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# Effect of Size, Storage, Age at Harvest, and Juice Season on Physicochemical and Technological Characteristics of Sugar Beetroot

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THE AIM of this study was to investigate effect of beetroot size, storage durations, and harvest age (150, 180, 210 days) on physicochemical and technological characteristics of sugar beet root. The results showed that chemical composition of fresh sugar beetroot was 77.20, 20.60, 17.88 0.15 and 0.71 for moisture, TSS, sucrose, reducing sugar and ash respectively; while purity of juice and beet quality recorded 86.80 and 81.80 respectively. Beetroot of medium size exhibited the highest sucrose content (19%), juice purity (87.73%) and beet quality (77.90%). Additionally, beetroot of the medium size showed the lowest sugar loss in molasses (2.01%) reducing sugar content (0.11%) and sugar loss in pulp (0.21%). On the other hand, the sucrose content and quality of beetroot decreased from 75.31, 81.11 at 0 day to 64.77, 72.80 after 8 days of storage respectively. However, the sugar loss in molasses increased from 2.58 at 0 day to 3.89 at 8 days of storage. Harvest beet roots at age of 210 days recorded the highest value of quality and sucrose content 81.26 and 19.03 as well as lowest value of reducing sugar (0.10). Middle season timing in mid-April recorded the highest values of sucrose content (15.74, 18.07 and 20.00%) with age of harvesting (150, 180 and 210 days) respectively;. while sucrose content and quality of beet roots recorded the highest value overall harvest age and timing of the juice season (19.21, 81.27 and 17.94, 78.40) in addition to the lowest values (0.15 and 0.26%) of reducing sugar in beetroots, respectively.

**Keywords:**………………………………..

## Introduction

Sugar beet (*Beta vulgaris* L.) is considered the second source of sugar and represents 38% of the total sugar production in the world, while sugar cane is considered the first source of sugar and represents 62% of the total sugar production. In Egypt, sugar beetroot is a crucial crop for the manufacturing of sugar. Approximately 67.7% of the domestic sugar production is produced there (SCC, 2021). In order to reduce the gap between the production and consumption of sugar, the types of sugar beetroot are regarded as the foundation or one of the key production wings. Late autumn or early winter is when sugar beets are harvested.A sugar manufacturing can begin processing sugar beets after six to eight months of growth. In beetroot roots, extending the postharvest period resulted in lower sugar and purity levels as well as a higher percentage of weight loss (Al-Zubi, 2016). Delay in sugar beet delivery to factory also lowers sucrose content and proportion of high-quality beets. On the other hand, the amount of sucrose lost in wastes increases as the duration between harvest and processing

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increases, from zero time (at harvest) to eight days (Abd Alraoof et al., 2020). Although changes in the composition of the cell wall and pathogen invasion also contribute to this loss, respiration is the predominant cause. Numerous studies have been conducted to look into how delivery delays affect the characteristics of sugar beets (Tsialtas & Maslaris, 2013; Al-Jbawi et al., 2015; El-Syiad, 2016, Hoffmann & Schnepel, 2016; Madritsch et al., 2020). Abd El-Rahman & El-Geddawy, 2019) showed that sugar beet manufacturing at 210 days gives the lowest percentage of nitrogen substance, thus sugar percentage increased in comparison with early periods.This study was carried out to evaluate chemical and quality parameters of different size of sugar beet roots storage at different days and harvest age with different time of working or processing juice season.

## Materials and Methods

*Beetroot samples*

During 2021 and 2022 harvest and working seasons, the experimental procedures were conducted at the laboratories of the Delta Sugar Company in Kafr El-Sheikh Governorate.Sugar beetroot samples (*Beta vulgaris L.*) of different cultivars were collected from Delta Sugar Company's research facilities. Beetroot samples of different cultivars were harvested manually after different periods of sowing in the period from February (start of working season) to June (end of working season) and stored directly in open air.The samples were divided into six groups of each cultivar, each group is about five tons of beet roots with different cultivars and stored for 8 days in open air directly after harvest.

