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Diversity of Nut and Kernel Weight, Oil Content, and the Main Fatty Acids of some Almond Cultivars and Genotypes

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ABSTRACT

To investigate the effects of cultivars on dry nut weight, kernel weight, oil content, and the main fatty acids of some cultivars and genotypes of almond, this study was conducted in 2019 in randomized complete blocks design with three replications. The findings revealed that the influence of genotype on all measured traits is significant. The results of oil content showed that D124 had the highest values in terms of oil content. Also, examination of kernel weight shows that there are significant differences between cultivars. So that the highest amount of kernel weight is related to genotype D at 2.19 grams, while the lowest amount of kernel weight is related to A5-17genotype at 0.52 grams. The investigation of nut weight analysis showed that genotype D had the highest value (6.40grams). All the traits considered in this research can be said that the D124 genotype and cultivars of Sahand, Shahroud 6, Saba, and Ruby respectively had oil content of 62.24, 62.12, 61.62, 60.41 and. 60.29 percent. In total, regarding to the all traits considered in this study, genotype D124 in the amount of 62.24% and then cultivars, Sahand, Shahroud 6, Saba, Ruby with oil values of 62.12%, 61.62%, 60.41% and 60.29, respectively. Also, palmitic acid, oleic acid, and linoleic acid in D124, Sahand, Shahroud 6, Saba, and Ruby were (5.44, 73.30 and 21.14%), (4.85, 76.33, and 18.48%), (5.64, 80.11 and 14.31%), (5.30, 73.89 and 20.80%) and (5.21, 77.44, and 16.32%) respectively. These are identified as the best cultivars and genotypes in terms of food quality in the climatic conditions of Karaj, which can be used for nutritional or technical applications to provide conditions for almond production and cultivation development.

Introduction

Almond [*Prunus dulcis* (Mill.) D.A. Webb] from the Rosaceae family, is found in most countries of the world (Socias i Company and Gradziel, 2017). Almond kernels are one of the most popular edible nuts in the world. When almond compared to hazelnuts, walnuts, and cashews, their yearly

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production is the greatest in the global market of nut crops (FAO, 2019). Almonds are cholesterol-free, gluten-free, high in monounsaturated fats and antioxidants, and a great source of energy for heart health and weight control (Kodad, 2017). Those are used not just as a snack, but also as a component in processed meals, as well as in the pharmaceutical and cosmetic industry (Bolling *et al*., 2010; Kodad, 2017). Almond oil is a well-known example that has been used in cosmetics as well as for medicinal purposes for many years (Socias i Company and Gradziel, 2017). One of the kinds of oils is almond oil that in addition to having health properties is also effective in nutrition and health (Zhou *et al*., 2016; Sorkheh *et al*., 2016). The major component of almond kernels and the key driver of its flavour is oil, which can account for 50% or more of the dry weight of almond kernels. These findings demonstrate that oil content and chemical composition have been used as selection factors in almond breeding projects. (Saura Calixto *et al*., 1988). According to reports (Kodad and Socias i Company, 2008), the edible part of the almond nut is the kernel, considered an important food crop with a high nutritional and medicinal value. The kernel of the eatable portion of nuts with tall dietary value and is a major component of the diet of many countries in the world (Kester *et al*., 1991; Ranjbar *et al*., 2020).). This high nutritional value of nuts is mainly due to their high oil content, which is an important source of calorie. Oil content in nuts is obtainable as a thrilling opportunity because of its excessive content which include almonds (53%), pistachios (50%), and walnuts (65%) (Roozban *et al.*, 2005; Sarikhani *et al.*, 2021). This oil can be used in the food and cosmetics industries, which will be an added value for these nut crops. Zhou *et al.* (2016) studied the houses of cold-pressed oil extracted from 8 almond cultivars in Xinjiang and observed that the nutritional value, oxidation stability, and flavor first-rate of oil in a few cultivars had been higher than others. Yin *et al.* (2015) determined the physical quality (shell thickness, kernel percentage, and kernel weight) and chemical value (crude oil content, crude protein content, and amygdalin content) of 38 almond cultivars in Xinjiang. They confirmed the comprehensive quality of cultivars which include 'Zhipi', 'Butte', 'Thompson', 'Sonora', 'Nonpareil', 'Ye'erqiang' and 'Badanwang' had been the best among cultivars studied. Heritability of oil content is pronounced to be high (0.57), which is less affected by environmental influences, and as a result, the selection for this trait might be easier (Ansari and Gharaghani, 2019; Gouta *et al.*, 2020 and Imani *et al.*, 2021). In the almond breeding program, to increase the oil content, those cultivars with high oil content may be used. In addition, the lipid content is a major feature of almond kernels and is a primary determinant of kernel flavor, especially after roasting (Socias i Company *et al*., 2008). However, cultivars with a notably low percent of oil also are required for the manufacturing of almond milk and almond flour (Kodad *et al*., 2013; Gouta *et al*., 2021).The objective of this study is to determine the oil content of various cultivars in order that almond cultivars may be used to assess their capability as a renewable supply of oil manufacturing for dietary or technical programs to offer manufacturing and development.

