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A Comprehensive Review on Physical Properties, Nutritional Composition, Culinary Uses and Processing of Cowpea (*Vigna unguiculata* L.)

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ABSTRACT

Cowpea is one of the highly nutritious grain and vegetable pulse crop with nutraceutical values in India, which is commonly known as lobia and chaura. Cowpea represents an economical source of protein, calories and B-vitamins and therefore it is regarded as the "poor man's meat". It is rich in nutraceutical compounds such as dietary fibre, antioxidants and polyunsaturated fatty acids and polyphenols. Compared with other pulses it is less expensive with almost same nutritive value. Being tolerant to drought famine and dry season, cowpea can make a significant contribution to the diet of the rural households. In this review, various characteristics of cowpea (Vigna unguiculata), including physical properties, nutritional and anti-nutritional composition along with culinary uses and processing of cowpea, were studied with the objective to demonstrate that cowpea is a most suitable legume crop for inclusion in food security programs especially for vulnerable poor.

Keywords: *Cowpea, Fibre, Lobia, Chaura, "Poor man's meat".*

INTRODUCTION

In developing countries like India where majority of the population is vegetarian, plant proteins play a significant role in human nutrition. Animal proteins also are beyond the reach of major segments of the population due to their high cost. Nutritional studies have shown that inclusion of various pulses in the cereal based diet can solve the protein-calorie malnutrition problem and will help to promote growth especially of the children with under nutrition.

In India, primarily a handful of conventional legumes have dominated the production and market chains and thus still playing crucial role in eradicating protein malnutrition. Some of the minor legumes like, cowpea hold great significance 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, which is commonly known as *lobia* and *chaura*. In other languages the names are *chola* or *chorap* (Gujrati), *chavalya* (Marathi), *alasandulu* (Telugu), *alasande* (Kannada) and *karamani* (Tamil).

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It is also known as black-eyed pea, southern pea, crowder pea or field pea in English language. 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). 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). 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 problems, particularly in traditional subsistence farming systems (Haq, 2002).

Cowpea (*Vigna unguiculata* L.) is one of the most ancient human food sources and has been used as a crop plant since Neolithic times (Summerfield et al., 1974). 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 (Allen, 1983; Ng and Marechal, 1985). Before 300 B.C., cowpea reached Europe and North Africa and in the seventeenth century A.D. the Spanish took the crop to the West Indies. The slave trade from West Africa resulted in the crop reaching Southern USA in the eighteenth 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.

Cowpea is an important grain legume crop for the livelihood of the millions of rural poor in the underdeveloped /developing countries of the tropical and subtropical regions of the world. 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). The cowpea seeds are a rich source of amino acids like tyrosine, tryptophan and 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) with almost same nutritive value.

Despite the nutritional benefits of cowpea, certain constraints like presence of antinutrients have been reported, which affects its utilization and popularity adversely (Akinjayeju and Enude, 2002). Food processing methods like dehulling, autoclaving, boiling and roasting have been shown to reduce the antinutrient content in cowpea to a considerable extent (Tewari et al., 2004). Heat treatment has been shown to be more effective in minimizing the naturally occurring toxic substance in cowpea (Udensi et al., 2007).

Cowpea, is a climbing annual in the family Fabaceae grown for its edible seeds and pods. The cowpea plant is usually erect and possess ribbed stems and smooth trifoliate leaves which are arranged alternately on the stems. The plant produces clusters of flowers at the end of a peduncle (flower stalk) and 2–3 seed pods per peduncle. The seed pods are smooth, cylindrical and curved, reaching up to 35 cm (10 in) in length, with distinctive coloration, usually green, purple or yellow. As the seeds reach maturity the pod changes color to tan or brown. The seeds can be white, cream, green, red brown or black in color or be a mottled combination. The seed may also possess an ‘eye’ where a lighter color is surrounded by one that is darker. Cowpea can reach in excess of 80 cm (31.5 in) in height and, as an annual plant, lives for only one growing season before harvest (https://plantvillage.psu.edu/topics/cowpea/infos). This crop is known as drought hardy nature, its wide and droopy leaves keeps soils and soil moisture conserved due to shading effect. Cowpea is warm weather and semi arid crop, where temperature ranging from 20 to 30°C. Well drained loam or slightly heavy soil are best suited. It can be sown in Kharif and summer season in Northern India and Rabi season in southern part of the country. Cowpea is grown for diversified uses for food, feed and green manuring (https://farmers.gov.in and https://mkisan.gov.in).