- The first group was beetroots with small size (500 gm)

- The second group was beetroots with medium size (1000 gm).

- The third group was beetroots with large size (2000 gm).

- The fourth group was beetroots with different cultivars at 150 days of growth (beet roots age) during different period of working season (starting, middle and end working of season).

- The fifth group was beetroots of different cultivars at 180 days of growth (beet roots age) during different period of working season (starting, middle and end working of season).

- The sixth group was beetroots of different cultivars at 210 days of growth (beet roots age) during different period of working season (starting, middle and end working of season).

The samples were dried to a constant weight at 105 °C using the air oven-drying method, in accordance with AOAC (2015), to estimate the moisture content.

The amount of sucrose and reducing sugars was measured using an automatic saccharimeter on a lead acetate basis in accordance with Delta Sugar Company practise and the approach provided by AOAC (2015). According to AOAC (2015), reducing sugar content of samples of beetroot roots was assessed using Ofner's volumetric techniques. Using a fully automatic digital refractometer, model ATR-S (04320), with temperature correction between 15 and 40 °C, the total soluble solids (T.S.S.) of fresh and stored samples were measured. This was done in accordance with a Delta Sugar Company practice. The AOAC (2015) method was used to measure the ash content in a muffle furnace operating at 550°C.

*Juice purity measurement*

Juice purity was obtained according to Spronova (1979) using the following equation: Purity = (sucrose % X 100)/total soluble solids (TSS).

*Determination of alpha amino nitrogen, Sodium and Potassium*

Using the venma, Automation BV Analyser IIG-16-12-99, 9716JP/ Groningen / Holland, alpha amino nitrogen, sodium, and potassium were calculated. According to AOAC (2012), the results were computed as milli equivalents per 100 grams of beetroot (meq/100 g beetroot), with a temperature range of 18 to 30 °C and a maximum relative humidity of 70%.

The following formulae were used to determinethe beetroot quality and sugar recovery % in accordance with Silin & Silina (1977) and Sapronova et al. (1979).

Beet quality = (sugar recovery/ pol) x 100.

Where:

Sugar recovery % = (pol-0.29) – 0.343 (k + Na) – α amino N (0.0939).

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

Percentage of sucrose loss in molasses (SLM %) Using the equation shown below, it was determined as described by Devillers (1988).

SLM% = [0.14(Na + K) + 0.25 (α-amino N) + 0.5].

*Measurement of sugar loss in pulp*

The loss of sugar in pulp was determined based on the formula suggested by Schneider (1968), as follows:

$$\text{Sugar loss in pulp} = WS,C - \frac{(WS,C \times \{(WDS,PP) - (WS,PP) \times (WDS,C)\}}{\frac{(wds,pp) - \{(wspp) \times 100\}}{Pdif.j}}$$

where: $W_{S,C}$ is the sugar content of cossette %.

$W_{DS,PP}$ is the dry substance of pressed pulp (%).

$W_{S,PP}$ is the sugar in pressed pulp (g% g).

$W_{DS,C}$ is the dry substance of cossette (%).

$P_{Dif.J}$ is the diffusion of juice purity

*pH measurement*

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

*Experimental design*

The experimental design was a completely randomized design (CRD) with three replications. Data were analysed by SAS software package. Duncan's values at 5% level were calculated to test the significance of differences between means according to Snedecor & Cochran (1980).

