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Versatile legume, chickpea (*C. arietinum*): An overview on nutritional, medicinal and immunological arenas

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Abstract
The review work deals with the extensive nutritional, medicinal, and immunological benefits of *C. arietinum*, where chickpea's chemical composition and pharmacological properties (*Cicer arietinum*) are investigated. Chickpeas have been found to contain several beneficial compounds including carbohydrates, amino acids, proteins, phenolic compounds, oils, glycosides, saponins, tannins, flavonoids, and alkaloids. These components contribute to its numerous immunological health uses, including antioxidant, antidiabetic, anti-inflammatory, hypocholesterolemic, hepatoprotective, and anticancer effects. The work also examines the traditional use of chickpeas in treating ailments such as bronchitis, cholera, constipation, and diabetes, highlighting its nutritional profile rich in vitamins, minerals, and amino acids. Pharmacological effects are also explored, highlighting the potential of chickpeas in blood sugar management and appetite control, supported by studies on their antihyperglycemic and antioxidant activities. This comprehensive review highlights chickpeas as a valuable food source with significant therapeutic potential and advocates their inclusion in the diet to improve overall health and manage chronic disease.

Keywords: *Cicer arietinum*, anti-inflammatory, anti-diabetic, anti-oxidant, chickpea, legume, nutrition, inflammation

Introduction
Legumes hold a special place in poor countries around the world due to their high protein profile, which has earned them the nickname "poor man's meat." Because they are legumes, they can be grown in any soil and can help nitrogen already present in the soil. They also significantly increase soil fertility and promote environmental and economic sustainability.
There has been an increasing interest in investigating in recent years the immunomodulatory properties of natural foods and botanicals, fuelled by a quest for holistic approaches to health and wellness. Among these, *Cicer arietinum*, commonly known as chickpeas or garbanzo beans, has become a viable contender because to its rich nutritional profile and traditional medicinal uses across various cultures. It was a crop that was farmed in temperate, tropical, and subtropical climates. The species was thought to have originated in southeast Turkey, Syria, northern Persia, and the southern Caucasus. Botanical and archaeological research revealed that the chickpea was initially domesticated in the Middle East. It has since been broadly cultivated and grown in India, Ethiopia, the Mediterranean region& the Middle East. The most abundant wild species are found in Turkey, Central Asia, Iran, and Afghanistan. Currently, chickpeas are cultivated across various regions, including: India, Turkmenistan, Egypt, Ethiopia, Kenya, Libya, Madeira, Morocco, Somalia, Sudan, Tanzania, Tunisia, Uganda, Zaire, and Zimbabwe. Asia: Afghanistan, Armenia, Azerbaijan, Bhutan, China, Indonesia, Iran, Chile, Java, Kyrgyzstan, Mongolia, Myanmar, Nepal, Pakistan, Russia (Asian part), Sri Lanka, Taiwan, Uzbekistan. Middle East: Cyprus, Bulgaria, East Aegean (Greece), Jordan, Lebanon, Oman, Romania, Syria, Turkey, Africa, Yemen. Europe: Albania, Balearic Islands, Estonia, Belarus, Corsica, Kazakhstan, Crete, former Yugoslavia, France, Italy, Algeria, Lithuania, Moldova, Russia (European part), Sardinia, Sicily, Spain, Ukraine.

