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Review on nutritional and anti-nutritional factor of raw, cooked and sprouted cowpea

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Abstract
Cowpea (*Vigna unguiculata* L.) belongs to family Leguminosae, other names commonly used include catjang, black-eyed bean or china pea. Traditional methods of cooking impact the nutritional and the precise cuases/reseasons are not yet known in detail at biochemical levels. In India, conventional legumes have dominated the production and market chains a though legumes play crucial role in eradicating protein malnutrition. Cowpea is rich in nutraceuticals compounds such as dietary fibre, antioxidants and polyunsaturated fatty acids. Compared with other pulses it is less expensive with almost same nutritive value. Despite the nutritional benefits of cowpea, certain constraints like presence of anti-nutrients have been reported, which affects its utilization and popularity adversely. Food processing methods like dehulling, autoclaving, boiling and roasting have been shown to reduce the anti-nutrient content in cowpea to a considerable extent. The raw cowpea seeds are very nutritive as it contains range of amino acids, antioxidants, vitamins, dietary fibre and minerals. Soaking of seeds revealed a significant decrease in ash content and this loss increased with increase in the period of soaking. The level of protein and ash content decreased significantly during both ordinary and pressure cooking. Increases in protein and ash content are observed with germination, on the contrary decrease in fats recorded. Traditional methods of cooking of cowpea in a regular pan or pressure cooker i.e. with or without previous soaking prove to be efficient for the maximum retention of iron and zinc. Further heat processing leads to loss of micro nutrients due to leaching in cowpea. Cooking, autoclaving and germination (sprouted) decreases the starch content and increases the level of total soluble sugars, reducing sugars, non-reducing sugars and starch digestibility while pressure cooking and solar cooking significantly reduces the phytic acid and polyphenol content of cowpea.

Keywords: nutritional, minerals, anti-nutritional, raw, sprouting and cooked

Introduction
Cowpea (*Vigna unguiculata* L.) belongs to family Leguminosae, and it is also known as catjang, black-eyed bean or china pea (Taiwo, 1998) [35]. The crop is widely cultivated in Africa, Asia and America as sole or intercrop with yam, cassava, maize, sorghum, millet and rice. The crop is heat, drought and salinity tolerant. Cowpea is one of the most ancient human food sources and has been used as a crop plant since Neolithic times (Summerfield *et al.*, 1974) [34]. Cowpea originated in Central Africa and was introduced from Africa to the Indian sub-continent approximately 2000 to 3500 years ago, at the time of introduction of sorghum and millet. The slave trade from West Africa resulted in the crop reaching Southern USA in the 18th century. At present, cowpea is grown throughout the tropics and subtropics. In Indian context, it is a minor pulse cultivated mainly in arid and semi-arid tracts of Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat. In North India, it is grown in pockets of Punjab, Haryana, Delhi, and West UP along with considerable area in Rajasthan (Kushwaha and Kumar, 2013) [23]. Cowpea is traditionally processed in different ways and the impacts of these traditional cooking methods on the nutritional composition of cowpea were yet unknown. In India, primarily a handful of conventional legumes have dominated the production and market chains, Yet these legumes play critical role in eradicating protein malnutrition. Some of the minor legumes like, cowpea hold great promse in the nutritional security of rural, tribal and underprivileged masses. Cowpea is one of the highly nutritious grain and vegetable pulse crop with nutraceutical values in India. Although it represents an economical source of protein, calories and B-vitamins, its consumption in the past two decades implied poverty and was associated with the low-income groups to the extent that it was regarded as the “poor man's meat” (Asiamah, 2004) [6].

Being tolerant to drought famine and dry season, cowpea can make a significant contribution to the diet of the rural households (Magbagbeola *et al.*, 2010) [24]. Besides, in many cases these are the life-savers for millions of resource poor people in the regions where ensuring food and nutritional security is one of the significant challenges, particularly in traditional subsistence farming systems. Cowpea is one of the most important food legumes crop widely grown in semi-arid tropics as an inexpensive source of protein in both human diet and animal feed. Its fresh or dried seeds, pods and leaves are commonly used in human food, since they are highly valuable as fodder. Cowpea has great flexibility in use, farmers can choose to harvest them for grain or to harvest forage for the livestock, depending on economical or climatologically constraints (Omenna *et al.*, 2016) [26].

