Archives of Agriculture Sciences Journal
Print ISSN: 2535-1680
Online ISSN: 2535-1699

ARCHIVES OF AGRICULTURE SCIENCES JOURNAL

Volume 3, Issue 3, 2020, Pages 64–81

Available online at www.agricuta.edu.eg

DOI: https://dx.doi.org/10.21608/aasj.2020.43246.1037

Sugar beet quality and juice purity of some sugar beet varieties (*Beta vulgaris* L.) grown in Toshka region, Egypt as effected by harvesting ages and storage conditions

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Abstract

The present study was carried out during 2017/2018 and 2018/2019 seasons at Desert Agricultural Research Station, Toshka, Aswan governorate, Egypt to find out the optimum harvesting age (165, 180, 195, and 210 days) for five multi-germ sugar beet varieties namely Oscar, poly, Athospoly, Sarah, Ravel and Friancesca. Addition to study the effect of post-harvest treatments and storage period on quality characteristics of tested sugar beet varieties. The results showed that the Ravel variety with an age of 195 days recorded the highest increase values of sucrose (20.39 and 19.70 %) as well as lowest decrease values with the age of 210 days (18.39 and 17.07%) during two seasons, respectively. Delaying the harvest age of sugar beet from 165 up to 195 and 210 days caused the increase in TSS % of sugar beet juice. Francesca variety produced the highest values of sugar beet juice TSS (22.75 and 22.45 %) in both seasons. Treatment by 1% Ca $(OH)_2$ recorded the higher value of sucrose content during storage (16.84 and 17.85%) in both seasons. Ravel variety surpassed the other varieties in beet quality (88.84 and 84.78%) and juice purity (94.35 and 92.61%) while, the Oscar poly variety had the lowest mean values (81.71and 80.05%) and (91.10 and 89.88%) at different harvest ages in the two seasons, respectively. The lowest value of sucrose loss in molasses was obtained from Ravel and Francesca than the other varieties by (1.56 and 1.84%) whereas the highest loss value was obtained from Oscar poly variety by (2.10 and 2.21%) at different harvest ages in the 1st and 2nd seasons, respectively.

Keywords: sugar beet, TSS, beet quality, juice purity, sucrose loss in molasses, storage treatments and harvesting age.

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1. Introduction

Sugar beet (*Beta vulgaris* L.) is considered as one of the most important sugar crops, not only for sugar producing but also the secondary productions, fodder and organic matter for the soil. It represented 62.2 % of locally sugar production (S.C.C., 2019). It ranks the first important sugar crop in Egypt and many countries all over the world. Egypt occupied the eighteen globally in the sugar beet production with 13323369 tons in 2018 (FAOSTAT, 2018). Production of world sugar increased from about 10 million tons to 181 million tons from 2008/2009 to 2018/2019 (Statista, 2019; USDA, 2019). Time of harvest is one of the factors that effects on quality of sugar beet crop, many studies showed the effect of harvesting ages on yields and quality characteristics of sugar beet varieties. Ahmed *et al*. (2017) indicated that sucrose, purity and sugar loss to molasses percentages were significantly affected by harvesting age. They add that sugar beet varieties differed significantly in sucrose, purity and sugar loss to molasses percentages. Gadallah and Tawfik (2017) reported that delaying harvesting from 180 up to 210 days from sowing increased significantly TSS, sucrose, purity percentages. Abd El-Razek (2003 and 2006) and Mahmoud *et al*. (2008) reported that the maximum root and sugar yields/fed were obtained when sugar beet plants were harvested at 180-210 days after sowing date. They also add that varying and harvesting ages affected sucrose and juice purity percentages, root and sugar yields/fed (fed = feddan = 4200 m^2 = 0.420 hectares = 1.037 acres). Abo El-Magd *et al*. (2004) tested the effect of three harvesting ages *i.e.* 180, 195 and 210 days from sowing on sugar beet variety Gloria. They recorded that harvesting ages were signinficantly affected root quality, sucrose and juice purity % in both seasons. Enan *et al*. (2009) showed that sugar beet varieties differed significantly in TSS % they add that Farida variety significant increase of total soluble solids %, sucrose %, purity %. Mohamed and Afifi (2017) revealed that, the varieties of sugar beet significantly differed in sucrose, purity and sugar lost in molasses percentages the two growing seasons. Mohamed *et al*. (2019) noted that there were significant differences among tested sugar beet varieties in sucrose, purity and sugar lost in molasses percentages. The delaying in transporting results a rapid qualitative deterioration and high quantities losses. During sugar beet storage and processing, sucrose losses due to microbial activity occur. One of the reasons is the formation of slimy microbial polysaccharides, which cause serve processing and quality problems (Aoki and Sakano, 1997). *Leuconostoc sp.* was suggested to be the reason for slime production in sugar factories (Bourne and Henrissat, 2001). Therefore, this work was aimed to find out the optimum harvesting age for some sugar beet varieties under Toshka conditions, as well as study the effect of storage periods on beet quality, juice purity and sucrose loss in molasses during the harvesting time and post-harvest.

