

were desirous of arriving at the amount of loss in the storage of sugar, and the losses as represented to the Government were not correct.

Mr. Malcolm stated that his company took half a ton of sugar from four mills; the moisture contents were taken of that sugar and also the sucrose. The test lasted six months, and during that period some of the sugar lost very little sucrose and did not gain very much weight. Some of it gained in weight and lost in sucrose, the reason being that the moisture in sugar was high and above what is considered a safe point. That point, of course, is disputed even to-day. There are people who think that sugar with a moisture content of .2 is safe; but he did not think it was safe; it has to be a bit drier if it is for consumption. He had had refinery sugar in the store for over a year which had not increased to any appreciable extent in moisture. Not many months

ago complaints were received that treacle sugar was arriving in Johannesburg with a loss in weight. Sugars that had been in the store for some months were then tested, and were something like ten to fifteen pounds over weight.

Mr. Alfred Townsend also spoke on the question of the storage of sugar, stating that some time ago at the mill he was connected with, they had occasion to store sugar in large quantities, and they therefore built a store and ventilated it well. The result was disastrous. On the second occasion, at Sea Cow Lake, he and his brother had to store sugar, and they adopted the opposite way and had a sealed store with the result that they had dry sugar. By keeping the atmosphere away from the store no trouble was experienced so far as sweating was concerned. The sugars in both instances were identical.

Fungi and Bacteria in Sugar and Sugar Cane.

(Paper by P. A. VAN DER BIJL, D.Sc., Professor of Plant Pathology, Stellenbosch University, late Government Mycologist, Durban.)

The sugar industry has during its development passed through various phases. In its early history man's taste was deemed sufficiently delicate to decide the degree of ripeness or the nature of the cane, but with the application of science to industries it soon appeared that chemical tests provided a far more delicate and certain means for ascertaining the qualities of cane and for controlling milling operations so as to minimise loss.

The cane grower and miller have also benefited from the application of botanical science to the sugar industry; on the one side, through the efforts made at increasing the yield of sugar by studying methods of cultivation and by selecting and breeding for high sugar content and other desirable properties, and on the other by investigations seeking to control losses occasioned to cane and cane products by those microscopic plants known as fungi and bacteria.

Like the majority of cultivated plants, sugar cane is also subject to a number of diseases of which some are caused by fungi, others by bacteria, and others again by constitutional derangements in the normal activities of the plant, and unfavourable conditions of growth.

We will first briefly refer to some of the diseases of cane caused by fungi and known to occur in Natal and Zululand. (No bacterial disease has thus far been recorded in cane from Natal and Zululand.)

The root disease of cane caused by the fungus *himantia stellifera*—the stellate crystal fungus—is prevalent in Natal and Zululand and may be responsible for a poor stand of cane and a consequent less yield per acre.

This disease is recognisable to the naked eye by the basal leaves of the cane being matted together, and if the stool is uprooted, white fungoid threads are seen on and between the roots and on old cane material decaying in the soil. Many of the roots of the stool will also be dead.

The fungus responsible for this disease is of the nature of a weak parasite, and the amount of damage caused by it is largely dependent on weather conditions and the nature of cultivation the cane is receiving.

Given good cultivation and moderately favourable weather conditions, the cane outgrows the fungus, but under dry conditions and poor cultivation the cane is handicapped, on the one hand by the poor cultivation—young buds find it difficult to force their way through the hard soil, and in their struggle may be killed by the fungus or other agencies; and on the other hand, by the scanty amount of moisture at its disposal. The fungus has also partly killed the roots of the cane, which is hence not in a position to get the full benefit from such moisture as may be still present in the soil.

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Control measures for this trouble must be largely sought in methods of cultivation, which will tend to promote the growth of the cane and conserve moisture in the soil. Fields badly affected benefit considerably by good cultivation around the stools.

Sugar cane stalks are in Natal subject to a number of diseases which cause an internal reddening of the stalks, which later frequently shrivel up and die in parts.

