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Effect of Harvest Age on Growth, Yield and Quality of Two Root Chicory Varieties (*Cichorium intybus* L.) under Egyptian Conditions

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ABSTRACT

Chicory (*Cichorium intybus* L.) related to the family *Asteraceae* is a winter crop and stores inulin in the taproots. Chicory is considerable a cash crop, whereas inulin is a polyfructans, which is widely used as prebiotic, sugar replacer, fat replacer, starting material for fructose syrup and oligofructose in several industrial applications. Thus, two field experiments were carried out in 2014/2015 and 2015/2016 seasons at El-Giza Agricultural Station Agricultural Research Center in Egypt (latitude of 30^0 03 N and longitude of 31^0 13 E) in a clay soil to evaluate the performance of two French chicory varieties namely Nues and Eurobees for its growth, yield and quality under three harvest ages 125, 145 and 165 days after sowing date in (October 15^{th} in the two growing seasons). The experimental design was split plots with four replications. The results indicated that the two chicory varieties differed considerably concerning their potential of growth, yield and quality characteristics. Eurobees variety surpassed Nues in root formation, root fresh and dry yields/fed, inulin% and inulin yield/fed.Delaying harvest ages from 125 to 145 and up to 165 day after sowing caused significant increases in fresh and dry root yields/fed, inulin % and inulin yield/fed in both seasons. The interaction between Chicory varieties and harvest ages indicated that Eurobees achieved the highest significant values of root fresh, root dry and inulin yields/fed with delaying harvest age to 165 days after sowing as compared to Nues variety harvested at 125 days. Both Eurobees and Nues varieties which harvested at 165 days from sowing attained the highest significant variance of inulin% as compared to them at 12° and/or 145 days after sowing.As for enzymetic analyses of inulin extracted from sample of root dry at the three harvesting ages under this work indicated that Eurobees has the longest inulin chain length, while Nues was the shortest inulin chain length. Thus, the variation in quality traits of the two chicory varieties allows a wide spectrum of utilization in food and pharmaceutical industries in Egypt. Under conditions of this present work, it could be recommended that both root chicory varieties sowing in October and must be harvesting at 165 days after sowing to get the highest yields of fresh and dry roots as well as inulin% and inulin yield/fed, also for highest total fructose, reducing sugar percentages.

Keywords: Harvest age, root chicory varieties, root and inulin yield, inulin chain length

INTRODUCTION

The words *chicory, succory, Cichorium intybus* L are all derived from Greek or Latin names for the herb. The crop native to Europe, and is traditionally grown for use as a coffee substitute, chicory drink, or for use in the sugar industry. The current production area for "sugar chicory" is more than 15,000 ha and is concentrated in Belgium, France and the Netherlands. Recently, new regions such as Poland, Puerto Rico, and Serbia have been trying to introduce industrial chicory into their cropping systems (FAO, 2013). Introduction of new crops into agricultural production systems is desirable to overcome problems associated with narrow crop rotation. Chicory is considered one of the most important sources of fractan type inulin since it has a high root yield potential and high inulin content (Schittenhelm, 1999). Chicory is winter crop which is a cold-requiring and long-day plant. Chicory is an annual and/or biannual with self-incompatibility characteristics (Zagal *et al*., 2001). Schittenhelm (2001) reported that root chicory is a potential alternative sugar crop which accumulates a high amount of linear fructose polymers (fructan) in its roots. Wilson *et al.* (2004) reported that glucose, fructose, sucrose, and fructans were as a percentage of total sugar content. Andrea *et al*. (2005) reported that fructans were further grouped into three categories: DP 3 to 10 fructans (short chain-length fructans), DP 11 to 20 fructans (medium chain-length fructans) and DP > 20 fructans (long chain-length fructans). Chicory plants related to the family *Asteraceae* manufactures linear inulin (fructan) consisting of one terminal glucose residue and a variable number of fructose residues exclusively linked by β-(2→1) bonds (Van Arkel *et al.*, 2012).