2. Materials and methods

2.1 Materials

This work conducted at the farm of Desert Agricultural Research Station, Toshka (latitude of 22°.49- N, longitude of 28° .58- E and an elevation of 188 m above sea level), Aswan Governorate, Upper Egypt, during 2017/2018 and 2018/2019 seasons, to find out the optimum harvesting age for five sugar beet varieties. The field trait included twenty treatments represent the combination of five multi-germ sugar beet varieties namely; Oscar poly, Athospoly, Sarah, Ravel and Friancesca as well as four harvesting ages (165,180, 195 and 210 days).

2.2 Preparation of samples for analysis

2.2.1 Harvest ages and Juice quality

Samples (each sample about ten guarded plants) representing each variety were taken and replicated three time from different areas of the experimental field in order to avoid as much as possible, soil variations to determine beet quality and technological parameters were determined in laboratory at Fayoum Sugar Company during different harvest ages at 165, 180 , 195 and 210 days from planting. These times or ages represented suitable time for maturity of sugar beet season. Ten roots were collected randomly from each replicate in middle rows of plot. Roots samples were stripped and weighted before taken for analysis.

2.2.2 Deterioration studies of sugar beet (post-harvest)

At harvest (195 days from sowing), 360 roots samples of each sugar beet variety were divided into three groups (120 roots of each group) to determine the changes in the root weight and in the root quality. Samples representing each variety were stored for (0, 2 ,4 and 6 days) in the open air after treating with following treatment at Toshka region conditions.

1. The first group without treatment (control).
2. The second group was treatment with covered with tops.
3. The third group was treated by dipping in calcium hydroxide solution 1% concentration for ten minutes.

2.3 Analytical Methods

At each of the studied harvest ages, a random sample of ten guarded roots of each plot was taken and the plant samples were immediately sent to the laboratory of quality analyses at Fayoum Sugar Company to determine the following quality characteristics:

1. Determination of total soluble solids (TSS or Brix): TSS of fresh and storage samples were determined using fully automatic digital refractometer, model ATR-S (04320), 0 - 95% Brix,

temperature compensation 15 to 40º C according to procedure Fayoum Sugar Company.

2. Determination of sucrose: Sucrose percentage was estimated in fresh samples of sugar beet root using "Saccharometer" according to the method described by A.O.A.C. (2012).

3. Root impurities in terms of α-amino N, Na and K percentages (meq/100 g beet) according to A.O.A.C. (2012).

4. Determination of beet quality: 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 Silin and Silina (1977) and Sapronova *et al*. (1979).

5. Determination of Juice purity: Juice purity percentage was calculated according to the following equation, described by Devillers (1988): Purity % = 99.36 – [14.27 (Na + K + α-N)/sucrose %].

6. Determination of sucrose lost to molasses: Sucrose lost to molasses percentage (SLM %) was calculated as described by Devillers (1988) using the following equation: SLM% = [0.14 (Na + K) + 0.25 (α- N) + 0.5].

2.4 Statistical analysis

The studied traits analyzed by using SAS program SAS Institute (2008). Comparing of means for each trait done by used the revised LSD determined using Duncan's multiple range tests.

3. Results and Discussion

3.1 Effect of harvesting ages of sugar beet varieties on total soluble solids percentage during two seasons

Results in Table (1) showed that harvest ages had a significant effect on brix % of sugar beet juice in the two growing seasons. Delaying harvest time of sugar beet from 165 up to 195 and to 210 days caused increase in brix % of sugar beet juice from 20.60 to 24.07% and from 19.43 to 23.50% in the 1st and 2nd seasons, respectively. The increase in total soluble solids percentage (TSS %) might be due to better maturity, consequently higher root content and dry matter accumulation. These results coincide with those reported by El-Sheikh *et al*. (2009), Enan *et al*. (2009), Abd El-Aal *et al*. (2010), Refay (2010) Aly *et al*. (2012), Hussein *et al*. (2012), Mohamed and Yasin (2013) and Awad *et al*. (2015). They reported that brix percentage of sugar beet juice ranged between 15.54 and 23.60%. Data illustrated in Table (1) revealed that the tested varieties significantly differed in brix % of sugar beet juice in both seasons. Francesca variety produced the highest values of sugar beet juice TSS (22.75 and 22.45 %) in both seasons, respectively. These results are probably

