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THE EFFECT OF DIFFERENT STORAGE DURATION PERIODS AFTER HARVESTING IN A SEMI-ARID ENVIRONMENT ON THE QUALITY COMPONENTS IN SUGAR BEET

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ABSTRACT

The storage of the harvested sugar beet (*Beta vulgaris* L.) before the processing stage is crucial, particularly regarding quality and durability. To maintain the quality of the beet prior to processing, appropriate storage conditions must be provided. Although siloing is a standard method for beet storage, this process may have some negative effects. Given the limited information on the impact of siloing on yield and quality, it is essential to determine the optimal duration of siloing. This study investigated the effect of different siloing periods on the root and weight and quality criteria of sugar beet in 2020 and 2021. Four siloing periods (immediately after harvest, ten days after harvest, 20 days after harvest, and 30 days after harvest) were analyzed. The siloing periods significantly affected both the root weight and quality criteria in both years of research. It was determined that the examined characteristics were significantly influenced by the treatments, with weight loss, dry matter content, sugar content, and sugar yield of roots increasing with the length of the siloing period. The results highlight the importance of the waiting time during the siloing period for sugar beet stored in silos after harvest. To minimize losses in the examined characteristics, it is recommended that the processing occur immediately after harvest. If it must be delayed processing is recommended between 10-20 days post-harvest.

Keywords: *Beta vulgaris saccharifera* L., storage duration time, sugar beet, sugar content, weight loss.

INTRODUCTION

Storage practices for food products range from post-harvest storage in highly controlled environments to leaving the product in situ until the next stage of processing. The storage process is determined by a combination of the product's volume value and its tendency to deteriorate in the current environment (Wills et al., 2007). Sugar beet harvesting in our country varies from region to region for different reasons, such as climatic conditions, shipment, and enterprises' processing programs. The harvested products, which are directly related to the sugar beet processing capacities of the factories, are either kept in the fields where they are planted, in the weighbridge areas of the planting areas, or the collective silo areas determined by the enterprise or in the silo areas within the factory (Sarwar et al., 2008; Barna et al., 2011). This waiting period can be prolonged for various reasons, leading to significant losses in yield and quality. Sugar beetroots contain an average of 75% water, making siloed difficult and increasing losses. Therefore, the loss of tuber weight increases linearly as the storage period increases after harvest in tuber crops (Ozturk and Polat, 2016). For this reason, post-harvest losses can be as significant as harvest losses. Post-harvest yield and quality characteristics may vary according to siloing conditions, and even under suitable storage conditions, yield and quality may be adversely affected as the storage duration increases (Kenter and Hoffmann, 2009).

To reduce siloing losses, proper siloing techniques are essential (Barna et al., 2011). In general, as storage temperatures increase, respiration rate and cell membrane permeability increase and quality losses occur more rapidly (Kazaz et al., 2009). Relative humidity and temperature are the most critical environmental factors affecting the successful storage of sugar beet. The optimum temperature should be between 4-6 ^{0}C and relative humidity between 95-98% to minimize losses. Bacterial growth, fungal infestations, and germination in the roots can hinder the formation of sucrose and raffinose in beets at 2 ^{0}C, 6% CO_2, and 5% O_2 (Demirel and Akinerdem, 2016).

Delaying the storage of beets after harvesting harvesting Results in a significant decrease in sugar yield; the highest sugar yield (12.37 tons ha^{-1}) was obtained in the control treatment. In the beets stored after leaf and head cutting and kept in the field for 48 hours, a sugar yield of 10.54 tons ha^{-1} was recorded, indicating a yield loss of 27.5%. The same study found no difference between sodium and amino nitrogen concentration and white sugar yield (Abdollahian-Noghabi and Zadeh, 2005). In another study, root yield, polar ratio, and sugar production of beet varieties stored both in sun and shade over 6 day periods and one-day intervals were monitored. It was found that root yield decreased, but polarity and sugar production increased in both storage conditions (Sarwar et al., 2008.).

