AN APPRAISAL OF THE USE OF DEXTRANASE

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ABSTRACT

The early work on the use of dextranase for the "removal" of dextran from deteriorated cane has been reviewed. In addition, the enzymic process has been appraised in terms of the experience gained since implementation of the procedure on a routine scale into Australian factories.

Considerable benefits in factory performance and sugar quality are to be gained from the process. Though turbidities of clarified juice improved dramatically, the filterabilities of the resultant raw sugars are still 5 to 10 units below normal production figures. Hydrolysis of cane dextran to a molecular weight of approximately $10^4$ (designated "complete removal") produces a marked reduction in the percentage of elongated sucrose crystals. In comparison, "partial removal" at high incoming dextran concentrations can result in severe problems with elongated crystals and fine grain, although other sugar quality parameters and viscosities of high-Brix factory products are about normal.

Initial enzymes rate studies indicated a surprising similarity in molecular size and type of dextrans present in deteriorated cane juices from a wide range of different sources. This has greatly simplified the implementation of the enzymic process to Australian conditions. However, extrapolation of these results to other countries may not be possible.

The properties of commercially available dextranases governed the selection of mixed juice as the enzymic addition point. However, final choice of the particular enzyme was based on the cost and the efficiency of hydrolysis at low dextran levels.

The low incubation temperature of 60°C requires that future developments should be directed towards providing a cheaper source of enzyme possessing a higher temperature optimum.
The haze analysis is by far the most suitable method for the estimation of dextran under factory conditions. Criticisms of the method do not hold up in practice mainly because it does give a reliable estimate of the high molecular weight fractions which are responsible for the major processing difficulties associated with this polysaccharide.

INTRODUCTION

Dextran is one of the by-products of deterioration of sugar cane in Australia (Egan, McNeill and Inkerman). The effect of this polysaccharide on factory processing has been outlined in dramatic fashion by Wells and James. In addition, raw sugars quality is affected adversely (Imrie and Tilbury). An enzymic method for the “removal” (hydrolysis) of dextran from deteriorated cane juice was proposed by Fulcher and Inkerman. The process involved incubation of mixed juice with dextranase at 60°C for 40 minutes at the natural pH of juice. Under these conditions, negligible synthesis of dextran occurred (Fulcher and Inkerman) and it was assumed that sucrose losses due to chemical and/or microbial action were small.

Other enzymic procedures were suggested by workers from the West Indies (Tilbury and French) and Australia (Hidi and Staker). Subsequently, these procedures were demonstrated to be impractical, in some instances, or uneconomic under factory conditions (Fulcher and Inkerman, Inkerman and James). Factory trials were carried out during the 1975 crushing season in northern Queensland factories on badly deteriorated cane containing dextran concentrations of the order of 5,000 to 13,000 ppm on Brix (Inkerman and James). Major improvements in factory performance and sugar quality were observed. Without dextranase treatment, this would have led to the discarding of large quantities of intermediate purity molasses and the production of sub-standard sugar. Contrary to the views of earlier workers, “complete removal” of dextran was not essential in order to achieve major benefits from the enzymic process. The following season, investigations were extended to the treatments of lower concentrations of dextran (1,500-3,000 ppm or Brix) in standing-burnt and stored burnt chopper-harvested canes in central Queensland factories (Inkerman and Riddell). No technological problems were experienced and results were similar to the earlier trials. The importance of not allowing the pan stage to become “poisoned” with dextran before attempting addition of dextranase was emphasized, as this strongly influences the decision on whether or not to aim for “complete removal” of dextran during enzymic treatment. Costs were considerably less than the earlier estimates reflecting the availability of longer incubation times for enzymic hydrolysis.

Thereafter, the use of dextranase has become a routine procedure and viable
PROCESSING

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industrial process in Australian sugar factories during the limited periods of processing of deteriorated cane. However, the process has not been recommended for general use due to the high cost of enzyme and the possible introduction of inefficient harvesting techniques.

In this paper, the earlier work has been reviewed and the process appraised in terms of the experience gained since the initial successful trials.