## Results and Discussions

Sugar beet composition is important to both sugar beet farmer and sugar factory. Sugar (sucrose) and non-sugar (non-sucrose) content determine the quality of the sugar beet, where high sugar and low non-sugar content is desirable. Therefore, it is important to evaluate the chemical and technological characteristic of beet juice in order to evaluate the quality of beet roots for sugar production. Table 1 listed the chemical composition of fresh sugar beetroots of various weights during the beet-processing stage. The moisture content of sugar beet recorded 77.20% during 2021working seasons. The results are in agreement with findings of Gomaa (2009) and Abd-Elghaney (2012) who found that moisture content of sugar beetroot ranges between 75.69% and 78.68%. It can also be noticed that the total soluble solids content of beet juice was 20.60%. The findings concur with those of Asadi (2007) and Gomaa (2009).The T.S.S. of sugar beetroot juice, according to their assessment, varied between 19.78% and 25%. Juice from sugar beets contained 17.88% sucrose. Abou ElMagd et al. (2004); Asadi (2007) and Gomaa (2009) discovered comparable findings. They claimed that the best range for sugar factories for the sucrose concentration of beetroot juice was between 17.5% and 19.57%. Relatively higher reducing sugar values were found in the sugar beet juice (0.15). These data shown in Table 1 are comparable with those reported by others, including Abou-Shady (1994), Abd EL-Mohsen (1996), and Gomaa (2009) who found that the reducing sugar ranged between 0.25 to 1.55% (dry weight basis). Also, Table 1 shows that the ash content was 0.71% of sugar beet juice during working season. The results agree with those reported by Alfaig et al. (2011). The data illustrated in Table 1 showed that the purity of sugar beetroots juice was 86.80%, which is consistent with those found by Abd El-Rahman & El-Geddawy (2019). The main goal of a sugar factory is to separate non-sugar from sugar materials to improve the beet juice purity to the extent that sugar with 100% purity is produced. Also, increasing the purity of beet juice would make sugar beet processing much faster and easier.

The quality of the beets is directly correlated with the case of the beet roots, as shown in Table 1. Because of this, the quality of beets decreases when alkaline (K and Na concentration) and nitrogen content are present. Sugar beetroot quality was 81.80% for fresh produce. The results are comparable to those from Zaki et al. (2014) who discovered that the quality of beetroot ranged from 77.63 to 80.15%. In accordance with findings by Gomaa (2009), who stated that the pH of sugar beetroot juice was 6.51, results in Table 1 showed that the sugar beetroot juice had a pH value of 6.20. Chemical and technological characteristics of sugar beet roots as affected by size of beetroots (small, medium, and large) are illustrated in Table (2). The moisture content was 78.03, 77.23, and 75.63% for the large, medium, and small size beetroot; respectively. The results are in agreement with findings of Gomaa (2009) and Abd-Elghaney (2012) who found that moisture content of sugar beetroot ranged between 75.69% and 78.68%. From the data in Table 2, it can also be noticed that the TSS content for juice of medium size beetroot was 22.48%, followed by 19.48% for juice of the small size roots, and 18.96% for juice of the large sized roots. The findings of Asadi (2007), who stated that the TSS of sugar beetroot juice ranged between 19.78% and 25%, are in agreement with these observations. Juice of the medium sized roots showed the highest sucrose content (19%), while the lowest sucrose content was found for juice of the large sized roots (14.53%).

Also, from Table 2 it can be seen that the lowest reducing sugar content was found for juice of the medium sized roots (0.11%), and increased in juice of the large sized ones (0.36%). This can be attributed to that some of sucrose was hydrolyzed to inverted sugar. The information in Table 2 is comparable to that provided by other sources, including Abou-Shady (1994), Abd EL-Mohsen (1996), and Gomaa (2009), who discovered that the reducing sugar concentration ranged from 0.25% to 1.55% (dry weight basis), indicating significant differences between medium size of sugar beet roots and other sizes.

The purity of raw juice recorded86.52, 87.73, and84.93 for the small, medium, and large size of sugar beet roots; respectively. The purity of juice from the medium sized roots is high due to in the low non-sugar content. These findings are consistent with Asadi's (2007) findings, according to which the purity of diffusion juice (raw juice) ranged from 85 to 88% and that it typically contains 15% dry material. While the dry substance in clear juice is roughly 0.5% lower than that in diffusion juice and is about 3 units greater in purity.