Materials and Methods

For each almond cultivar, 3 kg fruit samples from the total canopy of 3 selected trees from early August to early September, depending on the cultivars grown in Karaj of Iran, almonds in full maturity were harvested by hand and dried on the ground when exposed to the sun to bring the kernel moisture to 8%. After separating the almond kernels from the nuts, the kernels were ground using a universal cutting mill. 100 grams of almond kernels in each cultivar were ground into a powder and placed in plastic bags. The samples were frozen and stored at -80°C until oil extraction.

In this study, 3 characteristics of almonds including nut weight, kernel weight and oil content of 75 almond cultivars and genotype were measured.

Nut and kernel dry weight

Nut and kernel dry weight was measured using a digital scale with an accuracy of 0.001g. Measurements have been done at the kernel in keeping with replicate.

Among the initial samples that were superior to other genotypes in terms of some morphological characteristics and oil content, 13 cultivars and genotypes were selected to determine the number of fatty acids.

Total oil content

The total oil content for each replication of treatment were extracted from two grams of milled dry kernels using Soxhlet apparatus with 100 ml of ether oil as a solvent for 6 hours (boiling range 30-60°C). The solvent was evaporated under vacuum using a rotary evaporator and the oil was collected (Bligh and Dyer, 1959).

This process was repeated three times for each almond cultivar. To do this, first put the cut filter paper in the oven for an hour. It was then stored in a dryer for 20 minutes to absorb moisture and then the dry weight of the paper was measured with a digital scale. The ground almond kernels were placed on filter paper. The samples were then placed in the autoclave for 90 minutes. They were then placed in dryers for 30 minutes and weighed with a digital scale (paperweight and sample before the starting the process by Soxhlet apparatus), then placed for one day in the Soxhlet apparatus, which was based on the method of Zacheo *et al*. (2000); Therefore, the samples were exposed to air to evaporate their ether. Finally, they were put in the autoclave for 1:30 hours and then in the dryers for 45 minutes.

As a final point, their weight (weight of paper and samples after succulent) and their oil percentage were determined based on the method of Zacheo *et al*. (2000) according to the following formula:

Oil percentage = Sample weight and filter paper weight after Soxhlet - Sample weight and filter paper weight before Soxhlet / Dry paper weight - Sample weight and filter paper weight before Soxhlet × 100

Fatty acids

Fatty acids were extracted and measured by the method of Talebi *et al.* (2013). 500 microliters of extraction buffer containing methanol and 2% concentrated sulfuric acid was added to 100 mg of frozen and dried samples by Freeze Dryer (OPR-FBCF-12006, Operon) and the samples were dried for 2hours at 80°C and 750rpm were placed. 300 microliters of 0.9% sodium chloride solution and 150 microliters of hexane were added to the reaction tube, respectively.

