 1906-7 crop was	396,615
" " " harvested was	376,074
Acreage abandoned (5%)	20,541

The average yield of beets per acre was 11.26 tons.

The average per cent. of sugar in the beet was 14.9.

The average estimated extraction of sugar was 11.42% of the weight of the beets.

The average yield of sugar (refined) per acre, 1.29 tons.

The heavy increase in production of 1906 over 1905 is attributed to two reasons:

1. Increase of acreage, i. e., 68,710 acres or 23.51%
2. The unusual increase in yield per acre of 2.59 tons of beets or 31.03%

Total increase of output in Colorado over 1905 was 78,470 tons or nearly one-half of the total increase of the United States.

In round numbers we may say that the total output of beet sugar in the United States was six times what it was seven years previous, i. e., 1899-1900.

Notwithstanding the rapid increase of American beet production during the past seven years it has fallen far short of the increase of consumption.

The total consumption in 1906 was......	3,327,694	(short)	tons
" " " 1899 was......	2,327,436	"	"
An increase of	880,258	"	"
Total beet production for 1906-7........	483,612	"	"
" " " 1899-1900......	81,777	"	"
Increase	401,835	"	"

Or about 45% of the increase in consumption.

CAPITAL INVESTED.

According to the Commercial Census taken by the Department of Commerce and Labor for 1905, the total capital invested in the 51 beet factories in operation throughout the United States that year was $55,923,459.

During the past year, 12 new factories have been built and allowing $500,000 for each of them, would bring the total capital up to say $62,000,000 invested in beet plants, equipment and lands owned by the beet companies.

In addition to the above, about 80% of the beet area—or say 300,000 acres—is owned by farmers. Placing the average value at $100.00 per acre would make an additional investment of $30,000,000, and allowing say $8,000,000 for buildings, live stock, machinery, etc., would bring the total investment in the beet industry of the United States at the close of 1906 up to one hundred millions.

This figure agrees with an estimate made some months ago by the "Deseret News" at Salt Lake, which secular paper, by the way, is referred to by the Department of Agriculture, as being the best informed journal in the United States on matters pertaining to the beet industry. * * *

METHODS OF CONDUCTING THE INDUSTRY.

It is no easy matter to promote sufficient interest in new localities to justify the establishment of extensive beet factories. The capitalization of an ordinary plant involves a large amount of money—not less than $500,000. Extensive experiments have to be made to ascertain what soils in the locality are suitable for beet growing. The question of transportation of beets to factory and of the product to market is a very serious one, especially in many sections of the West. The disposition of by-products, rotation with other crops, securing competent labor, and contracts for sufficient supply of beets are all questions which have to be given careful attention.

SOURCES OF BEET SUPPLY.

The beet growers of the United States may be divided into three classes:

1. Farmers who grow beets on their own land under contract with the factory at a fixed rate per ton.
2. Farmers who rent lands from the beet companies and likewise sell their beets under contract.
3. Beets produced directly by the factories on their own lands.

According to the Commercial Census of 1905 the percentage of beets from each of the above three classes and the yield per acre respectively are shown as follows:

Class 1—82.5% of the entire crop yielding..	8.97	tons	per acre
" 2— 9.7% of total crop yielding.......	10.4	"	"
" 3— 7.8% of the total crop yielding...	7.55	"	"

The above brings out the significant fact that where beets are grown under contract the yield is much larger per acre than on lands operated directly by the factories with day labor.

The tendency among the factories is to contract for as much of the crop as possible among the independent farmers, encouraging them in every way possible with practical instruction regarding beet culture, rather than to attempt to grow large acreages directly by the factory. There are a few exceptions, like the Union Sugar Company of California, but in the majority of cases the labor conditions are such that it is desirable to get as many individual farmers interested as possible. The contracts with farmers who own their lands are made for periods varying from five to ten years. The usual price paid for the beets, all over the country, at the present time is $5 per ton.

SCIENTIFIC NATURE OF BEET CULTURE.

Each factory employs a scientific agriculturist who gives advice, and whose business it is to study the problems presented by the climate, soil and other conditions of his locality. This official generally has several assistants who keep in touch with the farmers, aiding and advising them as to the proper cultivation of the beet, the rotation of the same with other crops to the best advantage, the best use to make of by-products, etc.

The successful cultivation of the sugar beet necessitates high class farming and no other crop raised in the United States is given so much scientific attention. The Bureau of Plant Industry of the United States conducted last year forty-nine experiment stations throughout the sugar beet area, the principal object of which is to determine the relative importance of the various seeds growing in this country and also seeds imported from Europe.

The Bureau of Plant Industry is also conducting very extensive experiments with a view to producing what is termed a "single germ" beet seed. These experiments have been in progress for four or five years and they have now obtained as high as 50% of seeds containing a single germ. The process is a slow one and it will require several years of careful study and work to reach the end desired; but if it is attained it will almost revolutionize beet culture as it will do away with the hand labor of thinning beets which represents a considerable portion of the cost and is very hard and distasteful work to the American farmer. There are various opinions among beet men as to the success of the single germ proposition; some claiming that the present method is necessary in order to secure good stands. The probabilities are, however, that the Department of Agriculture will eventually succeed in the undertaking. If it is done it will go far toward solving the labor problem in beet culture. The rest of the hand work in growing beets consists principally in harvesting or gathering the beets after the same have been pulled with one of several implements now used for the purpose. A number of inventors in America and Europe are now endeavoring to produce machines that will do the entire work of pulling ,topping, polishing and collecting the beets in the field.

The German Government has offered a considerable reward for a perfected machine accomplishing this work. There is no question but that hand labor will eventually be almost eliminated from the beet culture as has been the case in most other branches of American farming.

ROTATION WITH OTHER CROPS.

The best quality of beet roots are long shaped, for the reason that the sugar content is much less near the crown of the beet. In order that the multitude of long fibrous roots which extend from the beet root proper may find their way down in the soil it is necessary that the sub-soil be stirred to a depth of from twelve to fifteen inches instead of from six to seven inches as is the case of cereal crops. When the beets are pulled or harvested these fibrous roots are broken off and left in the sub-soil; these furnish a certain amount of humus leaving the sub-soil in excellent condition for rotation with some other crop.

Of the various crops produced, in the West, alfalfa appears to be particularly adapted to rotation with the sugar beet as the two crops alternately tend to give the soil chemical elements needed by each. The farmers are just beginning to use alfalfa in connection with beet pulp by grinding the alfalfa to almost a powder, mixing it with the pulp until it acquires the consistency of bran; it is then bagged and sold under the name of "alfalfa meal." Several mills have been erected in Colorado for the manufacture of this product. The pulp weighs about half as much as the beets and sells for from $1.00 to $1.50 per ton. This mixture is said to be a very nutritous stock food. The fact that alfalfa grows luxuriantly on beet sugar lands in the west and can be rotated so successfully with beets makes it a valuable adjunct in using the pulp. For many years the revenue derived from the by-product of the sugar beet in Germany has been quite as great as that from the manufacture of sugar. The farmers of the United States are just beginning to make use of the by-products in the manner above described and also for the purpose of making de-natured alcohol. * * *

THE DETERIORATION OF SUGARS ON STORAGE.

By Noel Deerr and R. S. Norris.

The question of the deterioration of sugars on storage is one that has been much studied in both the cane and beet sugar industry. Since sugars here are often stored over lengthy periods, and also are frequently as much as 130 days in transit round the Horn ti New York, this subject is one of peculiar interest to the industry in these islands.

To obtain information on the causes of deterioration the matter has been studied at the Station, and the results of the investigation are included in the present Bulletin.

The scheme of work outlined at the inception of the investigation was as follows:

A number of sugars of known origin were to be obtained and analyzed on receipt; the analysis was to be repeated after intervals of two months and four months; from the analysis we hoped to obtain information correlating the composition of sugars with their keeping qualities. At the same time determinations of the number of organisms in the sugars examined were made.

