

Variability and correlation studies for nutritional and cooking quality traits in chickpea (*Cicer arietinum* L.)

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Abstract

Thirty genotypes of chickpea were studied to find out the variability for seed characters, nutritional components and seed yield. Interrelationships have also been found for these physico-chemical traits and seed yield to help breeders to find suitable strategy for quality improvement in chickpea. "Kabuli" types had highest mean of 100-seed weight (32.62 g), 100-seed volume (25.1 ml), solid dispersion after cooking (21.4%), hydration capacity (0.33 g/seed), hydration index (1.02), swelling capacity (0.32 ml/seed) over "desi" chickpea groups. However, highest seed yield (2038.9 kg/ha) and tryptophan (0.54 g/100 g protein) were recorded in "desi" medium bold group. "Desi" bold (23.7%) and "kabuli" types (23.3%) were on a par in protein content. Correlation analysis revealed that, irrespective of any group, an increase in 100-seed weight reduced cooking time and increased seed volume, hydration capacity, hydration index, swelling capacity and swelling index while an increase in hydration capacity and swelling capacity significantly decreased seed yield in kabuli chickpea. The study revealed significant variation for physico-chemical, nutritional and cooking quality attributes.

Key words: Protein, tryptophan, cooking quality, solid dispersion, water absorption

Introduction

Chickpea is a good source of carbohydrates (52.4-70.9%), proteins (17-26%), fats (3.8-10.2%) and essential minerals (Ca, Fe). Two types of chickpea viz., "desi" and "kabuli" are grown in the world. The "desi" type (coloured seeds) accounts for about 85% of world production, the remaining being "kabuli" type [1]. "Desi" chickpea can be categorized as bold (≥ 20 g/100 seed weight) and medium (≤ 20 g/100 seeds weight) seed sized, while Kabuli chickpea had normal (<25 g/100 seed weight), bold (25-35 g/100

seed weight) and extra bold (>35 g/100 seed weight) seed size. The identification of bold seed sized genotypes for better nutrient traits will help to design the breeding strategy for the enhancement of these traits of new cultivars. In the present study an attempt has been made to assess the nutritional and cooking quality traits in both desi (bold and medium) and kabuli chickpea genotypes.

Materials and methods

Thirty elite genotypes of "desi" (bold and medium bold) and "kabuli" type chickpea were grown in the same season in triplicate in randomized block design. After harvest, they were evaluated for physico-chemical, nutritional, cooking quality characteristics and seed yield using standard procedures. These genotypes were grouped into three, namely, A (medium small), B (bold) and C (Kabuli-bold and extra bold) depending upon seed size and type (Table 1). The material for study was procured from the Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. The samples were cleaned, dried in oven to bring the same moisture level and ground in Cyclotec (Tecator Sweden) electric grinder and used for chemical analysis. Protein content (%) was determined by using Kjeldhal method [2]. Physico-chemical and cooking quality parameters like 100 grain weight (g), 100 grain volume (ml), grain density (g/ml), water absorption (%), volume expansion (%) and hard shelled grains (%) after soaking, cooking time in minutes, water absorption (%) and volume expansion (%), solid dispersion (%) and *kokroos* (%) after cooking were determined by the standard methods [3, 4]. Hydration capacity, hydration index, swelling capacity and

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Table 1. Grouping of chickpea genotypes

Group	Genotype	Ecotype
A	FG 702, FG 711, FG 712, FG 897, FG 908, PBG 204, PBG 126, PBG 184, PBG 1, GPF 2	Desi (Medium small)
B	BG 1100, CSJ 204, BONG 787, BGM 539, BGM 541, JSC 9, GNG 1374, UPKGB 336, BGD 32, IPC 2000-1	Desi (bold)
C	PBGK 220, FGK 948, FGK 1085, FGK 1153, FGK 1140, FGK 1141, GLK 95079, GLK 95091, BG 1053, L 550	Kabuli (bold and extra bold)

swelling index were calculated as reported by Sharma *et al.* [5]. Oil content was determined on NMR [6]. Methionine and tryptophan contents were determined by the methods of Horn *et al.* [7] and Hernandez and Bates [8] respectively. Data on quality parameters were subjected to statistical analysis [9]. Pearson's product moment correlations among various traits were estimated using the computer software GSTAT.

