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Influence of Seed Physical Attributes on Nutritional and Culinary Characteristics of Chickpea

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ABSTRACT: This study delves into the pivotal role of moisture content in assessing seed viability and shelf life, particularly in chickpea seeds. Alterations in moisture levels influence biometric characteristics, affecting mean diameter and sphericity. Lower moisture content in chickpea varieties extends shelf life, preserving nutritional integrity. The research focuses on analysing moisture content across diverse chickpea genotypes, revealing values spanning 6.14% to 9.09%. AVRODHI demonstrates the highest moisture content (9.09%), while KGD-1814 records the lowest (6.14%). All chickpea genotypes can be stored extensively without degradation. Furthermore, the investigation examines seed weight variations, with GNG-2144 standing out with the highest weight of 30.84 grams per 100 seeds. Significant diversity in seed weight among different varieties/genotypes highlights the potential for robust seed selection through breeding trials. Seed volume and density analyses reveal substantial distinctions among genotypes, with GNG-2144 showcasing the highest volume content and JG-1749 exhibiting the highest seed density. Water absorption and volume expansion properties are thoroughly explored, revealing significant variations among chickpea genotypes. Swelling capacity and index evaluations provide insights into volume expansion potential, highlighting notable variation across genotypes. The comprehensive dataset contributes to a deeper understanding of chickpea genotype attributes, facilitating informed decisions in processing and utilization. The research shows and suggest breeder to select the best variety for biofortification process to increase quality in chickpea seeds.

Keywords: Moisture content, Seed volume, Seed density, Water expansion and volume expansion.

INTRODUCTION

Chickpea (*Cicer arietinum* L.), also known as Gram or Bengal gram, is a highly significant leguminous crop used for both grain and green pod vegetables. Its cultivation plays a crucial role in addressing challenges related to under nutrition in agriculture. The process of domestication transformed its wild progenitor, *C. reticulatum* Ladiz, which originated in southeastern Turkey and adjacent Syria. Over the centuries, chickpea cultivation has spread across various regions, primarily thriving in semi-arid environments (Kerem *et al.*, 2007; Shahal *et al.*, 2008).

Chickpea biotypes are categorized into two primary groups based on seed color and geographical distribution: Kabuli and desi (Wang *et al.*, 2010). Desi chickpea seeds have a robust, irregular seed coat and smaller seeds (weighing less than 28 g/100 seeds), varying in color from light to black. On the other hand, Kabuli chickpea seeds possess thinner seed coats, larger sizes (with weights ranging from 28 to 70 g/100 seeds), and colors spanning cream to white (Segev *et al.*, 2012). Distinct physicochemical properties, protein digestibility, phenolic content, and antioxidant activity set apart desi and kabuli chickpea varieties. The chemical composition of these two types notably differs in terms of protein, carbohydrate, polyphenol, and fiber content (Thudi *et al.*, 2016).

Chickpea (*Cicer arientum* L.) is considered as the fifth valuable food legume in terms of worldwide economic standpoint. It has been used for the preparation of various traditional foods such as ingredient in bakery products, imitation milk, infant food formulations and meat products (Ashok Kumar *et al.*, 2015; Jukanti *et al.*, 2012). Dried legume seeds generally promote slow and moderate postprandial blood glucose increase. They are also a source of high-quality protein and have been known as "a poor man's meat" (Taylor *et al.*, 2016). Information on physical properties of byproducts is needed in designing and adjustment of agricultural machineries (Ghamari, 2012). The geometric properties of chickpea such as size and shape are the most important physical properties considered during the separation and cleaning of grains (Nalbandi *et al.*, 2010). In view of this, several studies have been conducted on the physical properties such as size, weight, volume, bulk density, seed density of different crops. Because of varietal variability in chickpea seeds, understanding of physical properties of different varieties is necessary (Meng *et al.*, 2010).

METHOD AND MATERIALS

The physical characteristics of seeds, *viz.*, moisture content, test weight, seed volume, seed density, water absorption, volume expansion, swelling capacity, swelling index, hydration capacity and hydration index were determined as already discussed methods by Santhan and Shivshankar (1978).