To this end the following letter was addressed to all the plantations subscribing to this Association:

"It is the object of the Division of Agriculture and Chemistry to take up the question of the causes tending toward's a deterioration of sugar on storage. The Station will be much obliged if you will let us have average samples of about one-half pound each of sugars, both first product and second product in case two classes are shipped. Would you also supply the following information on the following points:

"1. The degree of alkalinity to which juices are limed.

"2. Is the sugar washed in the centrifugals, and if so, the source of the water?

"3. Is the sugar dried?

"Any further information bearing on the subject that you can give will be much appreciated."

In all we received replies from 29 factories, covering 45 samples of sugar.

Practically all these sugars were made from juices limed to neutrality, or to slight alkalinity.

Thirteen of the sugars were washed with water in the centrifugals, not including four sugars where it was stated enough water was used to wash down the spindles.

Seven of the sugars had been passed through a Hersey drier.

The deteriorations made on the sugars were:

Polarization.
Sucrose (Clerget) %
Glucose %
Moisture %
Ash %
Chlorine %
Number of organisms per gram.
Acidity.

Previous work.

Claassen[1] states:

"It is also a requisite of good raw sugar that it does not undergo change in storage. This is the case when the sugar shows an alkaline reaction with phenolphthalein, and when it is free from the germs that cause sugar to invert, and also free from easily decomposable non-sugars."

He also states that a raw sugar with an adhering layer of supersaturated molasses keeps well if the layer remains supersaturated, as in this case bacteria cannot develop if the sugar is kept in places where moisture can be absorbed there is danger of deterioration.

To sugars manufactured with sulphurous acid he ascribes enhanced keeping qualities, due to the antiseptic properties of this substance. He calls attention to the danger of bagging sugar while still warm, ascribing the deterioration then observed to the oxidization of organic non-sugars.

Strohmer[2] found alkaline sugars kept longest, and recommends an alkalinity in the sugar of not less than .033% lime.

Von Lippman[3] also finds that sugars alkaline to phenolphthalein undergo no change. On the other hand, Herzfeld[4] states that alkalinity is no criterion of the keeping qualities of sugar, and Koydl[5] claims that an excessive alkalinity increases the rate at which sugars deteriorate, and suggests that this is due to the action of lime on reducing sugars.

Pekalharing[6] shows that the inversion of sugars on storage is not due to the salts contained in the sugars, and suggests the deterioration is due to organisms introduced with the bags.

Grieg Smith[7] has studied the subject in Australia from a bacteriological standpoint, and ascribes the deterioration of sugars to a specific organism which he has named *Bacillus levaniformans*. He found this organism constantly associated with deteriorated sugars, and also in raw cane juice. The organism was also found in sugars from Demerara, Mauritius, Peru, Egypt, Java, Germany, Russia, France, Fiji, so that it has a truly cosmopolitan distribution. He gives the optimum temperature for its growth as 37° C. (96.6° F.), and concludes: "In view of this faculty of growing in poor media, and of the fact that an inversion of sugar accompanies the growth, there can be no doubt that it is alone responsible for the inversion of crystals in bulk, and that the chief condition for its growth is a more or less moist state of the sugar, and a warm temperature."

Shorey[8] states that alkalinity of sugars is not a cause of their keeping, and that high moisture is not a cause of their deterioration; he attributes inversion to the presence of the organism Penecillium glaucum, and believes that it is drawn into the sugars along with the current of air in the centrifugals. He recommends that in the curing of sugars dry steam be admitted to the baskets. Grieg Smith[7] objects to the conclusion of Shorey that the inversion of the sugars was not caused by bacteria, because he (Shorey) made no search for bacteria, and "his remarks about the Hawaiian sugars would apply equally to these Australian samples," which were known to contain inverting bacteria.

Watts[9] calls attention to a rise in the polarization of muscocado sugars on storage, followed by a fall in the polarization, and in a subsequent paper[10] in connection with Tempany attributes the rise to the selective action of certain organisms for the levulose present, the subsequent fall becoming apparent when the destruction of the dextrose and cane sugar begins.

The question of deterioration of sugars was very prominent in these Islands in 1897.

Dr. Maxwell[11] the then Director of this Station, attributed the deterioration to fermentation, and laid great stress on the necessity of working with very alkaline juices and obtaining alkaline products, and traced a greater deterioration when low sugars were returned than when "*straight*" first sugars were made. The source of infection he thought was the vessel containing the low grade massecuite. Shorey was at issue with Dr. Maxwell on many points, especially with regard to the return of low sugars and alkalinity. He also regarded fermentation as the cause of this deterioration, but considered the centrifugals the source of infection, the organism affecting the change being drawn into the sugar along with a current of air; he obtained good results by steaming the sugars in the baskets, and laid great stress on the necessity of shipping dry sugars.

Mr. J. N. S. Williams at the last meeting (1907) of the Panters' Association, called attention to the "sweating of sugars," i. e., to the absorption and exudation of moisture by stored sugars, and was inclined to attribute this behavior to climatic influences, and to the position of the warehouses.

In the pages that follow, these points and others are discussed in conection with the analyses that we have made.

For easy reference the polarization of the sugars as received and at intervals of two months and four months are brought together below in Table I; those sugars which retained their polarization being separated from those which did not. In this table is also included the results of the determination of the moisture in the different sugars, and of the determination of the number of micro-organisms found.

TABLE I.

Reference No.	Moisture	Initial Polarization	Polarization after 60 days	Polarization after 120 days	Initial % Sucrose (Clerget)	% Sucrose (Clerget) after 60 days	% Sucrose (Clerget) after 120 days	Initial Number of organisms per gram	Number of organisms per gram after 60 days	Number of organisms per gram after 120 days
21	1.04	96.7	95.8	95.1	97.0	96.3	95.4	148	2000	408
13 AA	.92	97.8	96.8	96.7	98.0	96.6	95.8	136	∞	∞
13 A	1.52	95.8	92.6	92.2	96.1	93.2	93.1	87	∞	∞
2 A	1.41	96.4	94.6	92.5	96.5	94.4	92.9	68	172	88
2 B	1.66	94.5	94.6	91.4	94.4	...	92.3	12	68	96
2 4A	.80	97.9	97.0	95.5	98.3	96.7	95.6	3000	∞	∞
19	1.50	95.8	94.5	93.0	96.3	94.8	93.6	56	∞	∞
12 First	1.68	95.2	93.9	92.7	95.7	93.8	92.8	1000	∞	∞
23 A	2.25	95.0	94.9	89.0	95.2	95.0	90.0	136	144	56
23 B	2.42	92.8	90.3	91.6	93.0	91.0	92.0	5000	∞	∞
37 First	1.52	96.9	95.4	95.2	97.0	95.3	95.6	4000	∞	∞
37 Second	1.66	95.5	95.0	...	96.0	95.1	...	4000	∞	∞
33 A	1.04	97.0	97.0	96.4	97.1	97.1	96.6	2000	∞	∞
7 AA	1.44	95.4	95.6	92.9	95.7	...	93.0	2400	∞	∞
Average	1.49	...	...	...	...	...	...	....	....	....
41 A	.75	97.4	97.3	97.3	97.6	...	97.4	12	32	24
41 B	1.54	94.4	94.2	95.0	95.0	...	95.0	56	360	112
27 A	.85	96.8	97.2	97.2	97.2	...	97.0	40	60	100
27 B	2.34	92.4	92.0	92.6	92.6	...	93.2	27	50	256
9	.69	96.7	96.8	97.1	97.0	...	97.2	4	20	16
34	1.23	96.2	96.4	97.0	97.0	...	95.9	40	40	40
4	.41	98.2	98.4	98.4	98.4	...	98.6	216	440	152
3 A	1.29	95.3	95.6	95.4	95.9	...	96.0	44	230	54
3 B	2.08	93.7	95.0	95.2	94.5	...	94.7	28	420	∞
36 A	.69	97.4	97.1	97.1	97.1	96.9	96.6	2000	2000	2000
36 B	.51	96.5	96.5	96.8	96.8	96.7	96.0	10000	10000	3000
39 A	.55	97.5	97.8	97.8	97.7	97.6	97.8	244	100	152
39 B	.73	96.5	96.6	97.2	96.9	96.8	96.4	848	....	760
43	1.25	96.4	96.6	97.2	96.5	96.6	97.1	40	32	76
30	.92	96.5	96.8	96.5	96.7	96.8	96.8	220	24	148
16 Syrup	.56	97.4	97.8	98.2	97.7	97.8	98.3	72	80	24
16 Syrup & Molasses	.63	96.8	96.9	97.4	97.0	97.0	97.6	176	180	68
20	1.01	97.2	96.8	96.8	97.3	...	97.3	46	48	28
6	.70	97.3	97.2	97.2	97.7	...	97.1	16	98	88
5 A	.77	97.3	97.1	97.3	97.5	97.4	97.9	24	252	224
5 B	.83	95.9	95.8	95.9	96.2	...	96.1	16	352	96
7 A	.62	97.5	97.8	97.8	98.1	...	97.9	508	1440	2000
45	.61	97.1	97.3	97.6	97.5	96.9	97.9	1236	1560	....
25	1.36	95.2	95.8	95.3	95.7	95.9	95.6	200	224	96
1	1.43	94.1	94.0	94.8	96.1	95.9	94.7	316	144	176
33 AD	1.31	95.8	95.2	95.6	95.8	...	95.8	124	120	76
12 Washed	1.25	95.8	95.2	95.8	95.9	94.3	95.7	4000	320	60
Average	1.02	...	...	...	...	...	...	....	....	....