There are differences between the outer surface and the inner part of the beet silo in terms of the rate of being affected by the external factors of the silo environment. It was noted that although the first 50 cm of the outer surface of the silo represents 17% of the whole silo, it accounts for 40-45% of the total losses, and sugar losses under covered and uncovered silo conditions differ. Kenter and Hoffmann (2006) stated that sugar yield decreases during storage, negatively impacting the processing quality of sugar beet roots. Consequently, sugar recovery becomes more expensive as the fabrication process extends.

In our country, sugar beet harvests vary by region due to climatic conditions, shipping and the processing programs of enterprises. The harvested sugar beet is kept in the harvested land, in weighbridge areas belonging to the cooperative, in the collective silo areas designated by the enterprise or in silo areas within the factory until it is processing (Ozgur, 2014). This waiting period can be prolonged for various reasons, resulting in serious losses in yield and quality.

The siloing of beet covers all the stages from the time it is harvested until it is processed (Ketizmen, 1987). Post-harvest losses are as critical as harvest losses due to the high moisture content in sugar beet. Yield and quality characteristics can vary according to siloing conditions, and even under suitable conditions, they may be adversely affected as storage duration increases (Yilmaz, 1987; Kenter and Hoffmann, 2009). To reduce siloing losses, it is essential to follow appropriate storage technique. Relative humidity and temperature are the most important environmental factors affecting successful storage. When roots are injured during harvesting or for other reasons, some parasitic fungi enter the root, increasing decay and losses (Lejealle and Cie, 1999).

The increase global demand brings nutritional challenges. Given that many countries face the threat of hunger and malnutrition, the importance of identifying crop losses in sugar beet becomes even more significant. This study aimed to determine the weight losses and changes in some quality characteristics that may occur in roots that cannot be processed immediately after harvest and must be kept in field conditions.

MATERIALS AND METHODS

Agronomic Practices

Field experiments were conducted (39° 47' 27" N and 40° 10' E; 1500 m above sea level) in Erzincan/Cayirli in 2020 and 2021. The soil of two experimental sites was a silty loam (fine, mixed, mesic assortments) with a pH 7.5, 2.21% organic matter, 140.6 kg ha^{-1} available P, and 2260 kg ha^{-1} available K in 2020 and pH 7.7, 2.30% organic matter, 154.0 kg ha^{-1} available P and 2280 kg ha^{-1} available K in 2021.

Temperature, rainfall, and relative humidity data during the crop-growing period are presented in Figure 1. Air temperatures during the two growing seasons were lower than the long-term mean. April to September temperatures, which averaged 18.7 ^{0}C, were slightly under normal in 2020 and 2021. There was considerable variability in rainfall amounts and distribution from year to year. The rainfall during the growing seasons of the Sentinel sugar beet variety was above the long-term average. The average rainfall for 2021 (18.67 mm) was lower than that observed (22.33 mm) in 2020.

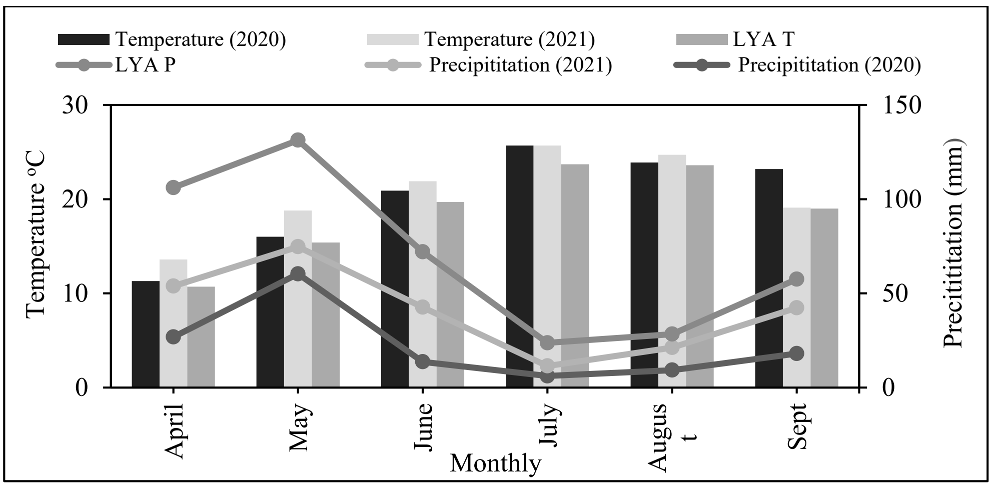

Figure 1. Some important climatic data of the experimental area for many years and 2020-2021(Erzincan/Cayirli)

