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Review

Quality Traits, Measurements and Possible Breeding Methods to Improve the Quality Traits of Kabuli Type Chickpea (*Cicer arietinum* L.)

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Chickpea is an excellent source of proteins, carbohydrates, dietary fiber, minerals and vitamins. There is a growing interest in consumption of chickpea for promoting healthy diet and reducing risk of some diseases and other health problems. 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. The information presented here showed the potential nutritional importance of chickpea and its role in improved nutrition and health. It is an affordable source of protein, carbohydrates, minerals and vitamins, dietary fiber, foliate, β-carotene and health promoting fatty acids.

Keywords: chickpea (*Cicer arietinum L.)*, Kabuli

INTRODUCTION

Chickpea (*Cicer arietinum L.)* is an important pulse crop, which belongs to Leguminose family and ranking third after dry beans (*Phaseolus vulgaris L.)* and dry peas (*Pisum sativum L.).* It is *grown* in the arid and semi-arid regions of the world. Chickpea is annual cool season food legume having a diploid (2n=2x=16) set of chromosomes with an estimated genome size of 738 Mb [1]. The seeds are a good source of protein and mineral nutrient cultivated throughout the world and is placed third in the importance list of the food legumes. It is one of the first domesticated, cool season autogamous grain legume grown in more than 50 countries [2]. [3] Stated that chickpea has one definable center of origin; Turkey around 5450BC and more than one secondary centers of diversity. India and Ethiopia have been proposed as secondary centers of diversity for cultivated chickpea. Chickpea is one of the most important food legumes grown in Ethiopia. The crop has several names in different parts of the world like Bengal gram (India), Chana (Urdu), Chickpea or gram (English), Garbanzo (Latin America), Kichar or Chicher (German), Hommas, Hamaz (Arab world), Nohud, Lablabi (Turkey), Poice chiche (French) and Shimbra (Ethiopia) [4].

There are two distinct types of cultivated chickpea (Kabuli and Desi) based on 23 morphological characters mainly seed size, shape and color, plant growth habit, pigmentation of vegetative floral part and so on [2]. *Desi* type is characterized by small seed size of various colours, thick seed coat due to rigid and extensively thickened palisade layer with pectic and protein, high percentage of fiber and angular seed shape with rough testa texture. It has semi erect to semi-spreading growth, presence of anthocyanin on the stem pink, purple or white flower colour and small leaves. Seeds are mostly decorticated and processed in to flour but some consumed as whole [5]. *Desi* type covers about 85 % of the global chickpea areas and it predominantly grown in South and East Asia, Ethiopia, Australia and Eritrea. Kabuli type is characterized by big size of seeds with whitish-cream colour, thin seed coat due to thinner palisade and parenchyma layers with fewer pectic polysaccharides and less protein, low percentage of fibre, owl's head shape and mostly smooth testa textured. They have large leaves, usually semi-spreading to semi-spreading growth habit, no anthocyanin with white flower colour. *Kabuli* seeds are normally cooked and consumed as whole and used as salads and vegetable mixes. *Kabuli* type covers 15 % of the world chickpea and grown mostly in Mediterranean regions, West Asia, North Africa and North America [6].

Chickpea is an excellent source of proteins, carbohydrates, dietary fiber, minerals and vitamins. The seeds of chickpea contain protein of 16.7% to 30.6% for desi type and 12.6% to 29.0% for kabuli type, commonly 2–3 times higher than that of cereal grains; carbohydrate of 51– 65% in desi type and 54 – 71% in kabuli type [5]; lipid of 2.9% to 7.4% for desi and 3.4% to 8.8% for kabuli types, and high percentage of different minerals nutrients such as calcium, magnesium, potassium, phosphorus, iron, zinc and manganese [7]. There is a growing demand for chickpea due to its nutritional value. In the semi-arid tropics chickpea is an important component of the diets of those individuals who cannot afford animal proteins or those who are vegetarian by choice.

Therefore, the objective of this paper is

✓ To discusses the major quality traits of kabuli type chickpea

✓ To review measurements and possible breeding methods to improve the quality traits of Kabuli type chickpea

REVIEW OF LITERATURE

Origin and Diversity of Chickpea

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, after dry bean and field pea [8]. [10] recognized the Near Eastern, Central Asian, Indian and Mediterranean regions as the probable centers of origin for chickpea. [4] and [3] also believed that the present day south eastern part of Turkey adjoining Syria is the possible center of origin of chickpea based on the presence of the closely related annual species in this region. Ethiopia is also considered as secondary center of origin as the wild relatives, particularly *Cicer cuneatum* exist in the country [9]. It is locally known as *shimbra* which is one of the major pulse crops in Ethiopia and the second most important legume crop after faba bean.

