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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(5): 816-823

www.thepharmajournal.com
Received: 03-02-2021
Accepted: 17-03-2021

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A comprehensive review on antinutritional factors of chickpea (*Cicer arietinum* L.)

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DOI: https://doi.org/10.22271/tpi.2021.v10.i5k.6306

Abstract
Chickpeas are a prominent legume mostly in the Mediterranean and Western regions. It is a vital part of the human diet because it is a cost-effective source of calories, proteins, carbohydrates, fibre, B-group vitamins, and minerals. However, a few antinutritional factors found in legumes reduce the bioavailability of some nutrients. Chickpea antinutrients have sparked health concerns as one of the most nutritious components of the human diet. Processing chickpea increases their sensorial, nutritional, and physical qualities while reducing antinutritional factors. Soaking, germination, boiling, extrusion, and microwave cooking are some of the common processing techniques for chickpeas. As a result of this processing, antinutritional factors i.e., tannins, trypsin, phytic acids, hemagglutinins, and other antinutritional factors are decreased. It also discusses the ability for anti-nutritional stimuli to have a negative impact on human health. Additionally, successful and effective strategies for reduction of anti-nutritional factors and maximisation of chickpea nutritional properties are discussed.

Keywords: Chickpea, antinutritional factor, health, processing

Introduction
Chickpea is the world's second most popular cool-season grain legume, grown by small-scale farmers in 59 countries. Chickpea is the most important cool-season food legume grown by resource-poor farmers in semi-arid regions of the world on marginal soils. It is crucial in meeting the protein needs of the human population. Chickpea, or chana (as it is known in Hindi), is an edible seed that is often used to make flour all over the world. In addition, it is served in different ways including roasted as snacks, raw, carbonised, or in broth. Its starch is ideal for fibre sizing, giving a light finish to silk, wool, and cotton cloths, and its acid exudates can be used medicinally or as vinegar. It was used by “hunter-gatherer societies” for feeding and preserving their families before 10,000 B.C., according to archaeological and botanical data (Ladizinsky, 1975) [35]. Chickpeas are native to south-eastern Turkey, and after being domesticated in the Middle East, they spread throughout the Mediterranean, India, and Ethiopia (Ladizinsky, 1975; Maesen, 1987) [35, 74].
This seed comes in two varieties: Kabuli and Desi. In the Mediterranean region, the Kabuli variety is common. The seeds are wide (100–750 mg), round-shaped, with a smooth surface and beige colour in the Americas, and have an energetic value of around 365 kcal/100 g. (Bulbula & Urga, 2018; Rachwa-Rosiak *et al*., 2015; Wang *et al*., 2010) [6, 54, 79]. Desi seeds are small (80–350 mg), angulated, with a rugged and striated surface, a dense and dark-colored coat, and a 327 kcal/100 g energetic value (Rachwa-Rosiak *et al*., 2015; Wang *et al*., 2010) [54, 79]. Chickpeas, which are widely available pulses around the world, have been suggested to help in the management of a variety of chronic disorders, including cardiovascular disease and obesity (Gupta *et al*., 2017; Padhi & Ramdath, 2017) [21, 49].
India is the world's largest producer of chickpeas, accounting for more than 75% of global demand. Around 1950-51 and 2013-14, the country's chickpea production increased from 3.65 to 9.53 million tonnes, a modest increase (Maurya & Kumar, 2018) [42]. The high protein content represents not just on the dietary level, but also on the availability of active peptides; moreover, it contains a variety of metabolites of pharmacological activities. Antioxidant, antihypertensive, hypocholesterolemic, and anticancer properties have been discovered in various chickpea compounds (Faridy *et al*., 2020) [16].

