RESEARCH ARTICLE Legume Research- An International Journal, Volume 49 Issue 5: 781-786 (May 2026)

Variation in Nutritional and Anti-nutritional Properties of Chickpea Cultivars Grown in Kalyan Karnataka Region

S.I. Triveni[1], Laxuman[2], R.V. Beladhadi[2]

10.18805/LR-5592

ABSTRACT

Background: Chickpea (*Cicer arietinum* L.) grown globally as good source of protein. Chickpea has high phenolic, flavonoid content present in seed and mainly in seed coat. Colored desi type has high phenolic and flavonoid content compare with kabuli type. The present work was to evaluate all ten chickpea genotypes for biochemical parameters which help to select superior genotypes for further crop production.

Methods: Ten chickpea eight (*desi*) and two (*kabuli*) type were analyzed for nutritional and anti-nutritional properties. The study was examined for total protein content, total free amino acid content, total phenolic content, total flavanoid content and total tannin content.

Result: All ten genotypes grown in the Kalyan Karnataka Region was screened for biochemical parameters. The present work determines the significance of nutritional quality of all ten genotypes. The result found desi type has high significance with total protein content of A-1 at 27%, SA-1 at 26%, total free amino acid content of A-1 at 6.69 mg/g, SA-1 at 6.29 mg/g, total phenolic content of A-1 at 48.39 mg of GAE/g , SA-1 at 41.98 mg of GAE/g, total flavonoid content of A-1 at 44.35 mg of QE/g, SA-1 at 38.11 mg of QE/g and total tannin content of A-1 at 12.35 mg of TQE/g, SA-1 at 10.98 mg of TQE/g with new released genotype KCD-11 has total free amino acid content 5.89 mg/gm of seeds, total protein content of 25.4%, phenolic content of 44.98 mg GAE/gm of seeds, flavonoid content of 39.09 mg QE/gm of seeds and tannin content of 11.09 mg TQE/gm of seeds compare with kabuli type have total free amino acid content of MNK-1 at 3.05 mg/g and KAK-2 at 4.0 mg/g, total protein content of MNK-1 at 21.34%, KAK-2 at 20.06%, phenolic content of MNK-1 at 41.11 mg GAE/gm of seeds, KAK-2 at 39.88 mg GAE/gm of seeds, flavonoid content of MNK-1 at 30.89 mg QE/gm of seeds, KAK-2 at 26.1 mg QE/gm of seeds and tannin content of MNK-1 at 10.35 mg TQE/gm of seeds, KAK-2 at 8.35 mg TQE/gm of seeds. This is the first report for nutritional and anti-nutritional property of all ten chickpea genotypes. The result of the study found that A-1, SA-1 and KCD-11 are highly significant and superior with other chickpea genotype.

Key words: Amino acid content, Flavanoid, Gallic acid, Phenolic, Quercetin, Tannin content, Total protein content.

INTRODUCTION

Legumes are major protein-rich food with high micro-nutrients. Chickpea (*Cicer arietinum* L.) is known as Bengal gram or garbanzo bean. Old-World legume and also the seventh Neolithic founder pulse in the Fertile Crescent of North East. Chickpeas are said to be a protein-rich diet after milk. Chickpea is a member of the family Leguminosae, the world's major grown pulse crop. Chickpeas are nutrient-dense with moderate levels of certain dietary elements such as iron, phosphorus, magnesium and zinc contents, thiamine and vitamin B6 (Jukanti *et al*., 2012; Segev *et al.,* 2010). Legume has some indispensable amino acids with an absence of sulfur-containing amino acids. It was shown that the combination of chickpeas with cereals and pulses was found helpful in protecting against genetic disorders like cardiovascular diseases, adult-onset diabetes and gastrointestinal diseases (Xu and Chang, 2008).