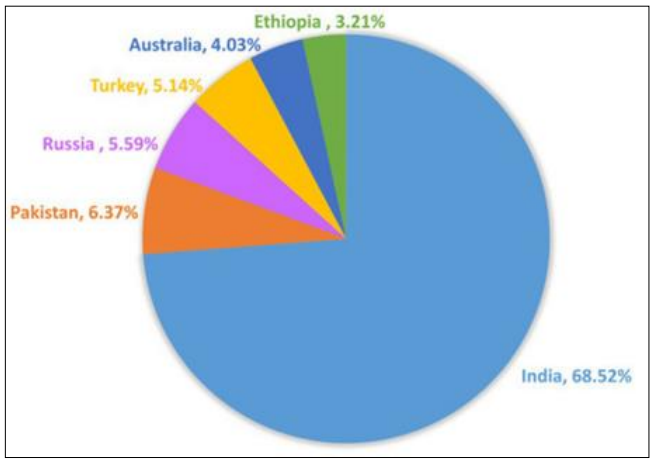

Fig 1: Leading chickpea producers and contributors to the global production

C. arietinum, also known as chickpea, is a valuable food source that has been associated with several immune benefits (Aggarwal *et al*., 2023). Chickpeas are rich in minerals and vitamins that are essential for a healthy immune system. They contain high levels of zinc, playing a vital part in the development and function of immune cells. Chickpeas are also an excellent source of protein, which is important for the production of antibodies and the overall functioning of the immune system. Chickpeas contain significant amounts of Fiber and antioxidants that can help reduce inflammation and boost the body' sprotection against pathogens. Including chickpeas in a balanced diet can contribute to overall immune health and support the body's ability to ward off disease. Chickpeas also contain a unique type of Fiber called resistant starch, which can promote the growth of beneficial microorganisms in the gut. This supports a thriving intestinal microbiota that is closely linked to a well-functioning immune system.

Additionally, antioxidants found in chickpeas, such as flavonoids and polyphenols, can aid in preventing harm from free radicals to the body's cells. Ultimately increasing the body's ability to fight disease. Incorporating chickpeas into meals can be as simple as adding them to salads, soups, or making homemade hummus. With a variety of nutrients that support immune health, chickpeas are a truly versatile and valuable addition to a well-rounded diet. *Cicer arietinum*, the technical name for chickpea, is a mainstay in many cuisines and has various immune-boosting properties. [1-3].

Review of Literature

Chickpeas, known for their culinary versatility, offer a plethora of immune-boosting benefits. Rich in vital nutrients such as zinc, selenium, vitamin C, and vitamin E, they strengthen the immune system and enhance overall health. These legumes harbor an impressive array of antioxidants like flavonoids, polyphenols, and carotenoids, which combat oxidative stress, quell inflammation, and neutralize harmful free radicals, thus fostering a robust immune response. Additionally, chickpeas play a crucial role in nurturing gut health, an essential aspect of immune function, by providing ample dietary Fiber, especially soluble Fiber, which nourishes beneficial gut bacteria. Noteworthy is chickpeas' anti-inflammatory potential, attributed to specific polyphenols and saponins, which alleviate prolonged inflammation, consequently bolstering immunity. The research underscores chickpeas' ability to enhance immune cell activity, particularly β-glucans role in boosting the performance of key immune cellular components such as macrophages and natural killer cells, essential for detecting and eliminating infections, thus fortifying the body's defense against pathogens. Overall, chickpeas emerge as a valuable ally in fortifying the immune system and promoting overall well-being through their diverse immunological benefits.

With this exploration, we aim to add to the increasing amount of data demonstrating the integration of chickpeas into a balanced diet for enhanced immune health. Additionally, we will discuss avenues for future research and potential applications, including the development of nutraceuticals and functional foods harnessing the immune-boosting potential of C. arietinum [4].

Nutritional Profile of *Cicer arietinum* L.

Chickpeas are rich in vitamins, minerals, and amino acids, making them a nutritious staple food. They are anexcellent source of vitamins, including thiamine, niacin, riboflavin, folate, and precursor to vitamin A, β-carotene.

These chemical constituents contribute to the reported antioxidant, anticarcinogenic, and cardiovascular protective activities of chickpeas.

Similar to other legumes, chickpeas include several antinutri tional elements that can be diminished or removed through v arious cooking methods. Table 1 [5-7].

