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(Original Article)

A Promising Application of Crude Dextranase Produced by *Aspergillus terreus* and *Aspergillus nidulans var. latus* on Sugar Beet Massecuite and Syrup

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Abstract

In instances of bacterial (primarily *Leuconostoc*) degradation of sugar beet, sugar manufacturers occasionally utilize dextranases to hydrolyze the dextran polysaccharide. Compared to many other industrial enzymes. Consequently, research and development initiatives are underway to acquire dextranase with properties tailored to the specific requirements of beet processing, ensuring efficient and economically viable sugar beet processing. The findings and conclusions from a trial involving the addition of dextranase to sugar beet syrup and massecuite at Delta Sugar Company in Kafr El-Sheikh Governorate, Egypt, are examined, focusing on its effect on factory throughput. The trial demonstrated a significant benefit of using fungi to obtain crude dextranase enzyme, which resulted in increased throughput, reduction in process chemical usage, and improved operational stability. *Aspergillus terreus* and *Aspergillus nidulans var. latus* both worked well, but *Aspergillus nidulans var. latus* worked better because it reduced the amount of dextran in the samples being studied by a larger percentage than the other strain.

Keywords: *Aspergillus terreus, Aspergillus nidulans var. latus, Crude dextranase, Dextran, Dextranase.*

Introduction

Sugar beets are conical plant organs of the biennial plant *Beta vulgaris saccharifera*, which is primarily grown in northern hemisphere climate zones. The first year of vegetation is when roots and leaves grow. The second year of vegetation is when flowering and seed production takes place. The disaccharide sucrose, the manufacturing target and the starting material for beet sugar production, is primarily stored in the roots (Asadi 2007).

More than 130 countries make sugar from either sugarcane or sugar beet. Sugar beet (*Beta vulgaris L.*) is the second most important source of sugar in the world after sugarcane. It provides about 30% of the world's sugar supply and can adapt to a wide

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range of environmental and climate conditions according to Solomon (2011); El-Hag Mohammad *et al*. (2015). Sugar beet is very important in Egypt because it makes up about 62.1% of the country's sugar production (Abazied and Al-Maracy 2023; Mahmoud *et al*., 2021). Its share grew from 20% in 2010/2011 to over 22% in 2019/2020 (Arslanoglu and Tumen 2012). Rodríguez-Entrena and Salazar-Ordóñez (2013) also point out that growing sugar beets could be useful for more than just making sugar.

Despite its economic significance, sugar beet processing faces several challenges that affect overall sugar recovery. Research has found that beets can lose sugar in at least three ways while they are being stored and processed (Liebe *et al*., 2016; Morris *et al.,* 2010). First, microbial spoilage causes sugar loss by breathing and changing sucrose into invert sugar with enzymes (Kenter and Hoffmann 2009). Second, the beet loses sugar through its own breathing, which is thought to be up to 0.5 pounds per ton of beet per day (Asadi, 2007). Third, inside the roots, sucrose can biochemically change into invert sugar and other carbohydrates, which prevents crystallization and makes processing more difficult later on (Eggleston *et al*., 2010). During sugar processing, invert sugars which are primarily glucose and fructose from the hydrolysis of sucrose hinder crystallization by making the sucrose less pure and increasing its viscosity. These monosaccharides have higher solubility than sucrose and interfere with crystal growth by adsorbing onto crystal surfaces, leading to reduced crystal size and lower yields. Additionally, their presence influences the quality of the product by encouraging the formation of color compounds and caramelization products during evaporation (Mutton *et al.* 2010; Eggleston and Vercellotti 2000).

Naessens *et al.* (2005) found that *leuconostoc mesenteroides* releases the enzyme dextransucrase, which plays a critical role essential to these spoiling processes. Under ideal humidity and temperature conditions, it converts sucrose into dextran; furthermore, molasses purity rises by 1% when 300 ppm dextran is added. Increased viscosity, elongated crystals, slowed evaporation, longer centrifuge cycles, and sugar losses into molasses are all consequences of dextran impurities (Bhatia *et al.*, 2010, Jiménez, 2009, Promraksa *et al*.,2009, Kim and Day 2004; Singleton *et al*., 2001).

