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Effect of Different Growing Periods on Yield and Quality Characteristics in Artichoke (*Cynara cardunculus var. scolymus*) Production

Enginar (Cynara cardunculus var. scolymus) Üretiminde Farklı Yetiştirme Dönemlerinin Verim ve Kalite Özelliklerine Etkisi

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ABSTRACT

The present study was carried out to determine the performance of artichoke as an alternative vegetable crop in Konya's ecological conditions. Thus, Jade F1 (JD) and Bayrampaşa (BP) cultivars were planted for 2 planting periods (1st - May 20 and 2nd - June 10) and some growth characteristics, yield characteristics, and head characteristics were investigated. BP planted on 2nd period and the JD planted on 1st period produced remarkable stem development. BP had higher plant height values than JD and reached the highest plant height values with the increase in air temperature. BP and JD well adapted to the field conditions as the temperature increased and they had a relatively higher leaf number. The maximum stalk number with head per plant was determined as 10.65 in 2nd planting period and the JD had the highest total head number per decare (da) in 1st planting period with 7850 heads. Likewise, the average head number and total head weight with stalk were the highest with 7.85 per plant and 1613 kg da^{-1} in the 1st period in JD, respectively. JD had the highest head diameter (9.15 cm) in 2nd period, followed by JD (8.10 cm) and BP (7.40 cm) in 1st period. JD plants had the highest heads (9.36 cm) and the highest calycle diameters (9.93 cm) in the 2nd period. Eventually, comparative economic analysis was realized with tomato production, and the 1st planting period with JD was determined to be feasible in Konya conditions.

Key Words: Artichoke, Cultivation period, Konya ecological conditions, Yield, Quality

ÖZ

Sunulan çalışma, enginarın alternatif bir sebze olarak Konya koşullarındaki performansını belirlemek amacıyla yapılmıştır. Jade F1 (JD) ve Bayrampaşa (BP) çeşitleri 2 farklı dönemde (1. - 20 Mayıs ve 2. - 10 Haziran) dikilmiş ve bitki büyüme özellikleri, verim özellikleri ve baş kalite özellikleri belirlenmiştir. 2. dönemde dikilen BP ve 1. dönemde dikilen JD, dikkate değer ölçüde kök boğazı gelişimi göstermiştir. BP JD'ye göre daha yüksek bitki boyu değerlerine sahip olmuş ve hava sıcaklığının artmasıyla birlikte en yüksek bitki boyu değerlerine ulaşmıştır. BP ve JD sıcaklık arttıkça arazi koşullarına iyi uyum sağlamış ve nispeten daha yüksek yaprak sayısı değerlerine sahip olmuşlardır. Bitki başına maksimum dal sayısı 2. dönemde 10.65 olarak belirlenmiş, JD 7850 adet ile 1. dönemde dekara (da) en yüksek toplam baş sayısına sahip olmuştur. Aynı şekilde, JD'de ortalama baş sayısı ve saplı toplam baş ağırlığı sırasıyla bitki başına 7.85 ve 1613 kg da^{-1} ile 1. dikim döneminde en yüksek olmuştur.

JD bitkileri 2. dönemde en yüksek baş çapına (9.15 cm) sahip olmuş, onu 1. dönemde JD (8.10 cm) ve BP (7.40 cm) takip etmiştir. En uzun başlara (9.36 cm) ve en yüksek kaliks çapına (9.63 cm) 2. dönemde yetiştirilen JD bitkileri sahip olmuştur. Domates yetiştiriciliği ile kıyaslamalı yapılan ekonomik analiz sonucunda JD çeşidi ve 1. dikim döneminin Konya koşullarında ekonomik olduğu belirlenmiştir.