Then the samples had been centrifuged (3000 rpm, 25°C, 5minutes) and finally, the supernatant containing hexane and fatty acid methyl ester (FAME) become used for gas chromatography analysis. Fatty acid dedication becomes done the usage of gas chromatography (Inc. Palo Alto, CA Varial,) Varian CP-3800 equipped with a CP-Sil88 silica column (100 meshes, 0.25 mm ID, and film thickness 0.25 μm). The oven temperature was maintained at 130°C for 4 minutes and then programmed to increase to 180°C at a rate of 5°C/min and held at this temperature for 8 minutes. Finally, the temperature of the oven is from 180 to 220 degrees Celsius at a speed of 4 degrees Celsius per minute in the condition of helium carrier gas (1 ml per minute), the gap ratio is 20:1. The flame ionization detector was raised to 280°C. Fatty acid peaks were determined by comparing the retention time with FAME standards. Fatty acid peaks were determined by comparing the retention time with FAME standards. Fatty acid standards were purchased from Merck (Darmstadt, Germany) (Table 1).

Table 1. Detailed chemical information for target FAMEs present in the identification and calibration standards.

Chemical name	Formula	Shortened name	Unsaturated compounds shortened synonym	Molecular weight (g mol^{-1})	CAS no.	Mass percentage (%)	Quantitation ions
Palmitic acid	$C_{15}H_{31}COOCH_3$	C16:0 ME		270.45	112-39-0	6	74
Oleic acid	$C_{17}H_{33}COOCH_3$	C18:1n9c ME	*cis*-9,C18:1 ME	296.49	112-62-9	4	55
Linoleic acid	$C_{17}H_{31}COOCH_3$	C18:2n6c ME	*cis*-9,12,C18:2 ME	294.47	112-63-0	2	67

Statistical analysis

Statistical analysis of this experiment was performed in a completely randomized block design with three replications. Data analysis was performed.

Based on the analysis of variance with mean values for significant differences at P <0.05 using Tukey's multiple range test in MiniTab, version 18. Correlation analysis between variables was performed using Pearson correlation coefficient with SPSS statistical software version 16 (SPSS Inc., Chicago, IL, USA).

Results

Analysis of variance of the effect of cultivar type on nut weight of almond kernels of selected cultivars and genotypes are given in Table 2. Nut and kernel weights were measured as Genotype D, (6.40 g), and 19_17 (6.34 g) respectively. The contents of almond kernel oil are given in Table 3.

Table 2. Analysis of variance of the effect of cultivar type on nut weight, kernel weight, and oil content.

Source	Df	MS		
		Nut	Kernel	Oil
Genotype/Cultivars	74	4.6541**	0.1737**	61.457**
Replication	2	4 8369^{ns}	2 7484^{ns}	99 585^{ns}
Error	148	0.0194	0.0045	0.609
CV (%)		1. 23	0. 36	1. 058

Table 3. The effect of cultivar on nut weight, kernel weight, and oil content of some almond cultivars and genotypes.

Genotype/ cultivar	Mean		
	Nut weight(gr)	Kernel weight(gr)	Oil content (%)
151	3.9cd^{f}	1.3c	44.04af-ag
Aviz	2.16e	0.86d	59.49b-f
Saba	4.08c	1.58b	60.42a-e
Shokoufe	1.08f	0.78d	53.562l-u
G	2.72e	0.96d	53.56l-u
16_23	3.2d	1.57b	54.30k-r
E	1.5f	1.04c	40.60ah
Kq1	3.93cd	1.86b	43.26ag-ah
F	1.54f	1.14c	53.08m-y
Genotype D	6.4a	2.19a	54.48k-q
A12-6	5.04b	2.18a	56.51g-k
4_10	4.87	1.72b	51.35t-aa