The Sentinel sugar beet variety research with different siloing periods was conducted in two phases in 2020 and 2021. In the first phase of the study, three blocks measuring 20 m in lenght, 4.5 m in width, and an area of 90 m^2 (4.5 x 20 m) were prepared in a farmer's field in the productive village in Cayirli district, Erzincan province, for the production of plant material needed for the research. Each block consisted of four plots. This phase was carried out according to the "Randomize Complete Block Design" experimental design with three replications. Nitrogen containing fertilizers, including 15-15-15 and urea fertilizers containing 46% nitrogen were used at 150 kg per hectare. Fertilizers were applied by sprinkling and mixed into the soil. Sowing was conducted on April 14, 2020, and April 18, 2021, using a five-row precision beet seeder with a sowing depth of 5 cm, a distance of 45 cm between rows, and 8 cm above rows. Each plot consisted of 10 rows. After emergence, the row spacing was adjusted to 17 cm by thinning. On September 29, 2020, and September 31, 2021, when the plants reached a vegetation period of approximately 170 days, harvesting was carried out with a single-row harvester after separating one row from the edges and three plants from each head to account for the edge effect.

Second Phase: Application of trial factors.

Traits Measured

The plant material obtained after harvesting (first stage) was used in the second stage of this study. In the experiment, 100 kg of roots from each plot in three blocks (4 x 100 kg) were harvested separately. The sugar beet roots harvested from each plot have been siloed in open storage field in the form of piles, with an average height ranging from 2 to 2.5 meters and an average width not exceeding 3 to 5 meters. Firstly, the roots harvested from the production field were cleaned from soil residues and taken to the siloing field under open conditions in the Erzurum Sugar Factory experimental site on September 29-30, 2020-2021. Measurement, weighing, and analysis procedures for 10 kg beet samples taken from each silo at 10-day intervals from the beginning of siloing were conducted. Weight losses were calculated by weighing the 10 kg beet samples taken from each silo at 10 days intervals from the beginning of siloing. The climatic data of Erzurum Sugar Factory trial area determined at 10-day intervals are given in Table 1. Quality parameters were analyzed at the Sugar Factory Laboratory in Erzurum (Türkiye) according to Kavas and Leblebici (2004).

Table 1. Climatic factors in postharvest sugar beet storage duration (Erzurum)

YEAR	Storage periods			
	21-30 September	**01-10 October**	**11-20 October**	**21-30 October**
Total rainfall for 10 days				
2020	1.67	0.03	0	0.62
2021	28.2	39	0	21.6
Average temperature for 10 days				
2020	15.41	11.56	12.35	10.42
2021	10.54	9.13	10.07	2.86
Relative humudity for 10 days				
2020	53.46	53.1	40.91	47.06
2021	64.42	69.88	57.82	63.78

Statistical analysis

All the data were analyzed using the SPSS package (SPSS, Version 20.0, SPSS Inc, Chicago, IL, USA). When the F-test indicated statistical significance at the P=0.05 level, the protected least significant difference (Protected DUNCAN) was used to separate the means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Statistically significant (p<0.01) differences were found between the years regarding the characters examined in the study (Table 2). Beet rootstocks ensiled in the first year exhibited greater weight loss and other quality parameters. The 2020 production season was drier and warmer than that of 2021 (Figure 1). The temperature values in 2021 negatively affected the quality criteria of sugar beet plants stored in the silo.

Weight Loss

In the study, the effects of year, storage duration, and year x storage duration interactions on weight loss were found to be significant (p<0.01) (Table 2). In the first year of the study, the weight loss of the roots in the silos was 1.6% higher than in the second year. It is thought that the higher air temperature in the first year of the research caused more weight loss in the roots due to rapid respiration and the resulting flushing. Indeed, Peterson et al. (1980) stated that the effect of temperature on siloing was significant. According to the storage period, the highest weight loss was observed at 30 days (38.29 kg), while the lowest was at ten days (18.5 kg). In the other storage period of 20 days, a weight loss of 32.6 kg occurred (Table 3, Figure 2). The change in weight loss values in all treatments was in the direction of increase compared to the values at harvest, which were accepted as the control. It was determined that the weight loss was 18.5% at the end of the first 10-day storage period after harvest, 32.6% at the end of the 20th day, and 62.5% at the end of the 30 days.

