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REVIEW ARTICLE **OPEN ACCESS**

ORIGIN, DOMESTICATION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETC DIVERSITY AND BREEDING OF CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

The chickpea or chick pea (*Cicer arietinum*) is an annual legume of the family Fabaceae, subfamily Faboideae. Its different types are variously known as gram or Bengal gram, chhana, chana, or channa, garbanzo or garbanzo bean, or Egyptian pea. Also known as ceci beans, Indian peas, kadale kaalu, sanaga pappu, and shimbra. The Sanskrit name for chickpea is *chennuka,* andhence, the name *chana* in the Sanskrit-derived languages such as Hindi. Chickpea is a cool season legume crop grown world- wide as a food crop. The seed is the main edible part of the plant. Chickpea is a cheap and important source of protein for those people who cannot afford animal protein or who are largely vegetarian. Furthermore, chickpea is also a good source of minerals (calcium, phosphorus, magnesium, zinc and iron), unsaturated fatty acids, fibre and β-carotene). Chickpea also plays an important role in maintaining soil fertility by fixing nitrogen at rates of up to 140 kg/ha/year. Therefore, this crop requires relatively low inputs of nitrogen as it derives 70% of its N through symbiotic N_2 fixation and benefits other cereal crops as well. On the basis of seed colour and geographical distribution, chickpea is grouped into two types: desi (Indian origin) and kabuli (Mediterranean and Middle Eastern origin). Desi seeds are brown, black or green in colour and are cultivated asa legume crop. Kabuli seeds are white to cream colouredand are used for cooking purposes for humans. The seed weight generally ranges from 0.1 to 0.3 g for desi and 0.2 to 0.6 g for kabuli/. The desi type accounts for about 80–85% of total chickpea production, and is grown mostly in Asia and Africa, while the kabuli types are largely grown in West Asia, North Africa, North America and Europe. Chickpeas appear in early recordings in Turkey about 3500 BCE and in France 6790 BCE. India produces the most chickpeas worldwide but they are grown in more than 50 countries. An excellent source of carbohydrate, protein, fiber, B vitamins, and some minerals, they are a nutritious staple of many diets. Chickpea is widely grown for its nutritious seeds. Chickpeas are an important food plant in India, Africa, and Central and South America. The seeds are high in fibre and protein and are a good source of iron, phosphorus, and folic acid. As with other legumes, chickpeas have a symbiotic association with nitrogen-fixing bacteria and can be rotated with nitrogen-intensive crops such as cereals to improve soil conditions. Till 17th century, roasted and grounded chickpeas and were brewed as a substitute for a coffee in Europe. Around 800 AD, chickpeas were associated with Venus, the Roman Goddess for beauty and love as it improves fertility by increasing sperm production, stimulating menstruation and lactation. In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Chickpea are discussed.

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INTRODUCTION

Chickpeas are of the Family Fabaceae or *Leguminosae* (the legume, pea, and pulse family), and Genus *Cicer*. Their binomial name is *cicer arietinum* **(**Lucas and Fuller, 2014**).** Even though we find chickpeas mostly in black and white varieties, scientists have discovered more than 90 genotypes, which include wild species as well (Netmeds. 2023).

The chickpea or chick pea (*Cicer arietinum*) is an annual legume of the family Fabaceae, subfamily Faboideae. Its different types are variously known as gram or Bengal gram, chhana, chana, or channa, garbanzo or garbanzo bean, or Egyptian pea. Also known as ceci beans, Indian peas, kadale kaalu, sanaga pappu, and shimbra. **(**Lucas and Fuller, 2014; Wikipedia, 2023; Britannica, 2023**).** The Sanskrit name for chickpea is *chennuka,* andhence, the name *chana* in the Sanskrit-derived languages such as Hindi (van der Maesen 1987). These yummy legumes are also popular as Kondaikadali in Tamil,

Senagalu in Telugu, Kadala in Malayalam and Kadale in Kannada (Netmeds. 2023). The name "chickpea," earlier "chiche pease," is modelled on Middle French *pois chiche*, where *chiche* comes from Latin *cicer*. "Chich" was used by itself in English from the 14th to the 18th centuries. The word *garbanzo*, from an alteration of Old Spanish *arvanço*, came first to English as "garvance" in the 17th century, being gradually anglicized to "calavance", though that came to refer to a variety of other beans, including the hyacinth bean. The current form *garbanzo* comes directly from modern Spanish (Wikipedia, 2023). Chickpea (*Cicer arietinum* L.) is cultivated in almost all parts of the world covering Asia, Africa, Europe, Australia, North America and South America continents. It is known by various com-mon or local names in different countries like *Hamas*, *Hommos*, *Humz*, *Nakhi* and *Melanch* in Arabian countries; *Keker* in the Netherlands; *Kichererbse* in Germany and Belgium; *Ceseror* and *Cicerolle* in France, *Ceci* in Vatican City and Switzerland, *Simbra* in Ethiopia; *Lablabi* in Turkey; *Garbanzo* or *Garbanzobean* in Spain; *Gravanço* in Portugal; and *Ovetichie* in Russia. Similarly, in India, chickpea is known by various names like *Chana* or *Gram* or *Bengal gram* or *Chani* in Haryana, Rajasthan, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand, etc.; *Chhole* in Punjab, Jammu and Kashmir and Delhi; *Chola* in West Bengal; *Harbara* in Maharashtra; *Boot* in Orissa; *Sanagulu* in AndhraPradesh; *Kadale* in Karnataka; *Kadalai* in Tamil Nadu; and *Kadala* in Kerala, indicating its wide-spread cultivation and knowledge of utilization Singh and Diwakar, 1995).Other names for this crop of Neolithic southwest Asian origin include garbanzo bean in the Americas, hamaz in Arabic countries, nohud or lablabi in Turkey, shimbra in Ethiopia, and bengal gram or chana in India **(**Lucas and Fuller, 2014**).** The name chickpea comes from the Latin word *cicer*, referring to the plant family of legumes, Fabaceae. It is also known by its popular Spanish-derived name, the garbanzo bean. These plants produce edible seeds, called pulses, that have high nutritional value. Two main varieties of chickpeas are the larger round light-colored Kabuli-type, common in the United States, and the smaller dark irregularly shaped Desi-type often used in India and the Middle East (Tori Avey, 2022)

Chickpeas appear in early recordings in Turkey about 3500 BCE and in France 6790 BCE. India produces the most chickpeas worldwide but they are grown in more than 50 countries. An excellent source of carbohydrate, protein, fiber, B vitamins, and some minerals, they are a nutritious staple of many diets (Tori Avey, 2022). Chickpea is a cool season legume crop grown world- wide as a food crop. The seed is the main edible part of the plant. Chickpea is a cheap and important source of protein for those people who cannot afford animal protein or who are largely vegetarian. Furthermore, chickpea is also a good source of minerals (calcium, phosphorus, magnesium, zinc and iron), unsaturated fatty acids, fibre and β-carotene). Chickpea also plays an important role in maintaining soil fertility by fixing nitrogen at rates of up to 140 kg/ha/year. Therefore, this crop requires relatively low inputs of nitrogen as it derives 70% of its N through symbiotic N_2 fixation and benefits other cereal crops as well (Rasool *et al*., 2015). On the basis of seed colour and geographical distribution, chickpea is grouped into two types: desi (Indian origin) and kabuli (Mediterranean and Middle Eastern origin). Desi seeds are brown, black or green in colour and are cultivated as a legume crop. Kabuli seeds are white to cream coloured and are used for cooking purposes for humans. The seed weight generally ranges from 0.1 to 0.3 g for desi and 0.2 to 0.6 g for kabuli/. The desi type accounts for about 80–85% of total chickpea production, and is grown mostly in Asia and Africa, while the kabuli types are largely grown in West Asia, North Africa, North America and Europe. *Desi chana* as it is known in north India or as *Boot* in Eastern India (Assam, parts of Bihar), has small, darker seeds and a rough coat. They are grown mostly in India and other parts of the Indian subcontinent, as well as in Ethiopia, Mexico, and Iran. *Desi* means "country" or "native" in Hindi; its other names include *kala chana* ("black chickpea" in Hindi) or *chholaa boot* or *Boot* in Assamese. Desi chana can be black, green or speckled. This variety is hulled and split to make *chana dal*, *Kurukshetra Prasadam* (channa laddu), and *Bootor Daali* (Wikipedia, 2023). Garbanzo beans or 'kabuli' chana are lighter-coloured, larger, and with a smoother coat and are mainly grown in the Mediterranean, Southern Europe, Northern Africa, South America, and the Indian subcontinent. *Kabuli chana* means "from Kabul" in Hindi. This variety was thought to come from Kabul, Afghanistan, when it was introduced to India in the 18th century (Wikipedia, 2023). Chickpeas are an important food plant in India, Africa, and Central and South America. The seeds are high in fibre and protein and are a good source of iron, phosphorus, and folic acid (Britannica, 2023). Chickpeas (*Cicer arietinum* or garbanzo beans) are large roundish legumes, that look rather like a large round pea with an interesting bumpy surface. A staple of Middle Eastern, African and Indian cuisines, the chickpea is the world's second most widely grown legume after the soybean, and one of the eight founder crops of the origins of agriculture on our planet. Chickpeas store really well and are high in nutritive value, although they are not very disease resistant, compared to other legumes (Hirst, 2019). It is cultivated on nearly every continent, but major traditional production is in India, Pakistan, Turkey, Myanmar, and Ethiopia. Chickpea can be consumed cooked, baked, roasted, popped (like popcorn), stewed, or ground into flour (gram flour). The success of chickpea on a global scale is due to its high seed-protein content (nearly 20 %) and, as a result, its potential as a valuable meat substitute. The high protein content makes it a perfect addition to cereals Chickpeas are of the Family Fabaceae or *Leguminosae* (the legume, pea, and pulse family), and Genus *Cicer*. Their binomial name is *Cicer arietinum* **(**Lucas and Fuller, 2014**).** Over 90 chickpea genotypes have had their genome sequenced, with researches having identified over 28,000 genes and several million genetic markers **(**Lucas and Fuller, 2014**).** Chickpeas currently supply over 20% of the world with protein, but crops are under threat from climate change coupled with a lack of genetic diversity **(**Lucas and Fuller, 2014**).** Chickpeas were bred so that the seed remains with the plant, but this has lead to less diverse plants. A lack of genetic diversity has left chickpeas susceptible to any environmental change **(**Lucas and Fuller, 2014**).** In addition to this, chickpeas are also highly susceptible to pathogens. Pathogens currently account for over 90% of crop loss in chickpeas **(**Lucas and Fuller, 2014**).**

Chickpea is widely grown for its nutritious seeds. Chickpeas are an important food plant in India, Africa, and Central and South America. The seeds are high in fibre and protein and are a good source of iron, phosphorus, and folic acid. As with other legumes, chickpeas have a symbiotic association with nitrogen-fixing bacteria and can be rotated with nitrogen-intensive crops such as cereals to improve soil conditions **(**Britannica, 2023a). Roasted and ground chickpeas have been used as a caffeine-free alternative to coffee for centuries. The beverage is also available as ready-to-brew commercial brands in some grocery stores. Don't throw out chickpea liquid, either from canned beans or from cooking the bean! It is called aquafaba, a thick liquid containing a mix of starch and trace amounts of protein, with emulsifying, binding, and thickening properties. It works well as a flavorless, odorless egg replacer in recipes: 1 tablespoon of aquafaba = 1 egg yolk, 2 tablespoons = 1 egg white, and 3 tablespoons = 1 one whole egg. It can also be whipped to replace the eggs in meringues or mayonnaise. Unlike many canned vegetables, canned chickpeas retain much of their nutritional value and are comparable to dried cooked versions (Tori Avey, 2022). Gram flour or besan is a pulse flour made from chana daal or brown/*kaala chana*, a chickpea. It is a staple ingredient in the cuisine of the Indian subcontinent, including in Indian, Bangladeshi, Burmese, Nepali, Pakistani, Sri Lankan and Caribbean cuisines. Gram flour contains a high proportion of carbohydrates, higher fiber relative to other flours, no gluten, and a higher proportion of protein than other flours (Wikipedia, 2023a). Till 17th century, roasted and grounded chickpeas and were brewed as a substitute for a coffee in Europe. Around 800 AD, chickpeas were associated with Venus, the Roman Goddess for beauty and love as it improves fertility by increasing sperm production, stimulating menstruation and lactation (Netmeds. 2023). In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Chickpea are discussed.

ORIGIN AND DOMESTICATION

The world distribution map of 131 kabuli, desi, pea-shaped and wild chickpea is presented in *Fig. 1*. Moreno and Cubero (1978) are of the view that the domestication seems to have occurred from the wild progenitor *C. reticulatum* (syn. *C. arietinum*ssp. *reticulatum*) with monophyletic origin, as shown by the low genetic variation of the cultigen *C. arietinum* ssp. *arietinum.*

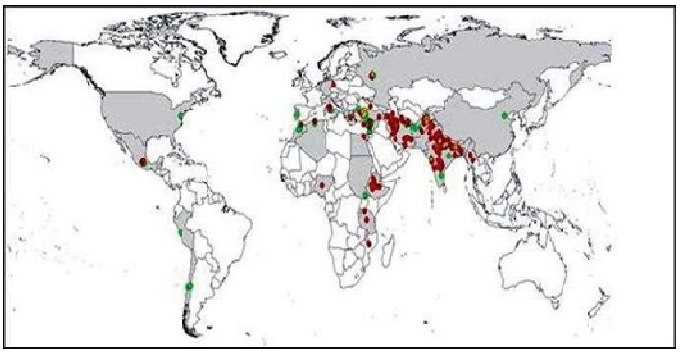

Fig. 1. The chickpea distribution, kabuli in green, desi in red, pea-shaped in orange and wild inyellow color dots

Chickpea (*Cicer arietinum* L.) is believed to haveoriginated in the area between south-eastern Turkey and adjoining Syria for the fact that three closely related wild annual species of chickpea, *C. bijugum*, *C. echinospermum* and *C. reticulatum*, are found there. Of the three, *C. reticulatum* is considered to be the progenitor of the cultivated chickpea (*Cicer arietinum*). From its place of origin,chickpea spread in both directions—European countries in the west and up to India, later to Myanmar in the east (van der Maesen, 1987). *Cicer arietinum*, commonly known as the chickpea, chick pea, or garbanzo bean, is a high protein legume. Originally found in the Mediterranean and Middle East, chickpeas have since become popular across the world. **(**Lucas and Fuller, 2014**).** Chickpea is one of the oldest legume crops and is consumed widely across the world. Vavilov (1926) was the first to recognize the Near Eastern, Central Asian, Indianand Mediterranean regions as the probable centres of origin for chickpea. The crop most probably originated in south-eastern Turkey and neighbouring parts of Syriaand may have been first grown in Turkey 7500 years ago (Rasool *et al*., 2015). Chickpea (*Cicer arietinum* L.) is the only cultivated species in the genus *Cicer* and is a self-pollinated diploid (2n = 2*x* = 16) crop. It has been domesticated from *C. reticulatum* Ladizinsky, a closely related wild species. Afterits domestication in the Middle East this crop spread throughout the Mediterranean region, India and Ethiopia (van der Maesan, 1987). It has now been introduced to Mexico, Argentina, Peru, Chile, Australia and the USA (Duke, 1981). And other upcoming chickpea producers include Ethiopia, Iraq, Israel, Jordan, Syria, Canada, Morocco, Malawi and Tanzania. The genus includes 34 perennial herbs and nine annuals (Rasool *et al*., 2015).

