Study on morphological parameters of the sweet almond nut *(Amygdalus communis l.)*

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Abstract. This article delves into the morphological features of various sweet almond (Amygdalus communis L.) varieties and forms, with the aim of analyzing their characteristics and applying the findings to obtain new types of almonds. Thirteen different sweet almond varieties were studied, including their total weight, kernel mass, number of seeds, and seed ratio. The results showed that one genotype (Qamashi-3) had medium to large nuts, while the other twelve genotypes had small nuts. All genotypes had easily peeled shells. Of the selected varieties, 15.38% were very large, 46.15% were medium to large, and 38.46% were small-fruited. The length, width, and thickness of the nut varied from 22.0 mm to 39.2 mm, 14.0 mm to 23.0 mm, and 11.0 mm to 16.5 mm, respectively. The thickness of the seed coat ranged from 1.5 mm to 3.1 mm. The number of nuts per 1 kg differed across varieties, ranging from 139 to 1076 pieces. Two genotypes had very hard shells (Tosh almond, Qamashi-3), four had hard shells, three had medium-hard shells, and six had soft shells. Most of the genotypes had sweet grains (12 genotypes), while one had a bittersweet taste. Overall, the studied sweet almond genotypes are important for expanding the genetic base in Uzbekistan through hybridization with each other or with standard varieties.

1. Introduction

Almonds are a popular food and medicinal plant with increasing worldwide consumption. This is due to their rich taste, nutritional and dietary benefits, and their use in processed products. Almonds are composed of high levels of proteins and unsaturated fatty acids, making them useful for dietary nutrition when natural resources should be limited. Additionally, their unique quality of long-term storage (up to three years) without loss of taste and consumer qualities allows for easy export over long distances.

Almonds can be found growing in the wild as well as in vegetable gardens, orchards, and forestry. There are approximately 40 different types of almonds known worldwide, and they are distributed in Asia, North and Central America, Southern Europe, Transcaucasia, and Central Asia [1]. Most modern almond varieties are known for their regular fruiting and high yields.

Sweet almond (*Amygdalus communis l.*) is a plant belonging to the almond family of the Rosaceae family [2, 3]. Almonds are widely distributed mainly in the countries of the Mediterranean, Central America and Central Asia. Italy, France, Crimea, Transcaucasia and the countries of Central Asia, including Uzbekistan, are the leading producers of almonds [4]. The sweet almond tree can reach a height of 4-10 meters and has branches with a red-brown color and leaf bundles with narrow, lanceolate shapes. The fruit is dry and contains oblong-ovoid seeds that are approximately 3-4 cm in length [5]. The almonds typically ripen 4-5 months after flowering and can yield crops in 3-4 years after planting, with a maximum yield after 10-12 years. These trees can live up to 100 years and have a deep root system, reaching up to 6 meters. Sweet almond kernels have a unique taste and are important in the food industry, with high-quality oil being extracted from them.

Many different types of almonds have been created using sweet almonds as a base. These varieties vary in the quality, size, and shape of their fruits. A study was conducted on the nut, core, and seed tree of the almond species Amygdalus communis L. found in the Datca peninsula in Turkey. It was discovered that this species is suitable for developing new varieties. It has been suggested that hybridizing genetically diverse almond genotypes with each other or with standard cultivars could expand the genetic base and create improved almond cultivars through the generation of necessary recombinants [6].

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There are four known species of almonds in Uzbekistan, with the sweet almond being the only one cultivated while the others grow in the wild. Almond groves in the country are mostly located in mountainous and foothill areas due to the favorable soil and climatic conditions for the plant. It is widely grown in mountainous regions at an altitude of 1000-1200 m above sea level, particularly in the Ferghana Valley, Kashkadarya, Surkhandarya, Samarkand, and Tashkent regions. With its high drought resistance, heat tolerance, and ability to thrive in undemanding soil conditions, almonds hold great promise for production in Uzbekistan. The total area of natural almond groves in our republic is more than 18,000 hectares, and to expand these areas, it is necessary to create almond groves on pastures and develop agricultural technology for their maintenance. Almonds are propagated by seeds, and cultivars by grafting [7, 8]. Taking into account the need for almonds in light, seedlings are planted in autumn or early spring according to the scheme 8x8 m on flat areas, and 6x6 m on mountainous and foothill dry lands (5x5 m on the southern slopes). In a young garden, agrotechnical activities are carried out, such as watering, top dressing, and formation [9].
During research Y.X. Yuldashov found that planting seedlings on warm January days when the soil reaches the norm for planting can result in up to 92% success in almond growth [10].