The average weight loss during storage was 37.9% (Table 3; Figure 2).

Table 2. Analysis of variance results of yield and quality parameters of sugar beet varieties in different storage duration treatments

a)

Sources of Variation	df	Weight Loss		Sugar Content		Sugar Yield Loss		Dry Matter Content	
		F Values	Mean Square	F Values	Mean Square	F Values	Mean Square	F Values	Mean Square
Year (Y)	1	269.85**	583.12	189.80**	157.28	30.57**	16.375	541.00**	246.81
Storage Duration Periods (S)	4	1030.71**	1747.93	83.67**	62.71	9.19**	4.802	424.30**	117.09
Y x S	4	33.88**	73.23	5.31**	4.39	2.15	1.125	18.91**	8.62
Eror	12	23.41	1.93	9.09	0.79	6.27	0.52	4.56	0.37
CV		1.8		4.34		4.15		2.26	

b)

Sources of Variation	df	α- Amino Nitrogen		Ash Content		Polarization in Usare		Usare Purity	
		F Values	Mean Square	F Values	Mean Square	F Values	Mean Square	F Values	Mean Square
Year (Y)	1	1.01	0.00011	172.11**	5.57	24.61**	170.05	99.72**	47.77
Storage Duration Periods (S)	4	13.05**	0.00004	2.11^{ns}	0.08	65.89**	73.63	3.64^{ns}	6.90
Y x S	4	1.23	0.00013	6.40**	0.21	9.16**	6.39	5.93*	2.80
Eror	12	0.0002	0.0054	0.12	0.36	12.84	0.91	9.77	1.18
CV		9.77		4.86		1.01		4.81	

*. ** significant at the 0.05 and 0.01 levels, respectively. ns; nonsignificant.

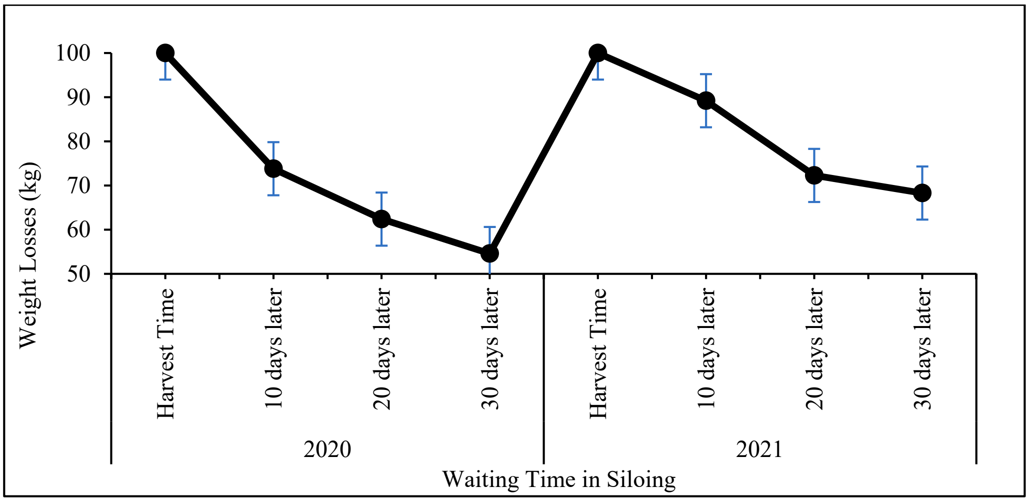

Figure 2: Effect of year × storage duration interaction on subsequent weight loss

As a result of the research, it was determined that the weight loss of roots kept after harvest increased in parallel with the number of days they were kept. Our study's average temperature during the thirty-day storage period was 11.42 ^{0}C. Sarwar et al. (2008) reported that 9.70%, 14.10%, 18.30%, 21.66%, and 25.11% weight loss was detected on average when sugar beets were stored in silos for 2, 3, 4, 5 and 6 days, respectively. In a similar study, Scalon et al. (2000) reported 55% weight loss in roots due to 12 days of storage when the siloing temperature was between 15-26 ^{0}C. Variety, climatic factors, physiological maturity of the beet, and silo size all effect post-harvest storage losses in sugar beet (Sefaoglu et al., 2016; Kocak et al., 2019). In addition, browning is observed depending on the size of the siloing, which causes the beet to lose weight and sugar (Haagenson et al., 2006).