Nutritional composition of chickpea

Dried chickpeas are largely made up of starch (30 to 56% w/w) and protein (19 to 27% w/w), with globulins accounting for the majority of the protein (Hall *et al*., 2017) [22]. Globulins make up 53% to 60% of proteins in dried chickpeas, and albumins (8% to 12%), glutelin's (18% to 24%), and prolamins (3% to 7%) are also present (Hall *et al*., 2017) [22]. The most common globulin proteins in dried chickpeas are legumin, vicilin, and convicilin (Rachwa-Rosiak *et al*., 2015) [54]. Chickpea protein presents a high bioavailability and good digestibility (48–89.01%) (Wang *et al*., 2010) [79]. Legumin is the main storage protein and represents 97% of the total globulins (Serrano-Sandoval *et al*., 2019; Yust *et al*., 2003) [64, 3]. Carbohydrates correspond to the most abundant component of the chickpea (62–70%) and are formed principally by oligosaccharides (α-galactosides), which are divided into two groups: the first constituted by raffinose, stachyose, and verbascose; and the second group constituted by galactosyl-cyclitol like ciceritol; stachyose and ciceritol are the most abundant in chickpea (Alajaji & El-Adawy, 2006; Sánchez-Mata *et al*., 1998) [1, 61].

The other compounds in chickpea correspond to polysaccharides, like starch (35% resistant and 65% available) and dietary fiber (18–22%), of which 4 to 8% is soluble and 10 to 18% is insoluble (Jukanti *et al*., 2012; Pittaway *et al*., 2006; Rachwa-Rosiak *et al*., 2015; Zhang *et al*., 2017) [30, 52, 54, 84]. In contrast, lipids are found in low concentrations in the chickpea (4–10%), however, it possesses unsaturated fatty acids, mainly linoleic (54.7–56.2%), oleic (21.6–22.2%), linolenic (0.5–0.9%), palmitic (18.9–20.4%), and stearic (1.3–1.7%) (Rachwa-Rosiak *et al*., 2015; Sarmento *et al*., 2015; Zia-Ul-Haq *et al*., 2007) [54, 63]. Moreover, chickpea is a relevant source of group B vitamins (riboflavin, thiamine, niacin, and pyridoxine) and microelements like Fe, Zn, Ca, Mg, K, Cu, and P (El-Adawy, 2002; Jukanti *et al*., 2012; Thavarajah, 2012) [12, 30, 72]. Finally, chickpea contains phytochemicals like phenols that represent between 0.72 and 1.81 mg/g of seed (Rachwa-Rosiak *et al*., 2015) [54]. Also, it contains alkaloids, lectins, saponins, phytic acid, and trypsin, chymotrypsin, and α-amylase inhibitors, among others (Chen *et al*., 2014; Domínguez-Arispuro *et al*., 2018; Jukanti *et al*., 2012; Rachwa-Rosiak *et al*., 2015; Thavarajah, 2012) [7, 9, 30, 54, 72]. Dry chickpeas also contain minerals including potassium (9.94 to 12.64 mg/g), phosphorus (3.94 to 4.52 mg/g), and calcium (0.82 to 2.72 mg/g) and have a limited amount of oil (2% to 7% w/w) (Jukanti *et al*., 2012) [30].

Antinutritional factors

Anti-nutritional factors (ANFs) such as tannins, phytic acid, protease inhibitors, and oligosaccharides hinder the consumption of pulse foods such as chickpea. Antinutritional factors are compounds or substances produced by normal species metabolism in natural foods that decrease nutrient intake, digestion, absorption, and consumption, as well as cause a variety of other negative effects (R. Kumar, 1992) [33]. If eaten fresh, these ANFs can cause adverse physiological effects in humans (Hotz & Gibson, 2007; Salunkhe & Kadam, 1989) [27, 60]. Antinutrients are usually synthesised by plants as a protection against predators and/or as a way of surviving in harsh growing environments. Protease inhibitors found in seeds block the actions of trypsin, pepsin, and other proteases in the intestine, blocking protein digestion and absorption. Tannins inhibit digestive enzymes, making most nutrients, including proteins and carbohydrates, less digestible. Minerals such as calcium, magnesium, iron, copper, and zinc have a high binding affinity for phytic acid, which decreases their bioavailability. Agronomic traits like ANF boost seed production while lowering market value and customer desire. It is strongly recommended that raw grains be processed before consumption.