correlated to gene make-up of these beet varieties. These results are in accordance with those found by Azzazy *et al*. (2007), Enan *et al*. (2009), Abd El-Aal *et al*. (2010), Aly *et al*. (2012), Al-Labbody *et al*. (2012) and Afez (2016). A significant interaction was found between harvest time and varieties of sugar beet with respect to brix% of sugar beet juice in both seasons as shown in Table (1).

Table (1): TSS percentages of sugar beet varieties as affected by harvesting age during two seasons.

Harvest age /day	2017 /2018 season					Mean
	Sugar beet varieties					
	Oscar poly	Arthospoly	Sarah	Ravel	Francesca	
165	19.33	20.33	21.33	21.33	20.67	20.60 ^{c}
180	20.33	22.00	22.33	21.67	21.33	21.53 ^{bc}
195	21.67	23.00	23.33	22.33	23.00	22.67 ^{b}
210	22.00	24.67	23.67	24.00	26.00	24.07 ^{a}
Mean	20.83 ^{b}	22.50 ^{a}	22.66 ^{a}	22.33 ^{a}	22.75 ^{a}	LSD: 1.30
LSD	1.46					
2018 /2019 season						
165	18.67	17.00	21.17	20.33	20.00	19.43 ^{c}
180	20.50	20.00	22.00	20.50	21.67	20.93 ^{b}
195	20.67	20.67	22.33	23.50	22.67	21.96 ^{b}
210	21.17	22.33	24.33	24.17	25.50	23.50 ^{a}
Mean	20.25 ^{b}	20.00 ^{b}	22.45 ^{a}	22.12 ^{a}	22.45 ^{a}	LSD: 1.09
LSD	1.22					

Francesca variety at age of 210 day recorded the highest increase values of brix % juice (26.00 and 25.50%) in the 1st and 2nd seasons, respectively. While, the lowest values in brix % of sugar beet juice (22.00 and 21.17 %) with age of 210 day were recorded for Oscar poly variety in the 1st and 2nd seasons, respectively. These findings are probably due to genetic variation among varieties in this trait. The same results were recorded by Abo Salama and El-Syiad (2000) and Fadel (2002).

3.2 Effect of harvesting ages of sugar beet varieties on sucrose content during two seasons

Results presented in Table (2) showed that harvesting date at 195 days from sowing significantly affected sucrose % in both seasons. The highest mean values of sucrose % were 18.96 and 18.97% in the 1st and 2nd seasons, respectively. This superiority at sucrose % may be due to the decreased temperature at this time of harvest. This result agrees with El-Sheikh *et al*. (2009). The effect of harvesting date was significantly increased sucrose percentage in both seasons. The delaying harvest date of sugar beet from 165 to 195 days caused the increase in sucrose % juice of sugar beet from 16.98 to 18.96% and from 15.69 to 18.97% in the 1st and 2nd seasons, respectively (Table 2). This superiority of sucrose% may be due to the decreased temperature at this time of harvest, also due to the better maturity,

consequently higher sugar content. Similar results were recorded by Abou El-Magd *et al*. (2004), Aly (2006), Asadi (2007), El-Sheikh *et al*. (2009) and Gomaa (2009). They reported that sucrose content of beet juice ranged between 17.50 to 19.57% and these optimal values for the sugar factories. Thereafter, sucrose % juice of sugar beet decreased from 18.96 to 16.88 % and from 18.97 to 16.25 % with delaying harvest from 195 to 210 in the 1st and 2nd seasons, respectively (Table 2). This decrease might be attributed mainly to the effect of high temperatures during the late harvest at 210 days, which increased respiration rate and sucrose inversion to invert sugars as a result of reach sugar beet to the over ripe. The over ripe of sugar beet is considered deterioration of sugar beet pre-harvest. As shown in Table (2) there were significant differences in sucrose % juice of sugar beet among the studied varieties at different harvest ages in the two growing seasons. Sugar beet variety Arthospoly surpassed the other varieties in sucrose % juice of sugar beet (18.36 and 17.79 %), while the lowest values were recorded by Oscar poly variety (16.72 and 15.38%) at different harvest ages in the 1st and 2nd seasons, respectively. This result treasured that this trait is strongly correlated with gene make-up. These results are in same line with those reported by Al-Jbawi, (2000), Abd El-Razek (2003), Abo El-Magd *et al*. (2003) and Abd Elrahim *et al*. (2005). A significant interaction was found between harvest date and varieties with respect to sucrose % juice of sugar beet in both seasons as shown Table (2).

