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(Original Article)

The Potential Impact of The Quality of Sugar Beet Roots (*Beta vulgaris* L.) on Sugar Loss in The Beet Molasses

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Abstract

The main objective of this study was to assess the potential factors that influence the amount of sugar lost during the final molasses processing of sugar beet roots. Late sugar beet roots harvesting has an impact on the beets' quality, and root rot infestations led to a large rise in the concentrations of inverted sugars, K, Na, and α-amino N, which had negative processing effects. For this purpose, during processing, samples of sugar beet molasses and sugar beet roots (from two separate designs of manufacturing lines) and research fields were collected in Delta Sugar Company during different times in the 2022 working seasons early season, middle season and late season (from middle of February to late March, from early April to middle of May and from middle of May to late June, respectively). The sucrose content of sugar beet roots drastically decreased over the harvesting season, meanwhile K, Na, α-amino N, inverted sugars and other ingredients accumulated in beets, therefore, the sugar beet roots' quality significantly deteriorated. However, sugar beets root quality was significantly enhanced from 79.71±1.96% to 81.47±2.07% till the middle of the season. Moreover, the sugar beet root juice's purity increased considerably from 86.92±2.04to 87.52±2.65% at the same time of the season. The obtained results showed a reversible correlation between sugar beets' quality, sugar losses in beet molasses. Furthermore, K, Na, α-amino N and inverted sugar levels in sugar beet were in a reversible relationship with beets quality. Therefore, the standards for evaluating quality may evolve in response to future processing industry needs.

Keywords: *Sugar beet (Beta vulgaris L.), Beet molasses, Sucrose, Beet roots quality.*

Introduction

Sugar beet roots flourish and play a significant role in 52 countries' agricultural systems in the centre and southern regions of Europe, the United States, and other temperate climate zones. Cane sugar is affordable as it is a perennial plant and because its bagasse provides free processing energy, whereas a 10,000 tonne per day beetroot processing facility needs at least 15-20 Mw/h of power that is totally produced from non-renewable energy sources (Stevanato *et*

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al., 2019). Overall sugar beet yields are expected to rise during the period 2020–2050 by around 10% due to increasing atmospheric CO_2 concentration (Demmers-Derks *et al*., 1998).

However, several factors can contribute to sugar loss in beet molasses during the sugar production process. To minimize sugar loss, sugar production processes are carefully monitored and optimized to maximize sugar extraction, minimize impurities, control heat and chemical treatments, and ensure proper storage and handling of molasses. The quality of the beet crop itself can affect sugar loss. Factors such as beet variety, maturity at harvest, and storage conditions can influence the sugar content and susceptibility to loss during processing (Eggleston and Lima., 2015). Moreover, the efficiency of the extraction process plays a crucial role in determining sugar loss. The extraction process involves slicing or diffusing the beets to release the sugar-containing juice. If the extraction process is not optimized, it may result in incomplete extraction and leave sugar behind in the beet pulp (Eggleston *et al*., 2017).

After extraction, the beet juice undergoes a purification process to remove impurities. This process typically involves adding lime or other chemicals to neutralize acidity, heating, and clarification. If the purification process is not properly controlled, it can lead to additional sugar loss through chemical reactions, precipitation, or adsorption onto impurities (Gharib-Bibalan *et al*., 2018). During the concentration of beet juice into molasses, evaporation and boiling are employed to remove water and increase sugar concentration. However, prolonged or inefficient evaporation and boiling can cause excessive caramelization and degradation of sugars, resulting in sugar loss (Marasinghege, 2023).

In the final stages of sugar production, the molasses is subjected to crystallization and centrifugation to separate sugar crystals from the remaining syrup. Improper control of crystallization conditions or inadequate centrifugation can lead to sugar loss in the residual syrup or molasses (Boote, 2010). Improper storage and handling of molasses can also contribute to sugar loss. Factors such as temperature, exposure to air, and microbial activity can degrade sugars over time, reducing the sugar content of molasses (Misra *et al*., 2022).

