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REVIEW ARTICLE

Nutritional characteristics and value-added products of Chickpea (*Cicer arietinum*) - a review

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ABSTRACT

Chickpea is an important leguminous crop in terms of both production and consumption. It has been widely consumed since centuries for its protein-rich seeds. It enriches the staple diet and provides balanced protein when consumed along with cereals. This review is mainly focused on the nutritional composition of chickpea and its application in the food systems. Chickpea consists of about 18-22% protein content and is a sustainable source of protein, mainly for the vegetarian population. Chickpea has been utilized in the preparation of various traditional food products as the base ingredient or as an admixture. Chickpea in the form of 'dhal' and 'besan' accounts for maximum consumption. Besan is used to form dough or batter for the preparation of various food products like boondi, soft chapatti or chilla, pokaras, bhujia and sweets. Besides this, it is used in the preparation of several value-added products like bakery products, snacks, extruded products, weaning foods, roasted chickpea, roasted chickpea flour, and plant-based beverages. Consumption of chickpea is associated with several health benefits like anti-diabetic, anti-inflammatory, hypo-cholesterolemic and prevention of cardiovascular diseases.

Keywords: Bengal gram, chickpea, cicer arietinum, value added product, nutritional composition

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INTRODUCTION

Recently, there is an increase in the demand for healthy and nutritious food with people being more focused on healthy lifestyle and balanced diet, because of the increase in health problems and chronic diseases (Gull et al., 2015, 2018; Haq et al., 2016; Haq and Prasad, 2017). With a change in consumer demand, research and industrial projects have also increased their investment in nutrition and functional foods, following the traditional approaches. Dietary needs of consumer and overall health status are the prime focus. Other than fulfilling the nutritional requirements, efforts are also made to combat several health issues and management of chronic diseases. There is a change in eating habits and consumer demand with time, for instance, the more population has started to follow the vegan diet as a recent trend. So, there is a requirement of plant-based protein sources to fulfil the nutritional requirement of protein and to deal with the issues of food safety. Research nowadays is more directed towards sustainable plant-based nutrient sources (Siddiqui et al., 2018). Pulses are the major source of protein for the vegetarian population. Chickpea (*Cicer arietinum* L) is the widely cultivated pulse crop in the world. It is a rich source of protein and dietary fibre along with other macro and micro-nutrients and has several health benefits (Ghadge et al., 2008).

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Pulses are widely consumed throughout the world, in combination with cereals as a staple diet. Food and Agriculture Organisation, jointly along with United Nations has declared the year 2016 as the "International Year of pulses" and also reported the pulses as "Nutritional seeds for sustainable future". Chickpea is a most widely consumed leguminous crop and ranks second in the world in terms of cultivation. Largest chickpea producing country in the world is India, with a share of about 66.19% in total chickpea production in the world. Table 1 indicates the production of top 10 chickpea producing countries in the world (FAOSTAT, 2019).

Chickpea also known as Bengal gram is drought resistant, cool-season crop, classified under the family Fabaceae. Chickpea seeds are classified into two types based on their size and colour- Desi (Microsperma) and Kabuli (Macrosperma). Desi chickpea is small in size and the dark brown seed coat, whereas Kabuli is larger and have a beige coloured seed coat (Cubero, 1987).

Table 1. Major chickpea producing countries in the World.

Country	Production (Million tonnes)
India	6.64358
Turkey	0.568593
Pakistan	0.541181
Australia	0.44537
Russian Federation	0.399791
Myanmar	0.319333
Ethiopia	0.270707
Iran	0.246848
Mexico	0.182734
Canada	0.129548

Nutritional Composition

Consumption of adequate nutritional food is critical in maintaining good health, proper growth and development of the body. Chickpea being an excellent source of nutrients (both macro and micronutrients), especially the protein content, has several health benefits such as anti-diabetic, hypocholesterolemic, anti-cancerous and anti-inflammatory activity (Yust et al., 2012; Milán-Noris et al., 2018). Table 2 represents the nutritional composition of chickpea.

Table 2. Composition of chickpea (per 100gm)

Component	Chickpea (whole)	Reference
Moisture (g)	6.64-10.42	(Kaur and Singh, 2005; Longvah et al., 2017; Ravi and Harte, 2009)
Protein (g)	17.1-22.6	(Haytowitz et al., 2011; Hulse, 1994; Kaur and Singh, 2005)
Ash (g)	2.23-4.2	(Jambunathan and Singh, 1980; Kaur and Singh, 2005; Ravi and Harte, 2009)
Fat (g)	2.7-7.42	(Alajaji and El-Adawy, 2006; Haytowitz et al., 2011; Kaur and Singh, 2005)
Fiber (Total) (g)	7.8-12.7	(Kaur and Singh, 2005)
Carbohydrate (g)	50.64-66.9	(Haytowitz et al., 2011; Oomah et al., 2003)