Connection between moisture in sugars and keeping qualities.

Referring to the tabulated results a connection between moisture and keeping qualities of the sugars is evident.

The average percentage of moisture in the sugars which deteriorated is 1.49, and in those which retained their polarization is 1.02; this result points to the advisabiity of reducing the moisture to as low a figure as is possible; at the same time, a low content of moisture in a sugar does not always mean that the sugar will retain its polarization on keeping, as amongst the sugars that have deteriorated are two, 13 AA and 24 A, which have less than 1% of moisture, but notwithstanding it is evident that a connection between deterioration and high moisture does exist. The value of a low content of moisture, in this instance obtained by drying the sugars in a Hersey drier, is illustrated in a very vivid manner in the sugars 36 A and 36 B. These sugars had a very low percentage of water, .69% and .51% respectively, and contained at the same time a relatively enormous number of organisms, which, owing to the dryness of the sugars were unable to develop and thus cause a fall in polarization. These sugars came from a factory which had at one time great trouble with deterioration, which after the installation of a drier disappeared. When these sugars were allowed to become wet by standing in a moist atmosphere a very rapid fall in polarization was observed.

Acidity.

None of the sugars that we examined were alkaline, but all as determined by the use of phenolphthalein showed an acid reaction. The method of determining the acidity was as follows:

Five grams of the sugar were dissolved in 50 c. c. of water, and titrated with a 1-10 normal solution of standard alkali until a distinct red coloration was given by phenolphthalein. Owing to the coloring matter present in the sugars the determination can lay no great claims to extreme accuracy. Below in Table II are given the results, the sugars being divided into those that retained and those that did not retain their polarization. The figures expressing the acidity are the number of cubic centimeters of tenth-normal alkali required to neutralize the acid in the 5 grams of sugar. On inspection it will be seen that no connection between the acidity of the sugars and their keeping qualities is to be found.

TABLE II.

SUGARS WHICH DETERIORATED

Reference No.	Acidity
13 A	.7
13 AA	.3
2 A	.6
2 B	.8
21	.3
24 A	.5
19	.5
12 First	.4
23 A	.5
23 B	1.2
37 A	.5
37 B	.9
33 A	.7
7 AA	.6
Average	.59

SUGARS WHICH RETAINED THEIR POLARIZATION

Reference Number	Acidity
20	.5
6	.3
17	.3
5 A	.4
5 B	.4
7 A	.4
12 Washed	.3
36 A	.4
36 B	.5
39 A	.5
39 B	.4
43	.3
30	.5
15 Syrup	.2
16 Syrup and Molasses	.2
45	.4
25	.4
1	.9
33 AD	1.2
41 A	.9
41 B	1.1
27 A	.4
27 B	1.6
9	.4
34	.7
4	.1
1	.8
Average	.57

Bacteriological examination of the sugars.

At the inception of this study the following scheme was mapped out: A count was to be made of the number of organisms in each sugar as it arrived, at an interval of two months, and again at an interval of four months, at the same time polarizations of the sugars were to be made, and it was in this way hoped to correlate a large number of organisms with a fall in the polarization of the sugars.

The method used to obtain the number of organisms in a sugar was as follows: A quantity of the sugar (we found that .25 gram was a convenient amount) was weighed out onto a square of sterile paper, and transferred to a tube of sterile nutrient agar, the temperature of which was from 45° to 50° C; the sugar was allowed to dissolve, and after solution the contents of the tube poured into a sterile Petrie dish, the usual precautions to prevent accidental contamination being scrupulously followed. At first organisms in these plates were allowed to develop at room temperature, and later, as the weather became colder, in an incubator at 30° C. After 48 hours the number of organisms which developed into colonies were counted; the results of this test are set out in the annexed table, which also included the polarizations of the sugars at the same time. The nutrient medium we used in these determinations was that recommended by Grieg Smith, and was of composition—Agar Agar 1.5%, Sugar 10%, Potassium chloride .5%, Sodium Phosphate .2%, Peptone .1%.

In making determinations in duplicate it was found that agreement between any two was not as close as could be wished; for example, in duplicate experiments we might find the number of organisms per gram varying from 20 to 50, and no great reliance must be placed on the number actually entered up; we have entered the number up as we found them, where duplicates were made entering up the mean of the observations; actually in work of this sort we think expressions as between 100 and 200 is as close a determination as the conditions of the experiment allows.

In carrying on this work we received much advice and assistance from Mr. L. Lewton-Brain, Director of the Division of Pathology and Physiology of this Station.

Varieties of organisms found.

The colonies in each plate culture made were subjected to a microscopical examination, and a preliminary classification of the organisms made. Five organisms capable of differentiation by microscopical examination were of frequent occurrence:

1. Rods with terminal spores associated with a surface amoeboid growth on the agar plates.

2. A pear shaped organism exceedingly granular, associated with raised, smooth and slimy colonies.

3. A short thick spore forming rod generally occurring in pairs, and less frequently in chains up to seven, the refractive spore causing the pair of organisms to simulate the appearance of an organism with two spores.

4. A very small rod shaped organism only distinctly visible with very careful focusing, associated with a smooth raised growth on the agar plates.

5. Yeasts.

It is intended to carry on the further study of these organisms in pure culture.

For the present we may say with reserve that we have not positively identified any of the organisms found with the *Bacillus levaniformans* of Greig Smith.

Connection between deterioration of sugars and bacterial activity.

In Table I are given results of the polarizations at different periods, and of the counts of the number of organisms present.

The first fourteen sugars entered up are those which have fallen in polarization. In these fourteen are ten where the number of organisms has increased to infinity, and in these the deterioration of the sugars may properly be attributed to the activity of the organisms present. In No. 21, the organisms increased at the end of the second month to 2000, after which they decreased in number. In three instances in which the sugars deteriorated markedly, there was no increase in the number of organisms to account for the fall in the polarization. These sugars are 2 A, 2 B, and 23 A. The sugar 23 A was most carefully examined, and plates of nutrient agar infected with this sugar were inoculated at temperatures 30° C, 35° C and 38° C, all the determinations leading to the same result.

