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Full Length Research Paper

Evaluation of selected almond types in Kocaköy and Hani Counties

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This study was carried out in Kocaköy and Hani counties of Diyarbakir province in Southeast Anatolia Region of Turkey during years 2006 and 2007. The aim of the research was to select and evaluate almond types which had good quality and late flowering. Although these populations have a special importance with respect to almond genetic resources, no studies have been made about almond in this area up to now. Therefore, this research had a great important. For this purpose, natural almond populations of these counties were surveyed and 130 types which had open late flowering according to the other almond types were labelled and evaluated for breeding objectives. At the end of this study, 15 promising types (21-HA-1, 21-HA-8, 21-HA-13, 21-HA-31, 21-HA-45, 21-HA-48, 21-KO-2, 21-KO-16, 21-KO-18, 21-KO-21, 21-KO-34, 21-KO-42, 21-KO-44, 21-KO-46 and 21-KO-49) having superior characteristics were selected. In this study, it was determined that the fruit weight with shell, fruit length with shell, fruit width with shell, kernel weight, kernel length, kernel width, widthness index, thickness index, kernel ratio, double kernel ratio, twin kernel ratio and sound kernel ratio ranged from 2.14 - 1.15 g, 28.51 - 23.94 mm, 19.13 - 15.03 mm, 1.25 - 0.69 g, 21.99 - 18.22 mm, 11.60 - 10.15 mm, 57.19 - 51.93, 47.55 - 36.08, 62.81 - 37.43%, 0.00%, 0.00% and 100%, respectively. In addition, It was determined that total points according to flowering and quality changed from 790-646 and 782-638, respectively.

Key words: Almond, selection, fruit characteristics, late flowering.

INTRODUCTION

Almond (*Prunus amygdalus* L.) is a long-lived and large-sized species showing a relatively short juvenile period (Socias et al., 1997). In addition, the almond is one of the oldest crops used by humans but its exact enviromental requirements have restricted its commercial production to specific areas of the world (Kester and Asay, 1979). Therefore, the almond production is concentrated in some regions (Mediterranean, Asian countries and California, with limited amounts in Argentina, Chile, South Africa, and Australia) of the world (Kester et al., 1990). In Turkey, almond is grown in all the areas except coast of East Black, a region and high plateau (Gulcan et al., 1989).

According to current statistical data, almond production was 4453 tons in Southeast Anatolia Region (Anon, 2008). Most of the almond trees in Southeast Anatolia Region are generally grown with seed, in field and polycultured with the fruit species such as pistachios, figs and walnuts.

Existing almond types and cultivars differ widely from each other in many characteristics, especially flowering time, yield, quality of nuts and tree vigour. This variability has provided an invaluable material for almond selection.

A lot of researchers have studied on almond selection in other regions (Dokuzoğuz and Gülcan, 1979; Kester et al., 1980; Kumar and Uppal, 1990; Cangi and Şen, 1991; Ledbetter and Shonnard, 1992; Aslantaş , 1993; Şimşek, 1996; Gercekcioglu and Gunes, 1999; Şimsek and Küden, 2007; Şimşek, 2008). But, no studies have been made about almond in this areas up to now although Kocaköy and Hani counties have a special importance with respect to almond genetic resources. In addition, many areas such as Kocaköy and Hani counties of Diyarbakir province are not suitable for almond cultivation because of some climatic conditions. Therefore, late

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flowering, high yield and quality-almond types will be selected in this research. In addition, these types should be the adaptations in the same ecological conditions with standard almond types and cultivars. As a result of adaptation, the best almond types and cultivars can be produce and contribute to the economy of our country.

MATERIALS AND METHODS

This study was carried out on almond population naturally grown in Kocaköy and Hani counties of Diyarbakir province in Southeast Anatolia Region of Turkey during years 2006 - 2007. on almond population naturally grown in Kocaköy and Hani counties of Diyarbakır, southeast Anatolia region of Turkey. Evaluation of the selected almond types was compared using weighted-ranked method in Table 1 (Gulcan et al., 1989). In this context, firstly, natural almond populations of Hani and Kocaköy counties were surveyed and 130 types which had late flowering according to the other almond types were labelled and evaluated for breeding objectives. Then, 30 fruits were randomly taken from each of the almond trees in summer season. In second year, it was determined date of flowering of 90 almond types which had flowering in this almond types and 30 fruits were randomly taken again from each of the almond trees in summer season. Finally, 15 promising types were selected according to this method, Flowering and pomological characteristics of the selected almond types were made according to Godini et al. (1977) and Gulcan (1985), respectively. Altitudes and coordinates were measured with GPS tool. The beginning of flowering in various almond types gets one day late at each 35 m in altitude (Özbek, 1977). The fruit weight with shell and kernel weight were measured with a scale sensitive to 0.01 g. In addition, the fruit length with shell, fruit width with shell, kernel length and kernel width were measured with a digital compass.