Nutrient	Nutrient value per 1 kg
Proteins (g)	187.7-240
Calories	3780-3960
Fat (g)	41-60.4
Carbohydrate (g)	395.6-542
Fiber (g)	74-122.2
Ash (g)	34
List of Minerals (g)	
Ca	0.057-0.16
P	0.25-0.31
Fe	0.004-0.0123
Na	0.024
K	0.7-0.72
Zn	0.003-0.0041
Mg	0.079-0.138
List of Vitamins (g)	
β-carotene (mg)	0.067
Thiamine	0.00045-0.0005
Riboflavin	0.0002-0.00026
Niacin	0.00154-0.002
Tocopherol	0.0112-0.0129
Folic acid	0.206-0.290
Pantothenic acid	0.001-0.002
Pyridoxine	0.0003-0.0004
List of Amino acids (g)	
Lysine	6.9 approx
Methionine	1.3 approx
Cysteine	0.5 approx
Arginine	8.4 approx
Glycine	3.75 approx
Histidine	2.4 approx
Isoleucine	3.9 approx
Leucine	7.3 approx
Phenylalanine	6.05 approx
Tyrosine	3.1 approx
Threonine	3.9 approx
Tryptophan	0.45 approx
Valine	4.25 approx
Alanine	3.9 approx
Aspartic acid	10.5 approx
Glutamic acid	16.5 approx
Proline	4.15 approx
Serine	5 approx

Medical Importance and Immunological Impacts of *Cicer arietinum*

In recent years, we have seen a surge in curiosity regarding the exploration of therapeutic/medicinal flora and their old-style applications across diverse regions worldwide. Among these, *Cicer arietinum*, commonly known as chickpea, has garnered attention for its potential pharmacological properties. Traditionally, chickpea seeds have been utilized for various purposes, including as aphrodisiacs and remedies for ailments such as bronchitis, constipation, and diarrhea. Additionally, they were believed to possess hypolipidemic properties due to the presence of malic and oxalic acids, which were harvested through a unique process in India. Chemical analysis of chickpea seeds has revealed diverse constituents, including amino acids, phenolic compounds, saponins, proteins, oils, glycosides, alkaloids, tannins, phytosterols,carbohydrates, and flavonoids. Furthermore, studies have demonstrated numerous pharmacological effects of *Cicer arietinum*, such as anticancer activities, hepatoprotective, aphrodisiac, antidiabetic, hypocholesterolemic, anti-inflammatory, estrogenic, and antioxidant. This review offers an understanding of the chemical composition of chickpea with its pharmacological effectsshedding light on its potential therapeutic applications [8-9].

Traditional Uses:

Traditionally, *Cicer arietinum* seeds have been employed for various therapeutic purposes, including as aphrodisiacs and remedies for warts, sunstroke,diarrhea, dyspepsia, cholera, flatulence, bronchitis, constipation, catarrh, and snakebites. The presence of oxalic and malic acids in the seeds has been believed to contribute to lowering blood cholesterol levels, with a unique extraction method involving soaking hot muslin covering the growing plants overnight in India. This extracted acid mixture is then utilized for its hypocholesterolemic properties. Additionally, chickpeas have been utilized to alleviate conditions such as stomach burning, hepatomegaly, bronchitis, stomatitis, skin diseases, and inflammations. In traditional Uighur medicine, chickpeas are utilized to address hypertension, hyperlipidaemia, flatulence, diabetes, low libido, tumour formation, itchy skin and osteoporosis. Various parts of the plant, including leaves, seeds, and seedpods, are utilized for therapeutic purposes [10].

Chemical Constituents of *Cicer arietinum*

1. **Identification of Key Compounds in Chickpeas**
2. The chemical constituents of *Cicer arietinum*, commonly known as chickpea or garbanzo bean, have been studied to understand its nutritional and health benefits. According to studies, chickpeas contain a variety of chemical constituents including proteins, Fibers, sugars, phenols, petroselinic fatty acid, sterols, and phytochemicals such as indole phytoalexins and glucosinolates.

   In addition, chickpea seeds are also known to contain high levels of vegetable and essential oils. They are also brimming with minerals such as choline, essential for the smooth functioning of the brain and nervous system, as well as potassium, magnesium, and iron.
3. **Exploring the Phytochemical Landscape of *Cicer arietinum*:**

   Cicer arietinum, or chickpea, is known for its rich phytochemical profile. Cumin seeds showed high contents in both essential and vegetable oils, sugars, and protein regardless of their source. They also exhibited high levels of petroselinic fatty acid and sterols. Additionally, cakes and aromatic water derived from chickpeas were found to have high levels of fibres, proteins, phenols and sugars. Chickpeas like many legumes, contain phytoestrogens. These are naturally occurring plant compounds that resemble the hormone oestrogen in structure found in human body [11].