Of the sugars where deterioration might reasonably be ascribed to bacterial activity the organism most frequently occurring was the one we have referred to above as No. 1, which occurred alone or in combination with the other forms in eleven of the sugars which have deteriorated the other forms in eleven of the sugars which have deteriorated; the other organism of most frequent occurrence was the form which we have temporarily designated No. 2. Amongst the sugars which have not deteriorated we particularly call attention to 36 A, 36 B and 39 B, notable for the large number of organisms present. These sugars did not deteriorate, and this we think attributable to the low water content of the material, and illustrates the benefits to be obtained by producing a dry article.

Actually we think the results of these determinations allow us to say:

1. That generally deterioration of sugars can be connected with bacterial activity.

2. That, however, cases occur when sugars deteriorate excessively and in which the deterioration can *not* be attributed to bacterial activity as illustrated by the sugars 2 A, 2 B, and 23 A.

3. That sugars containing a large number of organisms retain their polarization provided they contain but little water.

Effect of sterilization on sugars.

To demonstrate the deteriorating action of micro-organisms on sugars when kept in unfavorable conditions, the following experiment was performed:

A quantity of sugar was filled into wide mouthed Erlenmeyer flasks, and to this was added, drop by drop, so as to obtain a uniform distribution, a solution of the sugar 24 B, which we knew to be infected with micro-organisms. Three of these flasks were then submitted to fractional sterilization at 100° C. for a period of 20 minutes on three successive days. A fourth flask received no sterilization. These flasks, all plugged with cotton wool, were then placed over a flat dish containing water, and covered with a bell jar; a fifth flask, containing unsterilized, infected sugar was placed in a similar position, the water being replaced by a 40% solution of formaldehyde.

The polarization of these sugars was taken at the beginning of the experiment, and after the expiration of 45 days. The following results were obtained, the polarization being referred to dry weight. The amount of water absorbed by the different sugars averaged about five per cent.

	Initial Polarization	After 45 days
Sterilized sugar....................	97.6	97.2
" "	97.5	97.2
" "	97.6	97.2
Not Sterilized	97.6	95.6
Not Sterilized, over formaldehyde....	96.2	96.2

A very large fall in the polarization of the infected and not sterilized sugar is noted, and a smaller one in the sugars that had been sterilized, the sugar in the presence of formaldehyde remaining stationary.

These sugars were inoculated into nutrient agar when it was found that the sterilization had not been sufficient to destroy the organisms originally present; in these sugars there were found after 45 days about 300 organisms per gram; in the unsterilized sugar a very large number; the sugar exposed to formaldehyde being quite sterile.

Determination of the amount of water at which deterioration begins.

In order to determine the percentage of water which it is safe to leave in sugars, the following experiment was made:

A good quality of raw sugar was infected with a small quantity of the sugar 24 B, which we knew contained large quantities of organisms which we had connected with deteriorations. The infected sugar was allowed to become very moist, and portions of it, after thorough and complete mixing, were partially dried in vacuo over sulphuric acid, so that there was obtained a series of sugars of the same quality, with the moisture increasing in steps from .29% to 1.86%. These sugars were placed in tightly closed bottles and allowed to stand for a month.

This experiment was performed during the winter months, and an incubator not being at first available, the temperature in the box containing the sugars was maintained at night by means of a 4 c. p. incandescent lamp; the temperature varied between 25° C. and 32° C.

The sugars were kept for a second month in an incubator at a temperature of 35° C.

The following results were obtained:

Per cent. Water in Sugars	Initial Polarization	Polarization after one month.	Polarization after two months
.29	96.8	96.7	96.7
.40	96.6	96.6	96.6
.47	96.8	96.6	96.6
.59	96.8	96.6	96.7
.65	96.4	96.4	96.6
.74	96.4	96.4	96.5
.96	96.1	96.0	96.0
1.04	96.0	95.9	95.7
1.18	96.0	95.2	95.2
1.28	95.8	95.0	95.0
1.36	95.8	95.0	94.7
1.51	95.5	94.7	94.5
1.67	95.6	94.2	94.1
1.80	95.3	93.8	94.0
1.86	96.15	94.4	94.0

The polarizations were made on half normal weights of the sugars, and we do not therefore consider slight differences in the polarizations as indicative of any change in the sugars.

A distinct fall in polarization is observed when the water present has reached 1.04%. In the sugars which we examined from various plantations fourteen were found to deteriorate on keeping; two of these sugars contained less than 1.04% of moisture. Of the sugars that retained their polarization eleven contained more than 1.04% of moisture, seventeen contained less. The correspondence between this experiment and the actual experience with the sugars is, we think, satisfactory, and as a result we think we are justified in suggestion 1% of water as the maximum allowable limit in raw sugars if they are to be stored any length of time. We do not, of course, say that all sugars containing not more than 1% of moisture will keep, as two of our sugars, 13 A and 24 A, deteriorated, both of which contained less than 1% of water; nor, on the other hand, do we say that a sugar containing more than 1% of water will deteriorate; all we say on the point is that a sugar containing more than 1% of moisture, in the presence of organisms will probably deteriorate, and that a sugar containing less than 1% of moisture will in all probability retain its polarization.

Action of the Hersey Drier.

In the use of the Hersey drier the sugar is raised to an elevated temperature, and we thought it advisable to investigate the action of this elevation of the temperature on the bacterial content of sugars.

We were informed by Mr. C. B. Wells, of Wailuku, that in the Hersey drier there used the sugar remains in the apparatus for from 5 to 7 minutes, and that the temperature varies from 130° F. to 160° F.

At Niulii, Mr. Robert Hall informs us sugar stays in the Hersey drier 16 minutes, and reaches a temperature of 125° F.

Three sugars were exposed in a thin layer to a temperature of 80° C. (176° F.) for ten months, thus exaggerating the effect of the Hersey drier. Inoculation experiments in the way already described were then made.

	No. of Organisms per gram dried	No. of Organisms per gram not dried
1....................	42	32
2....................	25	22
3....................	35	34

It is thus seen that the action of the Hersey drier has no effect whatever on decreasing the number of organisms present, and its useful effect is to be attributed to the reduction of moisture in the sugars to such an extent that the micro-organisms to which the deterioration of sugars may be attributed cannot develop. Amongst the sugars that we examined were seven that had passed through a Hersey drier. The percentage of moisture, the number of organisms per gram and the behaviour of the sugars on keeping are set out below.

	Water %	No. of Organisms — Initially	Two Months	Four Months	
5A	.77	24	252	224	Did not deteriorate
5B	.83	16	352	96	" "
36A	.69	2000	2000	2000	" "
36B	.51	11000	10000	3000	" "
39A	.55	44	100	152	" "
2B	1.66	12	68	96	Deteriorated

Connection between washed sugars and deterioration.

The majority of the sugars examined were cured without the use of water in the centrifugals. The following were washed with water in the centrifugals:

5 A	Mixed condensed and well water.
5 B	Mixed condensed and well water.
39 B	Flume water
2 B	
36 A	Rain or distilled water.
36 B	Rain or distilled water.
24 A	Stored rain water.
43	Artesian water.
19	Enough water from flume to wipe down spindles.
7 A	Wet rag to wipe down spindles.
7 B	Wet rag to wipe down spindles.
27 B	Wet rag to wipe down spindles.
13 A	Artesian water.
13 AA	Very little or none.
12 First	Pump water.
12 Washed	Pump water.
37 B	Gulch water.

Of these sugars nine are included amongst those which lost in polarization, and this leads to a conclusion that a connection exists between the water used in washing sugars and their tendency to lose in polarization; amongst the washed sugars which retained their polarization are five which in addition to washing were passed through the Hersey drier, and were thus brought into a condition suitable for long keeping. It is notable that in three of these sugars which retained their polarization,—36 A, 36 B, and 39 A, a very large number of organisms were found, and we suggest that these organisms had been introduced along with the water used to wash the sugars, the damage to the sugars not being developed owing to the subseqnent drying.