The fructans are group of storage polysaccharides which the human body is unable to metabolize. Therefore, the fructans are considered dietary functional food ingredients (Ritsema and Smeekens, 2003). Chicory is an attractive as a cash crop since it can reach more than 50-62 tons ha^{-1} under favourable conditions. Meanwhile, inulin content can reach on average 15-20% of root fresh weight and a yield of 8 tons ha^{-1} of inulin is achievable (Papetti *et al.,* 2013). Inulin is a poly fructans which is widely used as prebiotic, as a (low calorie) sweetener, fat replacer texture modifier and several industrial and pharmaceuticals (González-Herrera *et al.,* 2015).

Construction of chicory yield and technological quality is complex process, which depends on many factors such as varieties. Both developmental and biomass transformation processes are reflected into growth of chicory root biomass (Dersch *et al.*, 1993) .Dried chicory root extract contains by weight approximately 98% inulin and 2% other compounds, while fresh chicory root may contain between 13 and 23% inulin, 14% sucrose, 5% cellulose, 6% protein, 4% ash, 89.4 % total carbohydrate and 3% other components by total weight (Meehye and Shin, 1996).

In addition, an important factor to boost yield production is the selection of suitable varieties for specific environmental conditions and optimalization of agro-technical activities (Černý *et al.,* 2008).

Baert (1997) concluded that the total amount of accumulated inulin in root is a role of variety. Kristine Koch *et al.* (1999) studied the effect of five harvest ages (121, 145, 158, 170 and 183 days after sowing date) on quality of inulin chicory root for six chicory cultivars, namely Orchies (French), Bergues (French), Tilda (Belgian), SZ 05-004.94 (Austrian), Cassel (French) and Rubis (French). They found that varieties varied with harvest age and the highest degree of polymerization (DP) for all cultivars was detected for harvests in 158 and 170 days after sowing. Černý *et al.* (2008) noted that suitable variety is necessary support on the basis of ability to adapt to physical environment. Kovár and Černý (2012) evaluated two chicory varieties ('Fredonia Nova' and 'Oesia' a 'Maurane') to growth, yield potentials, inulin content. Fredonia Nova' gave higher roots value 2.08 kg m^{-2} and 205.9 mg g^{-1} dry weight more than in the variety 'Oesia' a 'Maurane'. Fredonia Nova variety gave the highest root yield by amount 25.73 t $ha^{-1}$and 25.02 t ha^{-1}, while inulin content in fresh root were 20.85 % and 21.54 % with varieties 'Oesia' a, Maurane and Fredonia Nova, respectively in the first and second seasons. Sayed, Hala and Soha, Khalil (2017) reported that the quantity and quaintly of chicory root depends on variety.

Although different factors such as harvest date, temperature can affect inulin yield (Baert and Van Bockstaele, 1993). The content of free fructose and sucrose increased while the content of free glucose decreased with delaying harvest time Varallo *et al.* (1993). However, Ernst *et al.* (1995) mentioned that fructan yield and their degree of polymerization DP, influenced by climate and time harvest. Amaducci and Pritoni (1997) showed that retarding harvest time much affects the content and concentration of inulin content. Delaying harvesting time increased the root yield, total sugar content, total reducing sugar and inulin chain length. Moreover, the optimum date of harvesting roots is in non-physiological state and is given by the total content of sugars, as well as their ratio. On the other hand, Shoorideh *et al.* (2016) mentioned that root yield and inulin percentage are two major components to increase inulin yield.

The aim of this work was to evaluate the performance of two root chicory varieties for their growth, yield and quality characters at the three harvest ages under the Egyptian conditions.

MATERIALS AND METHODS

Two field experiments were carried out in 2014/2015 and 2015/2016 seasons at El-Giza Agriculture Station, Agricultural Research Center in Egypt, (latitude of 30^0 03 N and longitude of 31^0 13 E) in a clay soil to evaluate the performance of two French root chicory varieties namely Nues and Eurobees (*Chiorium intybus* L.) for its growth, yield and quality under three harvest ages (125, 145 and 165 days after sowing on October 15^{th}) in the two growing seasons. The size of each plot was 15 m^2 consisted of 5 ridges with 5 m length and 0.6 m width. The experimental design was split plots with four replications. The two varieties were sown randomly in the main plots, while the three harvest ages were in the sub plots. Chicory seeds sown mixed with amount of sand; seeds depth was 2-3 cm. Plant spacing within ridges was 15-17 cm, plant population was about 9-11 plants per m^2 after manual thinning (20 days from sowing and after full emergence). In both seasons, the trials were carried out on a well prearranged clay soil, with relatively apparent water. The agricultural practices were done. Mediate furrow irrigation was made to make easy the emergence of the crop sowing. Weeds were controlled manually from emergence until crop closure.