OBSERVATIONS AND DISCUSSION

Measurement of Dextran Concentration

(a) Methodology

The estimation of dextran in factory products was carried out by the method of Keniry et al. using a Pharmacia dextran (T2000, $\text{mw} > 2 \times 10^6$) as standard. The procedure tends to underestimate the concentration by approximately 8% due to the lower response of cane dextran in the analysis (McNeil and Inkerman, Keniry et al.). The identity of haze-forming material as dextran was confirmed enzymically viz. the non-appearance of an alcohol haze following preincubation of the sample with dextranase at pH 5 and 55°C (Fulcher and Inkerman). More elaborate checks may be made by measurement of apparent initial rates of enzymic hydrolysis (McNeil and Inkerman).

In the author’s opinion, the uncertainty in the identification of the haze material claimed by some authors (Richards and Stokie, Geronimos and Greenfield) is unfounded from a practical viewpoint. Among the numerous investigations carried out on cane deterioration at the Institute there have been only two occasions when substantial amounts of haze-forming material were not “removed” either by clarification or incubation with dextranase. Fulcher and Inkerman made a tentative identification of the material as sarkaran, the occurrence of which in Australia has been associated with the crushing of standover cane. Recent studies at the Institute have confirmed the earlier identification (Blake, unpublished). Therefore, in practice, enzymic confirmation of dextran has been deleted during routine analysis in the factory.

On various occasions, small amounts of non-dextran haze-forming materials (equivalent to dextran concentrations of up to 300 ppm on Brix) have been measured in cane juice. Generally, these materials can be removed by a simple laboratory clarification step. Hence, they are unlikely to be of any real significance during processing. In addition, inefficient vacuum-filtration of samples during analysis may result in the apparent presence of small amounts of haze-forming materials.

Another criticism of the haze analysis is that it does not give a measure of the average molecular weight of the particular dextran sample (Geronimos and Greenfield). For example, low-molecular weight dextrans such as Pharmacia T10 (mw
~10^4) remain virtually undetected under the assay conditions while the method does not differentiate between molecules or molecular weight greater than about 10^5 (Keniry et al.21).

(b) Estimation of incoming dextran levels

During the preliminary investigations, it had been expected that the measurement and subsequent treatment of incoming dextran levels would be a major problem because of their variability (Fulcher and Inkerman10). In practice, this has not been the case (Hidi and Staker16).

Prior experience with levels in deteriorated cane under a variety of conditions is of some assistance. Furthermore, some knowledge of levels can be gained by analysis of samples prior to the commencement of crushing. However, that is not completely reliable due to problems associated with obtaining a representative sample and, in the case of standing-burnt cane, the rapid increase in dextran levels that occurs during the cut-to-crush period (McNeil and Inkerman26).

Current procedure is to add excess enzyme for the first hour until some analyses become available. Thereafter, enzyme addition rates can be adjusted to accommodate the average dextran concentration. In this regard, analysis can be carried out on the cane juice payment stream i.e. first-express juice. Residual dextran levels should be monitored in treated juices emerging from the incubator after allowing for the mean residence time of this vessel. Thereafter, an appropriate adjustment can be made to the enzymic addition rate should this be deemed necessary.

In some instances, pH has been used to give an indication of dextran concentrations in deteriorated cane. Inkerman and Riddell19 applied selective addition of dextranase during the crushing of standing-burnt cane where rakes of deteriorated cane were intermixed with fresh cane. If the pH fell below 5.0, enzyme addition was commenced at a constant rate. Similarly, addition was discontinued when the pH rose above 5.0. Further, the rate of addition was doubled for juice of low pH (> 4.5). A similar procedure has been adopted for juices of low pH from stored chopper-harvested canes.

Recently, a method for the continuous monitoring of juice for dextran was proposed by Geronimos and Greenfield15, although the practical difficulties involved in implementation appear to be enormous. In view of the success of the methods outlined above and the limited occurrences of badly deteriorated cane, the author cannot envisage the application of this particular method to Australian factories especially for routine operation.