2. Materials and Methods

Selected varieties and forms of almonds were obtained from forests, farms, forestry, and squares of the southwestern ridges of the Gissar Range, located in the south of the Republic of Uzbekistan. Our research delved into the morphological characteristics of crops harvested from almond forests and orchards, both in their natural state and cultivated (see Figure 1).

Fig. 1. Collection area of varieties and forms of almonds

Morphological analysis was carried out on 100 nuts of each selected variety and form. Nut weight, nut size, nut width, nut thickness, kernel weight, kernel volume, number of kernels per shell, kernel ratio, kernel flavor, kernel color, kernel rot, ease of shell separation, shell thickness, and shell hardness and the results are shown in Tables 1 - 5. Nut weight (with shell) and kernel weight (g) were measured with an accuracy of 0.03 g using an MH-500 digital pocket scale. The length, width, and thickness (mm) of the bone were measured using a circular machine with an accuracy of 0.02 mm. Nut size, kernel size, number of kernels, kernel ratio, ease of peeling, shell hardness (according to the kernel ratio scale), and structure of the outer shell were measured according to the methodology for the description of almonds.

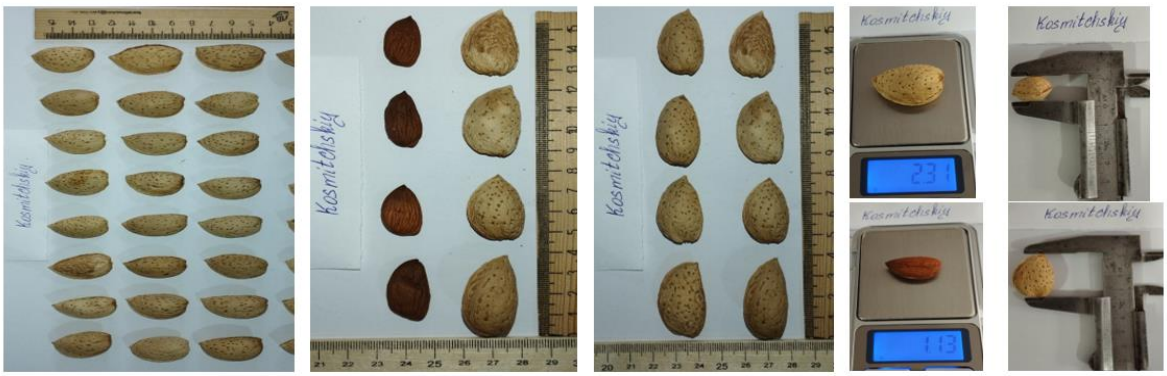

Fig. 2. "Kosmitchskiy" variety

Fig. 3. "Oq-po'stloq" form

Fig. 4. "Tish" almond form

Fig. 5. "Maymanaq" form

Fig. 6. "Yumoloq" almond form

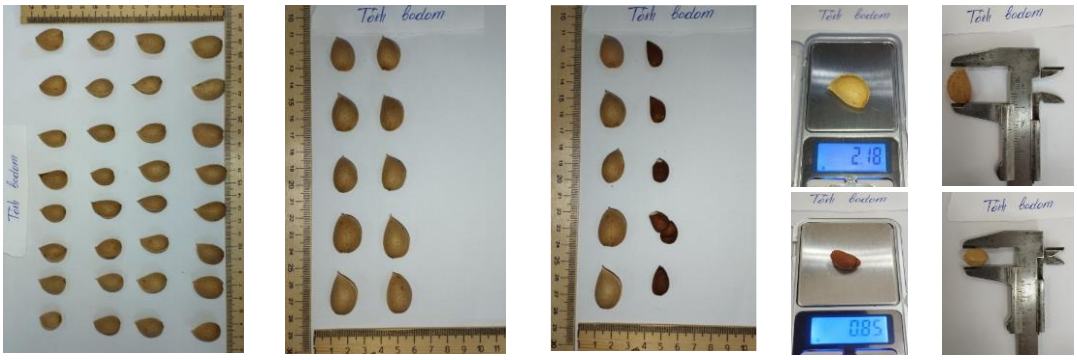

Fig. 7. "Tosh" almond form

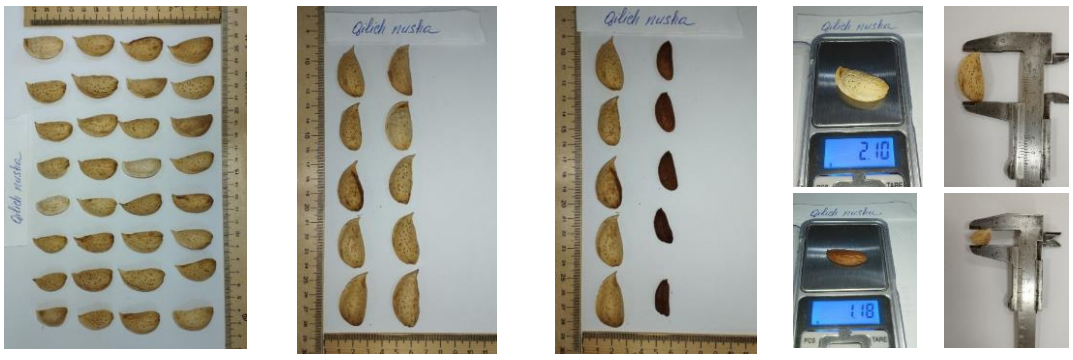

Fig. 8. "Qilish nusha" variety

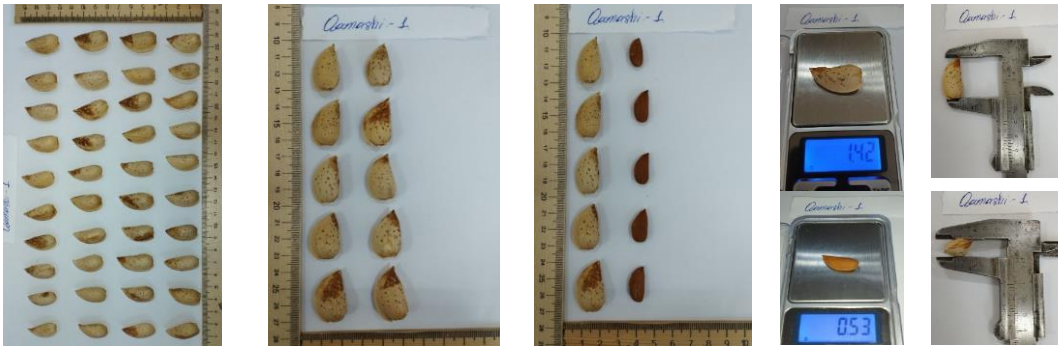

Fig. 9. "Qamashi-1" form

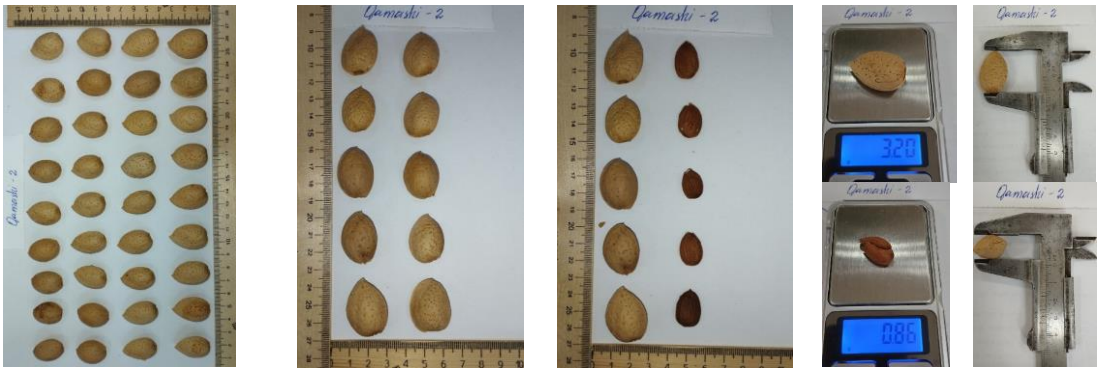

Fig. 10. "Qamashi-2" form

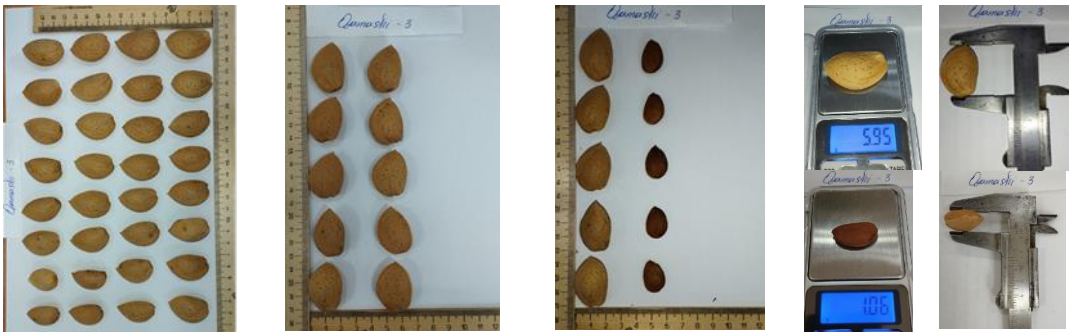

Fig. 11. "Qamashi-3" form

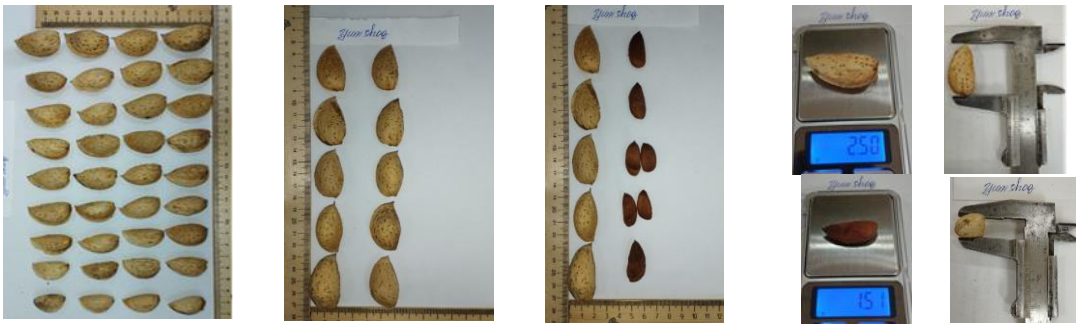

Fig. 12. "Yumshoq-1" (Soft-1) form

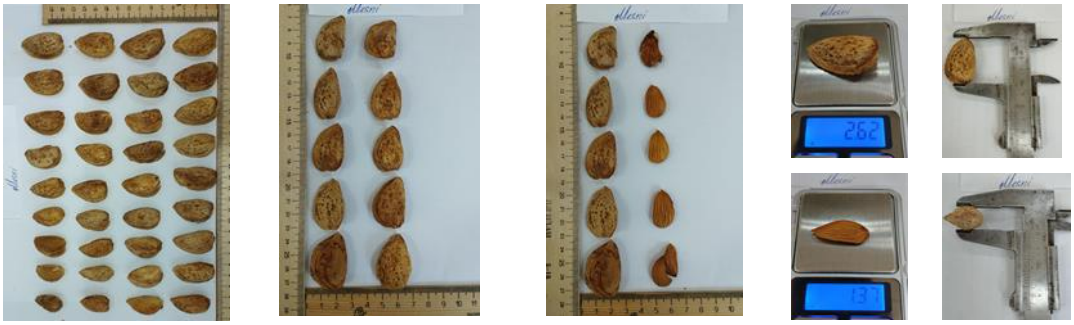

Fig. 13. "Langar" form

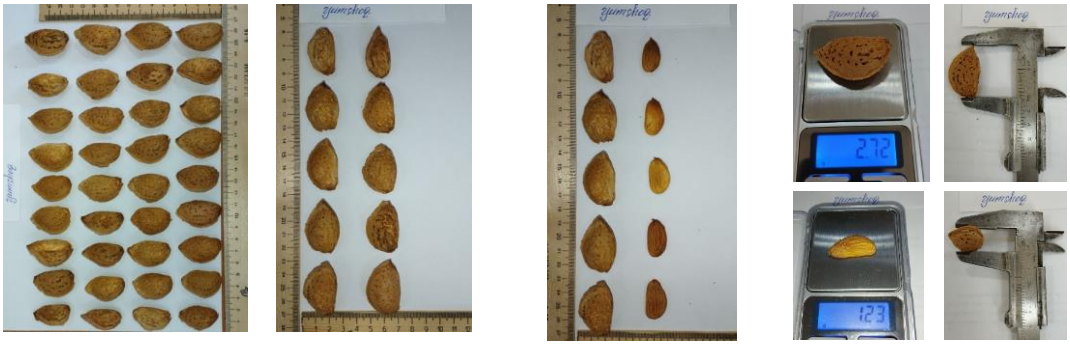

Fig. 14. "Yumshoq-2" (Soft-2) form

3. Results

Our study of 11 different varieties and 2 forms of nuts (see Figures 2-14) (Yomaloq almond, Maymanaq, Tish almond, Oq po'stloq, Kosmitchskiy, Tosh-bodom, Qilich nusha, Qamashi-1, Qamashi-2, Qamashi-3, Soft-1, Soft-2, Langar) conclusively determined their mass, kernel mass, number of kernels, and kernel ratio (see Figure 15). The range of nut weight was extensive, with the smallest nut weighing 0.95 g and the largest weighing 5.95 g. Similarly, the smallest