Pharmacological Effects of *Cicer arietinum*:

In terms of overall nutrition, the chickpea (*Cicerarietinum* L.), an annual plant, is the third-most significant grain legume in the world. Chickpea protein is considered a suitable protein source due to its low amounts of trace elements, excellent protein bioavailability, and balanced amino acid composition (Newman *et al*., 1987). Chickpea protein hydrolyzate has been reported to have many biological activities, including anti-inflammatory action, angiotensin I- converting enzyme (ACE) inhibition, iron-chelating capacity, antioxidant efficacy, and antigen-reducing action [12].

Anti-Cancer Effect:

A recent study highlights the promising anti-cancer potential of compounds derived from *Cicer arietinum*. The C-25 protein isolated from this legume exhibited significant cytotoxic activity against human oral carcinoma cells, with an IC50 valueof 37.5 µg/ml, while remaining non-toxic to normal human peripheral blood mononuclear cells at concentrations up to 600 µg/ml. Additionally, isoflavones from *Cicer arietinum* demonstrated dose-dependent suppression of cell proliferation in the MCF-7 breast cancer cell line. These findings underscore the potential application of *Cicer arietinum*-derived compounds in specifically focusing on cancer cells, indicating their potential use in cancer treatment [12].

Saponins: These are phytochemicals found in various plant foods, including chickpeas. Research suggests that saponins contain anti-cancer properties, interfering with the growth and proliferation of cancerous cells. They may induce apoptosis, prohibit angiogenesis, and suppress. However, the exact mechanisms by which saponins exert their anti-cancer effects are still under investigation [13].

Phenolic Compounds: Phenolic compounds, such as flavonoids and polyphenols, are potent antioxidants found in chickpeas. Antioxidants aid in the elimination of free radicals, which are unstable chemicals that can cause harm. DNA and other cellular structures, potentially leading to cancer development. By reducing oxidative stress and inflammation, phenolic compounds in Chickpeas have the potential to reduce the risk of breast, prostate, and colon cancer, among other cancers [14].

Dietary Fiber

A good source of dietary fiber, which is necessary to preserv e the health of the digestive system, is chickpeas... Soluble Fiber, found in chickpeas, creates a gel-like substance in the digestive tract that has the potential to reduce cholesterol

and assist control of blood sugar levels. Insoluble fiber encourages regular bowel motions and gives faeces more volume, reducing the time that potentially harmful substances stay in contact with the colon. By supporting healthy digestion and elimination, chickpeas may contribute to a reduced risk of colorectal cancer [15].

Protein and Nutrients: Chickpeas are not only rich in Fiber but also provide a great source of plant-based vitamins, and minerals and protein. Protein is important for various physiological processes, such as tissue regeneration and immune system operation. Additionally, chickpeas contain vitamins and minerals like folate, iron, and magnesium, which play vital roles in DNA synthesis, cell division, and overall cellular function. A well-balanced diet that includes chickpeas can help support a healthy immunity, which is importantfor locating and removing aberrant cells, including cancerous ones.

While chickpeas offer numerous potential health benefits, including anti-cancer properties, it's important to consume them as part of a varied and a well-balanced diet high in lean meats, healthy grains, and fruits and vegetables. Furthermore, taking up a healthy way of living that involves consistent exercise, keeping a healthy weight in addition to abstaining from smoking and heavy alcohol use will help lower your risk of developing cancer. The precise processes and ideal chickpea intake amount for the prevention and treatment of cancer are still being investigated [15].

Anti-inflammatory effects

Methanolic and Ethanolic extracts of *Cicer arietinum* seeds which show anti-inflammatory properties, were evaluated at specified doses in rats with paw edema induced by carrageenan and histamine. Results demonstrated significant anti-inflammatory activity at all doses in comparison to reference groups and the typical drug, Indomethacin (orally). The two extracts exhibited dose-dependent effects, with the highest anti-inflammatory activity observed with the extracts at the increased dose. Overall, these findings highlight the potential of *Cicer arietinum* extracts as effective agents in mitigating inflammation [16].