The timing of the sugar beet season can have an impact on sugar yield as a final product. Sugar beet maturity at harvest is an important factor in sugar yield. Beets harvested too early may have lower sugar content, while beets left in the ground for too long may start to deteriorate, leading to sugar loss. The optimal timing for harvest depends on various factors such as the beet variety, growing conditions, and local climate. Harvesting the beets at their peak maturity, when sugar content is highest, can result in a higher sugar yield (Spackman and Cobb, 2002).

Meanwhile, weather during the sugar beet growing season can influence sugar yield. Adequate moisture and sunlight are crucial for beet growth and sugar accumulation. Drought or excessive rainfall can negatively impact sugar yield by affecting beet growth and reducing sugar content. Extreme temperature fluctuations or frost can also damage the beets and result in sugar loss (Cheesman, 2004). The timing of the sugar beet season can influence the incidence and severity of pests and diseases. Certain pests and diseases can damage the beet crop, reducing both yield and sugar content. Early detection and appropriate pest and disease management practices are essential to minimize the impact on sugar yield (Harveson and Rush, 2002).

During storage, the chemical composition of the beets changes and the amount of recoverable sugar thus declines. Sucrolytic enzymes cleave sucrose to glucose and fructose. These hexoses mainly fuel beet respiration, but a certain amount accumulates in the cells (Klotz *et al*., 2006).

Whereas the timing of sugar beet season can affect the processing capacity of sugar mills or factories. If the sugar beet harvest is condensed into a relatively short period, the processing facilities may face challenges in efficiently handling and processing the large volume of beets. This can lead to delays, increased processing times, and potential sugar losses due to prolonged storage of harvested beets (Klein *et al*., 2019).

Sugar yield is not solely dependent on sugar content but also on other quality factors such as impurities, extraction efficiency, and processing techniques. The timing of the sugar beet season can influence these factors indirectly. Impurities or degradation can be more susceptible to occur if beets are harvested under unfavourable circumstances or stored for a long time, which may reduce the yield of sugar when processed. It's important for sugar beet growers to monitor and manage these factors closely, optimizing harvest timing, implementing appropriate agricultural practices, and coordinating with processing facilities to maximize sugar yield as a final product (Hoffmann, 2010).

Potassium (K) and sodium (Na) and α- amino-N are three of the major mineral elements found in sugar beet roots. They are essential nutrients for plant growth; however, they can also affect the sugar content of the roots and the amount of sugar that is lost to molasses during processing (Yassin *et al*., 2022). High levels of K and Na in sugar beet roots can lead to increased sugar losses in molasses. This is because K competes with sucrose for absorption by the plant roots. When there is too much K in the roots, the plant will not absorb as much sucrose, and the excess sucrose will be lost to molasses. K can also reduce the efficiency of the sugar extraction process. This is because K can bind to the proteins that are responsible for transporting sucrose out of the cells. When the proteins are bound to K, they are less able to transport sucrose, and more sucrose is lost to molasses (Alotaibi *et al*., 2021). As a result, in order to reduce sugar loss in molasses and increase sugar output, it is vital to maintain the quality of sugar beet roots after harvest by taking into account a few chemical parameters.

Therefore, the main aim of this study is to research the relations between the quality of sugar beet roots and sugar loss by taking K, Na and α-amino N contents in sugar beet roots into consideration. Moreover, this investigation was designed to figure out whether inverted sugar levels affect the sugar yield and sugar loss in molasses or not.

Materials and Methods

Experimental procedures

The experiment was conducted in the Delta Sugar Company's laboratories in the Kafr El-Sheikh Governorate of Egypt during the early, middle, and late harvest seasons of 2022, early season (from middle of February to late March), middle season (from early April to middle of May) and late season (from middle of May to late June).

Random samples of healthy sugar beetroot roots (*Beta vulgaris* L.) and beetroot molasses were taken from the two manufacturing lines as well as the research fields. Production lines 1 and 2 of the Old French FCB Company and the Delta Sugar Factory were designed by the German BMA Company, respectively. Each sample was displayed as the mean of five replicates for each season's period.

Analytical methods

Determination of chemical constituents

Ash content

Ash content was determined using Muffle furnace with digital PID controller, model, CWF-11/13 max, 1100 º C at 550 ºC according to the method of A.O.A.C (1990).

