

# Assessment of the Effect of Transit Time Between Harvesting and Processing on the **Physicochemical** Quality Parameters of Preharvest Burnt Sugarcane

## Abstract

**Aim:** This study was aimed at assessing the effect of time interval between harvesting and processing on the physical and chemical quality parameters of pre-harvest burnt sugarcane

**Study design:** A **qualitative experimental study design** was carried out that involve random selection of samples and sent to laboratory for analysis

**Place and Duration of Study:** The study was carried out on July from 26<sup>th</sup> to 30<sup>th</sup> 2023 in Kilombero Valley located in the eastern part of Tanzania, between latitude 7 0 42'42'S and longitude 37 0 00'00'E.

**Methodology:** The NCO 376 variety of sugarcane used, that were cut below ground level, the tops removed, stalks tightened in bundles. The sample size was 15. each sample constituted of 30 burnt sugarcane stalks samples that were randomly collected and sent to laboratory for analysis after 24, 72 and 120 hours of storage. On every respective storage time, the samples were scratched with knife to remove external contaminants, the stalks were then milled using two roller machines to extract juice. The juice was filled and sealed in sterilized and labelled bottles ready for laboratory analysis. **The laboratory analysis data collected were coded and entered in excel sheet and analysed using Statistical Package for Social Science (SPSS) version 26.**

**Result:** The result shows the means values for pH, brix, pol, purity and weight decreased with increase in storage time whereas the means values for dextran, yeast and *Leuconostoc* increased with increase storage time. The results revealed that purity values were satisfactory in all storage time levels as compared to SASTA standard purity values (97.0 – 98.0%), whereas mean values for brix and pol stored for 120 hours of storage time was not satisfactory as compared to SASTA standard values for brix (18 – 23%) and pol (14 – 21%). Dextran concentration was high as compared to South African Sugar Terminals (SAST) that maximum requirement for dextran is 150 mg/kg, dextran level as the measure of microbial deterioration was high in 72 and 120 storage hours indicating microbial contamination

**Conclusion:** Farmers and processors should be well informed about the consequence of delayed processing burned sugarcane to avoid economic loss for farmers and processors

**Key words:** *S. officinarum* deterioration, storage time, physical, biochemical changes, pre-harvest burning

## 1. INTRODUCTION

Sugarcane (*Saccharum officinarum*) is an important economic crop used for food and fuels. It is a member of the *Poaceae* family and grows in tropical and subtropical climates ([1]. It is composed of water (65-75%), sugars (11-18%), fibres (8-14%), and other soluble solids (12-23%) [2]. Sugarcane is very perishable and its quality deteriorates soon after harvest. Post-harvest deterioration of sugarcane includes both qualitative and quantitative changes. These changes include formation of organic acid, decrease in weight due to water loss and loss of sugar concentration which in turn affect farmers' income as they are paid based on sugar per ton. In addition, the deterioration rate increased as a result of preharvest burning, cut to mill delays, and microbial infection [3]. Because sugarcane contains high water content (65-75%), it is very susceptible to microbial growth that in turn utilizes sugar content such as sucrose and reduces the quality of final product. Thus, proper monitoring of sugarcane soon after harvest to ensure the quality of final sugar. Moreover, the quality of sugarcane depends on weight and sugar concentration which are used to establish selling price. In sugarcane sugar concentration is determined by either °Brix, as a measure of soluble solids content, or Polarization (pol), a measure of sucrose [4].

In Tanzania, sugarcane is an agricultural crop grown in Morogoro, Kagera, Kilimanjaro, and the coastal regions of Tanzania. The sugar production is reported to be 378,000 metric tons which is still inadequate as compared to the estimated demand of 470,000 metric tons in 2020 [4], [5]. In addition, productivity per hectare is also reported to be poor [6]. Kilombero Sugar Company is Tanzania's largest sugar producer, accounting for 45% of total sugar production [7]. It produces 128,000 metric tons of sugar where 40% of raw sugarcane is supplied by farmers and 60% by the company itself [8].

Post-harvest loss is among the main causes of low sugar yields. Sugarcane post-harvest deterioration is hugely concerning to the sugar industry, whereby the delay between cutting and milling has been identified as a major cause of postharvest degradation [9]. This delay has a direct impact on the composition of sugarcane [1] and is linked to the presence of simple sugars [10]. Reducing downtime between harvest and processing is a win-win situation for both producers and processor [11]. According to [11], the acceptable harvest to crush delay is between 4 to 6 days for South Africa, about 3 to 10 days for sub-tropical India, and around 36 to 48 hours for tropical India. Moreover, the average time between burn and crush, ranges from 2 to 4 days and is common in most sugar companies [12].

Sugarcane preharvest burning is a popular traditional practice aimed at easing harvest and transport operations and hence lowering harvesting costs [13]. The practice eliminates the leaves from the sugarcane stalk, making the manual cutting procedure easier [14]. Similarly, preharvest burning facilitates the exercise of harvesting, transportation and cleaning millable stalk [15]. However, despite its benefits, sugarcane preharvest burning has been shown to reduce sugar recovery and processing efficiency if the cane is delayed delivery to processing facilities [16].

Dextran is a bacterial polysaccharide compound that occurs in deteriorating sugarcane. It is structurally made up of D-glucose with  $\alpha$ -1,6- glucopyranosidic linkages within the main chain. Dextran is known to cause poor filtration, reduced evaporation and poor crystallization. Eventually causing sucrose losses which contribute to

economic losses[17]. The burning of sugarcane prior to harvesting and mechanical harvesting is described as facilitating the invasion of sugarcane by microorganism particularly *Leuconostoc spp* responsible for sucrose damage leading to the formation dextran. The reaction for the formation of dextran is catalyzed by dextransucrase the enzymes that is produced by *Leuconostoc spp*. The presence of dextran indicates the presence of microorganisms that cause sucrose inversion [18]

The duration between harvesting and milling has an impact on quality of sugarcane as a raw material for sugar processing. Some studies found that delayed delivery of harvested burnt sugarcane on time for milling has significant effect such as lower brix and sugar content, reduced purity, and sometime weight loss[19]. This has a severe impact on sugar quality and economics for both sugarcane manufacturer and producers/farmers[20];[21]

Several studies have been conducted on the influence of storage temperature from harvesting to processing burned sugarcane, with the majority of them focusing on sugarcane juice as a drink [1]; [22]; [23];[24]. However, limited studies have been conducted on the effect of time intervals (storage time) between harvesting and processing burned sugarcane at ambient temperature in tropical conditions. Moreover, the ambient temperature varies greatly from one sugar factory to another. Thus, the objective of this study is to determine effect of different storage times after harvesting burnt sugarcane on quality of sugar production. The study's findings are essential for the scientific community (processors) and sugarcane producers (farmers) as they will provide insight into how the time gap between the harvesting and processing process affects the physicochemical quality characteristics of sugarcane and suggest the minimum time required for maintaining the physicochemical quality of sugarcane as the raw material required for sugar production.