Moisture content (AOAC, 2000). The empty dish and lid were taken and dried at 105°C in the oven for 3 h. These were then transferred to desiccator for cooling and were weighed. Seeds of sample (3 g) were weighed in a dish and the dish with partially covered lid was dried in the oven at 105°C for 3 h. After drying, the dish was transferred to the desiccator for cooling. The dish along with the dried sample was reweighed. Moisture content was calculated by using the given formula:

$$\text{Moisture content (\%)} = \frac{w_1 - w_2}{w_1} \times 100$$

where, w_1 = weight(g)of sample before drying

w_2 = weight (g) of sample after drying

Seed Weight. To observe the extent of grain filling, 100 seeds of each replication were weighted out. The results were, however, reported as grains weight by multiplying ten times.

Seed Volume and Density. Hundred seeds from chickpea genotype were weighed in triplicates and the values were converted to gram per seed.

To determine seed volume, 100 seeds were transferred into a 100 ml measuring cylinder with subsequent addition of distilled water (50 ml). The seed volume (ml) was calculated by:

$$\text{Seed Volume (ml)} = \frac{\text{Gain in volume}}{100}$$

Seed density (g/ml) was determined by the formula:

$$\text{Seed density (g ml)} = \frac{\text{Seed Weight}}{\text{Seed Volume}}$$

Water absorption capacity and Volume Expansion. Weight of 100 healthy seeds was noted and the seeds were transferred to a measuring cylinder, subsequently noting down the volume. After soaking the seeds overnight in distilled water (100 ml) at room temperature, the seeds were drained after a period of 24 h while the superfluous water was soaked on a filter paper. The swollen seeds were then selected and weighed again followed by recording their volume in a measuring cylinder. Water absorption and volume expansion were calculated using the formulas:

$$\text{WAC (\%)} = \frac{\text{Wt. of soaked seeds - Wt. of unsoaked seeds}}{\text{Weight of unsoaked seeds}}$$

$$\text{VC (\%)} = \frac{\text{Volume after soaking} - \text{Volume before soaking}}{\text{Volume before soaking}} \times 100$$

Swelling Capacity and Swelling Index. Swelling capacity was calculated as the volume gain of healthy chickpea seeds after overnight soaking in water

$$\text{Swelling capacity (per seed)} = \frac{\text{Volume after soaking} - \text{Volume before soaking}}{\text{No. of seeds}} \times 100$$

Swelling index was determined by dividing swelling capacity per seed-by-seed volume

$$\text{Swelling index} = \frac{\text{Swelling capacity per seed}}{\text{Volume of one seed}} \times 100$$

Hydration capacity and Hydration index

Hydration capacity was calculated as the weight gain of healthy chickpea seed after overnight soaking in water

$$\text{Hydration capacity (per seed)} = \frac{\text{Wt. of soaked seeds} - \text{Wt. of unsoaked seeds}}{\text{No. of seeds}} \times 100$$

Hydration index was determined as:

$$\text{Hydration Index} = \frac{\text{Hydration capacity per seed}}{\text{Weight of one seed}} \times 100$$

RESULT AND DISCUSSION

Moisture content: The moisture content of seeds plays a vital role in assessing seed viability and shelf life. Changes in moisture levels of chickpea seeds can impact their biometric characteristics, altering mean diameter and sphericity. Generally, chickpea varieties with lower moisture content exhibit extended shelf life, allowing preservation without significant nutrient losses. In this study, we aimed to analyze the moisture content across various chickpea genotypes. The data on moisture content were subjected to pooled analysis and the results are presented for different varieties/genotypes of chickpea. Moisture content ranged from 6.14% in KGD-1814 to 9.09%. in AVRODHI, as shown in Table 1. Notably, AVRODHI displayed significantly higher moisture content (9.09%) compared to other chickpea genotypes. KWR-108 ranked second with a moisture content of 8.66%, followed by IPC-1370 (8.14%), GNG-2144 (8.10%), The variety KGD-1814 exhibited the lowest moisture content at 6.14%.The average moisture content of 7.18% serves as a safe threshold for preserving seed quality during storage. Consequently, all chickpea genotypes can be stored for extended periods without experiencing deterioration. According to Garg and Sabharwal (2014) chickpea varieties had significantly lower moisture content ranging from 7.15-7.17 g/100g, DM basis. Ozer *et al.* (2010) reported the high diversity the chickpea landraces in the contents of moisture (6.39–10.5 per cent). Karadavut and Genc (2012) conducted experiment with four chickpea cultivars and recorded moisture content ranging from 6.42 to 8 7.16 per cent. Singhai and Srivastava (2006) estimated the nutritional quality of chickpea. The proximate analysis of seeds included moisture (5.62% to 8.17%). Shad *et al.* (2009) reported the moisture content ranged from 6.30-7.60 g/100g.