Phosphorus fertilizer was applied in the form of calcium super phosphate (15% P_2O_5) at the rate of 100 kg/fed and potassium fertilizer was applied at the rate of 24 kg/fed in the form of potassium sulfate (48% K_2O) at seed bed preparation. Nitrogen fertilizer was applied as Urea (46.5% N) at the rate of 50 kg/fed applied in two equal doses after thinning and the other two weeks later. Soil samples (0-30 cm depth) were collected from the experimental site to determine its physical and prepared for mechanical and chemical analyses, according to Piper (1955) as shown in Table 1.

The monthly temperature degrees (^{0}c) of the two seasons were shown in Table 2.

At each harvest age, randomly sample of 10 plants were obtained from each plots and prepared for laboratory analyses to determine the following traits: 1. Root length (cm), 2. Root diameter (cm), 3. Root fresh weight (g), 4. Foliage fresh weight (g), 5. Root dry matter%; 100 g homogeneous slices of fresh chicory roots were dried at 75^{o}c for 48 h.

6. **Root dry weight (g/plant) using the following formula:**

Root dry weight (g/plant) = root fresh weight (g) x root dry matter%

The three inside ridges at each harvest age (9 m^2) were manually harvested, topped, washed, weighed (roots and tops) in all plots to calculate the following traits:

7. **Root fresh yield (t/fed). (feddan = 2.4 ha), 8. Top fresh yield (t/fed),**
9. **Root dry yield (t/fed) using the following formula:**

Root dry yield (t/fed) = Root fresh yield (t/fed) x Root dry matter%.

Preparation of chicory:

The plant of chicory root was washed with tap water to remove remaining soil and other impurities and then cut them into small pieces and dried at 40˚C for 10 hr. in an electric oven (Gasellsaft for Laboratory, D3006, German), then ground using an electrical mill to pass through 100 mesh sieves and stored in polyethylene bags in refrigerator at 4 ºC until used.

Chemical analyses on dry weight basis:

Inulin was determined using HPLC the chromatographic equipment consists of a Model LC-20AT pump system (Shimadzu, Japan), a 20-lL sample loop, and a LC solution system, which acquires data from the refractive index detector (RID 10A, Shimadzu, Tokyo, Japan). The analytical column put to use in this case is Shim-pack SCR 101C from Shimadzu (Tokyo, Japan). Inulin was determined according to the methods described by Wang *et al.* (2010) and inulin yield (t/fed) was calculated as root yield (t/fed) x inulin %

Extraction of inulin from root chicory:

The extraction process was made by adding hot water to the roots powder, in a 1:2 proportion (roots: water) at the average temperature of 80 °± 2 C for 1 hr with constant agitation. The liquid inulin extracts obtained was filtered (Leite *et al*. 2004). The extracted filtrate was then concentrated according to (Amin, 1997). The concentrated extract was dried firstly by freezing and water portion separation, and then the concentrated portion was oven dried under vacuum at 40°C to reach a complete dryness.

Table 1. Particle size distribution and some chemical properties of the soil of the experimental site in 2014/2015 and 2015/2016 seasons