## MATERIALS AND METHOD

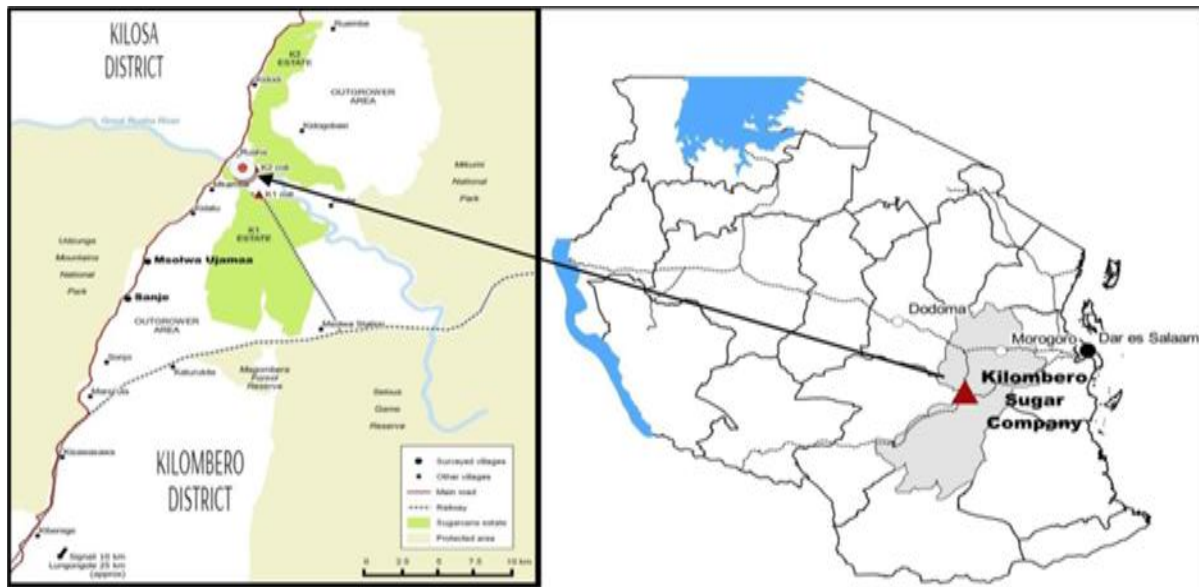
### 2.1 Experimental design,

A qualitative experimental design was used to determine the effect of storage time on the physical, chemical and microbial properties of harvested burnt sugarcane. Three different storage time were selected (24, 72, and 120 hours) as independent variables. Storage time has been selected on the basis of various studies that show harvesting, transportation, milling and other factors that are out of human control like weather condition take time. Moreover, sugarcane farms are located at varying distance combining these factors together contribute to a significant delay in processing. With regard to Kilombero Sugar Company, the acceptable range time from burn to crush is five days. The dependent variables studied were pH, brix (as a measure of total soluble solids), purity, weight, pol and microbial infestation (i.e., yeast and *Leuconostoc mesenteroides*).

### 2.2 Study area

The study was carried out on July from 26<sup>th</sup> to 30<sup>th</sup> under environmental field condition where the minimum temperature ranged from 15.4 -19.0 °C and maximum temperature ranged from 28.5-29.5 °C

The research was carried out in Kilombero Valley, where sugarcane is cultivated. It is located in the eastern part of Tanzania, between latitude 7 0 42'42'S and longitude 37 0 00'00'E. The Valley comprised of two close agricultural estates and sugar mills, Msolwa (in Kilombero district) and Ruembe (in Kilosa district), which are located on opposing banks of the great Ruaha river and are linked together by a low-level bridge. Kilombero agricultural estates comprise more than 8,000 sugarcane growers



**Figure 1.** Map of study area Kilombero Valley. [25]

### 2.3 Sample size estimation

The variety of sugarcane used in this study was NCO 376. The estimated sample size was 15 which represents different sugarcane farms (each farm equivalent to one acre) owned by different farmers. Each sample constituted of 30 burnt sugarcane stalks samples that were randomly collected and sent to the Department of Food Science and Agroprocessing laboratory for analysis after 24, 72 and 120 hours storage. The samples (15) were estimated using Kothari and Garg, (2014) as per equation 1

$$n = \frac{Z^2 * P(1-P)}{e^2} \dots\dots\dots 1$$

Where; n = sample size, Z = Standard variant at a given confidence level, for this study a 95% confidence level = 1.96, P = Standard deviation that will show how much the results will vary from each other and the mean number for this study (0.05) was used and e = acceptable error (the precision/ estimation error) is 0.11 for this study.

$$n = \frac{1.96^2 * 0.05(1-0.05)}{0.11^2} = 15 \dots\dots\dots 2$$

The samples of sugarcane stalks were cut below ground level, the tops removed, and the stalks tightened in bundles and packed in perforated nylon bags for

transportation. The transportation took three hours, counting of the storage time after cutting the Sugarcane stalks. The samples were scratched with knife to remove external contaminants, the stalks were then milled using two roller machines to extract juice. The juice was filled and sealed in sterilized and labelled bottles

## 2.4 Data collection

### 2.4.1 Brix determination

Brix (total soluble solids) of extracted burnt sugarcane juice was measured using an Atago 3810 PAL-1 Digital Hand-Held Pocket Refractometer manufacture by Cole-Parmer. Calibration was performed prior to measuring the brix by zeroing the refractometer with distilled water. The recorded value was used as the water blank when the measurement was not 0.00°Bx at 20.0°C. The sample was put into the refractometer cell compartment in three sections and when the temperature stabilized at 20.0°C, the reading was recorded.