One of these diseases is the so-called "Rind Disease," caused by the fungus *melanconium sacchari*. This fungus becomes evident to the naked eye through the black patches or spirals which develop on the surface of the stalks, and is composed of large numbers of spores of the fungus.

The fungus is exceedingly common on old cane stalks left lying in the fields or around the mills. In plantations it is frequently met with on cane suffering from "root disease," or on cane which has received a setback in its growth through unfavourable conditions, and also on cane which has become over-ripe.

I have frequently found this fungus on cane which showed a pithy and hollow centre, a condition which is attributed to unfavourable conditions of growth, such as rapid growth followed by a setback, which in turn is followed by a rapid growth. This pithy and hollow condition would appear to be not uncommon in Natal and Zululand during certain seasons.

Control measures for "rind disease" must also largely be sought in methods of cultivation, which will ensure an even growth. Destruction of diseased material would of course lessen chances of infection, but the fungus is so common on cane stalks left lying in the fields that total destruction is almost impossible. In view of the fact also that cane appears to become infected only after having been insect bored or having received a setback in its growth through some of the agencies above mentioned, or having become over-ripe, such total destruction would not be generally advocated.

In recommending the destruction of cane material we have always to consider that it means the destruction of what would become valuable humus material, and under present methods of cane cultivation in Natal such general destruction should be advocated only in cases of dire necessity.

Another fungus causing a red rot in cane stalks is *cephalosporium sacchari*. Experiments which Stowe carried out with this fungus go to show that infected cuttings die and rot in the soil without germinating. This at once suggests the importance of selecting only sound, vigorous cane for planting purposes.

It is further demonstrated that this fungus excretes the ferment, or enzyme, known as invertase, which

changes sucrose into grape sugar and fruit sugar. This would result in a loss of sucrose.

The leaves of sugar cane are also subject to several so-called leaf spot diseases. Of these the so-called "eye-spot" disease caused by the fungus *leptosphaeria sacchari* is common in Natal. These leaf spots cause damage by destroying tissues in the leaf, and by so doing impairing the important function the leaf has, viz., of building up carbohydrates from the carbonic acid gas of the atmosphere and the water brought up by the roots from the soil. The amount of damage caused would be dependent on the degree of infection.

Sugar cane growing in Natal differs from most other field crops in that the ground is under cane year after year, and rotation is not practised. This is opposed to modern methods for controlling the diseases of field crops, and is a factor which should not be lost sight of.

We will now leave the diseases of the cane and say a few words about fungi and bacteria in the mills and store-houses, as well as deal with the loss of sugar brought about by biological causes.

We have already noted that some fungi responsible for stalk disease may cause a loss of sucrose by inversion.

The enzyme invertase which causes inversion of cane sugar is normally present in cane stalks, but it has been shown that under modern milling conditions, with a brief period between crushing and boiling, the loss occasioned by it is negligible. The same enzyme excreted by disease organisms in the stalks would also be inactivated by the boiling process.

Anyone acquainted with a sugar mill would suggest that various fungi and bacteria would thrive on the walls of gutters through which the juice is conveyed, and that here they would excrete the enzyme invertase capable of inverting the juice as it passes along. Experiments have, however, shown that as the juice under normal conditions passes along rapidly and is soon in the boilers, the loss caused by enzymes excreted by fungi and bacteria thriving on the walls of gutters is a negligible quantity. I trust, however, that this statement will not lessen hygienic conditions in the mills.

We will now deal briefly with the deterioration of crystal sugar. Under the term deterioration, we understand the destruction of sucrose and the formation of invert sugar accompanied by partial liquefaction.

Through a long series of experiments I have isolated a number of fungi and bacteria from sugar in Durban, and have shown that they are capable of inverting cane sugar into grape sugar and fruit sugar. Grape sugar, as we know, is very hygroscopic and readily takes up moisture from the atmosphere, and this leads to a partial liquefaction of the sugar.

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The micro-organisms responsible for this deterioration gain access to the sugar at some stage or other after the sugar has left the pans, and from this stage onwards the sugar should hence be handled under as hygienic conditions as possible.