Table (2): Sucrose percentages of sugar beet varieties as affected by harvesting age during two seasons.

Harvest age /day	2017 /2018 season					Mean
	Sugar beet varieties					
	Oscar poly	Arthospoly	Sarah	Ravel	Francesca	
165	16.57	17.00	17.30	16.80	17.23	16.98 ^{c}
180	17.23	18.74	18.39	16.90	18.46	17.95 ^{b}
195	17.70	20.10	18.48	20.39	18.10	18.96 ^{a}
210	15.38	17.59	17.00	18.39	16.00	16.88 ^{c}
Mean	16.72 ^{b}	18.36 ^{a}	17.70 ^{a}	18.12 ^{a}	17.45 ^{ab}	LSD: 0.90
LSD	1.46					
2018 /2019 season						
165	14.15	16.10	17.53	16.70	13.97	15.69 ^{c}
180	14.40	18.80	17.70	17.25	15.97	16.82 ^{b}
195	18.20	19.50	18.62	19.70	18.85	18.97 ^{a}
210	14.80	16.77	16.37	17.07	16.27	16.25^{bc}
Mean	15.38 ^{b}	17.79 ^{a}	17.55 ^{a}	17.67 ^{a}	16.26 ^{b}	LSD: 0.80
LSD	0.90					

Ravel variety with age of 195 days recorded the highest increase values of sucrose % juice (20.39 and 19.70 %) as well as lowest decrease values with age of 210 days (18.39 and 17.07%), in the 1st and 2nd seasons, respectively. While,

the lowest values of sucrose % juice of sugar beet (15.38 and 14.80%) with age of 210 days were recorded for Oscar poly variety in the 1st and 2nd seasons, respectively. The differences among sugar beet varieties were found by Osman *et al*. (2003), Azzazy *et al*. (2007), El-Sheikh *et al*. (2009), Enan *et al*. (2009) and Abd El-Aal *et al*. (2010). The differences among sugar beet varieties could be due to the variation in the genes make up and their response to the environmental condition.

3.3 Effect of treatments and storage periods on total soluble solids

The effect of treatments and storage periods on the TSS content of sugar beetroots are given in Table (3). The results showed that delaying days of sugar beetroots delivery to the sugar factory had a significant effect on TSS content of sugar beetroots in the two growing seasons. There were a gradual and significantly increase in TSS% during storage using all treatments. This increase might be attributed to the reduction in root weight as a result of moisture losses from harvested cane stalk, without any change in soluble solids and the increase in TSS. These results are in the same line with Abou-shady (1994) and Gomaa (2013) they observed an increase in total solids during storage in four varieties under all storage conditions and harvest ages. The roots stored in the open air recorded the highest value of TSS (26.633 and 25.291%) in the both seasons. While the roots treated with 1% Ca $(OH)_2$ or cover with leave recorded low values of TSS during storage. In general, increase of TSS content in sugar beetroots after different treatments may be due to the high loss of water in the open air storage consequently increase the concentration of TSS and sucrose percentage. The present results agree with the findings of Gomaa (2013), who found that the TSS were increased under open air storage. Results in Table (3) indicated that tested sugar beetroots varieties significantly differed in TSS content in the two growing seasons as result of the processing delay. Sarah variety had a highest main value of TSS of sugar beetroots (28.819%) in the 1st season and Francesca (25.37%) in the 2nd season for delaying days post-harvest, while the lowest values (23.00 and 22.62%) were recorded for Oscar poly in the 1st and 2nd seasons after harvesting age 195 day. This may be due to the differences in water evaporation among the studied varieties at different post-harvest periods in brix percentage. These results agree with those reported by Abou-Shady (1994). Also, a significant difference was found between the interaction of treatments and sugar beet varieties. A significant interaction between storage periods as well as treatments and varieties regarding total soluble solids content of sugar beet (Table 3). The highest values of TSS content were recorded in Sarah variety (23.33 to 34.17%) in the 1st season and (22.67 to 34.00%) for Francesca variety in the 2nd

season, while the lowest values of TSS content were recorded in Oscar poly variety (from 21.67 to 23.50%) in the 1st season and (from 20.67 to 22.00 %) in the 2nd season these was achieved by roots treatment by cover roots with leave during storage periods from zero time (at harvest) for six days, respectively. Data after 2 days of storage, values of TSS were increase in all samples. The roots treated in the open air recorded the highest value during storage. Whereas, the roots treated with 1% Ca $(OH)_2$ or cover with leave showed the increasing values of TSS during storage periods and kept them lower than the increased.