### 2.4.2 Polarization determination

Polarization (abbreviated as pol) refers to the actual sucrose content expressed as a mass percent and determined by polarimeter by the optical rotation of polarized light flowing through a sugar solution. Polarization determines the purity of the sugar and provides the sucrose content as a mass percentage. It is the major benchmark used to determine the quality of the sugar. Sugar crystal is very near to 100% pure sucrose, pol is a good measure. The greater the polarization, the purer the sugar; the lower the polarization, the more the impurities in the sugar

Pol is determined according to **South Africa Sugar Technologist Association Method, (2005)**. Pol is an estimation of sucrose concentration. The pol was determined as per the [26] The polarimeter was used to determine the pol of the burnt sugarcane juice. The juice was clarified with lead sub-acetate powder before being filtered with paper (Whatman No. 91, S&S 3000). Then cleaned, the first 15 cm<sup>3</sup> of filtrate was discarded, and then 60 cm<sup>3</sup> was collected in a clean, dry beaker. After calibration of the polarimeter, the filtrate was put into the pol tube in three equal portions to achieve full displacement of the previous solution. Once stabilized, the reading was recorded. The polarimeter measurement was observed and recorded.

The polarimeter reading obtained, was then used in the formula for pol determination as per the Schmitz equation [26]

$$pol = \frac{\text{polarimeter reading}}{0.0000576 * Brix^2 + 0.014752 * Brix + 3.83545} \dots\dots\dots 3$$

### 2.4.3 Purity determination

The purity was determined as per **South Africa Sugar Technologist Association Method, (2005)**. Purity was determined based on the pol value and brix value as indicated by the Schmitz equation [26]

$$Purity = \frac{Pol}{Brix} * 100 \dots\dots\dots 4$$

### pH determination

The pH meter of the Edge Model HI2020 product of HANNA manufacturer was first calibrated at room temperature with buffer solutions of pH 4.00 and 7.00. About

200ml of juice was mixed in a 250 ml beaker before dipping the pH meter's glass electrode into it. The pH reading was taken when the pH meter was steady.

#### **2.4.4 Weight changes determination**

Weight changes were determined after 24, 72, and 120 hours of storage using the laboratory analytical balance 200G/0.001G model manufactured by WANT Balance Instrument Co., Ltd. Six sugarcane stalks were selected at random from each sample, chopped into sections of 25 to 30 cm length to facilitate weighing and kept under ambient environmental condition. A laboratory weighing balance was used to quantify the weight in grams of sample. The weighing balance was calibrated to zero to ensure correct reading. The weight of 30 bundles were weighed and recorded as per storage time.

#### **2.4.5 *Leuconostoc mesenteroides*.**

Detection of *Leuconostoc mesenteroides* bacteria producing dextran Preparation media and culturing was undertaken as follows: 23.5 grams from Sucrose Agar Media (S.A.M) Media was weighed and dissolved in 1000 ml of distilled water in a conical flask and then placed in a water bath at 40°C for 10 minutes to dissolve the media. Then the media was placed in an autoclave for 20 minutes after reaching temperature 121°C and pressure of 15bar, the media was removed and cooled at 40°C. After the inoculation of 1ml on each petri dish, 15 ml of Sucrose Agar Media prepared above was poured into each Petri dish. All dishes were left for about 30 minutes at room temperature to solidify and then all Petri dishes were incubated at 31°C for 72 hours. Colonies were counted after 72 hours and results were expressed as colony-forming units per milliliter (CFU/1ml), (ICUMSA)

#### **2.4.6 Yeast**

The yeast was determined according to ISO 21527 -2:2017 with some modifications. A 10mls sample was placed in a sterile sample bottle, then 90ml of sterile peptone water was added and mixed by shaking for two minutes to obtain first dilution, 1:10, and by using a micropipette of 1ml other dilutions 1:100, and 1:1000, were done, in which 1ml of  $10^{-1}$ ,  $10^{-2}$  and  $10^{-3}$  dilutions in duplicate were inoculated in the sterile petri dish, Molten Potatoes Dextrose Agar having temperature around 40-45 °C was poured and mixed thoroughly by rotating the petri dish clockwise and anticlockwise for five times. The prepared plates were incubated aerobically, lids uppermost in an upright position in the incubator at 25°C ± 1°C for 5 days.

#### **2.4.7 Dextran**

Dextran was determined as per Roberts Copper Method. About 10 mls of sugar cane juice was pipetted and transferred into a 100 mL beaker, then 0.3 g of anal was added filtered and stirred followed by the addition of 40mls of alcohol and stirring. It stands for 5 minutes to form precipitate and precipitate filtered off on sintered glass filter on a rubber ring. Precipitate was washed five times with 80% ethyl alcohol, each time filtered with alcohol, and alcohol was drawn through precipitate. This step was important to remove sugar that might remain adsorbed to precipitate and interfere in the phenol-H<sub>2</sub>SO<sub>4</sub> reaction.

When the last portion of alcohol wash has been completely drawn through precipitate, then precipitate plus filter aid is transferred to a 25 mL volumetric flask and the minimum amount of water was used for transfer.

Ten (10) mls of filtrate was taken for analysis in a plastic test tube followed by 2 mls 2.5N NaOH reagent solution, 2 mls of copper reagent solution and 0.2 g anal, filter aid. Then test tube containing the mixture of solution was boiled in a water bath for 5 minutes to precipitate Cu-dextran complex on filter aid, and cooled for 20 minutes and the precipitate contained Cu-dextran complex filtered.

About 2 mls of 2N Sulfuric acid solution was poured into the in a sintered glass funnel and the vacuum was turned on, so the acid solution was drawn through the precipitate. This procedure was repeated, then precipitate rinsed with 2 mL H<sub>2</sub>O. The quantity of filtrate, which contains solubilized dextran was transferred to a 25 ml volume flask and diluted to volume with water. Two (2) mls of this solution was pipetted into the test tube and the procedure for the Phenol-H<sub>2</sub>SO<sub>4</sub> test was followed as done in the standard dextran below.

### Preparation of Dextran Standard Curve

Dextran Standard Curve was prepared as per Roberts Copper Method. About 500 mg dextran were weighed and dissolved in water and diluted to 500 ml (the solution contains 1.0 mg of dextran/ml) and prepared solution was used for each standard curve determination. About 100 mls of a 1.0 mg dextran/mL standard solution was diluted to 1 L (0.1 mg dextran/ mL). This solution was used in aliquots of 20, 40, 60, 80 and 100 mL, each diluted to 100 mL to prepare standard curve. Each solution contains 0.02, 0.04, 0.06, 0.08 and 0.1 mg dextran/mL respectively. The data obtained was used to construct a calibration curve with concentration of dextran on the x-axis and the actual absorbance on the y-axis.

