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Research Article

Türkiye'nin Farklı Ekolojik Koşullarında Yetiştirilen Çekirdek Kabağı Hatlarının (*Cucurbita pepo* L.) Kimyasal Bileşimi ve Besin Değerinin Karşılaştırılması&

Sıtkı ERMİŞ[1]*, Ruhsar YANMAZ[2]

[1]Tohumluk Tescil ve Sertifikasyon Merkez Müdürlüğü, Ankara
[2]Ankara Üniversitesi, Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı, Ankara

*Corresponding author: seedman37@gmail.com

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Öz

Bu çalışma, ıslah çalışmaları sonucunda seçilen yedi çekirdek kabağı (*Cucurbita pepo* L.) hattında ekolojinin kabak çekirdeği kimyasal bileşinlerdeki etkisini araştırmak amacıyla yapılmıştır. Çekirdek kabağı yetiştiriciliğinde ülkemizin en yaygın yetiştiricilik yapılan Trakya Bölgesi'nden Kırklareli, İç Anadolu Bölgesi'nden de Nevşehir ve Ankara lokasyonları tercih edilmiştir. Çekirdek kabağı hatlarında elde edilen veriler incelendiğinde; tohum nem içeriği, toplam yağ miktarı, yağ asitlerinin bileşimi, protein, E vitamini ve mineral madde miktarları (Fe, Mn, Mg, K, P) bakımından hatlar ve ekolojiler arasında önemli farklılıklar bulunmuştur. Çekirdek kabağı tohumlarında toplam yağ oranının yüksek (%35-48), doymamış yağ asitlerinden oleik (%40-58) ve linoleik asidin (%30-40) baskın yağ asitleri olduğu, %35-40 oranında protein içerdiği belirlenmiştir. Çekirdek kabağı tohumları E vitamini bakımından zengin olup hatların E viamini miktarı 2.68 -4.47 mg/100g arasında değiştiği gözlenmiştir. Kabak çekirdeğinin önemli miktarda esansiyel minerallere (K, Mg ve P) sahip olduğu tespit edilmiştir. Elde edilen bulgulara göre üç farklı ekoloji altında yetiştirilen çekirdek kabağı hatlarının kimyasal özelliklerinin nasıl etkilendiği belirlenmiştir.

Anahtar kelimeler: Çekirdek kabağı, *Cucurbita pepo* L., tohum, kimyasal içerik, ekoloji

Comparative Study of The Chemical Composition and Nutritional Value of Pumpkin Seed (*Cucurbita pepo L.*) Grown In The Different Ecological Conditions of Turkey

Abstract

The present work has been carried out to examine the effect of ecology on pumpkin seeds' chemical composition among seven pumpkin lines (*Cucurbita pepo* L.) selected as a result of breeding studies. Kırklareli has been chosen to represent Thrace Region and Nevsehir and Ankara have been chosen to represent Central Anatolian Region where pumpkin production in Turkey is intensified. The data obtained for the seven pumpkin seeds (seed moisture content, total oil content, the composition of fatty acids, protein, vitamin E and amounts of essential minerals (Fe, Mn, Mg, K, P) were found considerable variation between lines and different environment locations. It has been concluded for the pumpkin seeds that total oil ratio was high (35%-48%), that oleic acid (40%-58%) and linoleic acid (30%-40%) are dominant oil acids, that it contains 35%-40 % of protein. Pumpkin seeds are a good source of vitamin E. The results of vitamin E contents were found between 2.68 -4.47 mg/100g. The pumpkin seeds were found to have considerable amounts of essential minerals (K, Mg, and P). According to the findings, it was determined how the chemical properties of pumpkin lines grown under three different ecologies were affected.

Key words: Pumpkins, *Cucurbita pepo* L., seed, chemical composition, ecology

Introduction

Cucurbita L. species of pumpkin and winter squash are grown each over the world. *Cucurbitaceae* is one of the most important family with significantly rich genetic resources in Turkey. The most common cultivated species of the Cucurbitaceae family in Turkey are *Citrullus lanatus* Thunb., *Cucumis flexuosus* L., *Cucumis sativus* L., *Cucurbita maxima* Duch., *Cucurbita moschata* Duch., and *Cucurbita pepo* L. (Balkaya and Karaağaç, 2005). Winter squash and pumpkins are traditional vegetables frequently grown in small gardens. Turkish farmers have grown pumpkin landraces due to their capability to adapt to local environmental conditions and suitability to the preference of local consumers. The current product of pumpkin seed (*Cucurbita pepo* L.) is based on local cultivars. Native varieties of pumpkin are occasionally grown as unimproved populations in different regions of Turkey. Consequently, pumpkin populations show an appreciable diversity in response to the range of ecological and human influences (Balkaya and Özbakır, 2008). This situation causes economic losses both in production and in the nuts sector (Duzeltir and Yanmaz, 2004). Little work has been performed on breeding of pumpkins in Turkey (Abak et al. 1994; Duzeltir and Yanmaz, 2004; Yegul 2007; Balkaya and Özbakır, 2008; Türkmen et al. 2016; Erdinç et al., 2018; Seymen 2020).