Side Effects and Toxicity

According to studies, administration of *Cicer arietinum* extracts at specific doses, orally in rats gave negative result in mortality. Similarly, in adult female Swiss albino mice, the C6H14 extract of Chickpea was found to be harmless at increased weight doses. Throughout this observation period of 48 hours following administration, no lethality or toxic reactions were observed. These findings suggest a favourable safety profile for *Cicer arietinum* extracts, indicating their potential for further exploration in preclinical and clinical studies without significant acute toxicity concerns [17].

Anti-Microbial Effect

Two antifungal peptides, cicerin and arietin, were isolated from chickpea, with arietin exhibiting greater potency against certain fungal strains. Additionally, an antifungal protein from *Cicer arietinum* demonstrated inhibitory effects against fluconazole-resistant fungal strains. The crude water extract of chickpea displayed significant antifungal activity against *Drechslera tetramera*, while the dichloromethane fraction exhibited a concentration-dependent inhibitory effect. Furthermore, extracts from *Cicer arietinum* showed notable antiviral activity when experimented against (PI-3 & HSV-1) viruses, particularly the seed extract from Aydin 92 variety. Overall, these findings highlight the potential of chickpea-derived compounds in combating fungal and viral infections [17].

Antidiabetic Effect

Research has indicated that *Cicer arietinum* seeds possess properties that can lower postprandial plasma glucose levels, making them potentially beneficial for diabetes treatment. A study evaluated the antihyperglycemic activity of PEECA seeds in alloxan-induced diabetic mice at orally in dosages of 100, 200, and 400 mg/kg... Both acute and subacute studies measured serum glucose levels, with variations in body weight observed throughout the subacute research. Mice with and without diabetes were subjected to oral glucose tolerance tests. The PEECA (400 mg/kg) group experienced the greatest decrease in serum glucose levels, according to the results, at 6 hours in the acute trial and on day 21 in the subacute research. Moreover, PEECA (400 mg/kg) stopped diabetic mice's body weight from dropping and exhibited antihyperglycemic activity comparable to glyburide, a standard drug used in diabetes treatment. Overall, these findings suggest the potential of PEECA as an effective antihyperglycemic agent.

When compared to other typical foods, chickpeas have been demonstrated to have a good effect on blood sugar management. Additionally, several research has suggested that chickpeas have a favorable effect on insulin, even if the results of the meta-analysis were not statistically significant. Actually, the large amounts of dietary fibre and amylose in legumes, together with the low digestion and high resistance of their starch, help to lower blood sugar levels by supplying less glucose to the bloodstream. The effect of chickpeas on blood sugar is particularly supported by their higher dietary fiber and amylose content, and their lower digestible starch content when compared to ordinary wheat starch. Moreover, it has been noted that their high protein and resistant starch content stimulates intestinal hormones like GLP-1, GIP, and PYY. In order to help with post-meal blood glucose concentration, both GLP-1 and GIP promote insulin production.

Numerous studies have demonstrated that ground or pureed chickpeas and whole chickpeas differ in terms of processing efficiency. Based on cell wall integrity, starch bio-accessibility seems to be the cause of this. In actuality, the integrity of the cell wall, which serves as a barrier to control hydration and α-amylase permeability, is mostly responsible for the degree of intracellular starch digestion from chickpeas. Thus, the mechanism behind the decreased post-prandial glucose response of undamaged chickpea cells is highlighted by the fact that their starch granules are generally less susceptible to gelatinization and amylolysis.

Furthermore, studies have compared lentils, navy beans, black beans, and yellow peas in addition to chickpeas. This allowed for the observation of chickpeas' second-meal effect. The only pulse crops that demonstrated a blood glucose-lowering impact in the second meal following ingestion were chickpeas and lentils. This implies that variations in the total intake of other macronutrients do not affect the variance in the second-meal effects of pulses. Put another way, neither the low glycaemic index nor the post-

consumption blood glucose response are responsible for the chickpeas' second-meal impact.

