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Determination of Quality Characteristics of Advanced Chickpea Genotypes

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Abstract
The research carried out between 2021 and 2022 to determine the quality parameters of some advanced chickpea genotypes in Kırşehir ecological conditions was established on the trial plots of Kırşehir Ahi Evran University Agricultural Research and Application Area. In the study, 40 chickpea genotypes, including 35 local chickpea genotypes selected by pure line selection method and 5 chickpea cultivars registered by Agricultural Research Institutes in our country, were used. The study, which was carried out for two years, was established in an augmented trial design with 4 replications. During the research, water uptake capacity (g seed^{-1}), water uptake index (%), swelling capacity (ml seed^{-1}), swelling index (%), coat ratio (%), and protein ratio (%) data of 6 quality characteristics of chickpea genotypes were revealed. According to the results of the analysis of variance, statistically significant or very important differences were determined between the chickpea genotypes in terms of all the quality parameters. In the study carried out, the highest protein rate was determined in the N-21 chickpea genotype at 24.99%, while the lowest protein yield was determined in the N-36 chickpea genotype at 19.34%.

Research Article

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1. Introduction

Chickpea is a legume plant grown both in our country and in the world. At the same time, it is important in terms of its cheap and abundant availability as a protein source whose need is constantly increasing (Bhan and Kukula, 1987). Chickpea, which is grown not only as human food but also as a valuable animal feed, is widely cultivated in the Eastern Mediterranean, Africa, and Central America. Chickpea grain has high protein (18-35%) and carbohydrate (38-59%) and 4.8-5.9% fat, 3% ash, 3% fiber, 0.2% calcium and 0.3% phosphorus (Hulse, 1991).

Thanks to the *Rhizobium cicer* bacteria living freely in the soil, they contribute to the organic matter enrichment of the fields grown as a result of the nodules they form in the roots, as a result of bringing the free nitrogen of the air to the soil. Chickpea is the second most resistant plant to high temperature and drought after lentils. In addition, since it is a plant that can grow in poor soils, it plays an important role in increasing the yield per unit area and reducing our fallow areas in our arid regions where crop rotation is applied (Eser, 1978).

It is one of the first plants to be cultivated among legumes, and there is no definite evidence of when it was cultivated, and there are strong estimates that it was cultivated at the same time as lentils and peas. As a result of the age determination analysis carried out as a result of archaeological excavations, it is stated that the chickpea materials date back to at least 7,000 years ago. The Eastern Mediterranean region, including Turkey, is shown as the gene center (Akçin, 1988). Today, it is known that chickpea cultivation is carried out in 56 countries in the world geography, where climate and soil conditions allow (FAO, 2021). However, although it is possible to grow it in larger areas, it is seen that some countries do not deal with this product enough because they use alternative products (Rao et al., 2002). However, it has managed to maintain its importance for many years in the geography in which our country is located (Ladizinsky, 1975).

The main goal of chickpea, which is a legume plant, is to develop varieties with high-quality content and grain yield. To determine this basic goal, chickpea varieties with high grain yield and quality content can be grown by applying cultivation techniques by the ecological conditions of the locations where they are grown. However, it is an undeniable fact that the use of certified chickpea seeds is very low in the Central Anatolia Region, which includes Kırşehir province, on the contrary, local chickpea populations are used.

In edible legumes, including chickpeas, quality elements are grouped under 3 main headings (the factors that the consumer considers, the factors that positively affect the nutritional value, and the factors that negatively affect the nutritional value) in terms of nutritional values (Pekşen and Artık, 2005). Due to its nutritional importance, it is important to develop and identify chickpea genotypes that can adapt to the ecological characteristics of the locations where it is grown and that are superior in terms of grain yield and quality content, in terms of adequate nutrition of our people.

The main purpose of this research is to determine the quality parameters of 40 chickpea genotypes, including 35 local chickpea genotypes and 5 standard chickpea varieties, collected from town, and villages of Kırşehir province and brought to the advanced level through selection, under Kırşehir ecological conditions.

2. Features of the Research Place

2.1. Features of the location where chickpea studies are carried out

2.1.1. Soil properties

The field studies of the research, which

was carried out for 2 years in 2021 and 2022, were carried out under Kırşehir ecological conditions in the Agricultural Research and Application Land of Kırşehir Ahi Evran University. The trial area, where the research was carried out, is at an altitude of approximately 1000 m from the sea, and the data on the soil properties of the trial area are given in Table 1. When the table is examined, it has been determined that the soil of the trial field is slightly alkaline, the organic matter is moderate, the amount of available phosphorus is very low (<3), the available potassium is high, the salt content is unsalted (<0.15) and the lime content is very calcareous (15-50).