Anahtar Kelimeler: Enginar, Yetiştirme dönemi, Konya ekolojik koşulları, Verim, Kalite

Introduction

The cultivated artichoke (*Cynara cardunculus var. scolymus*) is a member of the Asteraceae family, which includes many species such as chicory and lettuce (Ryder et al., 1983). The Asteraceae family has about 1000 genera and nearly 20 thousand species around the world. In Turkey, there are 133 genera and 1156 species (Baytop, 1999). Although the artichoke grows naturally in Mediterranean countries including Southern Europe, North Africa, and the Canary Islands, the plant is also cultivated (Sonnante et al., 2002). Wild species are mostly grown in countries in the Mediterranean Region. The origin of the artichoke, which is a vegetable of the compound flower family, is stated as the Mediterranean basin and the island of Cyprus (Bayraktar, 1981; Abak, 1987).

Artichokes are cultivated and consumed in many countries around the world. Chief among these countries are Egypt, Morocco, and Tunisia in Africa; In Asia, China, Israel, Lebanon, United Arab Emirates, Turkey; Argentina, Brazil, and Chile in South America; California comes from North America (Portis et al., 2005). Today, both wild forms and cultivated forms of the artichoke are abundantly encountered in Western and Eastern Mediterranean countries, North Africa, and Southern European countries (Thompson and Kelly, 1957). Italy and Spain come first in the cultivation of artichoke, which has a wide production network in Mediterranean countries (Llorach et al., 2002; Curradi et al., 2007). Although the Mediterranean countries play a major role in the consumption of artichoke as food, it is a plant species that is used as a supplement in treatments and registered in various pharmacopeias and monographs (Curadi et al., 2007).

The world artichoke production area is approximately 113.058 ha, and the production reached 1.58 million tons. Egypt is the first producer with 459.962 tons, followed by Italy (378.110 tons) and Spain (200.000 tons). Türkiye is ranked 8th in world artichoke production with 40.815 tons (FAO, 2022). Artichoke production is generally realized by vegetative methods and two artichoke varieties named Sakız and BP come to the fore in Turkey. The varieties are produced from seeds, which have been used as canned and frozen products since the 2000s. Moreover, it is also reported to be consumed in the form of jam with high antioxidant content (Durmuş et al., 2020). Domestic type and abroad-sourced small-headed canned artichoke varieties are also encountered (Eser et al., 2006; Kenanoğlu Bektaş and Saner, 2011). Artichoke production has largely shifted from the province of Istanbul to the Eastern Marmara Region in recent years. In addition, between these two species, some species grow in different forms called Yerli, Darıca, and Tuzla (Ekinci, 1956; Özzambak et al., 2006; Bölükbaşı, 2016). While the majority of production is realized in the provinces of Izmir, Bursa, and Aydın, especially in early growing, production has been carried out in Antalya and Adana provinces in Turkey (Anonymous, 2023).

Although Konya has come to the fore with cereal group, sunflower, and carrot, vegetable production has started to intensify, especially in Altınekin and Çumra, with the transition to irrigated agriculture. In this process, the production areas of watermelon and tomatoes, especially melons, have increased and the vegetable producers have been in search of alternative vegetable types that can have a high income. Thus, it aims to investigate the possibilities of growing artichokes in regional conditions, to determine the yield and quality characteristics, and to obtain literature information that will be a source for artichoke

cultivation in Konya and other regions that have similar climatic conditions.

In the present study, JD and BP cultivars were planted in 2 different periods (20 May and 10 June) and some plant growth, yield, and quality parameters of artichoke were investigated in Konya as an alternative vegetable crop.

Materials and Methods

The research was carried out between April and October 2019 in the producer's area in the Karatay-Konya.

Material

Jade (JD) and Bayrampaşa (BP) artichoke varieties were used as plant material (Figure 1). BP is consumed for both fresh and canning. It has a very large and flat head and also carries a large calycle. Being a late variety reduces the fresh consumption rate. It is widely grown in the Marmara, Black Sea, and Central Anatolia regions (Keskin and Namal, 2018). JD is produced from seed, has medium-sized heads, and is suitable for fresh consumption. Although the calycle is narrow, it is more preferred to be consumed as stuffed.