Chickpea is an affordable source of protein for low-income families. The protein content of chickpea varies from 18 - 22%. Protein quality of chickpea is better as compared to other pulses (Sahu et al., 2014). It has a higher biological value, protein digestibility, and protein efficiency ratio (Liu et al., 2008). It is deficient in sulphur-containing amino acids but is a rich source of lysine and arginine. Pulses when consumed along with cereals, act as complementary protein and maintains the amino acid balance (Livingstone et al., 1993; Rachwa-Rosiak et al., 2015; Kaur and Prasad, 2021b). The major portion of chickpea seed is contributed by carbohydrates. It contains both available and unavailable carbohydrates (Mudryj et al., 2014). Chickpea seeds have anti-diabetic activity due to their low glycaemic index, which is due to the high amylose content and resistant starch (Foster-Powell et al., 2002; Fredriksson et al., 2000). α- galactosides are the major oligosaccharides present in chickpea that are responsible for causing the flatulence. Due to the absence of the enzyme α- galactosidase in the human body, oligosaccharides are not digested, and they undergo microbial fermentation in the large intestine and leads to the formation of short-chain fatty acids (Christl et al., 1992; Han and Baik, 2006).

Ciceritol is the major oligosaccharide present in chickpea. The fat content of chickpea seeds ranges from 3-10% (Ghavidel and Prakash, 2006). Legumes like lentil, kidney bean, moong bean and pigeon pea have lesser fat content as compared to chickpea (Bhatia et al., 2009). Fatty acid composition of chickpea seeds varies with cultivar and environmental factors (Gül et al., 2008). Chickpea mainly consists of unsaturated fatty acids and linoleic acid the dominant fatty acid followed by oleic acid (Wang and Daun, 2004). Hypo-cholesterolemic activity of chickpea is associated with its fatty acid composition. Chickpea is a good source of several micronutrients, mainly iron, calcium, zinc and magnesium. Consumption of 100gm of chickpea can meet the daily requirement of iron and zinc (WHO, 2004). It also consists of substantial amounts of tocopherol (vitamin E), and vitamin B complex (Ciftci et al., 2010; Wang and Daun, 2004). Bioactive components of chickpea are mainly responsible for its several health benefits. Isoflavones are the major phenolic compounds present in chickpea. Seed coat of chickpea is the major reserve for flavonoids and phenolic acids. Canthaxanthin is the bioactive compound responsible for anti- cancerous activity. Beta-carotene, xanthophyll and cryptoxanthin are the major carotenoids present in chickpea seeds. Carotenoids promote the absorption of iron, thus increasing the bioavailability of iron in human body (Palozza et al., 1998; Segev et al., 2010; Welch, 2002).

Application of Chickpea in Food Systems

Chickpea, in comparison to other pulses, is consumed in several forms in a wide range of products (Joshi et al., 2001). The utilisation of chickpea in preparation of various traditional foods products has been performed since ancient times. It is used as a base ingredient or as an admixture in preparation of various meals. Chickpea harvested in the green stage that is 10-15 days before achieving maturity is consumed as a vegetable with meals. It can be consumed as whole grain, after subjecting to some processing methods such as soaked, boiled, germinated or roasted chickpea. Chickpea split, commonly known as ‘chana dhal’ is the major form of consuming chickpea (Jambunathan and Singh, 1989). ‘Besan’ is the flour prepared from chickpea dhal and is used for preparing various snack foods, sweets, bakery products etc., either as the main ingredient or in combination with other cereal and pulse flours (Wood and Malcolmson, 2011). It has already been reported in studies that consumption of chickpea has been associated with several physiological benefits and reduction in the risk of chronic health ailments (Duranti, 2006; Murty et al., 2010; Wood and Grusak, 2007). In addition to its high protein content and dietary fibre, chickpea is a good source of bioactive components, antioxidant properties and low glycaemic index, thus it is also considered as a functional food (Crujeiras et al., 2007; Fredriksson et al., 2000). The utilisation of chickpea in different forms in the food system is discussed.