Washing the sugars may also be regarded as affording a tendency towards a loss of polarization in that owing to the dilution of the molasses attached to the crystals a more favorable medium is afforded for the growth of micro-organisms than is the case if the film of molasses be more dense; this point has been referred to in the references already quoted.

Sweating of Sugars.

Independently of any question of bacterial deterioration of sugars, Mr. J. N. S. Williams at the last (1907) meeting of the Planters' Association called attention to the "sweating" of sugars, i. e., to the absorption and exudation of moisture by stored sugars. Mr. Williams was inclined to attribute this behaviour very largely to climatic conditions and to the positions of the warehouses.

Amount of moisture absorbed by different sugars.

We thought it would be advisable to actually determine the amount of water that the sugars we had under examination would absorb when exposed to the atmosphere under exactly equal conditions. The determination was made as follows:

About two grams of the sugar were placed in a thin layer and dried to constant weight at 100° C.; the dishes and their contents were then exposed to the atmosphere in a manner so as to be protected from the visits of ants and other insects; after 24 hours the dishes and their contents were again weighed. In Table III below, are collected the amounts of water absorbed in 24 hours expressed as percentages on the dry sugars.

TABLE III.

Reference No	Low Chlorine Chlorine % on Sugar	Moisture absorbed on exposure to atmosphere for 24 hours	Reference No.	High Chlorine Chlorine % on Sugar	Moisture absorbed on exposure to atmosphere for 24 hours
13A	trace	1.27	17	.006	1.34
13AA	"	1.13	2A	.01	2.62
20	.002	.85	2B	.022	1.75
6	.002	.67	5A	.01	1.03
21	.002	.95	5B	.008	1.13
7A	.002	.49	12 First	.006	2.16
7AA	.004	1.48	23A	.034	1.67
33A	trace	1.12	23B	1.62	2.91
33AD	.002	1.13	39A	.012	.79
24A	trace	.95	39B	.020	1.08
9	"	.22	43	.01	.99
3A	"	1.41	41B	.040	1.44
3B	"	1.08	27A	.022	1.16
12 Washed	"	1.77	27B	.078	2.03
36A	"	.34	25	0.28	1.51
36B	.002	.99	1	.076	1.38
37A	trace	1.39	Average		156
37B	"	1.12			
30	.004	.73			
16 Syrup	trace	.18			
16 Syrup and molasses	.004	.47			
45	trace	.37			
41A	.004	.80			
34	trace	1.08			
19	.002	2.03			
4	trace	.22			
Average		.91			

Size of grain as influencing absorption of moisture.

The absorption of moisture by any substance is essentially a contract reaction, and is connected with the area of the substance exposed.

The same weight of a sugar of small grain exposes a larger area than does that of a sugar of large grain, and will hence absorb moisture more quickly, and will retain a large amount.

In addition, owing to the larger exposed area a small grained sugar will have attached to its surface a greater quantity of molasses than a large grained sugar, and it is to the impurities or to the molasses that the hygroscopic character of a sugar is to be attributed.

To test this point experimentally two sugars were separated into three portions,—that retained by a 2 millimeter mesh, that passing a 2 millimeter mesh and retained by a 1 millimeter mesh, and that passing a 1 millimeter and retained by a .5 millimeter mesh. These different portions were dried to constant weight, and then exposed to the atmosphere under exactly equal conditions. The annexed table gives the percentages of water absorbed by the different portions.

	Retained by 2 m.m. mesh	Retained by 1 m.m. mesh	Retained by 5 m.m. mesh
A	.90	1.18	1.31
B	1.15	1.20	1.46

Connection between the non-sugar and moisture absorbed.

A raw cane sugar consists of cane sugar, dextrose and levulose (these last two being grouped together under the term glucose), organic and inorganic salts of lime, potash and magnesia, and various organic non-sugars. The organ acids which have been isolated from molasses and are consequently present in raw sugars are glucinic, malic, lactic, saccharic, and succinic; in addition, wherever disease attacked canes are being worked up, acetic acid will always be present. The inorganic salts present are chiefly sulphates, phosphates and chlorides.

Of the non-sugars, dextrose is the material present in largest amount and this substance when pure is not hygroscopic; levulose, included with dexrotse in the term glucose, was found to absorb 37.52% of its weight when exposed for 24 hours to the atmosphere.

Of the other bodies which may be present the following are known to be hygroscopic:

Calcium chloride, Calcium acetate, calcium glucinate, potassium acetate, potassium glucinate.

The glucinates are formed by the action of alkalies on dextrose and on levulose, and in this way glucose may be regarded as a body tending to give a hygroscopic product. This point was put to the test in the following experiment.

To 100 c. c. of a half per cent. solution of dextrose and of levulose were added 1 c. c., 2 c. c. . . . . . 5 c. c. of a saturated solution of lime. The lime solution contained 0.12 grams lime per 100 c. c. These solutions were evaporated to dryness and then exposed to the atmosphere for 24 hours; in all cases there was obtained a brown colored residue. The percentage increases in weight were found to be:

	1 C. G. Lime Water	2 C. C. Lime Water	3 C. C. Lime Water	4 C. C. Lime Water	5 C. C Lime Watet
Dextrose ...	22.5	20.6	21.3	21.7	23.0
Levulose ...	16.1	18.0	16.3	18.3	17.3

The decomposition products formed by the action of lime on dextrose are evidently very hygroscopic, and indicate the danger of obtaining a hygroscopic product liable to sweat, with juices containing a high content of reducing sugars. It is of interest to note, and a result not expected that increasing the amount of lime does not lead to an increased absorption of water, and that levulose treated in this way absorbs less water than does dextrose, and less than it does without the treatment with lime water.

The difference in the amount of moisture absorbed by the samples was probably due to a slight difference in the surface exposed in each case.

Connection between chlorine in ash and amount of water absorbed.

In Wray's Practical Sugar Planter, published in 1849, appears the following remark:

"Saline matter, present in cane juice, depends very much on the soil on which the canes are grown; as, for instance, in the low alluvial lands of Demerara, Louisiana, the Sunderbunds (below Calcutta), and Province Wellesley, canes often imbibe so much saline matter from the soil, that the sugar made from them may be said to be in a constant state of deliquescence."

We determined the chlorine in the ash of all the sugars examined, and this quantity, as a percentage on the sugar itself is entered up in Table III giving the amount of water absorbed by the sugars. To test the supposition that there is a relation between chlorine and amount of water absorbed we have divided the sugars into those of high chlorine content and low chlorine content; those sugars containing .004% chlorine and less are grouped as of low chlorine, and those containing more than .004% as of high chlorine content.

The average amount of water absorbed by the sugars of low chlorine content is .90%, and by those of high chlorine content 1.56%. We do not attribute of course this great difference entirely to the presence of chlorides, but regard it as evidence that a high content of chlorides in the juice and consequently in the sugars, is a cause of "sweating" of sugars. A large amount of chlorides in sugars may perhaps be connected with irrigation with saline water, with the presence of chlorides in fertilizers, or in the soil itself.

That the presence of chlorides is not the only cause of the absorption of a large amount of water is seen on reference to the results put forward in the table; for example, the sugars 19 and 37 A, remarkable for absorbing much water, are very low in chlorides, and the sugars 39 A and 39 B, both high in chlorides, are not remarkable for the amount of water absorbed.

The effect of small quantities of salts on the hygroscopic nature of sugars.

In the previous paragraph we brought forward evidence to show that a connection exists between the amount of chlorine present and the hygroscopic nature of a sugar. The amounts of chlorine are in most cases very small, and it seems unreasonable that so small a quantity of chloride could affect the properties of the sugar in so high a degree. This point was put to the test in the following experiment.