Squash seeds are used as snacks in some Mediterranean countries and in Turkey as well as Germany, Hungary, Austria and China (Sarı et al. 2008). The total production of pumpkin and squashes in Turkey in 2021 was 771.651 t. Pumpkin seed production has an 8.41 % share with 64.861 t annually. In Turkey, the major producing regions are located in the Central Anatolia Region, Kayseri province has a big share (26.08%) of pumpkin seed production with 16.920 t and followed, Nevşehir (20.064 tons), Konya (6.617 tons), Aksaray (5.211 tons) and Eskişehir (3.081 tons) (Anonymous. 2021).

Pumpkin, which has an important place in human nutrition, is also a delicious vegetable. Pumpkin seed oil is currently used in sweets and salad dressings, and it is also a popular cosmetic ingredient (Prommaban et al., 2021). Each part of the pumpkin vegetable has been associated with one or more applications in food and health (Sharma et al., 2020). Pumpkin seeds are consumed all over the world and their popularity is gradually increasing. The pumpkin seed oil has been produced in Austria, Slovenia and Hungary (Murkovic et al., 1996). Currently, pumpkin oil has been commercialized in the United States, Austria, Slovenia, Croatia, and Hungary (Fruhwirth and Hermetter, 2007; Xiang et al., 2017). Although these oils are not used industrially, they are used as cooking oil in many African countries and some Middle Eastern countries (Alfawaz, 2004) and are also used as salad oil in European countries (Sabudak 2007). Although pumpkin seeds are consumed extensively as nuts in our country, pumpkin seed oil is also used for medical purposes only. Pumpkin seeds are reported to be an excellent sources of both oil (37.8-45.4%) and protein (25.2-37.0%) (Lazos 1986). Seed oil was composed mainly of unsaturated fatty acids and palmitic acid (C16:0, 9-5-14.5%), stearic acid (C18:0, 3.1-7.4%), oleic acid (C18:1, 21.0-46.9%) and linoleic acid (C18:2, 35.6-60.8%) are the dominant fatty acids. These four fatty acids make up 98% of the total acid (Murkovic et al., 1999). Pumpkin seed oil also contains high amounts of tocopherols (Potočnik 2018). The literature points to the potential of pumpkin seed oil to prevent prostate disease and inhibit the progression of hypertension, arthritis, and kidney stones (Medjakovic et al., 2016; Potočnik et al., 2016; Procida et al., 2012; Andjelkovic et al., 2010). The mechanisms of these inhibitory effects are due to the antioxidant properties of the oil, mainly due to the high levels of vitamin E, in the form of α- and γ-tocopherol (Naziri et al., 2016; Procida et al., 2012; Murkovič et al., 2004).

Seed size, shape, and colour vary greatly among cultivated cucurbits (Nerson 2007). Crop cultivars, including watermelon and squash, can differ significantly in size and other seed characteristics. Decker and Wilson (1986) measured the seeds of 30 C. pepo accessions of mostly wild and cultivated pumpkins and gourds. They said that the pumpkin seed lines had the largest seeds and the gourds the smallest. Analogous studies were also carried out by Balkaya et al. (2005), Balkaya et al. (2010), Turkmen et al. (2016) in Turkey. Cucurbita moschata populations of Turkey showed high variability for seed dimensions, seed colour, seed bright and seed weight (Balkaya et al. 2010). However, the nutritive value of different environmental conditions on pumpkin seed genotypes has been inadequately studied. Thus, squash and pumpkin's yield are affected by genotypic and environmental factors. The size of the mature fruit is especially influenced by genetics, environment, and plant conditions during the development of pistillate flowers and fruit (Maynard, 2007). Environmental may impact the nutrient ingredients of seeds. The rate of oleic and linoleic acids in seed oils is too large to extend depending upon environmental conditions,

particularly humidity and temperature, during seed maturation (Can-Cauich et al. 2021).

To date, little work has been performed on the chemical and some nutritional values of the seeds in Turkish pumpkin genotypes. The study aimed to determine the chemical and some nutritional values of the seeds developed from these seven lines of pumpkins that grown in the different ecological conditions of Turkey and to make recommendations for their potential commercial production.

Material and Method

Pumpkin Cultivation

In order to develop new varieties of pumpkin for seed production, selection studies are conducted in the University of Ankara since 1993. In these studies, 20 different seed sources were collected and evaluated from different parts of Turkey (Düzeltir, 2004). Within this research, different pumpkin breeding lines were developed. In this experiment, five snack lines (R-3, R-5, B-7, B-10, R-14) and two naked lines (RN-3, BN5) were used. Field experiments were carried out at different locations in Turkey between two years. Samples were produced from pumpkin seeds from the 2008 and 2009 crop seasons grown in the Ankara (39º57' N, 32º51' E), Kırklareli (41º43' N, 27º60'" E), and Nevşehir (38º23' N, 34º47' E) province, respectively. Seeds were grown under agronomic management for these regions and cultures. All genotypes were sown in a randomised complete block design with four replicates of 20 plants per replicate. Meteorological data of average temperatures, rainfall and solar radiation recorded during pumpkin cultivation months (Table 1). The soil of the experimental field was clay loam with a pH of 7.6 in the Ankara, Kırklareli and Nevşehir locations were clay (pH: 7.3) and sandy loam (pH: 6.05), respectively. Fertilisation and weed control using standard cultural practices were applied regularly. After harvest, pumpkin seeds were washed and dried at room temperature the moisture content to below %7. After all these processes, seeds were packed separately in low-density polyethylene bags and stored at 4 °C for further analysis.