To stop dextran from building up, the sugar industry uses a number of methods, such as carefully controlling when sugarcane is harvested, milling fresh sugarcane right away, and cleaning equipment every eight hours with steam and biocides (Cuddihy *et al*., 1998). However, the amount of dextran in the juice tends to go up over time, from weak juice to final molasses. This causes problems with viscosity, filtration, and sugar yield.

Dextranase enzymes offer a promising solution by hydrolyzing dextran and reducing its adverse impact on processing efficiency. Although commercial dextranase enzymes are available, they are often costly and may not be optimized for local processing conditions. In this context, isolating native dextranase-producing microorganisms offers a potentially cost-effective and environmentally compatible alternative. Current industrial strategies to mitigate dextran accumulation, such as prompt milling, equipment sanitation, and biocide application, are preventive in nature and only partially effective, especially under conditions of processing delays, high

microbial loads, or suboptimal sanitation (Cuddihy *et al*., 1998). Moreover, these methods do not actively degrade dextran that has already formed, leading to persistent processing challenges such as increased viscosity, poor filtration, and sucrose losses. While commercial dextranase enzymes can address this issue, their use is often limited by high cost, limited local availability, and potential incompatibility with specific process conditions.

This highlights a gap in current mitigation strategies: the need for accessible, cost-effective enzymatic solutions to degrade dextran during processing. Therefore, this study aimed to isolate dextranase-producing fungi from sugar beet agricultural soils and assess the efficacy of their crude enzymes in reducing dextran content in sugar beet massecuite and syrup.

Materials and Methods

Materials

Agar, dextran, blue dextran, DNS (3,5-Dinitrosalicylic acid) were obtained from Sigma Aldrich Company. However, charcoal, phenol, sodium sulfite, sodium hydroxide, potassium sodium tartrate, and HCl were obtained from Elgomhoria Company, Assiut, Egypt.

Sugar beet row juice, molasses, massecuite and syrup samples were obtained from Delta Sugar Company, Kafr El-Sheikh Governorate, Egypt, at the early and late stages of the sugar beet roots harvesting season (2023-2024).

Methods

1. Soil sample preparation

The method described by Wakil *et al*. (2018) was applied with slight modifications as follows: a total of 10 soil samples were collected from agricultural soil (sugar beet roots cultivars) in the Faculty of Agriculture Farm from a depth of approximately 0–15 cm, from five different replicate locations within the farm to account for spatial variability, Assiut Governorate, Egypt. By using sterile tools, pooled samples were placed in labeled sterile plastic bags. To prepare the soil suspension, 1 g of soil was suspended in sterile distilled water (10 ml). Then, it was shaken vigorously for 10 min. to dislodge fungal spores. By using a sterile pipette, 0.1 ml of the soil suspension was transferred onto PDA media.

2. Dextranase production-screening medium

Dextranase production-screening medium was prepared similarly to potato dextrose agar (PDA), but with dextran used as the sole carbon source instead of dextrose. For 1 L medium: 250g of fresh potatoes and 20g of blue dextran were added, then cooked in 500 ml of water for 30: 45 min. After filtration, the pH of the filtrate was adjusted to 5 and then completed to 1L with distilled water. Then, 30 g of agar was added to 1 L of media and dissolved by boiling. After cooling to room temperature, 500 mg of antibiotic Flomax was added to the media and poured into petri plates. Afterward, the soil suspension was evenly spread across the agar and moved clockwise and anticlockwise. Then, they were incubated at 28° C for 7 days.