The wild version of chickpeas (*Cicer reticulatum*) is only found in parts of what is today southeastern Turkey and adjacent Syria, and it is likely that it was first domesticated there, about 11,000 years ago. Chickpeas were part of the culture that first developed farming on our planet, called the Pre-Pottery Neolithic period. (Hirst, 2019). The chickpea gained several very useful features from the domestication process. For example, the wild form of chickpea ripens only in the winter, while the domesticated form can be sown during the spring for summer harvest. Domestic chickpeas still grow best in winter when there is adequate water available; but during the winters they are susceptible to Ascochyta blight, a devastating disease which has been known to wipe out entire crops. The creation of chickpeas that could be grown in summer decreased the riskiness of relying on the crop. In addition, the domesticated form of chickpea contains nearly twice the tryptophan of the wild form, an amino acid that has been connected with higher brain serotonin concentrations and higher birth rates and accelerated growth in humans and animals. (Hirst, 2019). Domesticated chickpeas have been found at several early archaeological sites, including the Pre-Pottery Neolithic sites of Tell el-Kerkh (ca. 8,000 BC) and Dja'de (11,000-10,300 calendar years ago cal BP, or about 9,000 BC) in Syria, Cayönü (7250-6750 BC), Hacilar (ca 6700 BC), and Akarçay Tepe (7280-8700 BP) in Turkey; and Jericho (8350 BC to 7370 BC) in the West Bank. (Hirst, 2019).

The History of Chickpeas: Chickpeas are one of the earliest cultivated legumes. Remains of chickpeas from the Middle East have been found that are roughly 7,500 years old. These remains were found in the aceramic levels of Jericho and Çayönü, Turkey, meaning that humans had been cultivating chickpeas since before they could produce pottery. Other samples have been found in Neolithic pottery in Hacilar, Turkey, and appear throughout history in Greece, France, and other areas of Europe. They begin to appear in literature around 800 AD with Charlemagne's *Capitulare de villis*. In that text, Charlemagne describes how chickpeas were grown in each imperial demesne, or area of a manor controlled by a lord. Chickpeas are later mentioned by Albert Magnus in three different colors, and by Nicholas Culpeper as less "windy" then peas and more nourishing. Chickpeas are also mentioned by a German writer in 1793 as a substitute for coffee. Germany would later use this knowledge and grow chickpeas for this purpose during World War 1. Chickpeas are occasionally used as a coffee substitute even today. The name chickpea is derived from the French "chiche" and Latin "cicer," which is Latin for chickpea. The word chick-pea was first found in English print in 1338, which was later cited by mid-18th century dictionaries. In 1548, the *Oxford English Dictionary* noted, ""*Cicer*may be named in English Cich, or ciche pease, after the Frenche [sic] tongue. It is likely that the legume became known as a chickpea after the French word "pois chiche." As it travelled across the English Channel, this became "chiche pease." The "s" sound then became mistaken for a pluralization, leading many to the conclusion that one "chiche pease" was a "chickpea." "Garbanzo" comes from the Spanish term for chickpea, a compound of "garau" meaning "seed," and "antzu" meaning "dry " (Lucas and Fuller, 2014).

Cicer reticulatum is the wild progenitor of chickpeas. This species currently grows only in southeast Turkey, where it is believed to have been domesticated. The domestication event can be dated to around 7000 BC. Domesticated chickpeas have been found at Pre-Pottery Neolithic B sites in Turkey and the Levant, namely at Çayönü, Hacilar, and Tell es-Sultan (Jericho). Chickpeas then spread to the Mediterranean region around 6000 BC and India around 3000 BC. In southern France, mesolithic layers in a cave at L'Abeurador, Hérault, have yielded chickpeas, carbon-dated to 6790±90 BC. They were found in the late Neolithic (about 3500 BC) sites at Thessaly, Kastanas, Lerna and Dimini, Greece. Chickpeas are mentioned in Charlemagne's *Capitulare de villis* (about 800 AD) as *cicer italicum*, as grown in each imperial demesne. Albertus Magnus mentions red, white, and black varieties. 17th century botanist Nicholas Culpeper noted "chick-pease or cicers" are less "windy" than peas and more nourishing. Ancient people also associated chickpeas with Venus because they were said to offer medical uses such as increasing semen and milk production, inducing menstruation and urination, and helping to treat kidney stones.[13] "White cicers" were thought to be especially strong and helpful. In 1793, ground, roasted chickpeas were noted by a German writer as a substitute for coffee in Europe. In the First World War, they were grown for this use in some areas of Germany. They are still sometimes brewed instead of coffee (Wikipedia, 2023).

TAXONOMY

Chick pea belongs to the Family Fabaceae (Leguminosae), Subfamily Faboideae (Papilionaceae), Tribe Cicereae, Genus *Cicer* and species *Cicer arietinum* (Van der Maesen *et al*. 2007; Wikipedia, 2023)

Synonyms (Wikipedia, 2023)

- *Cicer album* hort.
- *Cicer arientinium* L. [Spelling variant]
- *Cicer arientinum* L. [Spelling variant]
- *Cicer edessanum* Bornm.
- *Cicer grossum* Salisb.
- *Cicer nigrum* hort.
- *Cicer physodes* Rchb.
- *Cicer rotundum* Alef.
- *Cicer sativum* Schkuhr
- *Cicer sintenisii* Bornm.
- *Ononis crotalarioides* M.E.Jones

Chick pea belongs to the Family Fabaceae (Leguminosae), Subfamily Faboideae (Papilionaceae), Tribe Cicereae, Genus *Cicer* and species *Cicer arietinum.* Initially, chickpea was a part of the tribe Viciae, but due to its distinct characters, it was included in a new monogeneric tribe Cicereae later. The genus *Cicer* has 9 annuals and 34 perennial species. Based on the morphology, geographical distribution and lifespan, the genus *Cicer* wasdivided into four sections (Table 1) (van der Maesen 1987; Singh and Diwakar, 1995; Van der Maesen *et al*. 2007)

Table 1. The genus *Cicer* was divided into four sections

Section	Species included	Lifespan	Morphology
Monocicer	*C. arietinum*	Annual	Firm erect or horizontal stems Branching from base or middle
	C. reticulatum	Annual	
	C. echinospermum	Annual	
	C. pinnatifidum	Annual	
	C. judaicum	Annual	
	C. bijugum	Annual	
	C. yamashitae	Annual	
	C. cuneatum	Annual	
Chamaecicer	*C. chorassanicum*	Annual	Thin stem Creepers with small flowers
	C. incisum	Perennial	
Polycicer	*C. anatolicum*	Perennial	Leaf rachis endsin a tendril or a leafl Again divided into twosubsections: N polycicer and Macro-polycicer. Members of Nano-p subsection have creeping rhizome,sho imparipinnate leaves, weak and short Species in Macro-polycicer subsection non-creeping short rhizome, stems growing to 75 cm, firm aristawh longer than pedicel
	C. atlanticum	Perennial	
	C. balcaricum	Perennial	
	C. baldshuanicum	Perennial	
	C. canariense	Perennial	
	C. fedtschenkoi	Perennial	
	C. flexuosum	Perennial	
	C. floribundum	Perennial	
	C. graecum	Perennial	
	C. grande	Perennial	
	C. heterophyllum	Perennial	
	C. isauricum	Perennial	
	C. kermanense	Perennial	
	C. korshinskyi	Perennial	
	C. microphyllum	Perennial	
	C. mogoltavicum	Perennial	
	C. montbretii	Perennial	
	C. multijugum	Perennial	
	C. nuristanicum	Perennial	
	C. oxydon	Perennial	
	C. paucijugum	Perennial	
	C. rassuloviae	Perennial	
	C. songaricum	Perennial	
	C. spiroceras	Perennial	
	C. subaphyllum	Perennial	
Acanthocicer	*C. acanthophyllum*	Perennial	Branched stems with woody basePers spiny leaf rachis Spiny calyx teeth Large flowers
	C. incanum	Perennial	
	C. macracanthum	Perennial	
	C. pungens	Perennial	
	C. rechingeri	Perennial	
	C. stapfianum	Perennial	
	C. tragacanthoides	Perennial	
*C. laetum			

The 8 annual species, namely, *C. arietinum, C. reticulatum, C. echinospermum, C. pinnatifidum, C. bijugum, C. judaicum, C. yamashitae* and *C. cuneatum*, were grouped in *Monocicer* section, *C. chorassanicum* and *C.incisum* (perennial species) in *Chamaecicer* section, 23 perennial species in *Polycicer* section and the remaining 7 woody perennial species in *Acanthocicer* section.

Chickpea is a herbaceous annual plant which branches from the base. It is almost a small bush with diffused, spreading branches. The plant is mostly covered with glandular or nonglandular hairs but some genotypes do not possess hair. Based on seed size and color, cultivated chickpeas are of two types. Macrosperma (kabuli type): The seeds of this type are large (100-seed mass >25 g), round or ramhead, and cream-colored. The plant is medium to tall in height, with large leaflets and white flowers, and contain no anthocyanin. Microsperma (desi type): The seeds of this type are small and angular in shape. The seed color varies from cream, black, brown, yellow to green. There are 2 - 3 ovules pod-1 but on an average 1-2 seeds pod-1 are produced. The plants are short with small leaflets and purplish flowers, and contain anthocyanin (Singh and Diwakar, 1995; Prem, 2010).

BATONICAL DESCRIPTION

Chickpea seeds have a seed coat, two cotyledons, and an embryo (Fig. 2 a). The seed coat consists of two layers, the outer testa and the inner tegmen, and a hilum. The hilum is the point of attachment of the seed to the pod. There is a minute opening above the hilum called the micropyle, and a ridge formed by the funicle called the raphe. The embryo consists of an axis and two fleshy cotyledons (Fig. 2 b to d). The pointed end of the axis is the radicle and the feathery end the plumule. Chickpea seeds germinate at an optimum temperature (28-33°C) and moisture level in about 5 - 6 days. Germination begins with absorption of moisture and swelling of the seed. The radicle emerges first followed by the plumule (Fig. 2 e to i). The portion of the axis above the cotyledon called the epicotyl, elongates and pushes the plumule upward. The growth of the plumule produces an erect shoot and leaves, and the radicle grows to produce the roots. The first true leaf has 2 or 3 pairs of leaflets plus a terminal one (Fig. 2 j). The plumular shoot and lateral branches grow continuously to develop into a plant (Singh and Diwakar, 1995) .

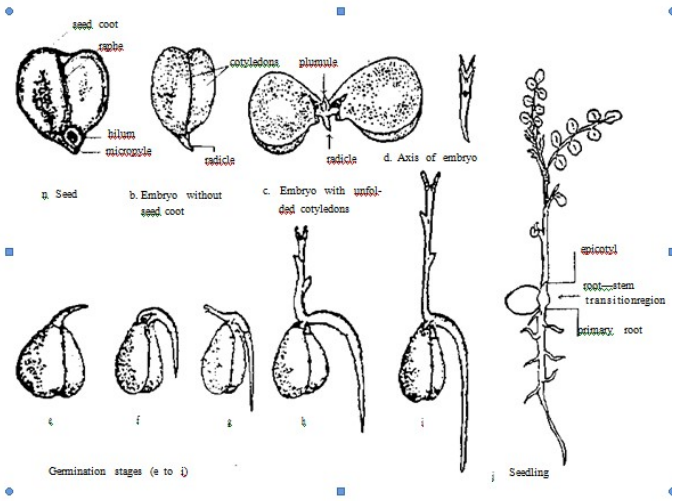

Fig. 2. Chickpea seed and its germination

Chickpea plants have a strong taproot system with 3 or 4 rows of lateral roots. The parenchymatous tissues of the root are rich in starch. All the peripheral tissues disappear at plant maturity, and are substituted by a layer of cork. The roots grow 1.5-2.0 m deep. Chickpea roots bear Rhizobium nodules. The chickpea stem is erect, branched, viscous, hairy, terete, herbaceous, green, and solid. The branches are usually quadrangular, ribbed, and green. There are

primary, secondary, and tertiary branches. Primary branches arise from the ground level as they develop from the plumular shoot as well as the lateral branches of the seedling. They are thick, strong, and woody, and may range from one to eight in number. Secondary branches develop at buds located on the primary branches. They are less vigorous than the primary branches. Their number ranges from 2 to 12. The number of secondary branches determines the total number of leaves, and hence the total photosynthetic area. Tertiary branches arise from the secondary branches. The primary branches form an angle with a vertical axis, ranging from almost a right angle (prostrate habit) to an acute angle (erect). Generally stems are incurved at the top, forming a spreading canopy. Chickpea leaves are petiolate, compound, and uniimparipinnate (pseudoimparipinnate). Some lines have simple leaves. The rachis is 3 - 7 cm long with grooves on its upper surface. Each rachis supports 10-15 leaflets each with a small pedicel. The leaflets do not end at the true terminal position (the central vein continuing the rachis) but at the subterminal position (the central vein oblique to the rachis). This indicates the presence of two terminal leaflet buds, one of them being aborted or transformed into a mucro or foliar shoot which is sometimes quite large. The leaflets are 8 - 17 mm long and 5 - 14 mm wide, opposite or alternate with a terminal leaflet. They are serrated, the teeth covering about two-thirds of the foliar blade. The shape of the leaflets is obovate to elliptical with the basal and top portions cuneate or rounded. Leaves are pubescent. The stipules are ovate to triangular in shape and serrated (2 - 6 teeth). They are 3 - 5 mm long and 2 - 4 mm wide. The longest margin is toothed and the smaller one entire. The external surface of the chickpea plant, except the corolla, is densely covered with glandular or nonglandular hairs (Pubescence). The hairs vary in form and dimension: short stalked, multicellular stalked (both glandular and nonglandular), and unicellular. Some genotypes, however, do not possess any hair. The solitary flowers are borne in an axillary raceme (Pubescence). Sometimes there are 2 or 3 flowers on the same node. Such flowers possess both a peduncle and a pedicel (Fig. 3). The racemose peduncle is 6-30 mm in length. At flowering, the floral and racemal portions of the peduncle form a straight line, giving the appearance that the flowers are placed on the leafy axil by a single peduncle. After fecundation the raceme is incurved. The bracts are 1-5 mm in length.