Botanical Description of Chickpea

Cultivated chickpea, is a self-pollinated, diploid (2n= 2x =16) annual pulse crop with a relatively small genome size of 738Mb [1]. It belongs to Family, Fabaceae Genus, *Cicer* and Species, *C. arietinum*. The crop is herbaceous, a small bush with diffused spreading branches from the base, which reach a height of 20 – 150 cm depending on cultivar and suitability of the growing environment. Its stem is mostly erect, branched and solid and has strong deep taproot system which makes it relatively drought tolerant. The crop has an indeterminate growth habit which continues to produce vegetative growth whenever soil moisture, temperature and other environmental factors are favorable [11]

World Production and Utilization of Chickpea

Chickpea is one of the major pulse crops grown throughout the world. It is cultivated on a large scale in arid and semi-arid environment, and has considerable importance as food, feed and fodder [12]. It is the most important food legume crops in the world grown on 11 million ha worldwide with a total production of 9 million tons in 2006-08 [13]. India is by far the largest chickpea growing country in the world. The two South Asian countries (India and Pakistan) together cover more than 75% of total world chickpea area. The other top chickpea growing countries from the developing world include Iran and Turkey (5% share in world chickpea area each), and Myanmar and Ethiopia (2% share each). Mexico ranked next followed by many other small producers (and less than 1% share in world chickpea area [13].

Chickpea has great importance as food, feed and fodder. The crop provides an important source of food and nutritional security for the rural poor, especially those who cannot produce or cannot afford costly livestock products as source of essential proteins. The consumption of chickpea is also increasing among the urban population mainly because of the growing recognition of its health benefits and affordable source of proteins [14].

Environmental requirements

Chickpea is one of the major pulses grown in Ethiopia, mostly by subsistence farmers usually under rain fed conditions. It is widely grown across different agro-ecological zones falling between 1400 to 2300 m above sea level on Vertisoils with a range of pH 6.4-7.9 where the mean annual rainfall ranges from 700 to 2000 mm [15]. The crop mainly grows under residual moisture at the end of the main rainy season in water-logging areas [16]. Chickpea is an annual crop that grows best on heavy soil, rough seed bed and requires moderately high temperature [17]. It also grows on poor soils and it cannot tolerate heavy rains. Hence, it fails to grow in wet tropical areas. Several factors, including the length of growing period, mean air temperature, soil drainage, soil reaction, soil depth, occurrence of soil borne diseases etc, determine the adaptation and performance of chickpea [18].

Distributional Zones of Chickpea in Ethiopia

The largest growing regions of chickpea in Ethiopia are Amhara, Oromia and few districts of Tigray and SNNPR [19]. In line with this idea, [20] noted that the major chickpea producing areas are concentrated in the two regional states - Amhara and Oromia. These two regions cover more than 90% of the entire chickpea area and constitute about 92% of the total chickpea production in the country. The top chickpea producing zones (North Gonder, South Gonder, North Shewa, East Gojam, South Wello, North Wello, West Gojam, and Gonder Zuria) belong to the Amhara region and account for about 80% of the country's chickpea production. In the Oromia region, the major producing zones are in West Shewa, East Shewa and North Shewa, which account for about 85% of the total area and production in this Regional State [20].

Importance of Chickpea in Ethiopia

Chickpea, locally known as *shimbra*, is one of the major pulse crops grown in Ethiopia. It plays a key role in providing protein to the diet of the population. The crop has high nutritive value and serves as an important cheap source of protein in developing countries in addition to improving land fertility [21]. The chickpea seed is a good source of carbohydrates and proteins, which collectively constitute 80% of the total dry seed weight [22]. The seeds contain 16.7% to 30.6% protein for desi type and 12.6% to 29.0% for kabuli type, commonly 2- 3 times higher than that of cereal grains; carbohydrate of 51– 65% in desi type and 54- 71% in kabuli type [5]; lipid of 2.9% to 7.4% for desi and 3.4% to 8.8% for kabuli types, and high percentage of different minerals nutrients such as calcium, magnesium, potassium, phosphorus, iron, zinc and manganese [7].