Sucrose content

According to the Delta Sugar Company's protocol, the amount of sucrose in the sample was measured using an automatic saccharimeter on a lead acetate basis. (Le Docte, 1977).

Reducing sugar

According to A.O.A.C. (1990), reducing sugar content of samples of beetroot roots was assessed using Ofner's volumetric techniques.

Total soluble solids (T.S.S)

According to the method used by the Delta Sugar Company, the total soluble solids of fresh samples were calculated using a fully automatic digital refractometer, model ATR-S (04320), 0 - 95%Brix, temperature compensation 15 to 40 ºC.

Alpha amino nitrogen, Sodium and potassium

Alpha amino nitrogen, Sodium and Potassium were determined using Venmo, Automation BV Analyzer IIG-16-12-99, 9716JP/ Groningen / Holland. Temp. 18 - 30 º C, surrounding humidity max. 70% according to Brown and Lillan (1964), the results calculated as milligram equivalents / 100 g beet. Or by mmol/100g beet.

Juice purity and beet quality

Purity = (sucrose. %100)/ (T.S.S %)

Quality= (SR.100)/pol.,   SR= (pol-0.29) – 0.343(k + Na) – α- N (0.0939)

Where:

Pol = Sucrose %, K = Potassium, Na = Sodium, α-N = Alpha-amino nitrogen,

SR = Sugar recovery and T.S.S = total soluble solids

According to Delta Sugar Company the previous procedures were described by Silin and Silina (1977) and Sapronova *et al*. (1979).

Molasses color measurement

By diluting 10 g of each sample in 200 ml of distilled water, the molasses samples were prepared. After that, the extracts were filtered using Whatman or filter paper. At 420 nm, color transmission (T) and absorbance (A) were measured using a spectrophotometer against blank solution as described in Guo *et al*. (2019).

Sucrose losses in molasses%

By using the Delta Sugar Company's method, the proportionate connection of sucrose losses in molasses was estimated using the following equation:

Sucrose losses in molasses% = Brix% * Purity% * Yield of molasses% / 10000

pH measuring

According to Delta Sugar Company protocol, pH was determined using a digital bench pH-meter, model pH-526/sentix - 20/AS- DIN / SIN / STH / 650.

Statistical analysis

In order to conduct the statistical analysis, IBM SPSS version 26 was used. Calculated descriptive statistics include means and standard deviation. The Independent-Samples T test was used to evaluate differences between the three groups (early season, middle season, and late season) and the two groups (production line 1, production line 2).

Results and Discussion

Chemical and technological characteristics of beet roots juice

Both sugar factories and sugar beet roots suppliers depend on the chemical composition of sugar beet roots. The quality of sugar beets is determined by the sugar and non-sugar content of the beet juice. Sugar beets with low non-sugar content and high sugar content are considered to be of higher quality. In order to evaluate the quality of beet roots for sugar production, it is important to measure the chemical and technological properties of the beet juice. These properties include the sucrose percentage, total soluble solids content, and reducing sugar percentage. Sucrose percentage is the amount of sucrose in the beet juice. The ideal sucrose percentage for sugar production is between 17.5% and 19.6%. Total soluble solids content is the total amount of dissolved solids in the beet juice. The total soluble solids content should be between 18.8% and 21.5%. The chemical and technological properties of beet juice can be used to evaluate the quality of beet roots for sugar production. By measuring these properties, it is possible to determine the sucrose losses in molasses and to optimize the sugar extraction process.

Sucrose percentage of sugar beet roots juice tends to range between 15.47% and 18.54% during the season of sugar beet. The chemical and technological properties of beet juice can also affect the sugar extraction process. Meanwhile, the sucrose percentage of the beet juice is an important factor to consider, as it determines the amount of sugar that can be extracted. The total soluble solids content of the beet juice is also important, as it affects the viscosity of the juice and the rate of sugar extraction. The sucrose percentage of sugar beet juice varies during the beet campaign. The sucrose percentage is typically highest in the middle of the season and lowest at the end of the season. This is because the sugar content of the beet roots decreases as the beet roots over matured.

