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Influence of post-harvest treatments on productivity and quality of sugar beet varieties under Kom Ombo conditions

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ABSTRACT

The present work was conducted at Kom Ombo Agricultural Research Station (latitude of 24o 28' N and longitude of 32o 57' E), Aswan Governorate, in the 2020 and 2021 harvesting seasons. This work aimed to study the effect of storage period before processing (0, 2, 4, and 6 days) and root pile coverage (covered with its top leaves or without cover) on yield and technological characteristics of three sugar beet varieties, i.e., Oscar poly, Ravel, and Francesca. A randomized complete block design (RCBD) arranged in a split-split plot with three replications was used. Sucrose, purity, quality index, sugar recovery percentages, roots, and sugar yields were significantly decreased by prolonging the storage period, while root fresh weight loss and impurities were increased. The decreases in root yield at 2, 4, and 6 days after harvesting compared to the control (0 day) were 3.122, 6.908, and 9.179 ton/fad in the 1st season, and 4.041, 6.032, and 8.595 in the 2nd. The decreases in sugar yield at 2, 4, and 6 days after harvesting compared to the control (0 day) were (30.9%, 48.5%, 59.3%) and (25.3%, 37.4%, 52.0%) in the 1st and 2nd seasons, respectively. Results showed that covering with its top leaves during storage significantly affected all studied traits except sucrose% at the first season. Roots and sugar yields were increased by 3.495, 1.642, and 0.559, 0.457 in the 1st and 2nd seasons, respectively, with leaves covered compared to without covering. The evaluated varieties differed significantly in respect to the studied traits except for the root fresh weight loss and sucrose percentage in both seasons, as well as the sugar recovery percentage in the first season only. All studied traits were significantly affected by the interactions among the three studied factors in both seasons. Under the conditions of the present work, results indicated that beet roots should be delivered for processing as early as possible to minimize root and sugar yield losses.

Key words: Sucrose, purity, sugar recovery post-harvest storage period, root pile covering.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is one of the most important sugar crops in the world. The sugar produced from sugar beet represents 38% of the international production, while in Egypt, sugar beet has become the first crop for sugar production. The total cultivated area of sugar beet reaches 597923 faddans, and the average sugar beet productivity is 20.96 tons per fad, which contributes about 61.2% of the total sugar production. The gap between sugar production and consumption is 576385 tons of sugar. Sugar beet is harvested from mid-February to mid-August (S.C.C., 2022). It is necessary to expand the planted area with sugar beet and increase its productivity to reduce this gap. Moreover, sugar beet is widely adapted to different soil conditions, and its water and fertilizer requirements are much lower than those of sugar cane, resulting in a lower cost of cultivation. Delivery delaying and processing of sugar beet is considered an important problem in the sugar industry because it results in deterioration of the insular yield and quality traits of the roots. So, roots should be processed directly after harvesting. There are many factors affecting the final output of sugar beet in terms of roots and sugar yields, as well as quality traits such as varieties, post-harvest storage periods, and methods of storage in fields or sugar mills. Differences in quality parameters as affected by crop delivery delays were reported by many investigators as Hassan *et al.* (2011); El-Shahaby *et al.* (2014); Al Jbawi-Entessar and Al Zubi-(2016); Mohamed *et al.* (2017);Besheit and El-Mansoub (2020). Many investigators proved an evidence of the effect of post-harvesting treatments on sugar beet traits (Kenter and Hoffmann, 2009; Al Osmsn, *et al*, 2010; Alfaig *et al,* 2011; Abd El-Rahman *et al,* 2019; Seadh *et al,* 2021 and Ibrahim *et al,* 2021).

Differences on quality characteristics among sugar beet varieties due to delivery delay were reported by many investigators, they noted that sugar beet varieties significantly differed in yield and quality parameters Ahmed *eal* (2017); El-Safy *et al.* (2020); Madritsch *el al.* (2020); Hefny *and Said* (2021); Galal *et al.*(2022) and Gorski *et al.*

(2022).The target of the present investigation was to study the effect of length of storage period as well as storage treatment on productivity and quality of three sugar beet varieties under Kom Ombo conditions.

MATERIALS AND METHODS

The present study was carried out at Kom Ombo Agricultural Research Station, (latitude of 24° 28′ N and longitude of 32° 57′ E), Aswan Governorate, upper Egypt, the sugar beet plants were harvested in the two harvesting seasons of 2020 and 2021 , to study the effect of post-harvest treatments (storage periods before processed for 0, 2, 4 and 6 days as well as storage treatments, covered with its tops and without covering) on technological and yield characteristics of three sugar beet varieties namely, Oscar poly, Ravel and Francesca.

A Randomized complete block design with three replications arranged in split- split plot was used, storage periods were arranged in the main plots, while storage treatments were distributed randomly in the sub plot and varieties were allocated in the sub-sub plots.

At harvest time(11th April in both seasons -at age of 195 days), 120 roots were collected at random for each variety from the station farm, and divided into two groups (60 roots of the group) to determine the changes in the weight, yield and quality traits. Represented samples of each variety were stored for (0, 2 ,4 and 6 days) under field conditions (covering and without covering). Further, samples from each pile (5 roots) were weighted and periodically before and after storing for two, four and six days to determine the following traits:

Weight loss

1. Root weight loss percentage. It was estimated by calculating the percentage of root weight difference between the harvest day to the second, fourth and sixth day.

Quality traits:

The following quality traits were determined at the laboratory of quality analysis at Fayoum Sugar Company.

2. Sucrose percentage was estimated in samples of sugar beet roots by using “Saccharometer” according to the method described by A.O.A.C. (2019).
3. Root impurities in terms of Na, K and α-amino N, percentages (meq/100 g beet) according to A.O.A.C. (2019).
4. Purity percentage was calculated according to the following equation, described by Devillers (1988): Purity % =99.36 – [14.27 (Na+ K + α-amino N)/sucrose %].
5. Sugar recovery % was calculated according to Cooke and Scott(1993) using the following equation:

Sugar recovery % = Pol %- [0.29 + 0.343 (K + Na) + α-N (0.094)].