Table (3): TSS percentags of sugar beet varieties as affected by post-harvest treatments and storage period during two seasons.

Treatment	2017/2018 Season												
	Control				Cover with leave				Ca $(OH)_2$				Mean
Days / Varieties	0	2	4	6	0	2	4	6	0	2	4	6	
Oscar poly	21.67	22.00	23.00	25.00	21.67	21.83	22.00	23.50	21.67	22.17	24.50	27.00	23.00 [d]
Arthos poly	23.00	27.00	28.00	29.00	23.00	26.00	28.00	34.00	23.00	25.33	28.00	33.00	27.27 [b]
Sarah	23.33	25.67	34.00	34.17	23.33	25.00	32.00	34.00	23.33	28.00	29.00	34.00	28.81 [a]
Ravel	22.33	26.50	28.00	32.00	22.33	26.00	26.50	29.00	22.33	24.00	25.00	29.00	26.08 [c]
Francesca	23.00	24.00	30.00	31.00	23.00	26.00	27.00	28.00	23.00	23.00	25.00	29.50	26.04 [c]
Mean	26.63 [a]				26.10 [b]				25.99 [b]				LSD
LSD	0.39												0.51
	2018/2019 Season												
Oscar poly	20.67	21.00	23.00	31.00	20.67	20.83	21.33	22.00	20.67	20.83	22.00	27.50	22.62 [d]
Arthos poly	20.67	23.67	26.67	28.00	20.67	22.50	23.00	27.00	20.67	23.50	26.17	30.00	24.37 [c]
Sarah	22.33	23.50	26.00	28.00	22.33	22.67	22.83	25.67	22.33	24.00	23.00	32.67	24.61 [bc]
Ravel	23.50	22.67	26.00	29.50	23.50	23.67	24.67	26.00	23.50	24.00	25.00	30.50	25.20 [ab]
Francesca	22.67	26.00	27.00	34.00	22.67	22.83	23.00	26.50	22.67	23.67	25.50	28.00	25.37 [a]
Mean	25.29 [a]				23.216 [b]				24.80 [a]				LSD
LSD	0.58												0.75

3.4 Effect of treatments and storage periods on sucrose content during two seasons

Effect of different treatments on sucrose content of sugar beetroots are presented in Table (4). It could be noted from the results that delaying periods of roots delivery to the sugar factory had a significant effect on sucrose% juice of sugar beet in the two growing seasons. There were a gradual and significantly decreased in sucrose content during storage under all chemical treatments used. The treatment by the concentration of 1% Ca $(OH)_2$ recorded the higher value of sucrose content during storage (16.84 and 17.85%) in the 1st and 2nd seasons, respectively. The use of this treatment decreased the inversion of sucrose. This may be due to the change of pH to undesirable value of enzyme activity. However, the roots were left in the open air recorded the lowest value of sucrose content (16.41 and 17.21%) in both seasons. This decrease might be attributed to spoilage by microorganisms, the high inversion rate of sucrose, where the sucrose molecule spliced into two new molecules, *i.e*. glucose and fructose,

picking up a molecule of water in the process as well as to the increase in the activity of degrading enzymes and higher rate of respiration under increasing post-harvest period and high temperature prevailing during harvest season. These results are in accordance with obtained by Abou-Shady (1994).

Table (4): Sucrose percentages of sugar beet varieties as affected by post-harvest treatments and storage period during two seasons.