Whole grain

Fresh green chickpea is commonly consumed as a vegetable, and grains are harvested 10-15 days before the attainment of maturity. Completely matured and ripened grains are harvested for storage purpose and further processing. Dried chickpea seeds are usually subjected to some technological processes before consumption. Soaking is the preliminary step in most of the processing techniques like germination, roasting and fermentation. It allows to water absorption by the cells and increase in the moisture content of grains, thus reducing the cooking time (Prasad et al., 2010; Kumar et al., 2018). Soaked and boiled chickpea are consumed as it is or in the form of salad. Soaking is also helpful in leaching out of anti-nutritional factors. It also improves the heat transfer phenomenon during cooking thus reducing the cooking time (Wang et al., 2019). Weight of chickpea seeds is found to increase by 1.76 to 2.12 times during soaking at 10 to 60°C (Kaur and Prasad, 2021a). It has also been observed that the soaking temperature of 30°C is suitable for carrying out the germination of chickpea seeds (Unpublished research data). Figure 1. shows the different forms in which chickpea is commonly consumed. Soaked Kabuli chickpea is ground to form a paste in which oil and spices are added to get the 'hummus'. Hummus is used as a spread or dip (Wallace et al., 2016).

Figure 1. Uses of chickpea in different forms

Chickpea sprouts are formed by carrying out the germination of soaked chickpea seeds. It is commonly consumed as chickpea salad, for improved nutritional quality and palatability. Germination improves the protein digestibility, reduces the anti-nutritional

components and also increases the bioavailability of minerals (El-Adawy, 2002). There is a reduction in the oligosaccharides mainly stachyose and raffinose, due to the enzymatic action during the germination process (Xu et al., 2019).

Roasted chickpea, either hulled or dehulled is widely consumed as a snack food item in India (Sahu et al., 2014). To improve palatability, roasted chickpea is coated with jaggery or some spices. Roasting is a thermal treatment that leads to the improvement in texture, colour and flavour (Raza et al., 2019; Kumar and Prasad, 2017; Kumar and Prasad, 2018; Kumar et al., 2016; Sharma and Prasad, 2016; Sharma et al., 2015). Figure 2. Describes the roasting process and changes occurring during the process (Jha, 2005; Köksel et al., 1998). Development of colour and flavour during the roasting process is mainly due to the conversion of carbohydrates into dextrins that further react with the amino acids (Gahlawat and Sehgal, 1992; Mariod et al., 2012).

Chickpea splits are formed by subjecting the desi chickpea to the removal of seed coat and then splitting the cotyledon into two halves. It is commonly known as 'chana dhal' in India. The major portion of chickpea consumption is in the form of 'dhal' or 'split' (Mangaraj et al., 2005). It is generally cooked in water with added spices and served along with rice or chapatti. Thus, the combination of cereal and pulse provides a balanced amino acid composition (Young and Pellett, 1994).

Chickpea flour

'Besan' is the flour prepared from dehulled desi chickpea. It is utilized as a base material in the preparation of food products. Blend of besan along with wheat flour is often used in making chapatti (Malhotra et al., 1987). In India, it is utilised in the preparation of several traditional food items such as bhujia, dhokla, pakoras, boondi and sweets are prepared from besan, by converting it into the batter, paste or dough (Wood and Malcolmson, 2011).

Roasted Chickpea flour (Sattu)

Sattu is a traditional Indian food product, obtained mainly from roasted Bengal gram and is commonly known as 'Chane ka Sattu'. It can also be prepared using combination of roasted cereal and pulse flours that will increase its nutritional profile. Sattu is a popular summer drink and consumed especially in rural India (Kaur and Prasad, 2021b). Fortification of sattu with vitamins and minerals as per the daily recommended intake may be helpful in enhancement of its nutritional profile and can be beneficial for the problem of under nutrition (Prasad, 2009). Supplementation of roasted Bengal gram flour with cereal flour helps in complementing the amino acid composition and improves the protein quality, and its further fortification with vitamins and minerals may be beneficial in obtaining a balanced diet. This can be helpful for providing complete nutrition to the people, those who have problem in chewing food and for the infants that are in their translational phase as they have risk of protein energy malnutrition. Due to its low glycemic index, it is beneficial for diabetic patients.

Beetroot enriched sattu beverage was developed to increase the nutritional composition of sattu. It was observed that incorporation of 10% beetroot juice was acceptable as per the sensory profiling and rheological properties (Sharma et al., 2019).

Value-added products and development using chickpea

Chickpea is a potential functional food due to its high protein content, dietary fibre and various physiological effects that are beneficial for health and reduce the chances of chronic disorders. It is used in a variety of ways to get value-added products, either by substituting any other grain or as the base ingredient. With an increase in global food safety issues and the requirement

of sustainable protein source, chickpea can prove to be a beneficial source of plant-based protein. Various studies have already been carried out to incorporate chickpea flour in bakery products, extruded products and plant-based beverages. To make a protein rich fruit leather roasted Bengal gram flour was used in contrast with the skimmed milk powder as a potential source of protein (Prasad, 2009).