Sugar Content

The effect of year, storage time in siloing, and year x storage time interactions on sugar content, which is one of the important factors in determining sugar yield, was significant (p<0.01). The sugar content of sugar beet averaged 22.63% and 14.49% in the 2020 and 2021 growing seasons, respectively. Ecological factors at the time of harvest play an important role in the sugar content of beet. The fact that respiratory activities continued at different levels in the siloing root under variable weather conditions led to changes in terms of sugar content.

Although the sugar content in the roots was the lowest at harvest (16.4%), it reached the highest value (23.7%) at the end of 30 days of storage. This was followed by a 20-day period with 21.22%; after 10 days of storage, the sugar content was 19.20% (Table 3, Figure 3). The storage duration significantly affects the amount of soil present and has a significant effect on availability; it has an increasing impact on sugar content compared to harvest time application. The sugar content, which increased by 19.70% in the 10-day application rose by 32.29% in the was 20 days application. The highest increase was 47.69% in the 30-day storage duration treatment.

Table 3. Effect of storage duration on sugar beet weight loss, sugar content, sugar yield loss, dry matter content.

Years	Harvest Time (Control)	10 Days Later	Change (%)	20 Days Later	Change (%)	30 Days Later	Change (%)
			Weight Loss (kg)				
2020	100±0.00a	73.8±0.36b	-26.20	62.41±0.49c	-37.60	54.6±1.78d	-45.10
2021	100±0.00a	89.2±1.27b	-12.10	72.30±0.40c	-27.70	68.8±0.23d	-31.20
Mean	100±0.00a	81.5±3.49b	-18.50	67,36±2.22c	-32.64	61.7±3.26d	-37.95
			Sugar Content (%)				
2020	17.4±0.06d	22.0±0.06c	26.90	24.2±0.05b	39.70	26.9±0.95a	54.8
2021	14.8±0.20c	16.4±0.98bc	10.80	18.2±0.42b	23.20	20.5±0.04a	38.7
Mean	16.0±0.59d	19.2±1.33c	19.70	21.2±1.35b	32.29	23.7±1.48a	47.7
			Sugar Yield Loss (kg)				
2020	17.3±0.06a	16.2±0.03b	-6.4	15.1±0.10c	-12.7	14.6±0.14d	-15.6
2021	14.8±0.20	14.7±1.08	-0.7	13.2±0.38	-10.8	14.1±0.07	-4.7
Mean	16.1±0.59a	15.5±0.60a	-3,7	14.1±0,46b	-12.4	14.4±0,13b	-10.6
			Dry Matter Content (%)				
2020	23.1±0.18d	29.1±0.40c	26.10	34.2±0.18b	48.00	35.4±0.82a	53.20
2021	19.9±0.07c	22.9±0.78b	14.90	25.9±0.11a	29.50	27.3±0.17a	36.70
Mean	21.5±0.70d	26.0±1.43c	20.90	30.0±1.86b	39.39	31.3±1.82a	45.56

For each main effect, values within columns followed by the same letter are not significantly.