3. Isolation of fungal strains by primary and secondary screening for dextranase-producing strains.

A total of 24 fungal strains were isolated from the soil sample. The resulting fungal isolates were streaked for purification on the previously prepared PDA and poured into petri plates. Then, they were incubated at 28° C for 7 days. Positive dextranase-producing strains produced a hyaline (clear) zone against the turbid background of this medium. To ensure reproducibility, each screening assay was conducted in triplicate, and the appearance of clear zones was confirmed in independent experiments. Also, negative control plates (without inoculation) were included to monitor any spontaneous degradation of the medium.

4. Identification of Dextranase-Producing Fungi

For identification of the dextranase-producing fungal strain, strain fungi were transferred to fresh PDA plates to obtain pure cultures to isolate single colonies. Pure cultures were examined microscopically to identify characteristic structures of the dextranase-producing fungi. Then, morphological features were identified in Assiut University Moubasher Mycological Centre (AUMMC), Faculty of Science, Assiut University, Egypt.

5. Culture conditions for crude dextranase production

For preparing spore suspension, the previously prepared media was poured into tubes and autoclaved followed by cooling as slant agar. Then, a separate colony of each isolate was subcultured on the slant agar tubes. Inocula were prepared by cultivating fungal isolates on PDA slants and incubating them at 28°C for 7 days (Wu *et al*., 2011). After incubation, 5 ml of sterile distilled water was added to each slant, and the surface was gently scraped to suspend the spores, thus preparing a spore suspension for subsequent use in crude dextranase production.

To produce crude extracellular dextranase, the liquid culture medium PDB (Potato Dextran Broth) was prepared as PDA as previously mentioned, however, without agar according to Netsopa *et al*. (2019) with slight modifications. The previously prepared spore suspension (1 ml) was suspended in 100 ml of PDB medium (in a 250 ml Erlenmeyer flask), followed by incubation in a rotary shaker at 120 rpm on 28°C for 7 days to allow fungal growth and enzyme production. Also, in parallel, control flasks containing only PDB medium without fungal inoculation were incubated under the same conditions to account for any non-biological changes or background enzyme activities. All fermentations were performed in triplicate. Afterward, the content of each flask was filtered. The filtrates were collected, which contain extracellular enzymes, followed by centrifugation at 10.000 rpm for 20 min (Wu *et al*., 2011; Subasioglu and Cansunar 2010) with slight modifications, and stored at −20°C on glycerin bases until further analyses of dextranase production.

6. Application of crude dextranase enzyme on sugar beet massecuite and syrup

A volume of 15 ml of crude enzyme was added to each 50 ml aliquot of the diluted (1:1) syrup and massecuite solutions. The sample-crude enzyme mixtures were shaken

at 120 rpm at 30ºC and incubated for 24 h according to Bhatia *et al*. (2016) with slight modifications.

7. Determination of dextranase activity

Dextran determination by HPLC

Dextran was determined before and after the application of crude dextranase in sugar beet syrup and massecuite using HPLC equipment. It consists of a Gilson manometric module (model 802 C), a pump (model 302), a refractive index detector, and an ion exchange column (Interaction, model 300); connected to a PC at National Research Centre, Cairo, Egypt.

Reducing sugar determination by DNS

Reducing sugars were determined in sugar beet raw juice, syrup, massecuite, and molasses (early and late harvesting season) by the DNS (Dinitrosalicylic acid) method (Miller 1959). As an indicator for dextranase activity, also, non-reducing sugars (sucrose) were determined by the same method after adding 0.5 ml of HCl 1 N and heating in a water bath for 1hour. Then, the DNS method was performed again. Sucrose content was calculated by the difference as follows:

Total sucrose content =

Reducing sugars value (After hydrolyses)-reducing sugars value (Without hydrolyses)

Dinitrosalicylic acid reagent (DNS)

Dinitrosalicylic acid; 10 g, phenol; 2 g; sodium sulfite; 0.5 g, sodium hydroxide; 10 g, and distilled water to complete 1 L. Potassium sodium tartrate solution: 400 g of potassium sodium tartrate was dissolved in distilled water and the volume was made to 1 L.