Figure 1. The cultivars (Original)

Methods

Experimental area

To determine the physical properties of the soil in the experimental area, degraded and undisturbed soil samples were collected from 0 - 30, 30 - 60, and 60 - 90 cm soil layers in soil profiles up to 90 cm depth at 2 different locations. The soil of the study area is slightly alkaline, slightly salty, very high in phosphorus and potassium, medium in organic matter, very high in lime, and has a clay-loamy texture. Thus, the fertilization program was established before and after planting, and additional fertilization was applied considering the development, needs, and vegetative part of the plant (Table 1).

Table 1. The fertilization program was applied via soil analysis.

Applying Time	***Fertilizer***	***kg da^{-1}***
Before planting	Decompose manure	3000
	Triple Super Phosphate 44 % (w/v)	5
	Potassium Sulphate 50 % (w/v)	10
During planting	Ammonium Nitrate 33 % (w/v)	20
When the first heads appear	Ammonium Sulphate 21 % (w/v)	30
	Potassium Sulphate 50 % (w/v)	5
20 days after the first heads appear	Ammonium Nitrate 33 % (w/v)	20

Since it is stated that potassium has a positive effect on yield and quality, care has been realized in fertilization (Öztürk et al., 2020). The base fertilizer was mixed with the soil during soil preparation, and the top fertilizers were applied with the drip irrigation system.

Cultivation

The seedlings of the BP were obtained from a commercial company in Antalya. Seeds of JD were sown in plastic containers containing peat moss in glasshouse conditions. The seedlings with 3-4 leaves were planted on 20 May 2019 (1st period) and 10 June 2019 (2nd period) at 1 x 1 m spacing and distances in the field conditions, and then sap water was applied with the drip irrigation system in 2019 spring. 20 seedlings were planted for each period and each cultivar (Figure 2).

Figure 2. The seedlings of the cultivars and plantation (Original)

A sprinkler irrigation system has been established in Konya to equalize the moisture balance and to provide the required humidity level, especially in the summer, due to the low relative humidity (approximately 40-50 %). For fungal diseases, it was preferred to irrigate at the necessary periods and during cool hours to prevent encounters with hot-cold weather conditions and to minimize transpiration (Figure 3).

Figure 3. The sprinkler irrigation (Original)

Hoeing, weeding, disease, and pest management were carried out regularly. In the production season, mole, aphid, leaf fly, and tomato moth pests were encountered and struggled. The mole ate the tubers of the plant, causing complete damage to the plant. During the production season, a drug containing 33 % w/w phosphine was poured into the molehills. Although the desired results could not be obtained in the fight against mole, the level of damage was tried to be minimized. Pests such as aphids and leaf flies were combated with 25 g l^{-1} Deltamethrin, 20 % Acetamiprid active ingredient agricultural pesticides every week for approximately 45 days after planting the plant in the field. The tomato moth pest was encountered once, approximately 30 days after planting the seedlings. It has struggled with an agricultural pesticide with a 35 % Chlorantraniliprole active ingredient.

During the production season, unfavorable weather conditions, and Alternaria were encountered on the artichoke leaves and caused a partial head loss in the 1st and 2nd harvests of the 1st period of JD. It struggled with 80 % FosetyL-Al active ingredient and considerable results were obtained. With the struggle, the head loss ended in the next harvests. 40 ppm of GA_3 was applied on 26 July 2019 in the 1st cultivation and on 16 August 2019 in the 2nd cultivation to ensure the elongation of the vegetative part and to encourage earliness, ensure regular head formation, and increase the quality of the heads formed (Figure 4).

Figure 4. GA_3 pulverization (Orijinal).