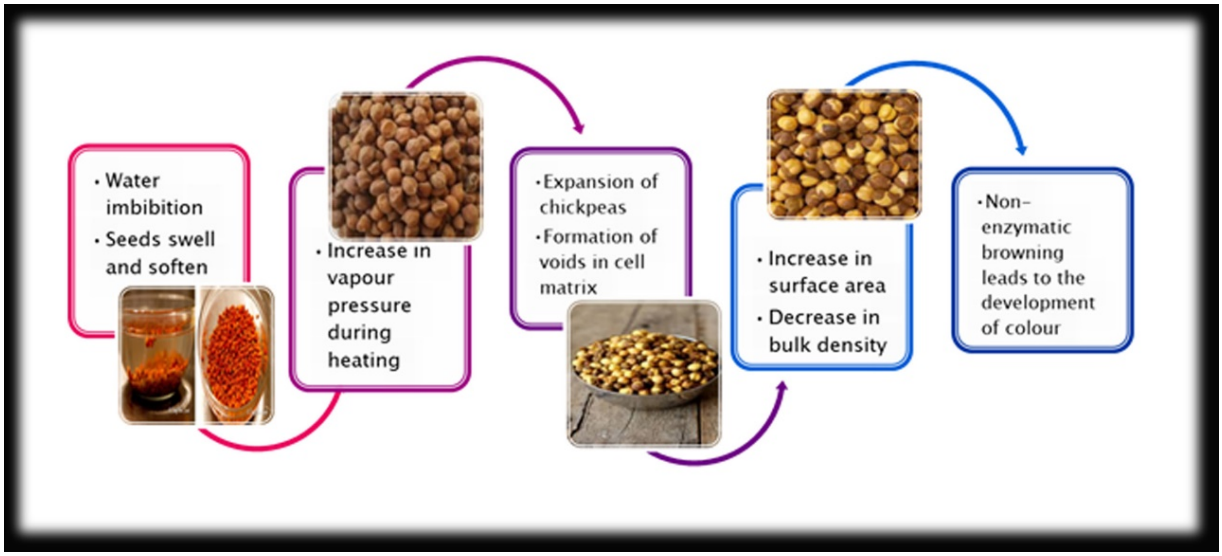

Figure 2. Changes in chickpea during roasting process

Inclusion of chickpea flour in the formulation of bread has been studied to improve the nutritional quality of bread. Gluten-free bread prepared using chickpea flour was reported to have high specific volume and it is beneficial for patients suffering from celiac disease (Miñarro et al., 2012). The utilisation of malted chickpea flour for partial replacement of wheat flour in bread resulted in higher protein digestibility (Guardado-Félix et al., 2020). Substitution of chickpea flour in white bread affected the colour parameters (Yamsaengsung et al., 2010). Chickpea seeds are often fermented and used as a leavening agent in the preparation of traditional bread in Mediterranean countries (Hatzikamari et al., 2007).

In today's lifestyle, snack foods have become an important part of the diet and greatly influence the overall nutrition intake of an individual (Shukla, 1994). Chickpea flour in combination with rice flour is commonly used for the preparation of extruded snack foods and thus maintains the essential amino acid balance (Bhattacharya and Prakash, 1994). Chickpea based extruded snacks have more nutrient density. Moreover, extruded snacks have more consumer acceptance due to their crisp texture (Harper, 2019). Extrusion cooking improves the starch digestibility, due to the gelatinization of starch at high temperature. This makes the extruded flours suitable for preparation of infant foods and instant soups (Pasqualone et al., 2020).

Lectins are the proteins that bind to the carbohydrates. Chickpea lectins have been reported to have anti cancerous activity (Gautam et al., 2020). At a concentration of 37.5µg/ml chickpea lectin was observed to have reduced cell proliferation of human oral carcinoma cells and had no toxic effect on normal cells even at concentration of 600µg/ml.

Several studies have been reported on the antioxidant activities of different food products (Haq et al., 2016; Haq and Prasad, 2017; Gull et al., 2015, 2018). Chickpea protein isolates have been observed to show various properties like antioxidant activity, hypo-cholestrolemic and anti-inflammatory activities. Various peptide sequences have been identified that have potential health

benefits due to their different activities. These can be utilised in developing functional foods and nutraceuticals (Yust et al., 2012). Utilisation of chickpea protein isolates for microencapsulation of flaxseed oil has also been studied. Flaxseed oil is highly susceptible to oxidative rancidity due to the presence of polyunsaturated fatty acids. Microcapsules prepared from chickpea protein isolates along with maltodextrin resulted in protective effect against oxidative rancidity over a period of 25 days of storage. In-vitro digestibility studies of chickpea protein isolate (CPI) based flaxseed oil microcapsules indicated that CPI based microcapsules had high release properties as compared to lentil protein isolate based microcapsules (Karaca et al., 2013). Chickpea protein had also been employed in encapsulation of vitamin B9 (folate). Encapsulation improved the stability of folate and thus can be beneficial for fortification of processed food products. Chickpea protein can also be used as a drug delivery vehicle because of its microencapsulation efficiency (Ariyarathna and Karunaratne, 2015).