Results and discussion

Genotypes in different chickpea groups *viz.*, "desi" medium small, "desi" bold seeded and "kabuli" types are given in Table 1. Performance of elite genotypes of chickpea (Table 2) revealed the existence of considerable variation for all the traits among three groups of chickpea. Kabuli group exhibited highest mean values for 100-seed weight (32.62 g), 100-seed volume (25.1 ml), hydration capacity (0.33 g/seed), hydration index (1.02), swelling capacity (0.32 ml/seed), and swelling index (1.35) after soaking. Mean values of one hundred seed weight were recorded non significant among genotypes of kabuli chickpea. Bold seeded desi chickpea group also showed highest mean values for seed density (1.32 g/ml), protein (23.7%), and methionine (1.44 g/100g protein) as compared to desi medium small and kabuli chickpea groups (Table 2). Amongst three groups, highest values of seed yield (2038.9 kg/ha) and tryptophan (0.54 g/100g protein) were possessed by medium bold desi chickpea group followed by Kabuli chickpea type (1942.1 and 0.33 % respectively). Seed yield was found non significant in all the three groups. Medium small desi chickpea cultivars also possess minimum cooking time (79.6 minutes) in comparison to desi bold (91.1 minutes) and kabuli type (83.3 minutes) (Table 3). Kabuli chickpea type exhibited highest solid dispersion

(21.4%); hydration capacity (0.377); swelling capacity (0.306 ml/seed) while swelling index (1.42) and hydration index (1.177) were found to be maximum for desi bold type. Hard shelled grains (%) after soaking and *kokroos* after cooking were not found in any group. Solid dispersion after cooking was registered non significant among genotypes of group A.

Association among various traits in three groups of chickpea (Table 4) revealed that seed weight was negatively correlated with cooking time indicating that larger seeds did not necessarily take longer time for cooking [10]. On the other hand, seed weight was significantly and positively correlated with hydration capacity(S) in all the groups, with swelling capacity in group B (0.72) and with seed volume in group B (0.96) and C (0.75). Williams *et al.* [11] and Khan *et al.* [12] in both desi and kabuli chickpea and Waldia *et al.* [13] in kabuli chickpea have also reported significant and positive correlation of seed size with seed volume, hydration capacity and swelling capacity. Yadava *et al.* [14] reported significant positive correlation of 100-seed weight with hydration capacity and swelling capacity. Pandey *et al.* [15] reported significant positive correlation of 100-seed weight with hydration capacity in bold seeded genotypes and negatively with hydration capacity and swelling capacity in extra bold seeded genotypes. Similar observations were also exhibited by Sharma *et al.* [16].

Seed volume was significantly and positively correlated with hydration capacity(S) and swelling capacity(S) in group B (0.92 and 0.76 respectively.) and C (0.75, 0.92 respectively), negatively with cooking time (-0.64) and swelling index (-0.92) in group A after soaking and positively with hydration index in group B (0.68). Seed density was significantly and negatively correlated with hydration capacity (-0.83) and swelling capacity (-0.67) in group B and positively with swelling index (0.74) in group A. Significant negative correlation of cooking time with solid dispersion after cooking in kabuli chickpea was also found (-0.72). Hydration capacity was positively correlated with swelling capacity in group B & C while hydration index was positively correlated with swelling capacity in group B indicating that increase in weight after soaking in water would also increase its volume [16].

Hydration capacity (C) strongly and positively correlated with seed weight (0.76), hydration capacity (0.832) and negatively with swelling capacity (-0.63) after soaking in group A, indicating thereby that smaller seeded genotypes which on soaking exhibit higher

Table 2. Performance of elite genotypes of chickpea for physico-chemical quality attributes