RESULTS

According to the results of the weighted-ranked method, 15 almond types (21-HA-1, 21-HA-8, 21-HA-13, 21-HA-31, 21-HA-45, 21-HA-48, 21-KO-2, 21-KO-16, 21-KO-18, 21-KO-21, 21-KO-34, 21-KO-42, 21-KO-44, 21-KO-46 and 21-KO-49) were selected.

Considering 2 years mean results (2006 and 2007), the fruit weight with shell, fruit length with shell, fruit width with shell, fruit thickness with shell, kernel weight, kernel length, kernel width and kernel thickness of the almond types were found statistically different from each other at 5% levels (Table 2). Fruit weight with shell was found to be highest at 2.14 g in 21-HA-8 and lowest at 1.15 g in 21-KO-49. Fruit length with shell was found to be highest at 28.51 mm in 21-KO-16 and lowest at 23.94 mm in 21-HA-45.

Fruit width with shell was found to be highest at 19.13 in 21-KO-16 and lowest at 15.03 in 21-KO-44. Fruit thickness with shell was found to be highest at 14.03 mm in 21-KO-16 and lowest at 11.78 mm in 21- KO-44. Kernel weight was found to be highest at 1.25 g in 21-HA-48 and lowest at 0.69 g in 21-KO-49. Kernel length was found to be highest at 21.99 mm in 21-HA-31 and lowest at 18.22 mm in 21-KO-49. Kernel width was found to be highest at 11.60 mm in 21-HA-31 and lowest at 10.15 mm in 21-HA-3. Kernel thickness was found to be highest at 9.76 mm in 21-KO-2 and lowest at 7.10 mm in 21-KO-44.

The widthness and thickness index of the selected almond types are shown in Figure 1. The widthness index was found to be highest at 57.19 in 21-HA-13 and lowest at 51.93 in 21-KO-44. The thickness index was found to be highest at 47.55 in 21-HA-45 and lowest at 36.08 in 21-KO-44. The kernel ratio and the kernel numbers in 1 Ons of the selected almond types are given in Figure 2. The kernel ratio was found to be highest at 62.81 in 21-HA-48 and lowest at 37.43 in 21-HA-1. The kernel number in 1 Ons was found to be highest at 41.01 in 21-KO-49 and lowest at 22.64 in 21-HA-48.

During years 2006-2007, the flowering time and periods, altitudes and coordinates of the selected almond types are shown in Table 3. First flowering started between 08-09 March in 21-HA-1 and 15 March in 21-KO-49. Full flowering started between 12-13 March in 21-HA-1 and 21-HA-45 and 19 March in 21-KO-46 and 21-KO-49. Last flowering started between 15 -16 March in 21-HA-45 and 24 March in 21-KO-49. It was determined flowering period of the selected types continued to be 8 - 10 days and 8-11 days. In addition, the altitude of the selected almond types changed between 822 m in 21-HA-45 and 911 m in 21-KO-46 and 21-KO-49.

The coordinates of 21-HA-45 type were 37618272 E-4247825 N. The coordinates of 21-KO-46 and 21-KO-49 types were 37633299 E-4239254 N and 37633328 E-4239234 N, respectively. The total scores according to the flowering were found to be highest at 790 in 21-KO-34 and lowest at 646 in 21-HA-45 (Figure 3). In addition, the total scores according to the quality were found to be highest at 782 in 21-KO-49 and lowest at 706 in 21-HA-45 (Figure 4).

It was determined that all the selected almond types had dropped tree habit, small fruit weight with shell,sweet kernel taste, 100% sound kernel ratios, no twin kernel ratios, no double kernel ratios and medium large kernel shape according to widthness index. In addition, yield and some other fruit properties of the selected almond types are shown in Table 4.

DISCUSSION

The sourness of the almond is undesired except special situations. In addition, the important selection criterions were date of full flowering, tree habit, yield, fruit weight with shell, suture openin, shell hardness, kernel colour intensity, shrivelling of kernel, kernel taste, double kernel ratio and sound kernel ratio (Gulcan, 1985; Gulcan et al. 1989; Aslantaş, 1993; Şimşek, 1996; Balta, 2002; Şimşek and Küden, 2007; Şimşek, 2008).