Table 1. Meteorological data recorded during cultivation months.

	Temperature (°C)						Rainfall (mm)					
	Ankara		Kırklareli		Nevşehir		Ankara		Kırklareli		Nevşehir	
Months	1	2	1	2	1	2	1	2	1	2	1	2
April	9.1	13.8	11.6	13.2	6.5	13.6	0.79	1.09	0.21	1.71	2.45	0.73
May	20.5	15.5	18.7	17.0	18.1	14.1	0.58	1.46	2.93	1.79	2.88	1.49
June	22.6	22.0	23.7	22.3	20.7	19.7	1.06	0.34	1.38	0.65	1.54	0.51
July	26.8	24.9	25.9	24.0	23.9	23.1	0.13	0	0.02	0.35	0.01	0
August	26.4	26.7	25.3	25.2	23.7	23.4	0.32	0.02	0.35	0.01	0.46	0.04
September	20.9	19.9	18.8	18.5	18.0	18.6	0	2.05	1.67	2.76	0.10	1.04

Chemical analysis of pumpkin seeds

Moisture, crude oil, fatty acid, protein and mineral contents of pumpkin seed samples were determined according to the reference procedures. All analysis was performed in triplicate to minimize errors in these results.

Determination of moisture content total oil and fatty acid composition

The moisture content was determined by the high-temperature oven method (130ºC, 1h). (ISTA, 2007). Crude oil was extracted from dried powdered seeds. The seeds (approximately 1.5 g) were ground and added to 80 mL of hexane. The mixture was then placed in FOSS Soxtec 2055 apparatus for oil extraction (Anonymous 2005). To determine the fatty acid fraction of each oil sample, fatty acids were esterified to methyl esters (AOAC, 1990) and the resulting solutions were analyzed by Agilent 7890A gas chromotography (split mode 1/80) equipped with a flame ionization detector (FID). The components were separated in an HP-88 capillary column (60m with an internal diameter of 250 mm, film thickness of 0.25). The injector temperature was 250 ºC and the temperature of the detector was 230ºC. The determination involved temperature programming; 120ºC for 1 min; the temperature was increased 10ºC per min up to 175ºC; 5ºC per min up to 210ºC and 210ºC for 5 min. Carrier gas helium was used at a constant pressure of 1 bar (Ermis and Yanmaz, 2012).

Determination of Total Nitrogen

The Kjeldahl method was used for protein content analysis. Protein compositions were obtained multiplying these values by the coefficient 6.25 (Anonymous, 2007).

Determination of Vitamin E

The vitamin E content was determined by direct injection of the oil samples into an HPLC. In brief, oil samples weighing 1 g were dissolved in a 9 ml acetone and vortex mixed for 30 seconds. 1.5 µl of this solution were injected onto the column. The used HPLC equipment was an Agilent Eclipase 1200 liquid chromatograph with a fluorescence detector (Agilent Technologies), equipped with an Agilent Eclipase XDB-C18 column (5 µl, 150x4.6mm). The column was eluted with a mobile phase of 480 ml HPLC Methanol+480 ml HPLC Acetonitrile+40 ml HPLC water+ 0.2 ml phosphoric acid. The flow rate of 1.5 ml/min and effluent were imaged at an excitation wavelength of 250 nm and emission wavelength of 410 nm for determination of tocopherol. Relative tocopherol amounts were calculated using an external standard method using reference tocopherol samples and used to calculate peak areas (Anonoymous, 1988).

Determination of mineral contents

Mineral elements were analyzed according to AOAC (2005) methods. About 0.5 g of grounded pumpkin seed was into a crucible with 10 ml of pure NHO3. And then the samples were incinerated in a micro-wave oven at 200 ℃. After the combustion process was completed, it was completed to 50 ml with 1% HNO3. The minerals iron, potassium, zinc and magnesium were determined by Atomic absorption spectrophotometry (Varian 240, Australia). Phosphorus was measured by converting phosphates into phosphorus molybdate blue pigment and assayed 700 nm.

Statistical analysis

Statistical analysis was performed using the statistical package SPSS (13.0 for Windows). Locations and lines were taken into consideration as variables. Significant differences were evaluated at $P<0.005$ error level. Data were presented as mean values of all genotypes ± standard error (SE) of mean.

Results and Discussion

Moisture content is an important parameter for the safe of grains and the seed moisture contents were determined similar levels in each year and found 5.38-7.24 % at Ankara, 5.61-7.03 % at Kırklareli and 5.55-6.93 % at Nevşehir location respectively. The moisture contents of the seeds were generally low indicating that the seeds could be stored for a long period. Similar results were reported by Lazos, (1986); Asiegbu, (1987); Warid et al., (1993); Al-Khalifa, (1996); Olaofe, (1994); Sing and Kumar, (2021).