Currently, chickpeas are grown in more than forty countries across the Indian subcontinent, America, North Africa, the Middle East, Southern Europe and Australia. Globally, chickpea production is in 3rd place, which is a major legume next to field peas and dry legumes. During 2023-24 the crop was grown in an area of 9.67 m ha with production of 10.09 m tones with productivity of 1043 kg/ha (Yuvraj *et al*., 2024). Chickpea is a major pulse crop that contributes ~20% of world pulse production. Karnataka is one of the major chickpea producing state in the country (Lambani *et al*., 2024). Chickpea is an important crop of Kalyan Karnataka Region of Kalburagi, Bidar, Raichur, Bheemarayangudi, Bijapur, Dharwad, Bellary, Hagari. In Karnataka, Kalburagi district occupies highest production of chickpea (1.24 lakh ha), production (8.63 lakh tonnes) and productivity (730 kg/ha).However lack of varietal adaptation and varied climatic conditions reduced average seed yield from 769-867 kg/acre to 605 to 650 Kg/acre (Laxuman *et al*., 2025). Two distinct types of chickpea are

[1]Department of Biochemistry, College of Agriculture, Kalaburagi-585 101, Karnataka, India.
[2]Zonal Agricultural Research Station, University of Agriculture Sciences, Kalaburagi-585 101, Karnataka, India.

Corresponding Author: S.I. Triveni, Department of Biochemistry, College of Agriculture, Kalaburagi-585 101, Karnataka, India. Email: inganakaltriveni@gmail.com

How to cite this article: Triveni S.I., Laxuman. and Beladhadi, R.V. (2026). Variation in Nutritional and Anti-nutritional Properties of Chickpea Cultivars Grown in Kalyan Karnataka Region. *Legume Research*. **49(5):** 781-786. doi: 10.18805/LR-5592.

Submitted: 25-10-2025 **Accepted:** 07-01-2026 **Online:** 27-01-2026

kabuli and *desi*. The *desi* (microsperma) types with pink flowers contain anthocyanin pigment on stems and are highly colored with thick testa. The *kabuli* (macrosperma) types with white flowers lack anthocyanin pigment on stems. White or beige-colored seeds with a ram's head shape and having thin testa with a smooth seed surface. Chickpea is a highly potential vital food that has high nutritive value. In the semi-arid tropics, chickpeas are a highly major nutrient component of the diets for individuals who cannot bear animal proteins or who are vegetarian by choice. The present investigation was to access the nutritional and anti-nutritional properties of ten chickpea genotypes of Kalyan Karnataka Region.

MATERIALS AND METHODS

Plant material

The experimental work was conducted during the year 2022-2023 and 2023-2024 at Department of Biochemistry, College of Agriculture, Kalaburagi, Karnataka. Chickpea (*Cicer arietinum* L.) genotypes were obtained from Agricultural Research Station (ARS), Zonal-1, Kalaburagi. The study consist of ten matured chickpea seeds (NBeG-49, BGD-103, JG-11, KCD-11, JAKI-9218, SA-1, A-1, GBM-2, MNK-1, KAK-2) collected, shade dried for 10 days to prepare seeds samples for nutritional and anti-nutritional analysis.

Chemical

Gallic acid, quercetin and tannic acid were obtained from Sigma chemical Co. $FeCl_2$ ferricyanide $NaNO_2$ and Al_3Cl_3 $6H_2O$ were purchased from Sigma Chemical Co. In this study all other chemicals used were of analytical grade.

Nutritional and anti-nutritional properties

Total free amino acids content

Total free amino acids content was determined using Ninhydrin method of Mahesha, (2012). Different dilutions of seed extract and standard were made (0.2, 0.4, 0.6 upto l ml) followed by 1 ml of ninhydrin reagent was added. The test tubes were kept in boiling water bath for 5 min and then allowed to cooling at room temperature and measured the optical density at 570 nm using a spectrophotometer. The total free amino acids content was calculated using a standard calibration curve of glycine.

Total protein content

Protein content was estimated by using colorimetric method (Lowry *et al*., 1951). Different dilutions of seed extract and standard were made (0.2, 0.4, 0.6 upto l ml) reacted with alkaline copper reagent (2 ml) and incubated for 10 min at room temperature. After 10 min of incubation, 0.2 ml of Folin-Ciocalteu reagent (FCR) was added and kept in dark for 20 min. After incubation the resulting blue color was read spectrophotometrically at 660 nm. The total protein content was calculated using a standard calibration curve of bovine serum albumin (BSA).