In some other studies, fruit weight with shell changed from 5.86 to 3.45 g (Bostan et al., 1995), 5.24 to 3.37 g (Kumar and Uppal, 1990), 6.14 to 2.89 g (Aslantaş, 1993), 7.58 to 2.18 g (Gercekcioğlu and Gunes, 1999),

Table 1. Evaluation of the selected almond types according to the weighted ranking method.

Characteristics	Classifications	Value scores	Relative scores according to flowering	Relative scores according to quality	Classifications	Value scores	Relative scores according to flowering	Relative scores according to quality
Date of full flowering	Extremely early	1	30	20	Intermediate/late	6	30	20
	Very early	2	30	20	Late	7	30	20
	Early	3	30	20	Very late	8	30	20
	Early/Intermediate	4	30	20	Extremely late	9	30	20
	Intermediate	5	30	20				
Tree habit	Extremely upright	1	3	3	Dropping	4	3	3
	Upright	2	3	3	Weeping	5	3	3
	Spreading	3	3	3				
Yield	Low	3	25	20	High	7	25	20
	Intermediate	5	25	20				
Fruit weight with shell	Small	3	8	10	Large	7	8	10
	Medium large	5	8	10	Very large	9	8	10
Suture opening of the shell	Very wide	0	3	6	No openinig	9	3	6
	Open	5	3	6				
Shell hardness	Extremely hard	1	5	6	Soft	7	5	6
	Hard	3	5	6	Paper	9	5	6
	Intermediate	5	5	6				
Kernel colour intensity	Extremely light	1	3	7	Dark	7	3	7
	Light	3	3	7	Extremely dark	9	3	7
	Intermediate	5	3	7				
Shrivelling of kernel	Wrinkle	1	2	4	Smooth	7	2	4
	Less wrinkle	5	2	4				
Kernel hairiness	Very hairy	3	7	6	Medium hairy	7	7	6
	Hairy	5	7	6	Less hairy	9	7	6
Kernel Taste	Bitter	3	11	15	Sweet	7	11	15
	Intermediate	5	11	15				

Table 1. Contd.

Percentage of double kernels	Low Intermediate	7 5	2 2	2 2	High	1	2	2
Percentage of sound kernel	%	100	1	1				
Total score				100				

Table 2. Some pomological characteristics of the selected almond types (average of years 2006 - 2007).

Code No.	Fruit weight with shell (g)	Fruit length with shell (mm)	Fruit width with shell (mm)	Fruit thickness with shell (mm)
21-HA-1	1.87 abc	25.89 de	16.54 bcd	12.50 bcde
21-HA-8	2.14 a	28.38 ab	17.28 abcd	13.73 ab
21-HA-13	1.53 de	27.99 abc	17.57 abc	13.68 ab
21-HA-31	1.88 abc	26.38 cd	18.41 ab	13.45 abc
21-HA-45	1.94 abc	23.94 f	16.45 bcd	12.10 de
21-HA-48	1.99 ab	26.48 cd	15.88 cd	11.79 e
21-KO-2	1.95 abc	27.69 abc	17.15 abcd	13.17 abcd
21-KO-16	1.83 a-d	28.51 a	19.13 a	14.03 a
21-KO-18	1.80 bcd	27.69 abc	18.44 ab	13.72 ab
21-KO-21	1.67 cd	26.50 cd	15.40 cd	12.32 cde
21-KO-34	1.96 abc	26.47 cd	15.18 d	12.30 cde
21-KO-42	1.69 bcd	26.36 cd	17.56 abc	12.61 bcde
21-KO-44	1.27 ef	26.70 bcd	15.03 d	11.78 e
21-KO-46	1.55 de	26.56 cd	16.27 bcd	12.05 de
21-KO-49	1.15 f	24.61 ef	16.77 bcd	11.91 de
Code No.	**Kernel weight (g)**	**Kernel length (mm)**	**Kernel width (mm)**	**Kernel thickness (mm)**
21-HA-1	0.70 e	19.26 cd	10.74 e	7.47 bc
21-HA-8	1.10 ab	19.99 a-d	11.04 b-e	9.74 a
21-HA-13	0.82 de	19.20 bcd	10.98 cde	9.09 ab
21-HA-31	1.02 bc	21.99 a	11.60 a	8.03 abc
21-HA-45	1.02 bc	19.79 a-d	11.00 cde	9.41 a
21-HA-48	1.25 a	21.77 a	11.58 a	9.31 a
21-KO-2	1.13 ab	20.60 ab	11.45 abc	9.76 a
21-KO-16	0.88 cd	20.54 abc	11.16 a-e	8.34 abc
21-KO-18	1.02 bc	20.32 a-d	11.51 ab	8.41 abc
21-KO-21	1.00 bc	20.16 a-d	10.85 de	8.31 abc
21-KO-34	1.22 a	20.37 a-d	11.23 a-d	9.42 a

Table 2. Contd.