Constraints of Chickpea Production in Ethiopia

Chickpea production is exposed to different abiotic and biotic constrains which penalize seed yields. The major bottlenecks limiting chickpea production and causing wide yield gap globally include biotic (Pod borer, Fusarium wilt, and Ascochyta blight) and abiotic (drought, heat, cold and salinity) stresses [23]. In chickpea, biotic and abiotic constraints could be estimated by yield gap between the potential and actual yield. Considerable yield losses occur due to abiotic stresses like drought, salinity, cold and frost. Resistance or tolerance to these stresses is more complex [24]. The most common abiotic stresses affecting chickpea production are drought (particularly terminal drought), heat and cold. In addition, there are other abiotic stresses specific to some regions such as salinity, water logging, soil alkalinity and acidity, and nutrient deficiencies and toxicities.

Qualitative Traits

Plant characters often are referred to as qualitative or quantitative depending on the number of genes that control them and the importance of the environment in expression of the genes. Qualitative characters have phenotypes that can be divided in to discrete classes. They are controlled by one or a few major genes whose expression is not influenced markedly by the environment. A quantitative character displays a continuous distribution of phenotypes. The variability is associated with the segregation of multiple minor genes or polygenes. Seed yield is a quantitative character controlled by polygenes and strongly influenced by environment.

Nutritional Aspect of Chickpea

Most legumes have high nitrogen contents, due to their ability to fix atmospheric nitrogen through a symbiotic association with soil microbes. 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 × 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. Nutritionally, Kabuli chickpeas are very slightly higher in protein content and fat, however Desi chickpeas provide more than three times the dietary fiber [25].

Chickpea Grain Composition

Carbohydrates

Carbohydrates are classified into available (mono and disaccharides), which are enzymatically digested in the small intestine and unavailable (oligosaccharides, resistant starch, non-cellulosic polysaccharides, pectins, hemicelluloses and cellulose), which are not digested in the small intestine [26]. The total carbohydrate content in chickpea is higher than pulses. Chickpea has: monosaccharides- ribose, glucose, galactose and fructose, disaccharides-sucrose, maltose and oligosaccharides, stachyose, ciceritol, raffinose and verbascose [27]. The amount of these fractions varies though not significantly, between desi and kabuli genotypes [28] reported chickpea monosaccharide concentration for galactose (0.05 g 100-g), ribose (0.11 g 100-g), fructose (0.25 g 100-g) and glucose (0.7 g 100 g). Maltose (0.6%) and sucrose (1-2%) have been reported to be the most abundant free disaccharides in chickpea [5]. The content of starch varies from 41-50% of the total carbohydrates [29] with kabuli types having more soluble sugars (sucrose, glucose and fructose) compared to the desi types [30]. The total starch content of chickpea seeds is reported to be ~ 525 g kg-1 dry matter, about 35% of total starch is considered to be resistant starch (RS) and the remaining 65% as available starch [31].

Dietary Fiber

Dietary fiber (DF) is the indigestible part of plant food in the human small intestine. DF is composed of poly/oligosaccharides, lignin and other plant-based substances [32]. Total dietary fiber content (DFC) in chickpea is 18-22 g of 100 g of raw chickpea seed [31] and it has higher amount of DF among pulses. Soluble and insoluble DFC is about 4-8 and 10-18 g of 100 g of raw chickpea seed respectively [33]. The fiber content of chickpea hulls on a dry weight basis is lower [75%] compared to lentils [87%] and peas [89%] [33]. The lower DFC in chickpea hulls can be attributed to difficulty in separating the hull from cotyledon during milling.

The DFC of chickpea seed is equal to or higher than other pulses like and dry peas [34]. The desi types have higher total DFC and insoluble DFC compared to the kabuli types. This could be due to thicker hulls and seed coat in desi (11.5 % of total seed weight) compared to the kabuli types (only 4.3-4.4 % of total seed weight) [35].

Protein Content and Amino Acid Profile

Pulses provide a major share of protein and calories in Afro-Asian diet. Among the different pulses, chickpea is reported to have higher protein bioavailability [36]. Chickpea protein quality is better than some pulse crops such as black gram (*Vigna mungo* L.), green gram (*Vigna radiata* L.) and red gram (*Cajanus cajan* L.) [37]. There are no significant differences in the amino acid profiles of kabuli and desi type chickpea [38].