Meals based on chickpeas have been demonstrated in several studies to really lower appetite rates. Hormones linked to appetite, such as ghrelin, leptin, and GLP-1, have been studied in certain investigations; most of the findings have shown a beneficial effect. In particular, it has been observed that gut hormones such PYY might heighten feelings of fullness. Moreover, the glucostatic theory states that it controls food intake by means of the hypothalamus mechanism, which causes satiety in response to elevated blood glucose levels. These results, however, differ between studies, and as a meta-analysis has not been done, more investigation is required in the future.

These findings allow us to consider the inclusion of chickpeas in a diabetic diet. In fact, a lot of recommendations state that patients with diabetes should stay away from processed foods, refined cereals, processed red meats, and beverages with added sugar. Rather, they promote the eating of veggies, yoghurt, and fibre. Refined carbs should be avoided in particular by those who have diabetes in order to improve the nutritional value of food. From this angle, eating whole chickpeas helps to lower the amount of refined carbohydrates consumed while increasing the nutritional value of whole grains. It also provides a means of supplying the circulatory system with less glucose at the same time.

Moreover, the benefits of chickpeas connected to hormones that regulate appetite may help people with diabetes lose weight and control their hunger. This study does, however, have certain shortcomings. It is not possible to ensure consistency in the control group given the nature of the investigation. Achieving homogeneity in nutritional components is particularly difficult when dietary treatments are involved, which could compromise the study's complexity [18-19].

The meta-analysis only included a small number of papers. Quantitative studies, such Egger's or Begg's tests for publication bias, were considered impractical and restricted due to the small sample size [20].

- **Rich in antioxidants:** Chickpeas have a range of antioxidants, like flavonoids, polyphenols, and carotenoids. These Antioxidants assist in neutralizing harmful free radicals in the body that can lead to oxidative stress and provoke inflammatory responses. By mitigating oxidative stress, chickpeas contribute to lowering inflammation levels.
- **Fiber content:** Chickpeas are an exceptional Fiber (both soluble and insoluble) source, present in significant amounts. Soluble fiber creates a gel-like substance in the digestive system that can bind to cholesterol, aiding in its removal from the body. It also acts as a prebiotic, fostering the growth of beneficial gut bacteria. These bacteria produce short-chain fatty acids (SCFAs) like butyrate, which possess anti-inflammatory properties. Insoluble fiber increases stool bulk, promotes regular bowel movements, and reduces inflammation in the intestines.
- **Low Glycaemic Index (GI):** Chickpeas have a relatively low glycaemic index, which means they cause a gradual and minor escalation in blood sugarlevels in comparison to foods with higher GI. It can bring about spikes in sugar levels & insulin, which can promote inflammation. In contrast, low GI foods like chickpeas help keep blood sugar stable and the risk of inflammation is reduced whenrelatedto blood sugar fluctuations.
- **Omega-3 fatty acids:** Although not as abundant as fatty fish, chickpeas contain small amounts of it, particularlyα-linolenic acid (ALA). They are recognized for their anti-inflammatory effects and contribute to regulating immune function and diminishing inflammation throughout the body.
- **Phytochemicals:** Chickpeas has a range of phytochemicals, such as saponins, phytosterols, isoflavones, which are known to have anti-inflammatory properties according to studies. The inhibition in the production of pro-inflammatory cytokines and enzymes is done by these bioactive compounds that help modulate the body's inflammatory response.
- **Gut microbiota regulation:** The Fiber and prebiotics in chickpeas support a healthy gut microbiome. A balanced gut microbiota is essential for the regulation of inflammation as it helps preserve the veracity of the barrier of the gut, modulates immune responses and produces anti-inflammatory metabolites such as SCFAs [21].