Preparation of samples for DNS method

Sugar beet massecuite, syrup, and molasses samples were mixed well. Then, 30g of mixed samples were diluted to 100 ml with distilled water (w/v). Activated carbon (charcoal) at 8% was blended with diluted samples. The mixture was heated up to 75º c for 1 hour, and coagulated protein and plant pigment caused it to float to the surface and form a scum on top of the flask. This layer is skimmed off by hand, according to El-Geddawy *et al*. (2014), the mixture was left to cool at room temperature for 30min, and the treated samples were centrifuged for 10 min at 4000 rpm and then filtrations with filter paper.

Procedure

Dinitrosalicylic acid reagent (3 ml) was added to the reaction mixture. The test tube containing this mixture was heated in a boiling water bath for 15 minutes, and then 1 ml of 40% potassium sodium tartrate solution was added to stabilize the color. After cooling to room temperature in a cold-water bath, the absorbance was measured by spectrophotometer at 545nm. One unit (U) of dextranase enzyme activity was defined as the amount of enzyme required to catalyze the formation of 1 mol of glucose in 1 min at standard assay conditions (U/m).

Results and Discussion

Dextran, a polysaccharide produced by certain bacteria such as *Leuconostoc mesontroids*, can significantly impact sugar beet processing if bacterial contamination occurs (El-Geddawy *et al*., 2024). Its presence in the production process leads to increased viscosity in sugar juices, which disrupts the normal flow and handling of the liquid streams. This results in difficulties during filtration, evaporation, and crystallization, reducing the overall efficiency of sugar extraction and increasing production costs (Abdel-Rahman *et al*., 2008). Dextran can also decrease the purity of the final sugar product, as it interferes with sucrose crystallization (Promraksa *et al*., 2009). To mitigate these issues, sugar beet manufacturers employ strategies like adding dextranase enzymes to degrade dextran or enhancing sanitation protocols to limit bacterial contamination during processing (Batista *et al*. 2021).

Isolation and identification of dextranase-producing fungi

From Fig 1, the two species of Aspergillus were obtained from cultivated soil samples: *Aspergillus terreus and Aspergillus nidulans var. latus. Aspergillus* section *Terrei* includes species with columnar conidial heads in shades of buff to brown. The most important species of this section is *A. terreus*, which is a ubiquitous fungus in our environment. Strains of this cosmopolitan species are frequently isolated from desert and grassland soils and compost heaps, and as contaminants of plant products like stored corn, barley, and peanuts. Conidiophore stipes are smooth-walled, hyaline. Vesicles are hemispherical, metulae are present, conidial heads compactly columnar, conidial masses buff, cinnamon, to orange-brown. Hülle cells are absent, but globose to ovate, relatively heavy-walled hyaline cells formed from submerged hyphae. Colonies velvety, conidial heads long, compactly columnar, in cinnamon to orange-brown or brown shades; born on short conidiophores *A. Sclerotium*-like masses of swollen, relatively heavy-walled cells lacking on MEA. These findings were consistent with those obtained by (Moubasher *et al.,* 1972; Fennell and Raper 1955) from soil samples such as *A. terreus var. africanus.*