Table 1. Some soil characteristics of the trial field

	2021	**2022**	**Meaning**
Saturation (%)	55	57	slightly alkaline
pH	7.59	7.63	neutral
Total Salt (%)	0.02	0.11	without salt
$CaCO_3$ (%)	27.9	25.9	very chalky
P_2O_5 (kg da^{-1})	2.14	2.22	very little
K_2O (kg da^{-1})	66.6	67.33	high
Organic Matter (%)	1.81	1.86	medium-level

2.1.2. Climate characteristics

In Kırşehir, summers are hot and dry, and winters are cold and rainy. The meteorological data of the trial plots where the research was carried out for two years were obtained from the Kırşehir Provincial Meteorology Directorate and the average values are given in Table 2.

When the table is examined in terms of average temperature, it is seen that there is not a big difference between the average of long years and the averages of 2021 and 2022. The long-term average shows that the lowest monthly temperature average is 5.9 °C in March, and the highest monthly average temperature is 23.7 °C in July. During the two-year trial period, these values were observed at 4.5 °C in March 2021 and 25.6 °C in July 2022, respectively. In the monthly average precipitation values of 2 years, it is seen that the total precipitation amounts in March (95.2 mm) of 2021 and June (38.3 mm) and July (9.7 mm) of 2022 are above the average for long years, whereas the average precipitation amount of the months in the vegetation period of 2021 and 2022 is below the average precipitation amount of the months for long years. In the monthly average relative humidity values, it was determined in Table 2 that the relative humidity value of June 2011 (55.1%) was above the relative humidity averages for many years.

Table 2. Climate data of Kırşehir province for long years, 2021 and 2022

Months	**Average Temperature (°C)**			**Total Precipitation (mm)**			**Average Relative Humidity (%)**		
	1980-2020	**2021**	**2022**	**1980-2020**	**2021**	**2022**	**1980-2020**	**2021**	**2022**
March	5.9	4.5	8.0	37.9	95.2	15.4	66.7	65.5	61.6
April	10.8	12.0	10.8	42.7	19.4	25.3	62.7	56.5	55.2
May	15.7	18.2	15.9	46.2	9.2	42.1	60.6	45.3	56.6
June	20.0	19.3	20.6	37.5	35.1	38.3	54.9	55.1	49.3
July	23.7	24.9	25.6	8.9	0.9	9.7	46.9	40.4	41.1
Total				**173.2**	**159.8**	**130.8**			
Average	**15.2**	**15.8**	**16.2**				**58.4**	**52.6**	**52.8**

3. Materials and Methods

3.1. Material

In the research, 40 chickpea genotypes, including 35 local chickpea genotypes and 5 chickpea cultivars, were collected from the districts, town, and villages of Kırşehir and their morphological characterizations were carried out.

The information on the province, district, town, and villages where the local chickpea genotypes were collected and some morpho-agronomic characteristics of the standard chickpea varieties used in the study are given in Tables 3 and 4.

3.2. Method

The trial areas of the research carried out were plowed deeply with plows in autumn and left for winter rains. In March of both years, just before the planting process, the fields where the trials will be carried out were first cleaned of weeds by inserting a cultivator tool, and then the trial areas were made ready with rotovators.

The research carried out in both years was established in the Augmented Experimental Design. In the experiments, 5 standard cultivars were included in each block and one of the standard cultivars was placed in the first parcel at the beginning of each block, and the other standard cultivars were randomly placed in the blocks. The local chickpea genotypes in the experiments were distributed to the blocks in sequence without repetition. The minimum number of blocks required was determined on the basis that the error degree of freedom in the analysis of variance of standard chickpea varieties was at least 10 (Peterson, 1994). In this respect, the research carried out for two years was established on 4 blocks. 3 blocks each consist of 29 parcels and 1 block each consists of 28 parcels. In both years, standard cultivars were planted in 20 of each block (4 blocks x 5 std. varieties), and local chickpea genotypes were planted in the others. In the research carried out, sowing was carried out on 15 March 2021 in the first year and on 24.03.2022 in the second year.

Table 3. Provinces, districts, and villages where local chickpea genotypes are collected