A solution of calcium chloride, containing .1 gram in 50 c. c. of absolute alcohol was prepared, and of this solution 5 c. c. were evenly distributed over 10 grams of a pure granulated sugar contained in a flat dish. The dish and its contents were then dried, and a sugar containing .1% of calcium chloride as impurity was thus obtained.

In a similar way, by dissolving .2 gram calcium chloride in 50 c. c. absolute alcohol a sugar with .2% calcium chloride as impurity was obtained. These sugars were then exposed in thin layers, after complete drying at 105° C., in flat dishes to the action of the atmosphere for 24 hours, and the increase in weight due to absorption of moisture observed; a check experiment with untreated sugar gave the amount of moisture absorbed by the sugar and its container.

The details of the experiment are as below:

Calcium Chloride per cent. on Sugar	Moisture Absorbed per cent. on Sugar	Moisture due to Calcium Chloride
.0	.09	..
.1	.37	.28
.1	.37	.28
.2	.47	.38
.2	.49	.40

That is to say, when .1% calcium chloride is present it apparently absorbs 2.8 times its own weight of water, and when .2% is present it apparently absorbs 1.95 times its own weight.

In this experiment the difference between the dry and wet bulb thermometer was 5.4° C. Different results were obtained in other experiments when there was a greater humidity in the atmosphere, in one instance the calcium chloride absorbing apparently seven times its own weight of water. Calcium chloride itself was found to absorb 36.4% of water calculated on its weight when dry.

This effect, which has a distinct bearing on the subject of this bulletin, we are inclined to regard as due to a contact reaction between calcium chloride, water and sugar, the calcium chloride first absorbing water, the water absorbed then dissolving the sugar and rendering the calcium chloride free to absorb more water; in this sense the calcium chloride acts merely as a carrier of water to the non-hygroscopic sugar.

Connection between glucose in sugars and moisture absorbed.

The average amount of glucose in the sugars examined was .78%; we have separated the sugars into two portions; those containing more than .78% glucose, and those containing less than .78% glucose, and have set out the results in Table IV, together with the amount of water absorbed on standing for 24 hours. The sugars with low glucose absorbed less than those with high glucose, but the difference is not very pronounced, and does not lead to any definite statements.

TABLE IV.

Reference No.	High Glucose Glucose % on Sugar	Moisture absorbed on exposure to atmosphere for 24 hours	Reference No.	Low Glucose Glucose % on Sugar	Moisture absorbed on exposure to atmosphere for 24 hours
2AB	1.87	2.62	13A	.36	1.27
2A	.86	1.75	13AA	.60	1.13
5A	.83	1.03	20	.48	.85
21	.82	.95	6	.68	.69
7A	.83	.49	17	.64	1.34
7AA	.80	1.48	65B	.77	1.13
12 Washed	2.91	1.77	33A	.44	1.12
43	.84	.79	33AD	.73	1.13
41B	1.08	1.44	41A	.50	.80
27B	1.48	2.03	27A	.55	.73
9	.92	.22	24A	.43	.95
34	.83	1.08	19	.61	2.03
3A	1.06	1.41	4	.21	.22
1	1.81	1.38	12 First	66	2.16
25	1.81	1.38	36A	.60	.34
Average	1.20	1.32	36B	.52	.99
			37A	.18	1.59
			37B	.74	1.12
			45	.37	.37
			23A	.47	1.67
			23B	.48	2.91
			39A	.30	.71
			39B	.32	.78
			30	.61	.73
			16 Syrup	.41	.18
			16 Syrup & Molasses	.56	.47
			Average	.51	1.05

Examination of "Sweated" Sugars.

During the time that the analyses and experiments detailed in this bulletin were in progress we had referred to us for examination two samples of "sweated" sugars. These sugars had sweated in the hold of the vessel by which they were shipped, and other sugars of similar origin had not sweated . The sugars that had sweated had fallen in polarization on an average five units below that which had remained sound. In the bacteriological examination of these sugars we found the organisms which we have come to associate with deteriorated sugars, but as they come to us the number of organisms in the sweated sugars was only a few more than in the sound sugars. A decrease in the number of organisms on storage has already been noted in the case of sugars that have deteriorated, and in the absence of further evidence some similar cause may have been at work here.

In these sugars we determined the amount of water absorbed (in the way already described) and the amount of chlorine in the sugars. The following results were obtained:

Reference No.	Amount of Water Absorbed	Chlorine per cent. on Sugars
43 Sweated	3.18	.014
43 "	3.58	.018
43 Sound	.96	.012
21 Sweated	2.58	.008
21 Sound	.94	.004

In all cases the "sweated" sugars are much more hygroscopic than sound sugars of the same shipment, but with the data to hand it is impossible to say if this high absorption of water is due to bodies already present or to products of decomposition due to bacterial action. In the experiment on storage of sterile sugars we had sugars of the same origin which had deteriorated and others which, being nearly sterile, had not. This gave us a means of checking the effect of the products of bacteria on the amount of water absorbed by the same sugar. It was found that the sterilized sugar and the infected sugar which had deteriorated both absorbed the same amount of water when examined as already described. In the actual experiment the percentage of water absorbed was 1.45% in both cases. This experiment would lead to the conclusion that the "sweated" sugars had sweated on account of the presence of certain impurities, and that then, due to the favorable conditions, bacteria had been responsible for the fall in polarization.

Use of "proofed" bags.

In certain districts, particularly where direct consumption sugars are made, it is not unusual to protect the product by the use of an interior bag of specially prepared paper.

To test the benefit of the use of such bags we made the following experiments. Samples of bags sold and used for this purpose were obtained; the bags were made of a paper material, crinkled so as to be very elastic, and had been treated with some material rendering them resistant to the action of water; from this material we had made small bags holding about one pound of sugar, and similar bags from the burlap material in general use.

Into these bags was filled a raw sugar which had just been completely dried; the bags were, after filling, closed as tightly as possible, and allowed to stand exposed to the atmosphere for 24 hours; after the expiration of this time determinations of the water in the sugars in the paper and burlap bags were made with the following results:

Paper bags	·55%
Burlap bags	·57%

The bags were allowed to remain a week, when determinations of the moisture were again made.

Paper bags	·74%
Burlap bags	.80%

The bags were then placed in a very wet atmosphere obtained by placing them in a large covered vessel at the bottom of which was a layer of water. After one week the bags were removed; the sugar in the burlap bags had sweated, and to outward appearance that in the paper bags had remained sound. On opening the bags the sugar in both paper and burlap bags was found to be exceedingly moist. Actually the moisture was found to be:

Paper bags	4·09%
Burlap bags	5·97%

As the result of these experiments we cannot say that the use of an interior lining of specially prepared paper will prevent the sugars absorbing moisture. To a certain extent such a scheme may be expected to mitigate "sweat damage"; whether it would be a practical scheme or not will depend on the cost of the bags and the amount of sugar their use will save from damage. This is a matter that can only be settled by a large scale experiment *in situ*, and we suggest such an experiment as worthy of trial in any factory which is obliged to store its sugars over long periods in unfavorable localities.

From a communication from a firm making these bags we gather that the extra cost—not including extra labor—would be from 50c to 60c per ton of sugar.

Infection from bags.

We referred above to a statement tracing the origin of the organisms causing deterioration to the bags in which the sugar is packed. This observation we were unable to confirm. We obtained bags from four different plantations taken at random from stocks, and made inoculations from these bags into sterile nutrient agar, incubating the infected agar at 35° C. Three of the bags were apparently sterile; that is to say, from 1 frame of bags, treated as above, we obtained no colonies of micro-organisms; from a fourth bag we obtained large numbers of colonies, but the organisms occurring in these colonies were different to those which we had observed in the sugars we had previously examined.

Suggestions towards preventing deterioration.