Seed weight (g/100 seeds) in chickpea varieties/genotypes: With this perspective, we conducted an assessment of seed weight for various chickpea varieties/genotypes. The data collected for 100 grain weight across different chickpea varieties/genotypes for both years is detailed in Table 1. It's evident from these findings that notable variations existed among varieties/genotypes, spanning from 11.60 to 30.84 grams per 100 seeds, with an average of 18.26 grams per 100 seeds for chickpea. Among these, the highest grain weight of 30.84 grams was observed in the GNG-2144 variety. The substantial amplitude of 19.40 grams in seed weight variability among different varieties/genotypes underscores the significant potential for identifying sources of bolder seeds, which can be harnessed through breeding trials. GNG-2144 emerged as the standout variety with the boldest seeds, as it significantly differed from all other varieties. JG-1746 (30.15g) and Avrodhi (27.44g) followed, securing the second and third positions in terms of seed boldness. These two varieties/genotypes also exhibited significant distinctions from other varieties/genotypes. Notably, GNG-2392 (22.14g), GNG-2171 (21.95g), RADHE (21.20g), PUSA-397 (21.18g), and IPC-1317 (20.85) displayed seed weights exceeding 20 grams per 100 seeds, positioning them as promising candidates for bolder seed-bearing varieties/genotypes. On the lower end, KGD-1814 showcased the minimum seed weight value. The weight of 100 seeds serves as a key indicator of seed quality and economic value. The diversity in seed weight observed across chickpea varieties/genotypes signifies the potential for selecting and cultivating seeds with robust traits through targeted breeding efforts. Similar results was shown by different scientist. Uttamrao *et al.* (2018) reported that 100 seed weight of 10 varieties/genotypes of gram varied from 11.70 to 22.80g. Tripathi *et al.* (2018) which was reported the test weight ranged Ron 13.10 to 24.00 g. Tripathi *et al.* (2018) reported the proximate composition varied significantly ($p<0.05$) among different types of chickpea genotypes. The 100 seed weight 13.61 to 24.70g. Yadav *et al.* (2018) seed weight of the adzuki seed ranged from 7.48 to 14.820 g/100 seeds. Yixiang *et al.* (2013) investigated the average weight of 4.48 g per 10 g.

Seed volume and seed density: The combined analysis of seed volume and seed density data from the experimental trial is presented in Table 2. Statistically, the highest seed volume content (0.40ml) was observed in the variety GNG-2144, while the lowest seed volume (0.16ml) was recorded in the genotype KGD-1814. Notably, genotypes JG-1746 (0.37ml) and AVRODHI (0.35ml) exhibited relatively higher seed volume, whereas all other genotypes, namely JG-1747 (0.24ml and KGD-2017 (0.17ml), had significantly lower seed volume compared to varieties PUSA-397 (0.30ml) and GNG-2171 (30.17ml). However, all genotypes, including PUSA-397 and GNG-2171, exhibited higher seed volume compared to KGD-1814. Seed density analysis for chickpea varieties/genotypes revealed significant differences. These findings highlight notable variations among varieties/genotypes, ranging from 0.63g/ml to 0.96g/ml, with an average of 0.74g/ml for chickpea. Among these, the highest seed density of 0.96g/ml was observed in the JG-1749 variety, whereas the lowest seed density (0.63g/ml) was found in genotype PUSA-391. With the exception of genotypes KWR-108 (0.85g/ml) and KGD-1168 (0.83g/ml), all other genotypes exhibited significantly lower seed density. Specifically, AVRODHI (0.77g/ml), IPC-1374 (0.76g/ml), GNG-2391 (0.76g/ml) and PUSA-391 (0.63g/ml) had lower seed density compared to varieties K-850 (0.79g/ml) and KGD-1918 (0.79g/ml). Nevertheless, all genotypes, including K-850 and KGD-1918, exhibited higher seed density compared to PUSA-391. Similar results was shown by different scientist. Yadav *et al.* (2018) Seed density of the adzuki seed ranged from 0.76 to 1.00 g/mL