Observations

Plant growth characteristics [stem diameter (mm), leaf number (per plant), plant height (cm)] were determined on the 10th, 20th, and 30th days after planting. Yield characteristics [stalk number with head (piece/per plant), total head number (da), average head number (per plant), total head weight with stalk (kg da^{-1}), total head weight without stalk (kg da^{-1}), average head weight (g)] and head quality characteristics [head stem diameter (cm), head diameter (cm), head height (cm) and calycle diameter (cm)] was evaluated.

Experimental design and data evaluation

The experiment was carried out according to the randomized blocks design with 3 replications and 20 plants in each replication. The obtained data were subjected to analysis of variance in the JUMP package program, and the differences between the means were determined by Duncan's multiple comparison test.

Results and Discussions

Plant characteristics

Stem diameter (mm), number of leaves per plant, plant height (cm)

The views of the JD and BP plants realized 3 times with an interval of 10 days are presented in Figures 5, 6, 7, and 8.

Figure 5. Development in 1st of JD at 10-day intervals from planting (Original).

Figure 6. Development in 2nd of JD at 10-day intervals from planting (Original).

Figure 7. Development in 1st of BP at 10-day intervals from planting (Original).

Figure 8. Development in 2nd of BP at 10-day intervals from planting (Original).

There is no statistical difference on the 30th day for SD values (Table 2). SD was 6.68 mm in the 1st and 6.06 mm in the 2nd in JD. On average, BP produced better results (7.62 mm) than JD (6.37 mm) on the 10th day. On the 30th day, SD values ranged from 28.62 mm to 31.39 mm. Respectable SD results were obtained from BP in 2nd and from the JD in 1st. Contrary to the findings of Namal (2019), BP and JD adapt to the field conditions as the temperature increases and show a good development in the SD.

Table 1. Stem diameter (SD), leaf number (LN), and plant length (PL) for varieties, growing periods (P), and days

		SD (mm)			***LN (number plant^{-1})***			***PL (cm)***		
	P	***10th***	***20th***	***30th***	***10th***	***20th***	***30th***	***10th***	***20th***	***30th***
JD	***1st***	6.06	13.35 cd	29.59 a	3.53	5.50 cd	9.25	15.00	21.58 de	38.18 c
	2nd	6.68	13.31 cd	28.76 ab	3.44	5.06 cd	8.52	14.34	23.96 d	41.56 bc
BP	***1st***	7.73	11.87 d	28.62 ab	3.62	6.25 c	10.17	14.00	20.57 de	44.27 b
	2nd	7.50	15.23 c	31.39 a	4.11	7.05 c	10.86	13.76	25.68 d	50.12 a
		LSD: 4.10			*LSD: 2.88*			*LSD: 6.16*		

In the LN, no statistical difference was determined and the values ranged from 3.44 (2nd in JD) to 4.11 (2nd in BP) on the 10th day. BP had the highest LN values with 7.05 and 6.25 for both periods on the 20th day. On the 30th day, there was no statistical difference for the LN value, and BP had the highest values in both periods and increased LN it had in parallel with the temperature increase. On the other hand, JD had fewer leaves than BP in both periods and formed

relatively fewer leaves in the 2nd when temperatures were high. It is possible to argue that BP was less affected by high temperatures and developed better than JD in plant growth.

Measurements realized between February and June in *Cynara cardunculus* L., LN values were 9.33 and 9.67, respectively (Wahba et al., 2017). In addition, as the amount of nitrogen fertilizer increased, an increase was observed in the LN, and it was stated that LN values ranged from 16 to 30 per plant (Allahdadi and Farzane, 2018). In addition, as the temperature increased, the LN in the seedlings of the BP decreased and remained the same at 25 °C and 35 °C (Namal, 2019). In this context, considering the LN, 35 oC was not an appropriate temperature for growing seedlings in artichoke.