6. Quality index was calculated as described by Cooke and Scott (1993) according to the following equation:

Quality index% = (sugar recovery % /sucrose) X100

Yield traits:

7. Root yield/fad. (ton) was calculated based on root yield/plot (kg).
8. Sugar yield/fad (ton) = root yield/fad (ton) X sugar recovery %.

Statistical analysis

The collected data were statistically analyzed according to the method described by Snedecor and Cochran (1981). Treatment means were compared using LSD at 5% level of probability. Also, simple correlation coefficients and linear regression were computed among studied traits according to Steel and Torrie (1980).

Table 1 . Meteorological data from 11th -17thApril in 2020 and 2021 in Kom Ombo

Day	2020				2021			
	Temperature °C		Humidity %		Temperature °C		Humidity %	
	Min	Max	Min	Max	Min	Max	Min	Max
11th	14.0	28.4	33	57	15.8	29.2	21	43
12th	11.8	29.6	24	67	12.8	30.0	23	44
13th	10.4	31.4	23	65	12.0	31.8	22	47
14th	11.4	31.0	20	57	11.4	34.2	19	53
15th	14.4	33.0	29	67	14.0	36.2	22	53
16th	15.4	35.4	27	69	13.0	38.0	20	60
17th	18.4	31.4	28	58	15.2	39.8	19	53

Source: Agricultural meteorological station in Kom Ombo sugar factory at Aswan

RESULTS

1. Weight losses percentage (W.L %):

Results in Table (2) pointed out that the effect of post-harvest treatments (storage periods before processing and covering treatments) on weight losses % was significant in both seasons, while insignificant variances among the tested varieties were in loss% in root fresh weight in both seasons.

Concerning the interaction effects, results in the same Table showed that weight losses % was significantly affected by all interactions among the tested factors in the first and second seasons.

Table 2. Effect of post-harvest treatments on weight losses % of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	**Covering**	**Varieties**			**Mean**	**Varieties**			**Mean**
		Oscar poly	**Ravel**	**Francesca**		**Oscar poly**	**Ravel**	**Francesca**	
0	**without**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	With top	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
2	**without**	15.39	13.73	15.76	14.96	15.49	13.76	15.30	14.85
	With top	6.21	6.38	8.07	6.89	6.26	5.47	7.05	6.27
Mean		**10.80**	**10.06**	**11.92**	**10.92**	**10.88**	**9.62**	**11.18**	**10.56**
4	**without**	24.28	23.45	24.87	24.17	24.03	23.24	24.24	23.83
	With top	14.35	15.97	16.35	15.56	14.09	13.63	15.33	14.35
Mean		**19.32**	**19.71**	**20.56**	**19.86**	**19.06**	**18.44**	**19.79**	**19.09**
6	**without**	32.13	31.48	33.24	32.28	32.65	32.08	33.56	32.76
	With top	22.81	22.21	24.11	23.04	22.11	21.52	23.89	22.51
Mean		**27.47**	**26.84**	**28.67**	**27.66**	**27.38**	**26.80**	**28.72**	**27.63**
B x C		17.95	17.14	18.47	17.85	18.07	17.25	18.27	17.86
		10.84	11.17	12.11	11.37	10.59	10.19	11.57	10.78
Mean		**14.40**	**14.15**	**15.29**		**14.33**	**13.72**	**14.92**	
L.S.D. at 0.05 level for									
Delivery delay periods (A)					0.720				1.11
Covering(B)					1.01				0.57
Varieties(C)					N.S				NS
(A) x (B)					2.03				1.15
(A) x (C)					1.52				1.51
(B) x (C)					1.08				1.28
(A) x (B) x (C)					2.16				2.56

2. Sucrose percentage

Data in Table (3) showed that delaying roots delivery from zero to six days after harvest caused significantly and gradually decreased sucrose % in both seasons. The effect of covering treatment on sucrose % was significant in the second season only, while insignificant variance among the tested beet varieties in sucrose percentage in both seasons.

Also, results in the same table showed that sucrose % was significantly affected by all possible interactions among the studied factors in the first and second seasons.

3. Impurities percentages (Na, K and α- amino N):

Results in Tables (4, 5 and 6) showed the significant effect of post-harvesting treatments (storage periods before processing and covering treatments) on impurities percentages (Na, K and α- amino N %) in both seasons.

Also, significant differences in impurities % were recorded among the tested sugar beet varieties in both seasons. Regarding the interactions, impurities% were significantly affected by all interactions among tested factors in both seasons.

Table (3). Effect of post-harvest treatments on sucrose % of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	20.00	18.55	18.14	18.90	19.30	18.71	18.96	18.99
	With top	17.80	20.34	18.06	18.73	18.40	19.61	18.74	18.92
Mean		**18.90**	**19.44**	**18.10**	**18.81**	**18.85**	**19.16**	**18.85**	**18.95**
2	without	16.21	16.49	15.88	16.19	17.27	16.90	17.15	17.11
	With top	15.86	16.80	16.20	16.29	17.85	18.35	17.92	18.04
Mean		**16.03**	**16.64**	**16.04**	**16.24**	**17.56**	**17.63**	**17.54**	**17.57**
4	without	15.66	14.87	15.18	15.24	16.80	15.27	17.01	16.36
	With top	15.87	15.83	15.00	15.90	16.35	18.05	18.00	17.47
Mean		**15.76**	**15.35**	**15.59**	**15.57**	**16.58**	**16.66**	**17.51**	**16.91**
6	without	15.32	14.54	14.90	14.92	15.50	14.43	15.39	15.11
	With top	15.16	15.43	15.03	15.21	15.75	17.34	17.25	16.78
Mean		**15.24**	**14.98**	**14.97**	**15.06**	**15.62**	**15.88**	**16.32**	**15.94**
B x C		16.91	16.02	16.00	16.31	17.39	16.24	17.04	16.89
		16.06	17.19	16.35	16.53	16.91	18.42	18.07	17.80
Mean		**16.48**	**16.61**	**16.17**		**17.15**	**17.33**	**17.55**	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.79	0.62
Covering (B)	NS	0.34
Varieties (C)	NS	NS
(A) x (B)	0.95	0.68
(A) x (C)	1.28	1.17
(B) x (C)	0.95	0.83
(A) x (B) x (C)	1.72	1.66