Several food products are being developed now a days. For the development and optimization of any process or product, one variable at a time method was used earlier, later on design-based experimentations and in recent days the trend is to use physical modelling and simulation-based approach are relevant, which is cost effective (Badwaik et al., 2012; Badwaik et al., 2014; Kumar and Prasad, 2017; Kukreja et al., 2002; Prasad and Nath, 2002). The facts in optimization approaches are being explored with the use of roasted chickpea flour, germinated flour admixture with the other flours in the development of nutritionally rich functional foods (Unpublished research data). This can help to prevent several present-day problems associated with the nutrition imbalance along with the problem of protein energy malnutrition in infants when they are in their translational phase (Kaur and Prasad, 2021b). Combination of various malted and roasted cereals, pulses and millets can be utilised based on the scientific approach for the development of optimized food formulations suits most of the subjects (Sahu et al., 2015).

CONCLUSION

The nutritional composition and health benefits of chickpea make it an important pulse crop for the food industry. It is an affordable source of protein, dietary fibre, and several bioactive components. It can be effectively utilized for the development of various value-added products that can prove to be helpful for people suffering from protein-energy malnutrition and useful for patients suffering from gluten intolerance. It is useful as a nourishing food for infants and can be used for preparing weaning foods in malted or extruded form. Although consumption of chickpea has been greatly increasing, it is essential to popularize the specifically designed food products for promoting its consumption and utilization.

REFERENCES

Alajaji S. A. and El-Adawy T. A. 2006. Nutritional composition of chickpea (Cicer arietinum L.) as affected by microwave cooking and other traditional cooking methods. Journal of Food Composition and Analysis. 19(8), 806-812.

Ariyarathna I. R. and Karunaratne D. N. 2015. Use of chickpea protein for encapsulation of folate to enhance nutritional potency and stability. Food and Bioproducts Processing. 95, 76-82.

Badwaik L., Prasad K. and Deka S. 2012. Optimization of extraction conditions by response surface methodology for preparing partially defatted peanut. International Food Research Journal. 19(1), 341-346.

Badwaik L. S., Prasad K. and Seth D. 2014. Optimization of ingredient levels for the development of peanut based fiber rich pasta. Journal of Food Science and Technology. 51(10), 2713-2719.

Bhatia T., Sharma R. K., Prasad K. K. and Prasad K. 2009. Studies on some physical properties of protein-rich legume (Lens esculantus) splits. Asian Journal of Chemistry. 21(10), 103-107.

Bhattacharya S. and Prakash M. 1994. Extrusion of blends of rice and chick pea flours: A response surface analysis. Journal of Food Engineering. 21(3), 315-330.

Christl S. U., Murgatroyd P. R., Gibson G. R. and Cummings J. H. 1992. Production, metabolism, and excretion of hydrogen in the large intestine. Gastroenterology. 102(4), 1269-1277.

Ciftci H., Ozkaya A., Cevrimli B. S. and Bakoglu A. 2010. Levels of fat-soluble vitamins in some foods. Asian Journal of Chemistry. 22(2), 1251-1251.

Crujeiras A. B., Parra D., Abete I. and Martínez J. A. 2007. A hypocaloric diet enriched in legumes specifically mitigates lipid peroxidation in obese subjects. Free radical research. 41(4), 498-506.

Cubero J. I. 1987. Morphology of chickpea. In. pp 35-66. CAB International, Wallingford, Oxon, UK.

Duranti M. 2006. Grain legume proteins and nutraceutical properties. Fitoterapia. 77(2), 67-82.

El-Adawy T. A. 2002. Nutritional composition and antinutritional factors of chickpeas (Cicer arietinum L.) undergoing different cooking methods and germination. Plant Foods for Human Nutrition. 57(1), 83-97.

FAOSTAT 2019. Food and agriculture data. FAO, Rome, Italy

Foster-Powell K., Holt S. H. A. and Brand-Miller J. C. 2002. International table of glycemic index and glycemic load values: 2002. The American journal of clinical nutrition. 76(1), 5-56.

Fredriksson H., Björck I., Andersson R., Liljeberg H., Silverio J., Eliasson A. C. and Åman P. 2000. Studies on α-amylase degradation of retrograded starch gels from waxy maize and high-amylopectin potato. Carbohydrate Polymers. 43(1), 81-87.

Gahlawat P. and Sehgal S. 1992. Formulation and nutritional value of home made weaning foods. Nutrition Research. 12(10), 1171-1180.