High protein (18-35%) and carbohydrates (50-60%) contents, together with an amino acid pattern complementary to that of cereal grains make cowpeas a potentially important nutritional component in the human diet (Prinyawiwatkul *et al.*, 1996) [31]. The cowpea seeds are a rich source of amino acids like tyrosine, tryptophan, lysine and contain substantial amount of histidine, phenylalanine and cysteine. Cowpea seeds also contain small amounts of carotene, thiamin, riboflavin, niacin, vitamin A and folic acid. It is rich in nutraceuticals compounds such as dietary fibre, antioxidants and polyunsaturated fatty acids and polyphenols. Compared with other pulses it is less expensive (Farzana *et al.*, 1996) [14] with almost same nutritive value.

Despite the nutritional benefits of cowpea, certain constraints like presence of anti-nutrients have been reported, which affects its utilization and popularity adversely (Akinjayeju and Enude, 2002) [3]. Food processing methods like dehulling, autoclaving, boiling and roasting have been shown to reduce the anti-nutrient content in cowpea to a considerable extent. Heat treatment has been shown to be more effective in minimizing the naturally occurring toxic substance in cowpea (Udensi *et al.*, 2007) [37].

Nutritional Quality: Raw, Sprouted and Cooked Cowpea

There were noticeable trends in the protein, carbohydrate and crude fiber as a result of the germinated and fermented samples contained more ether extractable lipids than the raw and cooked samples. Cooking the dry beans at 100 °C for 90 min had little effect on the phytic acid and phytate phosphorus. There were, however, significant decreases in total phosphorus and sugars of the cooked beans. After germination for 24 hours, 48 hours and 72 hours respectively, there was a significant decrease in phytic acid and total sugar and increase in total phosphorus and reducing sugar (Akpapunam and Achinewhu, 1985) [4]. Germination for 24 hr brought about a greater decrease in verbascose and stachyose content which was around 50% on the average. While sucrose, glucose, and fructose contents showed an increasing pattern (Rao and Belavady, 1978) [32]. Apata (2008) [5] stated that the values of available carbohydrates in each of the autoclaved legumes were similar to those of the raw form, while the cooked had lower values which may be a consequence of the leaching out of soluble starch portion and the soluble sugars, by boiling water during the cooking process. The protein content of mung bean, chickpea and cowpea increased by 9–11, 11–16 and 8–11% after germination respectively, Further, significant decrease in protein content was observed on pressure cooking and microwaving in all three legumes. The carbohydrates decreased by 1 to 3% during soaking and 2 to 6% during germination (Uppal and Bains, 2012) [38]. There was an increase in the β-carotene content of cowpea on seed sprouting. Thus, making sprouts a moderately good source of beta carotene. It has been observed that upon germination the concentration of beta carotene steadily increases with increasing germination time (Khyade and Jagtap, 2016) [22]. Omenna *et al.* (2016) [27] found that germinated cowpeas had the highest values of crude protein (22.89%), crude fat (3.81%) and crude fibre (2.10%) while boiled cowpeas had the least values of crude protein (17.79%), crude fat (3.56%) and crude fibre (1.81%). Protein content and transaminase activity were found to be highest in sprouted pulses. The nutritional benefits in terms of protein and transaminases increased on sprouting. The metabolic activity of resting seeds increases as soon as they are hydrated during soaking. Sprouting grains causes increased activities of hydrolytic enzymes like lipase, improvements in the contents of total proteins, fat, essential amino acids, total sugars, B-group vitamins, starch digestibility and lysine (Dipnaik and Bathere, 2017) [13]. Thummakomma and Meda (2017) [36] observed that pressure cooking could be the suitable processing method and can be recommended for the consumption of these pulses to increase the dietary intake of health beneficial bioactive compounds. Devisetti *et al.* (2020) [12] found that in cowpea, germination significantly decreased the palmitic and α-linoleic acid and increased stearic, oleic, and linoleic acids whereas, in chickpea, no differences were seen. Total polyunsaturated fatty acid content was higher in germinated cowpea, whereas in chickpea it was unchanged. Yasser *et al.* (2020) [39] found that legumes and pulses have high nutritive values and functional properties that exert positive effects on health and nutrition. This study developed a novel complementary baby food using germinated mung bean and cowpea as sources of extra nutrients supplemented to the infants (aging 6-12 months). The carbohydrate contents of mung bean and cowpea showed 64.3 and 64.0% reduction, respectively, during 48hr of germination.