2014/2015										
Particle size			**Soil textural**	**Ec (dSm^{-1})**	**Soil pH (1:2.5)**	**Organic matter%**	**SP**			
Sand%	**Silt%**	**Clay%**								
20.0	26.5	53.5	Clay	0.6	7.8	1.36	0.55			
Soluble cations (mq 1^{-1})				Soluble ions (mq 1^{-1})				Available nutrients (mg/1kg soil)		
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^-	Hco_3^-	Cl-	So_4^-	N	P	K
19.49	14.15	10.49	0.59	-	3.77	10.60	30.35	74.0	6.0	197.2
2015/2016										
Particle size			Soil textural	Ec (dSm^{-1})	Soil pH (1:2.5)	Organic matter%	SP			
Sand%	Silt%	Clay%								
22.3	27.1	50.6	Clay	0.7	8.0	1.31	0.71			
Soluble cations (mq 1^{-1})				Soluble ions (mq 1^{-1})				Available nutrients (mg/1kg soil)		
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^-	Hco_3^-	Cl-	So_4^-	N	P	K
19.95	15.10	9.70	0.85	-	4.10	12.50	29.0	70.1	6.85	213.4

Table 2. The temperature degrees and relative humidity of the two seasons at El-Giza.

Month	**2014/2015 season**				**2015/2016 season**			
	Mx. temp.	**Min. temp.**	**Av. Temp.**	**Relative humidity%**	**Mx. Temp.**	**Min. temp.**	**Av. Temp.**	**Relative humidity%**
October	30.9	18.5	25.0	63.7	32.7	20.7	28.3	57.0
November	26.1	13.9	21.6	59.3	26.9	15.7	22.9	46.0
December	24.6	11.4	19.6	56.0	21.6	9.9	17.6	64.7
January	19.9	7.1	15.8	54.0	23.0	11.1	15.5	60.3
February	21.4	8.2	16.9	51.0	22.9	10.3	16.9	54.0
Marsh	25.4	12.1	21.0	52.0	25.5	12.6	19.1	43.3
April	28.8	12.0	23.6	43.0	30.3	15.2	23.4	38.3

Source: Agro-meteorological station, Agric. Res. Center, Giza, Egypt,

Determination sugar profile and degree of polymerization (DP):

At each harvest age, randomly sample of 10 plants were obtained and prepared for laboratory analyses to determine the following traits by enzymatic hydrolysis, this process is the hydrolysis of inulin by inulinases to determine chain length of extracted inulin from dried roots of the two tested varieties according to the method described by (Petkova *et al*. 2015), then the samples were measured by Spectrophotometer measuring the absorption at wave length 410 nm for reducing groups and 480 nm for total fructose content and calculation by the following formula:

Total glucose content = reducing groups - total fructose content

Degree of polymerisation (DP) = (fructose content/glucose content) +1

At 165 days from sowing, Moisture, protein, fat, crude fiber and ash content of two chicory root variety samples were determined according to the methods described in AOAC (2010). Total carbohydrates content was calculated by difference.

At 165 days from sowing, Minerals content was estimated by Atomic Absorption pectrophotometer (model 3300, Perkin- Elimer, Beaconsfield, UK) and digestion according to the procedure outlined by AOAC (2010).

Statistically analysis

All measured and derived data were analyzed separately for each season by analysis of variance (ANOVA) as shown by Snedecor and Cochran (1980) using the technique of (MSTAT-c) computer software package. Least significant differences (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Duncun (1955).

RESULTS AND DISCUSSION

Data in Table 3 show that the difference between the two chicory varieties in root diameter, root fresh weight and foliage fresh weight traits were significant in both seasons except root length. Eurobees variety recorded an increase in root diameter amounted to 1.0 and 1.3 cm, corresponding to 33 and 29 g in root fresh weight g/plant, as well as 14 and 13 g in foliage weight g/plant in the 1st and 2nd season, respectively, as compared to Nues variety. The variation between the two tested chicory varieties in these traits might be due to their gene make-up.

These results are in line with those mentioned by Papetti *et al.* (2013) they obtained that significant differences among the tested root chicory varieties in root parameters.

Regarding harvest age, data in the same table indicate that decreasing harvesting age from 125 to145 and up to 165 days after sowing significantly and gradually increased all mentioned characters except foliage fresh weight g/plant which showed an opposite trend, in both seasons. These results are in harmony with those obtained by Dersch *et al.* (1993).

