

# Achievements and challenges in improving nutritional quality of chickpea

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**Abstract:** Chickpea (*Cicer arietinum* L.) grains are an excellent source of protein, carbohydrates, minerals, vitamins, dietary fibre, folate,  $\beta$ -carotene and health promoting fatty acids. Their consumption provides consumers with a variety of nutritional and health benefits. Limited breeding efforts have been made on nutritional quality traits of chickpea. Potential exists for further enhancing contents of protein, minerals (iron and zinc), folate and  $\beta$ -carotene and reducing the contents of flatulence causing raffinose family of oligosaccharides (RFOs).

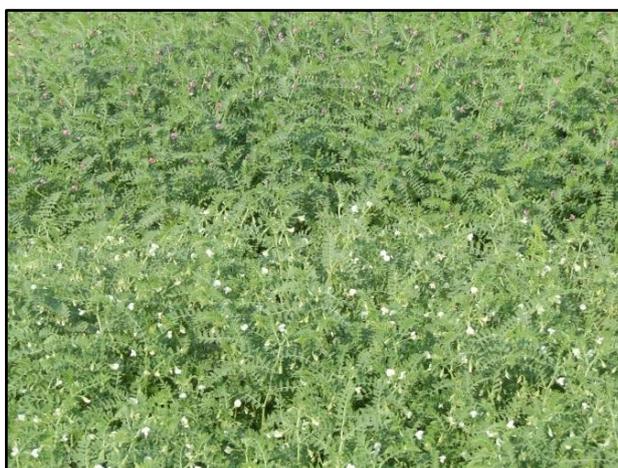
**Key words:** *Cicer arietinum*, dietary fibre, minerals, raffinose, protein, vitamins

The desi types account for about 80% to 85% of the global chickpea area and largely grown in South Asia, Eastern Africa, and Australia and mainly consumed in South Asia. Though the total chickpea area under kabuli type is less (15 to 20%), the production and consumption of kabuli type is globally more wide spread than the desi types. Chickpeas are mainly used for human consumption and a very small proportion as animal feed. The dry chickpea grains are used whole (after soaking and/or cooking, roasting or parching) or dehulled to make splits (*dal*) or ground to produce flour (*besan*).

The soaked/cooked chickpea grains are used in salads, making vegetable curries (*Chhole*) and several other preparations, such as falafel (deep fried balls or patties) and hummus (chickpea dip or spread). The chickpea flour is used in making a wide variety of snack foods, soups, sweets, and condiments besides being mixed with wheat flour to make Indian bread (*roti* or *chapati*). Invariably, splits (*dal*) and flour are made from desi type, while hummus is made from kabuli type. Chickpea leaves are used as leafy vegetable and immature green grains are eaten raw or after roasting and also used as vegetable.

Chickpea (*Cicer arietinum* L.), also called garbanzo bean, is globally the second most important food legume after common bean and grown in over 55 countries on an area of about 13 million ha (2). There are two distinct types in chickpea, *desi* (thick and darker coloured, mostly brown, seed coat) and *kabuli* (thin and cream-coloured seed coat) (Fig. 1 and 2).

**Figure 1. Desi (top) and kabuli (bottom) chickpea varieties**



**Figure 2: Desi (left) and kabuli (right) chickpea grains**



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Chickpeas are an excellent source of proteins, carbohydrates, dietary fibre, minerals and vitamins (Table 1). There is a growing interest in consumption of chickpea for promoting healthy diet and reducing risk of some diseases and other health problems. Chickpeas are rich in protein (20% - 22%) and the digestibility of chickpea protein is high as compared to several other legumes. Chickpea when consumed with cereals provide balanced amino acids in the diet because, like other pulses, it is high in lysine but limited in sulfur-containing amino acids (methionine and cysteine), while cereals are limited in lysine and rich in sulfur-containing amino acids. Chickpeas have high fibre content and low glycemic index (GI) value. The diets high in fibre and low in GI value are known to help in weight loss, management of type-2 diabetes, reducing cholesterol, and lowering risk of colon cancer. Chickpeas are low in sodium and fat and help in reducing the risk of coronary and cardiovascular diseases. Chickpeas are also known to reduce blood lipids that may help some serious complications of diabetes. Flour made from chickpeas is gluten free and can benefit people with celiac disease.

Market for chickpea products is growing even in developed countries. Hummus, a Middle Eastern dip, prepared from cooked and mashed chickpeas with optional ingredients, became very popular in the USA during the past two decades. The retail sales of hummus in the USA increased from \$5 million in 1997 to \$250 million in 2013. Hummus is preferred over other similar products (e.g. peanut butter) because of low fat and high protein content.

Chickpea is a part of regular diet of large number of people in developing countries and thus further enhancing its nutritional quality traits such as contents of protein, minerals and vitamins will help in improving nutrition and health of people. The protein content of currently available varieties of chickpea generally ranges from 20 % to 22%. Germplasm lines with high protein content (> 28%) have been identified and are used in breeding programs at ICRISAT and few other institutes. Improving the protein content by 20% - 25% appears feasible. The high protein cultivars will improve protein availability to the poor people by 20% to 25% from the same amount of chickpea consumed. ICRISAT and the University of Saskatchewan are working together on molecular mapping of genes / quantitative trait loci controlling chickpea protein content.