kernel weighed 0.52 g, and the largest weighed 1.51 g. We observed that the kernel yield from the total weight of the stone ranged from 17.81% to 64.50%, highlighting significant variability among the genotypes. Among the 13 genotypes studied, one had medium-large nuts, while the remaining twelve had small nuts. Two genotypes had very large seeds, six had large seeds, and five had small seeds, providing important insights into the diversity of nuts. We also found that all genotypes were easily purified, which is an important factor when considering their potential for commercial use. Our findings revealed that 15.38% of the varieties and forms belonged to the very large group, 46.15% to the medium-large group, and 38.46% to the small-fruited group (Table 1).

Some characteristics of nuts and shells of 13 selected varieties and forms of almonds were studied. When studying the length, width, thickness, and thickness of the nutshell, the results ranged from 22.0 mm to 39.2 mm in terms of the length of the nut. Nut width from 14.0 mm to 23.0 mm. Nut thickness from 11.0 mm to 16.5 mm. In terms of shell thickness, it ranged from 1.5 mm to 3.1 mm. It has been established that the number of nuts in 1 kg is from 139 to 1076 pieces. Taking into account the hardness of the shell, two genotypes are found to be very hard (tosh bodom), four genotypes are hard, three genotypes are medium hard, and six genotypes are soft (Table 2).

The characteristics of the outer shell, the ratio of double kernels, the shape of the nut, and the seam of the shell of 13 almond genotypes of selected varieties and forms are given. When studying the characteristics of the outer shell, it was found that four genotypes have pores in the shell with intermediate pores, seven genotypes have dense pores and two genotypes do not have pores in the shell. In terms of nut shape, seven genotypes are long oval, three genotypes are oblong, two genotypes are round, and one genotype is ovoid. In terms of the coefficient of the double core, it turned out to be equal to 0.00-75.00%. We found that two out of 13 genotypes had open shell sutures and eleven genotypes did not have open shell sutures (Table 3).