Treatment	2017/2018 Season												
	Control				Cover with leave				$Ca(OH)_2$				Mean
Days / Varieties	0	2	4	6	0	2	4	6	0	2	4	6	
Oscar poly	17.70	16.26	15.86	15.43	17.70	15.81	15.67	15.05	17.70	17.00	16.66	16.03	16.40 ^{b}
Arthos poly	20.10	16.50	15.36	15.04	20.10	18.00	16.21	15.10	20.10	16.76	16.22	15.38	17.07 ^{a}
Sarah	18.50	15.90	15.84	15.72	18.49	16.01	16.00	15.22	18.49	16.45	15.99	15.10	16.47 ^{b}
Ravel	20.40	16.46	14.77	14.38	20.40	16.83	15.93	15.59	20.40	16.88	16.22	15.93	17.01 ^{a}
Francesca	18.10	15.86	15.08	14.95	18.10	16.22	16.10	14.98	18.10	16.03	15.90	15.49	16.24 ^{b}
Mean	16.41 ^{b}				16.67 ^{ab}				16.84 ^{a}				LSD
LSD	0.35												0.45
	2018/2019 Season												
Oscar poly	18.20	17.57	16.90	15.60	18.20	17.55	16.25	15.65	18.20	17.95	17.75	17.40	17.26 ^{b}
Arthos poly	19.50	18.35	17.90	17.05	19.50	18.30	17.10	17.00	19.50	18.75	17.25	15.75	17.99 ^{a}
Sarah	18.62	17.50	17.00	15.90	18.62	16.45	16.40	16.15	18.62	18.00	17.70	15.95	17.24 ^{b}
Ravel	19.70	16.75	15.22	14.38	19.70	18.50	18.10	17.39	19.70	18.45	17.30	17.25	17.70 ^{a}
Francesca	18.85	17.00	16.96	15.34	18.85	18.07	18.05	17.30	18.85	18.75	17.50	16.45	17.66 ^{ab}
Mean	17.21 ^{b}				17.21 ^{b}				17.85 ^{a}				LSD
LSD	0.32												0.42

It could be noted from the results Table (4) that tested sugar beet varieties significantly differed in sucrose content in the two growing seasons as result of the processing delay. Arthospoly variety recorded the lowest decrease of sucrose content of sugar beetroots (17.07 and 17.99%) for delaying periods post-harvest in the both seasons. While the highest deterioration rates of sucrose content were recorded in Francesca variety (16.24%) in the 1st season and from (17.24%) in the 2nd season for Sarah variety for sugar beet harvested at age195 days. This decreasing was due to the increase in respiration rates and the variation among evaluated varieties in sucrose content of sugar beet could be attributed to their genetic structure. These findings agree with Abou-Shady (1994). Also, a significant difference was found between the interaction of treatments and sugar beet varieties. Treatments decreased the loss of sucrose content, but not stopped it. This may be due to the action of microorganisms, respiration of roots and biochemical transformation of sucrose. The same results (Table 4) indicated a significant interaction between the processing delaying times, sugarcane varieties and different treatments regarding sucrose content of sugar beetroots. The lowest deterioration rates of sucrose content were recorded in Oscar poly variety from 17.70 to 16.03 % and from 18.20 to 17.40 % in the 2nd season. While, the highest deterioration rates of sucrose% content were recorded in Ravel variety (from 20.40 to 14.38%) in the 1st season and from 19.70 to 14.38 % in the

2nd season. This achieved by use of 1% Ca $(OH)_2$ for sugar beet harvested at age 195 day as a result of delaying the processing from zero time (at harvest) for six days, respectively.

3.5 Effect of harvesting ages of sugar beet varieties on beet roots quality during two seasons

From Table (5), it can be recognized very clearly that the beet quality depends on the case of beetroots, healthy or injured. So, that the beet quality decrease in the case of arising alkaline (K and Na content) and nitrogen content, during the first and the end harvesting ages of campaign of the factory operated. Delaying harvest ages of sugar beet from 165 to 195 days caused the increase in quality of beet from 81.23 to 91.51% and from 79.20 to 88.62% in the 1st and 2nd seasons, respectively. The results are in agreement also with those reported by Gomaa (2009) and Al- Barbari *et al.* (2014) who found that the quality of beet increased during the period of the beet processing.

Table (5): Effect of harvest ages and sugar beet varieties on beet quality during two seasons.

Harvest age /day	2017 /2018 season					Mean
	Sugar beet varieties					
	Oscar poly	Arthospoly	Sarah	Ravel	Francesca	
165	73.71	82.85	82.28	83.38	83.97	81.23 C
180	81.51	89.28	88.5	88.93	88.42	87.32 b
195	88.7	91.61	90.94	94.30	92.01	91.51 a
210	82.91	89.92	88.62	88.74	88.38	87.71 b
Mean	81.71 b	88.42 a	87.59 a	88.84 a	88.20 a	LSD: 1.24
LSD	1.39					
2018 /2019 season						
165	76.61	80.18	81.43	80.44	77.36	79.20 d
180	77.96	83.90	82.38	82.21	80.37	81.36 c
195	85.89	88.37	89.57	89.81	89.44	88.62 a
210	79.73	85.34	84.69	86.64	86.67	84.61 b
Mean	80.05 b	84.45 a	84.52 a	84.78 a	83.46 a	LSD: 1.43
LSD	1.60					