Minerals Content: Raw, Sprouted and Cooked Cowpea

Meiners (1976) [25] showed that minerals in cooked legumes were about one-third to one-half of the values in raw legumes. Variability in mineral content is primarily due to differences in zinc and phosphorus content. Owuamanam *et al.* (2014) [28] studied that the advantages offered by seed sprouting in terms of high bioavailability of minerals and reduction in anti-nutrients might best be employed by blending the non-sprouted and sprouted flours in food preparations and premixes. The retention of zinc was higher when the cowpeas were prepared in the pressure cooker. Traditional methods of cooking of cowpea in a regular pan or pressure cooker and with or without previous soaking proved to be efficient for the maximum retention of iron and zinc (Pereira *et al.*, 2014) [30]. The micro elements composition of cowpeas showed that heat processing lead to loss of nutrients; this may be due to leaching during heat application. Germination had increased the amount of Na, K, Ca, P and Mg while boiling and pressure cooking had decreased the amount of macro element content as compared to raw sample. Heat treatments (boiling and pressure cooking) recorded decreased levels of micro elements (Fe, Zn, Cu, and Mn) while germination lead to increased the micro elements by 4.66%, 3.78%, 13.85% and

6.38% for Fe, Zn, Cu and Mn, respectively. (Omenna *et al.*, 2016) [27]. Potassium content reductions of up to 80% after soaking and cooking with final values under 120 mg/100 g edible portion. Reductions in phosphorus content were not as marked as those of potassium (Montserrat, 2019) [26]. Phosphorous, zinc contents and antioxidant activities of mung bean and cowpea and the iron content of cowpea increased over the same period of germination (Yasser *et al.*, 2020) [39]. Acquah *et al.* (2021) [1] found that diverse processing techniques like soaking, germination, boiling reduced the percentage of increase the bioavailability of macro- and micro-nutrients.

Effect of Processing on Digestibility of Cowpea Nutrients

Cooking, autoclaving and germination (sprouted) decreased the starch content and increased the level of total soluble sugars, reducing sugars, non-reducing sugars and starch digestibility of legumes. Soaking reduced the sugars considerably. Cooking and sprouting also improved starch digestibility appreciably (Jood *et al*., 1988) [18]. Bravo *et al.* (1998) [7] found that the effect of various processing methods on the *in vitro* starch digestibility and resistant starch content of Indian pulses. Cooked samples were analysed for their resistant starch content immediately after cooking or after storing for 24hr at 4 °C. Sprouting and direct cooking resulted in the lowest resistant starch content in freshly cooked and stored legumes, respectively. Soaking significantly improved starch digestibility. Sprouting yielded the highest hydrolysis index and glycemic index. Heat processing effects on anti-nutrients and protein of food legumes. Reduction in levels of the anti-nutrients, along with an improvement in protein and starch digestibility, was observed after cooking food legumes (Zia-ur-Rehman and Shah, 2004) [40]. Ghavidel *et al.* (2007) [15] revealed that germination caused significant increase in protein, thiamin, *in vitro* iron and calcium bioavailability and *in vitro* starch and protein digestibility contents of all the legume samples. Deol (2010) [10] showed that *in vitro* protein digestibility was highest (93.9%) on 3 min pressure cooking followed by 15 min boiling. These results also indicated that pressure cooking should be preferred for cooking. Pressure cooking for 3 min and boiling for 15 min improved *in vitro* protein digestibility by reducing anti-nutrients. A significant improvement in *in-vitro* protein digestibility was observed after soaking as well as after three germination periods. Germination resulted increase in *in vitro* protein digestibility from 15 to 25% in mung bean, 6 to 17% in chickpea and 6 to 17% in cowpea. A significant increase in *in vitro* protein digestibility was observed when raw sprouts of three legumes were subjected to pressure cooking and microwaving. *In vitro* starch digestibility increased significantly after germination, the percent increase being 8 to 12% in mung bean, 9 to 11% in chickpea and 10 to 13% in cowpea (Uppal and Bains, 2012) [38]. It was reported that results of *in vitro* starch digestibility demonstrated that autoclaving significantly increased the predicted glycemic index and slowly digested starch (Kasote *et al.*, 2014) [20].

Hemalatha (2006) [16] studied on the influence of germination and fermentation on bio accessibility of zinc and iron from food grains. Food grains such as green gram, chickpea and finger millet were subjected to traditional processing involving germination and fermentation. Germination of green gram, chickpea and finger millet for 24 and 48hr significantly enhanced the bio-accessibility of iron, bio accessibility of zinc was not beneficially affected. Thus, soaking, germination and fermentation of cereals and legumes offers a practical household method to reduce inhibitors of mineral absorption, especially phytic acid and tannin, thereby contributing to enhanced zinc and iron absorption.