Table 3. Root length, root diameter (cm), root and foliage fresh weight (g) of the two chicory varieties as affected by the three harvest ages in 2014/2015 and 2015/2016 seasons

Characters	Root length (cm)		Root diameter (cm)		Root fresh weight (g)		Foliage fresh weight (g)	
Treatments	**2014/15**	**2015/16**	**2014/15**	**2015/16**	**2014/15**	**2015/16**	**2014/15**	**2015/16**
Varieties (V)								
Nues	23.1	23.8	5.6b	5.8b	254b	269b	134b	149b
Eurobees	26.5	26.8	6.9a	7.2a	287a	298a	148a	162a
F. test	NS	NS	**	**	**	**	*	**
Harvest ages (H)								
H1 (125 day)	23.4b	23.4c	5.8c	6.0c	252c	265b	165a	178a
H2 (145 day)	25.0a	25.3b	6.4b	6.5b	271b	282ab	136b	152b
H3 (165 day)	26.1a	27.3a	6.7a	7.0a	289a	304a	122c	137c
LSD at 5%	1.4	0.69	0.2	0.3	16	27	14	11
V x H	NS	NS	NS	NS	NS	NS	NS	NS

***,** and NS at 0.05, 0.01 level of significance and not significant**

The interactions between varieties and harvest ages of the mentioned traits were not reached to 5% level of significance.

Data in Table 4 show that the evaluated the two chicory varieties were differed significantly in root traits in the two seasons. Eurobees variety surpassed Nues variety in all mentioned traits. These variations between the two tested chicory varieties in these traits may be related to the increments of root formation and root dry matter% which referred to their gene potential. These results are in line with those mentioned by Černý and Javor (2004) they mentioned that both of developmental and matter transformation processes are reflected into growth of chicory biomass. Therefore, the dependence of individual elements of chicory yield components on environmental conditions is very different.

Table 4. Root dry matter%, root dry weight (g), and top fresh yield (t/fed) of the two chicory varieties as affected by the three harvest ages in 2014/2015 and 2015/2016 seasons

Characters	Root dry matter%		Root dry weight (g)		Top fresh yield(t./fed)	
Treatments	**2014/15**	**2015/16**	**2014/15**	**2015/16**	**2014/15**	**2015/16**
Varieties (V)						
Nues	25.38b	25.72b	64.65b	69.22b	5.44b	5.72b
Eurobees	25.96a	26.33a	74.59a	78.59a	6.33a	6.72a
F. test	*	*	**	**	**	**
Harvest ages (H)						
H1 (125 day)	24.13b	24.67c	60.89c	65.29c	6.92a	7.26a
H2 (145 day)	25.91a	26.13b	70.12b	73.55b	5.86b	6.30b
H3 (165 day)	26.98a	27.27a	77.86a	82.87a	4.87c	5.11c
LSD at 5%	1.10	0.80	3.99	6.97	0.59	0.53
V x H	NS	NS	NS	NS	NS	NS

***,** and NS at 0.05, 0.01 level of significance and not significant**

Data in the same Table cleared that root dry matter% and root dry weight (g) significantly increased with delaying harvest age from 125 to 145 and up to 165 days after sowing in both seasons. Meanwhile, top fresh yield (t/fed) recorded the highest values when plants were harvested in the earlier harvesting age. These results proved that maturity stage was still continued to complete the storing processing of dry matter from leaves to roots. The distinct effect of delaying harvest dates on these traits is mainly due to the favorable climatic conditions especially the temperature degree in this stage which accelerated dry matter% as a mass production which resulted highest root dry weight. These results partially agreed with those reported by Monti *et al*. (2005), they stated that root dry matter% and root dry weight accumulation were increased by long growing season and high temperature conditions especially in maturity stage.

All mentioned traits were insignificantly affected by the interaction between harvest age and varieties in both seasons.

Results in Table 5 manifest that Eurobees variety significantly surpassed Nues in all mentioned traits in both seasons. The superiority of Eurobees variety may be correlated to the increment in root dimensions, and root fresh weight which finally participated in getting higher values of roots fresh, dry, inulin yields/fed, and inulin% as well as root dry matter% (Table 3) as compared to Nues variety. These results are in line with those mentioned by Baert (1997), Černý *et al.* (2008) and Papetti *et al.* (2013).