Gautam A. K., Sharma D., Sharma J. and Saini K. C. 2020. Legume lectins: Potential use as a diagnostics and therapeutics against the cancer. International journal of biological macromolecules. 142, 474-483.

Ghadge P. N., Vairagar P. R. and Prasad K. 2008. Some physical properties of chick pea split (Cicer arietinum L.). Agricultural Engineering International: The CIGR EJournal. 10(FP 07 039).

Ghavidel R. A. and Prakash J. 2006. Effect of germination and dehulling on functional properties of legume flours. Journal of the Science of Food and Agriculture. 86(8), 1189-1195.

Guardado-Félix D., Lazo-Vélez M. A., Pérez-Carrillo E., Panata-Saquicili D. E. and Serna-Saldívar S. O. 2020. Effect of partial replacement of wheat flour with sprouted chickpea flours with or without selenium on physicochemical, sensory, antioxidant and protein quality of yeast-leavened breads. Food Science and Technology LWT. 129, 109517-109517.

Gül M. K., Egesel C. Ö. and Turhan H. 2008. The effects of planting time on fatty acids and tocopherols in chickpea. European Food Research and Technology. 226(3), 517-522.

Gull A., Prasad K. and Kumar P. 2015. Physico-chemical, Functional and Antioxidant Properties of Millet Flours. Journal of Agricultural Engineering and Food Technology. 2(1), 73-75.

Gull A., Prasad K. and Kumar P. 2018. Nutritional, antioxidant, microstructural and pasting properties of functional pasta. Journal of the Saudi Society of Agricultural Sciences. 17(2), 147-153.

Han I. H. and Baik B. K. 2006. Oligosaccharide content and composition of legumes and their reduction by soaking, cooking, ultrasound, and high hydrostatic pressure. Cereal Chemistry. 83(4), 428-433.

Haq R.-u., Kumar P. and Prasad K. 2016. Physico-chemical, antioxidant and bioactive changes in cortex core sections of carrot (Daucus carota var. Pusa rudhira). Journal of Food Measurement and Characterization. 10(3), 701-708.

Haq R.-u. and Prasad K. 2017. Antioxidant activity, phenolic, carotenoid and color changes in packaged fresh carrots stored under refrigeration temperature. Journal of Food Measurement and Characterization. 11(4), 1542–1549.

Harper J. M. 2019. Extrusion of foods, vol 1. CRC press,

Hatzikamari M., Yiangou M., Tzanetakis N. and Litopoulou-Tzanetaki E. 2007. Changes in numbers and kinds of bacteria during a chickpea submerged fermentation used as a leavening agent for bread production. International journal of food microbiology. 116(1), 37-43.

Haytowitz D. B., Lemar L., Pehrsson P., Exler J., Patterson K., Thomas R., Nickle M. S., Williams J. R., Showell B. A., Khan M. and Duvall M. 2011. USDA national nutrient database for standard reference, release 24. US Department of Agriculture: Washington, DC, USA.

Hulse J. H. 1994. Nature, composition, and utilization of food legumes. Springer, UK

Jambunathan R. and Singh U. 1980. Studies on Desi and Kabuli chickpea (Cicer arietinum) cultivars. 1. Chemical composition. In: Proceedings of the International Workshop on Chickpea Improvement, 1980. ICRISAT Hyderabad, India, pp 61-66.

Jambunathan R. and Singh U. 1989. Present status and prospects for utilization of chickpea. In: Proceedings of the International Workshop on Chickpea Improvement, ICRISAT, Hyderabad, India, 1989. pp 41-46.

Jha S. N. 2005. Mathematical simulation of roasting of grain. Journal of Food Engineering. 71(3), 304-310.

Joshi P. K., Rao P. P., Gowda C. L. L., Jones R. B., Silim S. N., Saxena K. B. and Kumar J. 2001. The world chickpea and pigeonpea economies facts, trends, and outlook. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh,

Karaca A. C., Nickerson M. and Low N. H. 2013. Microcapsule production employing chickpea or lentil protein isolates and maltodextrin: Physicochemical properties and oxidative protection of encapsulated flaxseed oil. Food Chemistry. 139(1-4), 448-457.

Kaur M. and Singh N. 2005. Studies on functional, thermal and pasting properties of flours from different chickpea (Cicer arietinum L.) cultivars. Food Chemistry. 91(3), 403-411.

Kaur R. and Prasad K. 2021a. Effect of Hydrothermal Exposure on Physical Properties of Cicer Arietinum Seeds. AIP Conference Proceedings. In Press.

Kaur R. and Prasad K. 2021b. Technological, processing and nutritional aspects of chickpea (Cicer arietinum)-A review. Trends in Food Science & Technology. 109, 448–463.