Table (4). Effect of post-harvest treatments on sodium % of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	1.300	1.939	1.181	1.473	1.683	2.170	2.120	1.991
	With top	1.267	0.348	1.285	0.967	3.190	1.467	2.214	2.290
Mean		**1.283**	**1.143**	**1.233**	**1.220**	**2.437**	**1.818**	**2.167**	**2.141**
2	without	3.520	2.310	2.760	2.863	4.183	2.510	2.920	3.204
	With top	1.663	2.050	1.647	1.787	3.137	2.317	2.323	2.592
Mean		**2.592**	**2.180**	**2.203**	**2.325**	**3.660**	**2.413**	**2.622**	**2.898**
4	without	4.733	2.660	3.207	3.533	4.770	2.647	3.010	3.476
	With top	1.853	2.370	2.180	2.134	3.287	2.430	2.770	2.829
Mean		**3.293**	**2.515**	**2.693**	**2.834**	**4.028**	**2.538**	**2.890**	**3.152**
6	without	4.857	2.903	3.937	3.899	5.003	2.877	4.510	4.130
	With top	2.247	2.667	2.663	2.526	3.677	2.357	3.363	3.132
Mean		**3.552**	**2.785**	**3.300**	**3.212**	**4.340**	**2.617**	**3.937**	**3.631**
B x C		3.602	2.202	2.772	2.859	3.910	2.426	3.139	3.158
		1.758	2.109	1.943	1.937	3.322	2.268	2.668	2.753
Mean		2.680	2.156	2.358		3.616	2.347	2.904	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.453	0.432
Covering (B)	0.241	0.239
Varieties (C)	0.285	0.261
(A) x (B)	0.482	0.478
(A) x (C)	0.569	0.522
(B) x (C)	0.403	0.369
(A) x (B) x (C)	0.805	0.738

Table 5. Effect of post-harvest treatments on potassium % of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	2.577	2.351	1.582	2.170	3.576	2.664	2.430	2.890
	With top	3.010	1.026	1.704	1.913	2.907	2.696	2.344	2.649
Mean		**2.793**	**1.688**	**1.643**	**2.042**	**3.242**	**2.680**	**2.387**	**2.769**
2	without	3.188	3.307	2.265	2.920	3.420	3.525	2.435	3.130
	With top	3.292	2.293	1.858	2.481	3.117	2.622	2.702	2.810
Mean		**3.240**	**2.800**	**2.062**	**2.701**	**3.268**	**3.073**	**2.568**	**2.970**
4	without	3.823	3.475	2.383	3.227	3.905	3.777	2.915	3.532
	With top	3.133	2.935	2.242	2.770	3.062	3.110	2.728	2.967
Mean		**3.478**	**3.205**	**2.312**	**2.998**	**3.483**	**3.443**	**2.822**	**3.249**
6	without	3.868	4.107	3.765	3.913	4.407	4.375	3.845	4.209
	With top	3.728	2.957	3.495	3.393	3.307	3.058	3.312	3.226
Mean		**3.798**	**3.532**	**3.630**	**3.653**	**3.857**	**3.717**	**3.578**	**3.717**
B x C		3.362	3.313	2.498	3.057	3.832	3.583	2.907	3.441
		3.293	2.299	2.326	2.639	3.092	2.874	2.771	2.913
Mean		3.327	2.806	2.412		3.462	3.228	2.839	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.112	0.323
Covering(B)	0.113	0.430
Varieties(C)	0.208	0.294
(A) x (B)	0.225	0.860
(A) x (C)	0.381	0.588
(B) x (C)	0.269	0.416
(A) x (B) x (C)	0.538	0.832

Table 6. Effect of post-harvest treatments on α-amino nitrogen % of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	1.563	0.917	1.778	1.419	1.947	1.675	1.439	1.687
	With top	1.771	2.012	1.888	1.890	1.897	1.246	1.551	1.565
Mean		**1.667**	**1.463**	**1.833**	**1.654**	**1.922**	**1.460**	**1.495**	**1.626**
2	without	2.867	3.018	2.768	2.884	2.345	2.709	2.817	2.623
	With top	2.293	2.502	2.228	2.341	2.192	2.581	2.397	2.390
Mean		**2.580**	**2.760**	**2.498**	**2.613**	**2.268**	**2.645**	**2.607**	**2.507**
4	without	3.140	3.285	3.238	3.221	3.813	2.855	3.292	3.320
	With top	2.980	2.822	2.748	2.850	3.060	2.638	2.738	2.812
Mean		**3.060**	**3.053**	**2.993**	**3.036**	**3.437**	**2.747**	**3.015**	**3.066**
6	without	3.692	3.582	3.640	3.638	4.603	3.422	3.762	3.929
	With top	3.125	3.292	3.177	3.198	3.007	3.188	3.635	3.277
Mean		**3.408**	**3.437**	**3.408**	**3.418**	**3.805**	**3.305**	**3.698**	**3.603**
B x C		2.820	2.947	2.858	2.875	3.178	2.662	2.828	2.889
		2.538	2.410	2.509	2.486	2.538	2.416	2.578	2.511
Mean		**2.679**	**2.678**	**2.683**		**2.858**	**2.539**	**2.703**	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.169	0.191
Covering(B)	0.106	0.163
Varieties(C)	0.109	0.124
(A) x (B)	0.212	0.326
(A) x (C)	0.219	0.248
(B) x (C)	0.155	0.175
(A) x (B) x (C)	0.309	0.351

4. Purity percentage:

Data illustrated in Table (7) Showed that purity percentage was significantly and gradually decreased with the increase in the time elapsed between harvesting sugar beet up to processing. As well as sugar purity %was significantly influenced by the covering treatments in the two seasons. Also, results cleared that the tested sugar beet varieties varied significantly in purity percentage in the two seasons.