Data in the same Table cleared that delaying harvest age from 125 to 145 and up to 165 days after sowing caused significant increments in root fresh and dry yields as well as inulin % and inulin yield amounted by 0.80 and 1.30 corresponding 1.03 and 1.61 tons in root fresh yield, as well 0.41 and 0.67 corresponding to 0.44 and 0.73 tons of root dry yield, and also amounted by 11.12 and 21.29 % corresponding to 12.13 and 21.64 % of inulin%, moreover 0.64 and 1.19 corresponding to 0.71 and 1.28 tons of inulin yield (t/fed) as compared to the first harvest age (125 days) in the 1st and 2nd seasons, respectively. These results are in line with those obtained by Černý *et al.* (2008) they confirmed that the root fresh yield and inulin content were statistically high significantly influenced by year's weather conditions, meanwhile Wilson *et al.* (2004) concluded that the inulin accumulation in a root depends on environmental conditions especially high temperature and physiological state of plants.

Table 5. Root fresh yield, root dry yield, inulin yield and Inulin% of the two chicory varieties as affected by the three harvest ages in 2014/2015 and 2015/2016 seasons

Characters / Treatments	Root fresh yield (t/fed)		Root dry yield (t/fed)		Inulin%		Inulin yield (t/fed)	
	2014/15	2015/16	2014/15	2015/16	2014/15	2015/16	2014/15	2015/16
Varieties (V)								
Nues	11.32b	11.59b	2.88b	2.99b	78.90b	79.64b	2.30b	2.41b
Eurobees	12.60a	12.74a	3.28a	3.31a	83.15a	84.85a	2.75a	2.84a
F. test	**	**	**	**	**	*	**	**
Harvest ages (H)								
H1 (125 day)	11.26c	11.28c	2.72c	2.76c	70.22c	70.99c	1.91c	1.96c
H2 (145 day)	12.06b	12.31b	3.13b	3.20b	81.34b	83.12b	2.55b	2.67b
H3 (165 day)	12.56a	12.89a	3.39a	3.49a	91.51a	92.63a	3.10a	3.24a
LSD at 5%	0.39	0.47	0.14	0.17	3.51	3.85	0.13	0.22
V x H	*	*	*	*	*	*	*	*

***,** and NS at 0.05, 0.01 level of significance and insignificant**

Data in Table 6 show that root fresh yield, root dry yield, inulin% and inulin yield (t/fed) were significantly affected by the interaction between varieties and harvest ages in both seasons. Eurobees variety achieved the highest significant values of fresh and dry root and inulin yields/fed when delayed harvest age from 165 days after sowing as compared to Nues variety which harvested at 125 days in both seasons. Both Eurobees and Nues varieties which harvested at 165 days from sowing attained the highest significant variance of inulin% as compared to its harvested of them at 125 and 145 days after sowing.

Table 6. Significant interactions effect between varieties and harvesting ages on yields of root fresh, root dry, inulin (t/fed) and inulin% in 2014/15 and 2015/16 seasons

Interaction effects		Root fresh yield (t/fed)		Root dry yield (t/fed)		Inulin%		Inulin yield (t/fed)	
		2014/15	2015/16	2014/15	2015/16	2014/15	2015/16	2014/15	2015/16
Varieties x harvest ages (V x H)									
	H1	10.68d	10.68d	2.54d	2.61d	67.52e	67.69e	1.72d	1.77d
Nues	H2	11.29c	11.76c	2.90c	3.03c	78.72c	79.98c	2.28c	2.43c
	H3	11.99b	12.32bc	3.20b	3.32b	90.45a	91.25ab	2.89b	3.03b
	H1	11.83b	11.89c	2.89c	2.90c	72.93d	74.29 d	2.11c	2.16c
Eurobees	H2	12.83a	12.86ab	3.35b	3.36b	83.97b	86.27 b	2.82b	2.90b
	H3	13.12a	13.46a	3.58a	3.67a	92.57a	94.63a	3.32a	3.45a

Means with the same letter in each column, on the basis of Duncan test, have no significant differences at 5% level.
H1: harvesting date after 125 days from sowing, H2: 145 days from sowing and H3: 165 days from sowing.