21-KO-42	0.91 cd	20.01 a-d	11.06 b-e	8.46 abc
21-KO-44	0.74 de	19.68 a-d	10.22 f	7.10 c
21-KO-46	0.89 cd	20.32 a-d	10.94 de	8.21 abc
21-ER-31	0.69 e	18.22 d	10.15 f	7.40 bc

Mean separation within some columns by Tukey's test at 0.05 level.

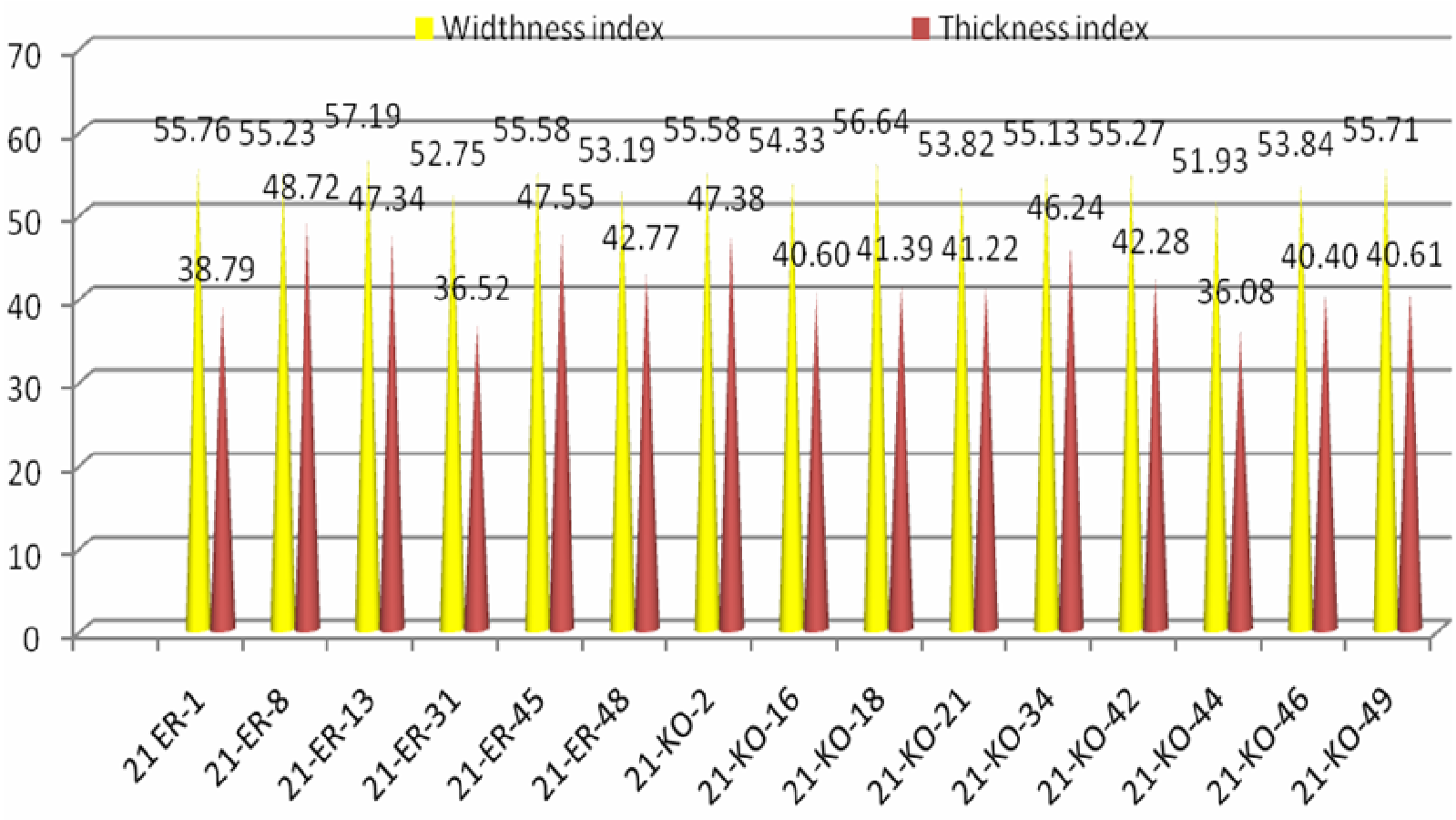

Figure 1. The widthness and the thickness index of the selected almond types (average of years 2006-2007).