Tannins

Tannins are versatile, astringent, and water-soluble phenolic compounds that are thought to reduce food bioavailability in the gut. Tannins also have antinutritional effects, lower digestibility, mutagenic and carcinogenic effects, inducer, hepatotoxic activity, and are co-promoters of a variety of diseases (K. Sharma *et al*., 2019) [66]. Tannin is an antinutritive compound found in a variety of plants, including legumes. Tannin is an antinutritive component used in almost all legumes. Bitter polyphenolic compounds bind to proteins and other organic compounds including alkaloids and amino acids to form precipitates, which distinguishes it from other plants (Redden *et al*., 2005) [56].

Tannins are polyphenolic compounds that contain sufficiently hydroxyl and other groups to form a solid complex with macromolecules. These tannins are present in legumes in a wide range of molecular masses, from 500 to 3000, and have exceptional heat stability. The accumulation of tannins in legumes leaves protein unavailable and decreases protein digestibility in both humans and poultry. The enzymes amylase, lipase, trypsin, and chymotrypsin are all inhibited by tannins, which are commonly present in fruit. Protein quality suffers as a result, and iron absorption is impaired (D'Mello, 2000) [8]. Tannin content can be reduced by some domestic processing such as roasting (62%) and pressure cooking (more than 2-fold), whereas open pan boiling and microwave heating increase total tannins quantity up to more than 3 fold (Hithamani & Srinivasan, 2014) [25].

Saponin

Saponins are a category of steroidal glycosides that produce foam in a number of plants, including oilseeds such as chickpea, lentil, pea, kidney bean, alfalfa, sunflower, groundnut, and soybean (Jenkins & Atwal, 1994; Price *et al*., 1987) [29, 53]. They decrease the uptake of certain nutrients in the intestine, such as glucose and cholesterol, by an intralumenal physicochemical interaction. Hypocholesterolemic effects have been reported as a result (Esenwah & Ikenebomeh, 2008) [14]. Meanwhile, when mixed with white clover and alfalfa, they cause bloat, haemolysis, and inhibit microbial fermentation and synthesis in the rumen (Lu & Jorgensen, 1987) [40]. It has a host of biochemical effects due to structural differences in their sapogenin fractions.

Saponins cause toxicity by lowering nutritional supply and decreasing digestive enzyme production, resulting in body growth inhibition in animals (Francis *et al*., 2002) [18]. Saponins (1–5.6 g/100 g) and tannins (0.68 mg/g) of seed dry weight are abundant in Chickpeas. βg saponin (a 2,3-dihydro-2,5-dihydroxy-6-methyl-4H-pyran-4-one type) is the most abundant saponin in chickpea, with smaller amounts of Bb and Be saponins (Kerem *et al*., 2005) [31]. As tannin content, "C- and O-glycosidic derivatives of gallic acid (3,4,5-trihydroxybenzoic acid) has been found in the chickpeas. Therefore, processing of chickpeas should be done before consumption to neutralize these antinutritional content.

Phytate

Phytate can be found in small amounts in cereal grains, legume seeds, nuts, tubers, and vegetables. Antinutritional components in legumes reduce the absorption of dietary minerals like copper, iron, and calcium in the human intestine. Phytate has been shown to absorb Fe, Ca, and Zn in humans (Sandberg, 2002) [62]. Since it absorbs Fe and Zn, Lönnerdal *et al*., (1988) [39] classified inositol pentaphosphate as a mineral inhibitor. The most severe danger to human health and diet is phytic acid, which is the most antinutritional of all antinutritional factors (V. Kumar *et al*., 2010) [34]. In legumes and other grain crop, phytic acid (myoinositol, 1, 2, 3, 4, 5, 6 hexakisdihydrogen phosphate) and phytates are abundant (Reddy *et al*., 1982) [57]. Phytic acid is formed during the processing of legume seeds and has a negative charge that allows it to bind to minerals including iron, zinc, calcium, and magnesium, resulting in an insoluble complex (Rimbach *et al*., 1994) [58]. It also forms complexes with proteins and starch (Oatway *et al*., 2001) [47].