I found that in Natal the common mould fungi, viz., penicillium and aspergillus spp? are amongst those chiefly responsible for the deterioration of sugar. As these fungi are very common saprophyty (I also found several of them in the air of sugar mills), too much attention cannot be given to proper clean hygienic conditions in and around sugar mills and store-houses. Deteriorated and partly liquefied sugar, for instance, should not be left in heaps in the store-houses, but should be instantly removed, and the store-houses kept scrupulously clean even if it should necessitate disinfecting and whitewashing. Fungi require moisture for their growth, and this is hence an important factor in sugar deterioration. Experiments indicate that sugar containing .5 per cent. moisture deteriorated less in a given time than sugar containing 1.5 per cent. moisture. This naturally suggests the desirability of drying the sugar well before bagging it, and keeping the store-house dry. The last word in the construction of sugar store-houses has not yet been said, and there appears to be considerable room for improvement. In store-houses the outer bags of a stack appear to be more liable to deterioration. This may be due to fluctuations of temperature accompanied by increased relative humidity, which favours deterioration. It may be advisable to cover stacks of sugar pockets with some non-conducting material.

Experiments with the bacteria isolated from deteriorating sugar indicate that they belong primarily to the "Potato Bacilli" group. (I isolated some of this group also from the air of sugar mills.) It would appear, however, that bacteria only come into play as causal agents of sugar deterioration after the amount of moisture in the sugar is abnormally high. They may hence follow on the fungi.

We have in experiments illustrated that if sterilised sugar be inoculated with fungi responsible for deterioration, and one set be incubated at 28 deg. C. and the other set in an ice chest, that the latter set deteriorated less in a given time than the former. This may solve the question of cool storage of sugar.

We have also shown that heating sugar at 70 deg. C. for 15 minutes or at 80 deg. C. for 10 minutes, decreased its subsequent deterioration. Here we are dealing with sugars which have been partially sterilised. Needless to say, such sterilised sugars would be liable to reinfection when exposed to the atmosphere.

In dealing with mill and unrefined sugar, the presence of hygroscopic non-sucrose substances is a

factor which should be borne in mind in considering the deterioration of the sugar.

To make our subject more complete, a few words may be said about fermentation. Alcohol is a valuable by-product of the sugar industry, and is obtained by the fermentation of treacle by yeasts.

The treacle as obtained from the mills contains a large number of micro-organisms, of which some are undesirable from the fermentation point of view and others absolutely harmful.

Many distilleries allow this treacle to ferment spontaneously, and do not exercise any control over the fermentation. This must of necessity result in a great loss of alcohol.

It is, however, satisfactory to note that there are some of the more progressive distilleries aiming at bringing about fermentation by using pure cultures of a particular yeast. Biological and chemical control is no less important to the fermentation industry than what chemical control is to the sugar mill.

The fermentation of cane treacle offers under South African conditions a wide subject for investigation and research. The subject has in South Africa scarcely been touched, but we may hope through investigation and research to obtain certain yeasts more suitable for fermenting our product and giving a high yield of alcohol.

One of the factories at least is carrying out work with this object in view, and have a chemical and biological control over the fermentation. In conclusion, I hope the "sugar week" in Durban will be a success, and that the benefit to the sugar industry from deliberations during the sugar week will be of such a nature that it will become an annual event.

DISCUSSION.

Mr. G. C. Dymond, of Empangeni, stated that in his experience the fermentation in and around mills has mostly been due to certain bacteria, and this fermentation they had managed to keep down to a great extent by the use of a 1 per cent. solution of sodium chloride over the mills. This had a curious effect on the purity of the molasses. If you have juice coming into the mills of a very low purity you naturally got molasses of a very low purity, but by getting a better juice and having the mill clean, the purity of the molasses rises; so that the purity of the final molasses seems to be somewhat deceptive, since it depends upon the quality of the juice coming in. It had been his experience that while with the ordinary fermentation only 25 per cent. of the available alcohol had been recovered from molasses, this had been increased by simple methods up to 75 per cent. It is a question of cleanliness and the use of pure yeast.

At 3.45 p.m. the Congress was adjourned until 8 o'clock p.m.