Extraction of phenolic compound

Total phenolic content (TPC)

The TPC in the extracts was determined as per the method of Dulf *et al*. (2017). Extracts of residues (0.5 ml) were diluted using distilled water (up to 3 ml) to which FCR (0.5 ml) and Na_2CO_3 (7.5% w/v, 0.5 ml) were added in the test tubes. Tubes were further incubated at room temperature for 30 min in dark conditions and the absorbance was spectrophotometrically read at 720 nm. Gallic acid was used as a standard for standard curve construction to calculate TPC in the extracts and expressed in terms of mg of gallic acid equivalents (GAE) per 100 g of extract (dry).

Total flavonoid content (TFC)

The TFC in the extracts was determined as per the modified method (Gawlik-Dziki *et al*., 2008). Extracts of residues (0.5 ml) were diluted with distilled water (up to 2 ml) in a volumetric flask (10 ml) to which $NaNO_2$ (5% w/v, 0.15 ml) was added and allowed to react at room temperature for 5 min and $AlCl_3.6H_2O$ (10% w/v, 0.15 ml) was added and incubated for 5 min. After incubation, this mixture was reacted with NaOH (1 M, 1 ml), mixed thoroughly and the absorbance was read at 510 nm spectrophotometrically, where quercetin was used as a standard for determining TFC in the extracts. It was expressed as mg of quercetin equivalent (QE) per 100 g of extract (dry).

Total tannin content (TTC)

The TTC in the extracts was determined as per the method (Faridy *et al*., 2020). Extracts of residues (0.5 ml) were diluted with distilled water (up to 1 ml) to which potassium ferricyanide (1% w/v, 1 ml) and ferric chloride solution (8% w/v, 1 ml) was added. Tubes were further incubated at room temperature for 5 min and the absorbance was spectrophotometrically read at 720 nm, where tannic acid was used as a standard for determining TTC in the extracts and expressed in terms of mg of tannic acid equivalents (TQE) per 100 g of extract (dry).

Statistical analysis

All the analysis was done in triplicates and the data presented are means±S.D. of three independent determinations. Significance was accepted at $P \leq 0.05$.

RESULTS AND DISCUSSION

Chickpea is considered to be an essential legume throughout the world and has important health benefits with functional nutritive value (Haeger *et al.,* 2022; Gulcin *et al.,* 2012). Chickpea (*Cicer arietinum* L.) is an important pulse crop in India and is well adapted to drought prone semi-arid tropical regions. Chickpea seeds are so healthy that they can also be called a "complete protein" as seeds of chickpea contain 17-34% of protein, 61.2% carbohydrates and also have all nine essential amino acids like isoleucine, leucine, lysine, phenylalanine and valine (Smartt, 1976; Karim and Fattah, 2006).

Amino acids are essential tools for building protein structure and these plays a vital role in biological activities such as in supporting tissue repair, cell metabolism and also have an important role in developing antibodies against bacteria and viruse (Kaur *et al*., 2014). As per reports, matured seeds were rich in free amino acid content having all essential amino acids, helps in building nucleoprotein (DNA and RNA) (Luo *et al.,* 2002). In the current study total free amino acid content of A-1 at 6.69 mg/g, SA-1 at 6.29 mg/g, KCD-11 at 5.89 mg/g genotypes were higher amongst the ten genotypes followed by JAKI-9218 at 5.11 mg/g, GBM-2 at 5.23 mg/g, JG-11 at 4.88 mg/g, BGD-103 at 4.39 mg/g, MNK-1 at 4.05 mg/g, KAK-2 at 4.29 mg/g, lowest value was recorded in NBeG-49 at 2.5 mg/g as shown in (Fig 1). Our findings for amino content agree with results ranged between (3.8-6.8 mg/g) reported by Vinod *et al*. (2022); Rakesh *et al*. (2025) and Mohammad *et al.* (2019).

Chickpea protein is lower in sulfur containing amino acid methonine and cystein but when combined with cereals, have high sulfur containing amino acid with low lysine content contribute feeling of fullness that can aid in weight management by reducing overall calorie intake. Protein with high fibre content slowdown the absorption of carbohydrates and helps stabilize blood sugar levels. It also supports healthy gut microbiome that benefits digestion and nutrient absorption.