Enzyme inhibitor

Amylase inhibitors and proteases including trypsin and chymotrypsin can be present in legume plants. There is approximately 0.2-2 percent water-soluble non-glucose proteinase inhibitor in the gross soluble protein of legume seeds (Sgarbieri & Whitaker, 1982) [65]. Protein absorption is hampered by these compounds. Eating raw or poorly cooked legumes can disrupt digestive functions and cause excessive gas or diarrhoea because these compounds decompose when exposed to sunlight. Weder & Link, (1993) [82] found that human pancreatic juice contains 10-20% of total active trypsin, which has the potential to bind proteases that inhibit digestion in the small intestine, causing them to be excreted from the body. Trypsin antagonists have insecticide-like effects (Hilder *et al*., 1990) [24]. Amylase inhibitors are used to control diabetes because they slow metabolism and therefore affect blood sugar and insulin levels (Lajolo *et al*., 1991) [36].

Protease inhibitor

Several studies on the occurrence, physiological activity, mechanism of action, and characterization of protease inhibitors derived from leguminous plants have been published in recent years. Protease inhibitors such as trypsin and chymotrypsin are well-known and can be present in a variety of Chickpeas (Wati *et al*., 2010) [80]. The "Desi" and "Kabuli" varieties of Chickpeas have higher levels of trypsin and chymotrypsin inhibitors than other CP varieties (U. Singh & Jambunathan, 1981) [69]. Protease inhibitors are known for their ability to block proteolytic enzymes, which can lead to protein digestion problems. Protease inhibitors have been shown to have negative health effects in animal models. Protease inhibitors have been linked to slowed body development and increased pancreatic hypertrophy (Hathcock, 1991) [23]. Instead of decreased protein digestibility in the intestine, these complications are caused by a negative feedback mechanism (Fushiki & Iwai, 1989) [20].

Owing to the presence of protease inhibitors, trypsin inactivation and scarcity can occur in the small intestine. As a result of the activation of the intestinal mucosa, cholecystokinin hormone is secreted, causing the pancreas to synthesise more trypsin. Since trypsin is rich in sulphur containing amino acids, large amounts of sulphur containing amino acids are needed for further trypsin synthesis. As a result, other body tissue metabolisms involving sulphur-containing amino acids are impaired, which can lead to weight loss. Simultaneously, the tension on the pancreas caused by this peculiar pattern contributes to abnormal modifications in pancreatic acinar cells that resemble hypertrophy and hyperplasia, which can contribute to the development of adenomatous nodules (Roebuck, 1987) [59].

The removal or inactivation of PIs, which improves the nutritional content of Chickpeas, is needed to combat pancreatic hypertrophy and body loss. It is well known that legume PIs are heat labile, with trypsin inhibitors being more susceptible to heat than chymotrypsin inhibitors (Liener, 1976) [38]. Soaking and heat therapies have been found to improve the nutritional value of many legumes, including Chickpeas, in order to accomplish this goal. Soaking accompanied by dry heat treatment results in partial or complete solubilization of trypsin inhibitor, resulting in trypsin inhibitor replacement with a discarded soaking solution (Frias *et al*., 2000) [19]. Heat therapy, on the other hand, often renders the trypsin inhibitor and volatile compounds in CP seeds inactive. Moist heat at 121°C for 30 minutes or boiling at 100°C inhibits CP trypsin inhibitors, but not dry heat (Concepción Vidal-Valverde *et al*., 1992) [74].

Many other processing processes, such as fermentation, autoclaving, and germination, have also been shown to greatly reduce PI activities in Chickpeas. In cultivar ICCV10, water soaking treatments resulted in a substantial decrease (approx. 14%) in trypsin inhibitor content, while cooking for 90 seconds totally inactivated the trypsin inhibitor. In the JG74 cultivar, however, 72 hours of germination resulted in a maximum reduction of trypsin inhibitor of 83.6 percent (P. K. Singh *et al*., 2015) [68]. Based on current understanding, it is possible to infer that a combination of moist heat treatment and autoclaving may be used as pivotal instruments to more effectively minimise the volume of PIs.