The total world production of pulses was 56.5 million tonnes in 2003/2004. In, India cowpea is grown in about 0.5 million hectares of land with an average productivity of 500-700 kg grain/hectare with a maturity period of 120-150 days. The major areas concentrated in cowpea production are Karnataka, Andhra Pradesh, Uttar Pradesh and Bihar. In India, cowpea is raised as a mixed crop along with either cereals or oilseeds (Ahlawat & Shivkumar, 2005). International Institute of Tropical Agriculture (IITA), Nigeria, Africa has developed cowpea varieties with yield potential ranging from 1.5-2.5 tonnes/hectare and maturity duration of 60 days. These improved varieties of cowpea are high yielding and early maturing (Pandey & Singh, 2006) and can fit in the gap between two Kharif crops i.e. rice and wheat. These improved varieties have been under trial at G.B. Pant University of Agriculture & Technology, Pantnagar and one of such varieties IT98K-205-8 and IT 97K-1042-3 have been released as Pant Lobia-1 and Pant Lobia-2 in the year 2008 and 2010, respectively.

Physical properties of cowpea seeds

The various physical characteristics of the seeds which influence the cooking quality and consumer acceptance are seed coat colour, kernel weight and type of seed coat. Summerfield et al. (1974) reported colour of seed coat of cowpea in the range of dull white, white, cream, green, red, brown and buff to black. The literature reviewed showed that the cowpea seeds occurred in varied range of colours. Omueti and Singh (1987) reported seed colour of cowpea varieties varying from white to brown and black. Sood et al. (1992) studied twenty-six strains of cowpea showing seed coat colour variations from dull white, white, brown, black to buff. The colour difference also has implication in the characteristics of the product produced from cowpea. Difference in colour also might have quality implications where cowpea is used as a composite flour (Chinma et al., 2008).

Ogle et al. (1987) classified cowpea varieties into size categories based on their 100-kernel weight. Varieties with kernel weight between 10-15 g were described as small; 15.1-20 g were medium size seed while large seed had 20.1-25 g. Kernel weight over 25 g were described as very large seeds. The kernel weight of cowpea variety could be a useful criterion for determining suitability for a particular end-use application. For example, varieties with large kernels would be preferred for canning. Kernel size is an important characteristic which affects the efficiency of the cooking process and considerable variations among pulses had been reported pertaining to the role of the kernel size affecting their cooking. The cooking time was positively and significantly correlated with the kernel size in chickpea (Williams et al., 1983) and in lentil (Erskine et al., 1985), implying that bolder grains would increase the cooking time. Generally, small seeds tend to cook faster than larger seeds. The seed size is a varietal characteristic, which can be strongly influenced by location and growing season (Singh, 1999). Omueti and Singh (1987) reported 100-kernel weight of cowpea ranging from 10.9 to 24.3 g (Table 1). And the average weight of white seeded lines in their experiment was 19.59g compared to 15.7 g for the brown-seeded lines. The interesting fact was that average 100 seed weight of cowpea was more in early maturing (17g) than the medium maturers (13g). The 100 kernel weight of nine improved varieties of cowpea ranged from 13.1 g to 24.2 g (Ajeigbe et al., 2008). The 100-seed weight of improved varieties of cowpea developed at Pantnagar (India) was in the range of 11.44 to 15.41g (Chaudhary, 2009; Bhavana, 2011; Devi, 2012) and can be termed as small to medium size. Kernel weight depicts size of the seed and its boldness and is positively correlated with cooking time (Viera et al., 1989). Difference in length, diameter and weight of the grain among varieties may be attributed to difference in genetic traits (Chinma et al., 2008).

Seed volume is an important from handling point of view, if seed volume is more it affects transportation and handling. Ajeigbe et al. (2008) reported 100 seed volume of improved varieties of cowpea in the range of 15.25 to 19.0 ml (Table 1). A positive correlation between seed weight and seed volume of pulses has been reported by Williams et al. (1983). Various researchers reported the 100-seed volume of improved varieties of cowpea developed at Pantnagar (India) in the range of 8.33 to 14.83ml (Chaudhary, 2009; Bhavana, 2011; Devi, 2012). The volume and density of the cowpea seeds play an important role in numerous technological processes and in the evaluation of product quality (Taiwo, 1998).