Initial approach to problem

(a) Characterization and selection of a suitable enzyme

Determination of the properties of available commercial enzymes was
necessary to enable a process to be devised which caused the least interference with the normal processing procedures in the factory. Enzymic parameters were measured under conditions likely to be encountered in a factory environment. For example, progress curves were used covering incubation times of 30 to 60 minutes, unlike the usual kinetic investigations which measure initial enzymic rates.

Dextran T2000 was chosen as substrate because it was (i) well characterized, (ii) readily available in highly purified form, (iii) relatively easy to solubilized, (iv) similar to cane dextran in structure and size, and (v) readily measured by the haze analysis (Keniry et al21) (Fig. 1).

![Graph](image)


The properties of three commercial enzymes were investigated viz. Talozyme, Tate and Lyle; Glucanase D-I Pfizer Chemicals; and Novo 25L, Novo industrial (Fulcher and Inkerman11, Inkerman and Riddell19). All enzymic preparations appeared to exhibit classical Michaelis-Menten kinetics, though the assay procedure would not have detected the hydrolysis of high molecular weight dextrans until the size had been reduced to about 10^3.

Maximal activity was obtained at approximately 45°C for Talozyme and approximately 55°C for Glucanase D-I and Novo 25L measured under the experimental condition (Fulcher and Inkerman11, Inkerman and Riddell19). Thus, the latter two enzymes are better suited to a factory environment, though both are rapidly denatured above 65°C (Fig. 2).

All dextranases exhibited maximal activity at about pH 5.0 (Fig. 3). The activities of Glucanase D-I at pH 6.5 and 6.8 (the approximate values in syrup) were about one-third to one-sixth, respectively, of the activity at pH 5.0. Furthermore, at the approximate limits of the pH range for most deteriorated cane (4.5-5.5), the
FIGURE 2. Effect of temperature on the activity of commercial dextranases (Inkerman and Riddell, 1977).

FIGURE 3. Effect of pH on the activity of glucanase D-1 (Fulcher and Inkerman, 1976).
enzyme exhibited about 80% of the activity observed at the optimum.

Sucrose had a similar inhibitory effect on all dextranases (Fig. 4). For example, a reduction in enzymic rate of about 15% was obtained at 15° Brix, the approximate value for cane juice. In contrast, the enzymic rate at 70° Brix (equivalent to syrup) decreased in excess of 100-fold over the value at 15° Brix. These results together with the unfavorable pH of syrup indicated an overwhelming preference for mixed juice over syrup as the enzymic addition point (Fulcher and Inkerman).

**FIGURE 4.** Effect of Sucrose Concentration on Dextranase Activity and Viscosity of the medium (Fulcher and Inkerman, 1976).

All enzymes contained insignificant amounts of invertase activity. In comparison, traces of amylolytic activity were detected in Glucanase D-1 and Novo 25L. The importance of the former result is obvious, while the latter can only be of benefit (though there is little solubilization of starch at 60°C).

The final selection of Novo 25L for Australian conditions was based mainly on the observation that this enzyme worked "more efficiently" at lower dextran...
concentration than Glucanase D-1 (Fig. 5 and Fig. 6). In this regard, the majority of recorded cases of deteriorated cane treated with dextranase contained dextran levels of the order of 1,000-5,000 ppm on Brix. Other factors in favor of Novo 25L were its competitive price and the many practical advantages of a liquid enzyme (Novo 25L) over a powder preparation (Glucanase D-1).

**FIGURE 5.** Progress curves for the glucanase — and Novo-Catalysed hydrolysis of Dextran T2000 (Inkerman and Riddell, 1977).

**FIGURE 6.** Progress curves for the glucanase — and Novo-Catalysed hydrolysis of Cane Dextran (Inkerman and Riddell, 1977).
Problems associated with dextran types and sizes

Major problems were predicted by various workers with regard to the probable variability of different types and molecular sizes of dextran entering the factory in deteriorated cane. These were in addition to the variations in dextran levels between and within different rakes of cane (Fulcher and Inkerman\textsuperscript{10}). Thus, development of an enzymic procedure to cover the above variations appeared a formidable task. In addition a study of the above variables would need to be comprehensive (and hence time-consuming) to obtain the necessary information. Fortunately, this proved not to be the true position in practice.