Chemical and technological properties of beet juice during the beet campaign (beet-processing period) are shown in Table (1). Similar results were reported by Abou EL-Magd *et al*. (2004), Asadi (2007) and Gomaa (2009) who reported that sucrose content in beetroot juice ranged from 17.5% to 19.6%, which is the perfect level to produce sugar. Total soluble solids (T.S.S.) content of beet juice varied from 19.93±0.89% to 21.98±1.04% as reported in Table (1). These data are in agreement with the results of Zalat (1993) and Hozayen (2002) who revealed that TSS in sugar beet juice was between 15.5% and 23.6%. On the other hand, higher reducing sugar percentages were observed as a significant increase in the sugar beet juice from 0.28±0.00 to 0.71±0.06%. These results were not consistent with those reported by (Abou-Shady, 1994); (Abd EL-Mohsen, 1996) and (Gomaa, 2009) who found that the percentages of reducing sugar varied from 0.3% to 1.6% (based on dry weight).

Ash content declined significantly from 0.59±0.02% to 0.32±0.03% at the end of the season in fresh sugar beet juice. These results were in contrary with our previous published data in season 2021 (Mohamed *et al*., 2023) who found that ash content elevated from 0.6±0.020 to 0.8±0 .021% at the end of the season in fresh sugar beet juice. Meanwhile, these results are almost consistent with Hozayen (2002) and Gomaa (2009) who reported that ash values of fresh beet juice varied between 0.5 to 0.8 %.

Table 1. Physical and chemical properties of fresh beet juice as Mean ±SD during processing of 2022 working season

Parameters	Mean (SD)			P Value
	Starting of season	Middle of season	End of season	
Sucrose %	17.73±1.10	18.54±1.05	15.47±0.89	<0.001**
Brix (T.S.S) %	19.93±0.89	21.73±0.69	21.98±1.04	<0.001**
Reducing sugar	0.39±0.06	0.28±0.00	0.71±0.06	<0.001**
Ash%	0.59±0.02	0.57±0.12	0.32±0.03	<0.001**
Sugar recovery (SR)	13.99±1.03	14.99±2.01	11.84±1.94	<0.001**
Sucrose loss (SL)	2.97±0.35	2.45±0.79	4.54±0.47	<0.001**
Purity %	86.92±2.04	87.52±2.65	82.18±3.09	<0.001**
Beet quality%	79.71±1.96	81.47±2.07	73.96±2.16	<0.001**
pH	6.15±0.98	5.95±0.21	5.37±0.57	<0.001**

*Each sample was represented as a mean of five replicates during each period of season.

Sucrose recovery is the amount of sucrose that is extracted from the sugar beet juice. The higher the sucrose recovery, the more sugar that is produced from the beet roots. Sucrose recovery is negatively correlated with the Na, K, and α-N contents of the juice, meaning that higher levels of these elements lead to lower sucrose recovery (Mosaad *et al*., 2022).

Sucrose recovery of sugar beet juice elevated significantly from 13.99±1.031% to 14.99±2.01% during the sugar beet campaign in the middle of the season. These results are agreed with Gomaa (2009), who mentioned that the recovery of sucrose (white sugar) in beet juice fluctuated from 14.2 to 15.2 % in beet laboratory. Results obtained in Table (1) showed that the sucrose loss value in sugar beet wastes was the lowest in the middle of the season (2.45±0.79%) and tend to increase to 4.54±0.47% at the end of season. Due to rising sugar losses in beet pulp, filter cake, and final molasses, the proportion of sucrose lost increased. In order to determine the effects of short storage (a few hours) and extended storage (more than 24 hours), it is suggested that you contrast analysis between manufacturing laboratory and beetroot laboratory.

These data disagreed with the results mentioned by Gomaa (2009), who revealed that the sucrose losses percentages fluctuated from 3.1 to 4.1 % in beet juice. It could be concluded that by decreasing the sucrose losses, the amount of white sugar produced increased.

The ratio of sucrose to total solids as a percentage is defined as the purity of sugar beet juice. The results in Table (1) show that the best purity value was obtained in the middle of the season (87.52±2.65%) and then declined significantly at the end of the season (82.18±3.09%). To elaborate, in order to produce high purity beetroot juice, the sugar factory's primary objective is to remove non-sugar from sugar. Additionally, improving beetroot juice purity would accelerate and enhance the production of beetroot sugar. These results were consistent with Asadi (2007), who stated that the purity of beet juice usually ranged from 85 to 88% in a standard washed beet (beet without peeling).