Regarding to the interaction effect among the three studied factors, purity percentage responded significantly to all possible interactions among the studied factors in both seasons.

Table 7. Effect of post-harvest treatments on purity percentage of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	95.22	96.14	95.14	95.50	93.17	95.20	95.30	94.55
	With top	94.75	96.08	96.16	95.66	94.02	94.62	94.28	94.30
Mean		**94.98**	**96.11**	**95.65**	**95.58**	**93.59**	**94.91**	**94.79**	**94.43**
2	without	91.70	91.50	92.00	91.72	90.90	92.44	92.29	91.88
	With top	92.25	93.93	94.67	93.62	92.82	93.02	93.75	93.20
Mean		**91.97**	**92.71**	**93.33**	**92.67**	**91.86**	**92.73**	**93.02**	**92.54**
4	without	89.87	89.82	90.41	90.03	89.73	90.10	91.20	90.34
	With top	91.07	92.50	93.58	92.38	90.11	93.41	93.28	92.27
Mean		**90.47**	**91.16**	**92.00**	**91.21**	**89.92**	**91.76**	**92.24**	**91.30**
6	without	87.62	88.82	88.73	88.39	86.32	88.91	88.09	87.77
	With top	90.98	91.14	90.26	90.80	90.40	92.16	90.83	91.13
Mean		**89.30**	**89.98**	**89.50**	**89.59**	**88.36**	**90.53**	**89.46**	**89.45**
B x C		90.78	91.54	91.92	91.41	90.14	91.51	91.75	91.13
		92.58	93.45	93.32	93.11	91.72	93.45	93.00	92.72
Mean		91.68	92.49	92.62		90.93	92.48	92.38	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.30	0.57
Covering(B)	0.28	0.54
Varieties(C)	0.35	0.37
(A) x (B)	0.60	1.09
(A) x (C)	0.69	0.74
(B) x (C)	0.49	0.53
(A) x (B) x (C)	0.98	0.55

5. Sugar recovery percentage

Results given in Table (8) revealed that sugar recovery percentage was significantly and gradually decreased with the increase in the storage periods up to 6 days. .Also data showed that covering treatments had significant influence on sugar recovery % in the two seasons. In the same Table data showed that significant differences among sugar beet varieties in sugar recovery percentage in the second season only.

Concerning the interaction effect among the studied factors, sugar recovery percentage responded significantly to all interactions among the studied factors in both seasons.

Table 8. Effect of post-harvest treatments on sugar recovery % of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	18.46	16.91	16.54	17.31	17.28	16.58	16.92	16.93
	With top	15.65	19.18	16.77	17.20	15.58	17.80	16.80	16.73
Mean		**17.06**	**18.04**	**16.66**	**17.25**	**16.43**	**17.19**	**16.86**	**16.83**
2	without	13.27	13.95	13.73	13.65	14.39	14.24	14.56	14.40
	With top	13.73	14.83	14.37	14.31	14.98	16.17	15.88	15.67
Mean		**13.50**	**14.39**	**14.05**	**13.98**	**14.69**	**15.20**	**15.22**	**15.04**
4	without	12.33	12.03	12.62	12.33	13.18	12.48	14.40	13.36
	With top	13.40	13.59	13.98	13.66	13.59	15.64	15.54	14.92
Mean		**12.87**	**12.81**	**13.30**	**12.99**	**13.39**	**14.06**	**14.97**	**14.14**
6	without	11.81	11.39	11.62	11.61	11.74	11.26	11.76	11.59
	With top	12.41	13.02	12.33	12.59	12.59	14.96	14.46	14.00
Mean		**12.11**	**12.21**	**11.97**	**12.10**	**12.17**	**13.11**	**13.11**	**12.80**
B x C		13.97	13.57	13.63	13.72	14.15	13.64	14.41	14.07
		13.80	15.16	14.36	14.44	14.18	16.14	15.67	15.33
Mean		**13.88**	**14.36**	**14.00**		**14.17**	**14.89**	**15.04**	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.78	0.65
Covering(B)	0.50	0.42
Varieties(C)	NS	0.57
(A) x (B)	1.00	0.85
(A) x (C)	1.14	1.11
(B) x (C)	0.81	0.78
(A) x (B) x (C)	1.62	1.56