Azar	2.74e	1.2c	59.08s-g
4_14	3.44d	1.82b	46.02ae-af
Touno	4.62c	1.56b	59.67a-f
D11	1.7f	0.7d	55.35j-n
BagalD7	3.3d	1.42c	54k-t
Sahand	4.468c	1.77b	62.12ab
Sefid	2.2e	1.3c	51.52s-aa
Rabii	5.46b	1.99a	61.62abc
shahrood6	2.16e	1.04c	61.09a-d
Shahrood15	1.02f	0.78d	60.29a-e
10Dm	3.28d	1.7b	51.64r-aa
19_20	4.9bc	1.56b	54.24k-s
19_17	6.34a	2.12a	58.62d-h
12_4	5.72ab	1.7b	54.18k-s
A5-17	1.07f	0.52d	53.64l-u
A1-16	3.25d	1.35c	52.56o-z
Perlis	4.32c	1.7b	52.45p-z
Omidbakhsh	2.35e	1.27c	49.03aa-ad
Nonpareil	1.54f	0.95d	53.47m-u
A200	3.44d	1.2c	55.04j-p
2_27	2.54e	1.08c	47ad-ae
9_24	5.51b	1.48c	58.08e-i
Ts1	3.92cd	1.46c	47.40ac-ae
Aydin	4.94bc	1.12c	53m-y
Shahrood21	4.06c	1.64b	53.41m-v
K49	2.74e	1.54b	54.59k-q
Ts4	3.28d	1c	51.09u-ab
13_40	5.49b	1.62b	55.62i-m
Ts6	4.02c	1.24c	58.56d-h
K3-3-3 asli	2.08e	0.98d	50z-ac
a7-17	2.76e	1.08c	61a-d
11_10	4.22c	0.98d	56.25h-l
16_30	3.98cd	1.54b	56.58g-k
100_8_1	2.3e	0.76d	56.53g-k
11_8	2.84e	1.3c	59.22c-g
100_1-1	2.92e	1.32c	55.18j-o
Texas	2.46e	1.16b	53.49m-u
A5-7	1.575f	0.85d	50.69v-ab
15_29	1.7f	0.9d	53.34m-w
shahrood12	4.06c	1.3c	59.36c-f
Carmel	1.02f	0.78d	48.5ab-ae
9_20	4.5c	1.42c	52.17q-z
8_39	4.3c	1.7b	56.60g-k
Fragiulio	5.50b	1.3c	54.31k-r
D51	1.7f	0.76d	51.21u-ab
D52	1.7f	0.8d	50.56x-ab
Ruby	5.6ab	1.30c	60a-f

D124	3.28d	1.66b	62.24a
A25-34	3.32d	1.18c	58.56d-h
Ts3	3.04d	1.12c	52.81n-y
D101	3.14d	1.45c	51.03u-ab
Marcona	4.5c	1.5b	53m-y
H	1.4f	0.575	50.62w-ab
37	3.32d	1.03c	54.18k-s
48	4.61c	1.54b	54.38k-q
21_8	3.34d	1.2c	59.56a-f
20_16	1.1f	0.5d	53.6533l-u
C11	2.7e	0.9d	50z-ac
9_7	2.6e	1c	50.38y-ab
Mamaii	6.16a	2a	59.62a-f
D8	3d	1.1c	53.03m-y
1_13	4.3c	1.2c	57.34f-j
21	2.76e	1c	53.12m-x

[1] Means in each column with the same letters are not s significantly different at the 5% level

In Table 4, the correlation among the studied traits such as nut weight, kernel weight, and oil content in 75 selected cultivars and genotypes is presented. Also, some investigated indicators in selected cultivars and genotypes including minimum, maximum, standard deviation, average, and their diversity index in Table 5 are shown.

Table 4. Correlation table of studied traits in 75 selected almond cultivars.

Trait	Oil (%)	Kernel (g)
kernel (g)	0.087 0.457	
Nut (g)	0.276 0.016	0.208 0.074

Table 5. Traits were studied in 75 selected almond cultivars, minimum, maximum, standard deviation, mean, and diversity index.