### Phenol-H<sub>2</sub>SO<sub>4</sub> Test.

Phenol-H<sub>2</sub>SO<sub>4</sub> Test was done as per Roberts Copper Method. In a series of six (6) test tubes, 2 ml of each dextran standard solution was placed and two (2) ml water in another test tube as a blank then 1ml of a 5% phenol solution was added to each tube. Tubes were swirled gently to mix phenol and carbohydrate solution. To each tube 10mls of Conc.H<sub>2</sub>SO<sub>4</sub> was added preferably using plastic automatic pipet and acid released rapidly to ensure that solution was well mixed. Tubes was placed in rack and boiled in water bath for 2 minutes and then cooled for 30 minutes and corresponding absorbance was measured on a spectrophotometer at 485 nm against a blank solution.

### Calculation

Dextran mg/ml, from standard calibration curve,

$$X, \frac{mg}{100ml} = (Y - C) * \frac{b}{M} * V \dots\dots\dots 5$$

Where by,

X, mg/100g = Amount of dextran in mg/100ml.

Y = Actual absorbance read from spectrophotometer

C = y-intercept

M = Slope from standard curve

B = conversion factor to 100 ml

V = Volume of analytical sample analyzed.

**Calculation**

The colony forming unit of microorganism per ml (CFU/ml) for all fresh sugarcane juice sample was calculated using the following formula: -

$$CFU / g = \frac{\sum C}{V(n_1 + 0.1n_2 + 0.01n_3)d} \dots\dots\dots 6$$

Where:

$\sum C$  is the sum of the CFU counted on all dishes retained from three successive dilutions.

$n_1$  is the number of dishes retained at the first dilution ( $n_1$ ) =2

$n_2$  is the number of dishes retained at the second dilution ( $n_2$ ) =2

$n_3$  is the number of dishes retained at the third dilution ( $n_3$ ) =2

V is the volume of inoculums in milliliters applied to each dish (V) =1

d is the dilution factor corresponding to the first dilution retained ( $d=10^{-3}$ )

**Statistical data analysis**

Data collected from laboratory were processed through coding and analyzed using the statistical software package for the social sciences (IBM SPSS version 25.2017)..

**2. RESULT AND DISCUSSION**

The Table 1 shows the result of the analysis of variance for different dependent variables that show significant differences in all variables.

Table 1: ANOVA Table of different dependent variables

Variables		Sum of Squares	Df	Mean Square	F	Sig.
CUF_BACT	Between Groups	458685163134.373	2	229342581567.186	107.503	.000
	Within Groups	185601683768.013	87	2133352686.989		
	Total	644286846902.386	89			
CUF_YEAS T	Between Groups	77284397658.151	2	38642198829.076	755.976	.000
	Within Groups	4447058481.303	87	51115614.728		
	Total	81731456139.454	89			
pH	Between Groups	1.887	2	.943	33.957	.000
	Within Groups	2.417	87	.028		

	Total	4.304	89			
BRIX	Between Groups	209.835	2	104.917	110.104	.000
	Within Groups	82.902	87	.953		
	Total	292.737	89			
POL	Between Groups	271.308	2	135.654	85.944	.000
	Within Groups	137.321	87	1.578		
	Total	408.629	89			
PURITY	Between Groups	498.320	2	249.160	11.774	.000
	Within Groups	1841.038	87	21.161		
	Total	2339.358	89			
WEIGHT	Between Groups	1333300.273	2	666650.13	140.211	.000
	Within Groups	413651.120	87	4754.611		
	Total	1746951.393	89			

Table 2 provide a description on multiple comparison of the effect of storage time as an independent variable with dependent variables. The table provide an overview by comparing each level of storage time with each other and their significance level. The result of multiple comparisons shows that for *Leuconostoc* bacteria count, yeast, pol, purity and weight there was no significant difference (P= 0.05) between 24 and 72 hours of storage time. The significant difference is noted between 24 to 120 and 72 to 120 hours of storage time. The result is contrary for brix and pH, indicating significant difference between all levels of storage time

**Table 2 Description of multiple comparison on the effect of storage time**

Dependent Variable	(I) Storage time	(J) Storage time	Mean Difference (I-J)	Std. Error	Sig.
CUF_BACT	24.00	72.00	-7794.59463	11925.74997	.791
		120.00	-155187.38747*	11925.74997	.000
	72.00	24.00	7794.59463	11925.74997	.791
		120.00	-147392.79283*	11925.74997	.000
	120.00	24.00	155187.38747*	11925.74997	.000
		72.00	147392.79283*	11925.74997	.000
CUF_YEAST	24.00	72.00	-3388.33947	1845.99774	.164
		120.00	-63787.72213*	1845.99774	.000
	72.00	24.00	3388.33947	1845.99774	.164
		120.00	-60399.38267*	1845.99774	.000
120.00	24.00	63787.72213*	1845.99774	.000	

pH	24.00	72.00	60399.38267*	1845.99774	.000
		120.00	.17667*	.04304	.000
	72.00	24.00	.35467*	.04304	.000
		120.00	-.17667*	.04304	.000
		120.00	.17800*	.04304	.000
BRIX	24.00	72.00	-.35467*	.04304	.000
		120.00	.72000*	.04304	.000
	72.00	24.00	-.17800*	.04304	.000
		120.00	.83000*	.25204	.004
		120.00	3.57333*	.25204	.000
POL	24.00	72.00	-.83000*	.25204	.004
		120.00	2.74333*	.25204	.000
	72.00	24.00	-3.57333*	.25204	.000
		120.00	-2.74333*	.25204	.000
		120.00	.67333	.32439	.101
PURITY	24.00	72.00	.67333	.32439	.101
		120.00	3.97333*	.32439	.000
	72.00	24.00	-.67333	.32439	.101
		120.00	3.30000*	.32439	.000
		120.00	-3.97333*	.32439	.000
WEIGHT	24.00	72.00	-3.30000*	.32439	.000
		120.00	-.36333	1.18775	.950
	72.00	72.00	4.80000*	1.18775	.000
		120.00	.36333	1.18775	.950
		120.00	5.16333*	1.18775	.000
Dextran	24.00	72.00	-4.80000*	1.18775	.000
		120.00	-5.16333*	1.18775	.000
	72.00	72.00	41.38000	17.80376	.058
		120.00	276.38667*	17.80376	.000
		120.00	-41.38000	17.80376	.058
Dextran	24.00	72.00	235.00667*	17.80376	.000
		120.00	-276.38667*	17.80376	.000
	120.00	72.00	-235.00667*	17.80376	.000

Table 3 provide descriptive information on the impact of storage time on pH, brix, pol, purity and weight(gram) of harvested burnt sugarcane juice. The result from descriptive table shows the general trend of pH, brix, purity and weight of harvested burned sugarcane over storage time under ambient environmental conditions. The result revealed that the meansvalues on all dependent variables were decreasing as storage increased, indicating deterioration of sugarcane. The pH, brix, pol, purity and weight mean values decreased with an increase in storage time from 24 hours after

harvesting to 120 hours. A decrease in mean values of pH, brix, pol, purity and weight over storage time indicate that the composition of sugarcane starts to change after harvesting burnt sugarcane. The change in sugarcane composition has a negative impact on quality of sugarcane as the raw material for sugar production [11].