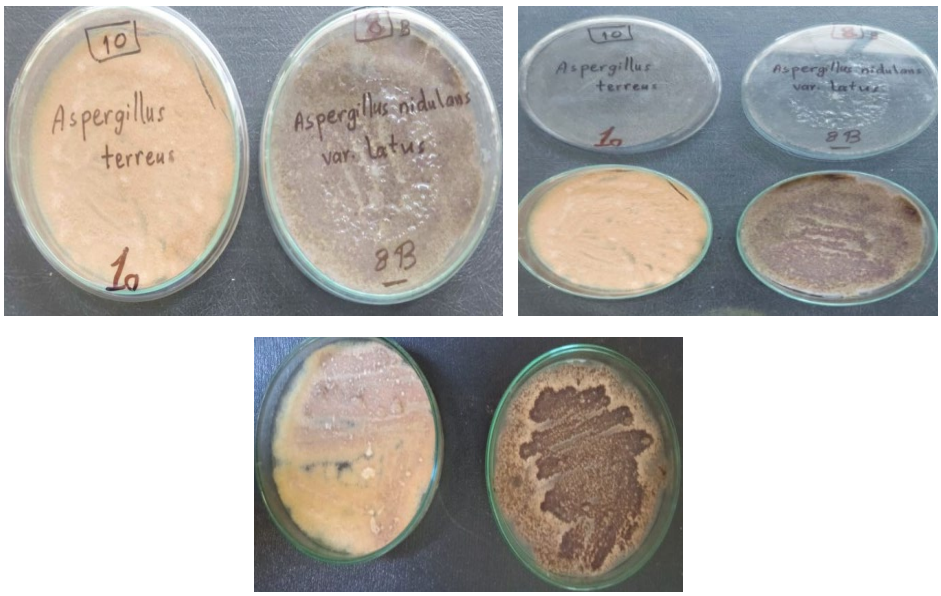

Figure 1. Secondary screening of the two target genera isolated from *Aspergillus* species.

Determination of dextranase activity

Dextran content in sugar beet processing streams, including juice, syrup, massecuite, and molasses, is closely linked to the concentration of reducing sugars. Dextran, a polysaccharide primarily composed of glucose units, is produced by microbial contamination, particularly by *Leuconostoc mesenteroides*, under conditions that favor sucrose hydrolysis (Jiménez 2009). The formation of dextran reduces sucrose availability and increases reducing sugars, such as glucose and fructose, due to enzymatic breakdown and microbial metabolism. High dextran concentrations lead to increased viscosity and processing difficulties, negatively affecting crystallization during massecuite formation and reducing sugar recovery efficiency. In molasses, elevated dextran and reducing sugar levels further complicate sugar extraction and decrease overall yield. Therefore, monitoring and controlling dextran and reducing sugar content throughout sugar beet processing are critical to maintaining product quality and maximizing recovery.

Dextran determination by HPLC in sugar beet syrup and massecuite

Crude dextranase enzyme was produced from both strains (*Aspergillus nidulans var. latus and Aspergillus terreus)*. Data displayed in Table 1 showed the dextran content in massecuite A, syrup A (control samples), massecuite T, syrup T (samples treated with dextranase enzyme produced by *Aspergillus terreus*) and massecuite N and syrup N (samples which were treated with dextranase produced by *Aspergillus nidulans var. latus*). Massecuite A and syrup A samples contained the highest amount of dextran (8.801 and 6.735 g/L, respectively). Meanwhile, massecuite and syrup treated with dextranase produced by *Aspergillus terreus* had moderate levels of dextran (6.176 and 5.513 g/L, respectively). This occurred due to the dextran hydrolysis by dextranase produced by *Aspergillus terreus*. On the other hand, massecuite and syrup treated with dextranase produced by *Aspergillus nidulans var. latus* exhibited the lowest levels of dextran content (5.280 and 4.272 g/L, respectively). This suggests that *A. nidulans* may produce a more active or efficient dextranase enzyme. The better performance could be due to several factors, such as higher enzyme secretion, better stability under processing conditions, or a stronger ability to break down the dextran polymer. Additionally, *A. nidulans* is known to produce a wide range of carbohydrate-degrading enzymes, which may enhance its dextran-hydrolyzing capability. Further studies would be needed to characterize the enzyme properties in detail, but the current findings clearly indicate that *A. nidulans* var. *latus* is a promising candidate for industrial dextranase production. Moreover, the crude version of dextranase produced by *A. nidulans* confirms that crude dextranase enzyme from microflora could effectively eliminate dextran that affects sugar production in sugar factories.