Traits	Number of observations	Mean	Standard deviation	Minimum	Maximum	Diversity index (%)
Nut weight	225	3.64	1.26	1.7	6.5	36. 20
kernel weight	225	1.29	0.29	0.55	1.88	8.5
Oil content	225	54.34	4.64	40.60	62.56	22.48

The results of the analysis of variance of the effect of cultivar type on the main fatty acids of some almond cultivars and genotypes (Table 6) showed that there were significant differences between the cultivars and genotypes in terms of major fatty acids. Also, the effect of cultivar on the main fatty acids of some almond cultivars and genotypes showed that the highest average obtained for the oleic acid variable with a rate of 80.10% belonged to shahrood 6 and the lowest with a rate of 60.98% in the genotype 4-14 was observed. Likewise, the amount of these three major fatty acids including palmitic acid, oleic acid, and linoleic acid acid in the seeds of the superior cultivars and genotypes D124, Sahand, Shahroud 6, Saba, and Ruby were (5.441, 73.302, and 21.1405%), (4.854, 76.331 and 18.48%), (5.64, 80.1017 and 14.3220%), (5.3044, 73.8955 and 20.8004%) and (5.213, 77.4414 and 16.393%) respectively among 13 varieties and selected genotypes of almonds (Table 7).

Table 6. Analysis of variance of the effect of cultivar type on the main fatty acids of some Almond cultivars and genotypes

Source	Df	MS		
		Palmitic acid	Oleic acid	Linoleic acid
Genotype/Cultivars	12	1.2832**	165.8**	49.234**
Replication	2	0.0119ns	153.1ns	0.160ns
Error	18	0.0389	149.0	0.087
CV (%)		5.20	2.58	3.67

Table 7. The effect of cultivar on the main fatty acids of some almond cultivars and genotypes

Cultivar/Genotype	Palmitic acid	Oleic acid	Linoleic acid
Saba	5.3044cd	72.8955bc	18.8004d
A12-6	6.0409b	78.703ab	13.1061j
4_10	6.149367b	74.9009b	17.0106f
4_14	6.026267b	60.9861d	31.0277a
Sahand	4.901d	75.331b	17.01f
shahrood6	5.64c	80.1017a	16.922g
19_17	6.4578a	77.2019ab	13.7371j
2_27	6.5871a	68.9461c	22.1667b
11_8	6.1603b	69.3548c	22.0042b
15_29	5.5485c	77.0165ab	14.6896i
Ruby	5.213cd	77.0414ab	15.393h
D124	5.941b	73.102bc	18.1405d
C11	6.0163b	71.0124bc	20.0168c

[!] Means in each column with the same letters are not s significantly different at the 5% level

Discussion

The findings revealed that the influence of genotype on all measured traits was significant (Table 2). The results of nut weight, kernel weight, and oil content showed that there are significant differences between cultivars (Table 3). So that genotype D had the highest value (6.40grams). Also, the highest amount of kernel weight is related to genotype D at 2.19 grams, while the lowest amount of kernel weight is related to A5-17genotype at 0.52 grams. These results showed that the range of nut and kernel weight varies between cultivars of almond. In this regard, Socias i Company *et al*. (2009) also reported that the almond fruit Physical parameters are greatly variable depending on the genotype. The Results showed changes in oil content in the range of 40.24% to 62.24%. In general, the D124 oil content was higher than the oil of other almond cultivars and genotypes and the highest amount of crude oil was observed in plant D124 (Table 3). The results of the present study were consistent with the results of Kodad *et al*. (Kodad *et al*., 2013). They reported that the total almond kernel oil content varied from 48.7% to 64.59%. Calixto *et al*. (19881) observed that the average kernel content contained 53.37% of oil. Martinez *et al*. (2000) reported that 12 varieties of almonds contained between 30% and 51% oil. Barbara *et al*. (1994) stated that the kernel content changed from 53.67% to 54.26% for oil.

In some other study, the quantity of *Prunus amygdalus* oil was determined in the range of 45.9% to 61.7% (Mehran and Falsof, 1974).