Genotype	Collected			Genotype	Collected		
	Province	District	Village		Province	District	Village
N-1	Kırşehir	Kaman	Yelek	N-29	Kırşehir	Kaman	Hacıömerli
N-2		Kaman	Tatık	N-30		Kaman	Ömerhacılı
N-3		Kaman	Savcılı	N-32		Central	Kortulu
N-5		Mucur	Rizvan	N-33		Central	Yeşilli
N-6		Mucur	Aydoğmuş	N-36		Akçakent	Polatlı
N-7		Mucur	Yazıkınık	N-37		Akçakent	Yaylaözü
N-10		Central	Yeşili	N-42		Akçakent	Avanoğlu
N-12		Mucur	Acıöz	N-44		Akpınar	Aşağıhomurlu
N-13		Mucur	Geycek	N-45		Central	Pekmezli
N-14		Mucur	Geycek	N-46		Akpınar	Köşker
N-18		Kaman	Benzer	N-48		Kaman	Çağırkan
N-19		Çiçekdağı	Kızılcalı	N-49		Kaman	Başköy
N-20		Çiçekdağı	Kızılcalı	N-52		Central	Merkez
N-21		Çiçekdağı	Büyükteflek	N-53		Central	Hacı Ahmetli
N-23		Kaman	Taşlık	N-54		Central	Merkez
N-24		Çiçekdağı	Boğazevci	N-55		Çiçekdağı	Merkez
N-27		Çiçekdağı	Hacıköy	N-57		Kaman	Hamit
N-28		Kaman	Kargınyenice				

Sowing was done manually at a depth of 4 cm in rows opened with a marker, on 8 cm rows at 30 cm row spacing, 50 seeds per row. For two years, 15 kg of DAP fertilizer was applied per decare together with the plantings in the trial areas. Weed pesticides were applied to combat weeds. In the two-year study, hoeing was done 3 times during the vegetation period. In the studies carried out for two years, the harvesting of the chickpea genotypes in the trial areas was carried out manually between 20 July and 05 August, which is the period when they reached harvest maturity. Harvested plants were placed in separate sacks labeled and brought to the laboratory of Kırşehir Ahi Evran University, Faculty of Agriculture, Field Crops Department, where necessary measurements and analyses would be made.

Table 4. Some morpho-agronomic characteristics of chickpea cultivars used in the study

Varieties	Aksu	Yaşa-05	Azkan	Uzunlu-99	Zuhal
Registration Year	**2009**	**2005**	**1998**	**1999**	**2012**
Variety Owner Organization	DAGKTAE (Kahramanmaraş)	GKTAE (Eskişehir)	GKTAE (Eskişehir)	TBMAEM (Ankara)	KTAE (Samsun)
Plant Height (cm)	45-50	30-45	41-46	50-55	30-35
The First Pod Height (cm)	25-35	12-20	35	20	16-22
Number of Pods per Plant	24-30	24-30	24-30	28-32	26-32
100 Seed Weight (g)	45-47	35-45	42.5-49,9	44-46	45.2-49,2
Yield (kg da^{-1})	175-200	150-230	130-210	150-175	150-175
Seed Color	beige	light beige	beige	beige	beige

DAGKTAE : East Mediterranean Transitional Zone Agricultural Research Institute, GKTAE : Transitional Zone Agricultural Research Institute
TBMAEM : Field Crops Central Research Institute, KTAE : Black Sea Agricultural Research Institute

After harvesting for two years, 6 quality parameters were evaluated in 100 seeds of each chickpea genotype, including water uptake capacity (g seed^{-1}), water uptake index (%), swelling capacity (ml seed^{-1}), swelling index (%), coat ratio (%) and protein ratio (%). The results obtained from the research were firstly subjected to the combined year variance analysis in the "JUMP 7.0" statistical package program by the Augmented Experimental Design, then the significance control between the standard chickpea varieties was made separately for each quality parameter according to the LSD test for the differences between local chickpea genotypes according to the variance analysis.

4. Findings and Discussion

4.1. Water uptake capacity

The most important factors affecting the water uptake capacity are the physical shape of the cell wall, the current state of the cells in the seed and the botanical content of the seeds. It has also been demonstrated that there is a significant and positive relationship between seed weight and water uptake capacity (Kaur and Singh, 2006). While the water uptake capacity of chickpea genotypes with large grain size increases, the water uptake capacity decreases as the seed size decreases (Karasu, 2003). The combined average water uptake capacity values of a total of 40 chickpea genotypes included in the study are given in Table 5.

Table 5. Combined average water uptake capacity (g seed^{-1}) values and statistical groupings

Number	Genotypes	Water Uptake Capacity	Number	Genotypes	Water Uptake Capacity	Number	Genotypes	Water Uptake Capacity
1	N-21	0.429 klm	15	N-19	0.431 kl	28	N2	0.403 q
2	**Azkan**	**0.420 mn**	16	N-37	0.406 pq	29	N-6	0.450 h
3	**Uzunlu-99**	**0.400 r**	17	N-14	0.461 efg	30	N-12	0.494 b
4	N-45	0.457 fgh	18	N-10	0.449 h	31	N-3	0.403 q
5	**Zuhal**	**0.463 ef**	19	N-54	0.454 g	32	N-27	0.440 ıj
6	N-44	0.459 f	20	N-28	0.422 m	33	N-48	0.464 ef
7	**Aksu**	**0.468 e**	21	N-13	0.459 f	**34**	**N-24**	**0.501 a**
8	N-52	0.443 ı	22	N-55	0.408 p	35	N-7	0.416 n
9	N-32	0.419 mn	23	N-18	0.394 s	36	N-42	0.437 j
10	**Yaşa-05**	**0.386 tu**	24	N-1	0.456 fgh	37	N-29	0.434 k
11	N-30	0.390 t	**25**	**N-49**	**0.380 u**	38	N-23	0.479 d
12	N-20	0.446 hı	26	N-5	0.484 c	39	N-46	0.426 l
13	N-33	0.412 o	27	N-57	0.399 r	40	N-36	0.465 ef
14	N-53	0.396 rs						
Average		**0.437**						
Significance		**						
CV (%)		**3.71**						