Sufiate *et al*. (2018) treated raw juice, clear juice, and syrup with a commercially available dextranase enzyme from *Paecilomyces lilaceous* (79.5u/mg). The use of dextranase enzyme to extract dextran from raw juice proved more efficient and cost-effective than incorporating it into clear juice and syrup. Dextranase was given at a concentration of 20u/100mL raw juice and incubated for 30 minutes, resulting in 60% dextran elimination (Abd Alraoof *et al*., 2021).

Table1. Dextran content (g/L) in sugar beet massecuite and syrup samples by HPLC before and after crude dextranase enzymes application.

Sample	Dextran Concentration (g/L)	%Dextran removal
Massecuite A	8.801	-
Massecuite T	6.176	29.8
Massecuite N	5.280	40.0
Syrup A	6.735	-
Syrup T	5.513	18.1
Syrup N	4.272	36.5

*A indicates the control sample, T indicates the treatment by dextranase enzyme produced by *Aspergillus terreus*, and N indicates the treatment by dextranase enzyme produced by *Aspergillus nidulans var. latus.*

Under varied conditions in clear juice, Abd Alraoof *et al*. (2021) revealed that the dextran concentration was reduced to 65% with 30 units. After 10, 20, and 30 minutes of incubation with the dextranase enzyme at 30u/100mol, the percentage of dextran reduction reached 25, 27, and 45%, respectively. The use of dextranase enzyme to extract dextran from raw juice proved more efficient and cost-effective than incorporating it into clear juice and syrup. On the other hand, in our investigation, in syrup A sample which was manipulated by dextranase enzyme produced by *Aspergillus terreus*, dextran content reduced by 18.1% and 36.5% when dextranase enzyme from *Aspergillus nidulans var. latus* was applied on syrup samples, respectively. The difference between the obtained results and other researchers' results might occur due to the state of the enzyme. Previous research discovered that commercial dextranase enzyme eliminated a greater amount of dextran than crude dextranase enzyme. Meanwhile, most of the dextran hydrolysis happened at commercial dextranase concentrations ranging from 4 to 80 mg/L, and techno-economic returns decreased as retention duration and dextranase concentration increased (Eggleston and Triplett 2024).

Additionally, in our investigation, we found that in massecuite A sample which was manipulated by dextranase enzyme produced by *Aspergillus terreus*, dextran content was reduced by 29.8% and 40% when dextranase enzyme from *Aspergillus nidulans var. latus* was applied to masscuite samples, respectively. Based on our current knowledge, results showed that commercial dextranase enzyme displayed a higher percentage of dextran removal compared to the obtained data when crude dextranase enzyme from *Aspergillus nidulans var. latus* and *Aspergillus terreus* was applied, respectively.

The superior performance of the crude dextranase enzyme produced by *Aspergillus nidulans var. latus*, as evidenced by higher dextran removal percentages in both syrup (36.5%) and massecuite (40.0%) compared to *A. terreus* (18.1% and 29.8%, respectively), may be attributed to inherent biochemical differences between the enzymes produced by the two fungal strains. One possible explanation lies in the difference in enzyme activity levels, where *A. nidulans* var. *latus* may produce higher amounts of extracellular dextranase or an enzyme with greater catalytic efficiency (k_cat/K_m) under the specific fermentation and application conditions used in this study.

Moreover, substrate specificity may also play a critical role. Dextranases differ in their mode of action, with some exhibiting endo-activity (cleaving internal α-(1→6)-

glycosidic bonds) and others displaying exo-activity (cleaving from non-reducing ends). If the dextranase from *A. nidulans* var. *latus* exhibits stronger endo activity or a broader substrate recognition profile, it could hydrolyze more complex or branched dextran structures present in sugar beet syrup and massecuite more effectively than the enzyme from *A. terreus* (Pittrof *et al*., 2021).

Additionally, enzyme stability under processing conditions, including resistance to temperature, pH fluctuations, and potential inhibitors in the beet matrix can influence enzymatic effectiveness. The dextranase from *A. nidulans var. latus* may retain its activity longer or under a wider range of operational parameters, thereby contributing to its higher efficacy (Jiménez 2009). Prior studies have shown that even small variations in glycosylation, folding, or molecular weight among dextranases can significantly affect their performance in complex food systems (Zhang *et al*., 2019).