Table 9. Effect of post-harvest treatments on quality index% of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	91.01	91.25	92.30	91.52	87.77	89.86	89.75	89.13
	With top	89.30	93.99	91.72	91.67	86.49	89.52	89.13	88.38
Mean		**90.16**	**92.62**	**92.01**	**91.60**	**87.13**	**89.69**	**89.44**	**88.75**
2	without	83.00	84.40	85.48	84.29	81.59	85.38	85.45	84.14
	With top	85.59	88.42	89.69	87.90	85.51	86.92	88.16	86.86
Mean		**84.30**	**86.41**	**87.59**	**86.10**	**83.55**	**86.15**	**86.81**	**85.50**
4	without	79.01	81.35	82.48	80.95	78.08	82.53	84.18	81.59
	With top	84.25	85.39	87.99	85.88	83.37	85.72	86.87	85.32
Mean		**81.63**	**83.37**	**85.24**	**83.41**	**80.72**	**84.12**	**85.52**	**83.46**
6	without	76.10	78.77	78.47	77.78	74.97	79.13	75.96	76.69
	With top	82.93	83.78	81.59	82.77	80.57	85.26	84.23	83.35
Mean		**79.52**	**81.27**	**80.03**	**80.27**	**77.77**	**82.19**	**80.10**	**80.02**
B x C		81.96	84.10	84.85	83.64	80.87	83.55	84.24	82.88
		85.84	87.74	87.59	87.05	83.72	87.53	86.69	85.98
Mean		**83.90**	**85.92**	**86.22**		**82.29**	**85.54**	**85.47**	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.72	1.29
Covering(B)	0.65	1.19
Varieties(C)	0.75	0.89
(A) x (B)	1.31	2.37
(A) x (C)	1.49	1.79
(B) x (C)	1.06	1.26
(A) x (B) x (C)	2.11	2.53

6. Quality index percentage

Data in Table (9) showed that quality index % significantly and gradually decreased with the increase in the time elapsed between harvesting sugar beet up to processing in the 1st and 2nd seasons. Covering treatments significantly affected quality index as shown in the same table, there were significant differences among the studied varieties with respect to quality index% in both seasons. The interaction effect among the studied factors was significant on sugar recovery percentage in both seasons.

7. Roots yield

Results in Table (10) indicated that roots yield significantly and gradually decreased with the increase in the time elapsed up to 6 days before processing in the two seasons.

Also data showed that roots yield was significantly affected by storage covering treatments and there were significant differences among the tested sugar beet varieties in the root yield in both seasons. Moreover, roots yield (ton/fad) was significantly affected by all possible interactions among the three studied factors in both seasons.

Table 10. Effect of post-harvest treatments on roots yield ton/fad of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	26.512	19.491	18.191	21.398	25.455	23.996	17.473	22.474
	With top	23.695	24.892	18.208	22.264	22.942	24.742	16.912	21.532
Mean		**25.103**	**22.190**	**18.200**	**21.831**	**24.198**	**24.368**	**17.443**	**22.003**
2	without	17.250	19.312	15.770	17.444	18.085	18.510	14.569	17.055
	With top	19.646	23.072	17.207	19.974	18.375	21.890	16.338	18.868
Mean		**18.448**	**21.192**	**16.488**	**18.709**	**18.230**	**20.202**	**15.453**	**17.962**
4	without	13.182	10.352	13.400	12.311	16.258	14.822	12.493	14.524
	With top	16.833	20.668	15.097	17.534	17.368	20.678	14.203	17.417
Mean		**15.010**	**15.510**	**14.248**	**14.923**	**16.813**	**17.750**	**13.348**	**15.971**
6	without	9.760	9.583	10.570	9.971	12.099	11.813	12.101	12.004
	With top	14.633	17.257	14.106	15.332	14.671	17.784	11.982	14.812
Mean		**12.197**	**13.420**	**12.338**	**12.652**	**13.385**	**14.798**	**12.042**	**13.408**
B x C		16.676	14.684	14.483	15.281	17.975	17.310	14.259	16.515
		18.703	21.472	16.154	18.776	18.338	21.249	14.884	18.157
Mean		**17.690**	**18.078**	**15.319**		**18.157**	**19.280**	**14.572**	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	1.40	0.740
Covering(B)	1.15	0.450
Varieties(C)	1.35	0.650
(A) x (B)	2.30	0.900
(A) x (C)	2.70	1.300
(B) x (C)	1.91	0.919
(A) x (B) x (C)	3.82	1.838

8. Sugar yield

Results in Table (11) indicated that delaying sugar beet roots processing from o up to 6 days after harvesting time was significantly decrease sugar yield in both seasons, also covering treatments was significantly affected sugar yield and there were significant differences among varieties in sugar yield ton/fad in both seasons.

Regarding to interaction effect, results in the same Table showed that sugar yield was significantly affected by the all possible interactions among three studied factors in 1st and 2nd seasons.

Table 11. Effect of post-harvest treatments on sugar yield of three sugar beet varieties

Treatments		2020				2021			
Delivery /day	Covering	Varieties			Mean	Varieties			Mean
		Oscar poly	Ravel	Francesca		Oscar poly	Ravel	Francesca	
0	without	4.688	3.324	3.121	3.744	3.322	4.574	3.024	3.640
	With top	3.918	4.683	2.945	3.849	3.712	4.259	2.842	3.604
Mean		**4.303**	**4.053**	**3.033**	**3.797**	**3.517**	**4.417**	**2.933**	**3.622**
2	without	2.487	2.624	2.052	2.387	2.435	2.812	2.113	2.453
	With top	2.507	3.498	2.585	2.863	2.925	3.362	2.597	2.961
Mean		**2.497**	**3.060**	**2.318**	**2.625**	**2.680**	**3.087**	**2.355**	**2.707**
4	without	1.598	1.328	1.637	1.521	2.045	2.042	1.713	1.933
	With top	2.278	2.728	2.170	2.392	2.472	3.048	2.287	2.602
Mean		**1.938**	**2.028**	**1.903**	**1.957**	**2.258**	**2.545**	**2.000**	**2.268**
6	without	1.168	1.003	1.287	1.153	1.520	1.134	1.523	1.392
	With top	1.803	2.331	1.679	1.937	1.760	2.852	1.634	2.082
Mean		**1.485**	**1.667**	**1.483**	**1.545**	**1.640**	**1.992**	**1.578**	**1.737**
B x C		2.488	2.091	2.025	2.201	2.409	2.567	2.088	2.355
		2.623	3.313	2.344	2.760	2.638	3.453	2.346	2.812
Mean		**2.556**	**2.702**	**2.185**		**2.524**	**3.010**	**2.217**	