**Table 3: Effect of time interval (storage time) on the pH, brix, pol, purity and weight of harvested of burnt sugarcane**

Storage time (hours)	pH Mean±SD	Brix Mean±SD	Pol Mean±SD	Purity Mean±SD	Weight Mean±SD
24	5.48±0.14 <sup>a</sup>	19.50±1.16 <sup>a</sup>	17.36±1.51 <sup>a</sup>	88.92±3.92 <sup>a</sup>	691.51±79.05 <sup>a</sup>
72	5.30±0.17 <sup>b</sup>	18.67±0.99 <sup>b</sup>	16.68±1.43 <sup>a</sup>	89.28±5.69 <sup>a</sup>	650.13±80.57 <sup>a</sup>
120	5.13±0.17 <sup>c</sup>	15.92±0.70 <sup>c</sup>	13.38±0.62 <sup>b</sup>	84.12±3.94 <sup>b</sup>	415.12±38.99 <sup>b</sup>

Values are means ± standard deviation of the mean of duplicate determinations. Values in the same column having the same superscripted letters are not significantly different ( $p > 0.05$ ) according to Duncan Multiple Range Test

Table 4 provides descriptive information on the microbial aspect indicating the Impact of storage time on *Leuconostoc* bacteria and Yeast determined from harvested burnt sugarcane. The result reveals that the mean values on *Leuconostoc* bacteria and Yeast were increasing as storage increase

**Table 4: Total *Leuconostoc mesenteroides* count (CFU/g) and yeasts (CFU/g) burnt sugarcane and dextran**

Storage time (hours)	<i>Leuconostoc mesenteroides</i> count (CFU/g) Mean±SD	Yeast (CFU/g) Mean±SD	Dextran Mean±SD
24	7500.30±3990.85 <sup>b</sup>	4755.82±2760.95 <sup>b</sup>	135.19±90.16778 <sup>c</sup>
72	15294.89±3207.96 <sup>b</sup>	8144.16±2920.72 <sup>b</sup>	334.56±141.23639 <sup>b</sup>
120	162687.68±79836.33 <sup>a</sup>	68543.54±11712.95 <sup>a</sup>	620.27±237.34300 <sup>a</sup>

Values are means ± standard deviation of the mean of duplicate determinations. Values in the same column having the same superscripted letters are not significantly different ( $P = 0.05$ ) according to Duncan Multiple Range Test

#### **Impact of storage time on pH of harvested burnt *S. officinarum***

The result shows a significant difference ( $P > 0.00$ ) in the mean pH of harvested sugarcane. The gradual decrease in pH over storage period indicate increased acidity in the stored burnt sugarcane. A similar trend was observed by [27] who reported decrease in pH of sugarcane stored for 12 days under environmental condition. Moreover, an increase in acidity signifies biochemical changes or degradation in harvested sugarcane. The pH is regarded as quality parameter to monitor quality of sugarcane [28]. A drop in pH caused by organic acid, specifically lactic acid [29]. According to [22], observed that the acidity of sugarcane juice has a relationship with the degradation characteristic of harvested sugarcane. A decrease in pH indicates

the presence of a considerable number of acid-forming bacteria, which leads to the creation of lactic acetic acid. Moreover, it was described by [30], that bacteria as main source of organic acid and lactic formation and comes from soil that contaminates sugarcane through the cut end, the development of these acid lead to decrease of pH and sucrose loss.

### **Impact of storage time on brix (total soluble solids) of harvested burnt *S. officinarum***

According to [31] sugarcane juice contains 20% total soluble solid (TSS). The dissolved solids include sucrose, glucose, fructose, and nitrogenous compounds in which sucrose contain higher proportion about 18%. The result shows that brix as a measure of total soluble solid decreased significantly as storage time increased. The brix mean with standard deviation values were  $19.50 \pm 1.16^a$ ,  $18.67 \pm 0.99^b$  and  $15.92 \pm 0.70^c$  for 24, 72 and 120 storage hours respectively. According SASTA, (2009) brix of sugarcane juice must be ranged between 18-23%. This indicate sugarcane stored for 120 hours is of range as compared to SASTA standard. The decrease brix values over storage time has been reported by [20]: [23] and [32] who reported a gradual drop in brix values with storage time This change in brix might be attributed by action of microorganisms that consume sugar in sugarcane during storage period. The decrease in brix indicates sugar deterioration is taking place due to delayed in processing harvested burnt sugarcane. The brix measure provides useful information to sugarcane growers and processor, that harvested sugarcane need to be processed immediately between 24 to 72 hours after harvesting as their brix value are within SASTA standard, any delay in milling harvested burned sugarcane beyond 72 hours after harvesting results in a significant loss of brix, which is accounted as an economic loss to both producers and processors. According to [33] brix is measure used to assess sucrose concentration and indicators of sucrose loss

### **Impact of storage time on pol value of harvested burnt sugarcane**

Polarization (pol), quantifies the percent proportion of sucrose in sugarcane. The results show that the storage time interval has a significant influence on the pol as a measure of the quality of burnt sugarcane. The mean values for pol were  $17.36 \pm 1.51^a$ ,  $16.68 \pm 1.43^a$  and  $13.38 \pm 0.62^b$  for 24, 72 and 120 storage hours respectively According to SASTA [34] the pol values should range from 14 – 21%. From this standard the pol values for 24 and 72 storage time are within recommended standard where 120 storage hours are beyond specification. The 120-storage time contribute to greater extent of deterioration, which is a significant challenge for sugarcane growers and the sugar industry. Looking on mean pol trend, there was decrease in pol with increase in storage time The results are in line with [35], who reported that prolonging the period between harvesting and crushing greatly decreases the sucrose content percent. Similarly, [36] and [37], reported that the proportion of sucrose decreases as the post-harvest time increases. Studies done by [1], [38], and [9], have explained the courses on sucrose decline throughout storage time and documented how microorganisms, chemical reactions, and enzyme activity as the main courses.