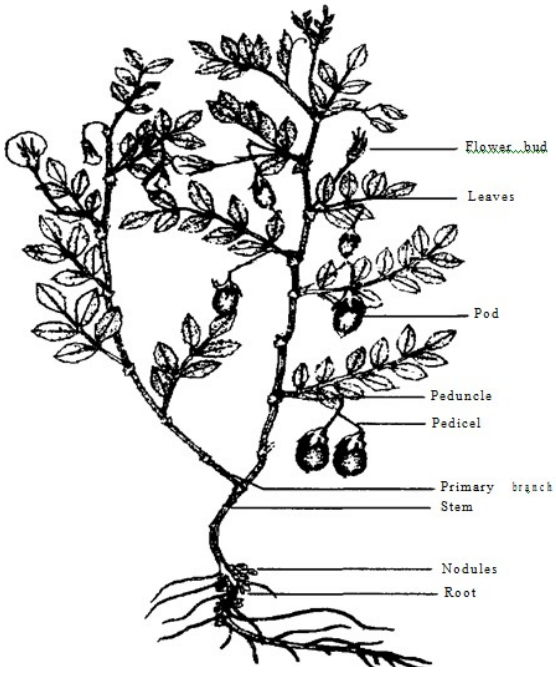

Fig. 3. A typical chickpea plant

Chickpea flowers are complete and bisexual, and have papilionaceous corolla. They are white, pink, purple or blue in color. In colored flowers, the peduncles may be of different colors, the floral part purplish and the racemal green. The axillary inflorescence is shorter than the subtending leaf. The calyx is dorsally gibbous at the base. There are five sepals with deep lanceolate teeth (Fig. 4a). The teeth are longer (5 - 6 mm) than the tube (3 - 4 mm) and have prominent midribs. The five sepals are subequal. The two dorsal (vexillar) sepals are closer to each other than they are to the two lateral ones in the ventral position. The fifth calyx tooth is separate from the others. The peduncles and the calyx are glabrous. The calyx tube is oblique. Chickpea flowers have five petals (Corolla) which are generally celeste and purplish red or light pink in color. The petals are polypetalous i.e., consisting of standard (vexillum), wings, and keel (Fig. 4b). The vexillum is obovate, 8 - 11 mm long, 7 - 10 mm wide, and either glabrous or pubescent with no glandular hair on its external surface. The wings are also obovate with short pedicels (nails). They are 6 - 9 mm long and about 4 mm wide with an auriculate base. The auricula are over the pedicel and form a pocket in the basal upper part, which is covered by the vexillum. The keel is 6 - 8 mm long, rhomboid, with a pedicel 2 - 3 mm long. Two-thirds of the frontal side of its ventral face is adnate. The wings do not show concrescence with the keel. There are 10 stamens in diadelphous (9)+1 condition (Fig. 4d,e). The filaments of nine of the stamens are fused, forming an androecial sheath; the tenth stamen is free. The staminal column is persistent. The fused part of the filament is 4 - 5 mm long and the free part 2 - 3 mm, upturned, and dilated at the top. The apex of the sheath is oblique (Androeclum). The stamens facing the petals are a little longer than the others. The anthers of these stamens are bicelled, basifixed, and round. The other anthers are dorsifixed, ovate, and longer than the basifixed ones at flowering. The anthers burst longitudinally. The pollen grains are orange. The ovary is monocarpellary, unilocular, and superior, with marginal placentation. It is ovate with a pubescent (glandular hairs predominate) surface. The ovary is 2 - 3 mm long and 1-15 mm wide. There are 1-3 ovules, rarely 4. The style is 3 - 4 mm long, linear, upturned, and glabrous except at the bottom (Fig. 4c). The stigma is globose and capitate. Sometimes it may be of the same size as the style (Gynoeclum) (Singh and Diwakar, 1995).

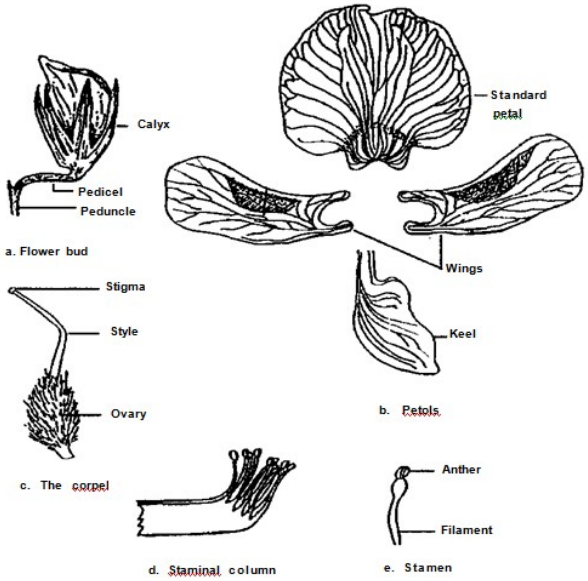

Fig. 4. Parts of a chickpea lower

Chickpea is a herbaceous annual plant which branches from the base. It is almost a small bush with diffused, spreading branches. The plant is mostly covered with glandular or nonglandular hairs but some genotypes do not possess hair. Based on seed size and color, cultivated chickpeas are of two types. Macrosperma (kabuli type): The seeds of this type are large (100-seed mass >25 g), round or ramhead, and cream-colored. The plant is medium to tall in height, with large leaflets and white flowers, and contain no anthocyanin. Microsperma (desi type): The seeds of this type are small and angular in shape. The seed color varies from cream, black, brown, yellow to green. There are 2 - 3 ovules pod-1 but on an average 1-2 seeds pod-1 are produced. The plants are short with small leaflets and purplish flowers, and contain anthocyanin Singh and Diwakar, 1995. The

variation observed in chickpea seed color is: black; brown; light brown; dark brown; reddish brown; grayish brown; salmon brown; orange brown; gray (grayed green); brown beige; yellow; orange; yellow beige (orange-white); ivory white; green; light green; variegated; black-brown mosaic; brownish red; and light orange (Pundir *et al*. 1988; Singh and Diwakar, 1995)

Chickpea seedlings are hypogeal and growth of the plumule produces an erect shoot. The primary root is long and produces lateral roots. Chickpea stems are branched, erect or dispersed, at times shrubby and much branched, 0.2 metre tall, glandular pubescent, dark green or bluish green in colour. Leaves are compound, arranged in an alternate phyllotaxy, and generally are imparipinnate with 11 to 13 leaflets arranged on a rachis with a small petiole. The foliage is covered with glandular hairs, which secrete highly acidic exudates, and this is considered important in conferring tolerance to insect pests, such as the pod borer. The plant has a deep root system and is considered a hardy crop. In deep Vertisols, roots have penetrated deeper than 120 cm. Plants attain a height of 20 to 100 cm, although tall cultivars under favourable conditions can grow up to 130 cm. The two distinct types of chickpea, 'kabuli' (known as *macrosperma*) and 'desi' (known as *microsperma*), differ in their geographical distribution and plant type. Desi types are found in Central Asia and in the Indian sub continent while the kabuli types are found in the Mediterranean region. Kabuli types are usually taller than the desi types. Flowers are axillary, solitary or in an inflorescence of two or three. They are white, pink, purplish or blue in colour. The corolla is generally purple in the desi type and white in the kabuli type, and is rarely blue. Plants in the genus *Cicer* have only one carpel per flower.

The small papilionaceous flowers of chickpea have diadelphous stamens – nine stamens have fused filaments and the tenth is free. During the growth of the flower bud, the filaments extend and anthers deposit pollen on the pistil. Both the pistil and the anther remain inside the keel. Self-pollination is the rule, although natural cross-pollination and cleistogamous pollination have also been found, which take place before opening of the bud. The pod is a rhomboid ellipsoid, with normally one or two seeds, three at maximum, and is inflated and glandular-pubescent. Pod size varies greatly, but the trait is least influenced by environment. Pod-filling is highly dependent on weather and varies from 8.97 to 56.53%. The seed colour is cream, yellow, brown, black, or green, and seeds are rounded to angular. The seed coat is smooth, wrinkled or tuberculate, and the seed is laterally compressed with a median groove around two-thirds of the seed, which is beaked anteriorly. Germination is cryptocotylar. Because of the deep taproot system, chickpea can grow to full maturity in conditions that are unsuitable for most other crops. The long taproot enhances the plant's capacity to withstand drought conditions, and makes chickpea well suited for cultivation in cooler areas with low rainfall (Rasool *et al*., 2015)

The chickpea, *Cicer arietinum*, is a leguminous annual plant in the family Fabaceae grown for its edible seeds. The plant has a branched, straight or bending stem with small feathery leaves arranged alternately on the stem. The leaves are composed of 11–15 individual leaflets which are oval in shape. The flowers are produced singly or in pairs and can be white, pink, purple or blue in color. The seed pod is rhomboid or ellipsoid and contains 1–4 cream, brown, green or black seeds. The chickpea plant can range in height from 20 cm (7.9 in) up to 100 cm (39.4 in) and as an annual, grows over only one growing season. Chickpea may also be referred to as gram pea, garbanzo bean or ceci bean and originate from south-eastern Turkey (Plantvillage, 2016).

Plant: *Cicer arietinum* is a short annual herb, attaining a height of less than a metre. Depending on the angle of the branches and the soil surface, the plant assumes 'erect, semi-erect, spreading, semi-spreading and prostrate' growth habit. Branching starts from the base at ground level giving plant a bushy appearance (Fig. 5). The plant surface including roots, stem, leaves and pods are pubescent, covered with glandular and non-glandular hairs. The glandular hairs secrete a mixture of acids containing malic, oxalic and citric acids. This acid mixture acts as a defence mechanism against sucking pests. The exudation from the roots helps in solubilizing the soil nutrients. Stem: The stem is firm due to hypodermal collenchyma, angular with ribs, straight or flexuous and pubescent. The plant produces three types of branches—primary, secondary and tertiary. The lowest nodes of the plant produce 1–8 primary branches. Alternately, the primary branches may arise from seed shoot as well. The primary branches are thick, woody with thick cuticle, and often mistaken for the main stem. The secondary branches arise from the buds on the primary branches and are comparatively thin. These branches bear the leaves and flowers. Depending on the genotype and growing condi- tions, tertiary branches may or may not be pre- sent. The plant grows to a height of up to 100 cm generally and occasionally reaching 150 cm depending on the growing conditions. Leaf: The compound leaves contain 5–7 pairs of hairy leaflets per leaf, opposite or alternate, and the rachis ends in a leaflet (imparipinnate). The leaflets are oval or elliptic in shape with serrated margins. Simple leaf types also exist.

Root: The root system is characterized by a thick tap root with several side roots developing into a robust system. The epidermis is hairy, exodermis is absent, and endodermis is thin. The presence of nodules on roots indicates symbiotic relationship between chickpea and the Rhizobium bacteria (*Mesorhizobium ciceri*) leading to biological nitrogen fixation. The tap root system is so robust that it reaches more than 3 m in soil favouring the plant to survive in moisture stress conditions.

Inflorescence: The inflorescence is an axillary raceme with generally a single papilionaceous flower though two to three flowers were also reported to occur rarely at the same node. The peduncle is 6–30 mm long, while the pedicel is 6–13 mm long. Both the peduncle and pedicel look like a single part because they are straight in line up to fertilization, and then the pedicel bends down.

Flower: The flower can be described as regular, bisexual, with five fused hairy sepals in a single whorl which form a calyx tube, five petals (pink, white, purple or blue in colour) in a typical papilionaceous arrangement with a big standard, two wings and two keel petals which form a boat shape, ten stamens in a diadelphous arrangement (9 stamens fused and a free 10th stamen) with orange-coloured pollen grains, linear style with globose stigma, sessile pubescent ovary containing 1–4 ovules.

Flowering: Commencement of flowering in chickpea is dependent on the duration of the genotype and the environment including soil and weather. Generally, flowering starts in the range of 24 days to 80 days after sowing and continues till the depletion of moisture owing to the indeterminate growth of chickpea. When moisture levels go down significantly, plants which bear pods and leaves start to senesce reaching maturity. Chickpea is a highly self-pollinated crop. The anthers dehisce one day before the flower opens ensuring self-pollination. Anthesis continues throughout the day.

Pod: Pods start appearing about six days after fertilization and may take up to four weeks for completing seed development. Initially, the pod wall starts to grow followed by the seed. The number of pods per plant depends on the genotype and the environmental conditions, especially availability of moisture. The pod size is generally in the range of 15–20 mm and may go up to 30 mm depending on the genotype, especially in kabuli types. Each pod contains generally one to two seeds and rarely three. Towards the end of the seed development, leaves start to turn yellow first and then the whole plant dries up indicating maturity.

Seed: The shape of the seed generally resembles a ram's (Aries) head, hence the name '*arietinum*', while other shapes do exist such as globular or quasi-spheric with a characteristicbeak. The surface of the seed coat may be smooth or tuberculate. Endosperm is absent. Seed size and colour is a varietal character and highly influenced by environmental conditions, especially moisture availability and heat. There are two types of cultivated chickpea based on seed size and colour—desi and kabuli.

Desi type: The seeds are generally small (around 0.2 g per seed); seed coat is thick with varying colours such as cream, yellow, brown, black and green. The stem and leaves may contain anthocyanin pigmentation.

***Kabuli type*:** The seeds are generally large(around 0.3–0.5 g per seed) to extra large (more than 0.5 g per seed); seed coat is thin and mainly cream or beige coloured, sometimes white. The plants will not have anthocyanin pigmentation. Seed colour in desi types assumes different shades of brown, black and green depending on the genotype, while the kabuli types have mainly beige-coloured seed. Cotyledons are mainly in three colours: cream, green or orange. Seed size exhibits huge variation starting from 0.08 g to nearly 0.8 g per seed. Generally, the kabuli types have larger seed size compared to the desi types.