Data in Table (1) revealed that the quality of sugar beets depends on the maturity of the sugar beet roots as reported by El-Sheikh *et al*. (2009). Therefore, during the first and last days of the factory's operating seasons, the beetroot quality declined due to alkaline (K and Na content) and nitrogen content arising. Consequently, it showed a significant increase from 79.71±1.96% at the first of season and increased to 81.47±2.07% at the middle of season then decrease to 73.96±2.16% at the end of season. It is evident that there is an inverse link between the variation in beetroot quality values and the variation in decreasing sugar percentages over the course of the working season. Additionally, because the lowering sugar levels were at their lowest in the middle of the season, the best beetroot root quality values were noted at that time. These results were in agreement also with those documented by Gomaa (2009), who mentioned that the beet quality fluctuated from 78.6 to 83.0% throughout the campaign of the beet processing.

The result in Table (1) showed the pH values of sugar beet juice significantly declined from 6.15±0.98 to 5.37±0.57during the beet campaign. These data were less than those recorded by Gomaa (2009), who mentioned that the pH of sugar beet juice ranged from 6.5 to 6.7.

Table 2. Chemical and physical properties of sugar beet molasses as Mean±SD during processing of 2022 working season

Parameters	Mean (SD)								
	Starting of season			Middle of season			End of season		
	Line (1)	Line (2)	T-test	Line (1)	Line (2)	T-test	Line (1)	Line (2)	T-test
Brix%	79.40±0.09	79.80±0.16	4.7	80.50±0.08	80.85±0.24	9.0	79.80±0.12	79.30±0.15	71.5
Purity%	61.30±0.16	61.92±0.87	68.0	59.59±0.49	62.71±0.81	8.4	61.75±0.59	64.85±0.80	7.6
Reducing sugar%	0.25±0.03	0.28±0.01	8.7	0.48±0.04	0.35±0.09	9.8	0.85±0.06	0.95±0.02	19.5
Color (MAU) at 420 nm	27330±1.28	41170±1.38	4548.7	30500±1.15	43225±2.91	3962.8	34180±1.87	45500±2.16	7225.1
Specific gravity	1.41±0.02	1.42±0.03	0.4	1.45±±0.04	1.46±0.06	1.9	1.41±0.00	1.40±0.05	1.2
pH	8.70±0.01	8.80±0.01	26.7	8.50±0.00	8.75±0.03	94.3	7.90±0.03	7.70±0.01	24.0

*Each sample was represented as a mean of five replicates during each period of season.

The runoff syrup from the last phase of crystallization, known as beetroot molasses, typically includes around 50% sugar and 80% dry ingredients (Brix). It is the sugar factories' most valuable byproduct (Moosavi and Karbassi, 2010). Table (2) contrasts the chemical and physical properties of beetroot molasses produced by the two production lines during the working season of 2022. The data in Table (2) revealed the following indication: the brix of beet molasses ranged insignificantly from 79.30±0.15 to 80.85±0.24% in both production lines 1,2, respectively throughout the studied season. Molasses purity fluctuated from 59.59±0.49 to 62.71±0.81% during the season. At the end of the season, reducedcing sugar content insignificantly increased from 0.25±0.03% to 0.85±0.06% for the production line (1) and from 0.28±0.01% to 0.95±0.02 in the production line (2).

The results in Table (2) showed the color of molasses that is produced from production line (1) which ranged from 27330±1.28 to 34180±1.87MAU. The production line (2) recorded higher colour values varied from 41170±1.38 to 45500±2.16 MAU. These results were in the same line with Asadi (2007), who found that the molasses colour fluctuated from 40000 to 70000 MAU. Whereas Rahimi *et al*. (2018) found that colour intensity improved by lowering pH level.