L.S.D. at 0.05 level for		
Delivery delay periods (A)	0.210	0.126
Covering(B)	0.250	0.105
Varieties(C)	0.253	0.112
(A) x (B)	0.501	0.209
(A) x (C)	0.507	0.225
(B) x (C)	0.358	0.159
(A) x (B) x (C)	0.717	0.318

DISCUSSIONS

1. Weight losses percentage (W.L %):

The weight losses% were 10.92, 19.86 and 27.66 at 2,4, and 6 days from harvesting compared to the control in first season, while in the second one the values of reduction % were 10.56, 19.09 and 27.63 %. These results could be attributed to the loss in evaporation, as well as the high temperature during storage periods (Table 1). These results are in line with those obtained by Al-Zubi *et al.* (2015); Al Jbawi and Al Zubi (2016) and Besheit and El-Mansoub (2020) who reported that, weight of sugar beet roots significantly dropped by prolonging storage period, Stored sugar beet roots in piles covered with its tops scored the lowest root weight loss % over storage periods. These results coincided with that obtained by Mohamed *et al.* (2017) and Seadh *et al.* (2021) they found that the lowest root weight loss % were obtained by covering roots with leaves top. Insignificant variance among varieties in loss% in root fresh weight in both seasons Table (2). This result agrees with that reported by Al Jbawi and Al Zubi (2016), they reported insignificant differences among varieties in root weight loss (%). The percentage loss in root fresh weight was markedly affected by the interaction between factors A and B in both seasons (Table 2). The results indicated that the variance in root weight loss% between covered and non-covered piles of roots was widened as the period of storage was gradually increased from 0 to 6 days after harvest, showing the effectiveness of root coverage. The interaction of A and C had a significant influence on the weight loss percentage that occurred in roots after harvesting in both seasons. Ravel and Francesca varieties varied significantly in this trait after 6 days of storage after harvesting, but there was no substantial variance between these two varieties in this trait after 4 days of storage in both seasons (Table 2).

2. Sucrose percentage

Delaying roots delivery from zero to six days after harvest significantly continuously decreased sucrose %in both seasons. These decreases were 2.57, 3.24 and 3. 75 at 2,4 and 6 days after harvesting compared to harvest day (0 day), in first season, while the decreases in second one were 1.38 , 2.04, and 3.01 %. These results may be due to that

during roots storage; respiration and conversion sucrose to reducing sugars formation consume sucrose. These results are in accordance with those obtained by El-Shahaby *et al.* (2014); Al Jbawiand Al Zubi (2016) and Besheit and El-Mansoub (2020) they found that sucrose % tended to decrease as delaying delivery increased up to 12 days after harvest. Sucrose % was significantly affected by the covering treatments in 2nd season only, covering roots with sugar beet foliates recorded the highest value of sucrose (17.80 %). Similar results were obtained by Alfaig *et al.* (2011) and Ibrahim *et al.* (2021). They reported that the highest sucrose % was recorded when covering sugar beet roots with foliage. Insignificant differences among tested varieties in the sucrose percentage in both seasons. In respect to the effect of interaction among the three studied factors was significant on this trait in the two seasons. These significant interactions means that the studied varieties did not behave the same under the two investigated post-harvest treatments in the 2nd season, sucrose percentage of Ravel and Francesca sugar beet varieties were significantly increased by covering with top, but this was not the case with the other variety.

3. Impurities percentages (Na, K and α- amino N):

From data, it could be seen that impurities % were significantly affected by the tested storage periods, by delaying processing of sugar beet roots to 6 days after harvesting, roots impurities % were increased in both seasons. These results are in line with those obtained by Hassan *et al.* (2011); El-Shahaby *et al.* (2014) and Besheit and El-Mansoub (2020) they reported that delaying delivery led to increase in roots impurities percentages. Also, impurities percentage was significantly affected by studied storage methods, in both seasons. Results of the present investigation are in line with those of Kenter and Hoffmann (2009) and Ibrahim, *et al.* (2021) they noted that impurities % trait was significantly affected by storage methods. Significant differences in impurities % were recorded among the studied sugar beet varieties in the two seasons. The differences between tested varieties in impurities content are mainly due to their gene make-up. This result is in agreement with those obtained by Madritsch *et. al.* (2020), Gorski, *et al.* (2022) and Galal, *et al.* (2022)**,** they reported that the tested sugar beet varieties exhibited different values in impurities %.

Impurities were significantly affected by the interaction among the tested factors. In general, the lowest sodium percentage (0.348 and 1.467) was recorded by the Ravel variety when it was processed immediately, and the lowest potassium percentage (1.026 and 2.344) was recorded by the Ravel and Francesca varieties. Meanwhile, the lowest -amino nitrogen values (0.917 and 1.246) were recorded by the Ravel variety when it was processed immediately in the first and second seasons, respectively (4,5 and 6).

4. Purity percentage:

Purity percentage was significantly and gradually decreased with the increase in the time elapsed between harvesting sugar beet up to processing, where the purity % decreased from 95.58 and 94.43 % in harvest day (0 day) to 89.59 and 89.45 % after six days from harvesting date in the 1stand 2ndseasons, respectively. The decrease in purity % may be due to the decrease in sucrose as well as increase in sodium, potassium, and α-amino nitrogen content (Tables 4,5 and 6). Hassan *et al.* (2011) and Al Jbawi and Al Zubi (2016) found that purity % significantly dropped by prolonging storage.

Covering treatments had significant influence on purity % in the two seasons. The highest values of purity % (93.11 % and 92.72 %) were recorded with using sugar beet foliage in covering of roots piles in 1st and 2nd seasons, respectively (Table 7). These results agree with those obtained by Al Osmsn, *et al.* (2010) and Abd El-Rahman *et al.* (2019), they reported that the piles covered with leaves, were the best method to store sugar beet roots after harvest compared to other methods.