Latunde-Dada (1993) reported the seed density of cowpea in the range of 0.91-1.28 g per ml. Seed density of nine improved cowpea varieties ranged from 1.05 g per ml to 1.31g per ml (Ajeigbe et al., 2008). Improved varieties of cowpea from Pantnagar (India) were reported to have seed density in the range of 1.03 to 1.54g per ml (Chaudhary, 2009; Bhavana, 2011; Devi, 2012).

Hydration capacity is dependent on the thickness of pericarp and on chemical composition of grain (Desikachar *et al*., 1982). Water absorption is related to cooking quality of beans and inversely correlated with hull thickness that in turn may be related to seed hardness, an important factor in dehulling**.** Seeds with a moderately attached seed coat absorbed more water than firmly attached seed coats (Olapade *et al*., 2002). Taiwo (1998) attributed increased water absorption of cowpea seeds to larger seed size. Hydration capacity of improved cowpea genotypes was 12.33 to 17.12g (Chaudhary, 2009; Bhavana, 2011; Devi, 2012).

Hardness in dried bean must be overcome by cooking in order to render them palatable, digestible and to inactivate antinutritional factors (Singh, 1999). Grain hardness depends on genotype, location, season, storage temperature, maturity, temperature during harvesting, moisture content and kernel size. Sefa-Dedeh *et al.* (1978) reported that the hardness of cooked cowpeas decreased with soaking time. Grain hardness of selected nine varieties of cowpea was ranged from 4.30 to 6.60 kgf (Ajeigbe et al., 2008)). Seed hardness recorded values between 6-8 kgf (Henshaw, 2008). Bhavana (2011) measured the hardness of cowpea grains in the range of 7.74-9.98kgf.

Water absorption characteristic represents the ability of a product to associate with water under conditions where water is limiting e.g. dough and pastes (Nwoji, 2004). Charanjeet et al. (1988) found water absorption capacity (WAC) as a criterion for good cooking quality. Chinma et al. (2008) documented the WAC of cowpea varieties in the range of 160 to 194 g per cent. High value of WAC is desirable for the improvement of mouth feel and viscosity reduction in food product (Oxarekua and Adeyeye, 2009).

Nutritional composition of cowpea

High protein (18-35per cent) and carbohydrate (50-60 per cent) contents, together with an amino acid pattern complementary to that of cereal grains, however, make cowpea a potentially important nutritional component in the human diet (Prinyawiwatkul et al., 1996). Matured cowpea seeds, either cooked or raw, have about the same values for proximate composition, amino acid spectrum, calcium and phosphorus, race elements, urease activity and metabolizable energy (Millamena and Lopez, 1986).

Cowpea seed is an important source of protein in many parts of the world (Phillips and McWatters, 1991; Sefa-Dedeh, 1978) and is prepared for consumption in grain split and ground forms. The chemical composition of cowpea seeds corresponds to that of most common edible legumes grown in arid and semi arid regions. The seeds also contain small proportions of O- carotene, thiamine, riboflavin, niacin, folic acid and ascorbic acid. The use of cowpea seeds as a vegetable provides cheap source of protein in vegetable dominated diets of underdeveloped nations. Fresh leaves and fast growing twigs of cowpea are often picked up and eaten like spinach (Bressani, 1985). Studies from IITA (Nigeria) have demonstrated that the addition of even a small amount of cowpea ensures the nutritional balance of the usual starchy diet of rural and urban poor of Africa (Singh et al., 1997).

Proximate composition

Moisture

The literature reviewed showed that the moisture content of cowpea as ranged from 6 to 13.4 per cent (Table 2). The variation in the moisture level of the varieties can be attributed to the time of harvest and storage condition since relative humidity of surrounding atmosphere affects moisture contents in legumes (Meiners et al., 1976). The moisture content found can help to suggest the stability in storage of flour, as higher the moisture content more the risk of spoilage of food material (Ghadge et al., 2008).

Protein

Pulses have high protein content, which is about twice that in cereals therefore they can help to improve the protein intake of meals wherein cereals are eaten in combination with pulses (Kushwaha et al., 2002). Proteins are mainly responsible for the bulk of water uptake (Sefa-Dedeh et al., 2001). Cowpea seeds contain varied amount of protein ranging from 19.96-33 g per cent (Table 2). Variations in the protein content may be due to environmental factors, such as geographical location and the growing season (Sathe et al., 1984). Variability in the protein content is also influenced by the genotypes (Bliss, 1975). The wide variation in the crude protein values can be attributed to the starch content in the mature seeds of cowpea (Omueti and Singh, 1987). Khan et al. (1979) conducted an experiment to study the nutritional quality of some improved varieties of legumes and found that the protein digestibility of cowpea varied between 87 to 92 per cent. Phillips and Adams (1983) reported the protein digestibility of whole cowpea seeds as 73 per cent. Marconi et al. (1990) conducted a comparative study on protein digestibility of cultivated and wild cowpea and reported that the protein digestibility of wild cowpea species was 77.9 per cent and that of cultivated was 80.9 per cent.