Water expansion and Volume expansion: Understanding the hydration properties is crucial for effective processing of whole chickpea seeds, as only consistently water-absorbing varieties are suitable for this purpose. The water absorption capacity of seeds has been observed to correlate with factors such as cell wall structure, cell composition, and compactness within the seed. A higher water absorption capacity may be attributed to enhanced permeability of the seed coat and softer cotyledons. Table 3 present comprehensive data on the water absorption capacity of different chickpea varieties/genotypes. Notably, a substantial variation in water absorption capacity (ranging from 18.91% to 101.50%) was observed among the chickpea genotypes in this study (as indicated in Table 3. Among these genotypes, K-850 exhibited a significantly highest water absorption capacity (101.50%), while JG-1749 demonstrated the lowest (18.91%). The second highest water absorption capacity was observed in AVRODHI (92.76%), followed by GNG-2144 (86.12%), KWR-108 (84.25%), JG-1746 (83.77%), JG-1747 (82.82%), PUSA-397 (82.57%). The pooled mean water absorption capacity of chickpea was determined to be 64.10. Significant variability in percent volume expansion was observed among various chickpea genotypes in this study (depicted in Table 3). The percent volume expansion ranged from 44.49% to 165.95%. KWR-108 exhibited the highest volume expansion, while IPC-1380 showed the lowest. An evident increase in volume expansion value (165.95%) was observed across different varieties compared to the mean value. Genotype K-850 demonstrated the second highest volume expansion capacity (156.59%), followed by AVRODHI (139.85%), KGD-1814 (136.30%), GNG-2144 (133.26%). For a comprehensive overview of the range, mean values, and the most promising chickpea varieties/genotypes in terms of volume expansion capacity, please refer to Table 3. This information provides insights into the water absorption and volume expansion characteristics of different chickpea genotypes, facilitating informed decision-making for processing and utilization. Yixiang *et al.* (2013) investigated the Water absorption capacities from 90.7% to 117.5%. Tiznado *et al.* (2012) analyzed the water absorption capacity (WAC) of the whole grains ranged from 97.7 to 117.5 g water/100g seeds.

Table 1: Moisture content and seed weight in important varieties/genotypes of chickpea (*Cicer arietinum* L.).