Simple enzymic rate experiments were carried out on dextran-containing juices from a number of different factory areas after adjustment of pH and Brix to 5.0 and 15\%\textsuperscript{o}, respectively. Values for the apparent enzymic rates were within 20\% indicating that as far as the enzyme was concerned, the types and sizes of dextran appeared to be of little consequence. These results were surprising since a number of different species of dextran-synthesizing organisms (\textit{Leuconostoc} and \textit{Lactobacillus}) have been isolated from deteriorated canes and cane juices (McNeil and Inkerman, unpublished).

Recent work on the physicochemical properties of cane dextrans tends to support the above results. Investigations by Covacevich and Richards\textsuperscript{3} and at this Institute (Leonard and Richards\textsuperscript{23}; Blake, unpublished) have established the similarity in structure of a number of stale cane dextrans isolated from a wide range of raw sugars and cane juices, respectively. In the former case, it is assumed that the dextrans isolated from raw sugar are representative of the dextrans present in stale cane juices. Furthermore, the pioneering work of Tsuchiya et al\textsuperscript{34} had indicated that the major factor governing the size of dextran was the sucrose concentration of the biosynthesis medium. Since this is very restricted in mature sugar cane in Australia, no major problems were envisaged in this area. However, it was appreciated at the time that data obtained from biosynthesis experiments in free solution may not apply to the biosynthesis of dextran inside a cane billet. Some aspects of this problem have been discussed in a previous publication, (Fulcher and Inkerman\textsuperscript{10}).

Preliminary molecular weight measurements have been carried out on two samples of cane dextran isolated from quite different sources \textit{viz}, from deteriorated cane juice, at one northern factory and from standing-burnt cane in the central district. A weight-average molecular weight of approximately $5 \times 10^6$ was obtained for each from light-scattering measurements, though, in both cases, the form of the Zimm plot suggested some degree of polydispersity (Crees and Inkerman, unpublished). Extensive studies in this area are planned for dextrans from both green and burnt chopper-harvested canes stored in bins for up to six days (See Table III, Foster et al\textsuperscript{14}).

The apparent similarity in structure and molecular size of stale cane dextrans has been a great practical asset in the implementation of the enzymic process.
Enzyme addition rates can be recommended for the treatment of various levels of dextran in any factory once the residence time available for incubation has been taken into account.

The above situation in Australia may not apply in other countries. For example, variations may occur in dextran structure (which would affect enzymic rate) and in the type of polysaccharide produced in cane (Tilbury and French33, Bruijn1).

(c) Conditions of incubation

The temperature optima of the available commercial dextranases restricted the incubation temperature for hydrolysis of dextran in the factory to about 60°C i.e. 10 to 15°C below the temperature normally used for starch “removal” by the naturally-occurring amylases (Imrie and Tilbury17, Nicholson and Horsley29). Hence, studies were implemented into possible sources of deterioration under the conditions proposed for incubation i.e. in deteriorated cane juice at natural pH and 60°C. Investigations at northern factories in 1973 indicated there was negligible synthesis of dextran in deteriorated cane juices under these conditions (Fulcher and Inkerman19), most probably brought about by denaturation of the existing levels of dextransucrase, the dextran-synthesizing enzyme. In addition, recent laboratory investigations carried out at the Institute have shown that bacterial cell growth does not occur above a temperature of 50°C for all dextran-synthesizing microorganisms (Leuconostoc and Lactobacillus) isolated to date from deteriorated canes and cane juices (McNeil, unpublished). For a variety of reasons, no attempt has been made to control the sucrose losses which obviously occur in deteriorated juice due to microbial and chemical action under these conditions.

These results strongly suggest that dextran synthesis would not be expected to occur in hot clarified juices (pH=7.5, 96-100°C) held for long periods of time or in other factory products due to a combination of high temperatures and Brix. Recent claims to the contrary by Coll et al2 are most probably due to errors in sampling and/or analysis.