Ash

The inorganic constituent in the food-stuff is generally referred to as ash content. Total ash represents total mineral content in the sample (Sefa-Dedeh et al., 2001). Various workers have reported the ash content of cowpea is vary from 2.0 -4.59 g per cent (Table 2). The difference in the mineral composition of the soil at absorbing surface of the roots may lead to variation in the mineral content of the pulses (Tewari et al., 1977).

Fibre

Crude fibre is the residue that remains after a food sample has been subjected to the treatment by acid and subsequently followed by an alkali. Various workers had reported that crude fibre content in cowpea in the range of 2.0-6.9 g per cent (Table 2). Kay (1979) and Tindall (1983) documented the crude fibre content of cowpea varieties in the range of 1.7 per cent to 7.3 per cent. Omueti and Singh (1987) found a significant inverse relationship between seed weight of cowpea and crude fibre content.

Fat

The term crude fat includes true fat or glycerol, various fatty acids, chlorophyll and other pigments, sterols and esters of fatty acids. Most pulses contain only small quantities of fats which generally account to less than 3 per cent (Aykroyd and Doughty, 1982). Total lipid content of pulses varies with variety, origin, location, climate, seasonal and environmental conditions and type of soil in which they are grown (Pattee et al., 1982). The literature reviewed showed the fat content of cowpea ranged from 0.3-3.5 g per cent (Table 2).

Carbohydrate

The carbohydrate content of pulses is high and contributes a great deal to the energy supply of pulses (Reddy et al., 1984). According to various workers, the carbohydrate content of cowpea varied from 48.3 to 66.4 (Table 2).

Minerals

Pulses contain reasonable amount of nutritionally important minerals such as calcium and iron. It is reported that the mineral content of legumes is related to mineral absorption which is influenced by the composition of the soil at the absorbing surface of the roots (Tewari et al., 1977). Cowpeas are a source of essential minerals, calcium, magnesium, potassium, iron, zinc and phosphorus (Table 3). Farinu and Ingrao (1991) analyzed thirteen cultivars of cowpea for trace elements and the analysis showed that iron ranged from 37.1-49.3 ppm. Phillips and Mcwatters (1991) estimated calcium, copper, iron, magnesium, phosphorus, potassium, sodium and zinc and the values reported were 1100, 8, 83, 1840, 4250, 11100, 162 and 34 ppm, respectively. Ologhobo and Fetuga (1982) estimated the mineral content of ten cowpea cultivars and reported the phosphorus, calcium, potassium, sodium, manganese, iron and zinc to be ranging from 4000-4800, 800-900, 18800-21800, 260-400, 20-40, 35-60 and 53-85 ppm, respectively. Khan et al. (1979) documented the calcium, phosphorus, sulphur and iron content of cowpea in the range of 1400-1600, 5200-5400, 355-381 and 58-69 ppm, respectively. Towo et al. (2003) found that the total iron content of cowpea was 47.4 ppm and out of it 11.2% was accessible *in-vitro*. According to Gopalan et al. (1989), cowpea contains iron 86, calcium 770, phosphorus 4140, sodium 232, potassium 11310, zinc 46, manganese 13.4, copper 8.7 ppm of dry seeds. Akinyele and and Akinlosotu (1991) stated that fermentation led to a decrease in all the minerals calcium, iron, magnesium, zinc and potassium both at 16 h and 24 h of fermentation. This could be due to their utilization by the micro-organisms involved in fermentation. However, a 96.2% increase in phosphorus was observed at 24 h fermentation (Akinyele and and Akinlosotu (1991). Some minerals are lost when the seed coats are removed upon decortication (Mamiro et al., 2011). Calcium and iron content of improved varieties of cowpea developed at Pantnagar (India) were in the range of 863.3-1381.8 and 47.4-67.5 ppm, respectively (Chaudhary, 2009; Devi, 2012). Sprouting significantly increased the calcium content in cowpea by 5.94-9.97 per cent in the three improved grain cowpea varieties (Devi, 2012).