Sr. No.	Varieties/Genotypes	Moisture Content (%)			Seed weight (gm)		
		Mean		Pooled Mean	Mean		Pooled Mean
		2021-22	2022-23		2021-22	2022-23	
1.	RADHE	6.39	6.41	6.40	21.21	21.18	21.20
2.	AVRODHI	9.08	9.10	9.09	27.45	27.44	27.44
3.	K-850	6.48	6.50	6.49	17.52	17.54	17.53
4.	KWR-108	8.65	8.67	8.66	18.52	18.53	18.53
5.	KGD-1168	8.01	8.03	8.02	16.83	16.84	16.84
6.	KGD-1918	6.78	6.80	6.79	16.23	16.23	16.23
7.	KGD-1145	6.98	6.96	6.97	13.78	13.77	13.78
8.	KGD-1316	6.51	6.53	6.52	13.64	13.68	13.66
9.	KGD-1320	8.02	8.04	8.03	14.76	15.11	14.94
10.	KGD-2017	6.52	6.54	6.53	12.59	12.5	12.55
11.	KGD-2012	6.49	6.56	6.53	14.93	14.94	14.94
12.	KGD-1812	6.40	6.48	6.44	13.34	13.47	13.40
13.	KGD-1814	6.13	6.15	6.14	11.63	11.58	11.60
14.	GNG-2391	7.02	7.06	7.04	16.87	16.86	16.86
15.	GNG-2392	7.04	7.06	7.05	22.19	22.1	22.14
16.	GNG-2144	8.09	8.11	8.10	30.81	30.87	30.84
17.	GNG-2171	7.54	7.52	7.53	21.98	21.93	21.95
18.	IPC-1370	8.12	8.15	8.14	20.85	20.85	20.85
19.	IPC-1374	7.54	7.58	7.56	13.64	13.54	13.59
20.	IPC-1380	6.52	6.53	6.53	14.52	14.52	14.52
21.	PUSA-391	6.25	6.27	6.26	12.43	12.48	12.46
22.	PUSA-397	7.86	7.82	7.84	21.22	21.14	21.18
23.	JG-1746	7.78	7.84	7.81	31.80	28.51	30.15
24.	JG-1747	6.52	6.50	6.51	19.34	19.34	19.34
25.	JG-1749	6.61	6.67	6.64	19.93	19.86	19.89
	Mean	7.17	7.20	7.18	18.32	18.19	18.26
	S.E. (m) ±	0.391	0.396	0.394	0.687	0.097	3.35
	C.D. (5%)	0.830	0.845	0.835	1.95	0.276	9.54

Table 2: Seed volume and Seed density in important varieties/genotypes of chickpea(*Cicer arietinum* L.).

Sr. No.	Varieties/Genotypes	Seed volume (ml)			Seed density(gm/ml)		
		Mean		Pooled Mean	Mean		Pooled Mean
		2021-22	2022-23		2021-22	2022-23	
1.	RADHE	27.33	29	28.17	0.74	0.73	0.74
2.	AVRODHI	35.00	35.33	35.17	0.76	0.77	0.77
3.	K-850	21.00	22	21.50	0.79	0.79	0.79
4.	KWR-108	20.33	21.66	21.00	0.84	0.85	0.85
5.	KGD-1168	18.67	20	19.33	0.82	0.84	0.83
6.	KGD-1918	19.67	20.33	20.00	0.79	0.79	0.79
7.	KGD-1145	21.67	21	21.33	0.65	0.65	0.65
8.	KGD-1316	19.33	19.66	19.50	0.69	0.69	0.69
9.	KGD-1320	19.00	20.66	19.83	0.71	0.73	0.72
10.	KGD-2017	17.00	17.66	17.33	0.69	0.7	0.70
11.	KGD-2012	19.67	20.33	20.00	0.73	0.73	0.73
12.	KGD-1812	17.67	18.33	18.00	0.71	0.73	0.72
13.	KGD-1814	15.67	16.33	16.00	0.71	0.7	0.70
14.	GNG-2391	22.33	22	22.17	0.75	0.76	0.76
15.	GNG-2392	29.33	30.33	29.83	0.73	0.72	0.73
16.	GNG-2144	40.00	40.33	40.17	0.74	0.76	0.75
17.	GNG-2171	30.00	30.33	30.17	0.71	0.72	0.72
18.	IPC-1370	28.00	29.66	28.83	0.69	0.7	0.70
19.	IPC-1374	17.33	17.66	17.50	0.76	0.76	0.76
20.	IPC-1380	21.33	20.33	20.83	0.71	0.71	0.71
21.	PUSA-391	18.00	19.66	18.83	0.63	0.63	0.63
22.	PUSA-397	31.00	29.66	30.33	0.71	0.71	0.71
23.	JG-1746	37.67	37.66	37.66	0.75	0.75	0.75
24.	JG-1747	24.33	25.33	24.83	0.75	0.76	0.76
25.	JG-1749	20.00	20.33	20.17	0.94	0.97	0.96
	Mean	23.65	24.22	23.94	0.74	0.74	0.74
	S.E. (m) ±	0.879	0.39	0.47	0.017	0.015	0.016
	C.D. (5%)	2.50	1.12	1.35	0.048	0.043	0.045

Table 3: Water expansion and Volume expansion of different varieties/genotypes of chickpea (*Cicer arietinum* L.).