Provided that a sterile sugar could be made, that it could be kept sterile, there is no doubt that a very great part of the loss due to deterioration could be prevented. It is a matter of no inconsiderable difficulty to sterilize even small articles in the laboratory, and the sterilization of so large a matter as a sugar factory may be regarded as impossible. In one of his communications Grieg Smith[12] shows that in Australia the organism *Bacillus levaniformans*, which he associates with deterioration, exits in the juices and syrups at all stages of manufacture, and hence its presence in the sugars is unavoidable. Similarly, the presence of micro-organisms has been noted by Laxa[13] in all stages of manufacture in beet sugar factories. Notwithstanding this, we think that all efforts toward a clean factory and to a rapid process of manufacture will be well rewarded. The place in the sugar factory most suited to the development of micro-organisms is the tanks used for storage of after massecuites, and to the remelting of these sugars is to be attributed the introduction of many micro-organisms. This is not, however, the sole cause, as amongst the sugars we examined were some which came from a factory using a crystallization in motion process, and these contained a very large number of micro-organisms.

Provided sugars are dry, no danger from bacterial damage is to be apprehended; dryness in sugars can be obtained by artificial drying by heat, but if such dried sugars are stored for any length of time they will, under unfavorable conditions, absorb moisture. To a limited extent we think that the use of an interior "proofed" bag is worthy of trial where sugars have to be stored under unfavorable conditions. With regard to treatment of sugars we ghave shown how that the action of small quantities of alkalies on dextrose gives rise to hygroscopic decomposition products, and consequently any excess of lime, particularly with juices containing much glucose, will tend to give a hygroscopic sugar, and hence one liable to deterioration.

A thick, viscuous material, such as molasses, is not a medium well suited to the development of micro-organisms, but if the film of molasses be diluted, as will occur if the sugars are washed, a more suitable habitat for their development is formed. The sugars we have examined afford evidence that washed sugars are liable to deterioration, and we would add that the use of any but distilled water in washing sugars is a process likely to introduce large numbers of micro-organisms.

Validity of a "count" of the micro-organisms in a sugar in connection with deterioration.

Although the determinations we have made point to a distinct connection between bacterial activity and deterioration, an inspection of the results recorded presents points that require further study.

We have mentioned that in the case of three sugars which deteriorated the "count" of the organisms found did not afford evidence to correlate the deterioration with bacterial activity; and further, in the sweated sugars we examined, we found no great number of organisms.

Mr. C. F. Eckart called our attention to somewhat parallel observations in the region of soil bacteriology. In Bulletin 194, U. S. Department of Agriculture, Drs. Voorhees and Lipman have reviewed the work that has been done up to date in soil bacteriology. Quoting from this publication we read:

"The same fact is recognized by Chester when he says that a soil may be low in numbers of bacteria, but contain such a bacterial flora, or combination of bacterial species which are known to be favorable to the rapid digestion of plant food, as to give what might be termed a high bacterial potential."

In the same way it does not seem unreasonable to suggest that in the case of deterioration of sugars it may be only the number of organisms at work, but also what Chester calls the "bacterial potential."

Increase in Polarization on Storage.

We called attention in our abstract of previous work on the storage of sugar to the statement of Watts regarding an increase in the polarization of sugars. In the course of the work described in this Bulletin we have come across similar instances. The initial polarization of the sugar 3 B was 93.7, and after storing for two months and for four months the polarization had increased to 95.0 and 95.2. Initially the percentage of reducing sugars was 1.65, and at the end of four months it had fallen to .22%. At the same time there had been a progressive increase in the number of organisms from 28 to 420, and to a very large number at the end of four months, and the only explanation we can offer of this behaviour is that of a selective action of the organisms present towards the reducing sugars, the cane sugar remaining unaffected.

During the time that his work was in progress a similar phenomenon was noticed in some sugars analyzed in the ordinary routine work of the station. On November 27th three second grade sugars gave the following results:

No.	Polarization
2	94.05
3	93.95
4	93.8

These sugars were polarized in duplicate by different analysts, with concordant results.

On December 19th the Station was requested to repeat the analysis, on the remainder of the samples, when the following results were obtained:

No.	Polarization
2	94.9
3	95.0
4	95.1

Summary.

1. In the great majority of cases of deterioration of sugars the fall in polarization can be connected with bacterial activity.

2. Sugars may fall in polarization without evidence of this fall being due to bacterial activity.

3. For bacterial action to take place a certain amount of moisture must be present; so long as the sugars do not contain more than 1% of moisture, the danger of bacterial action is small.

4. Four distinct organisms are of frequent occurrence in Hawaiian sugars, one of which was of very frequent occurrence in sugars, which deteriorated; these are now being studied.

5. The capacity of sugars for absorbing moisture varies largely, and this is an important factor in determining the keeping qualities of the sugars; some evidence exists that the amount of moisture absorbed is connected with the amount of chlorides in the sugars.

6. A sugar when dried will, when exposed to a damp atmosphere, absorb moisture; such a sugar will then be in a condition liable to deterioration. In factories which experience trouble with deterioration of sugars we suggest the experimental use of an interior paper lining as a means of protecting the sugar from atmospheric changes.

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JAPAN AND THE SUGAR INDUSTRY OF FORMOSA.

The consumption of sugar in Japan has reached 500,000,000 *kin* a year, and is still increasing, and the Japanese output, including Formosa, ranges from 150,000,000 to 200,000,000 *kin*, amounting to 300,000,000 *kin* being imported from abroad. The raw sugar from Java is predominant, but Japan possesses the territory of Formosa which is well suited to the cultivation of sugar, so that if properly managed and encouraged the output from this island will in future cover the total supply of sugar consumed in Japan. The climate and soil of Formosa are congenial to sugar planting, and according to the statement of older folks there, previous to Japan's possession of the land, the output of sugar per year amounted at one time to 300,000,000 *kin*, but with the importation of foreign sugar, the amount of the output dwindled into some 100,000,000 *kin*. This is chiefly owing to the imperfect system of producing and refining sugar, such as was practiced by the people from ancient times, and naturally the Formosan product can not compete with foreign sugar refined by the employment of up-to-date machinery. Neither the soil nor climate of Formosa is inferior to those of Java and Hawaii, but on the contrary, the former is superior to the latter in some respects of climate so that, could we improve the manufacturing process, we would be able to increase its output, and Formosa would be able to supply the vast amount of sugar imported to Japan. Such has been the opinion of experts, and this has been confirmed by the recent attitude of the Formosa administration by whose initiative the Formosan Sugar Refining Company was established. The experience of the company will show that the Formosan sugar industry is carried on after up-to-date methods.

The average output of Formosa sugar at present is 100,000,000 *kin*. Should these figures be increased by two or three times, there would hardly be in excess of the demand at home. The area of the field in the southern part of Formosa is 219,000 *cho*, and the plantations cover an area of a little over 20,000 *cho*, that is, 2-10 per cent. of the whole area. There is ample room for doubling or trebling the plantations, thus increasing the output of sugar which will be all consumed at home. With all the richness of material and an extensive market, the Formosan sugar industry is a promising one.—Far Eastern Review.

EXPERIMENTS WITH SEEDLING AND OTHER CANES AT BARBADOS FOR THE SEASON 1905-7.

The following is a summary of the principal results obtained in connexion with the sugar cane experiments carried on under the auspices of the Imperial Department of Agriculture for the West Indies for the season 1905-7.

The object, which is steadily held in view, is to obtain such varieties as will best suit the varying soil and climatic conditions existing in the different districts of the island.

To this end, numbers of new canes are raised from seed annually, the number depending in a great measure on the climatic conditions existing during the flowering season of the sugar canes. When the weather conditions are favorable, large numbers are easily grown; on the other hand, when drought ensues at the time the sugar canes are flowering, the seeds are by no means as fertile, consequently, comparatively few germinate. During the latter part of 1906, owing to the unfavorable climatic conditions, few seedlings were obtained. This, however, was an advantage rather than otherwise, as owing to the large number of seedlings at present under cultivation, there was little land available for planting many more.