The results in Table 2 showed that there are significant differences in pH values for juice obtained from beetroots of different sizes (small, medium and large size). Edye &Clarke (1998) reported that sucrose decomposition can be obtained by measuring pH drop. The higher pH drop is due to formation of organic acids (e.g. from monosaccharide degradation). Quality of sugar beet roots and sugar loss in molasses varied depending on size of beetroots. There is no significant difference between small and large size, while medium size presented the highest value of quality and lowest value of sugar loss in molasses. Data in Table 2 showed that when sugar beet's concentration of amino nitrogen, sodium, and potassium grew, the quality of the crop dropped, and as a result, the amount of lost sugar increased, and vice versa. The quantity of alpha amine nitrogen, sodium, and potassium present in sugar beet, as well as the sugar losses percent on beet in molasses, are all related in a reversible manner. These findings are in line with those of AL-Tantawy (2012), who showed that the quality of sugar beet declined as alpha amine nitrogen, sodium, and potassium content rose in sugar beet, and as a result, the amount of sugar lost in molasses increased.

Cutting beets into long, narrow strips known as cossettes is the method of slicing beets. The improvement of the diffusion process and sucrose removal from beets is the primary goal of the beet slicing operation. This was accomplished mostly as a result of the beetroots' increased surface area, which maximises the contact area between the beet cells and the water during the diffusion and enhances the flow of the sugar from the cells to the diffusion juice. Table 2 displays the impact of the beetroot slices on the extraction procedure. Purity of juice (sucrose % dry substance) is decreased as a result of the increased non-sugar produced by torn cells, which diffuse more contaminants (non-sugar) into the surrounding juice. According to El-Syiad et al. (2016), tearing increases the amount of foams produced because the juice releases saponin, which is undesirable.

The mass of cossettes shorter than 10 mm long divided by the total mass of cossettes (100 g) is the mush content, as shown in Table 2. The mush content 1.37%, slice length 7.98cm and thickness 4.02mm with medium size beet roots. While large size is more mush content 6.40%, less slice length 5.23cm and thickness 6.70 mm. According to Silin &Silina (1977) and Asadi (2007), who claimed that good cossettes have a Silin number of 6 to 10 m, are shorter than 10 cm, and are thinner than 5 mm, the results in Table 2 are consistent with their findings. Silin number (SN) is the length (in meters) of 100 g of cossettes. Additionally, the following qualities are preferred for premium cossettes: consistent thickness of 3 to 6 mm, a V-shape, and a length of 30 to 60 mm. The mush content must be less than 2 to 5% to ensure good operations.

From Table 2 the quality of beet slicing (cossettes) is one of the most important factors on the efficiency of extraction process. Generally, for the same result, thick cossettes need more diffusion (extraction) time, or a higher amount of diffusion water than thinner cossettes. Therefore, medium size recorded the lowest value of sugar loss in pulp% of beet (0.21%) followed by small size (0.30%) and large size (0.35%). Regulation of feeding beetroots to the factories is as important as many other aspects in beet sugar production, since once harvested have to be processed directly. The supply of beet can be regulated by adjusting the sowing and harvesting dates specially if the growing season is wide first beets were peeled at receiving area (beet-storage areas) located at the factory site or at the land itself after harvest the roots of sugar beet (El-Syiad et al., 2015).

**TABLE 1. Physicochemical properties of fresh sugar beet roots during working season.**

| Constituents | Moisture content% | Brix (T.S.S)% | Sucrose content% | Reducing sugar% | Ash | Beet juice purity% | Beet roots quality% | pH |
|---|---|---|---|---|---|---|---|---|
| **Average value** | 77.20±2.71 | 20.60±2.56 | 17.88±2.08 | 0.15±0.04 | 0.71±0.18 | 86.80±1.89 | 81.80±2.5 | 6.20±1.34 |