Vitamins

Cowpea seeds also contain small amounts of carotene, thiamin, riboflavin, niacin, vitamin A and folic acid. Vitamins are organic substances present in small amount in many foods. Pulses are rich sources of B-vitamins and they can contribute significantly to B-vitamin intake (Gopalan *et al*., 1989) (Table 4). Most legumes contain only small amounts of carotenoids (provitamin A) and little riboflavin (Aykroyd and Doughty, 1982). Ogunmodede and Oyenuga (1969; 1970) recorded considerable variation in vitamins content among thirty different varieties of cowpea. According to Akpapunam and Markakis (1981), the ground raw cowpeas and the processed flour contain thiamin 0.91 & 0.81, riboflavin 0.10 &0.09, niacin 2.30 & 1.59 mg/ 100g, respectively. Uzogara et al. (1991) studied vitamin retention in the alkaline cooking processes in cowpea and these ranged 15–20% (thiamin), 26–49% (niacin) & 53–64% (riboflavin). Soaking followed by boiling at 100°C or pressure cooking (121°C) increased levels and retention of vitamins (Uzogara et al., 1991).

Anti-nutrient factors in cowpea

Despite the potential of cowpea in upgrading diets of the poor people of the world, there are certain constraints to optimal utilization of cowpea as food. These are attributed to factors such as pest infestation of the beans, beany flavour, extended cooking time and presence of antinutrients that cause low digestibility and abdominal upsets.

Marconi et al. (1990) conducted a comparative study on tannin content of cultivated and wild cowpea and reported that the tannin content of wild cowpea species is 13.5 mg/100 g and that of cultivated is 0.5mg/100 g (Table 5). According to Ologhobo and Fetuga (1983) the tannic acid content of cowpea varied between 0.42 to 0.66 per cent on dry matter basis. Rao and Prabhavathi (1982) reported the tannin content of cowpea as 175 mg/100 g. Ogun et al. (1989) reported that tannins were eliminated by dehulling (which was applied in preparing moin-moin), indicating that only the testa of cowpea contained these substances.

Farinu and Ingrao (1991) reported the phytic acid content of 13 cowpea cultivars to be ranging from 510 to 1027 mg/100 g. Towo et al. (2003) reported the phytate content of cowpea in the range of 846 to 1318 mg/100 g. Cowpea is reported to contain 280 to 330 mg/100g phytic acid on dry matter basis (Ologhobo & Fetuga, 1983). Reddy et al. (1982) stated that unlike tannins, phytate concentration is increased by dehulling because it is located in the cotyledonous fraction of the seed.

Dehulling helps in eliminating the tannins however phytic acid was not affected by any of the treatments (cooking, hot soaking, cold soaking – dehulling) (Ogun et al., 1989). Akinjayeju and Enude (2002) conducted a study to see the effect of dehulling on some properties of cowpea flours. Results showed that proximate composition and physical properties of cowpea meal were not significantly affected by dehulling. Rao and Prabhavathi (1982) suggested that dehulling should be encouraged as it decreases the stachyose and removes tannins, the latter being known to render ionizable dietary iron unavailable to the body. In cowpea, antinutritional factors can be easily avoided with appropriate dehulling and heat treatment (Tewari et al., 2004).

Tuan and Phillis (1991) reported that cowpea seeds stored under conditions (high temperature and high humidity) easily get the hard-to-cook defect, which reduced the protein digestibility. This negative effect on protein digestibility may have been due to interactions between proteins and phenolic acids.

Udensi et al. (2007) studied the effect of boiling, roasting and autoclaving on the levels of some antinutrients present in cowpea. The reduction of trypsin inhibitors was found to be highest (100 per cent) with autoclaving at 60 minutes. Boiling was effective in reducing phytic acid (68.34 per cent) and haemagglutinin (75.98 per cent) at 60 minutes than any other processing treatments at the same time.

Onayemi et al. (1986) reported that in-vitro protein digestibility was 61 per cent for freshly harvested cowpea and after six months storage in jute bags it decreases to 59 per cent. Abbey and Ibeh (1988) found water absorption by the raw and heat processed cowpea flours was 2.4 and 3.6 g/g respectively. Tuan and Phillips (1991) reported that on storage of cowpea seeds, hardness and cooking time of cowpea increased.