Sr. No.	Varieties/Genotypes	Water absorption capacity (%)			Volume expansion (%)		
		Mean		Pooled Mean	Mean		Pooled Mean
		2021-22	2022-23		2021-22	2022-23	
1.	RADHE	55.43	55.06	55.25	89.61	90.64	90.13
2.	AVRODHI	92.62	92.89	92.76	140.04	139.66	139.85
3.	K-850	100.62	102.38	101.50	156.33	156.85	156.59
4.	KWR-108	84.65	83.85	84.25	165.67	166.23	165.95
5.	KGD-1168	74.28	74.21	74.25	126.35	126.62	126.49
6.	KGD-1918	38.82	37.62	38.22	81.03	80.4	80.72
7.	KGD-1145	78.35	79.12	78.73	98.90	98.49	98.70
8.	KGD-1316	81.63	83.43	82.53	125.43	125.63	125.53
9.	KGD-1320	75.22	72.37	73.79	118.44	117.78	118.11
10.	KGD-2017	38.37	35.58	36.98	55.88	55.77	55.83
11.	KGD-2012	48.97	49.32	49.14	84.97	84.56	84.77
12.	KGD-1812	59.27	61.57	60.42	95.18	94.64	94.91
13.	KGD-1814	79.45	79.5	79.48	136.35	136.25	136.30
14.	GNG-2391	35.48	35.17	35.33	64.27	64.23	64.25
15.	GNG-2392	46.42	47.46	46.94	75.61	75.02	75.32
16.	GNG-2144	86.00	86.23	86.12	133.44	133.08	133.26
17.	GNG-2171	70.05	70.48	70.27	93.54	93.44	93.49
18.	IPC-1370	56.22	55.83	56.03	92.16	92.11	92.14
19.	IPC-1374	42.39	43.51	42.95	71.86	71.79	71.83
20.	IPC-1380	40.27	41.15	40.71	44.86	44.12	44.49
21.	PUSA-391	47.81	49.6	48.71	56.90	57.02	56.96
22.	PUSA-397	82.44	82.7	82.57	115.41	114.67	115.04
23.	JG-1746	83.39	84.15	83.77	122.74	122.63	122.69
24.	JG-1747	83.13	82.51	82.82	126.25	126.64	126.45
25.	JG-1749	18.88	18.94	18.91	96.86	96.91	96.89
	Mean	64.01	64.18	64.10	102.72	102.60	102.67
	S.E. (m) ±	1.19	1.20	1.29	5.24	2.89	1.90
	C.D. (5%)	3.41	3.44	3.69	14.92	8.26	5.41

Swelling capacity and swelling index: In Table 4, we present comprehensive data concerning the swelling capacity and its index for seeds across a diverse range of chickpea genotypes. The observed swelling capacity of the chickpea seeds spanned from 0.19 to 1.03 ml/seed. The pooled mean swelling capacity calculated was 0.64 ml/seed. Notably, among the genotypes assessed, K-850 exhibited a significantly elevated swelling capacity, while JG-1749 showcased the lowest swelling capacity. The following list presents the ranked swelling capacities of the respective varieties: AVRODHI (0.93ml/seed), GNG-2144 (0.87ml/seed), KWR-108 (0.85ml/seed). This comprehensive data portrayal encapsulates the varying swelling capacities of chickpea genotypes, elucidating their potential for volume expansion and offering insights into their characteristics. Significant variation is observed among all the chickpea varieties/genotypes in terms of their swelling index. The swelling index measurements for seeds of different chickpea genotypes displayed a range from 1.44 to 2.66 ml/seed**.** The pooled mean swelling index was calculated to be 2.03 ml/seed. Among the genotypes assessed, KWR-108 exhibited the most substantial and statistically significant swelling index of 2.66ml/seed. Notably, genotype K-850 also exhibited a notable swelling index of 2.55ml/seed, at par with KWR-108. The third highest swelling index was recorded in genotype AVRODHI (2.40ml/seed), followed by KGD-1814 (2.38ml/seed) and GNG-2144 (2.34ml/seed). IPC-1380 demonstrated the lowest swelling index of 1.44 ml/seed, signifying the minimal extent of swelling among the genotypes under consideration. This comprehensive dataset underscores the variations in swelling index among chickpea genotypes, shedding light on their swelling characteristics and potential applications. Similar results were shown by different scientist. Yadav *et al*. (2018) swelling capacity ranged from 0.04 to 0.15 mL/seed.