Each value was an average of six determinations

**TABLE 2. Effect of roots size on the physicochemical characteristics of sugar beetroots.**

| Constituents | Small size | Medium size | Large size |
|---|---|---|---|
| **Moisture %** | 75.63±0.99b | 77.23±0.25a | 78.03±0.16a |
| **Brix (T.S.S) %** | 19.48±0.54b | 22.48±0.32a | 18.96±0.12b |
| **Sucrose %** | 17.15± 0.38b | 19.00±0.05a | 14.53±0.30c |
| **Reducing sugar%** | 0.26±0.01b | 0.11±0.01c | 0.36±0.04a |
| **juice purity%** | 86.52±0.42b | 87.73±0.21a | 84.93±0.06c |
| **pH value** | 5.89±0.29b | 6.38±0.10a | 5.44±0.04c |
| **Beet quality%** | 75.53±0.63b | 77.90±0.36a | 74.30±0.95b |
| **Slice length (cm)** | 6.92±0.10b | 7.98±0.19a | 5.23±0.74c |
| **Slice thickness (mm)** | 4.97±0.15b | 4.02±0.17c | 6.70±0.10a |
| **Mush % beet** | 4.00±0.50b | 1.37±0.15c | 6.40±0.36a |
| **Sugar losses in pulp % of beet** | 0.30±0.017b | 0.21±0.01c | 0.35±0.02a |
| **Sugar loss in molasses% of beet** | 2.82±0.27a | 2.01±0.15b | 3.15±0.23a |

Different letters within the same rows indicate significant differences ($P<0.05$)

Effect of storage on physicochemical and technological properties of different sized beetroots (small, medium, and large) is illustrated in Table 3. Generally, there are significant differences in properties of among beetroots of different sizes.Sucrose content of beetroots was decreased due to prolongation of storage periods until 8 days. Beetroot of medium size recorded the highest sucrose content at different storage periods. During storage, beetroot's respiration process caused an increase in water loss. The medium size recorded the lowest water loss (moisture content 74.68%) o during storage periods. Also, the action of invertase, by which sucrose transformed into invert sugars "which can inhibit crystallization of sucrose" increased the sucrose loss in wastes. According to sucrose loss equation when α- amino nitrogen, sodium and potassium increased, the sucrose loss increased. These results are comparable with those found by Asadi (2007) who reported that sugar loss during storage is any sugar-content reduction that occurs from the time the beets are weighted at the delivery to the storage and the time they are reweighted during processing (usually after beet slicing). Post-harvested beets are still alive and continue to consume sugar. The losses result from beet respiration and microorganisms that decompose part of sucrose to produce invert sugar. From Table 3 it can be also noticed that the relative losses in weight of all beet roots cultivars were increased as storage prolonged under all storage conditions. The losses in weight was 13.24%, 16.36 and 22.36% for medium, small, and large size of sugar beetroot after 8 days of storage; respectively. The small sized sugar beetroots recorded the lowest value of weight losses during storage. These results are in agreement with findings of Al-Jbawi et al. (2015).

**TABLE 3. Effect of storage periods on sucrose content, moisture content, weight losses, and quality of different sized sugar beetroots.**