The examined sugar beet varieties varied significantly in purity % in the two seasons. Sugar beet varieties (Francesca and Ravel) recorded the highest mean values of purity % (92. 62 and 92.48%), while the lowest (91.68 and 90.93%) were recorded by Oscar poly variety in the first and second seasons respectively (Table 7). These differences could be attributed to the genetic structure of the evaluated sugar beet varieties. Differences among sugar beet varieties with respect to purity % were reported by Ahmed *et al.*(2017); El-Safy*et al.* (2020); Hefny and Said (2021) and Galal, *etal.* (2022) they reported that there were significant differences among varieties in purity percentage. Concerning the interaction effect among the studied factors, it was significant in both seasons. This means that the tested varieties did not behave the same at the different post-harvest treatments. In the first season, the decrease in purity percentage of Francesca was about double that obtained with other varieties due to increasing the storage period from 4 to 6 days. Generally, the lowest values of purity (87.62 and 86.32%) were obtained from the Oscar poly variety when it was processed after six days from harvesting without covering in both seasons (Table 7).

5. Sugar recovery percentage

Sugar recovery % significantly and gradually decreased with the increase in the time elapsed between harvesting sugar beet and processing. The sugar recovery% decreased from 17.25 and 16.83 % in first day to 12.10 and 12.80 % after six days from harvesting in the first and second seasons respectively. The decrease in sugar recovery % is mainly due to the decrease in sucrose % as well as increase in sodium, potassium, and α-amino nitrogen content (Tables 5,6 and 7). These results are in harmony with those outlined by Hassan *et al.* (2011) they reported that the time elapsed between harvesting up to processing had a significant effect on sugar recovery percentage. Sugar recovery % was significantly influenced by the covering treatments in the two seasons. The highest values (14.44 and 15.33%) were recorded when covering root piles with sugar beet foliage. On the other hand, the lowest one (13.72 and 14.07 %) were recorded from the piles of roots left without covering, in first and second seasons respectively. Similar results were obtained by Kenter and Hoffmann (2009) and Abd El-Rahman *et al.* (2019) they found that storage covering treatment had significant effect in sugar recovery%. Statistical differences in sugar recovery % were recorded among tested varieties in 2nd season only. Francesca surpassed the other two varieties in sugar recovery %, followed by Ravel without significant different between them while, Oscar poly variety gave the lowest sugar recovery % (14.17). This result may be due to the genetic differences among tested sugar beet varieties. The differences between sugar beet varieties were reported by Al Jbawi and Al Zubi (2016); Hefny and Said (2021) and Galal *et al.* (2022) they found that significant differences among the tested varieties in sugar recovery%. The interaction between the three factors was significant; in the first season, the decrease in sugar recovery percentage of the Francesca variety was significantly decreased by an increased storage period of 4 to 6 days, but this was not the case for the other two varieties. In the 2nd season, the sugar recovery percentages of Ravel and Francesca sugar beet varieties were significantly increased by covering with top, but this was not the case with the other variety. In general, the lowest sugar recovery percentages (11.39 and 11.26) were recorded by the Ravel variety when it was processed after 6 days from harvesting without covering in both seasons (Table 8).

6. Quality index percentage

Quality index % significantly and gradually decreased with the increase in the time elapsed between harvesting time up to processing, where the quality index% decreased from 91.60 and 88.75 % in first day to 80.27 and 80.02% after six days from harvesting time in the 1st and 2ndseasons respectively. These results agree with those obtained by Hassan *et al.* (2011) El-Shahaby *et al.* (2014), they noticed that quality index % of beet roots decreased during the storage periods. Also, covering treatments significantly affected quality index which increased by 4.99%in the first season and by 6.66 %in the second season, when the roots of sugar beet covered with leaves compared to without covering treatment. These results are in line with those obtained by Kenter and Hoffmann (2009) and Ibrahim *et al.* (2021) they reported that quality index% significantly influenced by covering treatments. There were significant differences among the studied varieties with respect to quality index% in both seasons. Sugar beet varieties (Francesca and Ravel) recorded the highest means values of quality index% (86. 22 and 85.54 %), while the lowest values (83.90 and 82.29%) were recorded by Oscar poly variety in the first and second seasons respectively. Differences among varieties were reported by El-Safy *et al.* (2020); Hefny and Said (2021) and Galal *et al.* (2022), they obtained significant differences between the three sugar beet varieties in quality index % in both seasons. In respect to the effect of the interaction between sugar beet varieties and post-harvesting treatments was significant in both seasons. In the second seasons the decrease in quality index % of Francesca variety was insignificant by increasing storage period from 2 to 4 days, but this was not the case with the other varieties. The increase in quality index % of Oscar poly variety was time and a half of that obtained by Francesca variety due to covering with top. Generally, the lowest quality index %(76.10 and 74.97 %) was recorded by Oscar poly variety when delaying processing up to 6 days, without covering in 1st and 2nd seasons, respectively (Table 9).