BP and JD well adapt to the field conditions as the temperature increases and they show a relatively better development in the LN. Our findings were following Wahba et al. (2017) in February, and when we compared them with the measurements made in June, negative results were obtained. On the other hand, our results were lower than the findings of Allahdadi and Farzane (2018). It is possible to explain this contrast by the fact that the climatic conditions and growing periods of the places where the studies are carried out are different. In addition, it is possible to explain this difference with some cultural practices applied during the breeding period (such as GA_3 application, moistening, and appropriate fertilization program) and the difference in the genotypes. In the PL, no statistical difference was found and the values ranged from 15.00 cm (1st period) to 13.76 cm (2nd period) on the 10th day. BP and JD had the highest PL values with 25.68 and 23.96 in 2nd on the 20th day. On the 30th day, the highest PL value (50.12) was obtained from BP on the 2nd.

BP planted on 10 June 2019 in 2nd and the JD planted on 20 May 2019 in 1st showed remarkable stem development. BP reached the highest plant height values and dominated its plant height with the increase in temperature. Although JD had lower plant height values compared to BP, it increased plant height with the increase in temperature. It is revealed that artichokes like heat in terms of plant development. Following our results, plant height was examined between February and June in Cynara cardunculus L., a gradual increase was observed in both seasons. In February it was 88.33 and 93.33 cm, and in June it was 108.33 and 113.33 cm in two periods, respectively (Wahba et al., 2017).

Yield Characteristics

The number of stalks with head (SH; number plant^{-1}), total head number (THN; per da), average head number (AHN; per plant), total head weight with stalk (THWS), total head weight without stalk (THWWS) and mean head weight (MHW; g) were examined as yield characteristics, and were recorded for each harvest (Table 3). The first harvest of the 1st period JD was between August 22, 2019, and the last harvest was between October 5, 2019, and JD had a regular harvest period. The first harvest of the 2nd period in JD was on September 10, 2019, and the last harvest was on October 27, 2019. A total of 5 harvests were realized in both periods of JD. On the other hand, BP was harvested only once on October 5, 2019, in the 1st period.

In the 2nd period, BP maintained its plant growth parameters well for 60-70 days from planting. However, BP, which is a late variety and has a longer vegetative growth until head formation, although it shows an appearance close to JD in terms of external appearance, the last times of vegetative development and the first times of head formation are relatively cool. Since it coincided with the autumn (September - October) when the number of open days decreased (Figure 9), the head could not be formed; therefore, yield could not be obtained in BP in the 2nd period. In conclusion, BP needs relatively warmer periods and a higher number of sunny days for head formation compared to JD.