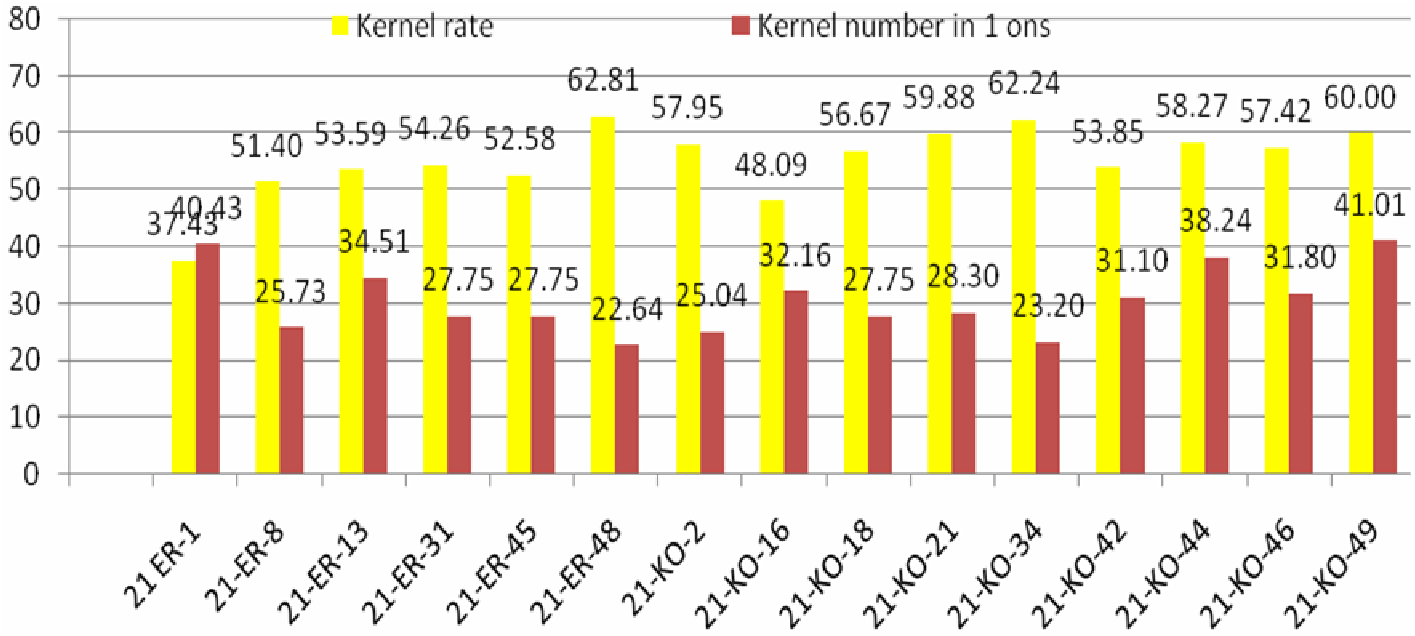

Figure 2. The kernel ratio and kernel number in 1 ons of the selected almond types (average of years 2006-2007).

Table 3. The flowering times and the periods, the altitudes and the coordinates of the selected almond types in 2007.