Germination: Seeds of cultivated chickpea do not exhibit any dormancy period. Seeds start to germinate within a week after sowing depending on the moisture level of the soil, temperature (28–33°C) and sowing depth (two inches). The germination is hypogeal with no hypocotyl. Plumule gives rise to a shoot bearing leaf-like scales at first and then true leaves (two pairs of leaflets and a terminal leaflet). Root growth fromthe radicle is much faster than above-ground shoot growth in initial stages of plant development (Fig.6) (Sajja *et al*., 2017).

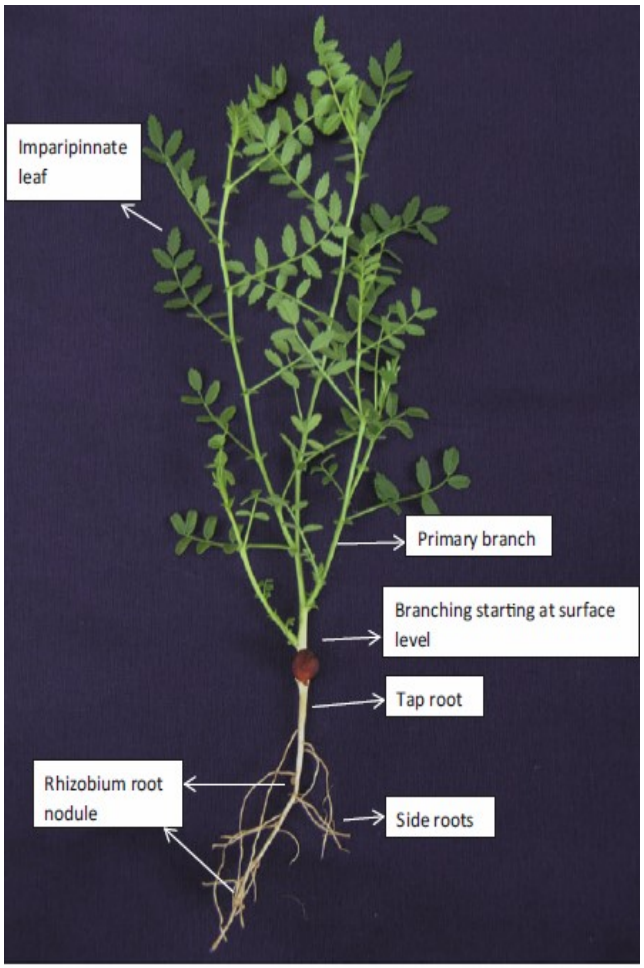

Fig. 5. Chickpea plant at30 days after sowing

Pubescence on stem, leaves, calyx of flowerand pods of chickpea

Leaf types in chickpea: compound leaf and simple leaf (centre)

Robust root system of chickpea with tap root and side roots

Robust root system of chickpea with tap root and side roots

Pedicel bending after fertilization

a. Papilionaceous flower of chickpea. b. Normal flower (left) and open-type flower (right). c standard, wingand keel petals. d Diadelphous stamens (9 + 1)

a. Immature chickpea pod

b. Immature chickpea pod

Chickpea plants at maturity

Desi (left) and kabuli (right) seed types

Chickpea- Dry pods

Seed germination, progressively, in chickpea

Fig. 6. Botanical Description

Chickpea, a member of the subfamily Fabaceae (syn. Papilionaceae) is a short annual herb attaining a height of around 1 m. The growth habit varies from erect, semi-erect, spreading, semi-spreading and prostrate. The plant possesses a deep taproot with several lateral roots and comprising a robust root system. The stem is erect, pubescent with three types of branching viz. primary, secondary and tertiary, and branching from the base at ground level which imparts to the plant a bushy appearance. Leaves are imparipinnately compound with 6–8 pairs of hairy leaflets arranged in an opposite or alternate manner on a rachis with a small petiole. The shape of leaflets is elliptic or oval with serrated leaf margins. Flowers are borne singly in axillary racemes and are pedicellate, bisexual with papilionaceous corolla and diadelphous stamens (9 + 1). The ovary is unicarpellary, unilocular and superiorharboring 1–2 ovules. The fruit is an inflated pod whichis pubescent, covered with glandular and non-glandular hairsbearing 1–2 seeds which may have either a smooth or wrinkled seed coat. Germination is hypogeal and the seeds of cultivated chickpea do not exhibit any dormancy period (Khan *et al*. 2011). Based upon seed size and color, chickpea is categorized as *macrosperma* or *kabuli* type and *microsperma* or *desi* type. *Macrosperma* or kabuli type: Seeds are bold, large and weigh around 0.3–0.5 g each, seed coat is thin ranging in color from white to pale cream. The plants do not possess anthocyanin pigmentation. It is believed that the desi type cultivars have undergone natural mutation and selection to give rise to kabuli type cultivars. Spontaneous mutations in *Cicer reticulatum* could be a possible reason for the evolution of kabuli cultivars. *Microsperma* or desi type*:* Seeds are small and weigh around 0.2 g each and are less than one-half the size of kabuli type and have a thicker seed coat ranging in color from brown to yellow (Raina *et al*., 2019).

The genus Cicer, earlier classified in the tribe Vicieae of the legume family, along with vetches, lentils, and faba beans, is now classified in its own tribe, the Cicereae. Pollen morphology and vascular anatomy Chickpea is a herbaceous annual plant which branches from the base. It is almost a small bush with diffused, spreading branches. The plant is mostly covered with glandular or nonglandular hairs but some genotypes do not possess hair. Based on seed size and color, cultivated chickpeas are of two types. Macrosperma (kabuli type): The seeds of this type are large (100-seed mass >25 g), round or ramhead, and cream-colored. The plant is medium to tall in height, with large leaflets and white flowers, and contain no anthocyanin. Microsperma (desi type): The seeds of this type are small and angular in shape. The seed color varies from cream, black, brown, yellow to green. There are 2 - 3 ovules pod-1 but on an average 1-2 seeds pod-1 are produced. The plants are short with small leaflets and purplish flowers, and contain anthocyanin (Singh and Diwakar, 1995). *Cicer* species further apart from the other members of Vicieae (Lathyrus, Lens, Vicia, Pisum, and Vavilovia) and closer to the tribe Trifolieae, which differs from the Cicereae only in having hypogeal germination, tendrils, stipules free from the petiole and nonpapillate unicellular hairs (Tori Avey, 2022). Chickpeas are in fact a pulse that grows on a plant with 20 to 50 cm in height, sporting small leaves that look like feathers on either side of the stem. The plant bears white flowers with beautiful pink, violet and blue veins with each seedpod enveloping two to three pods within. The size, type and texture of chickpeas differ from region to region. The Garbanzo or Kabuli chana variety that are white in colour are cultivated extensively in India and Italy. The one more super popular variety is Kala Chana or desi chana, which looks black, dried and shriveled. It is available in small globules and it is hulled and split to make it into chana dal. In Southern India, it is a practice to offer 'Sundal' – boiled chana with oil, mustard and jeera seasoning during Dasara Navaratri to the Goddess Durga while in North Indians love their Chole Masala – a spicy gravy to their heart's content, throughout the year (Netmeds. 2023).

Chickpea pods: The plant grows to 20–50 cm (8–20 in) high and has small, feathery leaves on either side of the stem. Chickpeas are a type of pulse, with one seedpod containing two or three peas. It has white flowers with blue, violet, or pink veins. Dozens of varieties of chickpea are cultivated throughout the world. In general, American and Iranian chickpeas are sweeter than Indian chickpeas. Kermanshah chickpeas in sizes 8 and 9 are considered among the world's highest quality (Wikipedia, 2023). The bushy 60-cm (2-foot) plants bear feathery innately compound leaves. The small white or reddish *flowers often have distinctive veins in blue or purple and are usually self-pollinated. The yellow-brown or dark green beans* are borne one or two to a pod. There are large- and small-seeded varieties (Britannica, 2023). The bushy 60-cm (2-foot) plants bear feathery pinnately compound leaves. The small white or reddish flowers often have distinctive veins in blue or purple and are usually self-pollinated. The yellow-brown or dark green beans are borne one or two to a pod. There are large- and small-seeded varieties **(**Britannica, 2023a)

Pollination, Emasculation and Crossing in Chickpea: Chickpea is a self pollinated species with normal out crossing limited to 1.58%. self pollination takes place one or two days before opening up of the flower. The flower open in the morning and close in the afternoon and each flower opens on two or three successive days. Time of anthesis is 3 AM to 9 AM. For hybridization crossing work should be started when the first pod on the selected plant is already formed. In Northern India, emasculation is done a day prior to pollination. The pollination is done in the morning hours give better setting. In south India, pollination immediately after emasculation give higher seed setting (Eagri, 2023). Material required are forceps, alcohol to sterilize the forceps, colored nylon threads, lens, pencil, and record book. Buds that are likely to be in anthesis after one or two days are selected for emasculation. In such a bud (hooded bud), the anthers are not yellow. The bud to be emasculated should be held gently at the base with the thumb and fore finger. Snip off the frontal sepal. Push the keel petal downwards by slitting it with a fine-pointed forceps to expose the anthers. Remove the anthers and count them, and also check with the help of a lens to ensure that no anther is left in the flower. The pedicel, style, and stigma are fragile. Therefore, care must be taken not to damage these parts during emasculation. A colored cotton thread is tied loosely around the pedicel of the emasculated flower for identification. The emasculated flowers are usually not covered with a setting bag to prevent cross- pollination. It is recommended simultaneous emasculation and pollination. They also reported that at ICRISAT Asia Center, Patancheru, India, pollination can be done at any time between 0800 and 1700 h and this practice gives an almost similar pod-set. The natural rate of pod-setting in chickpea lies between 18 and 59 %. Singh and Auckland (1975) reported 24 % pod-setting when artificial pollination was done on the same day as emasculation and 15% pod-setting when it was done one day after emasculation. Low seed-setting in chickpea is mainly due to high humidity and cloudy weather. When crossing is successful, the pedicel remains fresh and pod formation starts within five or six days. Mature pods are harvested 60 days after pollination (Singh and Diwakar, 1995).

GENETICS AND CYTOGENETICS

There has been limited information about the molecular mechanism underlying the colour variation of flower and seed coats in desi and kabuli chickpea. We profiled the anthocyanin and proanthocyanidin (PA) contents in chickpea flowers and seed coats. Tissue-specific silencing of two genes encoding a basic helix-loop-helix (CabHLH) protein and a tonoplast-localized multidrug and toxic compound extrusion (CaMATE1) transporter in a desi genotype resulted in the reduction in expressions of anthocyanin and PA biosynthetic genes and anthocyanin and PA contents in the flower and seed coat and produced flowers and seeds with kabuli characteristics. Transcriptional regulation of a subset of anthocyanin and PA biosynthetic genes by a natural CabHLH variant and transport assay of a natural CaMATE1 variant explained the association of these alleles with the kabuli phenotype. We carried out a detailed molecular characterization of these genes, and provided evidences that kabuli chickpea flower and seed colour phenotype can be derived by manipulation of single genes in a desi chickpea background (Pal *et al*., 2022). Flower and seed coat colour are important agronomic traits in chickpea (*Cicer arietinum* L.). Cultivated chickpeas are of two types namely, desi (dark seeded, purple flower) and kabuli (light colour seeded, white flower). Chickpea is classified in to two groups (Fig. 7).

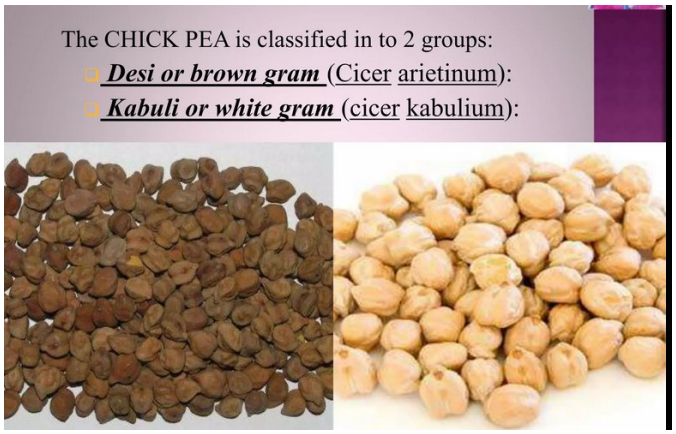

Fig. 7. Seeds color of Desi and Kabuli chickpeas

Cytogenetics: All chickpea cultivars and their wild relatives are self-fertilizing diploids (2n = 2x = 16 chromosomes) with a genome size of 740 Mbp. There are reports of chickpea species with a 2n=14 chromosome number, but presumably they are rare. Chickpea chromosomes are small and the average length of the mitotic metaphase chromosomes is around 2.2 µm. The structure of chromosomes in chickpea has also been shown to vary in different species and within genotypes of the same species. In both annual and perennial species of *Cicer* an invariant somatic chromosome number exists, yet a huge karyological variation is present. These variations in the chromosomal structures have played a role in evolution of cytotypes. In addition to the interspecific karyotype variation, intraspecific karyotypic variation also exits and is supported by several researchers who hold a different opinion with respect to length of chromosome, arm ratio and the secondary constriction position. Secondary constrictions are clearly visible and are formed due to close association of chromosomes with the NOR (nucleolus organizing region). In all species of *Cicer* only one chromosome pair harbors secondary constriction except *C. reticulatum* wherein two pairs show secondary constriction. The conclusion was that during the evolution of *C. echinospermum* and *C. arietinum* from *C. reticulatum*, one of the two NOR loci was lost. Depending on the species, the position of secondary constriction varies as in the annual *C. arietinum, C. reticulatum* and *C. echinospermum*, the longest chromosome pair harbors it while it is present on intermediate or a small-sized chromosomes in all other species. The variation in the position of the secondary constriction plays an important role in the classification of chickpea as all other chromosomal aspects do not reflect significant variation. The length of the mitotic chromosome range is 1.32–3.69 µm and three of the chromosomes are submetacentric and the others metacentric. An insignificant difference in relative chromosome length in the chickpea has been reported as in the kabuli type chickpea; out of the eight chromosomes three are longer than their equivalents in the desi type chickpea, while the other five are longer in desi types but these differences are small, with the range of 0.2–0.8% of the overall relative chromosome length. Morphology based recognition of chromosomes in *C. arietinum*are the two chromosomes i.e. shortest metacentric and longest submetacentric chromosome. Only the longest and shortest chromosomes being submetacentric and metacentric are always classified while atleast one of the six remaining chromosomes shows deviation from the mean length and/or arm ratio assigned to the reference accession. Cultivated chickpea harbours more distinctive karyotypes and the differences in the chromosome length are greater than the annual species. The system of naming chromosome used in *Cicer* varies from author to author, but two main naming systems are commonly used. One is numerical based with longest chromosome assigned as1 and shortest assigned as 8, and the other is letter based (A–H), where A = 1… H = 8. Recently, another system was employed based on linkage group numbers (LG) after the first linkage maps were developed. An attempt to cytogenetically characterize the perennial *Cicer* species was carried out by many researchers. In1972, Van der Maesen estimated 2n = 14 or 2n = 16 as the chromosome number in the perennial *Cicer* species. The initial description of the karyotype of the perennial *C. anatolicum,* established 2n = 16 as the chromosome number, as is the case for the annuals. Ensuing analysis revealed much similarity in the karyotype of *C. songaricum* with that of *C. arietinum*, *C. reticulatum* and *C. echinospermum* (Raina *et al*., 2019).