| Parameters % | Storage periods | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Root size** | **0 day** | **2 days** | **4 days** | **6 days** | **8 days** | **mean** |
| **Sucrose content % (dry weight)** | small | 75.05±0.23b | 71.69±0.66de | 69.44±0.50f | 66.06±0.15g | 63.85±0.56h | 69.22±4.13b |
| | medium | 77.57±0.40a | 75.24±0.56b | 73.43±0.21c | 71.05±0.22e | 69.82±0.24f | 73.42±2.91a |
| | large | 73.30±0.81c | 72.00±0.19d | 69.64±0.41f | 63.60±0.78h | 60.63±0.83i | 67.83±5.11c |
| | **mean** | 75.31±1.91a | 72.98±1.76b | 70.841.98±c | 66.90±3.31d | 64.77±4.07e | |
| **Moisture content%** | small | 72.47±0.32d | 70.15±0.12e | 68.94±0.05f | 65.02±0.45g | 59.58±59i | 67.23±4.69c |
| | medium | 77. 57±0.40a | 76.42±0.10b | 75.27±0.47c | 74.65±0.13c | 69.48±1.34ef | 74.68±2.93a |
| | large | 78.10±0.36a | 74.38±0.16c | 70.17±0.35e | 65.57±0.47g | 61.58±1.10h | 69.96±6.15b |
| | **mean** | 76.04±2.71a | 73.65±2.77b | 71.46±2.92c | 68.41±4.69d | 63.55±4.62e | |
| **Weight losses%** | small | 0.00±0.00k | 12.05±0.48i | 20.48±0.54f | 22.86±0.25e | 26.42±0.54c | 16.36±9.79b |
| | medium | 0.00±0.00k | 7.94±0.82j | 14.56±0.51h | 19.72±0.45fg | 24.00±1.05de | 13.24±8.84c |
| | large | 0.00±0.00k | 18.37±0.15g | 25.18±0.04cd | 31.12±1.03b | 37.13±2.54a | 22.36±13.29a |
| | **mean** | 0.00±0.00e | 12.79±4.57d | 20.07±4.62c | 24.57±5.13b | 29.18±6.21a | |
| **Beet quality%** | small | 82.13±0.25ab | 80.10±0.10cd | 77.82±0.67efg | 78.03±0.59efg | 75.02±0.56h | 78.62±2.69b |
| | medium | 82.58±0.48a | 80.54±0.46bc | 79.23±0.66cde | 78.33±0.51efg | 76.73±1.00g | 79.48±2.13a |
| | large | 78.63±0.64def | 77.08±0.81fg | 73.78±0.37h | 69.65±1.52i | 66.66±0.62j | 73.16±4.69c |
| | **mean** | 81.11±1.92a | 79.24±1.69b | 76.94±2.81c | 75.34±4.35d | 72.80±4.71e | |
| **Sugar loss in molasses% of beet** | small | 2.75±0.26f | 3.02±0.28ef | 3.21±0.27de | 3.70±0.10c | 4.03±0.17b | 3.34±0.52b |
| | medium | 1.96±0.16h | 2.01±0.08h | 2.42±0.10g | 2.76±0.20f | 3.06±0.08def | 2.44±0.45c |
| | large | 3.02±0.07ef | 3.35±0.18d | 3.72±0.06c | 4.05±0.18b | 4.58±0.15a | 3.74±0.57a |
| | **mean** | 2.58±0.50e | 2.79±0.63d | 3.12±0.59c | 3.50±0.60b | 3.89±0.67a | |

Different letters in (different size and storage period)" columns and rows for each parameter represent statistically significant differences in beetroot chemical and quality parameters.

The mass loss during storage is caused by beet respiration and microorganisms. Chemically, beets lose weight during storage mainly from dehydration (water loss) caused by respiration. This type of reaction is called a dehydration reaction. The amount of mass loss depends on the temperature and humidity. Normally the mass loss is more intense during the early days of storage (El-syiad et al., 2015).From Table 3 there are significant differences in beetroot of medium size after storage periods. The results revealed that sugar beet quality generally decreased during storage under normal conditions. The quality of all beetroots decreased gradually from 80.81% in fresh beetroots to 72.80% after the end of storage (8 days); while beetroot of medium size recorded the highest value 79.48% of beet quality overall other root sizes. These results are consistent with those from Hozayen (2002) and Gomaa (2009), who discovered that the quality of all beetroot samples gradually declined from 82.95% to 66.65% at the conclusion of storage periods (12 days).