Data in Table 7 show that chemical analyses of crud extracted inulin from two root chicory varieties detected us varieties Eurobees and Nues were varied considerably in their performance in both seasons for root inuline%, chain length distribution and sugar profile (glucose, fructose and total reducing sugar).

Moreover, total fructose % tended to increase and total glucose decreased with delaying harvest time for each variety whereas, increasing fructose levels from the first age up to latest harvest age associates with onset of cooler night at minimum temperatures which ranged from (7.1 to 12.6°C) as shown in table 2 in month of January, February and Marsh before harvest which suitable for accumulate sugar in the taproot. These results are in similar with those mentioned by Ernst *et al.* (1995) and Černý *et al.* (2008). A general pattern is a maximum chain length in latest harvest while decreased in the first and second harvest age. These findings are in agreement with those mentioned by Varallo *et al*. (1993) and Amaducci and Pritoni (1997).

Data in the same Table cleared that inulin chain length gradual increased with delaying harvest age from 125 to 145 and up to 165 day after sowing in both seasons

As for degree of polymerization (DP) as a class characteristic, the data obtained tells us Eurobees recorded the longest chine length because the DP>10 moreover associated with higher total reducing sugar%, total fructose% and inulin% while Nues variety gave the shortest chine length with DP<10 and associated with lowest total reducing sugar, total fructose% and inulin%. These findings are in agreement with those mentioned by Meehye and Shin (1996), Wilson *et al.* (2004), Kovár and Cerný (2012) and Petkova *et al*. (2014)

Table 7. Sugar profile, chain length (DP) and Inulin % of extracted inulin from both chicory roots varieties by enzymatic analysis at three harvest age in 2014/15 and 2015/16 seasons

Sugar profile	Nues variety			Eurobees variety		
	harvest ages at 2014/2015					
	H_1	H_2	H_3	H_1	H_2	H_3
Total reducing sugar%	36.5	41.0	45.70	59.70	69.9	74.9
Total glucose%	5.7	5.5	5.2	4.2	4.4	4.3
Total fructose%	30.8	35.5	40.5	55.5	65.5	70.6
chain length (DP)	6.4	7.4	8.7	14.2	15.8	17.4
Inulin%	65.50	78.73	90.85	78.55	82.53	91.65
	harvest ages at 2015/2016					
Total reducing sugar%	35.5	42.2	53.1	55.7	70.5	80.0
Total glucose%	5.5	6.0	5.9	4.5	5.1	4.8
Total fructose%	30.0	36.2	47.2	51.2	65.4	75.2
chain length (DP)	6.4	7.0	9	11.4	13.8	16.6
Inulin%	67.90	79.88	89.24	75.99	83.12	92.20

H1: harvesting date after 125 days from sowing, H2: 145 days from sowing and H3: 165 days from sowing.

Data presented in Table 8 show the chemical analysis of two tested root chicory varieties under this study. It was obviously clear that both chicory varieties had a high content of total carbohydrates and low level of protein, fat, ash and crude fiber. These findings are in agreement with those mentioned by Meehye and Shin (1996). Moreover, there are differences between them in the minerals content whereas, Nues variety was higher than other one in Zn, Fe, and Ca and K mg/100 g. these results manifest that chicory is a great source of carbohydrates and minerals. The variations between two tested chicory varieties in these contents may be related to varietal characteristic and their performance which depends on many factors such as their gene make-up and environmental conditions. These results are in line with those mentioned by Dersch *et al.* (1993) and Černý *et al.* (2008**)**.

Table 8. Chemical analysis of Eurobees and Nues chicory root variety on dry weight basis at 165 days from sowing

Constituents (%)	chicory varieties	
	Eurobees variety	Nues variety
Moisture	5.9	6.7
Crude Protein	2.5	3.2
Crude ether extract	0.95	1.5
Ash	2.8	4.5
Total carbohydrate	87.85	84. 1
Crude fiber	6.7	5. 5
Minerals (mg/100g)		
Zinc (Zn)	0.27	0.36
Iron (Fe)	0.76	0.98
Calcium (Ca)	28.92	37.5
Potassium (K)	30.74	35.59

CONCLUSION

Under conditions of this present work, it was found that both root chicory varieties which harvested at 165 days after sowing can be recommended to get the highest yields of fresh and dry roots/fed as well as inulin% and inulin yield/fed. Eurobees has the long chain length, while Nues variety has the short chain length which giving us the advantage of using them on a large scale in the food and pharmaceutical industries.