Genotype	100- seed weight(g)	100-seed volume (ml)	Seed density (g/ml)	Hydration capacity (g/seed)	Hydration index	Swelling capacity (ml/seed)	Swelling index	Protein (%)	Tryptophan (g/100g protein)	Methionine (g/100g protein)	Seed yield (kg/ha)
Group A (Desi chickpea – Medium small seeded)											
FG 702	17.13	13	1.32	0.17	0.98	0.13	1.00	17.9	0.67	0.95	1917
FG 711	14.96	12	1.25	0.12	0.83	0.13	1.08	17.9	0.31	1.14	1944
FG 712	16.05	15	1.07	0.14	0.88	0.13	0.87	23.6	0.61	0.85	1750
FG 897	16.12	15	1.07	0.14	0.87	0.11	0.73	21.4	0.63	1.56	2389
FG 908	14.67	13	1.13	0.13	0.87	0.11	0.85	17.5	0.32	1.17	1944
PBG 204	15.68	14	1.12	0.14	0.89	0.12	0.86	18.8	0.68	1.19	2361
PBG 126	14.01	10	1.4	0.11	0.79	0.12	1.20	23.2	0.72	1.12	2056
PBG 184	15.10	15	1.07	0.14	0.93	0.11	0.73	25.8	0.19	1.37	2222
PBG 1	13.08	12	1.09	0.12	0.91	0.12	1.00	23.3	0.50	1.13	1889
GPF 2	13.90	13	1.47	0.13	0.94	0.13	1.00	19.7	0.77	1.42	1917
Mean	15.07	13.2	1.20	0.13	0.89	0.12	0.93	20.91	0.54	1.19	2038.9
CD (5%)	0.05	0.8	0.01	0.01	0.01	0.01	0.01	3.13	0.01	0.01	NS
Range	13.08- 17.13	10-15	1.07- 1.47	0.11- 0.17	0.79- 0.98	0.11- 0.13	0.73- 1.20	17.5- 25.8	0.19- 0.77	0.85- 1.56	1750-2389
Group B (Desi chickpea – Bold seeded)											
BG 1100	23.31	16	1.46	0.15	0.64	0.16	1.00	24.0	0.43	0.76	2431
CSJ 204	27.13	21	1.29	0.27	0.99	0.27	1.28	24.0	0.02	0.85	2083
BONG 787	28.47	22	1.29	0.30	1.05	0.28	1.27	23.6	0.34	0.73	1667
BGM 539	25.03	19	1.32	0.24	0.97	0.26	1.37	22.7	0.49	1.26	2083
BGM 541	24.90	19	1.31	0.24	0.96	0.27	1.42	24.0	0.40	1.72	1667
JSC 9	24.79	20	1.21	0.26	1.06	0.26	1.30	25.8	0.30	1.60	1458
GNG 1374	25.14	19	1.32	0.25	1.00	0.28	1.47	25.5	0.30	1.09	1597
UPKGB 336	23.89	17	1.39	0.23	0.96	0.25	1.47	22.2	0.25	1.89	1354
BGD 32	25.82	19	1.36	0.25	0.98	0.31	1.63	21.9	0.22	2.60	2153
IPC 2000-1	30.83	25	1.23	0.32	1.05	0.33	1.32	23.2	0.28	1.89	2222
Mean	25.93	19.7	1.32	0.25	0.97	0.27	1.35	23.7	0.30	1.44	1871.5
CD (5%)	2.19	0.01	0.01	0.01	0.01	0.01	0.05	0.55	0.01	0.01	NS
Range	23.31- 30.83	16-25	1.21- 1.46	0.15- 0.32	0.64- 1.06	0.16- 0.33	1.00- 1.63	21.9- 25.8	0.02- 0.49	0.73- 2.60	1354-2431
Group C (Kabuli chickpea- bold and extra bold)											
PBGK 220	32.97	25	1.32	0.30	0.92	0.29	1.19	24.1	0.51	0.93	2106
FGK 948	36.99	29	1.26	0.34	0.92	0.32	1.10	26.7	0.24	1.26	2037
FGK 1085	35.26	26	1.36	0.34	0.95	0.33	1.26	24.8	0.31	1.13	1806
FGK 1153	30.05	29	1.04	0.35	1.17	0.39	1.34	24.5	0.12	0.68	1713
FGK 1140	34.39	25	1.38	0.38	1.10	0.32	1.28	18.7	0.51	0.93	1806
FGK 1141	34.71	27	1.29	0.39	1.11	0.35	1.29	24.2	0.42	0.70	1806
GLK 95079	38.24	25	1.53	0.35	0.93	0.31	1.24	23.6	0.24	0.17	1944
GLK 95091	33.63	27	1.16	0.33	0.99	0.36	1.33	24.1	0.26	0.16	1852
BG 1053	27.41	21	1.31	0.31	1.12	0.27	1.28	22.3	0.30	1.18	2268
L 550	22.54	17	1.33	0.23	1.01	0.19	1.11	19.7	0.38	0.57	2083
Mean	32.62	25.1	1.30	0.33	1.02	0.32	1.24	23.3	0.33	0.77	1942.1
CD (5%)	NS	0.01	0.01	0.01	0.01	0.01	0.05	0.13	0.01	0.01	NS
Range	22.54- 38.24	17-29	1.04- 1.53	0.23- 0.39	0.92- 1.17	0.19- 0.39	1.10- 1.34	18.7- 26.7	0.12- 0.51	0.16- 1.26	1713-2268