Chickpea protein is low in saturated fat and can help improve lipid profile by reducing LDL “bad” Cholesterol, promotes cardiovascular health (Rachel *et al*., 2018). Rakesh *et al*. (2025) reported similar results ranged between (15.7%-30.5%). Our study showed that total protein content ranged between7.0% to 27.0%. The genotypes varied significantly in respect to protein content of A-1 at 27.0%, SA-1 at 26%, KCD-11 at 25.4% have higher value among ten genotypes followed by moderate value seen in JAKI-9218 at 23.02%, GBM-2 at 20.08%, JG-11 at 18%, BGD-103 at 16%, MNK-1 at 21.34%, KAK-2 at 20.06% and lowest value was seen in the NBeG-49 at 7.0 % as shown in (Fig 2). Our findings agree with those of Vinod *et al*. (2022).

The phenolic compounds are natural nutritional supplements for living organisms that play an important role in homeostasis (Macar *et al*., 2017; Mohsenzadeh *et al.,* 2024). Moore and Stein (1948) have reported chickpea have high phenolic, phytate and saponin content. Uses of chickpea seed in the diet found to be very protective in preventing chronic and degenerative disease

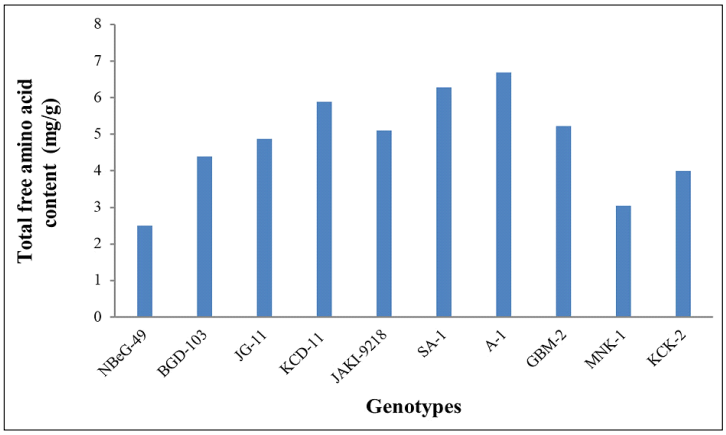

Fig 1: Total free amino acid content of ten chickpea genotypes.

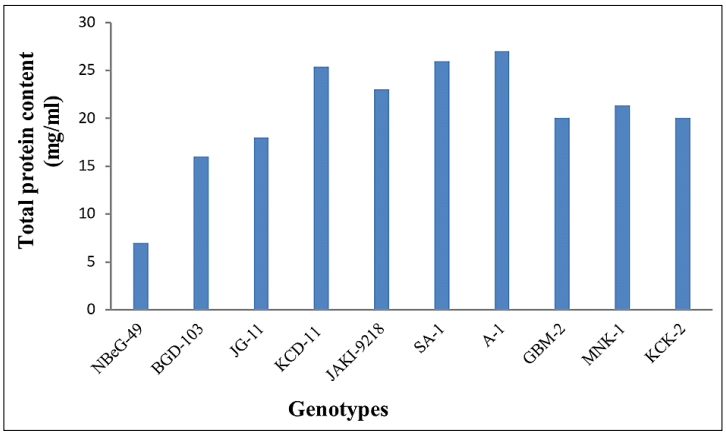

Fig 2: Total protein content of ten chickpea genotypes.

(Nabila *et al*., 2023; Lowry *et al*., 1951). Quintero-Soto *et al*. (2018) and Summon *et al*. (2008) reported that polyphenols act as scavengers of peroxyl and hydroxyl radicals, help in controlling cardiovascular disease and also play a vital role in deactivating metal ions.

In the present study, range of total phenolic content for chickpea genotypes varied between 21.35 mg of GAE/g to 48.39 mg of GAE/g. It was seen that the genotypes varied significantly in respect to phenolic content. Highest phenolic content A-1 at 48.39 mg of GAE/g, SA-1 at 41.98 mg of GAE/g, KCD-11 at 44.98 mg of GAE/g followed by BGD-103 at 40.88 mg of GAE/g, GBM-2 at 42.39 mg of GAE/g, JG-11 at 35.98 mg of GAE/g, JAKI-9218 at 32.11 mg of GAE/g, MNK-1 at 41.11mg of GAE/g, KAK-2 at 39.88 mg of GAE/g and lowest content was seen in NBeG-49 at 21.35 mg of GAE/g as shown in (Fig 3). Mohammad *et al*. (2019) and Rakesh *et al*. (2025) reported that phenolic content in chickpea genotypes ranged between (32.5 mg/g - 60.1 mg/g).