The quantity of alpha amino nitrogen, sodium, and potassium in sugar beet, as well as their concentration, can all be seen to have a reversible relationship with sugar beet quality, molasses sugar losses, and quality. These findings are in line with those made by AL-Tantawy (2012), who showed that as alpha nitrogen, sodium, and potassium content in sugar beet grew, the quality of the sugar beet deteriorated, and as a result, the amount of sugar lost in molasses increased. There are significant differences overall beetroot size, medium size recorded the lowest value of sugar loss in molasses (2.44) followed by small size (3.34) and large size (3.74) respectively;

Physicochemical and technological characteristics of sugar beetroots at different harvesting time are given in Table 4. There are significant differences between beetroots of different harvest ages (150, 180 and 210 days). The moisture content of sugar beet at different harvest ages (150, 180, and 210) days rare 78.33, 77.20 and 76.84%, respectively. Similar results were found by Ferweez et al. (2006). Harvesting beet roots at age of 210 days recorded the highest value of sucrose content % of juice (19.03%), followed by beetroots of 180 days (16.54%), while the lowest value was found for the beetroots of 150 days age (13.50%). In contrast, the reducing sugar content recorded 0.58, 0.25 and 0.10 for beetroots of 150,180 and 210 days age at harvest; respectively. The maybe attributed to the decrease in temperature at the time of harvest. These results are in agreement with the findings of El-Sheikh et al. (2009); Michalska-Klimczak et al. (2019) and Abido et al. (2015). The invert sugar in the crown, slice, and roots, according to Strochalska et al. (2014) was 0.72, 0.71, and 0.23%, respectively. Also, from Table 3 it can be noticed that the total soluble solids recorded 19.20, 20.83 and 22.32% at age of 150, 180 and 210 harvest days; respectively. Similar results were reported by ElSharnouby et al. (1999);Abido et al. (2015) and Michalska-Klimczak et al. (2019).

Data illustrated in Table 4 show that highest value of juice purity (87.42%) was at 210 days of harvest. Purity of sugar beetroots juice at three periods of harvesting time (150, 180 and 210 days) are 84.30, 86.02 and 87.42%; respectively. These findings are in line with those made by Asadi (2007), who claimed that a typical washed beetroot (beetroot without tare) typically had a purity of beetroot juice ranging from 85 to 88%. Quality starts with good management of the crop; thus the quality at harvest is excellent. It is also quite obvious from Table 4 that the quality of the beets depends on the situation with the beet roots. As a result, when there is an increase in alkaline (K and Na content) and nitrogen content, the quality of the beetroot falls. Fresh sugar beets of various ages (150, 180, and 210 days) were harvested with 67.81, 76.19, and 81.26% quality, respectively. The quality of beetroot ranged from 79.20 to 84.61% according to Sorour et al.'s (2020) findings, which are consistent with these findings.

The interaction between the start, middle, and end of the juice season, as well as the age of harvesting (150, 180, and 210 days), had a definite impact on the sucrose content, reducing sugar content, and quality indices of beetroots, as shown in Table 5. The middle season timing in mid-April recorded the highest values of sucrose content (15.74, 18.07 and 20.00%) with age of harvesting (150, 180 and 210 days);respectively. However, the sucrose content and quality of beetroots recorded the highest values overall harvest age and timing of the juice season (19.21, 81.27 and 17.94, 78.40) as well as the lowest values (0.15 and 0.26%) of reducing sugar in beetroots, respectively. These findings may be explained by the fact that the middle of the juice season, in mid-April, allows for proper sugar beet growth, promotes sugar accumulation, and lowers the rate at which beetroots respire. In contrast, the late juice season, in mid-June, at temperatures of about 30.0 °C, may result in slower sugar accumulation and higher beetroot respiration. As a result, beetroot quality and sugar content increased for the mid-April start of the middle juice season. This is consistent with the findings from Hozayn, et al. (2013) and Trebbi & McGrath (2004).

There was a positive correlation between sucrose % and quality of beetwith sucrose loss in molasses % of beet. On the other hand, the lowest values (2.32) of sucrose loss in molasses % of beet at 210 days of harvest age, as well as the highest values (2.98%) of sucrose loss in molasses % of beetroots were scored at 150 days. While middle of season recorded the lowest value of sugar loss in molasses % beetroots (2.48) followed by starting of season (2.63) and end of season (2.88) overall juice season periods. From Table 5 can also be noticed that the interaction between juice season and harvest age, the best value of sugar loss in molasses % of beetroot was 2.12% for harvest age of 210 days and middle of season. This agrees with the results of Elsayed et al. (2021).