The results of crude oil contents are shown in Table 2. Crude oil contents changed depending on location and lines for two years. It was ranged from 45.27-34.71% in the first, and 33.65-45.91% in the second year respectively. Line code with 3K (Ankara location), 7-3K (Kırklareli location), and 3K-5K (Nevşehir location) showed the highest crude oil contents. The results also showed similarities with the previous year with a reduction of 2-4% were observed in all the locations. Statistical analysis of the results showed that seed oil samples were influenced by climate conditions between two years. These results were confirmed by the findings of Loy, (1990); Idouraine et al., (1996) and Abak et al., (1999).

Table 2. Oil content of pumpkin lines grown in different localities.

Line	Ankara		Kırklareli		Nevşehir	
	1. year	2. year	1. year	2. year	1. year	2. year
3	37.41 e B	35.46 d A	38.99 d A	38.99 d A	36.73 c B	35.64 f A
5	39.37 d A	37.85 c A	36.06 e C	36.06 e C	36.43 c B	37.55 d A
7	39.60 d B	35.63 d B	42.16 a A	42.16 a A	35.40 d C	39.07 c A
10	41.11 c A	35.41 d B	39.60 cd B	39.60 cd B	34.71 d C	36.81 e A
14	42.59 b A	34.53 e B	40.50 cb B	40.50 cb B	39.13 b B	33.65 g B
3K	45.74 a A	41.45 a B	41.60 ab B	41.60 ab B	45.13 a A	44.19 a A
5K	42.10 bc B	39.48 b C	42.03 b B	42.03 b B	45.27 a A	43.00 b B

*Values in the same row sharing the same letters are not significantly different at the 5% level.

The fatty acid composition of seven lines of pumpkin seed was shown in Table 3. According to results, the main fatty acids in pumpkin seed oils are palmitic (C 16:0), stearic (C18:0), oleic (C18:1) and linoleic (C18:2) acids. This finding was similar to other studies of Murkovic et al., (1999) and Younis et al., (2000); Türkmen et al (2017). The fatty acid composition of the oil can be an indicator of its oxidative stability and nutritional quality. In general, the higher the degree of unsaturation of oil, the more susceptible it was to oxidative deterioration. Total unsaturated ranging from fatty acids content ranging from 80 to 85 %. Saturated fatty acids (palmitic and stearic acids) were

determined at 10-15% levels. Although linoleic acid content almost equalled oleic acid in some lines of C. pepo, oleic acid was the principal fatty acid followed by linoleic, palmitic and stearic acids. Furthermore, for all oil samples of seeds grown in three different locations, whenever the composition of oleic acid was highest, the linoleic acid was low vice versa. Compared to the findings of various authors (Glew et al., 2006 and Fagbemi, 2007) the values for individual fatty acids determined in this work fall well within the previously reported range. Oleic acid content was found 45.65-56.26 % at Ankara, 38.97-47.45 % at Kırklareli, 39.81-48.90 % at Nevşehir locations for both years. The composition of linoleic acid was found to be in the range of 26.02-43.35%. This result was similar to Murkovic et al., 1999 and Younis et al. 2000. This indicates that the C. pepo L. seed oil is a rich source of linoleic acid. The presence of high amounts of linoleic acid showed highly nutritious. There was an inverse relationship between oleic and linoleic acid contents. The composition of fatty acids could be attributed to climatic factors, more probably to the differences in temperature, relative humidity, soil texture and other climatic factors prevailing in the locations in which the pumpkin seeds were grown. However, Gencel et al., (2007) reported that genetic factors influenced fatty acid composition. This literature supports a strong correlation between oleic and linoleic content and temperature. While the linoleic content increases at low temperature values, the oleic content increases at high temperatures. (Younis et al., 2000; Çamaş et al., 2007). Another research by, Nederal et al. (2014), investigated pumpkin fruits with a longer maturation period and harvested in the late-season shows higher contents of linoleic acid. In the light of these findings, it can be concluded that an increase in temperature causes higher oleic acid synthesis and promotes a decrease in linoleic acid synthesis. Especially in naked line seeds (3K and 5 K) obtained high oleic acid content but low levels for linoleic acid.

Table 3. Fatty acid composition of oil for pumpkin lines grown in different localities(%).