Wang *et al*. (2018) reports that an increase in total phenolic and total flavonoid content in plants helps in protecting against antioxidant, antibacterial and anti-inflammatory activities. Verma *et al*. (2019) reports that stabilization of biological activity is carried out by flavonoids which have phenolic groups in their structure and flavonoid intake helps in the reduction of diabetes, obesity and osteoporosis and also in cancer prevention. Total flavonoid content range from 18.39 mg of QE/ g to 44.35 mg of QE/ g. It was observed that the genotypes varied significantly in respect to flavonoid content. Highest flavonoid content was evident in genotype A-1 at 44.35 mg of QE/ g, SA-1 at 38.11mg of QE/ g, KCD-11 at 39.09 mg of QE/ g followed by BGD-103 at 35.08 mg of QE/ g, MNK-1 at 30.89 mg of QE/ g, KAK-2 at 26.1 mg of QE/ g and lowest value was seen in the NBeG-49 at 18.39 mg of QE/ g as shown in (Fig 4). From the data it reveals desi type were rich in phenolic as well as flavonoid content compared with kabuli types present in seed and mainly in seed coat of chickpea. Mohammad *et al*. (2019) and Rakesh *et al*. (2025) reported that flavonoid content in chickpea genotypes ranged between (26.1 mg/g - 47.0 mg/g).

Tannin concentration is high in colored (desi) chickpea compared with lighter colored kabuli types. High percentage of tannin content is found in chickpea seed coat, these tannin are anti nutritional factor have the ability to form complexes with minerals and hinder intestinal absorption have recently gained recognition for their

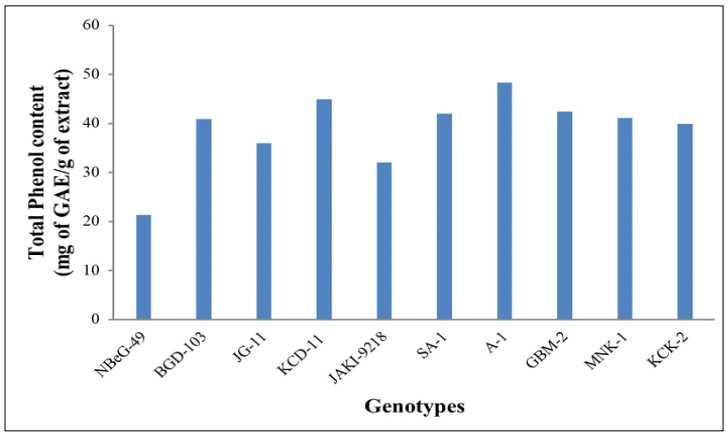

Fig 3: Total phenolic content of ten chickpea genotypes.

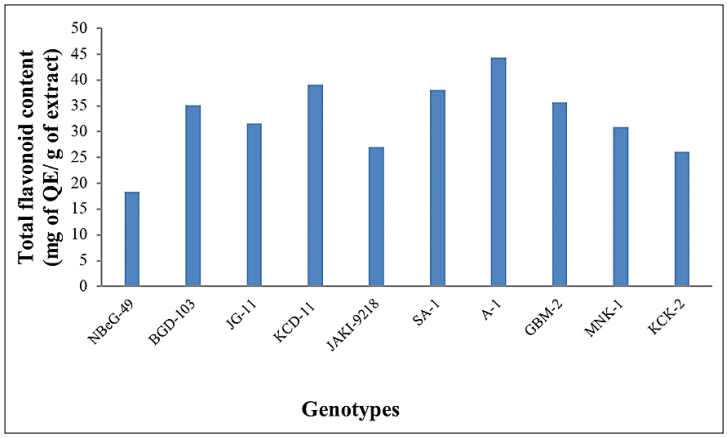

Fig 4: Total flavanoid content of ten chickpea genotypes.