Molasses's standard specific gravity is approximately from 1.41±0.02 to 1.46±0.06. Also, pH of beet molasses elevated from 7.70±0.01 to 8.80±0.01 insignificantly. These results are in agreement with those reported by AL-Tantawy (2012), who demonstrated the following results of beet molasses in Delta Sugar Company: the purity was varied from 59.5 to 61.92%, the colour is 28267 to 51630 MAU, and the specific gravity was 1.4 and the pH is 8 to 9.5. These dwere was tested in different periods of campaign.

Table 3. K, Na and α-N (mmol/100 g beets) contents in final molasses as Mean±SD in the production line (1) and line (2)

Parameter	Mean (SD)								
	Starting of season			Middle of season			End of season		
	Line (1)	Line (2)	T-test	Line (1)	Line (2)	T-test	Line (1)	Line (2)	T-test
Sugar%	17.75±0.02	17.96±0.01	26.4	18.81±0.91	19.73±0.52	0.8	15.59±0.76	16.24±0.05	47.2
K	5.59±0.4	5.50±0.02	18.7	5.76±0.04	5.55±0.02	17.4	6.40±0.03	6.20±0.01	18.1
Na	3.39±0.03	2.37±0.03	31.2	2.48±0.03	2.25±0.02	21.2	4.77±0.04	3.05±0.02	12.0
α-N	3.30±0.02	2.69±0.01	4.3	3.20±0.01	2.77±0.01	4.1	3.88±0.05	2..93±0.01	29.1
Quality%	79.27±0.01	83.19±0.01	141.2	81.83±0.09	83.65±0.07	61.9	71.23±0.19	76.98±0.21	2.2
Sugar loss %	2.49±0.01	2.61±0.01	3.2	2.53±0.01	2.85±0.01	2.2	3.65±0.04	3.90±0.03	3.9

*Each sample was represented as a mean of five replicates during each period of season.

It is well known that the quality of molasses depends on the nature of its sugar beet. In sugar technology, sugars in molasses are considered as sugar loss. Decreasing the sugar loss value in molasses is one of the most important goals of sugar factory because it increases profitability. Therefore, the easiest way to evaluate the performance of sugar factory is molasses purity. The lower the molasses purity, the less sugar is left in molasses, at the same amount of molasses production. Thus, credit that sugar beet factory can get. Data in Table (3) indicates the relation between sugar beets quality and sugar loss percentages in final molasses in production line (1) and line (2) during 2022 working season after 3 days from sugar beets harvest during different periods of season.

From Table (3), the obtained results showed that the sucrose content in sugar beet roots ranged from 15.6±1.1 to 19.1±1.3 % after (3 days) from beet harvest i.e., fresh beet. The results are in agreement with Gomaa (2009), who reported that sucrose content in sugar beet in the most cultivars is ranged from 17.3 to 19.3% directly after harvest.

The data in Table (3) and figure (1) demonstrated that as alpha amino nitrogen, sodium and potassium content increased at the end of season so that, the quality of sugar beet decreased and consequently the amount of sugar loss in final molasses increased and vice versa. As shown in Table (3) the quality of sugar beet decreased from 81.83±0.09 and 83.65±0.07% in the middle of season to 71.23±0.19 and 76.98±0.21% at the end of season in both production line (1) and line (2) respectively.

It also showed the differences in sugar loss in relation to beet roots quality during the whole season. At the middle of the season, sugar loss was at the lowest level then decreased insignificantly at the middle of the season in both production lines. This might happen due to the insignificant reduction in K, Na and α-N levels that occurred in the middle of the season (Hoffmann, 2010).

Consequently, the sugar loss in molasses increased from 2.53±0.01 and 2.85±0.01% in the middle of season to 3.65±0.04 and 3.90±0.03% at the end of season in both production line (1) and line (2) respectively, during different periods of beet season and after (3 days) from mature beet harvest. Also, it could be noticed that there is a reversible relationship between the quality of sugar beet, the sugar losses in molasses and the concentration of alpha amino nitrogen, sodium and potassium content in sugar beet. These results are confirmed by AL-Tantawy (2012) who demonstrated that as alpha amino nitrogen, sodium and potassium content increase in sugar beet, the quality of sugar beet decreases and consequently the amount of sugar lost in final molasincreasesease. This reversible relationship reflects some characters of the produced molasses.

