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Correlation among physiochemical and cooking quality traits in *kabuli* chickpea (*Cicer arietinum* L.)

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Abstract
The quality traits *viz*., seed weight, diameter, volume, protein content, water absorption after soaking, volume expansion after soaking, cooking time for raw seeds and cooking time for soaked seeds of 30 large seeded *kabuli* chickpea accessions were evaluated in Randomized Block Design having three replications during *rabi* at 2016-17 at Regional Agricultural Research Station, Nandyal, Andhra Pradesh. Seed weight exhibited positive correlation with all the traits studied *viz*., seed diameter, 100 grain volume, protein content, water absorption after soaking, volume expansion after soaking, cooking time for soaked seeds and cooking time for raw seeds. Hence, selection based on these traits will be effective for improving seed size. Whereas, cooking time exhibited positive correlation with seed size and indicated that cooking time increased with increase in size of the seed in *kabulis.*

Keywords: Cooking quality, correlation, *kabuli* chickpea, seed size

Introduction
Chickpea is the second most important food legume in the world after common bean (Gowda *et al*., 2015) [5]. Seed size is an important component of trade and yield in chickpea (Sharma *et al*., 2012) [21]. Water absorption**,** volume expansion (after soaking in water) and cooking time are important cooking quality traits in chickpea, particularly in *kabulis* which are mostly cooked as whole grain without decortication (Tripathi *et al*., 2012) [23]. Cooking time is defined as the time from commencement of boiling until 90-100 per cent of the seeds are cooked. Soaking and cooking of dry seeds induces chemical modification of protein-fiber complexes, which leads to an increase in crude fiber content. Thus, cooking can increase protein quality by destroying heat-labile antinutritional factors. Cooking also increases protein digestibility, essential amino acid index and protein efficiency ratio. The vitamin B complex dissolve into cooking water at differing rates and all cooking treatments leads to an improved protein digestibility, protein efficiency ratio and essential amino acid index.

The water absorbing capacity of the seed was determined by cell wall structure, composition, permeability of the seed coat and compactness of the cells (Muller 1967) [15]. High seed mass, seed volume and shorter cooking time across the environments in which it was grown are useful in crop improvement of chickpea for quality traits (Mehla *et al.*, 1999) [14]. Utilizable proteins are higher in *kabulis* (Singh *et al*., 1991). Therefore, due to their high protein content *kabulis* are utilized in many food formulations. Benefits of proteins usually depend on their physical and chemical properties and their interactions. Large seed size (seed diameter, volume and weight) with less cooking time is preferred in the *kabulis* which are largely used as whole grains in salads and vegetable curries (Tripathi *et al.*, 2012) [23] and limited information is available on the influence of various physiochemical traits on seed size. Therefore, the current investigation was undertaken to assess the relationships among physiochemical and cooking quality traits of 30 *kabuli* chickpea genotypes.

Materials and Methods
The present study was conducted during *rabi*, 2016-17 at Regional Agricultural Research Station, Nandyal, Andhra Pradesh. The present experiment was carried out with 30 *kabuli* chickpea genotypes in Randomized Block Design (RBD) with three replications under rainfed and irrigated situations and each genotype was raised in a single row plot of 4 meter length with inter row spacing of 30 cm and intra row spacing of 10 cm. Observations were recorded for 8 traits which include physiochemical and cooking quality characters *viz.*, 100 seed weight, seed diameter, 100 grain volume, protein content, water absorption after soaking, volume

expansion after soaking, cooking time for raw seeds, cooking time for soaked seeds. Phenotypic and genotypic correlations were worked out as per the procedures suggested by Johnson *et al*., (1955) [7]. Significance of correlation coefficients was tested by comparing phenotypic correlation coefficients with table values (Fisher and Yates, 1963) [2] at n-2 degrees of freedom at 5 per cent and 1 per cent level of significance.

Results and Discussion

The phenotypic and genotypic correlation coefficient analysis of eight physio-chemical and cooking quality traits in *kabuli* chickpea were presented in Table 1.

100 seed weight exhibited significant and positive phenotypic and genotypic correlation with all the seven traits *viz*., seed diameter (r_p= 0.8404, r_g= 0.9176), 100 grain volume (r_p= 0.9911, r_g= 0. 9967), protein content (r_p= 0.2300, r_g= 0.2398), water absorption after soaking (r_p= 0.9103, r_g= 0.9189), volume expansion after soaking (r_p= 0.9837, r_g= 0.9867), cooking time for soaked seeds (r_p= 0.7311, r_g= 0.7367) and cooking time for raw seeds (r_p= 0.7515, r_g= 0.7654).