Fat Content and Fatty Acid Profile

Total fat content in raw chickpea seeds varies from 2.70-6.48 % [37]. [39] reported lower values (~ 2.05 g 100-g) for crude fat content in desi chickpea varieties. Fat content of 3.40-8.83% and 2.90-7.42% in kabuli and desi type chickpea seeds respectively was reported by [5]. Further, even higher levels (3.80-10.20%) of fat content in chickpea were reported [40]. The fat content in chickpea (6.04 g 100-g) is higher than the other pulses like lentil (1.06 g 100 g), red kidney bean (1.06 g 100g), mung bean (1.15 g 100-g) and pigeon pea (1.64 g 100-g) and also cereals like wheat (1.70 g 100-g) and rice (~0.60 g 100-g)([41]. Chickpea is composed of polyunsaturated fatty acids (PUFA; ~ 66%), monounsaturated fatty acids (~19%) and ~ 15% saturated fatty acids. On average oleic acid was higher in the kabuli types and linoleic acid was higher in the desi types. Chickpea is relatively a good source of nutritionally important PUFA, linoleic acid (51.2 %; LA) and monounsaturated oleic acid (32.6%; OA). Chickpea has higher amounts of linoleic and oleic acid compared to other edible pulses like lentils (44.4% LA; 20.9 OA), pea (45.6 LA; 23.2 OA) and bean 46.7% LA; 28.1% OA)(56). Linoleic acid is the dominant fatty acid in chickpea followed by oleic and palmitic acids.

Oil Characteristics

Chickpea cannot be considered as oilseed crop since its oil content is relatively low [3.8 10%] in comparison to other important oilseed pulses like soybean or groundnut [40]. However, chickpea oil has medicinal and nutritionally important tocopherols, sterols and tocotrienols (Zia-Ul-Haq M, *et al.* (2007).

Minerals

Chickpea, like other pulses, not only brings variety to the cereal-based daily diet of millions of people in Asia and Africa, but also provides essential vitamins and minerals [42]. Raw chickpea seed (100 g) on an average provides about 5.0 mg 100-g of iron, 4.1 mg 100-g of zinc, 138 mg 100-g of magnesium and 160 mg 100-g of calcium. About 100g of chickpea seed can meet daily dietary requirements of iron (1.05 mg/day in males and 1.46 mg/day in females) and zinc (4.2mg/day and 3.0 mg/day) and 200g can meet that of magnesium (260 mg/day and 220 mg/day)[43]. There were no significant differences between the kabuli and desi genotypes except for calcium, with desi types having a higher content than kabuli types [44].

Vitamins

Vitamins are required in tiny quantities; this requirement is met through a well-balanced daily diet of cereals, pulses, vegetable, fruits, and meat and dairy products. Pulses are a good source of vitamins. Chickpea is a relatively inexpensive and good source of folic acid and tocopherols [both γ and α; [45]. It is a relatively good source of folic acid coupled with more modest amounts of water soluble vitamins like riboflavin (B2), panthothenic acid (B5) and pyridoxine (B6), and these levels are similar or higher than that observed in other pulses. However, the niacin concentration in chickpea is lower compared to pigeon pea and lentil [46].

Improving Protein Content and Nutrition Quality

In order to devise the best strategy to improve protein content in legumes, we surveyed the genetic variability of seed protein content in major food legumes, its relationship with other important traits such as yield components, its heritability and interactions with environment, and its genetic determinants. To improve seed protein content, there should be enough genetic variability for this trait. A second important factor for efficient selection is the heritability of the trait. Seed protein content in grain legumes is strongly influenced by the environment.

Achievements in improving nutritional quality of chickpea

Chickpea is an excellent source of proteins, carbohydrates, dietary fiber, minerals and vitamins. 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 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. 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) (Jukanti AK, *et,al*, 2012).

SUMMARY AND CONCLUSIONS

Chickpea is an excellent source of proteins, carbohydrates, dietary fibre, minerals and vitamins. There is a growing interest in consumption of chickpea for promoting healthy diet and reducing risk of some diseases and other health problems. Chickpea is rich in protein (20% - 22%) and the digestibility of its 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.

The information presented here shows the potential nutritional importance of chickpea and its role in improved nutrition and health. It is an affordable source of protein, carbohydrates, minerals and vitamins, dietary fibre, folate, β-carotene and health promoting fatty acids. Scientific studies provide some evidence to support the potential beneficial effects of chickpea components in lowering the risk for various chronic diseases, although information pertaining to the role of individual chickpea components in disease prevention and the mechanisms of action are limited to date. This is due to the complex nature of disease etiology and various factors impacting their occurrence. It is imperative the scientific community continues to unravel the mechanisms involved in disease prevention and determine how food bio-actives from such foods as chickpea can influence human health. Further research, especially well conducted RCTs, and needs to be performed to provide compelling evidence for the direct health benefits of chickpea consumption.

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