Hydration capacity and hydration index: Table 5 present comprehensive data regarding the hydration capacity and hydration index of chickpea seeds. The hydration capacity exhibited a range among the varieties, spanning from 0.05 g/seed to 0.27 g/seed, with a mean value of 0.13 g/seed. Significant variations in hydration capacity were observed between the highest and lowest varieties in the current study. For an overview of the range, mean values, and the most promising chickpea varieties/genotypes concerning volume expansion capacity, refer to Table 5. The variety with the most substantial hydration capacity is GNG-2144, boasting a value of 0.27 g/seed, which stands out among other chickpea genotypes. AVRODHI ranks second with a hydration capacity of 0.25 g/seed, and JG-1746 secures the third position with the same hydration capacity, both on par with GNG-2144.

The remaining varieties also exhibit significant distinctions and follow a descending order in hydration capacity as follows: KGD-1814 (0.08 g/seed), KGD-1812 (0.08 g/seed), and KGD-2017 (0.05 g/seed) exhibited the lowest hydration capacity. The hydration index values for different varieties are presented in Table 5. The observed hydration index values among the various genotypes ranged from 0.21 to 1.01. The mean hydration index value was calculated to be 0.64.

Table 4: Swelling capacity and swelling index in important varieties/genotypes of chickpea (*Cicer arietinum* L.).

Sr. No.	Varieties/Genotypes	Swelling capacity (ml/seed)			swelling index		
		Mean		Pooled Mean	Mean		Pooled Mean
		2021-22	2022-23		2021-22	2022-23	
1.	RADHE	0.56	0.55	0.55	1.90	1.9	1.90
2.	AVRODHI	0.93	0.93	0.93	2.40	2.39	2.40
3.	K-850	1.04	1.01	1.03	2.53	2.56	2.55
4.	KWR-108	0.84	0.85	0.85	2.65	2.66	2.66
5.	KGD-1168	0.71	0.74	0.73	2.23	2.26	2.24
6.	KGD-1918	0.36	0.39	0.38	1.84	1.8	1.82
7.	KGD-1145	0.76	0.78	0.77	2.21	1.98	2.10
8.	KGD-1316	0.83	0.82	0.82	2.28	2.25	2.27
9.	KGD-1320	0.72	0.75	0.73	2.22	2.17	2.19
10.	KGD-2017	0.36	0.38	0.37	1.57	1.55	1.56
11.	KGD-2012	0.47	0.49	0.48	1.84	1.84	1.84
12.	KGD-1812	0.57	0.59	0.58	1.97	1.94	1.95
13.	KGD-1814	0.77	0.79	0.78	2.40	2.36	2.38
14.	GNG-2391	0.33	0.35	0.34	1.65	1.64	1.65
15.	GNG-2392	0.43	0.46	0.45	1.73	1.75	1.74
16.	GNG-2144	0.87	0.86	0.87	2.34	2.33	2.34
17.	GNG-2171	0.70	0.7	0.70	1.93	1.93	1.93
18.	IPC-1370	0.57	0.56	0.57	1.87	1.92	1.90
19.	IPC-1374	0.42	0.42	0.42	1.69	1.71	1.70
20.	IPC-1380	0.40	0.4	0.40	1.44	1.44	1.44
21.	PUSA-391	0.48	0.48	0.48	1.55	1.57	1.56
22.	PUSA-397	0.83	0.82	0.83	2.20	2.14	2.17
23.	JG-1746	0.84	0.83	0.83	2.26	2.22	2.24
24.	JG-1747	0.85	0.83	0.84	2.30	2.26	2.28
25.	JG-1749	0.19	0.19	0.19	2.00	1.96	1.98
	Mean	0.63	0.63	0.64	2.04	2.02	2.03
	S.E. (m) ±	0.024	0.012	0.015	0.049	0.029	0.039
	C.D. (5%)	0.068	0.034	0.043	0.140	0.083	0.111

Table 5: Hydration capacity and Hydration index in different varieties/genotypes of chickpea (*Cicer arietinum* L.).