	No	Ankara location		Kırklareli location		Nevşehir location	
		1. year	2. year	1. year	2. year	1. year	2. year
Palmitic ($C_{16:0}$)	3	13.90 ^{bA}	12.62 ^{aA}	13.14 ^{cB}	12.45 ^{bB}	12.69 ^{aC}	12.11 ^{bC}
	5	12.11 ^{eA}	11.40 ^{cB}	11.36 ^{gB}	11.95 ^{dA}	12.16 ^{dA}	11.51 ^{dB}
	7	14.62 ^{aA}	11.32 ^{cA}	12.90 ^{eB}	13.07 ^{aC}	12.22 ^{cdC}	12.59 ^{aB}
	10	12.47 ^{dB}	11.42 ^{cB}	13.75 ^{aA}	12.33 ^{cA}	12.28 ^{cdB}	11.31 ^{eC}
	14	13.88 ^{bA}	12.29 ^{bA}	13.20 ^{bB}	11.93 ^{dB}	12.44 ^{bcC}	11.77 ^{cC}
	3K	12.81 ^{cA}	10.54 ^{eC}	12.18 ^{fC}	11.48 ^{eA}	12.37 ^{cdB}	10.67 ^{eB}
	5K	11.78 ^{fC}	10.70 ^{dB}	12.99 ^{dA}	11.02 ^{fA}	12.62 ^{abB}	9.97 ^{fC}
Stearic ($C_{18:0}$)	3	5.24 ^{eB}	5.67 ^{dB}	5.27 ^{deB}	5.48 ^{bC}	6.89 ^{bA}	5.94 ^{bA}
	5	6.21 ^{aC}	5.11 ^{fB}	7.24 ^{aA}	5.69 ^{aA}	6.37 ^{cB}	5.82 ^{cA}
	7	5.47 ^{dC}	5.93 ^{cA}	6.36 ^{bB}	4.93 ^{eC}	7.25 ^{aA}	5.38 ^{dB}
	10	6.08 ^{bB}	5.52 ^{eA}	4.99 ^{fC}	5.24 ^{cC}	7.20 ^{aA}	6.14 ^{aB}
	14	5.15 ^{fC}	5.70 ^{dB}	5.24 ^{eB}	5.19 ^{dC}	6.72 ^{bA}	5.76 ^{cdA}
	3K	5.58 ^{cB}	7.19 ^{aA}	5.70 ^{cA}	5.47 ^{bB}	4.03 ^{eC}	5.04 ^{eC}
	5K	5.57 ^{cA}	6.50 ^{bA}	5.34 ^{dB}	4.74 ^{fC}	5.02 ^{dC}	5.69 ^{dB}
Oleic ($C_{18:1}$)	3	43.62 ^{eA}	44.29 ^{gA}	42.67 ^{cB}	41.43 ^{fB}	42.97 ^{cB}	41.92 ^{dC}
	5	47.67 ^{cA}	51.37 ^{eA}	40.94 ^{dC}	41.77 ^{eB}	41.80 ^{dB}	42.38 ^{cC}
	7	41.65 ^{fB}	51.82 ^{dA}	41.30 ^{dC}	40.38 ^{dB}	45.77 ^{aA}	43.99 ^{eC}
	10	47.01 ^{dA}	52.72 ^{cA}	38.97 ^{fC}	39.43 ^{bB}	44.56 ^{bB}	46.50 ^{gC}
	14	40.82 ^{gB}	48.52 ^{fA}	40.05 ^{eC}	39.54 ^{cB}	45.90 ^{aA}	44.73 ^{fC}
	3K	49.26 ^{bA}	56.26 ^{aA}	46.87 ^{aB}	44.60 ^{aB}	42.94 ^{cC}	48.90 ^{bC}
	5K	51.50 ^{aA}	54.34 ^{bA}	45.85 ^{bB}	47.45 ^{aB}	39.81 ^{eC}	48.82 ^{aC}
Linoleic ($C_{18::2}$)	3	36.39 ^{cC}	37.42 ^{aC}	38.11 ^{eA}	40.63 ^{dA}	37.49 ^{dB}	40.05 ^{bB}
	5	33.13 ^{eB}	32.12 ^{cC}	39.58 ^{cA}	40.59 ^{dA}	39.66 ^{bA}	40.31 ^{aB}
	7	37.43 ^{bB}	30.94 ^{dC}	38.97 ^{dA}	41.63 ^{cA}	34.79 ^{gC}	38.04 ^{cB}
	10	33.54 ^{dC}	30.35 ^{eC}	41.40 ^{aA}	43.02 ^{bA}	36.06 ^{eB}	36.07 ^{eB}
	14	39.57 ^{aB}	33.48 ^{bC}	40.69 ^{bA}	43.35 ^{aA}	34.96 ^{fC}	37.74 ^{dB}
	3K	31.12 ^{fC}	26.02 ^{gC}	34.81 ^{fB}	38.45 ^{eA}	39.32 ^{cA}	35.40 ^{fB}
	5K	30.83 ^{gC}	28.46 ^{fC}	34.69 ^{fB}	36.79 ^{fA}	41.27 ^{aA}	35.53 ^{gB}

*Values in the same row sharing the same letters are not significantly different at the 5% level.

Palmitic and stearic acids were present in all pumpkin seed oil samples, ranging from 9.97 to 14.62 and 4.03 to 7.25% respectively. Results shown in Table 3 revealed that the palmitic acid content was almost higher at the Ankara location. Furthermore, the naked pumpkin lines (3K and 5 K) were produced high palmitic acid of the three localities. Similar results on the content of palmitic and stearic acids were found by Tanska et al. (2020) in their recent study on naked pumpkins in

Poland. These significant differences in the unsaturated fatty acid could be attributed to the species and their growing conditions.