(d) Philosophy behind the initial experiments

Rather than carry out a detailed laboratory investigation with the inherent dangers involved in extrapolating the data to the factory environment, full-scale factory trials were carried out in north Queensland during the 1975 crushing season. Various workers had reported that a major processing problem associated with dextran was the large increase in viscosity of factory materials (McCalip and Hall25, Foster et al13, Davis6). Therefore, major benefits were expected in the factory from even partial enzymic hydrolysis of dextran because of the rapid decrease in viscosity resulting from the decrease in molecular size.

The aim of the initial experiment was to obtain “complete removal” in an endeavor to determine the maximum benefits possible from the process (Inkerman and James18). This was virtually achieved in practice viz. dextran removal from...
mixed juice averaged 97.4% for cane with an average dextran concentration of 13,300 ppm on Brix. Unfortunately, recirculation of high dextran-containing stocks already on the pan stage tended to detract from the results. For example, dextran levels in treated syrups increased to about 1,400 ppm on Brix when remelted C-products were added to the syrup tank (Inkerman and James18). Nevertheless, major improvements were observed in overall factory performance and sugar quality. The assessment was based on a comparison with an earlier influx of deteriorated cane to the same factory (average dextran 12,000 ppm on Brix), but to which dextranase had not been added (Wells and James35). The results were more impressive than at first realized, because the recirculated dextran stocks had not been subjected to dextranase treatment and hence would have been of high molecular weight.

Subsequent trials at other factories were used to optimize the process. Incubation times were increased by addition of dextranase to the mixed juice tank, However, accurate temperature control must be maintained on the primary heaters to prevent denaturation of the enzyme. In lieu of the above, enzyme would be added directly to the incubation vessel.

Benefits from the Process

The use of the enzymic process has resulted in considerable improvements in a number of areas of processing. Most of these have been discussed in detail in previous publications (Inkerman and James18, Inkerman and Riddell19). However, at the time, little attention was given to two important aspects, namely clarification and grain elongation.

(a) Clarification of juice and the filterability of raw sugars

The low filterabilities associated with the processing of untreated deteriorated cane are probably the result of poor clarification. Under these conditions, mud and/or flocculant carry over may occur. Davis6 has explained the effect in terms of an interference by dextran in the coagulation process which results in fine suspended matter passing out in the juice from the clarifier. In addition, recent studies have shown that dextran has little effect on the filterability of raw sugar (Fulcher and Inkerman12) as assessed by the method of Nicholson and Horsley28.

In comparison, the turbidities of clarified juice produced from dextran-containing canes improved dramatically upon addition of dextranase at the mixed juice stage of processing. This is an extra factor in favor of mixed juice as the enzymic addition point. However, filterabilities are still 5 to 10 units below the normal factory production figures.

The most severe influxes of dextran are associated with long delays between cutting and crushing due to mechanical breakdowns or industrial stoppages. Under these conditions, various procedures, especially clarification (Davis6) need to be optimized to process these low purity, juices. Failure to carry these out may be responsible, in part, for the observed decrease in filterability (Crees et al5.
In addition, it must be remembered that the comparison of sugar quality had been made between sugars produced from canes which differed by as much as 5 to 7 units of purity. This purity difference is probably responsible for at least part of the observed decrease in filterability. Aspects of this problem are currently under investigation.

Unfortunately, refinery trials have not been carried out on raw sugars produced from enzymed-treated deteriorated cane juices. However, it may be that the sugar will not perform in the refinery to the same standard as the corresponding raw sugars produced from fresh cane juice (Whayman and Meredith36).

(b) Elongation of sucrose crystals

There is overwhelming evidence to suggest that the presence of dextran during processing results in significant elongation of sucrose crystals along the C-axis (Leonard Richards22, Sutherland and Paton32). A comprehensive investigation by Day7 has indicated that a number of parameters affect the rate and extent of elongation. These include (i) dextran concentration and molecular size, (ii) degree of supersaturation, (iii) purity of the growth medium, and (iv) temperature of growth.

Since these parameters undergo considerable interaction in the factory, correlations between dextran concentrations and mean elongation ratios (c/b axes) are not good (Covacevich et al.4). For example, individual analyses of this relationship for the total production from five north Queensland factories during the 1975 crushing season gave similar results. The highest dextran concentration in any instance was no greater than 900 ppm on Brix.