Dried seeds of *Prunus domestica*, *Prunus armeniaca*, and *Prunus persica* contained 32%, 37%, and 43% of oil, respectively (Hassanein, 1999) and

Filsoof *et al.* (1976) reported the oil contents of *P. Amygdalus*, *P. armeniaca* and *P. persica* in the range of 45.9% to 58.7%. Although genotypes showed similar findings to related sources in terms of oil content, some genotypes contained more oil than the identified almond cultivars or genotypes (Askin *et al*., 2007). The high oil content of almonds is comparable to common oilseeds such as rapeseed or sunflower seeds, making the kernels of some Prunus species very suitable for commercial oil production.

Nutritionally and technologically, almond kernel oil is very interesting. Careful exam of those analyzes has a critical application for the nutrients sciences, due to the fact oils have a very important effect on health.

These experimental results show the physical properties and oil of different cultivars and genotypes, based on which the desired cultivars and genotypes can be used for breeding studies (Melhaoui *et al*., 2021).

Based on the average of the obtained data, it seems that D124, Sahand, Shahroud 21, Shahroud 6, 7-17, Saba, Shahroud 15, Ruby, and 16-25 are the dominant cultivars in terms of total oil content. Also, the total oil content of D124 (62.24%) and Sahand (62.12%) cultivars was similar to 62.24% and 62.12% in the present study. According to the obtained results, it can be concluded that the commercial value of these cultivars increases, and they can be used as parents in breeding studies. In addition, D124 was the most important genotype due to its high total oil properties and oil stability (Abdallah, *et al.* 1998).

As shown in Table 4, there was a significant positive correlation between oil and nut at the level of 1% (r = 0.27) and this was the highest correlation among the correlations of the studied traits in 75 selected almond cultivars. Also, traits such as kernel weight and content with a correlation of 8% show the relationship between these two traits. Traits such as kernel weight and nut weight indicate the importance of these traits in estimating the yield potential of cultivars. These types of differences vary depending on the type of cultivar (Rodriguez and Sherman, 1986). Kernel weight and nut weight are controlled by quantitative and qualitative traits. According to a report (Gradziel and Beres, 1993), the trait is qualitatively controlled as a single gene. As shown in Table 4, the highest and lowest standard deviations are related to oil content (4.64) and kernel weight (1.26g), and the most important of them is the diversity index column, which is of special importance in helping to select the originator. So that the highest diversity index (36.20%) and the lowest diversity index (8.5%) are related to nut weight and kernel weight, respectively. These findings are similar to the results of the study of almond cultivars in terms of fruit traits, especially phenotypic diversity about fruit traits by Gradziel and Beres (Gradziel and Beres, 1993). However, these diversity indices are of particular importance. Assists in the selection of originators in the fields of racial and hereditary studies and studies of molecular markers. Nowadays, using multivariance analysis of biochemical and morphological parameters and also using the phenotypic correlation between some agrochemical traits, they have been able to obtain indicators for differentiating cultivars and clones in the almond collection.

The percentage of the main fatty acids was shown in Table 6. It can be seen that linoleic acid, oleic acid, and palmitic acid were the three main fatty acids in the thirteen cultivars and genotypes of almond seed oils, accounting for more than 97 % of the oil fatty acids. The seed oil of almonds was rich in oleic acid, and the contents ranged from 60.98% to 80.10%. Linoleic acid was the highest content of fatty acids in 4_14 seed oil (31.0277%). The contents of oleic acid and linoleic acid in shahrood6 seed oil were 80.10% and 16.922%, respectively. Anyway, oleic acid is the main fatty acid in almond oil. According to reports, in most almond samples, oleic, linoleic, palmitic, and stearic acids (in decreasing order) constitute more than 95% of the total fatty acids content, while other fatty acids contain 5%. Oleic acid and linoleic acid are

the most important unsaturated fatty acids in almond oil (about 90%), while saturated fatty acids, especially palmitic, palmitoleic and stearic acids, have very little content. A large variation for the content of oleic and linoleic acids was reported (Askin *et al.*, 2007; Socias I company *et al.*, 2008; Melhaoui *et al*., 2021). In this research, three standards of oleic, linoleic and palmitic acids were used to measure fatty acids and expressed as a percentage.