Although further purification and characterization studies, including enzyme kinetics and thermostability profiling, would be required to definitively confirm these hypotheses, the observed differences support the potential industrial applicability of *A. nidulans* var. *latus* as a more effective source of crude dextranase for use in sugar beet processing.

Meanwhile, Abd Alraoof *et al.* (2021) discovered that the presence of dextran gum might create the most significant processing issues. The use of dextran in sugar processing decreases sucrose while posing issues for sugar producers by raising viscosity, lowering sugar output, improving molasses purity, and delaying filtering. They also found that employing dextran enzyme to remove dextran from raw juice was more efficient and cost-effective than adding it to clear juice or syrup. Dextranase was added at a concentration of 20u/100mL raw juice and incubated for 30 minutes, resulting in 60% dextran removal.

Reducing sugar determination by DNS

According to Kenter and Hoffmann (2006), the concentration of sucrose in sugar beets develops in the opposite direction as the melassigenic components between June and October. Seasonal patterns of conventional parameters (potassium, sodium, and α-amino nitrogen) reflect the course of non-conventional components. However, growth conditions may induce variations in absolute concentration levels.

Sugar concentrations in beetroots appear to be very unpredictable before the processing campaign, fluctuating throughout the growing season until the end. Storage conditions on the farm or at the plant may also affect beet quality and hence processing capacity after harvest. Throughout the season, no influence of weather conditions on quality development was seen. If sucrose and reducing sugar concentrations are known ahead of time, the demand for processing aids in a sugar plant may be predicted before processing begins (Kenter and Hoffmann 2006).

The data in Table 2 illustrate the changes in reducing sugars and sucrose concentrations across different processing stages (juice, syrup, massecuite, and molasses) of sugarcane during early and late harvesting seasons.

Late-season samples exhibit higher concentrations of both reducing sugars and sucrose compared to early-season samples in most stages. For instance, in juice, reducing sugars increase from 1.91±0.32 g/L in the early season to 5.74±0.75 g/L in the late season, while sucrose rises from 139.17±19.14 g/L to 157.23±19.47 g/L. Similarly, syrup and massecuite from the late season have markedly higher reducing sugar and sucrose levels than there early-season counterparts. Molasses, as the final product, shows a substantial accumulation of reducing sugars (160.53±25.35 g/L late season vs. 107.78±12.57 g/L early season), though sucrose content is slightly higher in late-season samples. These results suggest significant seasonal variations, with late-season processing yielding products richer in both reducing sugars and sucrose.

Table 2. Sucrose and reducing sugars content as g/L (Av±SD) during beet sugar manufacturing by DNS method at early and late season

	Late season		Early season	
	Reducing sugars	**Sucrose**	**Reducing sugars**	**Sucrose**
Juice	5.74±0.75	157.23±19.47	1.91±0.32	139.17±19.14
Syrup	15.18±3.82	748.46±52.27	5.15±0.89	623.22±46.35
Massecuite	10.11±1.91	618.84±41.58	5.63±1.12	524.79±32.28
Molasses	160.53±25.35	472.12±36.91	107.78±12.57	446.38±41.57

The observed changes in reducing sugar and sucrose concentrations between the early and late seasons indicate how harvest time affects sugar beet root composition and processing efficiency. Late-season samples exhibited consistently higher levels of reducing sugars and sucrose throughout the processing phases. This development can be attributed to increased photosynthetic activity and a longer maturation period, which increases sucrose accumulation in sugar beet roots (Mohamed *et al*., 2023). Furthermore, the increase in reducing sugars in late-season samples might be attributable to sucrose hydrolysis produced by enzyme activity during storage and processing in warmer conditions, which occur more often later in the harvest season (Van Heerden *et al*., 2013). The increased sucrose content in late-season syrup and massecuite may improve sugar recovery efficiency, while higher reducing sugar levels in molasses may cause problems in downstream applications like ethanol production, where inhibitory effects are anticipated. These findings emphasize the need to optimize harvest and processing schedules to balance sugar yield and quality (Eggleston and Monge 2005).