Köksel H., Sivri D., Scanlon M. G. and Bushuk W. 1998. Comparison of physical properties of raw and roasted chickpeas (leblebi). Food Research International. 31(9), 659-665.

Kukreja T. R., Kumar D., Prasad K., Chauhan R. C., Choe S. and Kundu P. P. 2002. Optimisation of physical and mechanical properties of rubber compounds by Response Surface Methodology—Two component modelling using vegetable oil and carbon black. European Polymer Journal. 38(7), 1417-1422.

Kumar M. M., Prasad K., Sarat Chandra T. and Debnath S. 2018. Evaluation of physical properties and hydration kinetics of red lentil (Lens culinaris) at different processed levels and soaking temperatures. Journal of the Saudi Society of Agricultural Sciences. 17(3), 330-338.

Kumar S. and Prasad K. 2017. Optimization of Flaked Rice Dry Roasting in Common Salt and Studies on Associated Changes in Chemical, Nutritional, Optical, Physical, Rheological and Textural Attributes. Asian Journal of Chemistry. 29(6), 1380-1392.

Kumar S. and Prasad K. 2018. Effect of parboiling and puffing processes on the physicochemical, functional, optical, pasting, thermal, textural and structural properties of selected Indica rice. Journal of Food Measurement and Characterization. 12(3), 1707-1722.

Kumar S., Shekhar S. and Prasad K. 2016. Temperature dependent roasting kinetic changes in opto-physical and textural characteristics of flaked rice. In: Recent advances in emerging technologies. pp. Sri Guru Granth Sahib World University, Fatehgarh Sahib, India.

Liu L. H., Hung T. V. and Bennett L. 2008. Extraction and characterization of chickpea (Cicer arietinum) albumin and globulin. Journal of Food Science. 73(5), C299-C305.

Livingstone A. S., Feng J. J. and Malleshi N. G. 1993. Development and nutritional quality evaluation of weaning foods based on malted, popped and roller dried wheat and chickpea. International journal of food science & technology. 28(1), 35-43.

Longvah T., Anantan I., Bhaskarachary K., Venkaiah K. and Longvah T. 2017. Indian food composition tables. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad,

Malhotra R. S., Pundir R. P. S. and Slinkard A. E. 1987. Genetic resources of chickpea [Cicer arietinum] In: The Chickpea. Commonwealth Agricultural Bureaux International, UK

Mangaraj S., Agrawal S., Kulkarni S. D. and Kapur T. 2005. Studies on physical properties and effect of pre-milling treatments on cooking quality of pulses. Journal of Food Science and Technology, Mysore. 42(3), 258-262.

Mariod A. A., Abdelwahab S. I., Elkheir S., Ahmed Y. M., Fauzi P. N. M. and Chuen C. S. 2012. Antioxidant activity of different parts from Annona squamosa, and Catunaregam nilotica methanolic extract. Acta Scientiarum Polonorum Technologia Alimentaria. 11(3), 249-258.

Milán-Noris A. K., Gutiérrez-Uribe J. A., Santacruz A., Serna-Saldívar S. O. and Martínez-Villaluenga C. 2018. Peptides and isoflavones in gastrointestinal digests contribute to the anti-inflammatory potential of cooked or germinated desi and kabuli chickpea (Cicer arietinum L.). Food Chemistry. 268, 66-76.

Miñarro B., Albanell E., Aguilar N., Guamis B. and Capellas M. 2012. Effect of legume flours on baking characteristics of gluten-free bread. Journal of Cereal Science. 56(2), 476-481.

Mudryj A. N., Yu N. and Aukema H. M. 2014. Nutritional and health benefits of pulses. Applied Physiology, Nutrition, and Metabolism. 39(11), 1197-1204.

Murty C. M., Pittaway J. K. and Ball M. J. 2010. Chickpea supplementation in an Australian diet affects food choice, satiety and bowel health. Appetite. 54(2), 282-288.

Oomah B. D., Patras A., Rawson A., Singh N. and Compos-vega R. 2003. Chemistry of Pulses. 1 edn. Elsevier Ltd., Netherland

Palozza P., Maggiano N., Calviello G., Lanza P., Piccioni E., Ranelletti F. O. and Bartoli G. M. 1998. Canthaxanthin induces apoptosis in human cancer cell lines. Carcinogenesis. 19(2), 373-376.

Pasqualone A., Costantini M., Coldea T. E. and Summo C. 2020. Use of Legumes in Extrusion Cooking : A Review. Foods. 9(7), 958-958.

Prasad K. 2009. Protein fortification of mango and banana bar using roasted Bengal gram flour and skim milk powder. Agricultural Engineering International: CIGR Journal. 11, 1390.