As a result of the analysis of variance, it was observed that there was a statistically significant ($P<0.01$) statistical difference between local chickpea genotypes and standard chickpea cultivars in terms of the combined average water uptake capacity of both years. When the Table is examined in terms of standard chickpea varieties included in the study, the Aksu variety ranks first with a water uptake capacity of 0.468 g seed^{-1}, followed by the Zuhal variety with a water uptake capacity of 0.463 g seed^{-1}. The Yaşa-05 variety, on the other hand, took the last place in terms of water uptake capacity of all standard varieties with 0.386 g seed^{-1} and it was determined that the average water uptake capacity value of all standard varieties was 0.427 g seed^{-1}. In the study carried out in laboratory conditions to determine the quality characteristics of chickpea lines in Tunisia, it was determined that kabuli-type chickpea varieties had a higher seed weight and a certain volume than desi chickpea lines. In addition, it was reported by Sfayhi and Kharrat (2011) that a positive relationship was revealed between the cooking time and the water uptake capacity (R^2: 0.67). When the 35 local chickpea genotypes included in the study were examined in terms of water uptake capacity, it was seen that while the N-24 genotype was in the first place with a value of 0.501 g seed^{-1}, this genotype was followed by the N-12 genotype with a value of 0.494 g seed^{-1} and it was found in the 'b' statistical group. While the average water uptake capacity value was determined as 0.435 g seed^{-1} for all local chickpea genotypes, it was revealed in the study that the lowest water uptake capacity value was found in the N-49 genotype with a value of 0.380 g seed^{-1}. In the study carried out under laboratory conditions to determine the technological properties of 14 chickpea cultivars registered in Turkey, it was determined that the water uptake capacity values of the cultivars ranged between 0.979-1.223 g seed^{-1} (Toğay et al., 2001). In other studies on this quality parameter, Özer et al. (2007) 0.258-0.616 g seed^{-1}, Kaya et al. (2016) 0.390-0.720 g seed^{-1} and Yiğit (2018) 0.360-0.450 g seed^{-1} values determined.

4.2. Water uptake index

The water uptake index is calculated by dividing the water uptake capacity by the weight of a single seed. This value found for each genotype/variety is expressed as an indication of how much water a seed takes according to its original weight (Williams et al. 1986). Average water uptake index

values of 40 chickpea genotypes included in the study are given in Table 6.

Table 6. Combined average water uptake index (%) values and statistical groupings

Number	Genotypes	Water Uptake Index	Number	Genotypes	Water Uptake Index	Number	Genotypes	Water Uptake Index
1	N-21	1.183 ef	15	N-19	1.189 e	28	N-2	1.129 ghı
2	**Azkan**	**1.069 j**	16	N-37	1.086 ıj	29	N-6	1.136 gh
3	**Uzunlu-99**	**1.048 kl**	17	N-14	1.238 cd	30	N-12	1.090 ı
4	N-45	1.120 h	18	N-10	1.053 k	31	N-3	1.049 kl
5	**Zuhal**	**1.059 jkl**	19	N-54	1.112 hı	32	N-27	1.258 bc
6	N-44	1.204 de	20	N-28	1.134 gh	33	N-48	0.502 m
7	**Aksu**	**1.241 c**	21	N-13	1.211 d	34	N-24	1.065 jk
8	**N-52**	**1.296 a**	**22**	**N-55**	**0.422 o**	35	N-7	1.034 l
9	N-32	1.108 hıj	23	N-18	1.140 g	36	N-42	1.118 h
10	**Yaşa-05**	**1.152 fgh**	24	N-1	1.168 f	**37**	N-29	1.055 k
11	N-30	1.233 cde	25	N-49	1.117 h	38	N-23	1.141 g
12	N-20	1.266 b	26	N-5	1.159 fg	39	N-46	0.467 n
13	N-33	1.161 fg	27	N-57	1.078 ıjk	40	N-36	1.252 bcd
14	N-53	1.091 ı						
Average		**1.141**						
Significance		******						
CV (%)		**3.49**						