Conclusions

This study highlights the significant potential of using crude dextranase produced by *Aspergillus terreus* and *Aspergillus nidulans var. latus* in enzymatic dextran removal during sugar beet processing. Both strains effectively reduced dextran content in massecuite and syrup samples, with *A. nidulans var. latus* shows slightly superior dextranase activity. The crude dextranase exhibited promising activity, with *A. nidulans* var. *latus* achieving up to 40.0% dextran removal in massecuite and 36.5% in syrup. These results suggest a potential for application in sugar processing industries, particularly for mitigating processing losses associated with dextran accumulation. The findings demonstrate that crude dextranase enzymes derived from these strains offer a

cost-effective and economic alternative for controlling dextran levels, thereby improving sugar yield and quality compared to commercial dextranase enzymes. Seasonal variations in sugar composition also influenced processing efficiency, with late-season samples exhibiting higher sucrose and reducing sugar concentrations, likely due to prolonged maturation and enzymatic activity during warmer conditions. Future research should focus on optimizing the application of crude dextranase enzymes to enhance further their efficacy, economic viability, and feasibility in industrial sugar production during processing. However, this study also has limitations. The use of crude enzyme preparations may lead to batch variability, and the lack of pilot-scale or industrial trials limits direct scalability. Additionally, enzyme activity under industrial conditions was not fully characterized. Therefore, future work should focus on enzyme purification and kinetic characterization to understand catalytic mechanisms, explore genetic or fermentation-based improvements to enhance yield and stability, and conduct pilot-scale validation to assess practical feasibility. A comprehensive cost-benefit analysis will also be essential to support commercial adoption of soil-derived fungal dextranases. These results contribute valuable insights and promising approaches to managing microbial contaminants and maximizing sugar recovery during beet sugar manufacturing.

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تطبيق واعد للديكسترانيز الخام المنتج بواسطة *Aspergillus terreus* و *Aspergillus nidulans var. latus* على ماسكويت وشراب بنجر السكر.

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الملخص

في حالات التحلل البكتيري (وخاصةً *Leuconostoc*) لبنجر السكر، يستخدم مصنعو السكر أحيانًا انزيم دكسترانيز لتحليل بوليمر الدكستران. مقارنة بالعديد من الإنزيمات الصناعية الأخرى ونتيجة لذلك، تجرى حاليا مبادرات البحث والتطوير للحصول على دكسترانيز بخصائص مصممة خصيصا لتلبية المتطلبات المحددة لمعالجة البنجر، مما يضمن معالجة فعالة ومجدية اقتصاديا لبنجر السكر. تم فحص النتائج والاستنتاجات من تجربة تتضمن إضافة الدكسترانيز إلى شراب بنجر السكر والماسكويت في شركة الدلتا للسكر بمحافظة كفر الشيخ، مصر، مع التركيز على تأثيرها على إنتاجية المصنع. أظهرت التجربة فائدة كبيرة لاستخدام الفطريات للحصول على إنزيم الدكسترانيز الخام، مما أدى إلى زيادة الإنتاجية، وتقليل استخدام المواد الكيميائية في العملية، وتحسين الاستقرار التشغيلي. كل من *Aspergillus terreus* و*Aspergillus nidulans var. latus* عملتا بشكل جيد، ولكن *Aspergillus nidulans var. llatus* كانت أفضل لأنها قللت كمية الدكستران في العينات التي تم دراستها بنسبة أكبر من السلالة الأخرى.

الكلمات المفتاحية: *الدكستران، الدكسترانيز، الدكسترانيز الخام، Aspergillus terreus, Aspergillus nidulans var. latus,*