During extensive trials at North Eton during the 1976, 1977 and 1978 crushing seasons, the percentage of elongated crystals was found to be reduced markedly by the addition of dextranase to deteriorated cane juices (Riddell and Inkerman, unpublished). In the boiling process, the degree of elongation was minimal during the period of feeding effect liquor on to the strike. However, on "boil back" of first strike molasses, elongation did become evident. The latter was probably brought about by the presence of dextran-containing stocks on the pan stage prior to enzymic treatment (Inkerman and James18, Inkerman and Riddell19) and the increased concentration of low molecular weight dextran fractions in molasses (due to the removal of sucrose) together with the increased impurity loadings.

The above results apply to situations in which the average size of the dextran molecules had been reduced by enzymic hydrolysis to about the lower limit of detection of the haze method i.e. a molecular weight of approximately $10^4$ (This has been referred to as "complete removal" in earlier publications (Inkerman and Riddell19)). Hence, the author cannot agree with the conclusion of Kelly and Mak20 of the need to achieve complete hydrolysis to the monosaccharide stage to ensure the avoidance of strong needle development.
Severe problems have been observed with elongation under some conditions. For example, in one instance, incoming dextran levels and the corresponding residual levels following enzymic hydrolysis averaged 10,000 and 4,700 ppm on Brix, respectively, by the haze analysis. Subsequently, considerable difficulty was experienced on the pan stage with grain elongation and fine grain. Furthermore, a quantity of low grade massecuite had to be remelted. In contrast, other sugar quality parameters and the viscosities of high-Brix factory products were about normal upon processing this low purity juice i.e. of the order of 5 units of purity below that of fresh cane juice.

Although analysis indicated a 53% reduction in dextran concentration, the approximately normal viscosities suggest that the residual dextran levels must have been of considerably lower average molecular weight compared to those of the incoming juice. This result points out an apparent deficiency in the haze method of dextran analysis, (Geronimos and Greenfield15), though this has not proved to be of any consequence in practical terms.

The above results confirm the earlier findings by Inkerman and James18 that "complete removal" of dextran is not essential in order to achieve major benefits from the enzymic process.

Economics of Dextranase Addition

Generally, dextran levels below an average of 500 ppm on Brix are not treated with dextranase. Successful handling of these levels requires optimum operating conditions on the clarification station although factories with a restricted capacity on the pan stage may experience some difficulties.

Recent calculations have shown that the use of dextranase can be justified solely on economic grounds when the average incoming dextran concentration reaches or exceeds approximately 750 ppm on Brix. The cost of dextranase is balanced by the value of the extra sugar recovered which normally would be lost in the molasses (Miller and Wright27). Obviously, the benefits are greater at higher dextran levels, (Weil and James35), while processing costs decrease with an increase in the incubation time (Fulcher and Inkerman10).

Future Developments

There is a great need for improvements to occur in two areas, namely the cost of enzyme and a higher temperature optimum (70-75°C) for the enzyme. The latter would enable the hydrolysis of dextran and starch to be carried out simultaneously by dextranase and the natural amylases present in cane juice, respectively. During dextranase addition, primary control would have to be lowered to about 60°C which adversely affects starch removal because of the requirement for a high temperature to solubilize the starch granules (Nicholson and Horsely29). Consequently, bacterial amylase would have to be added to the evaporators in order to maintain low starch levels in sugar (Imrie and Tilbury17, Madsen24).
The dextranase process is expected to be in limited operation for a considerable time in Australia. However, should green cane harvesting eventuate, negligible use of the process would be envisaged. Ultimately, these enzymic procedures may be replaced by ultrafiltration processes. The result would be the complete removal of all high molecular weight materials.

General Comments

Use of the enzymic process results in the production of raw sugar of reasonably good quality without the discarding of large quantities of intermediate-purity molasses or the rejection of cane for its dextran content alone. Once the cane has been cut and placed in bins, the preferred procedure is to crush it, rather than have to dispose of the cane physically and, in so doing, create an effluent problem.