Data in Table (4) and Figure (1) represented the Mean (SD) of the first 8 days after beets harvest of the 3 stages (early, middle and late) of the 2022 working season. The tabulated data revealed that there was a reversible relationship between the quality of sugar beet and sugar loss in molasses in all stages of the working season. A significant increase has been recorded of alpha amino nitrogen 2.91±0.02, sodium 3.09±0.02 and potassium 5.83±0.09 mmol/100g beets leads to reduce the sugar beet quality to 79.96±0.92% significantly at the beginning of the season. Consequently, the average of sucrose losses% in final molasses was increased to 2.36±0.01%. These results are very close to those reported by Al-Barbari (2017), who found that in the starting of beet season the sucrose content of sugar beet juice was 16.6 and 17.0%, beet quality with low values was 74.9 and 78.8%.

Table 4. The relation between sugar beet roots quality and sugar loss in final molasses throughout working season 2022

Season time	Beet quality%	Sucrose %	K*	Na*	α-N*	Sugar loss %	P-value
Early season	79.96±0.92	18.07±0.16	5.83±0.09	3.09±0.02	2.91±0.02	2.36±0.01	**<0.001****
Middle season	81.86±0.79	18.85±0.42	5.60±0.06	2.69±0.04	2.95±0.01	1.36±0.3	**<0.001****
Late season	75.50±0.54	15.91±0.27	6.07±0.04	3.50±0.02	3.82±0.01	4.05±0.04	**<0.001****

Each sample was represented as a mean (SD) of five replicates during each period of season.

* Potassium (K), Sodium (Na) and α -amino nitrogen (α-N) contents determined as mmol/100 g beets (Mean±SD)

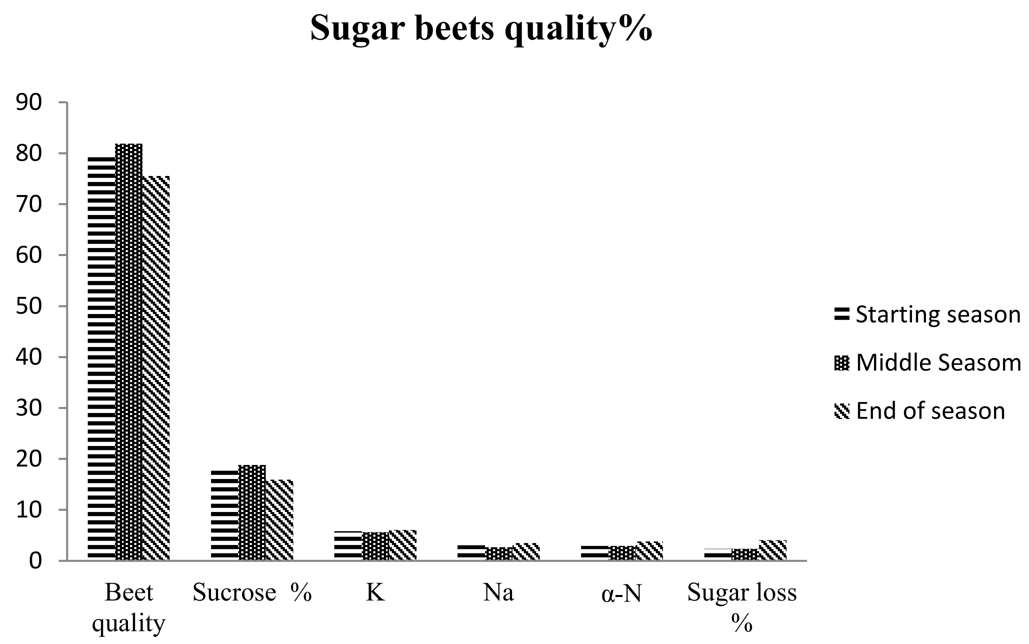

Figure 1. Effect of K, Na and α-N content on fresh beets quality and sugar loss in molasses

On the other hand, at the middle of working season there was a reversible relationship between the quality of sugar beet and the sugar loss percentage in molasses. Data in Table (4) indicated that at the middle of the season, the mean of sucrose content of sugar beet juice increased to 18.85±0.42 significantly. Moreover, by increasing the quality of sugar beet to 81.86±0.79%, the sucrose loss percentage in final molasses recorded a significant decrease to 1.36±0.3%. These results also are very close to those reported by Al-Barbari (2017), who revealed that at the middle of the season, the sucrose content of sugar beet juice elevated to 20.0 and 20.0%, while the beet quality increased to 84.1 and 86.0%.