Table 3. Performance of elite genotypes of chickpea for cooking quality attributes

Genotype	Hydration capacity (g/seed)	Hydration index	Swelling capacity (ml/seed)	Swelling index	Cooking time (min.)	Solid dispersion after cooking (%)
Group A (Desi chickpea – Medium small seeded)						
FG 702	0.20	1.12	0.22	1.69	78	10.2
FG 711	0.15	1.09	0.18	1.50	79	11.6
FG 712	0.17	1.06	0.21	1.40	76	10.9
FG 897	0.18	1.12	0.20	1.33	78	11.1
FG 908	0.17	1.16	0.16	1.23	81	12.2
PBG 204	0.17	1.08	0.18	1.29	79	13.7
PBG 126	0.13	0.99	0.13	1.08	81	11.2
PBG 184	0.18	1.28	0.13	1.30	78	12.4
PBG 1	0.16	1.06	0.20	1.33	84	14.5
GPF 2	0.13	0.93	0.19	1.46	82	10.9
Mean	0.164	1.089	0.18	1.361	79.6	11.87
CD(5%)	0.01	0.01	0.01	0.07	1.26	NS
Range	0.13-0.18	0.93-1.28	0.13-0.22	1.08-1.69	76-84	10.2-14.5
Group B (Desi chickpea – bold seeded)						
BG 1100	0.25	1.07	0.19	1.19	93	12.0
CSJ 204	0.31	1.14	0.27	1.29	90	12.8
BONG 787	0.36	1.26	0.29	1.32	75	11.3
BGM 539	0.25	0.99	0.27	1.42	100	18.2
BGM 541	0.31	1.25	0.26	1.37	102	17.6
JSC 9	0.32	1.21	0.25	1.25	85	14.0
GNG 1374	0.33	1.31	0.29	1.53	86	19.0
UPKGB 336	0.31	1.30	0.25	1.47	93	15.2
BGD 32	0.31	1.20	0.29	1.53	95	13.3
IPC 2000-1	0.32	1.04	0.46	1.84	92	19.7
Mean	0.307	1.177	0.282	1.421	91.1	15.3
CD (5%)	0.01	NS	0.01	0.01	1.20	0.11
Range	0.25-0.36	0.99-1.31	0.19-0.46	1.19-1.84	75-100	11.3-19.7
Group C (Kabuli chickpea-bold and extra bold)						
PBGK 220	0.40	1.21	0.33	1.32	82	24.9
FGK 948	0.49	1.32	0.42	1.45	77	25.9
FGK 1085	0.41	1.16	0.36	1.36	79	20.4
FGK 1153	0.36	1.20	0.31	1.34	84	22.2
FGK 1140	0.40	1.16	0.31	1.24	81	21.2
FGK 1141	0.34	0.98	0.34	1.26	83	23.2
GLK 95079	0.37	0.97	0.26	1.04	89	15.2
GLK 95091	0.39	1.16	0.31	1.15	89	17.7
BG 1053	0.37	0.97	0.21	1.24	90	18.7
L 550	0.24	1.06	0.21	1.09	84	25.1
Mean	0.377	1.119	0.306	1.249	83.8	21.4
CD (5%)	0.05	0.05	0.01	0.01	1.03	0.13
Range	0.24-0.49	0.97-1.32	0.21-0.42	1.09-1.45	77-90	15.2-25.9