Sr. No.	Varieties/Genotypes	Hydration capacity (gm/seed)			Hydration index		
		Mean		Pooled Mean	Mean		Pooled Mean
		2021-22	2022-23		2021-22	2022-23	
1.	RADHE	0.12	0.12	0.12	0.56	0.55	0.56
2.	AVRODHI	0.25	0.25	0.25	0.92	0.93	0.93
3.	K-850	0.19	0.18	0.19	1.01	1.01	1.01
4.	KWR-108	0.17	0.16	0.17	0.84	0.85	0.85
5.	KGD-1168	0.13	0.13	0.13	0.75	0.74	0.75
6.	KGD-1918	0.07	0.06	0.07	0.40	0.39	0.40
7.	KGD-1145	0.12	0.11	0.11	0.78	0.78	0.78
8.	KGD-1316	0.11	0.11	0.11	0.82	0.82	0.82
9.	KGD-1320	0.13	0.11	0.12	0.77	0.75	0.76
10.	KGD-2017	0.06	0.05	0.05	0.39	0.38	0.38
11.	KGD-2012	0.08	0.07	0.08	0.49	0.49	0.49
12.	KGD-1812	0.08	0.08	0.08	0.59	0.59	0.59
13.	KGD-1814	0.08	0.09	0.08	0.80	0.79	0.80
14.	GNG-2391	0.07	0.06	0.07	0.35	0.35	0.35
15.	GNG-2392	0.11	0.10	0.10	0.48	0.46	0.47
16.	GNG-2144	0.27	0.27	0.27	0.88	0.86	0.87
17.	GNG-2171	0.16	0.15	0.16	0.70	0.70	0.70
18.	IPC-1370	0.13	0.12	0.13	0.58	0.56	0.57
19.	IPC-1374	0.07	0.06	0.06	0.42	0.42	0.42
20.	IPC-1380	0.08	0.06	0.07	0.40	0.40	0.40
21.	PUSA-391	0.09	0.06	0.07	0.45	0.48	0.47
22.	PUSA-397	0.18	0.17	0.18	0.81	0.82	0.81
23.	JG-1746	0.26	0.24	0.25	0.85	0.83	0.84
24.	JG-1747	0.18	0.16	0.17	0.87	0.83	0.85
25.	JG-1749	0.06	0.04	0.05	0.22	0.19	0.21
	Mean	0.13	0.12	0.13	0.65	0.64	0.64
	S.E. (m) ±	0.005	0.002	0.003	0.007	0.012	0.014
	C.D. (5%)	0.015	0.006	0.009	0.021	0.034	0.039

The genotypes with the highest and lowest hydration capacities were identified as K-850 (with a value of 1.01) and JG-1749 (with a value of 0.21), respectively. The second-highest hydration index value was associated with the variety AVRODHI (0.93), followed by decreasing values for GNG-2144 (0.87) and JG-1747 (0.85). Yadav *et al.* (2018) swelling capacity ranged from 0.04 to 0.15 mL/seed.

CONCLUSIONS

In conclusion, this study underscores moisture content's crucial role in chickpea seed viability and shelf life, affecting biometric traits. Lower moisture content extends shelf life and preserves nutrients. Diverse chickpea genotypes exhibit moisture content variation impacting seed quality. Variations in seed weight, with GNG-2144 as the heaviest, highlight breeding potential. Seed volume and density analyses reveal diversity, and water absorption traits impact processing. Swelling capacity insights illuminate volume expansion potential. Hydration capacity findings, notably GNG-2144 high value, offer valuable processing insights. Overall, this study enriches understanding of chickpea genotype traits for enhanced processing, utilization, and breeding strategies.

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