Protein content was found to range from 30.76 to 37.90 % being measured in two years for all locations (Table 4). The pumpkin seeds contained a high percentage of crude protein. Abak et al. (1999), was reported that protein contents were not affected between sowing dates or genotypes, but we were found significant differences among lines and tested locations about protein contents in this study. Idouraine et al. (1996), recorded protein contents were affected by genetic variation. In addition, environmental factors, such as locations, physiological maturity time of the seeds, harvesting period, soil texture, fertilization and relative humidity can affect the protein content of pumpkin seeds (Younis, 2000; Artık, 2004).

Table 4. Protein contents (%) of seed oil from 7 pumpkin lines in different localities.

No	Ankara location		Kırklareli location		Nevşehir location	
	1. year	2. year	1. year	2. year	1. year	2. year
3	33.73 $^{d\,B}$	33.55 $^{c\,A}$	36.60 $^{ab\,A}$	32.69 $^{e\,A}$	36.86 $^{bc\,A}$	31.23 $^{b\,A}$
5	35.53 $^{b\,C}$	33.56 $^{c\,AB}$	36.30 $^{b\,B}$	34.04 $^{cd\,A}$	37.90 $^{a\,A}$	32.97 $^{ab\,B}$
7	36.38 $^{a\,A}$	34.79 $^{b\,A}$	34.65 $^{cd\,B}$	36.70 $^{a\,A}$	36.17 $^{c\,A}$	30.76 $^{b\,B}$
10	34.77 $^{c\,B}$	35.00 $^{b\,A}$	37.17 $^{a\,A}$	33.77 $^{d\,AB}$	37.85 $^{ab\,A}$	33.39 $^{ab\,B}$
14	33.80 $^{d\,B}$	31.02 $^{d\,AB}$	35.27 $^{c\,B}$	33.53 $^{d\,A}$	37.77 $^{ab\,A}$	30.77 $^{b\,B}$
3K	36.60 $^{a\,A}$	36.48 $^{a\,A}$	34.32 $^{d\,C}$	35.51 $^{b\,B}$	35.13 $^{d\,B}$	32.84 $^{ab\,C}$
5K	34.90 $^{c\,B}$	35.73 $^{ab\,A}$	34.13 $^{d\,C}$	34.69 $^{c\,B}$	37.83 $^{ab\,A}$	34.69 $^{a\,B}$

*Values in the same row sharing the same letters are not significantly different at the 5% level.

The vitamin E content of the 7 pumpkin line seeds oil were shown in Table 5. In the first experiment year, vitamin E contents were changed between 3.72-4.47 mg/100g, 2.75-4.67 mg/100g 2.68-4.19 mg/100 g at Ankara, Kırklareli and Nevşehir locations, respectively. The vitamin E content of line 3K was higher tocopherol level than the other lines. Among the locations, all lines produced the highest vitamin E values in Ankara ecological conditions. Similarly, 3K line was the highest content of vitamin E at Ankara (3.87 mg/100g), Kırklareli (3.45 mg/100g) and Nevşehir (3.50 mg/100g) locations in the second year. Kırnak et al (2019) noted that vitamin E contents in pumpkin seed oil largely depend on the seeds' fatty acid contents and compositions. Nakic et al., (2006) found that total tocopherol contents in vegetable oils for pumpkin seeds depend on different factors (cultivar, climate extraction conditions, method of determination). The content of tocopherols in oils is also affected by the processing conditions.

Table 5. Vitamin E contents (mg/100 g) of seed oil from 7 pumpkin lines in different localities.

No	Ankara location		Kırklareli location		Nevşehir location	
	2007	2008	2007	2008	2007	2008
3	3.72 $^{b\,A}$	2.85 $^{d\,B}$	3.32 $^{cd\,B}$	2.82 $^{b\,B}$	3.57 $^{ab\,AB}$	3.07 $^{bcd\,A}$
5	3.75 $^{b\,A}$	3.74 $^{ab\,B}$	3.93 $^{b\,A}$	2.79 $^{b\,B}$	3.71 $^{ab\,A}$	3.08 $^{bcd\,A}$
7	4.02 $^{ab\,A}$	3.41 $^{c\,A}$	3.58 $^{bc\,B}$	2.75 $^{b\,B}$	3.46 $^{b\,B}$	3.31 $^{abc\,A}$
10	4.14 $^{ab\,A}$	3.75 $^{ab\,A}$	3.01 $^{de\,B}$	2.52 $^{c\,C}$	3.26 $^{bc\,AB}$	3.48 $^{ab\,B}$
14	4.17 $^{ab\,A}$	3.03 $^{d\,A}$	2.75 $^{e\,B}$	2.87 $^{b\,B}$	2.68 $^{c\,B}$	2.84 $^{d\,B}$
3K	4.47 $^{a\,A}$	3.87 $^{a\,A}$	4.67 $^{a\,A}$	3.45 $^{a\,A}$	4.19 $^{a\,A}$	3.50 $^{a\,A}$
5K	3.79 $^{b\,A}$	3.48 $^{bc\,A}$	3.14 $^{de\,A}$	2.81 $^{b\,B}$	3.68 $^{ab\,A}$	3.03 $^{cd\,B}$

*Values in the same row sharing the same letters are not significantly different at the 5% level.