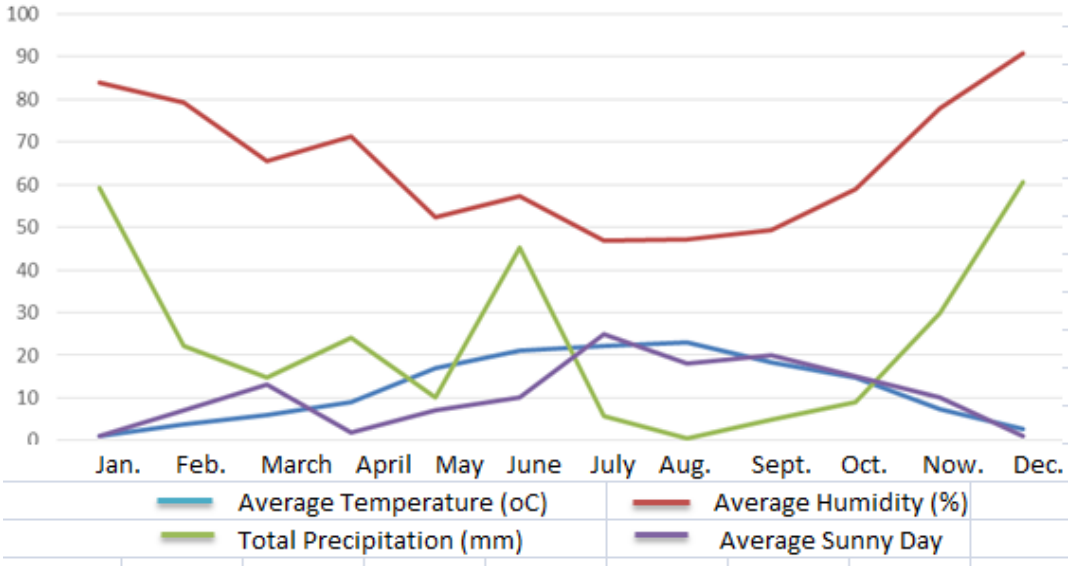

Figure 9. Some climatic data from the experimental area

Table 3. Number of stalks with head (SH), total head number (THN), average head number (AHN), total head weight with a stalk (THWS), total head weight without a stalk (THWWS) and mean head weight (MHW) for varieties and growing periods (P).

	P	SH	THN	AHN	THWS	THWWS	MHW
JD	1st	5.50 b	7850 a	7.85 a	1613 a	1463 a	205 b
	2nd	10.65 a	6011 ab	6.01 ab	1449 a	1328 a	249 a
BP	1st	4.36 b	3383 b	3.38 b	574 b	507 b	165 c
	2nd	0 c	0 c	0 c	0 c	0 c	0 d
		LSD: 1.61	*LSD: 1628.43*	*LSD: 1.63*	*LSD: 332.09*	*LSD: 300.75*	*LSD: 17.69*

In the number of SH, JD had the highest value (10.65 units plant^{-1}) in the second period, and the harvest could not be realized in BP in the 2nd period. JD showed better results than BP and there was no significant difference between the periods. Vural et al. (2000) emphasized that the SH was between 2 and 5, and this situation showed parallelism with the results obtained from our findings. It has been stated that this situation is much different for wild artichoke varieties. With the cultivation of the artichoke, the number of branches decreased and the number of branches provides great benefits for the producers in economical artichoke cultivation.

The highest SH was determined in C. syriaca28 in the wild form. It was followed by C. syriaca21 and C. syriaca14 and C. syriaca7, respectively. It was determined that Sakız and Bayrampaşa cultivars were placed before C. syriaca1, which was in the last place with an equal number of branches (5) (Aktar, 2019). When we compare the results of the number of SH (number plant^{-1}) determined by Vural et al (2000) and Aktar (2019), the 1st period is similar in JD and BP. On the other hand, the 2nd period yielded approximately twice as high results in JD.

In the THN, JD ranked first with 7850 heads da^{-1}, BP was the third rank in the 1st period with 3383 heads da-1 and there was no harvest in BP in the 2nd period. JD showed better results than the local variety BP. The artichokes planted in the 1st period showed better results compared to the 2nd period. In a study evaluating the yield and quality of varieties treated with GA_3 to achieve early production, harvesting started after 85 days in early varieties and 118 days in late varieties, and the total number of heads varied between 21.800 and 17.500 units per da^{-1} (Calabrese and Bianco, 1998).

The total number of heads reached 20.700 units per da (Calabrese et al., 2004) and it was 7549, 8221, and 9745 in three different cultivars, respectively (Santini et al., 2008). An average of 1300 kg head is produced per da in Türkiye. This is 2200 kg in Egypt, which corresponds to an average of 10.000-15.000 heads per da

(Özzambak et al., 2006; Sarı, 2012; Bölükbaşı, 2016). The highest number of heads was 21.666 per da and the lowest number of heads was 3.600 per da (Duman and Nas, 2020). BP and Starline F1 had 4000 and 6000 heads da^{-1} THN under the optimum irrigation conditions, respectively (Yılmaz, 2015). Our findings followed the results of Santini et al. (2008), Yılmaz (2015), and Duman and Nas (2020), but it was lower than the findings of Calabrese and Bianco (1998) and Calabrese et al. (2004).