### **Impact of storage time on purity of harvested burnt sugarcane**

The percentage of sucrose included in the total soluble solids content of the juice is referred to as its purity. A higher purity suggests a higher sucrose concentration of the total soluble solids contained in the sugarcane juice. A solution's purity is defined as the percentage ratio of pol to brix insugarcane the samples. Based on the result, the mean purity at 24 storage time was 88.92%, and it remained fairly steady at 89.28% at 72 indicating no significant difference between the two-storage time. However, there was a significant decline in purity to 84.12% after 120 hours, which might indicate a deterioration in sugarcane quality due to enough storage time. The data indicates a mean purity of 87.44% across the storage time, indicating that overall sugarcane purity is still satisfactory as compared to specification recommended by SASTA, (2009) that the Purity % of sugar cane must be ranged between 77 – 93.5 %. The purity mean value was not significant difference according to the analysis of variance results. Despite a slight drop in purity%, the difference is insignificant. This might be due to the mathematical computation required in obtaining purity.

### **Impact of storage time on weight of harvested burnt sugarcane**

The ANOVA table (Table .1) findings show that the weight loss during the given storage duration was significant difference ( $P=0.05$ ) across the storage time. The result reveal that the mean values for weight decreased as storage duration increased. The mean values for weight dropped from  $691.51 \pm 79.05$  to  $415.12 \pm 38.99$  grams. The result was in agreement with [16] who described the decrease in weight of harvested burnt sugarcane over storage time. The weight loss could be due to moisture loss in juice content over time. It was reported by [29], that losses in weight of harvested sugarcane caused by increase in rate of respiration. Moreover, according to [39] preharvest burning of sugarcane causes horizontal cracking along sugarcane stalk that lead to loss of moisture content. In addition, it observed by [40] that harvested sugarcane experiences moisture loss, that reduce weight of sugarcane. According to [41] study, weight loss began immediately 24 hours after harvesting and increase with storage duration caused by moisture loss due to evaporation as well as increased respiration. The major function of sugarcane weight is to tell sugar companies and growers about how successfully the plant was managed prior to harvesting. On the other hand, well-managed sugarcane will have a large weight compared to less-managed sugarcane.

### **Microbial infestation**

Sugarcane is a crop that provide good environment for microbial growth as it contains around 15-18% sucrose, 0.5% reducing sugar and sufficient amount of organic nitrogen and mineral salt with pH 5.0 to 5.5 allowing mostly acidophilic organism particularly lactic acid bacteria and yeast [42]. According to [6], reported that green sugarcane contains minimal number of microorganisms as compared to burnt harvested sugarcane that allow easily invasion and multiplication of microbial growth that led into conversion of sucrose into nonsugar and polysaccharide compounds

### **Yeast**

Result shows that yeast population increased with increase in storage time (Table.4). The mean value for yeast population increased from  $4755.82 \pm 2760.95$  to  $68543.54 \pm 11712.95$  Cfu's. The result indicate that the increase in yeast population was significant. According to [43], presence of yeast in sugarcane play role in

converting sucrose into non sugar byproduct (ethanol and carbon dioxide) thereby contributing to postharvest sucrose losses

### ***Leuconostoc* bacteria**

Contamination of sugarcane with *Leuconostoc* bacteria occurs during harvesting through cross contamination with cane cutters machete and soil. The bacteria enter the internal part of sugarcane stalk and reproduce. The results show that number *Leuconostoc* bacteria (cfu) increased from 24 to 72 hours of storage and highest level was noticed in 120 hours of storage. The mean values for *Leuconostoc* bacteria count were  $7500.30 \pm 3990.85$ ,  $15294.89 \pm 3207.96$  and  $162687.68 \pm 79836.33$  Cfu's for 24, 72 and 120 hour of storage respectively. The presence and increase in microbial proliferation is evident that deterioration of sugarcane is taking losses. Similarly, [44] reported that entrance *Leuconostoc* spp into sugarcane juice allow to grow, multiply and consume sugar

### **Dextran**

Result (in Tab No.4) shows that amount of formed dextran (mg/kg) varied and increased across the storage time. The concentration increased from 24 to 72 and highest level was observed in 120 hours of storage. The mean values in 24, 72, and 120 hours were  $135.19 \pm 90.16778^c$ ,  $334.56 \pm 141.23639^b$  and  $620.27 \pm 237.34300^a$  mg/kg respectively. The formation of dextran in stored sugarcane provide evidence that microbial activity is taking place essentially *Leuconostoc* spp which consume sucrose leading to sucrose loss. Dextran has been reported by several studies that its formation indicates postharvest deterioration of sugarcane [45]:[46]

According to [47] high level of dextran (>150 mg/kg) cause a serious problem as recommended by South African Sugar Terminals (SAST) that maximum requirement for dextran is 150 mg/kg. Comparing result with this recommendation, show that dextran content found in 72 and 120 storage hours was greater than 150 mg/kg. Based on these results and dextran as indicator of deterioration, it shows greater post-harvest sucrose losses due to burn to crush (burn to mill) delay. Furthermore [42], pointed out that for each 0.1 percent of dextran being formed represent 0.04 percent sucrose loss

### **3. Conclusion**

The results reveal that purity values were satisfactory in all storage time levels as compared to SASTA standard, whereas brix and pol were affected negatively by 120 hours of storage as compared to SASTA standard and dextran level as the measure of microbial deterioration was high in 72 and 120 storage hours as compared to given reference. These findings suggest that storage time of 120 hours affect mostly the quality of sugarcane as a raw material for sugar manufacturing. The harvested sugarcane needs to be processed between 24 and 72 hours after harvesting to reduce postharvest sucrose losses. Apart from time interval from harvest to mill, preharvest-burning of sugarcane is noted as the factor that create friendly environment for quality deterioration to occur as it causes damage of wax that provide protective layer on sugarcane stalk and bursting of protective external layer of sugarcane stalk leading to easily moisture loss and access by microorganism