**Table 1. Chemical composition and nutritive values in mature grains of chickpea (6)**

Grain type	Kabuli	Desi
<b>Proximates (g 100g<sup>-1</sup>)</b>		
Protein	17.9-30.8	20.3-27.5
Starch	38.2-43.9	33.1-40.4
Amylose (% of total starch)	24.4-29.2	20.5-25.9
Fat	5.5-6.9	4.4-5.9
Acid Detergent Fibre	3.0-5.7	12.7-13.5
Neutral Detergent Fibre	4.2-7.7	10.1-13.6
<b>Minerals (mg 100g<sup>-1</sup>)</b>		
Calcium (Ca)	80.5-144.3	115.0-226.5
Copper (Cu)	0.7-1.4	0.5-1.4
Iron (Fe)	4.3-7.6	4.6-7.0
Potassium (K)	816.1-1580.1	1027.6-1479.1
Magnesium (Mg)	152.9-212.8	143.7-188.6
Manganese (Mn)	2.3-4.8	2.8-4.1
Phosphorus (P)	294.1-828.8	276.2-518.6
Zinc (Zn)	3.6-5.6	2.8-5.1
<b>Vitamins (mg 100g<sup>-1</sup>)</b>		
Ascorbic acid (C)	0.28-2.40	0.67-3.01
Thiamin (B1)	0.39-0.78	0.22-0.34
Riboflavin (B2)	0.10-0.34	0.16-0.24
Niacin (B3)	0.48-1.49	1.43-2.28
Folic acid (µg/100g)	153.8-486.5	109.0-294.4
<b>Fatty acid (% in oil)</b>		
Palmitic (C16:0)	8.52-10.30	8.56-11.05
Stearic (C18:0)	1.21-1.68	1.04-1.60
Oleic (C18:1)	27.70-42.46	18.44-28.51
Linoleic (C18:2)	42.25-56.59	53.13-65.25
Linolenic (C18:3)	2.23-3.91	2.54-3.65
<b>Sugars (g 100g<sup>-1</sup>)</b>		
Sucrose	3.10-4.41	1.56-2.85
Raffinose	0.48-0.73	0.46-0.77
Stachyose	1.76-2.72	1.25-1.98
Verbascose	Not detected	Not detected
Oligosaccharides (raffinose + stachyose + verbascose)	2.32-3.44	1.72-2.75
Phytic acid (g 100g <sup>-1</sup> )	0.78-1.25	0.63-1.24

The deficiencies of iron and zinc are widespread among people, especially in South Asia and sub-Saharan Africa. Chickpea has the potential to contribute to daily iron and zinc intake, and can help alleviate these problems of micronutrient malnutrition. Limited number of accessions evaluated for the contents of iron and zinc suggest that, like other pulses, chickpea has higher content of iron and zinc as compared to staple cereals (wheat and rice) (4).

Recent studies conducted at ICRISAT over two years (2011 and 2012) showed the existence of large genetic variability for Fe (35 ppm - 150 ppm) and Zn (25 ppm - 50 ppm) contents in cultivated and wild chickpea accessions (PM Gaur, unpublished results). These genotypes are being used for developing chickpea cultivars with enhanced iron and zinc contents.

Among various carotenoids,  $\beta$ -carotene is the most important carotenoid present in chickpea and converted into vitamin A more efficiently than the other carotenoids. Limited studies available on the availability of  $\beta$ -carotene in chickpea suggest that chickpea has a higher amount of  $\beta$ -carotene than 'golden rice' (1) or red-coloured wheat (5). There is a need to assess genetic variability for  $\beta$ -carotene in the germplasm of cultivated and wild *Cicer* species and identify high  $\beta$ -carotene lines for use in breeding programs.

The only negative factor associated to chickpea consumption is the flatulence caused by RFOs (mainly raffinose, stachyose, verbascose and ciceritol) which are  $\alpha$ -galactosides carbohydrates and present in all legume seeds. As the humans lack galactosidase enzyme, the RFOs are not digested and accumulated in the large intestine resulting in the production of hydrogen, methane and CO<sub>2</sub>, major components of flatulent gases. Despite numerous well-proven health benefits, RFO-induced flatulence reduces the acceptance of chickpea. A recent study showed a wide genotypic variation in total RFO concentration in both desi (1.58 mmol 100 g<sup>-1</sup> to 5.31 mmol 100 g<sup>-1</sup>) and kabuli (2.11 mmol 100 g<sup>-1</sup> to 5.83 mmol 100 g<sup>-1</sup>) chickpea (3), indicating possibility of developing varieties with low RFO contents. Moderate broad sense heritability values (0.25-0.56) observed for RFOs (3) suggest that the selection for low RFOs should be carried out in advanced generations and based on evaluation in multilocation trials.

The chickpea breeding programs have so far not given much emphasis on nutritional quality traits in chickpea. There is a need to assess genetic variability available in the germplasm of cultivated and wild species for various quality traits. Studies are also needed on establishing genetics, linkage relationships and G  $\times$  E interactions for many of these traits and identification of molecular markers/candidate genes associated with these traits. The wild *Cicer* species, induced mutations and transgenic technology have potential to provide additional genetic variability for exploitation in breeding programs. An integrated breeding approach would help in making rapid progress in developing chickpea varieties which are further enhanced for nutritional quality traits. Such varieties will help in improving nutritional security of the poor in the developing countries. 

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