Anti-Nutritional Factor: Raw, Sprouted and Cooked Cowpea

Pasrija and Punia (2000) [29] found that pressure cooking and solar cooking significantly reduced the phytic acid and polyphenol content of cowpea cultivars. The percentage reduction increased when the soaked cowpeas were dehulled and then cooked by both pressure and solar cooking. The results of the study revealed that solar cooking was more effective than pressure cooking in reducing the concentrations of phytic acid and polyphenols in cowpeas. The cumulative effect of soaking and dehulling, followed by solar cooking was the removal of most of the polyphenols. It was found that soaking for 18 hr removed 28% of the phytic acid, the extents of removal were higher with longer periods of soaking. Saponins and polyphenols were relatively less affected. Phytic acid was reduced to a greater extent than polyphenols or saponins (Kataria *et al.*, 1988) [21]. Germination reduced the phytic acid content of urd bean by about 40%. Fermentation reduced phytic acid contents by 26-39%. It was observed that autoclaving and roasting were more effective in reducing phytic acid (Chitra *et al.*, 1995) [9].

Efficacy of some treatments, namely soaking (in water and bicarbonate solution), ordinary and pressure cooking, germination and fermentation in reducing or removal of anti-nutritional factors usually present in cowpeas (protease inhibitors, tannins, phytic acid and flatus-producing oligosaccharides (raffinose and stachyose) showed that long-time soaking (16 hr) in bicarbonate solution caused remarkable reduction in the anti-nutritional factors. Pressure cooking was more effective than ordinary. Cooking pregerminated cowpeas was most effective. Fermentation completely removed trypsin inhibitor, oligosaccharides and reduced remarkably phytic acid. However, tannins noticeably increased (Ibrahim *et al.*, 2002) [17].

Sinha and Kawatra (2003) [33] studied that soaking for 18 hours resulted in 20 and 17.6% reductions in phytic acid and polyphenol contents, respectively. The extent of removal was higher with longer periods of soaking. Losses of antinutrients were greater when soaked versus unsoaked seeds when cooked. Pressure cooking had a more beneficial effect than traditional cooking. Germination for 72 hours led to a reduction of 47.8% in phytic acid and 32.5% in polyphenol content, which was more than noted with 24, 48 or 60 hours.

Hemalatha (2006) [16] experimented that soaking, germination and fermentation of cereals and legumes offers a practical household method to reduce inhibitors of mineral absorption, especially phytic acid and tannin, thereby contributing to enhanced zinc and iron absorption.

Decortications of cowpea grain resulted in significant reduction of total phenolics, total tannins and phytate contents of the cowpea varieties (Adebooye and Singh, 2007) [2]. Phytic acid and tannin were reduced by 18–21% and 20–38%, respectively in germination. There were negative correlations between nutrients bioavailability and digestibility with anti-nutritional factors (Ghavidel *et al.*, 2007) [15]. Pressure cooking and boiling resulted in significant destruction in the anti-nutrients like phytates, tannins and trypsin inhibitors

(Deol, 2010) [10]. Devi *et al.* (2015) [11] found anti-nutritional factors like phytic acid and trypsin inhibitor decreased after sprouting. Sprouting is an effective method for removing anti-nutritional factors in cowpea without application of heat processing methods, which may reduce content of heat sensitive nutrients. Chipurura *et al.* (2018) [8] found that boiling caused a significant decrease in total phenolic content, total flavonoid content, and content of condensed tannins and saponins in cowpea. The most effective combination method for reducing tannin, phytic acid and trypsin inhibitor activity content is soaking, roasting and pressure cooking. Hence, the best processing means were soaking/roasting followed by pressure cooking (Kamalasundari *et al*., 2018) [19].

Scenario of Nutrition and Anti- Nutrition Contents: Raw, Sprouted and Cooked Cowpea

It was seen that maximum amount of gain in protein (%) was found in pressure cooking followed by sprouting. Therefore, when compared to alternative processing techniques and raw cowpeas, pressure cooking was a healthy option. Sprouting had the greatest globulin level, followed by pressure cooking and raw. Sprouting caused the greatest reduction of prolamine content. In relation to total soluble sugar content, it can be concluded that pressure cooked cowpea conserve higher total soluble sugar content. Regarding antioxidant activity, the results of raw seeds are best followed by sprouting and pressure cooking. Sprouting cowpeas had a higher content than other processing techniques when compared to other processing methods in terms of crude fat content, there is no doubt about it. The sprouting is the best method for retaining crude fiber content. The anti-nutrient component in our diet reduces the nutritional quality of food, which may be reduced by using alternative cooking methods. When several processing techniques were compared in terms of anti-nutrient component, the pressure cooking treatment had the lowest tannin and phenol levels.

Raw cowpea has a higher sodium level whereas sprouting treatment had the highest manganese content and zinc concentration. Raw cowpea has the greatest potassium, magnesium and calcium level.

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