These results are consistent with the conclusions of many researchers (Kodad and Socias i Company, 2008; Yildirim *et al.*, 2008; Yildirim *et al.*, 2016).

A study of 77 almond cultivars of different origins grown in the CITA International Almond Collection (Kodad *et al.*, 2011a) showed that the range of oleic acid variation significantly depended on the origin, and the greatest range of variation was observed among cultivars from the USA (62.86-77.35%), followed by France (65.31-76.99%), Greece (64.00-74.97%), Spain (67.42-74.92%) and Portugal (67.66-74.10%). It is known that these values are conditioned by cultivar and geographical origin (Yada *et al*, 2011; Abaspour *et al*., 2011). According to reports, almonds are characterized through excessive quantities of monounsaturated and polyunsaturated fatty acids (Socias i Company and gradziel, 2017).

Based on the studies, it has been shown that oleic and linoleic acids are the most abundant unsaturated fatty acids in almonds, which constitute about 80 to 90%, while saturated fatty acids such as palmitic and stearic fatty acids are in smaller amounts (<10 percent) exist (Kodad and Socias i Company,2008, Yang *et al*., 2018).

Higher oleic acid content is important for both stability and quality, as it increases the nutritional value and stability of the oil against rancidity (Kodad and Socias i Company 2008).

Linoleic acid is less saturated and stable than oleic acid, it has been reported that there is a strong negative correlation between linoleic acid content and oil stability in almonds (Kodad and Socias i Company 2008, Ibourki *et al*., 2022).

A low quantity of linoleic acid is related to more oil stability (Zacheo *et al.*, 2000; Kodad *et al*., 2010), while a high content of oleic acid is considered a positive characteristic from a nutritional point of view.

Therefore, parental choice for decrease linoleic acid and better oil content can be performed in a breeding application to raise kernel quality (Kodad *et al*., 2014).

Conclusions

It was found that almond cultivars and genotypes have a wide diversity in terms of nut weight, kernel weight, and oil content. There was a significant difference between the studied cultivars and genotypes for the oil content trait that is important for improving the quality of breeding programs. So that the highest amount of kernel weight is related to genotype D at 2,19 grams, while the lowest amount of kernel weight is related to A5-17genotype at 0.52 grams. The results of nut weight analysis showed that genotype D had the highest value (6.40grams). In total, all traits studied in this study, cultivar D124 in the amount of 62.24% and then cultivars, Sahand, Shahroud 21, and Shahroud 6, Saba, Ruby with oil values of 62.12%, 61.62%, 61.09%, 60.41% and 60.29, respectively, were identified as the best genotypes in terms of food quality in the climatic conditions of Karaj, which can be used for nutritional or technical applications to provide the conditions for the production and development of almonds. The results also showed that some genotypes had high oil content, for example, Shahroud 21, Shahroud 6 genotypes had 61.62% and 61.09% oil, which can be used in almond development programs.

It was found that almond cultivars and genotypes have a wide variety in terms of all pomological traits and oil content. There was a significant difference between the studied cultivars and genotypes for the oil content trait that is important for improving the quality of breeding programs. The highest weight of fruits and nuts (6.500 and 1.8800g) was observed in

genotypes 8-9 and H, respectively. The lowest weight of fruits and nuts (1.07 and 0.55 g) were in Carmel and 16-20 genotypes, respectively. The results also showed that some genotypes had high oil content, for example, Shahroud 21, and Shahroud 6 genotypes had 61.62% and 61.09% oil, which can be used in almond development programs. Also, palmitic acid, oleic acid and linoleic acid in D124, Sahand, Shahroud 6, Saba, and Ruby were (5.441, 73.302 and21.1405%), (4.854, 76.331 and 18.48%), (5.64, 80.1017 and 14.3220%), (5.3044, 73.8955 and 20.8004%) ,and (5.213, 77.4414 and 16.393%) respectively. These are identified as the best cultivars and genotypes in terms of food quality in the climatic conditions of Karaj, which can be used for nutritional or technical applications to provide the conditions for the production and development of almonds.

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