**TABLE 4. Physicochemical and technological characteristics of sugar beetroots of different harvesting ages.**

| Harvest age | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Moisture content% | Brix (T.S.S)% | Sucrose content% | Reducing sugar% | juice purity % | Beet roots quality% | pH value |
| **150 days** | 78.33±0.15a | 19.20±0.40c | 13.50±0.15c | 0.58±0.03a | 84.30±0.46c | 67.81±1.86c | 5.48±0.08b |
| **180 days** | 77.20±0.70b | 20.83±0.56b | 16.54±0.35b | 0.25±0.01b | 86.02±0.18b | 76.19±0.49b | 6.18±0.07a |
| **210 days** | 76.84±0.38b | 22.32±0.25a | 19.03±0.16a | 0.10±0.00c | 87.42±0.19a | 81.26±0.32a | 6.33±0.07a |

Different letters in "different harvest age" columns for each parameter represent statistically significant differences in beetroot chemical and quality parameters.

**TABLE 5. Effect of juice season periods and age at harvest on chemical and technological characters of sugar beetroots.**

| parameters | Harvest age | Starting of season | Middle of season | End of season | mean |
|---|---|---|---|---|---|
| **Sucrose content%** | 150 | 13.87±0.35e | 15.74±0.47d | 12.400.81±e | 14.00±1.54c |
| | 180 | 17.50±0.30bc | 18.07±0.16b | 16.98±0.22c | 17.52±0.51b |
| | 210 | 19.40±0.46a | 20.00±0.10a | 18.22±0.32b | 19.21±0.84a |
| | mean | 16.92±2.46b | 17.94±1.86a | 15.87±2.69c | |
| **Reducing sugar%** | 150 | 0.58±0.03b | 0.41±0.04c | 0.79±0.02a | 0.59±0.17a |
| | 180 | 0.25±0.01d | 0.23±0.03d | 0.43±0.07c | 0.30±0.10b |
| | 210 | 0.10±0.01e | 0.13±0.02e | 0.22±0.03d | 0.15±0.06c |
| | mean | 0.31±0.21b | 0.26±0.13c | 0.48±0.25a | |
| **Quality of beet%** | 150 | 69.60±1.50g | 73.27±0.75f | 65.70±0.75h | 69.52±3.40c |
| | 180 | 77.27±0.55d | 78.50±0.50dc | 75.49±0.73e | 77.09±1.41b |
| | 210 | 80.95±0.75b | 83.44±0.66a | 79.43±0.40c | 81.27±1.83a |
| | mean | 75.94±5.09b | 78.40±4.44a | 73.54±6.15c | |
| **Sugar loss in molasses% of beet** | 150 | 2.94±0.05b | 2.81±0.07b | 3.20±0.05a | 2.98±0.18a |
| | 180 | 2.63±0.12c | 2.51±0.08c | 2.91±0.17b | 2.68±0.21b |
| | 210 | 2.32±0.10d | 2.12±0.08e | 2.52±0.09c | 2.32±0.19c |
| | mean | 2.63±0.28b | 2.48±0.31c | 2.88±0.31a | |

Different letters in "different time of season and harvest age" columns and rows for each parameter represent statistically significant differences in beetroot chemical and quality parameters.

## Conclusion

To increase the quantity of sugar that can be extracted from beetroot, sugar factory need beetroot with high sucrose concentrations and low percentages of sugar loss in molasses. The obtained results may help farmers, to choose size of beet roots, medium size was the best compared to small and large sized beetroots. Also, appropriate harvest time, i.e., in middle of season (April) with 210 days of harvest age when beet and their corresponding liquor qualities have superiority.In order to decrease sugar losses during production and to stop sucrose inversion into glucose and fructose, sugar beetroot should be processed right away after harvesting. Furthermore, storage of beetroots should not exceed 8 days after harvest to keep higher sucrose content, purity, and beetroot quality.

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