As a result of variance analysis, it was revealed that there is a statistically significant ($P<0.01$) statistical difference between chickpea genotypes and chickpea cultivars in terms of water uptake index. When the table is evaluated in terms of chickpea varieties included in the study, the Aksu chickpea variety came in first place (1.241%), followed by the Yaşa-05 variety (1.152%). The lowest value in terms of water uptake index was determined in the Uzunlu-99 chickpea variety (1.048%), and the average water uptake index value of all varieties was found to be 1.110% in the study. Yiğit (2018) determined that the water uptake index of 5 chickpea cultivars varies between 1.05% (Gökçe)-1.10 (Yaşa-05) values in his study conducted in 2016 in Kırşehir ecological conditions to reveal the quality characteristics of 5 chickpea cultivars. When the water uptake index values of 35 local chickpea genotypes were examined, the genotype N-52 came first with a water intake index value of 1.296%, while the lowest water uptake index value was found in the genotype N-55 with 0.422%, and the average water uptake index value for the local chickpea genotypes was found to be 1.140. In the study carried out on the determination of the technological properties of some chickpea varieties, it was stated by Karasu (2003) that negative and significant relations were found between 100-seed weight and water uptake index, and positive and significant relations between cooking time and water uptake index. In the study, in which 12 chickpea cultivars were used to determine some technological features of chickpea cultivars in Van ecological conditions, it was determined by Sarımurat (2018) that the water uptake index of the cultivars varied between 0.73-1.20%. In other studies on this quality parameter, Singh et al. (1991) 0.9-1%, Atmaca (2008) 0.973-1.053%, Mart et al. (2011) 0.84-1.06%, Kaya et al. (2016) 0.70-3.46%, Yiğit (2018) 1.05%-1.10%, Cin (2020) 1.09%, Mart et al. (2021) 0.91-1.08%, Peker (2022) 0.417-1.313% and Kulaz et al. (2023) 0.89-1.11% values determined.

4.3. Swelling capacity

There is a very important relationship between dry and fresh weight and swelling capacity in chickpeas as in legumes. It has been reported by Atlı et al. (1994) that the swelling capacity decreases or increases

with the increase or decrease in dry and wet weight. Average swelling capacity values in 40 chickpea genotypes are given in Table 7. As a result of the analysis of variance, it was observed that there was a statistically significant ($P<0.05$) difference between local chickpea genotypes and standard varieties in terms of swelling capacity. When the table is examined, the Zuhal variety ranks first among all standard varieties with 0.522 ml seed^{-1} value in terms of standard varieties. This standard variety was followed by the Aksu chickpea variety with a value of 0.422 ml seed^{-1}. In terms of cultivars, the average swelling capacity value was determined as 0.330 ml seed^{-1}, and the lowest swelling capacity value in the study was found with 0.220 ml seed^{-1} value in the Yaşa-05 cultivar. It has been reported by Köksal et al. (1993) that dry and wet capacity, 100-seed weight, wet weight, water uptake capacity, water uptake index, and swelling capacity are affected by environmental conditions.

When 35 local chickpea genotypes included in the study were evaluated in terms of swelling capacity, the N-24 genotype ranked first with 0.576 ml seed^{-1} value, while this local chickpea genotype N-48 genotype followed with 0.471 ml seed^{-1} value. N-20 genotype took the last place among all local chickpea genotypes with a value of 0.177 ml seed^{-1}, and the average swelling capacity value of all local chickpea genotypes was 0.340 ml seed^{-1}. In the study carried out with the technological characteristics of some chickpea varieties, positive and significant relationships were found between protein ratio and swelling capacity, and oil ratio and swelling capacity (Karasu, 2003). In other studies on this quality parameter, Özer et al. (2007) 0.15-0.32 ml seed^{-1}, Atmaca (2008) 0.420-0.481 ml seed^{-1}, Erdemci (2012) 0.398-0.530 ml seed^{-1}, Kaya et al. (2016) 0.253-1.153 ml seed^{-1}, Yiğit (2018) 0.14-0.29 ml seed^{-1} and Kulaz et al. (2023) 0.25-0.47 ml seed^{-1} values determined.