Genetic Diversity

The variation observed in chickpea seed color is: black; brown; light brown; dark brown; reddish brown; grayish brown; salmon brown; orange brown; gray (grayed green); brown beige; yellow; orange; yellow beige (orange-white); ivory white; green; light green; variegated; black-brown mosaic; brownish red; and light orange (Pundir *et al*. 1988; Singh and Diwakar, 1995) (Fig. 8& 9). Variability has been reported for plant type, flower color (Fig. 10) and other traits.

Fig. 8. Genetic variability for chickpea seeds shape, size and color

Fig. 9. Genetic variability for chickpea seeds shape, size and color

White flower of chick pea

Pink flowers of chick pea

Fig. 10. Flower color in chick pea

The present investigation was undertaken with thirty five genotypes of chickpea, (including one check) Allahabad. The data was recorded for ten characters to study genetic variability, heritability and genetic diversity. Analysis of variance among 35 genotypes showed highly significant difference. High estimates of genotypic coefficient of variation and phenotypic coefficient of variation were observed for economical yield followed by biological yield and number of pods per plant. High heritability coupled with high genetic advance was recorded for economical yield suggesting greater role of non-additive gene action in their heritance. Mahalnobis's D^2 analysis revealed considerable amount of diversity in the material. Thirty five genotypes were grouped into six heterogeneous clusters. Among these clusters Cluster VI has maximum number of genotypes. On the basis of mean performanceof the genotypes, IC-275323 was recorded high yield among 35 genotypes under study. Characters such as economical yield, biological yield should be given top priority for effective selection. The present investigation revealed that the cluster II and cluster V are most diverse to each other, and the genotypes constituted in these clusters may be used as a parent for further hybridization programme (Balasaheb *et al*., 2018). By traditional and modern plant breeding methods, breeding of pulses, cereals, and other important food crops, especially chick- 13 pea, can be accomplished by exploiting available genetic diversity. Chickpea and other pulse crops are important foods in many nations and play a vital role in the diet of malnourished populations worldwide. Globally, chickpea is mainly grown in developing countries, accounting for ~97% of world area and 96% of world production. At present the average global yield of chickpea is 0.9 mt/ha, very low compared to its estimated potential of 6 mt/ha under favorable growth conditions. The main constraints that limit desired goals of chickpea productivity

include low genetic variability, low and unstable yield and low resistance to biotic and abiotic stresses. Chickpea being a self-pollinated crop harbors low genetic variability. Mutation breeding is the logical tool to create variability in a crop species in a very short span of time, as compared to breeding methods. This chapter coversorigin, classification, cytogenetics, germplasm and breeding methods for chickpea improvement (Raina *et al*., 2019). Genetic diversity and relationships of 37 chickpea genotypes were studied using 10 SSR markers and 10 morphological characters. High diversity and coefficients of variation were recorded for all morphological characters. Considerable diversity was observed with high PCV in comparison to GCV. High heritability (>80%) was observed for most of the characters like 100-seed weight followed by number of seeds per pod, number of pods per plant, harvest index, biological yield per plant and number of primary branches per plant. The moderate (60-80%) heritability revealed by grain yield per plant and plant height. The analysis of genetic divergence through Mahalanobis D^2 statistics revealed considerable genetic diversity among genotypes. PIC values ranged from 0.053 (Primer 7) to 0.876 (primer 4) with an average of 0.497. The resolving power (RP) varies between 0.702 (Primer 4) to 1.942 (Primer 7) with an average value of 1.311. Results showed that the introduction of genetic materials from exotic sources broadened the genetic base of the national chickpea breeding program. Further implications of the findings of this study can be useful for selective breeding of specific traits and in enhancing the genetic base of breeding programs. In conclusion, results of the present study indicate that the extent of genetic variability in the germplasm studied seem to have remained quite constant. Information about the current genetic diversity permits the classification of our available germplasm into various/ heterotic groups, like RSG-931, JGK-1 and ICCV-143309 are particularly important to hybrid/cross-breeding programs for chickpea (Kumar *et al*., 2020).

Domesticated chickpeas (also called garbanzo beans) come in two main groups called desi and kabuli but you can also find varieties in 21 different colors and several shapes. Scholars believe that the oldest variety of chickpea is the desi form; desi are small, angular, and variegated in color. The desi likely originated in Turkey and was subsequently introduced into India where kabuli, the most common form of chickpea today, was developed. Kabuli have large beige beaked seeds, which are more rounded than desi (Hirst, 2019). By traditional and modern plant breeding methods, breeding of pulses, cereals, and other important food crops, especially chickpea, can be accomplished by exploiting available genetic diversity. Chickpea and other pulse crops are important foods in many nations and play a vital role in the diet of malnourished populations world wide. Globally, chickpea is mainly grown in developing countries, accounting for ~97% of world area and 96% of world production. At present the average global yield of chickpea is 0.9 mt/ha, very low comparedto its estimated potential of 6 mt/ha under favorable growthconditions. The main constraints that limit desired goals of chick peaproductivity include low genetic variability, low and unstable yield and low resistance to biotic and abiotic stresses. Chickpea being a self-pollinated crop harbors low genetic variability. Mutation breeding is the logical tool to create variability in a crop species in a very short span of time, as compared to breeding methods (Raina *et al*., 2019). Chickpea (*Cicer arietinum* L.) is one of the most important food legumes in the world. However, Fusarium wilt is one of the major yield limiting factors in chickpea. Therefore, creating significant genetic diversity is a fundamental step to develop Fusarium wilt-resistant varieties. In this study, 47 advanced recombinant inbred lines derived from multi-parent intraspecific crosses and three checks were assessed for Fusarium wilt resistance and major yield-related morphological traits for two consecutive years. Analysis of variance showed the presence of significant difference ($P < 0.05$) among test genotypes for major yield-related morphological traits. Consistently, multivariate analyses showed high genetic diversity between test genotypes. Cluster analysis grouped test genotypes into four distinct clusters. The first two principal coordinates with eigenvalues greater than one accounted for 93.94% of the total variation suggesting high genetic diversity between test genotypes. Based on these, we identified 20 high-yielding and novel Fusarium wilt-resistant genotypes with mean wilt incidence of 3.83%. Therefore, these genotypes can be utilized in any chickpea breeding program as a novel Fusarium wilt resistance sources to develop wilt-resistant varieties with high yield and yield-related morphological traits (Bekele *et al*., 2021). Chickpea (*Cicer arietinum* L.) is one of the most important food legumes in the world. However, Fusarium wilt is one of the major yield limiting factors in chickpea. Therefore, creating significant genetic diversity is a fundamental step to develop Fusarium wilt-resistant varieties. In this study, 47 advanced recombinant inbred lines derived from multi-parent intraspecific crosses and three checks were assessed for Fusarium wilt resistance and major yield-related morphological traits for two consecutive years. Analysis of variance showed the presence of significant difference ($P < 0.05$) among test genotypes for major yield-related morphological traits. Consistently, multivariate analyses showed high genetic diversity between test genotypes. Cluster analysis grouped test genotypes into four distinct clusters. The first two principal coordinates with eigenvalues greater than one accounted for 93.94% of the total variation suggesting high genetic diversity between test genotypes. Based on these, we identified 20 high-yielding and novel Fusarium wilt-resistant genotypes with mean wilt incidence of 3.83%. Therefore, these genotypes can be utilized in any chickpea breeding program as a novel Fusarium wilt resistance sources to develop wilt-resistant varieties with high yield and yield-related morphological traits (Bekele *et al*., 2021). The present investigation aimed to study the genetic diversity among 45 elite chickpea genotypes using agro-morphological traits and ISSR molecular markers. The experimental material comprised of 45 elite chickpea genotypes, grown in Randomized Block Design (RBD), Hisar during Rabi 2014-15. Genetic divergence was studied using 11 agro-morphological traits by Non-hierarchical Euclidean cluster analysis and 25 ISSR primers using UPGMA based method. Genetic divergence study based on agro-morphological traits and molecular markers showed ample amount of genetic variation among elite chickpea genotypes which were discussed and compared their diversity analysis as well. The present study confirmed the importance of agro-morphological traits and ISSR markers for detecting tremendous amount of genetic diversity in chickpea which may be used to select good parental material in chickpea breeding programmes for further improvement (Janghel *et al*., 2021).

The genetic variability available in the germplasm, particularly in wild species, should be exploited for broadening the genetic base of varieties and introgressing useful traits, such as resistance to insect pests and diseases. The barriers to interspecific hybridization have restricted utilization of several wild species, and, therefore, dedicated efforts are needed to access genes from these species. High-throughput precision phenotyping protocols need to be developed and used for screening of germplasm and breeding materials for different traits related to stress tolerance and nutritional quality. Rapid advancements in development of chickpea genomic resources during the past decade have made it possible to initiate genomics-assisted breeding in chickpea improvement. Molecular markers associated with several useful traits have been identified. Some of these markers have been validated and are being used in the breeding programmes. Efforts should be made on increasing the number of validated/diagnostic markers, so that genomics-assisted breeding becomes an integrated approach in chickpea breeding programmes. Marker-assisted selection can accelerate breeding process and facilitate combining different desired traits. Integration of these approaches would be important for improving precision and efficiency of chickpea breeding programmes. In this paper, we have reviewed the status of current research efforts and advancements in Indian and future research priorities to tackle newer challenges (Dixit *et al*., 2022).

BREEDING

Breeding Objectives

- Breeding for higher yield.
- Breeding for extended adaptation of chickpea.

- Breeding for resistance to biotic stress.
- Breeding for resistance to abiotic stress.
- Identification of stable form of male sterility.

Germplasm: The huge number of landraces, cultivars and varieties represent a wealth of alleles and can be incorporated into the breeding programs with the objectives to improve yield stress resistance and adaptability. The ICRISAT genebank maintains the largest number of chickpea accessions with more than 20,000, collected from 60 nations, including 308 wild accessions. Of the 308 wild chickpea accessions, 6 countries provided 233 accessions; 75 from Afghanistan, Turkey, Syria and Pakistan. The ICRISTAT genebank maintains 4153 accessions obtained from 65 collecting missions in 15 nations and the remaining were donations from 19 countries. The Indian National Genebank, New Delhi, preserves 14,651 accessions of chickpea. A core set of 1103 accessions has been maintained by employing allelic richness, 70.0% of which were of Indian origin. Shannon-Weaver diversity indices indicate that the chickpea core harbors greater diversity as compared to the whole collection in agro-morphological traits, which in turn reflects that the chickpea core maximized the phenotypic diversity available in the Indian chickpea germplasm (Raina *et al*., 2019).

Level of Diversity in Crop Germplasm: The sum total of hereditary materials present in a crop species and its wild relatives is referred to as germplasm. This is also known as genetic resources or gene pool. In other words, germplasm is a collection of genetic resources for an organism which include inbred lines, landraces, open pollinated varieties, exotic accessions, wild species, cultivars and breeding stocks. These types of germplasm can carry unidentified variation that may be a valuable resource for breeders and other researchers. Germplasm can be collected from centres of diversity, gene banks, gene sanctuaries, farmer's field, markets and seed companies. Genetic pool represents the entire genetic variability or diversity within a crop species. Agricultural practices have gradually dispersed the local traditional varieties and crop wild relatives (CWRs) leading to a loss of indigenous diversity. However, CWR and landraces (LR) are the two major components of agro-biodiversity that offer the widest range of diversity for breeders in crop improvement programs. The CWRs and locally adapted traditional crop varieties contain vital sources of useful genes. These invaluable resources are threatened by the climate change as well as by a range of other human-induced pressures and socio-economic changes, while the value of CWR and LR for food security is widely recognized. A systematic strategy for the conservation of the highest priority CWR and LR resources is required at global level (Singh and Diwakar, 1995).

Breeding approaches: In the early phase of chickpea breeding, most varieties were developed through selection from land races that were either collected in the country or introduced. from other countries. Presently, hybridization is invariably being used to increase genetic variability in the breeding material, and thus most of the recent varieties are cross-bred. The pedigree method, earlier used at many institutes, is not in much practice at present in its original form, because it is cumbersome and only a limited number of crosses can be handled by this method. The bulk method, variously modified, is now the most common selection method used after hybridization in chickpea.

It is well established that individual plant selection for yield in early segregating generations is not effective in chickpea. Thus, selection for simple traits (e.g. seed traits, maturity, resistance to diseases) is done in early segregating generations (F_2 and F_3), while single plant selection for yield usually starts from F_4 or later generations. A recombinant-derived family method that uses early generation selection for yield in F_2-derived F_4 or later generation families to eliminate inferior crosses and inferior F_2-derived families have also been suggested. Many breeding programs prefer to take more than one generation per year to reduce the time in development of a variety. Off-season nurseries or greenhouse facilities are used to take one or two generations in the off-season. The long-day nature of chickpea has been exploited for its rapid generation turnover. Early flowering can be induced by extending day length to 15-16 hrs through artificial lighting until flower initiation. Single seed descent (SSD) method is generally used to advance generations in greenhouse, as often available space is not adequate to accommodate large populations. Most chickpea breeding programs have been confined to intraspecific hybridization that include desi x desi, kabuli x kabuli or desi x kabuli or kabuli x desi crosses. Crosses between desi and kabuli parents have been used extensively to exploit genes present in one group but not the other. For example, desi parents have contributed important genes for fusarium wilt and as cochyta resistance and drought tolerance in kabuli programmes; conversely, kabuli parents have been a source of improved seed quality, especially large seed size, in desi programs. Desi x kabuli crosses have consistently produced high yielding progeny and have been the source of many new cultivars. Efforts have been made to use interspecific crosses for enhancing genetic variability and introgressing useful genes into the cultigen from wild *Cicer* species. Thus far, only two annual wild species, *C. reticulatum* and *C. echinospermum*, have been exploited in breeding programs, as the crossing of the cultigen with other species has remained a challenge even with embryo rescue techniques. There is a need to continue efforts on exploiting wild *Cicer* species of the tertiary gene pool, as these contain many useful genes, particularly resistance to some of the biotic and abiotic stresses. Through interspecific hybridization using *C. reticulatum* in the crosses only one variety BG 1103 from Indian Agricultural Research Institute, New Delhi have been released for commercial cultivation for north India in 2005.