Amylase inhibitors

Since their discovery in many legumes, including Chickpeas, biochemists and nutritionists have been paying close attention to pancreatic alpha amylase inhibitors. However, as opposed to other widely eaten legumes, Chickpeas had lower -amylase inhibitor activity (Jaffe, 1973) [28]. When activity in pancreatic and human salivary amylases was tested, Desi varieties of Chickpeas were found to have higher amylase inhibitory action than Kabuli varieties (U. Singh *et al*., 1982) [70]. The amount of amylase inhibitors in CP cultivars was found to vary significantly.

Amylase inhibitors were found to range in size from 11.6 to 81.4 g/unit in various varieties, with pancreatic amylase being more susceptible to inhibition than salivary amylase (Veerappa H Mulimani *et al*., 1994) [44, 45]. The - amylase inhibitor may have a negative impact on mammalian diet. Depending on pH, ionic strength, temperature, binding time, and inhibitor concentration, AIs inactivate amylase by forming an inhibitory complex with the enzyme. As a result, AIs inhibit starch digestion and reduce body growth (Obiro *et al*., 2008) [48]. Heat-labile existence of CP-AIs is well-known, as it is for other proteinaceous ANCs. After 10 minutes of boiling the Chickpeas extract, the operation of CP-AIs was completely lost (V H Mulimani & Rudrappa, 1994) [44, 45]. Since CP are typically eaten after being boiled, functional effects on starch digestibility do not exist until the seeds are consumed fresh.

Phytolectins (Hemagglutinin)

Many leguminous foods contain phytolectins, a structurally complex class of sugar-binding glycoproteins. Lectins from legumes have been shown to interact with glycoprotein on the surface of erythrocytes, inducing hemagglutination of all human blood types (A, B, AB, and O) and, in extreme cases, death. Lectins are thought to have evolved as storage proteins in seeds and to play a defensive role in plants, but their biological functions are unknown. Phytolectins hemagglutination behaviour is determined by a number of variables, including its molecular properties, cell surface properties, cell metabolomics, cultivar, growing location, and selection methods (Mekbungwan, 2007; Pedroche *et al*., 2005) [43, 51]. Previously, we focused on the purification and characterization of legume lectins from Chickpeas (Esteban *et al*., 2002) [15]. Pa2, which is made up of two 23-kDa subunits, is one of the most abundant lectins present in Chickpeas (Vioque *et al*., 1998) [78]. Chickpeas lectins have a much lower hemagglutination activity than lentils and peas lectins.

Recently, the structure of a lectin from the plant albumin family was determined, and it was found to have hemagglutination activity in rabbit RBCs (Sharma *et al*., 2015) [67]. Aside from hemagglutination, lectins induce a reduction in villi surface area by protecting brush boundary membranes in the intestine, which reduces the gastric secretion needed for nutrient absorption. Continuous secretion of gastric enzymes can trigger adverse health effects such as gastric ulcers, which could lead to a pathological disorder in the intestine. Feeding raw pulse seeds to livestock reduces body development and efficiency, most likely due to the lectin's preference for intestinal mucosal cells, causing blood glucose homeostasis to be disrupted (Bardocz *et al*., 1996). Since eating unprocessed or less refined pulses can cause food poisoning, optimization of processing methods should be considered to reduce the risk factor. The lectins are very heat sensitive, and after moist heat treatments at 100 °C, they can be fully killed (Liener, 1979) [37]. Also, after 18 hours of dry heat treatment at 100 °C, some activity persists, indicating that dry heat cannot totally kill lectins. As a result, it is critical to stress that these legumes, like Chickpeas, should be given a moist heat treatment prior to consumption.