Table 7. Combined average swelling capacity (ml seed^{-1}) values and statistical groupings

Number	Genotypes	Swelling Capacity	Number	Genotypes	Swelling Capacity	Number	Genotypes	Swelling Capacity
1	N-21	0.349 ı	15	N-19	0.281 mn	28	N-2	0.291 lmn
2	**Azkan**	**0.258 opq**	16	N-37	0.285 m	29	N-6	0.371 h
3	**Uzunlu-99**	**0.222 s**	17	N-14	0.314 kl	30	N-12	0.451 d
4	N-45	0.441 de	18	N-10	0.407 f	31	N-3	0.298 l
5	**Zuhal**	**0.522 b**	19	N-54	0.320 k	32	N-27	0.416 ef
6	N-44	0.254 p	20	N-28	0.335 j	33	N-48	0.471 c
7	**Aksu**	**0.422 e**	21	N-13	0.261 op	34	**N-24**	**0.576 a**
8	N-52	0.403 fg	22	N-55	0.330 jk	35	N-7	0.395 g
9	N-32	0.345 ıj	23	N-18	0.249 q	36	N-42	0.352 ı
10	**Yaşa-05**	**0.220 s**	24	N-1	0.405 f	37	N-29	0.293 lm
11	N-30	0.275 n	25	N-49	0.237 r	38	N-23	0.443 de
12	**N-20**	**0.177 t**	26	N-5	0.449 d	39	N-46	0.329 jk
13	N-33	0.316 kl	27	N-57	0.327 jkl	40	N-36	0.343 ıj
14	N-53	0.264 o						
Average		0.342						
Significance		*						
CV (%)		3.55						

4.4. Swelling index

The swelling index value is found by dividing the amount of seed after wetting by the amount before wetting. The swelling index value reveals how many times the chickpea seed absorbs water compared to its original capacity, and it has a positive and positive relationship with the water absorption capacity, water absorption index, and swelling capacity. The average swelling index values of 40 chickpea genotypes included in the study are given in Table 8. As a result of variance analysis, it was seen that there was a statistically

significant (P<0.05) statistical difference between chickpea genotypes and chickpea cultivars in terms of swelling index values. When the table is evaluated in terms of chickpea varieties included in the study, Zuhal chickpea cultivar came in first place (2.30%), followed by Aksu (1.98%). The lowest value in terms of swelling index among standard chickpea cultivars was determined in the Uzunlu-99 chickpea cultivar (1.43%), and the average swelling index value of all chickpea cultivars was 1.76%. It was reported by Özer et al. (2007) that the swelling index varied between 0.7207-1.1859 in a study conducted under laboratory conditions to examine the cooking, physical properties, and physicochemical structure of 91 local chickpea cultivars.

Table 8. Combined average swelling index (%) values and statistical groupings

Number	Genotypes	Swelling Index	Number	Genotypes	Swelling Index	Number	Genotypes	Swelling Index
1	N-21	1.92 f	15	N-19	1.64 p	28	N-2	1.66 o
2	**Azkan**	**1.55 t**	16	N-37	1.69 n	29	N-6	1.83 j
3	**Uzunlu-99**	**1.43 w**	17	N-14	1.65 o	30	N-12	2.06 d
4	N-45	2.20 c	18	N-10	2.04 d	31	N-3	1.70 n
5	**Zuhal**	**2.30 b**	19	N-54	1.87 h	32	N-27	1.89 g
6	N-44	1.50 v	20	N-28	1.87 h	33	N-48	2.19 c
7	**Aksu**	**1.98 e**	21	N-13	1.57 s	**34**	**N-24**	**2.71 a**
8	N-52	1.80 k	22	N-55	1.85 ı	35	N-7	1.98 e
9	N-32	1.1.92 f	23	N-18	1.59 r	36	N-42	1.79 k
10	**Yaşa-05**	**1.52 u**	24	N-1	1.97 e	37	N-29	1.61 q
11	N-30	1.53 u	25	N-49	1.49 v	38	N-23	2.08 d
12	**N-20**	**1.29 y**	26	N-5	2.18 c	39	N-46	1.76 l
13	N-33	1.74m	27	N-57	1.77 l	40	N-36	1.73 m
14	N-53	1.64 p						
Average		1.812						
Significance		*						
CV (%)		3.49						

When the 35 local chickpea genotypes included in the study were examined in terms of swelling index, the genotype N-24 came first with a swelling index value of 2.71%, while the genotype N-20 was in the last place with a swelling index value of 1.29%. The average swelling index value for all local chickpea genotypes was determined as 1.82%. In the study carried out to reveal some quality parameters of 32 local chickpea genotypes and chickpea varieties collected from Kırşehir province, it was determined by Şamcı and Sözen (2018) that the swelling index values of the genotypes varied between 1.02% and 2.46%. In other studies on this parameter, Özer et al. (2007) 0.7207-1.1859%, Atmaca (2008) 2.426-2.596%, Erdemci (2012) 2.128-2,628%, Kaya et al. (2016) 1.847-3.633%, Yiğit (2018) 1.27-1.57% and Kulaz et al. (2023) 1.92-2.63% values determined.