Mutation breeding has also been used in chickpea improvement for creating variability. Some mutants have been directly released as varieties, while many others have been used as parents in crossing programs. At least 12 varieties have been developed through mutation breeding. These include three (RS 11, RSG 2 and WCG 2) developed by State Agricultural Universities in India; four (CM 72, CM 88, CM, 98 and CM 2000) developed by the Nuclear Institute of Agriculture and Biology, Faisalabad, Pakistan; and one (Hyprosola) developed by the Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Recent advances in development of transformation and plant regeneration protocols for chickpea have made it possible to exploit transgenic technology for its improvement. Transgenic technology is now being used to improve traits for which adequate variability is not available in the primary gene pool. These include resistance to pod borer and other biotic and abiotic stresses and content of sulphur containing amino acids.

Marker-assisted selection (MAS) is being considered for improving the precision and efficiency of conventional plant breeding methods. MAS would be useful for improving those traits that are difficult or inconvenient to select directly (e.g. root traits for drought avoidance, antinutritional factors, quality traits etc.), for pyramiding of resistance genes from different sources when the resistance is polygenically controlled (e.g. resistance to ascochyta blight), for bringing together genes conferring different resistance mechanisms (e.g. antixenosis, antibiosis and tolerance for pod borer), and for combining resistance to two or more stresses (e.g. resistance to fusarium wilt and resistance to pod borer). MAS will also be used for tracking introgression of resistance genes from transgenics to cultivars/elite breeding lines **(**Gaur *et al*., 2007**)**.

Genome Sequencing: The first draft whole genome shotgun sequence of both desi and kabuli breeding lines was published in 2013. Varshney *et al*. Discovered that genetic diversity was slightly higher in the desi, compared to kabuli, supporting earlier contentions that desi is the older of the two forms. The scholars identified 187 disease resistance genes homologies, considerably fewer than other legume species (Hirst, 2019).

Most of the released varieties were developed through rigorous evaluation and critical selection introduced germplasm lines (Table 2) for diverse agro morphological traits over years under diverse agro-ecologies in multiple environments/locations (Fikre and Bekele, 2020).

Table 2. Breeding methods and chickpea varieties released in Ethiopia for commercial production from 1974 to 2019

Variety	Type	Origin	Breeding methods	Year of release
DZ-10-4	Kabuli	Ethiopia	Local selection	1974
DZ-10-11	Desi	Ethiopia	Local selection	1974
Dubie	Desi	Ethiopia	Local selection	1978
Mariye	Desi	ICRISAT	Introduction & Hybridization*	1985
Worku	Desi	ICRISAT	Introduction & selection	1994
Akaki	Desi	ICRISAT	Introduction & selection	1995
Arerti	Kabuli	ICARDA	Introduction & Hybridization	1999
Shasho	Kabuli	ICARDA	Introduction & Hybridization	1999
Habru	Kabuli	ICARDA	Introduction & Hybridization	2004
Chefe	Kabuli	ICARDA	Introduction & Hybridization	2004
Ejere	Kabuli	ICARDA	Introduction & Hybridization	2005
Teji	Kabuli	ICARDA	Introduction & Hybridization	2005
Kutaye	Desi	ICRISAT	Introduction & Hybridization	2005
Mastewal	Desi	ICRISAT	Introduction & Hybridization	2006
Fetenech	Desi	ICRISAT	Introduction & Hybridization	2006
Yelbie	Kabuli	ICRISAT	Introduction & Hybridization	2006
Natoli	Desi	ICRISAT	Introduction & Hybridization	2007
Acos Dubie	Kabuli	Mexico	Introduction & adaptation	2009
Minjar	Desi	ICRISAT	Introduction & Hybridization	2010
Kasech	Kabuli	ICRISAT	Introduction & Hybridization	2011
Akuri	Kabuli	ICRISAT	Introduction & Hybridization	2011
Kobo	Kabuli	ICRISAT	Introduction & Hybridization	2012
Dalota	Desi	ICRISAT	Introduction & Hybridization	2013
Teketay	Desi	ICRISAT	Introduction & Hybridization	2013
Dimtu	Desi	ICRISAT	Introduction & Hybridization	2016
Hora	Kabuli	ICARDA	Introduction & Hybridization	2016
Dhera	Kabuli	ICARDA	Introduction & Hybridization	2016
Koka	Kabuli	ICRISAT	Introduction & Hybridization	2019
Geletu	Desi	ICRISAT	Introduction & MABC*	2019

*Crossing for hybridization and MABC (Marker Assisted Back Cross) performed at the origin before introduction

The chickpea varieties released by the Central and State varieties release committees are given in Table 3.

Table 3. Central and State released varieties of Chickpea in India

Variety	Year ofrelease	Originatingcentre	Yield(q/ha)	Days to maturity	Area of Adoption
Ganguar (GNG 1581)	2007 (CVRC)	ARS, Sri GangaNagar	24	151	NWPZ
Aparna (RSG 991)	2007 (SVRC)	Durgapura	16	135	Rajasthan
Arpan (RSG 896)	2007 (SVRC)	Durgapura	14	135	Rajasthan
Aruna (RSG 902)	2007 (SVRC)	Durgapura	20	135	Rajasthan
Gauri (GNGK 1499)	2007 (SVRC)	Srinagar	18	143	Rajasthan
Sangam (GNG 1488)	2007 (SVRC)	Srinagar	18	134	Rajasthan
Akash (BDNG 797)	2007 (SVRC)	ARS, Badnapur	15-16	102	Maharashtra
Rajas (Phule-G-9425-9)	2007 (SVRC)	MPKV, Rahuri	18	136	NEWZ
JGK-2	2007 (SVRC)	JNKVV	15	95-110	M.P.
JGK-3 (JGK 19)	2007 (SVRC)	JNKVV	14-15	92-121	M.P.
Lam shanaya(LBeG 7)	2007 (SVRC)	ANGRAU	20-25	90	M.P.
Jawahar Gram226 (JG 226)	2007 (SVRC)	JNKVV	20-22	112-115	M.P.
GNG 1581 (Ganguar)	2008 (CVRC)	ARS, Srigan-ganagar	24.00	127-177	NWPZ
Abhilasha(RSG 974)	2008 (SVRC)	Durgapura	15	130	Rajasthan
Ankur (CSJ 140)	2008 (SVRC)	Durgapura	16	128	Rajasthan
Anshul (RSG 959)	2008 (SVRC)	Durgapura	15	130	Rajasthan
JG 14	2008 (SVRC)	Jabalpur	19	110	MP
JG 6	2008 (SVRC)	Jabalpur	21	113	MP
Vallabh Kallar Channa 1 (WCG 3)	2008 (SVRC)	Meerut	19	135	UP
IPCK 2002-29	2009 (CVRC)	IIPR, Kanpur	22	107	CZ
Shubra (IPCK 2004-29)	2009 (CVRC)	IIPR, Kanpur	20	108	CZ
Kripa (Phule G 0517)	2009 (CVRC)	Rahuri	18	110	MS, MP & Karnataka
PKVKabuli 4	2009 (CVRC)	Akola	20	110	MS, MP
BGD 103	2009 (SVRC)	UAS, Dharwad	11-13	95-100	Karnataka
Pank KabuliChana 1	2010 (SVRC)	Pantnagar	14	125	Uttarakhand
Gujarat Junagadhgram 3	2010 (SVRC)	Junagarh	15	110	Gujarat
MNK 1	2011 (CVRC)	Gulbarga	13	100	SZ
Raj Vijay KabuliGram 101 (RVKG 101)	2011 (SVRC)	Sehore	20	110	MP
Raj Vijay KabuliGram 201 (RVKG 201)	2011 (SVRC)	Sehore	25	105	MP
PKV Harita (AKG 9303-12)	2012 (SVRC)	PDKV, Akola	12-18	106-110	Vidarbha region of MS
HK 05-169 (HK 4)	2012 (CVRC)	Hisar	16	125	NEPZ
JSC 55 (RVG 202)	2012 (CVRC)	Sehore	20	102	CZ
JSC 56 (RVG 203)	2012 (CVRC)	Sehore	19.0	100	CZ

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CSJK 6	2012 (CVRC)	Durgapura	11	188	NHZ
GLK 26155 (L 555)	2012 (CVRC)	Ludhiana	22.8	146	NWPZ
Phule G0027	2012 (CVRC)	Rahuri	14	196	NHZ
GNG 1958	2013 (CVRC)	Sriganganagar	26.8	145	NWPZ
GNG 1969	2013 (CVRC)	Sriganganagar	22	146	NWPZ
GLK 28127	2013 (CVRC)	Ludhiana	21	149	NWPZ
NBeG 3	2013 (SVRC)	Nandyal	23	110	AndhraPradesh
Vallabh Kabuli Chana-1 (WCGK 2000-16)	2015 (CVRC)	Modipuram	23	147	NWPZ
Birsa Chana 3	2015 (SVRC)	BAO, Jharkhand	18-20	115-118	Jharkhand
Bidisha (BG 1084) WBG 29	2015 (SVRC)	Berhampur, WB	25	131	West Bengal
GNG 2144	2016 (CVRC)	Sriganganagar	22.8	133	NWPZ
NBeG 119	2016 (CVRC)	Nandyal	18.8	90-95	SZ
JGK 5	2016 (CVRC)	Jabalpur	15-17	110-115	MP
CSJ 515	2016 (CVRC)	Durgapura	24	135	NWPZ
BDNGK 798	2016 (SVRC)	ARS, Jalna	16-18	120-135	Maharashtra
Gujarat Junagarh Gram 6 (GJG 6)	2016 (SVRC)	Junagarh	16-18	120-130	Gujarat
JG 36 (Jawahar Gram 36)	2016 (SVRC)	JNKVV, Jabalpur	18-20	110-120	MP
GBM 2	2016 (SVRC)	UAS, Raichur	18-20	100-110	Karnataka
GJG 0809	2017 (CVRC)	Junagadh	16	157	NHZ
GNG 2171	2017 (CVRC)	Sriganganagar	20.14	163	NWPZ
Indira Chana 1	2017 (SVRC)	IGKVV, Raipur	16	101-116	Chhattisgarh
Nandyal Gram 49 (NBeG 49)	2017 (SVRC)	ARS, Nandyal	14-20	90-105	Andhra Pradesh
Pant Gram-4 (PG 065)	2017 (SVRC)	GBPAUT (Patnagar, UT)	18-20	126-162	Uttarakhand
Pant Gram -3 (PG043)	2017 (SVRC)	GBPAUT (Patnagar, UT)	18-24	139-152	Uttarakhand
Pant Kabuli gram-2 (PG 071)	2017 (SVRC)	GBPAUT (Patnagar, UT)	16-17	135-163	Uttarakhand
Dheera (NBeG 47)	2017 (SVRC)	ARS, Nanadyal	20-25	90-105	AndhraPradesh

USES

Chickpeas are used for human consumption, and for animal feed. Chickpeas are rich in protein and energy, which makes them great for animal feed. Raw chickpeas have been shown to be a healthier alternative than similar legumes, such as peas. Research has shown that chickpeas have no adverse effects on livestock, allowing animals to grow and produce milk equally as well as soy or cereal. For human consumption, chickpeas are nutrient dense, providing more than 20% Daily Value of protein, dietary fiber, folate, and minerals like iron and phosphorous. They also provide a moderate amount of zinc, thiamin, vitamin B6, and magnesium. Cooked chickpeas are high in amino acids. When cooking chickpeas for human consumption, preparation typically involves 10 minutes of boiling followed by a long period of simmering.

Dried chickpeas must be cooked for 1 to 2 hours, but this can be cut to half an hour with 12-24 hours of soaking. Chickpeas can also be consumed raw, most frequently being used in salad. Chickpeas are commonly used in hummus, which comes from the Arabic word for hummus. Hummus is prepared by cooking chickpeas, and then ground into a paste. Chickpeas might also be popped and eaten like popcorn, or ground into flour. Chickpeas and garbanzo beans are also commonly used in soups, stews, and chilis **(**Lucas and Fuller, 2014**).** Chickpea is consumed mostly as seed in different forms and preparations are determined by ethnic and regional factors. On the Indian subcontinent it is ground to make flour (besan) used to prepare different snacks. In Asia and Africa, chickpea is used in stews, soups and salads and consumed in boiled, salted, roasted and fermented forms. These different forms of consumption provide consumers with valuable nutrition and potential health benefits (Rasool *et al*., 2015). Chickpea is primarily consumed as a dry pulse. The shelled peas are eaten as snack or vegetable. The seed husks can be used as a feed for animals. Chickpeas are also commonly cooked and ground into a paste to produce the popular dish, hummus. (Plantvillage, 2016). Based on a 2,000-calorie-per-day healthy eating pattern, the 2020 USDA Dietary Guidelines for Americans recommends a weekly serving of 1.5 cups of beans, peas, and lentils. Get into the "half-cup habit" by eating a half cup of chickpeas three times a week. To do that, pick any form that suits your cooking and eating style. You might pick canned, frozen, or dry packaged chickpeas, or even chickpea flour. Or try an expanding offering of chickpea products, like hummus, roasted chickpea snacks, chickpea pasta, and falafel mixes.

There are also prepared dishes featuring chickpeas, including soups, frozen meals, plant-based burgers, and even smoothies (Newgent, 2021). If you have canned chickpeas, the culinary possibilities are endless—and can be quite easy. Just sprinkling them onto a salad makes that salad extra nutritious while pumping up the protein. If you enjoy the art of cooking, prepare chickpeas into delightful recipes. Make your own hummus and serve it with fresh veggies. Use chickpeas to prepare a comforting curry or potpie. Or up the fun factor by making double-decker falafel sliders or dark chocolate hummus (Newgent, 2021). Canned chickpeas are quick and easy, but some people prefer dried because they're cheap and don't have any preservatives. Before cooking, you'll need to soak dried chickpeas in water. From there, you can cook them on a stovetop or in the oven or a pressure cooker or slow cooker (Newgent, 2021). Chickpea flour can be used as a nutrient-rich swap for all-purpose flour. Make a super-quick skillet flatbread with it. Or sneak it in as the flour of choice to create a better-for-you cookie (Newgent, 2021). Chickpeas are used to make many Ethiopian traditional chickpea-based food products such as nifro, kollo, shiro, dabo, mitad shiro, ashuk, boklet, kita, genfo, injera, and shimbra-asa by using different processing methods (Yegrem, 2021). Don't just toss the liquid in your chickpea can—it's 100 percent edible and can be used in so many ways. Canned bean liquid is called aquafaba. You can easily transform this liquid (just whip it!) into a plant-based egg replacement, whipped cream, mousse, mayonnaise, and more. With an electric mixer and a little cream of tartar, whip the aquafaba until it's foamy, and then flavor it as you like (Newgent, 2021). The chickpea is a key ingredient in Mediterranean and Middle Eastern cuisines, used in hummus, and, when soaked and coarsely ground with herbs and spices then made into patties and fried, falafel. As an important part of Indian cuisine, it is used in salads, soups and stews, and curry, in chana masala, and in other food products that contain channa (chickpeas) (Wikipedia, 2023).