Antioxidant Effect

Numerous investigations have looked into the antioxidant qualities of various *Cicer arietinum* components. Compared to the cream variety, sprouts showed greater efficacy against lipid peroxide, hydrogen peroxide radicals, and DPPH radicals. Furthermore, in a cell-free system at pH 7.4, the root extracts of *Cicer arietinum* showed the ability to donate electrons and reduce ferric ion to ferrous... Hydroalcoholic root extract showed greater efficacy in scavenging radicals compared to alcoholic and water extracts. The lectin isolated from *Cicer arietinum* seeds also exhibited antioxidant activity, with higher concentrations showing increased DPPH scavenging activity. Moreover, mature pod wall extracts and its fractions demonstrated notable antioxidant activity using a variety of tests, such as DPPH, nitric oxide, and hydrogen peroxide scavenging. In a rat model, treatment with petroleum ether Hepatoprotective properties of *Cicer arietinum* extract were demonstrated against CCl4-induce liver damage, as evidenced by the maintenance of antioxidant enzyme levels and reduction in lipid peroxidation. Similarly, lower doses of methanol and aqueous extracts showed hepatoprotective effects, while ethanolic seed extract demonstrated hepatoprotection against paracetamol-induced hepatotoxicity in rats. These findings collectively suggest the potential of *Cicer arietinum* as a source of natural antioxidants with hepatoprotective properties.

Recently, because of the growing interest in antioxidants' health advantages, the antioxidant properties of chickpeas have also been investigated. Additionally, research on the amino acid components and antioxidant capacities of antioxidant compounds has also aroused interest. However, to our knowledge, there are few studies on peptide sequences obtained from chickpeas. The content, sequence, and structure of amino acids determine the activity of 3e20 amino acid residues. However, the size, amino acid content, hydrolysate peptide sequence, and ensuing antioxidant activity depend on the kind of protease, quantity of protein, and hydrolysis procedure. According to the majority of

scientists, antioxidant peptides interact with free radicals and either neutralise them or stop them from developing by performing hydrogen/electron donation or metal chelating activities. Antioxidant peptides are predicted to function better when hydrophobic amino acids and one or more residues of Pro, His, Met, Tyr, Cys, Phe, Trp and Met are present. The majority of antioxidant peptides also contain amines. Amino Acids: Including imidazole-containing amino acids (His), aromatic amino acids (Tyr, Trp, and Phe), and nucleophilic sulfur amino acids (Cys and Met).

Nevertheless, the sequences of certain antioxidant peptides lack any of the deprotonated amino acid residues listed above. For instance, it has been suggested that Glu-Leu and Gln-Gly-Ala-Arg play a significant part in scavenging free radicals. To fully understand the structure/activity relationship of antioxidant peptides, more investigation is necessary. Low molecular weight chickpea peptides have been shown to have antioxidant properties. Furthermore, following enzymatic hydrolysis, chickpea protein's antioxidant qualities may be enhanced. Peptide antioxidants assist in lowering oxidative stress and the chance of developing several oxidative stress-related degenerative illnesses, including cancer, heart disease, and inflammatory diseases. Chickpea peptides' antioxidant potential hasn't been thoroughly studied, though.

Studies have demonstrated how peptide structure affects the antioxidant capacity of isolated peptides or peptide hydrolysates. Globulin and albumin are the two primary components of chickpea protein. Storage proteins called globulins are derived from vicilin and legumes. Less than globulin, albumin makes up between 15 and 25 percent of the total protein in cotyledons. However, because albumin includes the majority of enzymes and metabolic proteins, it plays a significant function in genes. For instance, it has been found that the albumin fraction has stronger trypsin inhibitory activity than the globulin fraction. Additionally, the low bioavailability of legume proteins could be partly attributed to albumin [22-25].

Properties

- A variety of bioactive substances with antioxidant qualities can be found in chickpeas. These substances lessen oxidative stress, prevent cell damage, and balance out free radicals in the body. Important antioxidants in chickpeas include polyphenols, flavonoids and vitamin C [25].