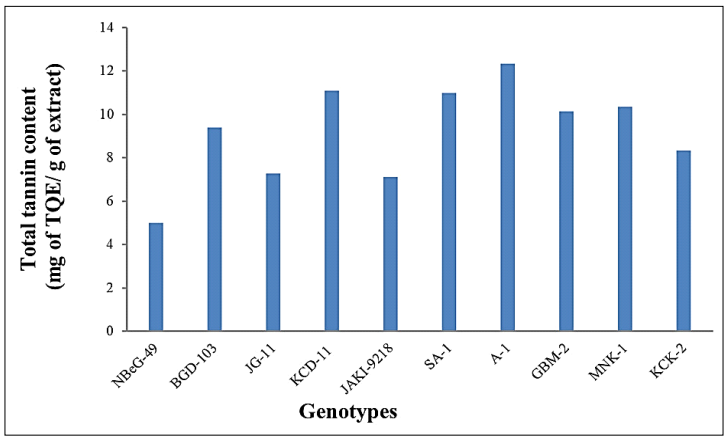

Fig 5: Total tannin content of ten chickpea genotypes.

potential health promoting properties. Jayalakshmi and Kumar, (2023) reported that tannin has antiviral, antibacterial, chemo protective and also has potential application in preventive health care. According to the report of Xu and Chang (2008) during food mastication, saliva protein and mucosal membrane of the mouth bind to tannin content, this helps in reducing the digestibility of carbohydrates and protein.

Tannin is mainly present in the seed coat and plays a major role in protecting the seeds from oxidative damage by many environmental conditions. It was observed that the genotypes varied significantly in respect with tannin content. Highest tannin content was observed in A-1 at 12.35 mg of TQE/g, SA-1 at 10.98 mg of TQE/g, KCD-11 at 11.09 mg of TQE/g followed by BGD-103 at 9.39 mg of TQE/g, MNK-1 at 7.35 mg of TQE/g, KAK-2 at 8.05 mg of TQE/g and lowest value was seen in the NBeG-49 at 4.99mg of TQE/ g shown in (Fig 5). Rakesh *et al.* (2025) and Mohammad *et al.* (2019) reported that tannin content in chickpea genotypes ranged between (4.12 mg/g - 12.0 mg/g).

Jodha and Subbarao (1987) introduction of chickpea crop in a cereal based crop rotation can break the disease and pest cycle and increase the productivity of the entire rotation and thus plays an important role in sustaining soil fertility. In view of its role in sustaining nutritional security and soil fertility the crop is being preferred by marginal farmers of India.

The current study reveals that (desi) chickpea genotypes have a high source of protein, amino acids, phenolic compounds, flavonoid and tannins content compared with kabuli type. As per the report, it was believed that a legume with high phenolic content helps in curing various diseases. Fig (1-5) clearly state that chickpea seeds and seed coat have elevated levels of nutritional and anti nutritional value for the betterment of mankind.

CONCLUSION

Nowadays, people are aware of health consciousness; the demand for delicious and easily accessible food products with high nutritional value. Chickpea is a major and functional food with a low price. The result showed that all genotypes have good source of protein content, amino acid content, phenolic content, flavonoid content and tannin content were analyzed and witnessed for nutritional and anti-nutritional properties. The result of the study found that A-1, SA-1 and KCD-11 are highly significant and superior followed by JG-11, JAKI-9218, GBM-2, MNK-1, KAK-2, BGD-103 and low value was found in NBeG-49 genotype. The results of the study showed that all genotypes can be accepted as functional foods that are supported by rich nutritional and anti-nutritional property. The present research is original and this is the first report for nutritional and anti-nutritional properties of all ten chickpea genotypes of Kalyan Karnataka Region. Hence, may recommend to the breeder for selecting the genotypes for the beneficiary of mankind, as chickpea is a major functional food with cost-effective and high-nutritive value.

Conflict of interest

All authors declare that they have no conflicts of interest.

REFERENCES

Dulf, F.V., Vodnar, D.C., Dulf, E.V. and Pintea, A. (2017). Phenolic compounds, favonoids Lipids and antioxidant potential of apricot (*Prunus armeniaca* L.) fermented by two filamentous fungal strains in solid state system. *Chemistry Central Journal*. **11:** 92.