Table 4. Correlations among various soaking quality traits of chickpea in three groups

Character 1	Character 2	Group A	Group B	Group C
100-seed weight	100-seed volume	0.56	0.96**	0.75*
	Cooking time	-0.87**	-0.35	-0.27
	Hydration capacity	0.84**	0.87**	0.75*
	Swelling capacity	0.11	0.72*	0.62
100-seed volume	Seed density	-0.64*	-0.80**	-0.40
	Protein	0.18	0.05	0.70*
	Cooking time	-0.64*	-0.34	-0.34
	Hydration capacity	0.59	0.92**	0.76*
	Hydration index	0.45	0.68*	-0.02
	Swelling capacity	-0.25	0.75*	0.92**
	Swelling index	-0.92**	0.05	0.37
Seed density	Hydration capacity	-0.15	-0.83**	-0.01
	Swelling capacity	0.54	-0.67*	-0.48
	Swelling index	0.74*	-0.16	-0.34
Cooking time	Solid dispersion after cooking	0.50	0.45	-0.72*
Hydration capacity	Hydration index	0.76*	0.89**	0.28
	Swelling capacity	0.12	0.88**	0.81**
	Seed yield	0.09	-0.21	-0.64*
Hydration index	Swelling capacity	0.16	0.86**	0.25
Swelling capacity	Swelling index	0.60	0.69*	0.69*
	Seed yield	-0.63	-0.15	-0.74*
Swelling index	Methionine	-0.41	0.73*	-0.30
Methionine	Seed yield	0.67*	-0.09	0.31
Critical value	5 %	0.632	0.632	0.632
	1 %	0.765	0.765	0.765

*,**Significant at 5% and 1% level of significance

Table 5. Correlations among various cooking quality traits of chickpea in three groups

	Hydration capacity (g/seed)	Hydration index	Swelling capacity (ml/seed)	Swelling index (%)	Cooking time (min.)
Group A					
Hydration index	0.7277				
Swelling capacity (ml/seed)	0.3680	-0.2709			
Swelling index (%)	0.4166	0.0065	0.7269		
Cooking time (min.)	-0.5581	-0.4196	-0.1652	-0.2944	
Solid dispersion after cooking (%)	-0.0289	0.1782	-0.1788	-0.2944	0.4996
Group B					
Hydration index	0.6886				
Swelling capacity (ml/seed)	0.3935	-0.2366			
Swelling index (%)	0.2388	-0.1186	0.8876		
Cooking time (min.)	-0.6813	-0.3879	-0.0726	0.1642	
Solid dispersion after cooking (%)	-0.0756	-0.1519	0.5504	0.1642	0.4482
Group C					
Hydration index	0.6170				
Swelling capacity (ml/seed)	0.7637	0.7170			
Swelling index (%)	0.6660	0.6962	0.7607		
Cooking time (min.)	-0.4207	-0.6828	0.7561	0.7337	
Solid dispersion after cooking (%)	-0.0108	0.5181	0.3799	0.5580	-0.7242

swelling capacity would also exhibit higher hydration capacity after cooking. Swelling capacity(C) exhibit a very strong correlation positive with 100 seed weight, hydration capacity(S), swelling capacity(S) in group B and Kabuli type thereby indicating that soaking characters in kabuli type and group B desi bold seeded genotypes could predict the cooking characteristics as well, while these characters in desi medium bold genotypes have a positive correlation. Swelling index(C) had a positive correlation with swelling capacity, hydration capacity, hydration index, swelling index after soaking in medium bold seeded chickpea genotypes.

Swelling index(S) was positively correlated with methionine in group B. Seed yield was negatively correlated with hydration capacity and swelling capacity in group C and positively with methionine in group A. Irrespective of different groups the Kabuli type genotypes were superior to desi type with respect to most of the physico-chemical and cooking quality traits, however desi type chickpea possess protein, tryptophane and methionine equal to or higher than that of kabuli type chickpea genotypes.

The results obtained from the present study revealed the existence of significant variation for physico-chemical, and cooking quality characteristics and seed yield in all groups of chickpea and that quality breeding can enhance quality level of this crop without affecting yield and that small seeded chickpea genotypes with better soaking characters might have superior swelling characters after cooking as well.

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