The indicators of 13 almond genotypes of selected variations and forms were evaluated in terms of taste, color, rotting of the kernels, and drying out of the kernels. The kernels are sweet in the majority of genotypes (12 geno types), but bittersweet in one genotype. It was discovered that five genotypes have an intermediate, medium color, three genotypes are light, four genotypes are dark, and one genotype is very dark color. The kernel skin of seven genotypes was somewhat wrinkled, while the skin of six genotypes was moderately wrinkled (Table 4). Studies of the index of decay of the kernels showed that the kernels of almonds of seven genotypes had an average index of decay, and the kernels of 8 genotypes had a light index of decay. Color, wrinkling, and rotting of the almond kernel are of great importance in the production of almond products.

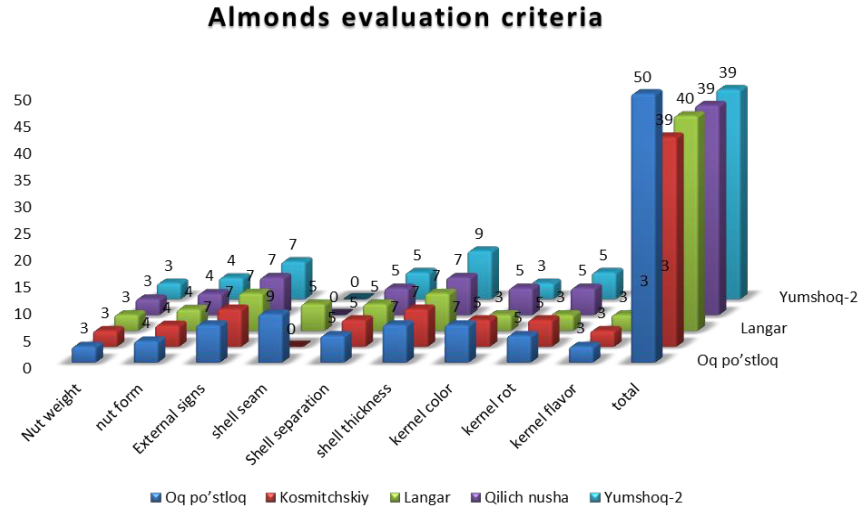

Fig. 15. Almonds evaluation criteria

Among 13 types of almonds, it was discovered that one type had large nuts while the other 12 had small nuts. Among the kernels, two types had very large kernels and six had medium-sized kernels. Five types of almonds had a kernel ratio above 50%. Additionally, seven types of almonds had nuts that were longer than 30 mm and five types had nuts thicker than 15 mm. Eight types had nuts wider than 20 mm, while only five had a shell thickness of 2.0 mm or less. Six types of almonds had soft shells and seven had dense holes. Two types of almonds had a double kernel ratio above 50%. Seven types of almonds had an elongated oval shape and two had an open seam. For all 12 types of almonds, the kernels were sweet, except one - bittersweet. Among the five types with a medium-colored kernel, four had a dark-

colored kernel. Six types of almonds had an average level of kernel rottenness and seven had a low level of decay (Table 5).

Table 1. Characteristics of nut weight, kernel weight, number of kernels and ratio of kernels of selected varieties and forms of almonds

T/r	Selected varieties and forms	Nut weight (g)	Nut size	Kernel weight (g)	Kernel volume	Kernel ratio (%)	Shell separation
1	Yomaloq bodom	2.29 ± 0.61	small	1.11 ± 0.07	Medium large	48.50	Easy
2	Maymanaq	2.52 ± 0.97	Small	1.33 ± 0.12	Medium large	52.77	Easy
3	Tish bodom	1.47 ± 0.56	Small	0.71 ± 0.03	Small	48.30	Easy
4	Oq po'stloq	0.93 ± 0.38	Small	0.60 ± 0.02	Small	64.50	Easy
5	Kosmitchskiy	2.32 ± 1.02	Small	1.13 ± 0.09	Medium large	48.70	Easy
6	Tosh bodom	2.18 ± 0.85	Small	0.85 ± 0.03	Small	39.00	Easy
7	Qilich nusha	2.10 ± 0.96	Small	1.18 ± 0.10	Medium large	59.20	Easy
8	Qamashi-1	1.44 ± 0.63	Small	0.52 ± 0.03	Small	36.11	Easy
9	Qamashi-2	3.20 ± 0.71	Small	0.86 ± 0.05	Small	26.87	Easy
10	Qamashi-3	5.95 ± 1.15	Medium large	1.06 ± 0.08	Medium large	17.81	Hard
11	Soft-1	2.50 ± 1.06	Small	1.51 ± 0.11	Large	60.40	Easy
12	Soft-2	2.72 ± 0.74	Small	1.23 ± 0.09	Medium large	45.50	Easy
13	Langar	2.62 ± 0.95	Small	1.37 ± 0.10	Large	52.30	Easy