While JD had the highest average number of heads per plant (7.85) in the 1st period, BP gave the lowest values (3.38) in the 1st period and the harvest could not be realized in BP in the 2nd period. JD showed better results than BP, and planting in the 1st period had better results compared to the 2nd period. Calabrese et al. (2004) investigated some morphological characteristics by applying GA_3 between vegetatively propagated cultivars and seed-propagated hybrid artichoke cultivars. To achieve early production, GA_3 treatments were performed three times at three-week intervals, starting from the 10th leaf stage. Harvests were made from October to May and 14 - 19 head $plants^{-1}$ were harvested. The average number of heads per plant was 4.0 and 6.0 in BP and Starline F1 under fully irrigated conditions (Yılmaz, 2015).

The AHN results obtained in our study were lower than the results of Calabrese et al. (2004) who obtained 14-19 head per plant. Partially similar results were obtained with Yılmaz (2015). In terms of THWS, JD ranked first with 1613 and 1449 kg da^{-1} in 1st and 2nd, respectively, and BP was ranked second with 574 kg da^{-1}, statistically. The highest head yield was obtained as 1.104 kg da^{-1} and the lowest head yield was 160 kg da^{-1} in Emerald F1 in İzmir conditions (Duman and Nas, 2020). In our study, the average stem weight (kg da^{-1}) of JD was higher than the findings of Duman and Nas (2020). JD had the highest values in THWWS data with 1463 and 1328 kg da^{-1} in the 1st and 2nd periods, respectively, while BP could reach 507 kg da^{-1}. 1st-period plants of JD showed better results in the MHW outputs (249 g).

The heads vary in size and shape as oval, long-oval, shoulder-oval, cylindrical, round, and flattened as different groupings (Abak, 1987). The heads can vary between 200 and 700 g on average. Calabrese and Bianco (1998) evaluated the yield and quality of cultivars treated with GA_3 to achieve early production by applying 5 ppm GA_3 to leaves three times, starting 60 days after planting in Southern Italy. Harvest started after 85 days in early cultivars and 118 days in late cultivars, and it was reported that the average head weight reached 150 g in all cultivars. Some morphological features were examined by applying GA_3 between vegetatively propagated varieties and seed-propagated hybrid artichoke varieties. Harvests were made during the period from October to May, and the heaviest heads ranged between 165 and 124 g, respectively (Calabrese et al., 2004).

Artichoke heads can be formed on the main or side shoots and branches. The main head weight was 120-250 g, and the weight of the secondary heads varied between 50-120 g (Özzambak et al., 2006; Sarı, 2012). In the BP, the heads are large and weigh around 150-200 gr. The average head weight (g) results obtained from our study were in agreement with previous studies.

Head Quality Characteristics

In this respect, head stem diameter (HSD; mm), head diameter (HD; cm), head height (HL; cm), and calycle diameter (CD; cm) were examined. JD gave the highest values (22.27 mm) in HSD in 2nd period, followed by BP (17.29 mm) and JD (13.58 mm) in 1st period. The best results were obtained from JD and 2nd cultivation (Table 4).

JD had the highest HD value (9.15 cm) in 2nd period, followed by JD (8.10 cm) and BP (7.40 cm) in 1st period. It was determined that JD and 2nd cultivation showed better results. In a study examining the water-yield relationship, head diameter values ranging from 12.09 – 12.69 cm and 12.22 – 12.61 cm were obtained from BP and Starline F1 cultivars, respectively (Yılmaz, 2015). When the yield and head quality characteristics of

the Emerald F1 were examined, the average head diameter was 4.62 cm (Duman and Nas, 2020). The results we obtained were following the previous study conducted by Yılmaz (2015), and even better results were obtained than the findings of Duman and Nas (2020).

Table 4. Head stem diameter (HSD; mm), head diameter (HD; cm), head height (HL; cm), and calycle diameter (CD; cm) for varieties and growing periods (P).