At the end of working season as it is crucial time since all farmers harvest beets to allow for timely preparation of the land multi-cropping. Sugar beet roots stored directly in atmospheric air which leads beet roots to be exposed to high temperatures. In this case, alpha amino-nitrogen, sodium and potassium content will increase significantly in sugar beet leads to a significant decrease in beet roots quality index. Consequently, the mean of sugar loss in final molasses was increased. Data in Table (6) showed that by significant increase of alpha amino-nitrogen, sodium and potassium (3.82±0.01, 3.50±0.02and 6.07±0.04 mmol/100 g beets, respectively) in sugar beet leads to decrease the beet quality to 75.50±0.54% significantly. These results are confirmed by Asadi (2007), who mentioned that the molasses is sold as a by-product of the factory; the amount sugar loss in molasses is considered as the largest loss about 80% of unrecoverable sugar which ends up in molasses.

Conclusion

One could draw the conclusion that expediting the sugar manufacture process minimises deterioration in beet roots quality. The beets accumulated α-amino N, inverted sugar, K, and Na, escalating the price of sugar production. Additionally, there were notable variations in the concentration of elements that influence the quality of beetroot roots. With an emphasis on non-sucrose substances that limit sugar recovery, more research is required to assess the effect of storage temperature on the change of quality in sugar beets. Quality evaluations based on K, Na, α-amino N, and inverted sugars seem to be insufficient for long-stored beetroot roots. Furthermore, not enough research has been done on technological processes that are minimizing the impact of these impurities.

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التأثير المحتمل لجودة جذور بنجر السكر (*Beta vulgaris*) على فقدان السكر في مولاس البنجر

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الملخص

الهدف الرئيسي من هذه الدراسة هو تقييم العوامل التي تؤثر على كمية السكر المفقودة أثناء المعالجة النهائية لمولاس جذور بنجر السكر. الحصاد المتأخر لجذور بنجر السكر له تأثير على جودة البنجر، كما أدت الإصابة بتعفن الجذور إلى ارتفاع كبير في تركيزات السكريات المحولة، Na،K ، و α-amino N، والتي لها آثار صناعية سلبية. ولهذا الغرض، أثناء الصناعة، تم جمع عينات من مولاس بنجر السكر وجذور بنجر السكر (من تصميمين منفصلين لخطوط التصنيع) والتجارب البحثية في شركة الدلتا للسكر خلال أوقات مختلفة في مواسم العمل لعام 2022، بداية الموسم ووسط الموسم واخر الموسم (من منتصف فبراير إلى أواخر مارس، ومن أوائل أبريل إلى منتصف مايو ومن منتصف مايو إلى أواخر يونيو، على التوالي). انخفض محتوى السكروز في جذور بنجر السكر بشكل كبير خلال موسم الحصاد، وفي الوقت نفسه Na،K، α-amino N ، والسكريات المحولة والمكونات الأخرى المتراكمة في البنجر، وبالتالي تدهورت جودة جذور بنجر السكر بشكل ملحوظ، بينما تحسنت جودة جذور بنجر السكر معنوياً من 1.96±79.71% إلى 2.07 ±81.47% حتى منتصف الموسم. علاوة على ذلك، زادت درجة نقاء عصير جذور بنجر السكر بشكل كبير من2.04 ± 86.92إلى2.65 ±87.52% في نفس الوقت من الموسم. أظهرت النتائج المتحصل عليها وجود علاقة عكسية بين جودة بنجر السكر وفقد السكر في مولاس البنجر. علاوة على ذلك، كانت مستويات α-amino N, Na , K والسكر المحول في بنجر السكر في علاقة عكسية مع جودة البنجر. ولذلك، فإن معايير تقييم الجودة قد تتطور استجابة لاحتياجات العمليات الصناعية المستقبلية.