4.5. Coat ratio (%)

In edible legumes, the rate of coat in the seed is seen as an important feature in the quality parameters in terms of determining the preferences of the consumers. At the same time, in a study examining the relationship between seed coat thickness and heritability, flower color, and seed size, it was stated by Gil et al. (1996) that seed coat thickness was determined by a single gene. In addition, although there is a significant relationship between the cooking time and the water uptake potential of the seed, it is seen that the seeds with thick skins cannot absorb water. It has been stated by Williams et al. (1986) that besides ecological factors, the vegetation period of the grown species and the temperature

values in the environment are also effective on the shell thickness of the seed. The average coat ratio values of the chickpea genotypes included in the study are given in Table 9.

Table 9. Combined average coat ratio (%) values and statistical groupings

Number	Genotypes	Coat Ratio	Number	Genotypes	Coat Ratio	Number	Genotypes	Coat Ratio
1	N-21	3.88 p	15	N-19	4.37 k	**28**	**N-2**	**3.37 u**
2	**Azkan**	**4.55 ıj**	16	N-37	4.70 ghı	29	N-6	4.90 e
3	**Uzunlu-99**	**4.44 jk**	17	N-14	3.97 o	30	N-12	4.87 ef
4	N-45	4.58 ı	18	N-10	4.54 ıj	31	N-3	3.66 rs
5	**Zuhal**	**3.56 s**	19	N-54	5.26 cd	32	N-27	4.44 jk
6	N-44	4.19 m	20	N-28	4.07 n	33	N-48	4.29 l
7	**Aksu**	**3.48 t**	21	N-13	4.75 g	34	N-24	4.73 gh
8	N-52	5.49 ab	22	N-55	5.29 c	35	N-7	4.05 no
9	N-32	4.30 l	23	N-18	3.80 q	36	N-42	4.85 efg
10	**Yaşa-05**	**3.69 r**	24	N-1	4.69 ghı	37	N-29	4.45 jk
11	N-30	3.96 op	25	N-49	5.12 d	38	N-23	4.65 h
12	N-20	4.18 m	26	N-5	5.27 cd	**39**	**N-46**	**5.54 a**
13	N-33	3.78 qr	27	N-57	4.27 lm	40	N-36	4.48 j
14	N-53	5.35 b						
Average		4.45						
Significance		**						
CV (%)		3.11						

As a result of the analysis of variance, it was seen that there was a statistically significant ($P<0.01$) statistical difference between local chickpea genotypes and standard chickpea cultivars in terms of coat rate. When the Table 9 is examined in terms of standard chickpea varieties included in the study, the Azkan chickpea cultivar ranks first with a 4.55% coat rate, followed by the Uzunlu-99 chickpea cultivar with a 4.44% coat rate. While the Aksu chickpea cultivar ranks last among all cultivars with a 3.48% coat rate, the average coat rate value of the cultivars is determined as 3.94%. In the study carried out on 8 chickpea cultivars to determine some quality characteristics of chickpea cultivars in Afyonkarahisar and Yozgat conditions, according to the combined results of two years, it was determined that the coat rate in Afyonkarahisar varied between 4.763-6.003% and 4.766-5.985% in Yozgat (Yalçın, 2017). When the 35 local chickpea genotypes in the study were evaluated in terms of coat ratio, the N-46 genotype ranked first with a coat ratio of 5.54%, followed by the local chickpea genotype N-52 with 5.49%. In the study, the lowest coat ratio value was determined in the N-2 genotype (3.37%), while the average coat ratio value in local genotypes was determined as 4.52%. In the study, in which 30 chickpea genotypes were used in laboratory conditions of Uşak University Faculty of Agriculture between 2018-2020, the average coat rate of chickpea genotypes was determined as 4.53% (Cin, 2020). In other studies on this quality parameter, Akçin (1998) 4.93-6.04%, Özçelik et al. (2001) 5.31-5.41%, Kaya et al. (2016) 0.66-3.07%, Yalçın et al. (2018) 5.21-6.0% and Yiğit (2018) 4.29-4.68% values determined.

4.6. Protein ratio (%)

Protein, one of the basic functions in living things, is a large organic compound formed as a result of linking amino acids together in chains. Proteins, which are of great importance for the continuity of human life, have many functions in the human body. In addition to the fact that chickpea genotypes in terms of protein ratios have been determined by scientific studies, depending on different factors, genetic ability, ecological factors,

agronomic studies, and breeding techniques come to the fore among these factors. In addition, edible legumes have approximately twice the protein content (20-25%) than cereal seeds in terms of cheap and high-quality vegetable protein sources (Pekşen and Artık, 2005). The average protein ratio values of a total of 40 chickpea genotypes in the study are given in Table 4.10. As a result of variance analysis, it was revealed that there was a statistically significant ($P<0.05$) statistical difference between chickpea genotypes and chickpea cultivars in terms of protein content. When the table is evaluated in terms of chickpea varieties included in the research, the Azkan chickpea cultivar came in first place with a protein ratio of 24.91% and this variety was followed by Uzunlu 99 (24.87%). The lowest value in terms of protein ratio among standard chickpea varieties was determined in the Yaşa-05 chickpea variety (24.17%), and the average protein ratio value of all varieties was found to be 24.56% in the study. In the study carried out in Çukurova Region, 24 chickpea cultivars were tested in 5 different locations for 2 years and it was reported by Mart (2000) that chickpea cultivars showed different adaptability in different environments in terms of the characteristics examined and the crude protein ratio varied between 19.1-26.5%.