Protein content showed highly significant and positive association with seed size. Similar results are reported by Anuradha *et al*. 2009 [1], Kauthar and Salah 2015 [9] for significant positive correlation of protein content with seed weight and seed volume and Williams *et al*. (1983) [24] reported significant positive correlation between cooking time and weight of seeds, seed diameter. Reports for positive and significant association of 100 seed weight with seed volume are also reported by Malik *et al.* (2011) [13]. Similar findings for positive correlation of seed volume with hydration capacity and swelling capacity and positive correlations among 100 seed weight and seed volume with hydration capacity and swelling capacity was reported by Tripathi *et al.* (2012) [23]. Seed diameter exhibited significant and positive *inter se* association with 100 grain volume, protein content, water absorption after soaking, volume expansion after soaking, cooking time for soaked seeds and cooking time for raw seeds. Similar findings for significant positive correlation between seed diameter with weight of seeds, seed volume, cooking time, water absorption and volume expansion are also reported by Williams *et al*. (1983) [24]. 100 grain volume showed significant and positive *inter se* association with 100 seed weight, water absorption after soaking, volume expansion after soaking, cooking time for soaked seeds. These results revealed increased in seed weight might be due to the high seed volume, water absorption and volume expansion. However, cooking time increased with increased seed volume. These findings are in consonance with the reports of Malik *et al*. (2010) [12], Malik *et al.* (2011) [13], Tripathi *et al*. (2012) [23] for 100 seed weight. Gil *et al*. (1996) [3], Kaur *et al*. (2005) [8] for water absorption. Khattak *et al*. (2006) [11, 16], Nizakat *et al*. (2006) [6] for volume expansion and cooking time.

Protein content revealed significant and positive *inter se* association with 100 seed weight, water absorption after soaking, volume expansion after soaking. These results showed that increased in protein content might be attributed to the high seed weight, seed volume, hydration capacity, swelling capacity. These findings are in accordance with the earlier reports of Govil *et al*. (1980) [4], Anuradha *et al*. (2009) [1]. Water absorption after soaking showed significant and positive *inter se* association with 100 seed weight, volume expansion after soaking, cooking time for soaked seeds. These results showed that increased in water absorption after soaking might be due to the high seed weight, seed volume, swelling capacity. However, cooking time increased with increased water absorption after soaking of the seeds. These results are supported by Williams *et al*. (1983) [24], Singh *et al*. (1992) [22], Khan *et al.* (1995) [10], Gil *et al*. (1996) [3], Kaur *et al*. (2005) [8], Iqbal *et al*. (2006) [6], Khattak *et al*. (2006) [11, 16], Ozer *et al*. (2010) [17], Tripathi *et al.* (2012) [23] for 100 seed weight. Similar reports for positive *inter se* association between water absorption after soaking and volume expansion after soaking reported by Kaur *et al*. (2005) [8], Pandey *et al.* (2007) [18], Saxena *et al*. (2013) [19].

Volume expansion after soaking showed significant and positive *inter se* association with 100 seed weight, cooking time for soaked seeds. These results revealed increased in volume expansion after soaking might be due to the higher water absorption, seed weight, seed volume. However, cooking time increased with increase in volume expansion after soaking of the seeds in chickpea. These results are in consonance with the reports of Gil *et al*. (1996) [3], Kaur *et al*. (2005) [8], Malik *et al*. (2010) [12] for volume expansion after soaking with 100 seed weight and Khattak *et al*. (2006) [11, 16], Nizakat *et al*. (2006) [6], Malik *et al.* (2011) [13] for volume expansion with cooking time.

Cooking time for soaked seeds and raw seeds exhibited significant and positive *inter se* association with all of characters studied and these findings are supported by the reports of Williams *et al*. (1983) [24], Malik *et al.* (2011) [13], Sfayhi and Kharrat (2011) [20], Tripathi *et al.* (2012) [23]. In the present investigation, traits *viz.*, seed diameter, 100 grain volume, water absorption after soaking, volume expansion after soaking, cooking time for soaked seeds and cooking time for raw seeds were showed positive and significant association among themselves and with 100 seed weight. However, cooking time increased with the increase in seed size. This is contradictory to the preferences of the consumers of bold grain with less cooking time. So, attention may be focused on higher the seed weight but with shortest cooking time for improving the seed size with less cooking time in *kabulis*.

Table 1: Phenotypic (r_p) and genotypic (r_g) correlation coefficients among cooking quality characters in 30 chickpea genotypes under rainfed condition during *rabi* 2016-17

Character		100 Grain Volume	Protein Content	Water absorption after soaking	Volume expansion after soaking	Cooking time for soaked seeds	Cooking time for raw seeds	100 seed weight
Seed diameter	r_p	0.8193**	0.4514**	0.7007**	0.8431**	0.468**	0.4661**	0.8404**
	r_g	0.8941	0.5352	0.7734	0.9171	0.5115	0.5039	0.9176
100 Grain Volume	r_p		0.2561*	0.9228**	0.9747**	0.7188**	0.7499**	0.9911**
	r_g		0.2666	0.9326	0.9805	0.7294	0.7686	0.9967
Protein Content	r_p			0.2462*	0.2828**	0.0785	0.0450	0.2300*
	r_g			0.2559	0.2976	0.0758	0.0377	0.2398
Water absorption after soaking	r_p				0.9160**	0.7810**	0.7576**	0.9103**
	r_g				0.9280	0.7981	0.7831	0.9189
Volume expansion after soaking	r_p					0.7426**	0.7539**	0.9837**
	r_g					0.7479	0.7661	0.9867
Cooking time for soaked seeds	r_p						0.9645**	0.7311**
	r_g						0.9715	0.7367
Cooking time for raw seeds	r_p							0.7515**
	r_g							0.7654

r_p= Phenotypic correlation; r_g = Genotypic correlation; *, ** Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively

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