Table 2. Indicators of length, thickness and width of nuts of selected varieties and forms of almonds

Selected varieties and forms	Nut length, mm	Nut thickness, mm	Nut Width, mm	Shell thickness, mm	The number of nuts in 1 kg picks	Shell thickness
Yumaloq almond form	24.0 ± 0.51	15.0 ± 0.47	21.5 ± 0.50	1.6 ± 0.14	437 ± 37	hard
Maymanaq form	30.0 ± 0.85	16.5 ± 0.56	23.0 ± 0.63	2.2 ± 0.11	397 ± 31	medium hardness
Tish almond form	23.8 ± 0.49	12.5 ± 0.32	16.2 ± 0.42	2.1 ± 0.23	681 ± 68	medium hardness
Oq po'stloq form	22.0 ± 0.25	11.0 ± 0.25	14.0 ± 0.29	1.5 ± 0.12	1076 ± 96	Soft
Kosmitchskiy variety	32.0 ± 0.89	13.5 ± 0.58	17.8 ± 0.46	2.0 ± 0.19	432 ± 42	Soft
Tosh almond form	25.0 ± 0.94	14.5 ± 0.61	21.6 ± 0.53	2.2 ± 0.30	456 ± 61	Very hard
Qilich nusha variety	34.0 ± 1.02	21.5 ± 0.84	27.0 ± 0.89	1.9 ± 0.18	477 ± 43	Soft
Qamashi-1 form	29.5 ± 1.11	11.0 ± 0.51	14.0 ± 0.65	2.0 ± 0.26	695 ± 70	medium hardness
Qamashi-2 form	28.5 ± 1.08	14.0 ± 0.62	20.0 ± 0.78	1.8 ± 0.20	313 ± 30	Hard
Qamashi-3 form	39.2± 1.36	14.2 ± 0.63	20.5 ± 1.12	3.1 ± 0.25	169 ± 17	Very hard
Soft-1 form	39.0 ± 1.44	13.0 ± 0.49	18.2 ± 0.74	2.0 ± 0.15	400 ± 30	Soft
Soft-2 form	38.0 ± 1.03	15.5 ± 0.57	22.5 ± 0.69	2.1 ± 0.16	368 ± 27	Soft
Langar form	38.5 ± 1.00	15.0 ± 0.53	22.0 ± 0.65	2.2 ± 0.15	382 ± 25	Soft

Table 3. Characteristics of the ratio of the number of shells, the kernel of the selected varieties and forms of almonds

Selected varieties and forms	Signs of the outer shell	Double kernel ratio	One kernel ratio	Form of nut	Outer shell seam
Yomaloq almond form	Intermediate Pores	50.00	50.00	Round	Closed
Maymanaq form	Intermediate Pores	75.00	25.00	Oblong	Closed
Tish almond form	Intermediate Pores	25.00	75.00	Round	Closed
Oq po'stloq form	Dense Pores	0.00	100.00	Long oval	Opened
Kosmitchskiy variety	Dense Pores	0.00	100.00	Long oval	Closed
Tosh almond form	Without Pores	10.00	90.00	Ovoid	Closed
Qilich nusha variety	Dense Pores	0.00	100.00	Long and narrow	Closed
Qamashi-1 form	Intermediate Pores	0.00	100.00	Long and narrow	Closed
Qamashi-2 form	Without Pores	0.00	100.00	Oblong	Closed
Qamashi-3 form	Dense Pores	0.00	100.00	Oblong	Closed
Soft-1 form	Dense Pores	40.00	60.00	Long oval	Closed
Soft-2 form	Dense Pores	0.00	100.00	Long oval	Closed
Langar form	Dense Pores	10.00	90.00	Long oval	Opened