7. Roots yield

Root yield was significantly and gradually decreased with the increase in the time elapsed between harvesting and processing in the two seasons. The decreases were 3.122, 6.908 and 9.179 at 2, 4 and 6 days after harvesting compared to the control in first season, while in the second one the decreases were 4.041,6.032and 8.595 ton/fad at the same post harvested period compared to control. These results may be due to the loss in evaporation with high temperature during storage period (Table 1). These results are in accordance with those obtained by Mohamed (2017) and El-Safy *et al.* (2020), they revealed that significant differences among storage periods in root yield ton/fad. Also, roots yield ton/fad

was significantly affected by storage methods studied in both seasons. Roots yield increased by 3.495 ton/fad in the 1st season and by 1.642 ton/fad in the 2nd season when the roots of sugar beet covered with leaves compared to without covering treatment. These results coincide with that obtained by Alfaig *et al.* (2011) they reported that roots yield was significantly affected by storage methods. Significant differences among the tested sugar beet varieties in root yield in both seasons. In the first season, Ravel variety out-yielded Oscar poly, and Francesca beet varieties by 0.388, and 2. 759 ton/fad corresponding to 1.123 and 4.708 in the second seasons. This result may be due to the genetic differences among the tested sugar beet varieties. These findings agree with those obtained by Ahmed *et al.* (2017); Hefny and Said (2021) and Gorski *et al.* (2022) they reported that significant differences among the tested varieties in roots yield. Moreover, roots yield was significantly affected by the interaction among studied factors in both seasons. This means that beet varieties did not behave the same at the different post-harvest treatments. The decrease in roots yield of Ravel variety was higher than that recorded by the other varieties due to increasing the time elapsed between harvesting and processing from 2 to 4 days in the two seasons. Generally, the lowest roots yield (9.583 and 11.813 ton/fad) were recorded by Ravel variety when it is processing after 6 days from harvesting, without covering in the 1st and 2nd seasons respectively (Table 10).

8. Sugar yield

Delaying roots processing from o up to 6 days after harvesting significantly decrease sugar yield in both seasons, this decrement amounted to 30.9, 48.5and 59.3 % as compared to processing after 2, 4and 6 days in 1stseason, while these decreases were 25.3, 37.4, and 52.0% in 2ndseason respectively. The decrease in sugar yield by delaying processing is due to the decrease in sugar recovery percentages and roots yield (Tables 8 and 10) which reflected on sugar yield as a final product. These results are in coincid with those mentioned by and El-Safy *et al.* (2020), they reported that there were significant differences between storage periods in sugar yield in both seasons. Covering treatments significantly affected sugar yield. Sugar yield increased by 0.559 ton/fad in the 1stseason and by 0.457 ton/fad in the 2ndseason, when the roots of sugar beet covered with leaves compared to without covering. These results are in harmony with those outlined by Kenter and Hoffmann (2009) and Alfaig *et al.* (2011), they found that sugar yield was significantly affected by storage methods. Also, significant differences among varieties in sugar yield ton/fad in both seasons. Sugar beet variety Ravel out yielding Oscar poly and Francesca varieties by 0.146 and 0.517 ton/fad in 1st season, corresponding to 0.486 and 0.793 ton/fad in 2nd respectively. These results could be attributed to their superiority in roots yield (Table 10). This result agrees with those obtained by Al Jbawi and Al Zubi (2016); Hefny *and Said* (2021) and Galal *et al.* (2022), they found that there were significant differences among the three sugar beet varieties in the sugar yield. was significantly affected by the interaction among the studied factors on both seasons. The varieties did not behave the same under the two studied factors. In the first season sugar yield of Francesca beet variety was insignificantly decreased by delaying processing from 2 up to 4 days, but this was not the case with the other varieties, as well as Ravel variety was significantly increased in sugar yield by covering with top but this was not the case with the other variety. Generally, the lowest sugar yield (1.003 and 1.134 tons/fad) was recorded by Ravel variety when it is delaying processing up to six days, without covering in 1st and 2nd seasons, respectively (Table 11).

CONCLUSION

Under the conditions of the present work, the results suggest that Oscar poly and/or Ravel sugar beet varieties gave the highest roots and sugar yield and quality when delivered at the same day of harvesting in Kom Ombo. The work showed the importance of the quick delivery for processing as possible (at the same harvesting time) and covering the harvested roots piles if manufacturing is difficult after harvesting directly to minimize the deterioration rate in sucrose and root fresh weight as the period of delivery is delayed.

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تأثيرمعاملات ما بعد الحصاد على إنتاجية وجودة أصناف بنجر السكر تحت ظروف كوم امبو

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اجريت هذه الدراسة فى مزرعة محطة البحوث الزراعية بكوم امبو (دائرة عرض 24,28 شمال و خط طول 57,32 شرق)،محافظة اسوان خلال موسمي الحصاد 2020 و 20201 لدراسة تأثير فترة التخزين (0 ، 2 ، 4 و 6 أيام) ومعاملات تغطية جذور البنجر (مغطاة باوراق البنجر- بدون تغطية) على الحاصل والخصائص التكنولوجية لثلاثة أصناف من بنجر السكر (أوسكار بولي ، رافيل وفرانشيسكا). تم استخدام التصميم التجريبي قطاعات كاملة العشوائية فى قطع منشقة مرتين ، بثلاثة مكررات.أظهرت النتائج الى ان اطالة مدة التخزين ادت الى انخفاض واضح فى حاصلى الجذور و السكر بالطن للفدان و النسبة المؤية للسكروز والنقاوة وجودة البنجر وناتج السكر النظرى فى حين ادت الى زيادة ملموسة فى النسبة المئوية للفقد فى الوزن الطازج للجذور و النسبة المؤية للشوائب. كما أظهرت النتائج أن معاملة تغطية الجذور باوراق البنجر أثرت معنوياً على جميع الصفات محل الدراسة. هذا و قد اختلفت أصناف بنجر السكر المختبره معنوياً فى جميع الصفات محل الدراسة عدا نقص الوزن الطازج للجذور والنسبة المؤية للسكروز في كلا الموسمين وكذلك النسبة المؤية لناتج السكر النظرى في الموسم الأول فقط.تحت ظروف هذا العمل البحثى ، أوضحت النتائج على ضرورة سرعة توريد جذور بنجر السكر للمصانع لتقليل الفقد فى حاصلى الجذور و السكر ، وفى حالة حدوث تأخير فى التوريد لمصنع السكر ، يجب تغطية الجذور بالعرش.

الكلمات المفتاحية: سكروز , نقاوة, ناتج السكر النظرى, مدة التخزين بعد الحصاد, , تغطية جذور البنجر