Such effect might be attributed to the increase in sugar recovery and pol percentages. Thereafter, quality of beet decreased from 91.51 to 87.71% and from 88.62 to 84.61% with delaying harvest from 195 to 210 days in the 1st and 2nd seasons, respectively. This decrease may be due to the decrease in sugar recovery % and pol percentage of sugar beet. Moreover, high and rapid deterioration in the beet quality have been observed under high temperature, dry weather and delay milling in addition to, the sugar beet became more maturity. Data revealed that there were significant differences in quality of beet among the studied varieties at different harvest ages in the two growing seasons (Table 5). Ravel variety surpassed the other varieties in quality of beet by 88.84 and 84.78% while, Oscar poly variety contained the lowest mean values (81.71

and 80.05%) at different harvest ages in the two seasons, respectively. This finding is probably due to genetic variation among varieties in this trait. Significant interaction was found between harvest date and varieties with respect to quality of beet in both growing seasons as shown in Table (5). Ravel variety at age of 195 days recorded the highest increase values of the beet quality (94.30 and 89.81%) as well as lowest decrease values at age of 210 days (88.74 and 86.64%), in the 1st and 2nd seasons, respectively. While, the lowest values of the beet quality (82.91 and 79.73%) at age of 210 days were recorded for Oscar poly variety in the 1st and 2nd seasons, respectively.

3.6 Effect of harvesting ages of sugar beetroots varieties on juice purity during two seasons

Data represent in Table (6) showed that the harvest date had a significant effect on juice purity of roots in the two growing seasons. Delaying harvest ages of sugar beet from 165 to 195 days caused the increase in juice purity of roots from 90.68 to 95.57% and from 89.81 to 94.36% in the 1st and 2nd seasons, respectively. It can be noted that, the main goal of the sugar factory is to separate non-sugar from sugar to improve the beet juice purity to the extent that sugar with 100% purity is produced. Also, by increase the purity of beet juice would make sugar beet processing much faster and easier. Such effect of delaying harvest up to 195 days after sowing might have been due to extending of the growing period and consequently an expected increase in translocation of assimilates from leaves to roots which was then reflected in sucrose per cent in addition to the low values of both impurities in juice. These results agreed with Abo Salama and El-Syiad (2000), Al-Jbawi (2000) and Asadi (2007). Thereafter, juice purity of roots decreased from 95.57 to 93.74 % and from 94.36 to 92.10% with delaying harvest from 195 to 210 days in the 1st and 2nd seasons, respectively. These results coincide with those reported by Mohamed and Yasin (2013) and Awad *et al*. (2015). It could be noticed from the result (Table 6) that there were significant differences in juice purity of roots among the studied varieties at different harvest times in the both growing seasons. Ravel variety surpassed the other varieties in juice purity of roots (94.35 and 92.61%) while, Oscar poly variety contained the lowest mean values (91.10 and 89.88%) at different harvest ages in the 1st and 2nd seasons, respectively. The differences among sugar beet varieties under study could be due to the variation in the genes make up and their response to the environmental condition. The differences among sugar beet varieties were found by Enan *et al*. (2009) and Abd El-Aal *et al*. (2010). A significant interaction was found between harvest ages and varieties of sugar beet with respect to juice purity in two growing seasons as shown in Table (6). Ravel variety at age of 195 days recorded the highest increase values of juice purity (97.09 and 95.11%) as well as lowest decrease values at age of 210 days (94.15 and 93.08%), in the two seasons, respectively. While, the lowest values of juice purity of roots (91.74 and 89.93%) at age of 210 days were recorded for

Oscar poly variety in the 1st and 2nd seasons, respectively. These observations assured that the final output of the tested varieties was affected by their gene make-up in addition to the surrounded environment.

Table (6): Effect of harvest ages and sugar beet varieties on the juice purity of sugar beetroots during two seasons.