Table 4. Taste, color, indicators of wrinkling and decay of individual varieties and forms of almonds

Selected varieties and forms	Kernel flavor	Kernel color	Kernel skin	Kernel rot	Kernel form
Yomaloq almond form	Sweet	Very dark	Smooth	Middle	Round
Maymanaq form	Sweet	Middle	lightly wrinkled	Past	Oblong
Tish almond form	Sweet	Dark	lightly wrinkled	Past	Round
Oq po'stloq form	Sweet	Dark	Smooth	Middle	Long oval
Kosmitchskiy variety	Sweet	Middle	Smooth	Middle	Long oval
Tosh almond form	Sweet	Middle	lightly wrinkled	Past	Ovoid
Qilich nusha variety	Sweet	Middle	Smooth	Middle	Long and narrow
Qamashi-1 form	Sweet	Light	Lightly wrinkled	Past	Long and narrow
Qamashi-2 form	Sweet	Dark	Smooth	Middle	Oblong
Qamashi-3 form	Bitter-sweet	Dark	lightly wrinkled	Past	Oblong
Soft-1 form	Sweet	Middle	lightly wrinkled	Past	Long oval
Soft-2 form	Sweet	Light	Smooth	Middle	Long oval
Langar form	Sweet	Light	lightly wrinkled	Past	Long oval

Table 5. Nut scoring of 13 identified genotypes by morphological parameters

Selected varieties and forms	Nut weight (1-9 score)	Nut form (1-9 score)	Signs of the outer shell (1-9 score)	Outer shell seam (1-9 score)	Shell separation (1-9 score)	Shell thickness (1-9 score)	Kernel color (1-9 score)	Kernel skin wrinkling (1-9 score)	Kernel flavor (1-9 score)	Total score
Yomaloq almond form	3	1	5	0	5	2	9	5	3	**33**
Maymanaq form	3	3	5	0	5	7	5	3	3	**34**
Tish almond form	3	1	5	0	5	5	7	3	3	**32**
Oq po'stloq form	3	4	7	9	5	7	7	5	3	**50**
Kosmitchskiy variety	3	4	7	0	5	7	5	5	3	**39**
Tosh almond form	3	2	0	0	5	1	5	3	3	**22**
Qilich nusha variety	3	4	7	0	5	7	5	5	3	**39**
Qamashi-1 form	3	4	5	0	5	2	3	3	3	**28**
Qamashi-2 form	3	3	0	0	5	2	7	5	3	**28**
Qamashi-3 form	5	3	7	0	5	1	7	3	7	**38**
Soft-1 form	3	4	7	0	5	7	5	3	3	**37**
Soft-2 form	3	4	7	0	5	9	3	5	3	**39**
Langar form	3	4	7	5	5	7	3	3	3	**40**

4. Conclusion

Thirteen different types of sweet almonds were analyzed for their morphological indicators. Out of these, one genotype had a large shell while the remaining twelve had small shells. Two genotypes had large seeds while six had medium-large seeds. Five genotypes had a ratio of almonds above 50%. Seven genotypes had nuts longer than 30mm, while five genotypes had shells thicker than 15mm. Eight genotypes had almonds wider than 20mm, and five had shells 2.0mm or less thick. Six genotypes had soft shell hardness, while seven genotypes had dense holes. Two genotypes had almonds with a double kernel ratio above 50%. Nuts of seven genotypes had an elongated oval shape, and two genotypes had an open seam. Twelve genotypes had sweet-tasting kernels, five had sweet-colored kernels, and four

had mediums to dark-colored kernels. Six genotypes had an average level of kernel rottenness, while seven had a low level. Based on the above indicators, morphological features were evaluated. The results showed that the “Oq pustloq” form of almonds scored 50 points, the “Langar” form - 40 points, the varieties “Kosmichesky”, “Qilich Nushva” and the “Langar” form - 39 points. We concluded that these varieties and forms of the common almond will serve as the basis for the creation of high-quality almond plantations and orchards in the future.

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