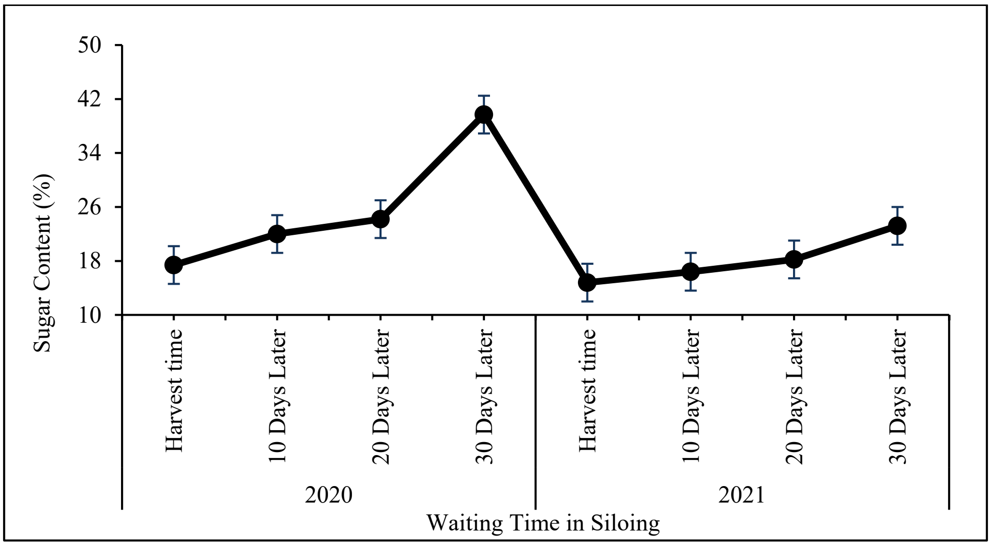

Figure 3: Effect of year × storage duration interaction on the sugar content losses

The impurities on the beet during storage (head, leaves, and soil amount) have a significant effect on the ensilability of the beet. Beets with neatly cut heads lose less sugar in silos. By siloing beets in this way, the silo temperature will be lower, and the losses that may occur due to respiration can be kept at lower levels. Steensen and Augustinussen (2002) reported that after 50 days of siloing, an average of 4.1% sugar loss occurred in silos made from undamaged beets, while 5.7% sugar loss occurred in silos consisting of damaged and bruised beets. Ada and Akinerdem (2006) reported that the highest sugar loss (19.53%) was observed after 90 days of storage. Similarly, Barna et al. (2011) and Kocak et al. (2019) reported that the sugar content increased with the extension of the storage period.

Sugar Yield Loss

While the effect of storage periods on sugar yield, based on stem yield and sugar content, was significant in the first production season, the impact of storage periods on sugar loss was insignificant in the second production year. On average, sugar loss in sugar beet was higher in 2020 than in 2021. This difference between the years was statistically significant at the $p<0.01$ probability level (Table 2). The higher sugar yield loss in the first year of the experiment, compared to the second year, is due to the greater average root yield loss and sugar content (Tables 2 and 3). When examining Table 3, which shows the sugar loss at the time of harvest and at 10, 20, and 30 days after harvest, it is observed that the response of sugar yield to storage periods is irregular. Beets kept for 30 days in the first research year and beets kept for 20 days in the second research year caused more sugar loss than beets kept for 10 days. In the first experimental year, 14.6 kg of sugar yield was obtained from beets kept for 30 days, while in the second year, 13.2 kg sugar yield was obtained from beets kept for 20 days. All treatments significantly decreased sugar yield compared to the harvest time (control). In the first year, the highest loss was 15.6% in roots stored for 30 days, followed by a 12.7% loss after 20 days of storage. In the 10-day storage period, the smallest loss was determined at 6.4% compared to the harvest time (Table 3). In the second experimental year, the highest loss was 10.8% in beets kept for 20 days, while losses 4.7% and 0.7% were observed in beets kept for 20 and 10 days of siloing, respectively. Harvested roots start to lose water rapidly through respiration immediately after harvesting, causing sugar losses (Ada and Akinerdem, 2006). Likewise, the longer the siloing period, the more rootstocks are exposed to frost damage. While 16.5% sugar is obtained from well-stored beet, this rate decreases to 12.5% in partially frost-damaged rootstocks (Batu, 2002).