Therefore, it is recommended that farmers and processors should be properly informed about the consequence of delayed processing burned sugarcane to avoid economic loss and be informed that minimum burn to crush/mill interval time should not exceed 72 hours, this is important to ensure minimal postharvest sucrose losses. and finally, a joint effort that will ensure timely harvesting, transportation and milling are necessary between the investor (sugarcane processor), sugarcane cooperatives (representing farmers), and Tanzania Sugar Board to bridge the gap from harvest to mill by examining the underlying causes and creating regulations that can be used to address issues such as poor infrastructure, burning, and poor truck condition that demand regular service. Poor infrastructure, preharvest burning and poor truck condition are among the major issues. increasing post-harvest losses

#### ACKNOWLEDGEMENT

The authors are grateful for the financial support provided by Ministry of Agriculture, Tanzania

#### COMPETING INTERESTS

Authors have declared that no competing interests exist

#### REFERENCE)

- [1] C. Panigrahi, A. E. Y. Shaikh, B. B. Bag, H. N. Mishra, and S. De, "A technological review on processing of sugarcane juice: Spoilage, preservation, storage, and packaging aspects," *Journal of Food Process Engineering*, vol. 44, no. 6. Blackwell Publishing Inc., Jun. 01, 2021. doi: 10.1111/jfpe.13706.
- [2] J. Santaella, "The sugarcane agribusiness-An energy focused vision," *Technische University*, vol. 69, 2007.
- [3] R. Jain, A. Chandra, and S. Solomon, "Post-harvest Handling of Sugarcane for high sugar recovery," 2017.
- [4] M. Naderi-Boldaji, M. Fazeliyan-Dehkordi, S. A. Mireei, and M. Ghasemi-Varnamkhashti, "Dielectric power spectroscopy as a potential technique for the non-destructive measurement of sugar concentration in sugarcane," *Biosyst Eng*, vol. 140, pp. 1–10, Dec. 2015, doi: 10.1016/j.biosystemseng.2015.09.003.
- [5] Kalume, V.M, Kongolo, and M, "Impact of Local Sugar Producing Industries on National Economy: A Case of Kagera Sugar Ltd, Tanzania," *International Journal of Social Sciences and Management Review*, vol. 05, no. 03, pp. 47–62, 2022, doi: 10.37602/ijssmr.2022.5305.
- [6] P. R. Singh, B. E. Kashando, M. Couvreur, G. Karssen, and W. Bert, "Plant-parasitic nematodes associated with sugarcane in Kilimanjaro, Tanzania," *J Nematol*, vol. 52, pp. 1–17, 2020, doi: 10.21307/jofnem-2020-059.
- [7] A. G. Rweyendela and W. J. S. Mwegoha, "Industrial symbiosis in Tanzania: A case study from the sugar industry," *African Journal of Science, Technology, Innovation and Development*, pp. 1–12, 2020, doi: 10.1080/20421338.2020.1773605.

- [8] A. Andreoni, D. Mushi, and O. Therkildsen, "The political economy of 'scarcity' in East Africa: a case study of sugar production, smuggling and trade in Tanzania," 2020.
- [9] V. Misra, A. K. Mall, S. Solomon, and M. I. Ansari, "Post-harvest biology and recent advances of storage technologies in sugarcane," *Biotechnology Reports*, vol. 33. Elsevier B.V., Mar. 01, 2022. doi: 10.1016/j.btre. 2022.e00705.
- [10] Krishnakumar T, Thamilselvi C, and Devadas CT, "African Journal of Agricultural Research Effect of delayed extraction and storage on quality of sugarcane juice," vol. 8, no. 10, pp. 930–935, 2013, doi: 10.5897/AJAR12.1807.
- [11] S. Solomon, "Post-Harvest Cane Deterioration and its Milling Consequences," 2000.
- [12] Zvomarima N, Rambwawasvika H, and Mutatu W, "Full Paper the Impact of Burn-To-Crush Delays on Selected Commercial Sugarcane Varieties In The Zimbabwean Sugar Industry." [Online]. Available: <https://cabidigitallibrary.org>
- [13] M. R. L. V. Leal, M. V. Galdos, F. V. Scarpore, J. E. A. Seabra, A. Walter, and C. O. F. Oliveira, "Sugarcane straw availability, quality, recovery and energy use: A literature review," *Biomass Bioenergy*, vol. 53, pp. 11–19, Jun. 2013, doi: 10.1016/j.biombioe.2013.03.007.
- [14] G. F. Prado *et al.*, "Burnt sugarcane harvesting: Particulate matter exposure and the effects on lung function, oxidative stress, and urinary 1-hydroxypyrene," *Science of the Total Environment*, vol. 437, pp. 200–208, Oct. 2012, doi: 10.1016/j.scitotenv.2012.07.069.
- [15] M. R. L. V. Leal, M. V. Galdos, F. V. Scarpore, J. E. A. Seabra, A. Walter, and C. O. F. Oliveira, "Sugarcane straw availability, quality, recovery and energy use: A literature review," *Biomass Bioenergy*, vol. 53, pp. 11–19, Jun. 2013, doi: 10.1016/j.biombioe.2013.03.007.
- [16] A. Dengia and E. Lantinga, "Effect of Pre-Harvest Cane Burning on Human Health, Soil Quality and Rate of Cane Moisture Loss in Ethiopian Sugarcane Plantations," *Advances in Crop Science and Technology*, vol. 06, no. 05, 2018, doi: 10.4172/2329-8863.1000396.
- [17] S. Hegazi, M. M. Bukhari, S. El Khaseh, A. Osman, S. Eldeen, and F. Hegazi, "Investigations of the influence of dextran on sugar cane quality and sugarcane processing in Kenana sugar factory," Available online [www.jocpr.com](http://www.jocpr.com) *Journal of Chemical and Pharmaceutical Research*, vol. 7, no. 4, pp. 381–392, 2015, [Online]. Available: <https://www.researchgate.net/publication/301633455>
- [18] J. D. Castilla-Marroquín *et al.*, "Dextran synthesis by native sugarcane microorganisms," *Revista Mexicana de Ingeniera Quimica*, vol. 19, pp. 177–185, 2020, doi: 10.24275/rmiq/Bio1793.
- [19] A. Dafalla Elfadil, "Effect of dry-off period and crushing and extracting delays on sugarcane quality and productivity," 2015. [Online]. Available: <https://www.researchgate.net/publication/280620976>
- [20] Krishnakumar T, Thamilselvi C, and Devadas CT, "African Journal of Agricultural Research Effect of delayed extraction and storage on quality of sugarcane juice," vol. 8, no. 10, pp. 930–935, 2013, doi: 10.5897/AJAR12.1807.
- [21] Y. Sharath, K. Reddy, and K. V. N. Madhuri, "N Save Nature to Survive Impact of delayed crush on post-harvest deterioration of promising early maturing sugarcane clones." [Online]. Available: [www.thebioscan.in](http://www.thebioscan.in)