When 35 local chickpea genotypes were evaluated in terms of protein ratio, the genotype N-21 ranked first with a protein ratio of 24.99%, followed by the genotype N-45 (24.67%). The lowest protein ratio value was determined as 19.34% in the genotype N-36, while the average protein ratio value the local chickpea genotypes was 22.67%. In the study carried out to determine the quality characteristics of 11 chickpea genotypes in Bursa ecological conditions in 1996-1997, the lowest protein rate was obtained from line 4N-495/2 with 18.64%, and the highest protein rate was obtained from Aziziye-94 with 23.25% (Vural and Karasu, 2007). In other studies on this quality parameter, Kaçar et al. (2004) 20.83-23.98%, Karasu and Vural (2006) 18.64-23.25%, Ceyhan et al. (2007) 17.42-21.10%, Aydoğan (2012) 22.2-24.5%, Dinç (2014) 20.32-24.35%, Ceran (2015) 25.60-27.03%, Kaya et al. (2016) 18.24-27.57%, Biçer et al. (2017) 23.0-25.6%, Sarımurat (2018) 18.16-23.0% and Yücedağ (2021) 18.0-22.9% values determined.

Table 10. Combined average protein ratio (%) values and statistical groupings

Number	Genotypes	Protein Ratio	Number	Genotypes	Protein Ratio	Number	Genotypes	Protein Ratio
1	**N-21**	**24.99 a**	15	N-19	23.65 hı	28	N-2	22.20 no
2	**Azkan**	**24.91 b**	16	N-37	23.21 ı	29	N-6	22.19 no
3	**Uzunlu-99**	**24.87 bc**	17	N-14	23.16 ıj	30	N-12	22.08 o
4	N-45	24.67 c	18	N-10	23.12 ıjk	31	N-3	22.02 op
5	**Zuhal**	**24.62 cd**	19	N-54	22.95 j	32	N-27	21.88 p
6	N-44	24.51 d	20	N-28	22.90 jk	33	N-48	21.75 q
7	**Aksu**	**24.25 e**	21	N-13	22.89 jk	34	N-24	21.43 r
8	N-52	24.22 ef	22	N-55	22.86 jkl	35	N-7	21.39 rs
9	N-32	24.18 efg	23	N-18	22.66 k	36	N-42	21.24 s
10	**Yaşa-05**	**24.17 efg**	24	N-1	22.55 l	37	N-29	21.19 st
11	N-30	23.95 f	25	N-49	22.51 lm	38	N-23	21.17 st
12	N-20	23.92 fg	26	N-5	22.39 m	39	N-46	20.86 t
13	N-33	23.80 g	27	N-57	22.24 n	**40**	**N-36**	**19.34 u**
14	N-53	23.69 h						
Average		22.91						
Significance		*						
CV (%)		4.59						

5. Conclusion

In the study carried out in 2021 and 2022 to determine the quality parameters of 40 chickpea genotypes, significant relationships were determined between genotypes and cultivars in terms of swelling capacity, swelling index and protein ratio, while very significant statistical differences were determined in terms of water uptake capacity, water uptake index and coat ratio. It is estimated that these differences between local chickpea genotypes and cultivars may be due to the effect of climate and environmental factors in the years they were grown and cultivation techniques. In this context, in the breeding studies to be carried out to determine the variety candidates in chickpeas, it is necessary to consider the changing abiotic stress factors while choosing the variety of candidates in terms of quality parameters. In studies to determine local chickpea genotypes as cultivar candidates, it is necessary to focus on swelling capacity, swelling index, coat ratio, and protein ratios, which are important quality parameters. In terms of the technological features we examined in our study, it was seen that the local chickpea genotypes N-2, N-21, N-24, and N-52 were more promising than other local chickpea genotypes. In chickpea breeding, especially in the medium term, studies on quality parameters will need to be taken into account. In this context, it is also important to include local chickpea genotypes, which can stand out in terms of quality parameters, in the gene pool. In addition, there are many studies conducted in previous years on the quality characteristics of chickpeas in our study. Therefore, it is thought that the results we obtained in our study can contribute to scientific studies to be made in the future at the citation level.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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