	P	HSD	HD	HL	CD
JD	1st	13.58 c	8.10 b	7.53 b	8.29 b
	2nd	**22.27 a**	**9.15 a**	**9.36 a**	**9.93 a**
BP	1st	17.29 b	7.40 c	7.18 b	8.18 b
	2nd	0.00 d	0.00 d	0.00 c	0.00 c
		LSD: 0.44	*LSD: 0.29*	*LSD: 0.21*	*LSD: 0.26*

JD plants had the longest heads (9.36 cm) at HL planted in the 2nd period and the lowest values were obtained from BP with 7.18 and 7.53 cm planted in the 1st period. The average HL was between 9.81 and 10.51 cm in BP and Starline F1 cultivars (Yılmaz, 2015), while it was found to be 5.29 cm in canned artichoke cultivars (Duman and Nas, 2020). Our findings were similar to the results of Yılmaz (2015) and were higher than the findings of Duman and Nas (2020).

Similarly, JD had the highest value (9.93 cm) in the CD in 2nd period and the lowest values (8.18 and 8.29 cm) were measured in BP in the 1st period. While the widest CD value of 8.51 cm in BP and Starline F1 formed a relatively smaller CD (Yılmaz, 2015). The CD values of the BP, showed similarity with the results obtained by Yılmaz (2015), while the JD produced higher values than the BP.

Economic analyses

To be able to recommend the economical cultivation of artichoke as an alternative vegetable in Konya conditions, an economic analysis was made in comparison with tomato cultivation. The expense item and their cost taken into account in the economic analysis have been prepared by the manufacturer's conditions of Turkey in 2023.

As a result of the analysis, the tomato has achieved a relatively higher gain in the total amount of gain obtained from the unit area. However, since the unit cost of artichoke cultivation is lower than tomato, it has been revealed that artichoke cultivation is a more profitable production method than tomato cultivation in terms of net income (Table 5). This result has revealed that artichoke can be grown economically in Konya and other regions with similar climates and that it can even be a more profitable production method than many products.

Table 5. Comparative economic analysis of artichoke with tomato.

Expense items	Expense amount (TL da^{-1})	
	Tomato	Artichoke
Land leasing	1600	1600
Tillage	320	320
Fertigation	2600	1800
Irrigation system	1520	1800
Seedling	11000	6000
Irrigation	6360	3880
Disease and pest management	5800	2000
Labor	5600	3400
Total expense	34800	20800
Average yield	6000 kg da^{-1}	7500 heads da^{-1}
Average price	17	12
Total income	102000	90000
Net profit	**67200**	**69200**

Conclusions

Although Konya has come to the fore with its products such as cereal group, sunflower, and carrot, vegetable agriculture has started to intensify with the spread of irrigated agriculture. In this process, the production areas of some vegetables such as watermelon and tomatoes, especially melons, have increased and the producer has been in search of the production of

alternative vegetable types that can have high profits. An alternative product has been offered to the Konya producer and its production is recommended in case of commercial activities. Thus, the possibilities of growing artichokes in regional conditions were investigated for the first time scientifically. The yield and quality characteristics were determined, and literature information was supported that will constitute a source for artichoke cultivation in Konya and other regions that have similar climates.

In light of the data we obtained from this study, in the artichoke cultivation to be carried out in Konya and regions with similar climatic conditions;

1) Early varieties with relatively shorter vegetation periods should be included.

2) Due to both tolerance to biotic and abiotic stress conditions and high productivity and fruit quality, F1 hybrid varieties should be used in cultivation.

3) Planting times should be shifted to earlier times as late April or early May.

4) To encourage earliness and regular head formation, GA_3 applications should be done regularly.

5) Humidity-increasing irrigation systems should be used in periods when the relative humidity is low.

6) Promotional activities should be carried out to reveal the consumption habits and thus the market demand.

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Conflict of interest:
The authors declare that there are no personal and financial conflicts of interest within the scope of the study.

Author contributions:
CK and ESK conceptualized the study, developed the methodology, and validated the findings. CK performed data analysis and visualized the data. ESK contributed to writing, editing, and reviewing the manuscript.

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