Dry Matter Content

In the study conducted over two years under field conditions, the effect of years, storage duration, and the impact of year x storage duration interaction on dry matter content was significant ($p<0.01$). In the first experimental year, the dry matter content was higher than in the second year because the soils were rich in organic matter and potassium; the temperature was higher (17.1 ^{0}C), while precipitation (158.5 mm), and relative humidity (47.3%) were lower. It was determined that the storage duration treatments gradually increased the dry matter content. In both research years, the lowest dry matter content was obtained from sugar beet roots at harvest (23.1 and 19.97% g, respectively), and the highest dry matter content was obtained from the treatment kept for 30 days (35.4 and 27.29%, respectively). The results show that the dry matter content increased gradually with increasing storage duration. The amount of dry matter is directly related to the compounds that effect in root quality. Sohrabi and Heidari (2008) stated that sugar yield is a dry matter-related characteristic and that a high sugar yield can be obtained when a high proportion of dry matter is produced in the root. The findings of our research are supported by the results of Demirel and Akinerdem (2016), who reported a significant increase in weight loss due to the progression of storage duration and an increase in the dry matter ratio.

α- Amino Nitrogen

According to the results of variance analysis, the effect of storage periods on α- amino nitrogen ratio was insignificant in the first harvest year. In contrast, the impact of storage periods was significant in the second harvest year (Table 4). The α- amino nitrogen content was higher in the first harvest year than in the second crop year. In both research years, the highest α- amino nitrogen content was obtained in the 30-day storage duration, while the lowest α-amino nitrogen content was obtained in the control (at harvest) and 10-day storage duration (Table 4). These results showed that the α- amino nitrogen ratio increased with the storage duration compared to the harvest time. The highest increase of 14.29% was detected in roots kept for 30 days, while no change was detected in the 10-day storage period (Table 4). These results indicate that biological activity continues in beet after harvest. The absence of green parts in the plant during storage causes changes in the structure of nitrogenous compounds in the root. In addition, the increase in the dry matter content of root due to the prolonged storage period may also increase the amount of α amino nitrogen. Demirel and Akinerdem (2016) reported that the biological activity in the root of sugar beet continues after harvest, and the amount of amino nitrogen increases as this period extends.

Ash Rate

The amount of ash in sugar beet is a factor that reduces sugar yield and includes all the inorganic substances contained in beet fabrication products and white sugar (Kavas and Leblebici, 2004). Climate factors are critical in affecting the amount of ash in sugar beet. The highest amount of ash was obtained in the second harvest year when the climatic conditions were favorable. This difference in ash content between the years was statistically significant (Table 4). When examining Table 3, the ash percentage (13.82%) was highest in the first harvest year, when the storage duration in the heap was the longest (30 days). The value at 20 days was 3.14%. The lowest ash percentage was 1.59% at harvest time, and roots were kept for ten days. In the second crop year, the opposite was true; the highest value (2.93%) was obtained at 20 days of storage, while the ash percentage was lowest (2.26%) when the storage duration was the longest (30 days). In other words, the ash percentage increased by 5.50% in the 20-day storage period, where the highest ash percentage was obtained. The ash amount determined in the 30-day storage period decreased by 18.40% compared to the harvest time (Table 4). The 10-day storage period did not affect the ash percentage value.

Purity (Q) in Usare

A difference in purity was observed between 2020 and 2021 when the experiment was conducted. The purity obtained from roots was higher in the first and second experimental years (Table 4). The higher purity rate in 2020 compared to 2021 is thought to be due to the favorable effects of ecological factors in 2020. In both research years, beets kept for 30 days from different storage duration subject to the experiment showed higher purity than beets kept for 10 and 20 days at the time of harvest. In the first research year, the highest increase was 60.42% while in the second year, it was 28.00%. This increase was obtained with 30 days of roots in the pile, followed by increases of 40.35% and 19.80% with 20 days of waiting time. At 10 days of the siloing, the lowest increase was determined at 29.62% and 15.40%, respectively, compared to harvest time (Table 4). All treatments significantly increased purity compared to the harvest time (control). In cases where extremely low temperatures do not occur, the prolonged vegetation period leads to an increase in yield and quality and consequently to a rise in the purity of the juice (Cakmakcı and Tıngır, 2001). This difference in purity may be due to the gradual decrease in the ratio of soluble sugar to dry matter during siloing.