The mineral composition of all the lines of pumpkin seeds is presented in Table 6. Pumpkin lines appeared to be an important source of phosphorus, potassium, magnesium, ıron and zinc. In the seeds, phosphorus was the majorly found and determined 846.77 to 1751.33 mg/100 g in both years. Phosphorus is an essential element in carbohydrate biosynthesis and energy transfer reactions. It has been reported by many researchers that pumpkin seeds are rich in P content (El-Adawy, 2001; Erdinç, et. al. 2018) and our findings are consistent with these reports. Potassium is very important for the body as it is the essential macro element for managing hypertension (Sing and Kumar, 2021). Similarly, potassium gave significant results in both years but contents varied by location. Potassium content ranged from 488.33 to 1437.33 mg/100 g for all the lines. Rezig et al., (2019) reported a nearly aligned value of potassium in pumpkin seeds.

Magnesium is also essential for humans due to blood pressure, insulin metabolism, cardiac excitability, vasomotor tone, nerve transmission and neuromuscular conduction (Gröber. 2015). Magnesium varied from 410.70 to 719.00 mg/100 g in pumpkin seeds between locations. Our results are in agreement with previous studies (Mansour et. al. 1993). Other minerals such as zinc and ıron ranged between 4.02 to 12.87 mg/100 g and 5.22 to 13.07 mg/100 g respectively. Similar results were obtained by Seymen et. al. (2020).

Table 6. Mineral contents (mg/100g) of seed from 7 pumpkin lines in different localities.

	No	Ankara location		Kırklareli location		Nevşehir location	
		2007	2008	2007	2008	2007	2008
P	3	1133.00 $^{d A}$	1006.10 $^{a B}$	1149.00 $^{bc A}$	959.40 $^{bc B}$	1121.33 $^{c A}$	1037.33 $^{b A}$
	5	1216.67 $^{c AB}$	846.77 $^{c B}$	1180.33 $^{b B}$	1077.33 $^{a A}$	1249.00 $^{b A}$	1056.33 $^{b A}$
	7	1127.67 $^{d A}$	871.63 $^{c C}$	1151.33 $^{bc A}$	987.20 $^{b B}$	1035.00 $^{d B}$	1074.67 $^{b A}$
	10	1156.67 $^{d A}$	913.20 $^{c C}$	1163.00 $^{bc A}$	966.00 $^{bc A}$	893.00 $^{f B}$	949.87 $^{c AB}$
	14	1174.00 $^{cd A}$	1028.00 $^{a B}$	1098.67 $^{d B}$	927.97 $^{c C}$	963.13 $^{e C}$	1218.67 $^{a A}$
	3K	1663.00 $^{b A}$	927.40 $^{b B}$	1521.00 $^{a B}$	961.03 $^{bc B}$	1311.33 $^{a C}$	1090.00 $^{b A}$
	5K	1751.33 $^{a A}$	907.97 $^{b C}$	1135.33 $^{c B}$	934.53 $^{c B}$	1029.27 $^{d C}$	1216.33 $^{a A}$
K	3	527.00 $^{cd B}$	886.90 $^{c A}$	515.33 $^{d C}$	750.83 $^{d B}$	666.00 $^{a A}$	962.63 $^{cd A}$
	5	581.00 $^{bc A}$	607.40 $^{d B}$	566.00 $^{cd A}$	853.73 $^{cd A}$	382.67 $^{c B}$	890.17 $^{d A}$
	7	595.33 $^{bc A}$	777.20 $^{c A}$	560.00 $^{cd A}$	830.00 $^{cd A}$	546.67 $^{b A}$	880.97 $^{d A}$
	10	488.33 $^{d B}$	784.03 $^{c A}$	559.33 $^{cd A}$	846.40 $^{cd A}$	494.67 $^{b B}$	845.57 $^{d A}$
	14	560.33 $^{cd A}$	852.60 $^{c B}$	589.67 $^{c A}$	1055.47 $^{bc B}$	484.67 $^{b B}$	1076.67 $^{c A}$
	3K	995.67 $^{a A}$	1180.67 $^{c A}$	759.33 $^{b B}$	1089.00 $^{ab A}$	500.00 $^{b C}$	1243.67 $^{b A}$
	5K	636.33 $^{b B}$	1340.00 $^{a A}$	917.67 $^{a A}$	1177.33 $^{a A}$	609.33 $^{a B}$	1437.33 $^{a A}$
Mg	3	544.67 $^{cd A}$	578.10 $^{a AB}$	523.33 $^{b AB}$	520.33 $^{a B}$	512.00 $^{c B}$	616.83 $^{bc A}$
	5	570.00 $^{c A}$	410.70 $^{d C}$	528.00 $^{ab B}$	558.67 $^{a B}$	535.00 $^{b B}$	643.20 $^{b A}$
	7	536.67 $^{de A}$	499.33 $^{bc B}$	518.00 $^{b B}$	570.97 $^{a A}$	477.67 $^{d C}$	605.37 $^{bc A}$
	10	556.67 $^{cd A}$	520.13 $^{b B}$	528.33 $^{ab B}$	517.23 $^{a B}$	417.33 $^{g C}$	574.97 $^{c A}$
	14	510.33 $^{e B}$	633.13 $^{a B}$	546.67 $^{a A}$	521.70 $^{a C}$	463.67 $^{e C}$	771.83 $^{a A}$
	3K	613.67 $^{b A}$	452.87 $^{cd B}$	525.67 $^{ab C}$	534.17 $^{a A}$	569.33 $^{a B}$	604.83 $^{bc A}$
	5K	719.00 $^{a A}$	469.30 $^{bcd B}$	456.00 $^{c B}$	454.30 $^{b B}$	447.33 $^{f B}$	626.00 $^{bc A}$
Zn	3	7.53 $^{b C}$	5.18 $^{b A}$	8.63 $^{b B}$	4.23 $^{ab B}$	12.87 $^{a A}$	5.89 $^{a A}$
	5	9.27 $^{a A}$	4.34 $^{bc B}$	8.70 $^{b B}$	4.73 $^{ab B}$	7.93 $^{d C}$	5.84 $^{a A}$
	7	7.03 $^{d C}$	3.93 $^{c B}$	8.96 $^{a A}$	4.40 $^{ab B}$	8.02 $^{d B}$	4.96 $^{b A}$
	10	4.80 $^{f C}$	4.60 $^{bc A}$	6.23 $^{f B}$	4.02 $^{b A}$	9.30 $^{b A}$	3.89 $^{c A}$
	14	7.30 $^{c C}$	6.11 $^{a A}$	7.53 $^{c B}$	5.03 $^{a B}$	8.73 $^{c A}$	5.62 $^{ab AB}$
	3K	6.27 $^{e C}$	4.68 $^{bc A}$	6.53 $^{e B}$	4.54 $^{ab A}$	7.73 $^{d A}$	4.22 $^{c AB}$
	5K	7.27 $^{c A}$	4.76 $^{bc A}$	6.90 $^{d B}$	4.93 $^{a A}$	7.20 $^{e A}$	5.51 $^{ab A}$
Fe	3	9.30 $^{c C}$	8.58 $^{a A}$	11.02 $^{a B}$	8.83 $^{a A}$	13.07 $^{a A}$	6.60 $^{bc B}$
	5	11.40 $^{a A}$	6.40 $^{b B}$	10.70 $^{b B}$	7.08 $^{c A}$	9.49 $^{b C}$	6.52 $^{bc AB}$
	7	10.20 $^{b A}$	6.50 $^{b B}$	8.77 $^{c C}$	7.50 $^{bc A}$	9.67 $^{b B}$	7.12 $^{ab AB}$
	10	6.01 $^{g C}$	5.72 $^{bc B}$	6.93 $^{e B}$	6.77 $^{c A}$	9.70 $^{b A}$	5.22 $^{d B}$
	14	8.33 $^{d A}$	5.34 $^{c C}$	8.33 $^{d A}$	8.03 $^{b A}$	7.91 $^{d B}$	6.57 $^{bc B}$
	3K	7.90 $^{e B}$	6.14 $^{bc A}$	6.37 $^{f C}$	6.93 $^{c A}$	9.23 $^{c A}$	6.15 $^{c A}$
	5K	6.83 $^{f C}$	8.52 $^{a A}$	8.63 $^{c A}$	6.85 $^{c C}$	7.27 e B	7.73 $^{a B}$