Code No	First flowering	Full flowering	Last flowering	Flowering period (days)	Altitudes (m)	Coordinates
21-HA-1	08 M/09 M	12 M/13 M	17 M/18 M	10/10	904	37617868 E-4251763 N
21-HA-8	09 M/09 M	13 M/13 M	17 M/17 M	9/9	906	37616674 E-4251977 N
21-HA-13	09 M/09 M	13 M/13 M	17 M/17 M	9/9	905	37616779 E-4252006 N
21-HA-31	10 M/10 M	14 M/14 M	18 M/18 M	9/9	914	37616660 E-4250953 N
21-HA-45	08 M/09 M	12 M/13 M	15 M/16 M	8/8	822	37618272 E-4247825 N
21-HA-48	10 M/10 M	15 M/16 M	19 M/20 M	10/11	825	37618298 E-4247843 N
21-KO-2	10 M/10 M	14 M/14 M	19 M/19 M	10/10	845	37630711 E-4238830 N
21-KO-16	09 M/09 M	14 M/14 M	18 M/18 M	10/10	864	37630666 E-4238807 N
21-KO-18	09 M/10 M	14 M/15 M	18 M/18 M	10/9	864	37630622 E-4238797 N
21-KO-21	12 M/12 M	16 M/16 M	20 M/20 M	9/9	907	37633734 E-4239527 N
21-KO-34	13 M/13 M	17 M/18 M	21 M/22 M	9/10	902	37633717 E-4239564 N
21-KO-42	13 M/13 M	16 M/16 M	21 M/21 M	9/9	900	37633791 E-4239612 N
21-KO-44	12 M/12 M	17 M/17 M	21 M/21 M	10/10	895	37633785 E-4239640 N
21-KO-46	14 M/14 M	19 M/19 M	23 M/23 M	10/10	911	37633299 E-4239254 N
21-KO-49	15 M/15 M	19 M/19 M	24 M/24 M	10/10	911	37633328 E-4239234 N

Note: M= March

7.58 to 3.39 g (Beyhan and Şimek, 2007), 2.75 to 1.21 g (Şimşek and Küden, 2007) and 4.93 to 1.42 g (Şimşek, 2008). The values of fruit weight with shell in this study were partly similar to thoe of Şimşek and Küden (2007) but were mostly lower than those of the other researchers. Karadeniz and Erman (1996), Şimşek and Küden (2007) and Şimşek (2008) determined that the kernel weight of the selected types changed from 1.80 to 1.01 g, 1.52 to 0.51 g and 1.14 to 0.66 g, respectively. The values of kernel weight in this study were mostly similar to those of Şimşek and Küden (2007) and Şimşek (2008) but partly lower than those of Karadeniz and Erman (1996). Fruit weight with shell is desired to be very large (Gulcan et al., 1989). In addition, fruit weight with shell, fruit length with shell, fruit width with shell, fruit thickness with shell, kernel weight, kernel length, kernel

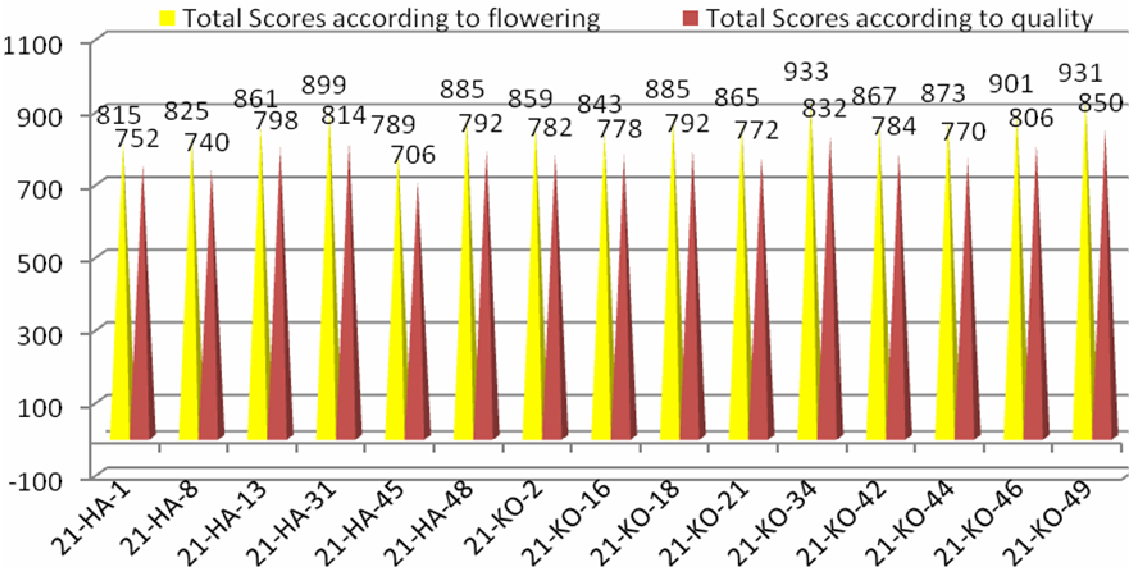

Figure 3. The total scores according to flowering of the selected almond types (average of years 2006 - 2007).