- [22] S. Yusof, L. S. Shian, and A. Osman, "Changes in quality of sugar-cane juice upon delayed extraction and storage." [Online]. Available: [www.elsevier.com/locate/foodchem](http://www.elsevier.com/locate/foodchem)
- [23] O. P. Chauhan, D. Singh, S. M. Tyagi, and D. K. Balyan, "Studies on preservation of sugarcane juice," *Int J Food Prop*, vol. 5, no. 1, pp. 217–229, 2002, doi: 10.1081/JFP-120015603.
- [24] R. Kaavya, R. Pandiselvam, A. Kothakota, E. P. Banuu Priya, and V. Arun Prasath, "Sugarcane Juice Preservation: A Critical Review of the State of the Art and Way Forward," *Sugar Tech*, vol. 21, no. 1. Springer, pp. 9–19, Feb. 13, 2019. doi: 10.1007/s12355-018-0622-2.
- [25] H. Bahati, P. Ndaki, E. Kisetu Nassary, B. Hakimu Msomba, and P. Madulu Ndaki, "Journal of Global Agriculture and Ecology Assessing impact of climate change and extreme weather events on the sustainability of sugarcane production assessing impact of climate change and extreme weather events on the sustainability of sugarcane production," *Journal of Global Agriculture and Ecology*, vol. 11, no. 4, pp. 33–45, 2021, [Online]. Available: <https://www.researchgate.net/publication/354820730>
- [26] South Africa Sugar Technologist Association (SASTA), "Laboratory Manual," in *SASTA Method 3.1: Brix, pol and purity*, 2005.
- [27] S. Bhatia, · Jyoti, · S K Uppal, · K S Thind, · S K Batta, and J. · S. K. Uppal, "Post harvest quality deterioration in sugarcane under different environmental conditions," 2009.
- [28] P. Saetear, N. Saechua, and K. Sereenonchai, "Sequential injection system for analysis of degree brix, orthophosphate and pH in raw sugarcane juice applicable to sugar industry," *Molecules*, vol. 26, no. 21, Nov. 2021, doi: 10.3390/molecules26216484.
- [29] V. Misra, A. K. Mall, S. Solomon, and M. I. Ansari, "Post-harvest biology and recent advances of storage technologies in sugarcane," *Biotechnology Reports*, vol. 33. Elsevier B.V., Mar. 01, 2022. doi: 10.1016/j.btre. 2022.e00705.
- [30] P. Saxena, R. P. Srivastava, and M. L. Sharma, "Impact of cut to crush delay and bio-chemical changes in sugarcane," 2010.
- [31] N. L. Zaidan *et al.*, "Physicochemical and sensory characteristic of treated sugarcane juice," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, May 2021. doi: 10.1088/1755-1315/736/1/012073.
- [32] M. N. H. A. Ali *et al.*, "Post-Harvest Losses and Control of Unprocessed Sugarcane," *Pakistan Journal of Agricultural Research*, vol. 31, no. 4, Nov. 2018, doi: 10.17582/journal.pjar/2018/31.4.355.360.
- [33] K. Chandran and M. N. Premachandran, "Sugar accumulation pattern in tropical and subtropical sugarcane varieties of different maturity groups."
- [34] S. Khan, "Screening of promising sugarcane genotypes in relation to agroecological conditions of Tandojam district of Sindh, Pakistan," *Article in Asian Journal of Agriculture and Biology*, 2023, doi: 10.35495/ajab.2023.199.
- [35] "EJAR-Volume 82-Issue 1- Page 239-249".
- [36] A. Zaky, S. El-maghraby Samia, A. Ahmed, and K. S. El-soghier, "post-harvest change studies in sugar cane cultivars under upper Egypt condition," 2018. [Online]. Available: <https://www.researchgate.net/publication/326446147>

- [37] S. Abazied, "Influence of Delivery Delay on Quality of Some Promising Sugar Cane Varieties under Aswan Condition," *Egyptian Journal of Agronomy*, vol. 0, no. 0, pp. 21–29, Dec. 2018, doi: 10.21608/agro.2018.5684.1123.
- [38] M. G. S. Cox and P. Sahadeo, "Post harvest deterioration of burnt cane in bundles," 1992.
- [39] J. Davies, "The causes and consequences of cane burning in Fiji's sugar belt."
- [40] S. Solomon, "Post-harvest deterioration of sugarcane," 2009.
- [41] P. Mehrotra & N. Sharma, "Effect of different storage conditions on sugarcane weight loss," 2020. *Int. J. Eng. Appl. Sci. Technol*, 5(5), 2455-2143.
- [42] S. Solomon, "Post-harvest deterioration of sugarcane," 2009.
- [43] G. Eggleston, "Deterioration of cane juice-sources and indicators." [Online]. Available: [www.elsevier.com/locate/foodchem](http://www.elsevier.com/locate/foodchem)
- [44] V. Misra, A. K. Mall, A. D. Pathak, S. Solomon, and R. Kishor, "Microorganisms affecting Post-Harvest Sucrose Losses in Sugarcane," *Int J Curr Microbiol Appl Sci*, vol. 6, no. 7, pp. 2554–2566, Jun. 2017, doi: 10.20546/ijcmas.2017.607.361.
- [45] K. Schlumbach, M. Scharfe, and E. Flöter, "Effect of quality and origin of technical sucrose solutions on the inclusion of colourants into the sugar crystal matrix," *J Sci Food Agric*, vol. 98, no. 8, pp. 2953–2963, Jun. 2018, doi: 10.1002/jsfa.8792.
- [46] Z. Tatiana Daza-Merchan, G. Carolina Prieto Correal Ingenio Providencia, D. Palacios Garcia, and N. Javier Gil, "Microbial action in cane processing goes beyond sucrose loss," 2019. [Online]. Available: <https://www.researchgate.net/publication/335724904>
- [47] M. Moodley and S. Khomo N Proc, "Dextran: a refiner's perspective," 2018. [Online]. Available: <https://cabidigitallibrary.org>