*Values in the same row sharing the same letters are not significantly different at the 5% level.

Zinc acts as a co-factor for important enzymes involved in the proper functioning of the antioxidant defence system (Marreiro, 2017) Iron is also an important component for humans and 100 g of pumpkin seeds meet about 35-40% recommended Dietary Allowance (RDA) of this mineral (Sing and Kumar, 2021).

Overall, the 3K and 5 K naked pumpkin seeds showed the maximum amount of phosphorus and potassium for both years as well as locations. It was found that the concentration of minerals depends on the line and the culture of the location. Varietal differences may be the major factor. Therewithal, environmental factors such as

fertilization, soil composition and climatic factors may be responsible for a small amount of the differences. (Idouraine et al., 1996).

Conclusions

This study revealed that pumpkin seeds of different lines are rich sources of nutrients and a good source of protein, fat, and vitamin E, suggesting their greater use in the nutraceutical and food industries. In this study, the performance of 7 pumpkin lines was investigated according to seed genotype and growing conditions. Pumpkin lines showed, on average, 34.53% to 45.74% oils and 30.70 to 37.90 proteins; thus, the climate changes the oil and protein contents. Unsaturated acids (oleic and linoleic) predominate in seed oil and their proportions depend on pumpkin genotypes and location. The high degree of unsaturation makes it suitable for use as a valuable drying agent, and the lower free fatty acid content indicates the oil's suitability for possibly edible purposes. Although less saturated fatty acids (Palmitic and stearic) show high variation under the influence of climatic conditions. The pumpkin seeds of this experiment have high vitamin E content, which makes them desirable for human health. Vitamin E content has been replaced by lines and locations. The nutritional analysis of the seeds revealed that pumpkin lines were rich in phosphorus, potassium, magnesium, ıron and zinc.

Further study is also needed to understand, how the chemical content of pumpkin seeds is affected, which variety is used, when the harvest time is according to the region, the estimation of the ripening time of the seeds, the suitability of the storage period and conditions are important.

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