Oligosaccharides

Stachyose, raffinose, and verbascose are oligosaccharides from the raffinose sugar family that cause flatulence in humans. In Chickpeas, the two sugars stachyose and raffinose together make up approximately 37% of the total soluble sugars (U. Singh & Jambunathan, 1981) [69]. Due to the lack of digestive enzymes for these carbohydrates in the human gut, these sugars are decomposed by bacterial fermentation, resulting in the development of significant quantities of carbon dioxide, hydrogen, and methane gas. Despite their well-documented health benefits, pulse use has historically been poor in Western countries. This is partly attributed to the misconception that pulses induce flatulence and gastrointestinal upset, as well as stomach pain and bowel movement symptoms. In a randomized, double-blind, placebo-controlled cross-over study, 21 healthy males aged 19–40 were given 100 g dry weight Kabuli chickpeas, green Laird lentils, and green peas for 28 days and were compared to a potato control for perceived flatulence, abdominal comfort, bowel movements, and overall gastrointestinal function. There were small differences in the frequency and/or severity of flatulence and abdominal pain during the treatment time, but no improvements in overall gastrointestinal function. As a result, when oligosaccharide-rich pulses are used in the diet of healthy adult males, they are well tolerated with minimal increases in flatulence and overall gastrointestinal efficiency (Veenstra *et al*., 2010) [75]. However, consuming a lot of raw chickpeas can cause stomach pains and gastrointestinal problems.

Elimination methods

Soaking, autoclaving, heating, germination, microwave cooking, extrusion, fermentation, irradiation, and enzymatic treatments are both common chemical and physical methods for removing or reducing antinutritional causes. Ramírez-Cárdenasi *et al*., (2008) [55] found that soaking and cooking procedures reduced the tannin content of beans. When beans are cooked after soaking, the tannin content is lower than when they are cooked without soaking (Nergiz & Gökgöz, 2007) [46]. If the soaked water is discarded before cooking, the tannin content may be completely reduced. Heat-sensitive anti-nutritive elements including tannins, phytic acid, volatile compounds, trypsin, and chymotrypsin inhibitor are inactivated by cooking. Decortication, germination, autoclaving, extrusion, immersion, microwave cooking, and fermentation are some of the most common therapies used to eliminate phytate and other antinutritional factors in foods. Because of this property, phytate is used as a chelating agent to decrease the bioavailability of divalent cations (Weaver & Kannan, 2002) [81].

Appertization (Tabekhia & Luh, 1980) [71] is one of the thermal and biological therapies that can reduce phytate content. Antinutritional factors such as protease, tannins, trypsin inhibitors, and phytates, which restrict nutrient absorption in legume seeds, are partially or completely destroyed by extrusion cooking (Alonso *et al*., 2001) [3]. Extrusion cooking is a method of cooking that decreases antinutritional factors and thereby improves nutritional consistency. This procedure is less expensive than other heat treatments like baking and autoclaving, and it also provides a superior cure thanks to better process management and energy efficiency (El-Hady & Habiba, 2003) [13]. However, germination and fermentation are thought to be the most efficient therapies for reducing the antinutritional factor (Honke *et al*., 1998; Marfo *et al*., 1990) [26, 41], but their use is restricted due to the added workload. Longer soaking before germination and fermentation could result in phytate content losses (Duhan *et al*., 2002) [10]. Germination conditions and results, on the other hand, can differ depending on the plant type, cultivar, or seed variety (Paucar-Menacho *et al*., 2010) [50]. Soaking, dehulling, frying, and fermentation with Rhizopus oligosporus decrease the impact of anti-nutrients on oligosaccharides, trypsin inhibitor, phytic acid, and tannins in soybean, cowpea, and ground bean (Egounlety & Aworh, 2003) [11].