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تأثير عمر الحصاد علي نمو وحاصل وجودة صنفين من شيكوريا الجذور تحت الظروف المصرية

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الشيكوريا محصول شتوي ينتمي الي العائلة المركبة، حيث يخزن الإنيولين في الجذور. تعتبرالشيكوريا محصول نقدي ، حيث أن الأنيولين يتكون من عديد الفركتوز(بولي فركتانز)، التي تستخدم على نطاق واسع كمكون غذائي غير قابل للهضم يشجع على نمو الكائنات الدقيقة النافعة في الأمعاء ، وكبديل للسكر والدهون ، كمادة خام لصناعة شراب الفركتوز والاوليجوفركتوز. لذلك أجريت تجربتان حقليتان في موسمي ٢٠١٤/٢٠١٥ و ٢٠١٥/٢٠١٦ في محطة الجيزة للبحوث الزراعية بمركز البحوث الزراعية بمصر (دائرة عرض ٣٠.٠٣ ^{0} شمالاً وخط طول ٣١.١٣ ^{0} شرقاً) في تربة طينية لتقييم آداء صنفين فرنسيا المنشأ وهما (نيوس، يوروبيز) من حيث النمو وحاصل وجودة الجذور تحت ثلاثة أعمار حصاد ١٢٥، ١٤٥ و ١٦٥ يوماً بعد الزراعة (ميعاد الزراعة في الخامس عشر من شهر أكتوبر في الموسمين). كان التصميم التجريبي هو القطع المنشقة مرة واحدة في أربعة تكرارات. أشارت النتائج إلي أن صنفي الشكوريا إختلافا معنوياً فيما يخص صفات النمو والمحصول والجودة. تفوق الصنف يوروبيز علي نيوس في سمك الجذور، حاصلا الجذور الطازجة والجافة/فدان، نسبة الإنيولين و حاصل الإنيولين/فدان. تأخير عمر الحصاد من ١٢٥ الي ١٤٥ يوم و حتي ١٦٥ يوماً بعد الزراعة سبب زيادات معنوية في حاصلا الجذور الطازجة والجافة/فدان، ونسبة الإنيولين و حاصل الإنيولين/فدان في كلا الموسمين. دل التفاعل بين أصناف الشيكوري وأعمار الحصاد أن الصنف يوروبيز أعطي أعلي القيم المعنوية في حاصل الجذور الطازجة والجافة والأنيولين/فدان بتأخير عمر الحصاد حتي ١٦٥ يوم بعد الزراعة بمقارنته بالصنف نيوس المحصود عند ١٢٥ يوم. أحرز كلا من الصنفين يوروبيز ونيوس عندما حصدا عند ١٦٥ يوماً بعد الزراعة أعلي التباينات المعنوية في النسبة المئوية للإنيولين بمقارنتهما معاً عند عمر حصاد ١٢٥ و ١٤٥ يوما بعد الزراعة. إتضح من التحليل الإنزيمي لعينات الأنيولين المستخلصة من جذور صنفي الشيكوريا المجففة عند أعمار الحصاد الثلاثة المدروسة في الموسمين أن الصنف يوروبيز كان طويل السلسلة بينما الصنف نيوس كان قصير السلسلة. مما يتيح لنا هذا الاختلاف في خصائص الجودة للصنفين باستغلاهما في مجالات واسعة في الصناعات الغذائية والدوائية.تحت ظروف هذه التجربة يمكن التوصية بزراعة صنفي شيكوريا الجذور يوروبيز ونيوس في شهر أكتوبر وحصادهما عند عمر ١٦٥ يوماً للحصول علي أعلي حاصل للجذور الطازجة والجافه/فدان، وكذلك النسبة المئوية للأنيولين وحاصل الأنيولين/فدان.