Harvest age /day	2017 /2018 season					Mean
	Sugar beet varieties					
	Oscar poly	Arthospoly	Sarah	Ravel	Francesca	
165	87.21	91.69	90.73	91.87	91.91	90.68 [c]
180	91.18	94.47	94.10	94.30	94.10	93.63 [b]
195	94.25	95.72	95.13	97.09	95.65	95.57 [a]
210	91.74	94.64	94.11	94.15	94.04	93.74 [b]
Mean	91.10 [c]	94.13 [ab]	93.52 [b]	94.35 [a]	93.93 [ab]	LSD: 0.74
LSD	0.82					
2018 /2019 season						
165	87.87	90.12	91.01	90.60	89.46	89.81 [d]
180	88.69	91.98	91.61	91.63	90.71	90.92 [c]
195	93.02	94.17	94.71	95.11	94.79	94.36 [a]
210	89.93	92.28	92.06	93.08	93.13	92.10 [b]
Mean	89.88 [a]	92.14 [a]	92.35 [a]	92.61 [a]	92.02 [a]	LSD: 0.68
LSD	0.76					

Table (7): Effect of harvest ages of sugar beet varieties on sucrose loss in molasses during two seasons.

Harvest age /day	2017 /2018 season					Mean
	Sugar beet varieties					
	Oscar poly	Arthospoly	Sarah	Ravel	Francesca	
165	2.83	2.00	2.32	1.95	2.04	2.23 [a]
180	2.10	1.61	1.66	1.55	1.66	1.72 [b]
195	1.59	1.38	1.47	1.06	1.36	1.37 [c]
210	1.86	1.54	1.59	1.67	1.55	1.64 [b]
Mean	2.10 [a]	1.63 [bc]	1.76 [b]	1.56 [c]	1.65 [bc]	LSD: 0.18
LSD	0.20					
2018 /2019 season						
165	2.49	2.25	2.18	2.17	2.05	2.23 [a]
180	2.36	2.12	2.04	2.00	2.06	2.12 [b]
195	1.85	1.70	1.54	1.45	1.51	1.61 [d]
210	2.14	1.97	1.94	1.81	1.73	1.92 [c]
Mean	2.21 [a]	2.01 [b]	1.93 [bc]	1.86 [c]	1.84 [c]	LSD: 0.11
LSD	0.12					

3.7 Effect of harvesting ages of sugar beet varieties during two seasons on sucrose loss in molasses

The harvest ages had a significant effect on the loss of sucrose in molasses of sugar beet in the two growing seasons (Table 7). The beet harvested after 165 days had the highest loss of sucrose in molasses (2.23%) and decreased gradually by delaying harvest to reach its minimum values (1.37 and 1.61%) at 195 days of age in the 1st and 2nd seasons, respectively. The reduction of sucrose

loss percentage in molasses as harvest was delayed due to the gradual decrease in the three main impurities i.e. Na, K and α amino-N with the advance of plant age up to 195 days after sowing. So, it could be said that by decrease the losses of sucrose in molasses, the sugar produced as white sugar increase. These results are in harmony with those obtained by Lauer (1997). Thereafter, sucrose loss percentage in molasses of sugar beet increased from 1.37 to 1.64% and from 1.61 to 1.92 % with delaying harvest from 195 to 210 days in the 1st and 2nd seasons, respectively. This increase might be attributed mainly to the weather events such as frost or cold temperatures can also influence loss to molasses. The same data (Table 7) clarified that the loss of sucrose in molasses was significantly different among studied varieties in both seasons at different harvest ages. The lowest value of sucrose loss in molasses was obtained from Ravel and Francesca than the other varieties by 1.56 and 1.84%, whereas the highest value of sucrose loss was obtained from Oscar poly variety by 2.10 and 2.21%at different harvest ages in the 1st and 2nd seasons, respectively. The results obtained agreed with those obtained by Lauer (1997). A significant interaction was found between harvest ages and varieties with respect to sucrose loss in molasses of sugar beet in both seasons as shown in Table (7). Ravel variety with age of 195 days recorded the lowest values of sucrose loss in molasses (1.06 and 1.45 %), in the 1st and 2nd seasons, respectively. While, the highest values of sucrose loss in molasses were 1.59 and 1.85 % at age of 195 days were recorded for Oscar poly variety in the two seasons, respectively.

4. Conclusion

It could be concluded that the chemical and technological properties of sugar beet varieties affected by harvested age. The harvest age 195 day was suitable for all sugar beet varieties, delaying harvest time of sugar beet from 165 up to 195 and 210 days caused the increase in TSS % of sugar beet juice. Treatment by 1% Ca $(OH)_2$ recorded the higher value of TSS and sucrose content during storage, delaying harvest ages of sugar beet from 165 to 195 days caused the increase in quality of beet and juice purity of roots. Loss of sucrose in molasses decreased gradually by delaying harvest to reach its minimum values at 195 days of age.

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