Antioxidant mechanism of action:

- **Polyphenols:** Chickpeas are rich in polyphenols that will eliminate free radicals and prevent lipid peroxidation. Polyphenols activate Nrf2 (nuclear factor erythroid 2-related factor 2), a transcriptional regulator of antioxidant defense-related enzymes. Nrf2 contributes to cellular protection superoxide dismutase (SOD), catalase, and glutathione peroxidase are examples of transcriptional regulators of enzymes involved in antioxidant defense against oxidative stress [26].
- **Flavonoids:** Flavonoids such as quercetin and kaempferol contribute to the antioxidant activity of chickpeas. It destroys free radicals, prevents lipid peroxidation and protects cellular components. Flavonoids also regulate antioxidant activity by modulating the MAPK (mitogen-activated protein kinase) pathway. Isoflavones support overall health by reducing inflammation and oxidative stress 12 [26].
- **Vitamin C:** Chickpeas contain vitamin C (ascorbic acid). Vitamin C directly scavenges free radicals and replenishes other antioxidants such as vitamin E. Increases collagen synthesis and supports healthy skin [27].

Other antioxidants

- **Saponins:** Chickpeas contain saponins, which have antioxidant and anti-inflammatory properties. They inhibit lipid peroxidation and prevent oxidative damage [28].
- **Phytate:** Phytate chelates metal ions and reduces their oxidative effects. They also regulate antioxidant enzymes [29].

Chromosomal Localization& Molecular Structure of Main Repetitive Sequences in C.arietinum Genome

From a genomic library of chickpeas (*Cicer arietinum*), three major repetitive DNA sequences were found, and their genomic organization and chromosomal location were examined. The majority of these genus-specific repeating elements are located in the AT-rich pericentric heterochromatin. CaSat1 and CaSat2, two of these families, have repeat lengths of 162-168 bp and 100 bp, respectively, and are organized as satellite DNAs. While CaSat2 makes up a large portion of the pericentric heterochromatin on all chromosomes, CaSat1 is mostly found next to the 18S rDNA clusters on chromosomes A and B. These sequences are highly prevalent in species that are closely related to the genus Cicer. Their structural variety and variations in copy number among the annual species make them useful tools for taxonomic studies [30].

Discussion

The review paper on *Cicer arietinum*, or chickpea, and its immunological benefits emphasises the plant's potential as inefficient food with important health-supporting qualities. Bioactive substances found in abundance in chickpeas, such as flavonoids, saponins, and polyphenols, have potent anti-inflammatory properties through their inhibition of pro-inflammatory cytokines and enzymes. This promotes general immunological health and aids in the management of chronic inflammatory disorders.

Additionally, chickpeas have a complex nutritional profile that includes vital vitamins, minerals, and antioxidants that guard against oxidative stress on immune cells. The high fibre and protein content helps to maintain gut health and stimulates the creation of antibodies, which in turn improves immunological function.

Furthermore, antifungal peptides such as arietin and cicerin are effective against a variety of fungal strains, indicating that chickpeas possess noteworthy antibacterial qualities. Additionally, they exhibit antiviral properties against viruses like Parainfluenza-3 and Herpes simplex type 1.

Studies on safety show that chickpea extracts are safe even in high concentrations, which supports their usage in medicinal and nutritional applications. The current study supports traditional applications of chickpeas as a treatment for conditions like hyperlipidemia, diabetes, and bronchitis by highlighting their anticancer, hypocholesterolemic, antidiabetic, and antioxidant properties.

Conclusion

To sum up, chickpeas, or *Cicer arietinum*, are a helpful addition to the diet due to their strong immune-boosting characteristics. Chickpeas' immunomodulatory properties are attributed to their bioactive components, which include vitamins, minerals, antioxidants, and other phytochemicals. Studies show that chickpeas improve the innate and adaptive immune systems, lessen inflammation, and may even reduce the risk of immunological-related chronic illnesses. Eating chickpeas helps to maintain a healthy gut microbiota, which is essential for a strong immune system. Furthermore, chickpeas' accessible iron, zinc, and selenium support the healthy operation of immune cells. Moreover, the high protein and fiber content of chickpeas contributes to an overall increase in nutritional status, which is closely related to immunological function.

Although the available data is encouraging, more investigation is required to completely understand the molecular mechanisms underlying chickpeas' immunomodulatory effects and to develop consistent guidelines for their use. However, adding chickpeas to a well-balanced diet can be an easy and natural way to boost immunity and support general health.

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