Seeds of the sugar cane are sown in boxes towards the end of November or the beginning of December in each year. As soon as the plantlets are sufficiently advanced they are pricked out into pots, and when they are about 10 or 12 inches high they are planted, usually in the month of May, in a field arranged for irrigation, so that they may be grown to maturity by the May of the following year. In a year's time those varieties which from their field character are considered good enough for reproduction are cut, weighed, crushed, and the juice is analyzed, but only the stools from those canes which contain fairly rich and pure juice are replanted. The stools of the canes selected are taken up, divided in half and planted where they can be irrigated; care is also taken to label each variety. At the same time a plan is made showing the position of each stool in the field. During the following December the canes from these stools are made into cuttings and replanted. From that time onwards each variety is annually propagated and multiplied in the usual manner, and grown in competition with the White Transparent, the standard cane. If the results of the new canes when grown under similar conditions as the standard cane justify it, the new canes are cultivated on the various experimental plots in the black-and-red-soil districts, until they are either ultimately rejected or cuttings are supplied to the planters with the recommendation to try them on a small scale, and, if the results justify it, gradually to increase the areas under cultivation.

In addition to growing canes from seeds obtained from different varieties, a further effort was made in November and December, 1904, by Mr. F. A. Stockdale, B.A., F.L.S., to carry on the work started by Mr. Lewton-Brain, B.A., F.L.S., in 1903 in obtaining seedlings by cross-fertilization under control; and a number of the flowers of the best seedling canes were cross-fertilized. Unfortunately, however, owing to unfavorable climatic conditions, no seedlings were obtained from this work.

The selected varieties were cultivated during the season 1905-7 at fourteen estates, representative of the localities in which they are situated, eleven being on black soil and three on red.

Of the eleven black-soil estates eight are used as intermediary stations, in which different varieties are tested before they are finally sent to what is known as "selected-seedling" estates, these latter being the estates on which the standard variety and the best seedling canes are cultivated in duplicate plots. * * *

NEW SEEDLINGS.

Of the 4.874 seedling canes which were planted in 1905, 126 from their field characters, and the richness and purity of their juice passed the standard and were replanted. From these, 118 varieties were obtained, and they will be replanted at the close of 1907.

At the end of 1906, owing to the unfavorable weather conditions, only 219 seedlings were obtained. These were transplanted in due course and will be tested during the reaping season of 1908, and all the stools of the best varieties will be replanted.

It has been mentioned in previous reports that artificial hybridization had been successfully performed. From the canes so obtained, the following varieties are under experimental cultivation at present, viz: B. 11,629, B. 11,660, B. 11,692, B. 11,724, and B. 11,756.

In addition, the following six varieties obtained from arrows bagged to prevent cross-fertilization, are being sown, viz: B. 11,360, B. 11,385, B. 11,482, B. 11,788, B. 11,820, and B. 11,852.

None of these, however, we regret to state, show any indication of giving better results than some of the newer seedlings at present under cultivation.

In 1902, a number of the seedling canes B. 208 and D. 95 were planted in alternate rows and in alternate holes in the rows, i. e., chess-board fashion, in such a position that they would not be likely to be cross-fertilized by canes of other varieties.

From these canes were obtained 196 seedlings. From their field character and saccharose content, fourteen have been thought worthy of further trial. Of these fourteen, five resemble the D. 95, four resemble the B. 208, four partake of the nature of both canes, and one resembles neither.

These canes were tested this season, but three only of the fourteen gave better results than the White Transparent grown in the same field.

SITUATION WANTED.

Sugar Plantations, Cane Growers and Sugar Mills.

ISLAND AND NAME.		MANAGER.	POSTOFFICE.
OAHU.			
Apokaa Sugar Co	*	G. F. Renton	Ewa
Ewa Plantation Co	*	G. F. Renton	Ewa
Waianae Co	***	Fred Meyer	Waianae
Waialua Agricultural Co	*	W. W. Goodale	Waialua
Kahuku Plantation Co	x*	Andrew Adams	Kahuku
Waimanalo Sugar Co	**	G. Chalmers	Waimanalo
Oahu Sugar Co	x	E. K. Bull	Waipahu
Honolulu Plantation Co	**	Geo. Ross	Aiea
Laie Plantation	x*	S. E. Wooley	Laie
MAUI.			
Olowalu Co	**	Geo. Gibb	Lahaina
Pioneer Mill Co	x	L. Barkhausen	Lahaina
Wailuku Sugar Co	**x	C. B. Wells	Wailuku
Hawaiian Commercial & Sugar Co.	x*	F. F. Baldwin	Puunene
Maui Agricultural Co	...	H. A. Baldwin	Paia
Kipahulu Sugar Co	x	A. Gross	Kipahulu
Kihei Plantation Co	x*	A. J. McLeod	Kihei
HAWAII.			
Paauhau Sugar Plantation Co	**	James Gibb	Hamakua
Hamakua Mill Co	*x	A. Lidgate	Paauilo
Kukaiau Plantation	x	A. Horner	Kukaiau
Kukaiau Mill Co	*x	E. Madden	Paauilo
Ookala Sugar Co	**x	W. G. Walker	Ookala
Laupahoehoe Sugar Co	*x	C. McLennan	Papaaloa
Hakalau Plantation	**	J. M. Ross	Hakalau
Honomu Sugar Co	**x	Wm. Pullar	Honomu
Pepeekeo Sugar Co	**x	Jas. Webster	Pepeekeo
Onomea Sugar Co	**x	J. T. Moir	Hilo
Hilo Sugar Co	**	J. A. Scott	Hilo
Hawaii Mill Co	x	W. H. Campbell	Hilo
Waiakea Mill Co	*x	C. C. Kennedy	Hilo
Hawaiian Agricultural Co	**x	Wm. G. Ogg	Pahala
Hutchinson Sugar Plantation Co	**	Carl Wolters	Naalehu
Union Mill Co	*x	H. H. Renton	Kohala
Kohala Sugar Co	*	Geo. C. Watt	Kohala
Pacific Sugar Mill	x**	A. Ahrens	Kukuihaele
Honokaa Sugar Co	x**	K. S. Gjerdrum	Honokaa
Olaa Sugar Co	xx	J. Watt	Olaa
Puna Sugar Co	...		Kapoho
Halawa Plantation	x*x	R. H. Atkins	Kohala
Hawi Mill & Plantation	††	John Hind	Kohala
Puako Plantation	††	Jno. C. Searle	S. Kohala
Niuli Sugar Mill and Plantation	*x	Robt. Hall	Kohala
Puakea Plantation	*x	H. R. Bryant	Kohala
KAUAI.			
Kilauea Sugar Plantation Co	**	F. Scott	Kilauea
Gay & Robinson	x*x	Gay & Robinson	Makaweli
Makee Sugar Co	...	G. H. Fairchild	Kealia
Grove Farm Plantation	x	Ed. Broadbent	Lihue
Lihue Plantation Co	x	F. Weber	Lihue
Koloa Sugar Co	x	L. Weinzheimer	Koloa
McBryde Sugar Co	*x	W. Stodart	Eleele
Hawaiian Sugar Co	x*	B. D. Baldwin	Makaweli
Waimea Sugar Mill Co	*	J. Fassoth	Waimea
Kekaha Sugar Co	x	H. P. Faye	Kekaha

KEY.	HONOLULU AGENTS	
*	Castle & Cooke	( )
**	W. G. Irwin & Co	(8)
***	J. M. Dowsett	(1)
x	H. Hackfeld & Co	(9)
*x	T. H. Davies & Co	(8)
**x	C. Brewer & Co	(6)
x*	Alexander & Baldwin	(6)
x**	F. A. Schaefer & Co	(2)
x*x	H. Waterhouse Trust Co	(2)
††	Hind, Rolph & Co	(2)
xx	Bishop & Co	(1)