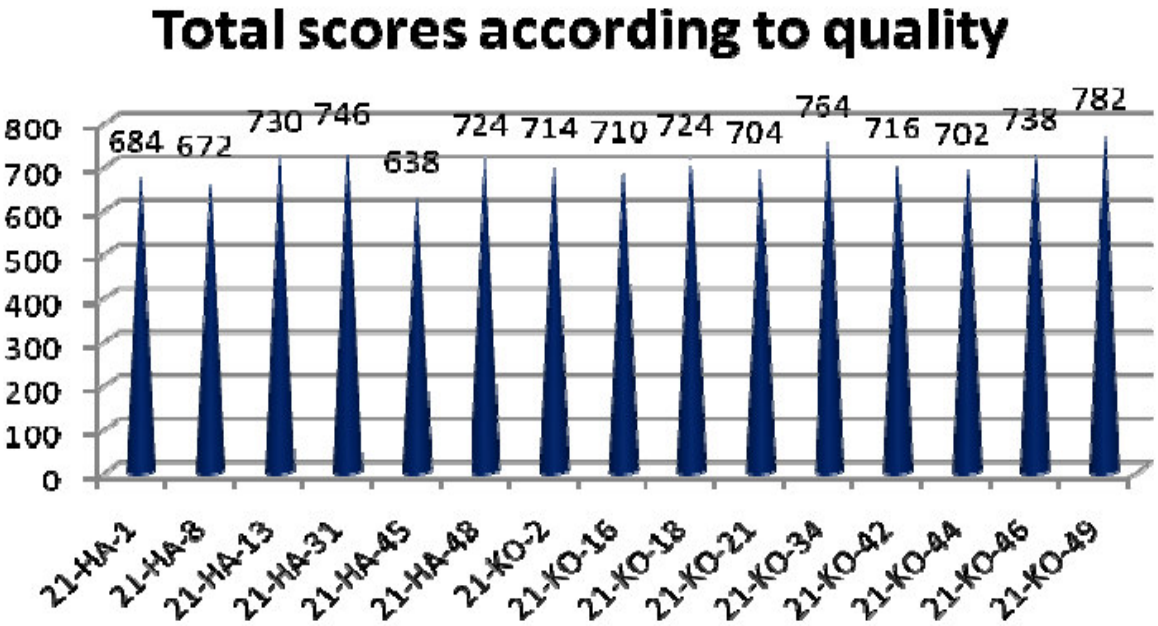

Figure 4. The total scores according to flowering of the selected almond types (average of years 2006 - 2007).

width, kernel thickness and kernel numbers in 1 ons can change according to the genetic characteristics, maintenance requirements and the ecological conditions.

Şimşek and Küden (2007) and Şimşek (2008) determined that kernel ratio changed from 62.41 to 25.39% and 60.16 to 13.91%, respectively. The values of the kernel ratio in this study were bigger than those of Şimşek and Küden (2007). Şimşek and Küden (2007) determined that the shell hardness was shown to be very hard in 4 types, medium in 3 types and soft in 2 types. In addition, Şimşek (2008) determined that the shell hardness was shown to be very hard in 3 types, medium in 1 type and soft in 2types. The shell hardness can change according to the genetic characteristics.Aslantaş (1993), Şimşek and Küden (2007) and Şimşek (2008) determined that the double kernel ratio changed from28.00 to 0.00%, and 0.00%, respectively. The values of the double kernel ratio in this study were better those of Aslanta (1993) but similar to those of Şimşek and Küden (2007) and Şimşek (2008). The double kernel ratio is desired not to exceed 5% (Özbek,1978). Şimşek and Küden (2007) determined that the sound kernel ratio

Table 4. Yield and some other fruit properties of the selected almond types.

Code No.	Nut shape	Suture opening of the shell	Shell hardness	Yield	Sizes of groups according to tons
21-HA-1	Extremely narrow	Not open	Hard	Intermediate	Small
21-HA-8	Extremely narrow	Open	Intermediate	Intermediate	Medium large
21-HA-13	Extremely narrow	Not open	Intermediate	Intermediate	Small
21-HA-31	Oblong	Open	Intermediate	High	Medium large
21-HA-45	Ovate	Open	Intermediate	Intermediate	Medium large
21-HA-48	Extremely narrow	Open	Soft	High	Large
21-KO-2	Extremely narrow	Not open	Soft	Intermediate	Medium large
21-KO-16	Ovate	Not open	Intermediate	Intermediate	Small
21-KO-18	Ovate	Open	Soft	High	Medium large
21-KO-21	Extremely narrow	Open	Soft	Intermediate	Medium large
21-KO-34	Extremely narrow	Open	Soft	High	Large
21-KO-42	Extremely narrow	Not open	Intermediate	Intermediate	Small
21-KO-44	Oblong	Open	Soft	Intermediate	Small
21-KO-46	Extremely narrow	Open	Soft	Intermediate	Small
21-KO-49	Ovate	Not open	Soft	Intermediate	Small