Prasad K. and Nath N. 2002. Comparison of sugarcane juice based beverage optimisation using response surface methodology with fuzzy method. Sugar Tech. 4(3-4), 109-115.

Prasad K., Vairagar P. R. and Bera M. B. 2010. Temperature dependent hydration kinetics of Cicer arietinum splits. Food Research International. 43(2), 483-488.

Rachwa-Rosiak D., Nebesny E. and Budryn G. 2015. Chickpeas—composition, nutritional value, health benefits, application to bread and snacks: a review. Critical Reviews in Food Science and Nutrition. 55(8), 1137-1145.

Ravi R. and Harte J. B. 2009. Milling and physicochemical properties of chickpea (Cicer arietinum L.) varieties. Journal of the Science of Food and Agriculture. 89(2), 258-266.

Raza H., Zaaboul F., Shoaib M. and Zhang L. 2019. An Overview of Physicochemical Composition and Methods used for Chickpeas Processing. International Journal of Agriculture Innovations and Research. 7(5), 495-500.

Sahu U., Prasad K., Sahoo P. and Sahu B. B. 2014. Studies on engineering properties of raw and roasted pulses. International Journal of Processing and Post Harvest Technology. 5(2), 184-188.

Sahu U., Prasad K., Sahoo P., Sahu B. B., Sarkar P. C. and Prasad N. 2015. Biscuit making potentials of raw and roasted whole grain flours: Cereals and millets. Asian Journal of Dairy and Food Research. 34(3), 235-238.

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 of Food Science. 75(2), 2-6.

Sharma A., Mazumdar B. and Keshav A. 2019. Formulation, standardization and characterization of novel sattu beverage enriched with beetroot juice. Journal of Food Science and Technology, 1-8.

Sharma S. and Prasad K. 2016. Varietal variations on roasting and nutritional characteristics of linseed kernels. In: Recent advances in emerging technologies. pp. Guru Granth Sahib World University, Fatehgarh Sahib, India.

Sharma S., Sharma H. P. and Prasad K. 2015. Effect of roasting on comparative physical characteristics of linseed kernels. South Asian J Food Technol Environ. 1(1), 58-63.

Shukla T. P. 1994. Future snacks and snack food technology. Cereal foods world. 39(9), 704-705.

Siddiqui M. W., Lara I., Ilahy R., Tlili I., Ali A., Homa F., Prasad K., Deshi V., Lenucci M. S. and Hdider C. 2018. Dynamic Changes in Health-Promoting Properties and Eating Quality During Off-Vine Ripening of Tomatoes. Comprehensive Reviews in Food Science and Food Safety. 17(6), 1540-1560.

Wallace T. C., Murray R. and Zelman K. M. 2016. The nutritional value and health benefits of chickpeas and hummus. Nutrients. 8(12), 766-766.

Wang N. and Daun J. K. 2004. The chemical composition and nutritive value of Canadian pulses. Canadian Grain Commission Report, 19-29.

Wang S., Ai Y., Hood-Niefer S. and Nickerson M. T. 2019. Effect of barrel temperature and feed moisture on the physical properties of chickpea, sorghum, and maize extrudates and the functionality of their resultant flours—Part 1. Cereal Chemistry. 96(4), 609-620.

Welch R. M. 2002. Breeding strategies for biofortified staple plant foods to reduce micronutrient malnutrition globally. The Journal of nutrition. 132(3), 495S-499S.

WHO 2004. Vitamin and mineral requirements in human nutrition. 2nd edn. World Health Organization, Food and Agriculture Organization, Rome,

Wood J. A. and Grusak M. A. 2007. Nutritional value of chickpea. Chickpea breeding and management, 101-142.

Wood J. A. and Malcolmson L. J. 2011. Pulse milling technologies. Pulse Foods: Processing, Quality and Nutraceutical Applications. Academic Press, US,

Xu M., Jin Z., Simsek S., Hall C., Rao J. and Chen B. 2019. Effect of germination on the chemical composition, thermal, pasting, and moisture sorption properties of flours from chickpea, lentil, and yellow pea. Food Chemistry. 295, 579-587.

Yamsaengsung R., Schoenlechner R. and Berghofer E. 2010. The effects of chickpea on the functional properties of white and whole wheat bread. International journal of food science & technology. 45(3), 610-620.

Young V. R. and Pellett P. L. 1994. Plant proteins in relation to human protein and amino acid nutrition. The American journal of clinical nutrition. 59(5), 1203S-1212S.

Yust M. d. M., Millán-Linares M. d. C., Alcaide-Hidalgo J. M., Millán F. and Pedroche J. 2012. Hypocholesterolaemic and antioxidant activities of chickpea (Cicer arietinum L.) protein hydrolysates. Journal of the Science of Food and Agriculture. 92(9), 1994-2001.