Dhokla, steamed chickpea flour snack. Chickpeas are usually rapidly boiled for 10 minutes and then simmered for longer. Dried chickpeas need a long cooking time (1–2 hours) but will easily fall apart when cooked longer. If soaked for 12–24 hours before use, cooking time can be shortened by around 30 minutes. Chickpeas can also be pressure cooked or *sous vide* cooked at 90 °C (194 °F). Mature chickpeas can be cooked and eaten cold in salads, cooked in stews, ground into flour, ground and shaped in balls and fried as *falafel*, made into a batter and baked to make *farinata* or *socca*, or fried to make *panelle*. Chickpea flour is known as *gram flour* or *besan* in

South Asia and is used frequently in South Asian cuisine. In Portugal, chickpeas are one of the main ingredients in *rancho*, eaten with pasta, meat, or rice. They are used in other hot dishes with *bacalhau* and in soups, meat stews, salads mixed with tuna and vegetables, olive oil, vinegar, hot pepper and salt. In Spain, they are used cold in *tapas* and salads, as well as in *cocido madrileño*. Hummus is the Arabic word for chickpeas, which are often cooked and ground into a paste and mixed with tahini (sesame seed paste), the blend called *ḥummuṣ bi ṭaḥīna*. Chickpeas are roasted, spiced, and eaten as a snack, such as *leblebi*. By the end of the 20th century, hummus had become commonplace in American cuisine. By 2010, 5% of Americans consumed hummus regularly, and it was present at some point in 17% of American households. Chickpeas and Bengal grams are used to make curries. They are one of the most popular vegetarian foods in the Indian subcontinent and in diaspora communities of many other countries, served with a variety of bread or steamed rice. Popular dishes in Indian cuisine are made with chickpea flour, such as *mirchi bajji* and *mirapakaya bajji.* In India, as well as in the Levant, unripe chickpeas are often picked out of the pod and eaten as a raw snack, and the leaves are eaten as a leaf vegetable in salads. In India, desserts such as besan halwa and sweets such as mysore pak, besan barfi and laddu are made. Chickpea flour is used to make "Burmese tofu," which was first known among the Shan people of Burma. In South Asian cuisine, chickpea flour (besan) is used as a batter to coat vegetables before deep frying to make pakoras.

The flour is also used as a batter to coat vegetables and meats before frying or fried alone, such as *panelle* (little bread), a chickpea fritter from Sicily. Chickpea flour is used to make the Mediterranean flatbread *socca* and is called *panisse* in Provence, southern France. It is made of cooked chickpea flour, poured into saucers, allowed to set, cut into strips, and fried in olive oil, often eaten during Lent. In Tuscany, chickpea flour is used to make an oven-baked pancake: the flour is mixed with water, oil and salt. Chickpea flour, known as kadlehittu in Kannada, is used for making sweet dish Mysorepak. In the Philippines, chickpeas preserved in syrup are eaten as sweets and in desserts such as *halo-halo*. Ashkenazi Jews traditionally serve whole chickpeas, referred to as *arbes* in Yiddish, at the *Shalom Zachar* celebration for baby boys. The chickpeas are boiled until soft and served hot with salt and lots of ground black pepper. *Guasanas* or *garbanza* is a Mexican chickpea street snack. The beans, while still green, are cooked in water and salt, kept in a steamer to maintain their humidity, and served in a plastic bag. A chickpea-derived liquid (*aquafaba*) can be used as an egg white replacement to make meringue or ice cream, with the residual pomace used as flour (Wikipedia, 2023). Chickpeas are an energy and protein source as animal feed. Raw chickpeas have a lower trypsin and chymotrypsin inhibitor content than peas, common beans, and soybeans. This leads to higher nutrition values and fewer digestive problems in nonruminants. Nonruminant diets can be completed with 200 g/kg of raw chickpeas to promote egg production and growth of birds and pigs. Higher amounts can be used when chickpeas are treated with heat. Experiments have shown that ruminants grow equally well and produce an equal amount and quality of milk when soybean or cereal meals are replaced with chickpeas. Pigs show the same performance, but growing pigs experience a negative effect of raw chickpea feed; extruded chickpeas can increase performance even in growing pigs.

Only young broilers (starting period) showed worse performance in poultry diet experiments with untreated chickpeas. Fish performed equally well when extruded chickpeas replaced their soybean or cereal diet. Chickpea seeds have also been used in rabbit diets. Secondary components of legumes—such as lecithin, polyphenols, oligosaccharides; and amylase, protease, trypsin and chymotrypsin inhibitors—can lead to lower nutrient availability, and thus to impaired growth and health of animals (especially in nonruminants). Ruminants generally have less trouble digesting legumes with secondary components since they can inactivate them in the rumen liquor. Their diets can be supplemented by 300 g/kg or more raw chickpea seeds. However, protein digestibility and energy availability can be improved through treatments such as germination, dehulling, and heat. Extrusion is a very good heat technique to destroy secondary legume components since the proteins are irreversibly denatured. Overprocessing may decrease the nutritional value; extrusion leads to losses in minerals and vitamins, while dry heating does not change the chemical composition (Wikipedia, 2023). In some parts of the world, young chickpea leaves are consumed as cooked green vegetables. Especially in malnourished populations, it can supplement important dietary nutrients because regions where chickpeas are consumed have sometimes been found to have populations lacking micronutrients. Chickpea leaves have a significantly higher mineral content than either cabbage leaves or spinach leaves.[32] Environmental factors and nutrient availability could influence mineral concentrations in natural settings. Consumption of chickpea leaves may contribute nutrients to the diet (Wikipedia, 2023). Hummus (or hummous)—chickpeas mashed to a paste with lemon juice, olive oil, and tahini (sesame paste)—is widely eaten in the Middle East as a sauce and dip for bread. Mashed cooked chickpeas are formed into small flat cakes or balls and fried for falafel, a popular Middle Eastern dish. In southern Europe and Latin America, chickpeas are a common ingredient in soups, salads, and stews.

A kind of meal or flour is also made from chickpeas and can be used to make a flatbread known as socca or mixed with wheat or other flours for baking. As with other legumes, chickpeas have a symbiotic association with nitrogen-fixing bacteria and can be rotated with nitrogen-intensive crops such as cereals to improve soil conditions (Britannica, 2023). Gram flour is in popular use in the Indian subcontinent and the Caribbean, where it is used to make the following: A variety of snacks, Sev, Bhajjis, Bikaneri Bhujia, Bonda, Boondi, Chakli, Chila//Dhirda (besan dosa), Dhokla/Khaman, Kadhi, Zunka/Pithala/Pithla, Laddu, Soan papdi, Mysore pak, Pakoras, Papadums, Patra and Pholourie. In Andhra Pradesh, it is used in a curry with gram flour cakes called Senaga Pindi Kura (Telugu) and is eaten with Chapati or Puri, mostly during winter for breakfast. Chila (or chilla), a pancake made with gram flour batter, is a popular street food in India **(**Wikipedia, 2023a).

Chickpeas are widely available dried or canned. Occasionally you may find young, fresh green chickpeas in their pods at farmers' markets (Tori Avey, 2022).

- ***Dried:*** Sort through the beans to check for and remove small stones or debris, then place in a strainer and rinse well. To speed up the cooking time, dry beans may be presoaked by covering with water and allowing to sit for at least 3 hours, or overnight. Some people who feel bloated after eating beans may find that presoaked beans are better tolerated, as this reduces the amount of oligosaccharides that are responsible for the uncomfortable side effects.
- ***Cook:*** For 1 cup of dry garbanzo beans, add 3 cups of water or broth. Add to pan and bring to a boil. When boiling, reduce the heat to low-medium and simmer for 60-90 minutes or until desired tenderness. Add more water if the beans do not reach desired tenderness and further cook time is needed. Using presoaked beans will reduce the cook time by 25%.
- ***Canned:*** Place in a strainer, drain, and rinse well. This will remove about 40% of the sodium, or you can purchase low sodium or no-salt-added canned versions. These do not need additional cooking but hold up well when added to cooked or baked dishes.

Products such as dal, fried dal, roasted chana are also prepared (Fig. 10).

NUTRITIONAL VALUE

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has reported that chickpea seeds contain on average 23% protein, 64% total carbo- hydrates (47% starch, 6% soluble sugars), 5% fat, 6% crude fibre and 3% ash. Studies have also shown that chickpea is helpful for lowering blood cholesterol. Chickpea is relatively economical and a good source of folic acid and tocopherols.

Chana dal Roasted chana Fried chana dal

Fig. 10. Chick pea products

Table 4. Nutritional value of chickpea, raw (dry weight) per 100 g. Nutrient values and weightsare for edible portion

Nutrient	Per 100 g	Nutrient	Per 100 g
Water	7.68	Leucine	1.465 g
Energy	378	Lysine	1.377 g
Protein	20.47	Methionine	0.270 g
Carbohydrate	62.95	Phenylalanine	1.103 g
Fiber, total dietary	12.2	Proline	0.849 g
Sugars, total	10.7	Serine	1.036 g
Calcium, Ca	57	Threonine	0.766 g
Iron, Fe	4.31	Tryptophan	0.200 g
Magnesium, Mg	79	Tyrosine	0.512 g
Phosphorus, P	252	Valine	0.865 g
Potassium, K	718	Fat	6.04 g
Sodium, Na	24	Saturated fatty acids	0.603 g
Iron, Fe	2.76	Butanoic acid	0.000 g
Phosphorus, P	4	Decanoic acid	0.000 g
Potassium, K	0.477	Dodecanoic acid	0.000 g
Sodium, Na	0.212	Hexadecanoic acid	0.508 g
Niacin	1.541	Hexanoic acid	0.000 g
Vitamin B-6	0.535	Octadecanoic acid	0.086 g
Folate, DFE	557	Octanoic acid	0.000 g
Vitamin B-12	0	Tetradecanoic acid	0.009 g
Vitamin A, RAE	3	Monounsaturated fatty acids	1.377 g
Vitamin A, IU	67	Docosenoic acid	0.000 g
Vitamin E (alpha-tocopherol)	0.82	Eicosenoic acid	0.000 g
Vitamin D (D2 + D3)	0	Hexadecenoic acid	0.012 g
Vitamin D	0	Octadecenoic acid	1.365 g
Vitamin K (phylloquinone)	9	Polyunsaturated fatty acids	2.731 g
Cholesterol	0	Docosahexaenoic n-3 acid	0.000 g
Amino Acids	7.68	Docosapentaenoic n-3 acid	0.000 g
Alanine	0.882 g	Eicosapentaenoic n-3 acid	0.000 g
Arginine	1.939 g	Eicosatetraenoic acid	0.000 g
Aspartic acid	2.422 g	Octadecadienoic acid	2.629 g
Histidine	0.566 g	Octadecatetraenoic acid	0.000 g
Isoleucine	0.882 g	Octadecatrienoic acid	0.102 g

Chickpea is an excellent source of folic acid and contains other water-soluble vitamins like riboflavin, pantothenic acid and pyridoxine. These levels are similar or higher than those observed in other pulses. The most important and widely distributed carotenoid that is converted to vitamin A is β-carotene. On a dry weight basis, the chickpea seed has a greater concentration of β-carotene than golden rice endosperm or red coloured wheat. Physiological benefits from the consumption of chickpea have also been reported, which reduce the risk of chronic diseases and optimize health. Therefore, we can say that chickpea is a functional food in addition to its accepted role as a source of protein and fibre. (Rasool *et al*., 2015). The most important oligosaccharides in chickpea are raffinose, stachyose, ciceritol and verbascose. Ciceritol is the most abundant oligosaccharide, hence the name *cicer,* while starch is the main polysaccharide in chickpea. Chickpeascontain all the essential mineral such as Ca, Mg, K, P, S, Cl, B, Fe, Mn, Zn, Cu, Niand Mo, which are vital for normal human growth and development. Chickpea is also a good source of vitamins such as A, B-complex, C, K and E. The nutritional composition of chickpea is given in Table 4 (USDA, 2018).

Chickpeas have many bioactive compounds, important vitamins, and minerals. Besides having nutritional benefits, the consumption of chickpeas always requires some processing as they have many antinutritional factors. Various traditional processes such as soaking, cooking or boiling, germination, roasting, fermentation, and dehulling have their own effects on the availability of nutrients (Yegrem, 2021).