Code No.	Shrivelling of kernel	Kernel hairiness	Kernel colour intensity	Kernel shape according to thickness index
21 HA-1	Smooth	Less hairy	Light	Thick
21-HA-8	Less wrinkle	Medium hairy	Light	Thick
21-HA-13	Smooth	Less hairy	Very open	Thick
21-HA-31	Smooth	Less hairy	Very open	Medium thick
21-HA-45	Less wrinkle	Medium hairy	Medium	Thick
21-HA-48	Less wrinkle	Medium hairy	Light	Thick
21-KO-2	Smooth	Less hairy	Medium	Thick
21-KO-16	Less wrinkle	Medium hairy	Very open	Thick
21-KO-18	Less wrinkle	Medium hairy	Light	Thick
21-KO-21	Less wrinkle	Medium hairy	Medium	Thick
21-KO-34	Smooth	Less hairy	Light	Thick
21-KO-42	Less wrinkle	Medium hairy	Light	Thick
21-KO-44	Less wrinkle	Less hairy	Medium	Medium thick
21-KO-46	Less wrinkle	Medium hairy	Very open	Thick
21-KO-49	Smooth	Less hairy	Very open	Thick

were found to be 100% in all the selected almond types. Şimşek and Küden (2007) determined that the suture opening was shown as: not open in 5 types and open in 4 types. Şimşek (2008) determined that the suture opening was shown to be: not open in 4 types and open in 2 types. The values with respect to the suture opening in this study were similar to those of Şimşek and Küden (2007). Very wide suture opening is seen as an undesirable characteristics. In addition, the kernel ratio, shell hardness, double kernel ratio, twin kernel ratio, sound kernel ratio and suture opening of almond types and cultivars can change according to the genetic characteristics. Şimşek (2008) observed that the kernel colour intensity was found to be light in 1 type, medium in 3 types and dark in 2 types. The kernel colour intensity is desired to be light. Şimşek (2008) observed that the shrivelling of kernel was found to be smooth in 2 types and less wrinkle in 4 types. In addition, Aslantaş (1993) observed that the shrivelling of kernel was found to be wrinkle in 1 type, less wrinkle in 11 types and smooth in 8 types. Although shrivelling of kernel is an inherited property, it can change according to early or late harvest.

Kalyoncu (1990) observed that the kernel hairiness was determined to be less hairiness in 8 types and medium hairiness in 4 types in the selected almond types. Kernel hairiness is undesirable because it is not welcome by the mouth and does not create a beter image. In addition, hairiness is negatively affected by the roast of kernels. Şimşek and Küden (2007) and Şimşek (2008) determined that the kernel taste observed to be sweet in all selected

almond types. The values with respect to kernel taste in this study were similar to those of Şimşek and Küden (2007) and Şimşek (2008). Kernel taste of almond types and cultivars can change according to the purpose of researches.

Şimşek (2008) determined the yield was shown to be high in 3 types and medium in 3 types. Although the yield is an inherited property, it can change according to pollination, maintenance requirements and ecological conditions of almond types and cultivars. Aslantaş (1993) determined that the flowering occured to be 11th April-4th May in 1992 and 5th April - 3rd May in 1993. In addition, Aslantaş (1993) determined that flowering lasted 9 – 10 and 8 – 12 days in the same years, respectively. Kuden et al. (2001) determined that flowering occurred to be 25th February - 26th March in 1999 and 10th March - 24th March in 2000. In general, the difference between the flowering periods of almond types and cultivars can change according to altitude, ecological conditions and genetic characteristics.

Finally, the selected almond types in Kocaköy and Hani counties of Diyarbakir province were seen in their outcome in most characteristics. 21-KO-34 according to flowering and 21-KO-49 according to quality have the highest total scores. In addition, these types should be the adaptations in the same ecological conditions with standard almond types and cultivars. As a result of adaptation, the best almond types and cultivars can be produce and contribute to the economy of our country.

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