Polarization in Usare

The most important economic indicator in sugar beet production is white sugar content (Dadkhah, 2005). According to the results of variance analysis, the differences between years in terms of root refined sugar content were statistically significant ($p<0.001$) (Table 4). When examining Table 4, it was determined that root refined sugar content was 5.3% higher in the first research year. The higher polarity in the first year of the experiment compared to the second year may be due to the low rainfall, high temperature, and elevated lime and potassium levels in the soil during the growing period in this year. It was found that the polar sugar ratio of the harvested roots increased with the application of storage duration without processing. The polar sugar ratios of root in 2020 were 17.99%, 23.32%, 25.25%, and 28.86%, while in 2021 were 15.4%, 18.2%, 19.2%, and 21.4%, respectively (Table 4). According to the polar sugar content at harvest, the highest increase was observed at 30 days of waiting time, with increase of 60.42% and 28.00%, respectively, in both research years. The lowest increase rate was determined at 10 days of storage duration, with increase 29.62% and 19.2%, respectively. The study found that the polar sugar ratio increased with the prolongation of storage time of the harvested roots without processing. This may be due to the increase in the total sugar ratio resulting from the conversion of starch to sugar with the prolongation of the storage duration, which may have caused an increase in the polarization ratio in the juice. Demirel and Akinerdem (2016) reported that the rate of purified digestion increased with the extension of storage duration, and the rate of purified digestion increased in percentage with the increase in weight loss as the storage duration increased.

Table 4. Influence of storage duration on sugar beet α- amino nitrogen, ash rate, purity (q) in usare, polarization in usare.

Years	Harvest Time (Control)	10 Days Later	Change (%)	20 Days Later	Change (%)	30 Days Later	Change (%)
α- Amino nitrogen (g/100g)							
2020	0.043±0.0008	0.045±0.0002	4.7	0.047±0.0005	9.30	0.051±0.004	16.27
2021	0.034±0.0046b	0.039±0.0052ab	17.7	0.048±0.0003a	41.20	0.048±0.006a	41.20
Mean	0.042±0.0005b	0.042±0.0030b	-	0.045±0.0010a	7.14	0.048±0.004a	14.29
Ash Rate (%)							
2020	1.59±0.050b	1.59±0.020b	-	1.64±0.025b	3.14	1.80±0.021a	13.20
2021	2.77±0.098ab	2.54±0.230b	-9.10	2.93±0.063a	5.50	2.26±0.159c	-18.40
Mean	2.18±0.268	2.06±0.233	-5.83	2.29±0.289	5.05	2.03±0.123	-6.88
Polarization in Usare (g/100g)							
2020	17,99±0.490c	23.32±0.16b	29.62	25.25±0.10ab	40.35	28.86±1.14a	60.42
2021	15,40±0.050c	18.2±0.85b	15.40	19.2±0.23b	19.80	21.40±0.17a	28.00
Mean	16,71±0.627d	20.75±1.21c	24.18	22.20±1.371b	32.85	25.13±1.74a	50.39
Purity (Q) in Usare (g/100g)							
2020	88.36±0.030b	90.07±0.220ab	1.93	90.15±0.810ab	2.02	91.84±1.04a	3.93
2021	88.39±0.168a	87.01±1.045ab	1.60	85.86±0.499b	2.86	87.88±0.02a	0,57
Mean	89.27±0.539	89.43±1.267	0.18	87.11±0.602	2.48	88.98±0.500	0.32

For each main effect, values within columns followed by the same letter are not significantly.

CONCLUSIONS

Because roots maintain their vitality after harvesting, weight and quality losses during siloing constitute the most significant disadvantage of this plant. To reduce these losses, it is essential that siloing is carried out in suitable environments and for specific periods. Although the increase in the storage duration of roots after harvest generally causes weight loss, it can result in a partial increase in sugar content. While this leads to an increase in sugar availability, it also causes a significant decrease in sugar yield, which is the final product. When siloing is extended to 30 days, a 38.0% weight loss occurs, alongside a 47.7% increase in sugar availability, and a 10.6% loss in sugar yield.

The results highlight the importance of the waiting time during the siloing period for sugar beet stored in silos after harvest. To minimize losses in the examined characteristics, it is recommended that the processing occur immediately after harvest. If it must be delayed processing is recommended between 10-20 days post-harvest.

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