The oligosaccharides, trypsin inhibitors, tannins, and phytic acids are altered after pre-treatments (soaking, dehulling, shaving, and cooking) and fermentation with Rhizopus oligosporus. Pre-treatment resulted in a 50% loss of raffinose and a 55-60% loss of sucrose and stachyose. Stachyose was reduced by 83.9 percent in soybean, 91.5 percent in cowpea, and 85.5 percent in ground bean after fermentation, while raffinose remained stable. The tannin content of the seed coat was extracted during dehulling (Concepcion Vidal-Valverde *et al*., 1994) [76]. The trypsin inhibitor activity, phytic acid, catechin content, and tannin content of lentils are all affected by soaking in distilled water, citric acid, or sodium bicarbonate solutions. Soaking had little effect on the trypsin inhibitor, but it did lower the level of phytic acid and improved the tannin and catechin content. Cooking pre-soaked seeds deactivated trypsin inhibitors, lowered phytic acid, and improved tannin and catechin content (Vagadia *et al*., 2017) [73].

Extrusion and conventional processing techniques reduce the content of faba and kidney beans by significantly reducing antinutrients and *in vitro* protein and starch digestibility (Alonso *et al*., 2000) [2]. In both faba and kidney beans, dehulling raises protein content thereby lowering concentrated tannins and polyphenol levels. Extrusion reduces the activity of trypsin, chymotrypsin, a-amylose, and hemagglutinin thus leaving the protein content unchanged. Furthermore, the protein and starch digestibility get improved by the thermal treatments. Traditional processing methods for improving the nutritional quality of chickpeas in terms of crude protein, crude fat, crude fibre, moisture content, and total ash may be beneficial. Germination and fermentation, in particular, tend to be the best options for chickpea preparation (Bulbula & Urga, 2018) [6].

Germination makes chickpea an outstanding source of bioactive compounds as it increases phenolic compound amounts, antioxidant activity, and GABA content (6.42 to 245.76 352 mg/100 g) (Ferreira *et al*., 2019) [17]. In addition to improving the textural properties of chickpeas, high pressure treatment reduced tannin content by about 26.7 percent and phytic acid content by about 16.7% from initial levels. Though both pre-soaked high pressure treated samples and pre-soaked high pressure treated samples improves consistency over overnight soaking, pre-soaked high pressure treated samples shows better effect (Alsalman & Ramaswamy, 2020) [4]. Gemination of chickpea for 48 hours and blue lighting are most effective in reducing phytic acid content to a maximum level. The same level of germination are also enough to minimise the methanol extractable polyphenol to its lowest level, despite the fact that these forms of polyphenol are more susceptible to red illumination (Khattak *et al*., 2007) [32].

Conclusion

Chickpeas are a popular legume all over the world, particularly in the Middle East and Western regions. This research looks into how various processing processes affect the nutritional quality and anti-nutritional factors of legumes. As one of the most basic and essential nutritional elements in the human diet, chickpea toxicity and allergens have caused health issues. This is due to the fact that it is a low-cost source of calories, nutrients, carbs, fibre, B-group vitamins, and minerals. They are rich in bio-active and functional compounds including phenolic and flavonoid content, which have important health benefits, in addition to these nutritious data. However, a few antinutrients found in chickpeas prevent the availability of such bioactive nutrients. Processing legumes increases their sensory appeal, nutritious value, and physical qualities while reducing antinutritional factors. Soaking, boiling, germination, extrusion, autoclaving, and microwave cooking are all popular processing methods for chickpeas before consumption. Antinutritional factors such as tannins, trypsin enzyme activity, phytic acids, hemagglutinins, and other antinutritional factors are reduced during this processing. Chickpea consumption, on the other hand, raises allergic reactions in individuals who are allergic to many allergens. Researchers have concentrated on the health effects of chickpea consumption, such as phytic acid, lectins, dietary fibres, saponins, dietary fibres, resistant starch, oligosaccharides, unsaturated fatty acids, amylase inhibitors, and certain bioactive compounds like carotenoids and isoflavones, which have demonstrated the ability to mitigate clinical complications associated with a number of human diseases. Finally, this will assist the researcher in determining the properties of chickpea in different ways, as well as potential developments in chickpea products.

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