The above procedure describes the first industrial application of the enzyme, dextranase. Thus, dextranase joins the rather short list of enzymes for which a viable industrial usage has been found. Further, a comparison with other commercial enzymic processes has indicated that this process (as applied to Australian sugar factories) involves the highest throughout of material treated in the world viz. for a factory crushing 400 tons of cane per hour, this is equivalent to a juice flow rate of approximately 400,000 liters per hour.

The overall use of the process is rather restricted under Australian conditions. In this regard, less than 2% of Australian raw sugar is produced with the aid of dextranase; though, if enzymic treatment had not been carried out, a considerably larger percentage of sugar would have been affected due to the persistence of dextran in the factory well after the initial influx of deteriorated cane (Inkerman and James18). Mill breakdowns, industrial stoppages and unavoidable delays in cane supply are envisaged as conditions under which the process may be used. Recently, burnt chopper-harvested cane which had stood in the field for long periods of time after burning due to wet weather has also been processed successfully (Inkerman and Riddell19).

Regardless of its use, the enzymic process does not overcome the basic problem of deterioration, that is, loss of sucrose.

SUMMARY

The application of dextranase to the factory during the processing of deteriorated cane results in considerable improvements in factory performance and sugar quality. Though turbidities of clarified juice improve dramatically, the filterabilities of the resultant raw sugars are still 5 to 10 units below normal production figures. Hydrolysis of cane dextran to a molecular weight of approximately $10^4$ (designated "complete removal") produces a marked reduction in the percentage of elongated sucrose crystals. In comparison, "partial removal" can result in severe problems with elongated crystals and fine grain, although other sugar quality parameters and
viscosities of high-Brix factory products are about normal.

Initial enzymic rate studies indicated a surprising similarity in molecular size and type of dextrans present in deteriorated cane juices from a wide range of different sources. This has greatly simplified the implementation of the enzymic process to Australian conditions. However, extrapolation of these results to other countries may not be possible.

The properties of commercially available dextranases governed the selection of mixed juice as the enzymic addition point. However, final choice of the particular enzyme was based on the cost and the efficiency of hydrolysis at low dextran levels.

The haze analysis is by far the most suitable method for the estimation of dextran under factory conditions. Criticisms of the method do not hold up in practice mainly because it does give a reliable estimate of the high molecular weight fractions which are responsible for the major processing difficulties associated with this polysaccharide.

REFERENCES


UNA EVALUACION DEL USO DE DEXTRANASA
P.A. Inkerman

RESUMEN

Se hace la revision de los primeros trabajos sobre el uso de dextranas para “eliminar” dextrana de canas deterioradas. Ademas, se evalua el proceso enzimatico en relacion a la experiencia obtenida desde que se establecio este procedimiento en forma rutinaria en los ingenios australianos.

Se logran grandes ventajas en la operacion de la fabrica y en la calidad del azucar con el empleo de este proceso. A pesar de que la turbidez del jugo clarificado aumenta en forma impresionante, la filtrabilidad de los crudos obtenidos es aun 5 a 10 unidades menos que la lograda normalmente.

Los primeros estudios del regimen enzimatico indican que hay una similitud sorprendente en el tamaño molecular y en el tipo de la dextrana encontrada en los jugos de cañas deterioradas procedentes de fuentes muy diversas. Esto ha simplificado mucho la implementacion del proceso enzimatico en Australia. Sin embargo es posible que la extrapolacion de estos resultados a otros paises no de resultado.

Las propiedades de las dextranasas disponibles comercialmente determinan que el jugo mixto sea el escogido para la adicion de la enzima. Sin embargo, la seleccion final de la enzima especifica se basa en el costo y la eficiencia de la hidrolysis a niveles bajos de dextrana.

La baja temperatura de incubacion de 60°C hace recomendable la busqueda de enzimas de bajo costo que puedan actuar a mayores temperaturas.

El analisis de turbidez es sin duda el mejor metodo para estimar el contenido de dextrana en escala industrial. En la practica no son aceptables las criticas al metodo porque tiene el merito de dar un indice confiable del contenido de fracciones de alto peso molecular que son responsables de las mayores dificultades de procesamiento asociados con este polisacarido.