Faridy, J.C., Stephanie, C.G., Gabriela, M.M. and Cristian, J.M. (2020). Biological activities of chickpea in human health (*Cicer arietinum* L.). A review. *Plant Food Hum. Nutr*. **75(2):** 142-153.

Gawlik-Dziki, U. (2008). Effect of hydrothermal treatment on the antioxidantproperties of broccoli (*Brassica oleracea* var. botrytis italica) florets. *Food Chem*. **109:** 393-401.

Gulcin, I. (2012). Antioxidant activity of food constituents: An overview. *Arch. Toxicol*. **86(3):** 345-391.

Haeger, G., Bongaerts, J. and Siegert, P. (2022). A convenient ninhydrin assay in 96-well format for amino acid-releasing enzymes using an air-stable reagent. *Analytical*. **654(1):** 114819.

Jadhav, A., Rayate, S., Mhase, L., Thudi, M., Chitikineni, A. and Harer, P. (2015). Marker-trait association study for protein content in chickpea (*Cicer arietinum* L.). *J. Genet*. **94:** 279-286.

Jayalakshmi, V. and Kumar, B. (2023). Nutritional profile of Chickpea (*Cicer arietinum* L.): Breeding efforts for enhancing nutritive value. *Journal of Food Legume*. **36:** 111-119.

Jodha, N.S. and Subbarao, K.V. (1987). The Chickpea. In: Chickpea: World Importance and Distribution [(Eds): M.C. Saxena and K.B. Singh], CAB International, Walling ford, Oxon, UK. pp 1-10.

Jukanti, A.K., Gaur, P.M., Gowda, C.L. and Chibbar, R.N. (2012). Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): A review. *Br. J. Nutr*. **108(1):** 1126.

Karim, M.F. and Fattah, Q.A. (2006). Changes in biocomponents of chickpea (*Cicer arietinum* L.) sprayed with potassium napthenate and napthenic acetic acid. *Bangladesh Journal of Botany*. **35(1):** 39-43.

Kaur, N., Kumar, A., Kaur, K., Kaur, S., Gupta, A.K. and Singh, I. (2014). Abiotic Stress Tolerance of Chickpea Genotypes Depends upon Antioxidative Potential and Nutritional Quality of Seeds. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, No-2, p. 615-623.

Lowry, O.H., Rosembrough, N.J. and Al Farr, R.J. (1951). Randall protein measurement with folin phenol reagent. *J. Biol. Chem.* **193:** 265-275.

Lambani, Y., Laxuman., Lokesha, R., Thudi, M., Roorkiwal, M., Palakurthi, R., Rachappa, V., Muniswamy, S., Kenganal, M. and Varshney, R.K. (2024). Screening and validation of drought tolerance and *fusarium* wilt resistance in advance breeding lines of chickpea (*Cicer arietinum* L.). *Legume Research*. **47(9):** 1599-1605. doi: 10.18805/LR-4745.

Laxuman, Avinalappa, H., Sidramappa, Kuchanur, P.H., Kumar, K.S. and Kumar, A. (2025). Seed yield stability assessment of Chickpea genotypes through AMMI and Bi plot analysis. *Legume Research - An International Journal.* **48(2):** 218-223. doi: 10.18805/LR-4911.

Luo, X.D., Basile, M.J. and Kennelly, E.J. (2002). Polyphenolic antioxidants fromthe Fruits of *Chrysophyllum cainito* L. (Star apple). *J. Agric. Food Chem.* **50:** 1379-1382.

Macar, T.K., Macar, O. and Mart, D. (2017). Variability in some biochemical and nutritional characteristics in desi and Turkish kabuli chickpea (*Cicer arietinum* L.). *CBUJOS*. **13(3):** 677-680.

Mahesha, H.B. (2012). Estimation of Amino Acid by Ninhydrin Method. Current Medical Imaging. pp: 1-2.

Mohammad, A.A., Agnihotri, M., Khan, M.S., Dubey, A., Tyagi, B., Kumar, R. and Prakash, N. (2019). Biochemical basis of resistance in chickpea varieties against *Callosobruchus chinensis* Linn. (Coleoptera: Bruchidae). *Legume Research.* **42(2):** 282-286. doi: 10.18805/LR-3848.