Chickpeas nutrition facts (Newgent, 2021)
On average, in one cup of canned chickpeas after draining and rinsing them contains,
Calories: 210
Fat: 4 g (5 percent daily recommended value, or DV)
Sodium: 322 mg (14 percent DV)
Carbohydrate: 35 g (13 percent DV)
Fiber: 9.6 g (34 percent DV)
Sugars: 6 g
Protein: 11 g (21 percent DV)
Calcium: 65 mg (5 percent DV)
Iron: 1.5 mg (8 percent DV)
Manganese: 1.2 mg (53 percent DV)

Nutritional value of cooked mature seeds, raw dried seeds and flour are given in Tables 5, 6, 7 (Wikipedia, 2023; Wikipedia, 2023a)

Table 5. Nutritional value per 100 g (3.5 oz) Chickpeas, mature seeds, cooked, no salt

Energy	686 kJ (164 kcal)
Carbohydrates	27.42 g
Sugars	4.8 g
Dietary fibre	7.6 g
Fat	2.59 g
Saturated	0.27 g
Monounsaturated	0.58 g
Polyunsaturated	1.16 g
Protein	8.86 g
Vitamins	Quantity %DV†
Vitamin A equiv.	0% 1 µg
Thiamine (B1)	10% 0.12 mg
Riboflavin (B2)	5% 0.06 mg
Niacin (B3)	4% 0.53 mg
Pantothenic acid (B5)	6% 0.29 mg
Vitamin B6	11% 0.14 mg
Folate (B9)	43% 172 µg
Vitamin C	2% 1.3 mg
Vitamin E	2% 0.35 mg
Vitamin K	4% 4 µg
Minerals	Quantity %DV†
Calcium	5% 49 mg
Iron	22% 2.89 mg
Magnesium	14% 48 mg
Manganese	49% 1.03 mg
Phosphorus	24% 168 mg
Potassium	6% 291 mg
Sodium	0% 7 mg
Zinc	16% 1.53 mg
Other constituents	Quantity
Water	60.21 g

Table 6. Nutritional value per 100 g (3.5 oz) Chickpeas, dried seeds, raw

Energy	1,581 kJ (378 kcal)
Carbohydrates	62.95 g
Sugars	10.7 g
Dietary fibre	12.2 g
Fat	6.04 g
Saturated	0.603
Monounsaturated	1.377
Polyunsaturated	2.731
Protein	20.5 g
Vitamins	Quantity %DV†
Vitamin A equiv.	0% 3 µg
Thiamine (B1)	41% 0.477 mg
Riboflavin (B2)	18% 0.212 mg
Niacin (B3)	10% 1.541 mg
Pantothenic acid (B5)	32% 1.588 mg
Vitamin B6	41% 0.535 mg
Folate (B9)	139% 557 µg
Vitamin C	5% 4 mg
Vitamin E	5% 0.82 mg
Vitamin K	9% 9 µg
Minerals	Quantity %DV†
Calcium	6% 57 mg
Copper	33% 0.656 mg
Iron	33% 4.31 mg
Magnesium	22% 79 mg
Phosphorus	36% 252 mg
Potassium	15% 718 mg
Sodium	2% 24 mg
Zinc	29% 2.76 mg
Other constituents	Quantity
Water	7.68 g

Table 7. Nutritional value per 100 g flour (3.5 oz)

Energy	1,619 kJ (387 kcal)
Carbohydrates	57 g
Sugars	10 g
Dietary fiber	10 g
Fat	6 g
Protein	22 g
Vitamins	Quantity %DV†
Niacin (B3)	7% 1 mg
Folate (B9)	109% 437 µg
Minerals	Quantity %DV†
Calcium	5% 45 mg
Iron	31% 4 mg
Magnesium	47% 166 mg
Phosphorus	45% 318 mg
Potassium	18% 846 mg
Selenium	11% 8 µg
Sodium	4% 64 mg
Zinc	21% 2 mg
Other constituents	Quantity
Water	10 g

Chickpeas boast an impressive nutritional profile. They contain a moderate number of calories, providing 269 per cup (164 grams). Approximately 67% of these calories come from carbs, while the rest comes from protein and fat. Chickpeas also provide a variety of vitamins and minerals, as well as a decent amount of fiber and protein. A 1-cup (164-gram) serving of cooked chickpeas offers **(**Elliott and Ajmera, 2023).

- **Calories:** 269
- **Protein:** 14.5 grams
- **Fat:** 4 grams
- **Carbs:** 45 grams
- **Fiber:** 12.5 grams
- **Manganese:** 74% of the Daily Value (DV)
- **Folate (vitamin B9):** 71% of the DV
- **Copper:** 64% of the DV
- **Iron:** 26% of the DV
- **Zinc:** 23% of the DV
- **Phosphorus:** 22% of the DV
- **Magnesium:** 19% of the DV
- **Thiamine:** 16% of the DV
- **Vitamin B6:** 13% of the DV
- **Selenium:** 11% of the DV
- **Potassium:** 10% of the DV
-

As you can see, this legume is a particularly good source of the mineral manganese and the B vitamin folate **(**Elliott and Ajmera, 2023). Kala Chana Nutrition Facts Serving Per 1 Cup (Netmeds. 2023) Kala Chana is a type of legume loaded with nutrients such as protein, fibre and carbohydrates. It is an incredible source of vitamins like B6, C, folate, niacin, thiamin, riboflavin and minerals including manganese, phosphorus, iron and copper. The wealth of nutrients in Kala Chana is beneficial in boosting the immune system, promote muscle mass, regulates diabetes and enhance hair, skin and nail health.

Calories 210
Fat 3.8g
Sodium 322mg
Carbohydrates 35g
Fiber 9.6g
Sugars 6g
Protein 10.7g
*As per USDA

HEALTH BENEFITS

Accoding to Newgent (2021) the health benefits of chickpeas are given below: There's no doubt that chickpeas are good for your

health. "According to a study published in the journal Nutrients, people who regularly consume chickpeas and/or hummus have higher intakes of several key nutrients," says Sass. "These include fiber; vitamins A, E, and C; folate; magnesium; potassium; and iron." Does that mean eating chickpeas will boost your intake of those vitamins? Potentially. It may be that people who eat a more nutrient-packed diet are more likely to eat chickpeas. Either way, the petite pulses are a great source of nutrition.

They may help weight management: Haas says the sense of satiety provide by chickpeas' fiber and protein can help prevent overeating. "According to government data, chickpea/hummus consumers were 53 percent less likely to be obese," says Sass. "They also had lower BMIs [body mass indexes] and waist measurements compared to non-chickpea/hummus eaters."

They may help reproductive health: If you're trying to get pregnant, chickpeas can play a helpful role there, too. "There is a lot of research [like a 2018 study in Frontiers in Public Health] that points to a plant-based diet for improving fertility, so chickpeas check the box," says Haas. "Swapping plant protein for some of your regular meat-based protein is a fertility-friendly option."

They may help prevent type 2 diabetes: Chickpea consumption may be protective for a variety of chronic health conditions, including type 2 diabetes. A study published in Nutrients in 2018 found that chickpeas contain bioactive compounds that can reduce insulin resistance, a major risk factor for type 2 diabetes. In a study published in Nutrients in 2017, researchers found that pairing chickpeas with white rice led to less of a blood sugar response than eating white rice alone. The chickpeas essentially blunted the high glycemic index effect of the white rice. One thing to note: this was a very small study, involving only 12 women. They are good for the planet: If you like to choose foods that are good for the planet, chickpeas are an earth-conscious pick. Pulses, like chickpeas, are considered nitrogen-fixing crops. This means that they decrease the need for fertilizers, which therefore boosts their sustainability.

Risks and side effects*:* If you're ready to pump up the pulses in your eating plan, good for you. But don't rush to eat chickpeas in everything. "You may experience more gas when you first up your chickpea intake, but over time, your body will adapt," says Sass. "If you purchase canned chickpeas, rinsing them thoroughly can also help curb bloating." Make sure the chickpeas that you eat are cooked in some manner. (Canned beans are already cooked, by the way.) The act of cooking chickpeas increases the amount of protein and other nutrients that you can absorb while reducing or inactivating anti-nutrients (compounds that reduce or block nutrient absorption).

Accoding to Tori Avey (2022) the health benefits of chickpeas are given below:

Chickpeas and all pulses contain several components that, when eaten as part of a balanced plant-rich diet, may help prevent the development of various chronic diseases.

Diabetes: Both dried and canned chickpeas have a low glycemic index and low glycemic load, and contain amylose, a resistant starch that digests slowly. These factors help to prevent sudden surges in blood sugar and insulin levels, which can improve overall blood sugar control in people with type 2 diabetes.

Gut Flora: Chickpeas contain a soluble fiber called raffinose, a type of oligosaccharide that is fermented in the colon by beneficial bacteria called *Bifidobacterium*. As bacteria break down this fiber, a short chain fatty acid called butyrate is produced. Butyrate plays a role in reducing inflammation in the cell wall of the colon, promoting regularity in the intestines, and possibly preventing colorectal cancer by promoting cell apoptosis (death).

Heart Disease: Chickpeas contain a plant sterol called sitosterol that is structurally similar to cholesterol in the body. It interferes with the body's absorption of cholesterol and thereby can help to lower blood cholesterol levels. The fiber and unsaturated fats in chickpeas may also favorably affect blood lipid levels.

Obesity: High fiber foods can help to promote a feeling of fullness and satiety by delaying digestion and adding bulk to meals. The satiating effect of the high fiber and protein content of chickpeas may help with weight management.

Kala chana in ayurveda (Netmeds. 2023): Known as Chanaka in Ayurveda and grouped as legumes – Shimbi Dhanya Varga, Kala Chana is a super source of protein. Add this to your daily diet not just for great nutritional value but also for preventing a plethora of health conditions including high cholesterol, liver enlargement, mouth ulcers, skin ailments etc. Interestingly, the chickpeas exhibit different properties on the body, depending on how they have been cooked. According to Ayurveda, Kala Chana balances all three doshas – vata, kapha and pitta and are certainly preferred over the white or kabuli chana variety. The ancient medicine describes Chana as astringent to taste with Shita Virya or cold potency, dry in nature, easy to digest but causing constipation. While it effectively balances pitta and kapha doshas, it also increases vata dosha and is recommended for those suffering from high body temperature and blood-related problems.

Accoding to Netmeds (2023) the health benefits of Kala chna/chickpeas are given below: Cuts down cholesterol levels: Chickpeas being high on soluble fiber, prevent bile acids from getting absorbed into the body and reduce the levels of LDL cholesterol and total triglycerides. In fact, studies reveal that the amounts of dietary fiber found in black chana is far more superior and effective than compared to other legumes.

Rich in iron*:* Boiled and roasted Kala Chana is a must-have in your diet plan if you are suffering from anemia. It plays a crucial role in improving the levels of hemoglobin for transporting oxygen to various body parts. Being rich in iron, it is also recommended for pregnant and lactating mothers in limited quantities.

A Powerhouse of Phytochemicals*:* Black Chana contains a wide range of phytochemicals including carbohydrates, amino acids, proteins, flavonoids, iron, phosphate, chloride etc. These phytochemicals serve as antioxidants and prevent various cancers. Regular intake of black chickpeas strengthens bones and reduces hot flushes in menopausal women.

Protein source*:* Kala Chana is an amazing source of protein. If you are a vegetarian and worried to find your source of protein, black chickpeas come to your rescue. It has a whopping amount of 11 grams for every 100 grams of serving and it aids in repairing tissues, manages biochemical reactions, provides connective framework of certain structures in skin, hair and nails and keeps bones, ligaments stronger.

Aids in Digestion*:* The rich amounts of fibre available in Kala Chana aids in digestion. It adds bulk, prevents constipation and eases stress on the intestines. Ayurveda suggests eating a fistful of soaked black chickpeas in the morning to avoid various digestive disorders.

Regularizes Blood Sugar*:* The complex carbs in black chana digest slowly and the soluble fibre regulates the absorption of sugars into the blood. The low glycemic index of chickpeas is 28, it prevents sudden spike in blood sugars, keeps you satiated for longer hours thus avoiding hunger pangs.

Stimulates weight loss*:* It is a well-known fact that foods rich in fibre reduce hunger and aid in losing weight. While soluble fibre facilitates bile excretion for smooth digestion and insoluble fiber prevents constipation. Traditional medicine practitioners suggest drinking water boiled with chickpeas to reduce appetite and to cut down on calorie intake.

Keeps heart healthy*:* Chickpeas available black in colour are a good mix of antioxidants, anthocyanins, cyanidin, delphindin,

phytonutrients that help in maintaining healthy blood vessels. Being rich in folate, magnesium and other minerals, these legumes prevent formation of plaque in the arteries, blood clots. Include black chana in your diet at least twice in a day to maintain good cardiovascular health.

Brings down inflammation*:* Inflammation is a chronic disorder caused due to various factors including stress. Several studies reveal that consuming at least 4 servings of Kala Chana can boost metabolism and bring the inflammation down, owing to its wide range of nutrients including Vitamin A, Vitamins C, B6, protein, magnesium, iron and selenium that ably fight chronic inflammation.

Effectively heals jaundice: Bestowed with proteins, kala chana is an excellent natural remedy to mend jaundice, a disorder caused by the inability of the liver to process blood, either due to infection or a decline in hepatic functions. Consuming some black chickpeas soaked in water with jaggery aids in restoring optimal liver operations in instances of jaundice fever, ensuring smooth filtration of detrimental wastes in blood and nourishing hepatic tissues.

Elevates brain functions*:* Kala Chana is packed with vitamin B6 i.e. pyridoxine, as well as choline. These confer splendid wellness incentives for promoting the relay of signals to and from the brain via nerves and augmenting memory, mood, concentration. Moreover, selenium, a key trace mineral in kala chana, supplies useful antioxidant traits to flush out harmful free radicals, toxins from oxidising healthy cells in the nervous system, besides preventing neurodegenerative disorders like dementia, Alzheimer's.

Strengthens bones and joints*:* Vast reserves of calcium, magnesium in kala chana assure the intake of vital essential nutrients for increasing bone density and improving joint flexibility. Adding this wholesome legume to the daily diet in moderate quantities averts the risk of arthritis, osteoporosis and other debilitating illnesses in old age. Furthermore, kala chana is blessed with iron, which is crucial for the synthesis of collagen – a major protein for fortified bones and joints.

Black chana for skin diseases*:* The benefits of black chana on skin are numerous and it in fact is recommended for treating several skin conditions.

Reduces white spots in leukoderma*:* Leukoderma is a skin condition caused due to low or total loss of pigmentation on the skin. It is an autoimmune disorder mainly affecting the healthy skin causing white patches. Ayurvedic doctors recommend soaking black chickpeas in water along with a 1tsp of triphala churna overnight and consuming it after sprouting. This treatment if continued for a month will show positive results and would bring down white patches on the skin.

Treats fungal infections*:* Black chickpeas are an excellent remedy to bring down fungal infections like ringworm that can cause severe itchiness on the skin. Ringworm can happen on scalp, feet or even in the groin. Doctors recommend eating soaked and boiled Kala Chana daily without salt to reduce fungal infections.

Arrests hair fall*:* Kala Chana is an amazing source of Vitamin B6 and zinc, which play a crucial role in stronger hair growth. These minerals are responsible for building protein in the hair follicles for strengthening the hair.

Clears dandruff: If you are suffering from dandruff, apply black chana flour mixed with water on the scalp and wash it after 30 minutes. This remedy not only clears dandruff but also provides shine to the hair.

Prevents grey hair*:* Premature greying of hair is a common problem that is being faced by many teenagers. Include Kala Chana in your daily diet as protein and manganese in these legumes prevent changes caused due to pigmentation and slow down the greying of hair.

HB: Chickpeas have several potential health beneficial effects on some of the important human diseases like cardiovascular diseases, type 2 diabetes, digestive diseases, and cancers. This review summarized that different Ethiopian chickpea varieties have significant differences in the nutritional composition profiles between different varieties grown in Ethiopia and are an excellent source of micronutrients and macronutrients (Yegrem, 2021).

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