Mohsenzadeh, S. (2024). *Cicer arietinum* L. (Chickpea): A mini-review. *Agricultural Reviews*. **45(3):** 430-438. doi: 10.18805/ag.RF-269.

Moore, S. and Stein, W.H. (1948). Analysis of Amino Acids. In: Methods in Enzymology. [Colowick S.P., Kaplan N. (eds)], Academic Press, New York. pp 468-471.

Nabila, B., Qudrat, U.K., Liu, L.G., Li., W., Liu, D. and Ul Haq, L. (2023). Nutritional composition, health benefits and bioactive compounds of chickpea (*Cicer arientinum* L.). *Front Nutr.* 1**0:** 1218468.

Quintero-Soto, M.F., Saracho-Pena, A.G., Chavez Ontiveros, J., Garzon-Tiznado, J.A., Pineda Hidalgo, K.V., Delgado-Vargas, F. and Lopez Valenzuela, J.A. (2018). Phenolic profiles and their contribution to the antioxidant activity of selected chickpea genotypes from Mexico and ICRISAT collections. *Plant Foods Hum. Nutr.* **73(2):** 122-129.

Rachel, A., Gada, G., Hagai, C. (2018). The metabolic roles of free amino acid during seed development. *Plant Science*. **275:** 11-18.

Rakesh, K.Y., Tripathi, M.K., Tiwari, S., Asati, R., Tripathi, N., Sikarwar, R.S. (2025). Estimation of biochemical parameters in chickpea (*Cicer arietinum* L.) genotypes. *Legume Research - An International Journal.* **48(4):** 550-558. doi: 10.18805/LR-5327.

Segev, A., Badani, H., Kapulnik, Y., Shomer, I., Oren Shamir, M. and Galili, S. (2010). Determination of polyphenols, flavonoids and antioxidant capacity in colored chickpea (*Cicer arietinum* L.). *Journal Food Science*. **75:** 115-119.

Smartt, J. (1976). Tropical Pulses. Tropical Agriculture Series Southampton Univ. Longman Group Ltd., London. pp 96.

Summon, C., De Angelis, D., Ricciardi, L., Caponio, F., Lotti, C. and Pasqualone, P.S. (2008). A Nutritional physico-chemical and functional characterization of global chickpea collection. *J. Food Compost Anal.* **84:** 103306.

Verma, S. and Bhatia, S. (2019). Analysis of genes encoding seed storage proteins (SSPs) in chickpea (*Cicer arietinum* L.) reveal co-expressing transcription factors and a seed-specific promoter. *Funct. Integr. Genomic.* **19(3):** 373-390.

Vinod, K.S., Tiwari, S., Gupta, N., Tripathi, M.K., Yasin, M. (2022). Evaluation of physiological and biochemical contents in desi and Kabuli chickpea. *Legume Research- An International Journal*. **45(10):** 1197-1208. doi: 10.18805/LR-4265.

Wang, Y., Li, L., Liu, H., Zhao, T., Meng, C., Liu, Z. and Liu, X. (2018). Original article bioactive compounds and *in vitro* antioxidant activities of peel flesh and seed powder of kiwifruit. *Int. J. Food Sci. Technol.* **53(9):** 2239-2245.

Xu, S.C. and Chang. (2008). Total phenolics, phenolic acids, isoflavones, anthocyanins and antioxidant properties of yellow and black soybeans as affected by thermal processing. *Journal of Agricultural and Food Chemistry*. **56:** 7165-7175.

Xu, B. and Chang, S.K. (2008). Effect of soaking, boiling and steaming on total phenolic content and antioxidant activities of cool season food legumes. *Food Chemistry*. **110:** 1-13.

Yuvraj, L., Laxuman., Lokesha, R., Thudi, M., Roorkiwal, M., Palakurthi, R., Rachappa, V., Muniswamy, S., Kenganal, M. and Varshney, R.K. (2024). Screening and validation of drought tolerance and *fusarium* wilt resistance in advance breeding lines of chickpea (*Cicer arietinum* L.). *Legume Research*. **47(9):** 1599-1605. doi: 10.18805/LR-4745.