Extrusion cooking is one of the food processes which destroys naturally occurring toxic substances and also increase digestibility of proteins and carbohydrates in a food (Harper, 1981; Tuan and Phillips, 1991). Extrusion cooking is a popular means of preparing snacks and ready to eat foods and is used for processing of starch as well as proteinacious material. Extrusion cooking seems to be the apt process for seeds. Compared with other pulses it is less expensive (Farzana et al., 1996) with almost same nutritive value.

The protein efficiency ratios of extruded cowpea products were found to be significantly higher (1.8-2.0) than the raw food materials (1.4). *In vitro* protein digestibility values gave similar results, with lower values for raw and steamed/ drum-dried meals (78per cent and 81per cent) and higher values for extrudates (83-85per cent) (Chinnan et al., 1985). Extrusion cooking gelatinizes the starch, denatures the protein, inactivates many raw food enzymes which can cause food deterioration during storage, destroys naturally occurring toxic substances such as trypsin inhibitors and reduces microbial count in final product (Harper, 1981).

Tuan and Phillips (1991) reported that the in-vitro protein digestibility of extruded cowpeas was 79.9 per cent and that of raw flour was 74.1per cent, which implicates that extrusion cooking has a positive influence on the digestibility of cowpea proteins. Therefore extrusion cooking seems to be the apt process for promoting utilization of cowpea in the form of ready to eat snack.

Culinary uses and processing of cowpea

The young leaves, green pods and seeds are used as vegetable, while several snacks and meals are also prepared from the seeds. With its increasing significance as a multipurpose crop in agriculture and human nutrition, cowpea deserves more attention towards its utilization into novel uses. The cowpea can be used to produce a large range of dishes and snacks (Table 5). The erstwhile research has emphasized expanding the utilization of cowpea in the form of meal and flour for use as a functional ingredient in food products. Various researches have shown that cowpea could be used as functional food ingredient in many recipes like *akara*, *halwa*, *idli*, *laddu* and *papad*, wherein it replaced the conventional ingredient like Bengal gram and Black gram (Kushwaha, 2009; Bhagirathi et al., 1992). Cowpea can be converted to a variety of recipes, for example, cooked dehulled or under dehulled foods, fried sponge called "Akara", steamed paste such as "Moin-Moin", fermented foods such as "Tutic" in Brazil, "Idli" and "Dosa" in India or it can be made into soups and stews.

Different food products like *akara, halwa, idli, laddu* etc., made from cowpea were palatable and highly acceptable. This demonstrated the potential of cowpea flour in successfully replacing Bengal gram flour, which is the conventional ingredient of such recipes (Kushwaha, 2009). Utilization of cowpea in both infant and adult foods is recommended in the preparation of traditional and novel products in order to avert the perennial problem of malnutrition in developing countries (Uzogara and Ofuya, 1992).

There are several dishes using cowpea flour produced in the household (cake, pie, stew, fritters, buns, pancake, pudding and chips) and these provide a varied nutritious diet and have added desirable attributes, which include easy cooking, availability and favourable taste. Although, a large number of food processors are aware of the new cowpea utilization technologies (Nyankori et al., 2002).

In India, cowpea seeds are mostly utilized in the boiled form. Bhagirathi et al. (1992) determined the physicochemical and sensory characteristics of cowpea papads and compared it with the blackgram papads. Dough making, rolling properties, physical appearance and proximate composition were similar in both the papads. Interestingly, cowpea papads were rated to be highly acceptable by both trained and untrained panels. Varietal differences of cowpea did not affect the quality characteristics of the papads. The results revealed that cowpea flour has all the desirable functional properties for making papads; hence cowpea flour makes an excellent raw material for the papad industry. According to Siegal and Fawcett (1976), cowpea seeds can be processed into flour or powder, protein concentrate and starch isolates.

Table 1: Physical characteristics of raw whole cowpea seeds

References	Varieties studied	Seed weight (g/100seeds)	Seed volume (ml/100seeds)	Seed density (g/ml)	Hydration capacity (g/ 100 seeds)	Hydration index	Grain hardness (KgF)
International studies (Botanical characters not reported)							
Kabas et al. (2007)	8	19.78-21.56	-	-	-	-	-
Henshaw (2008)	28	10.1-25.8	-	-	-	-	-
Amonsou et al. (2009)	3	14-18	-	-	-	-	-
Singh (2010)	20	6.378-15.143	0.8-1.6cc/25 seeds	-	-	-	-
Tchiagam et al. (2011)	10	16.51-25.06	-	-	-	-	-
Improved varieties from Nigeria (Erect type)							
Onayemi et al. (1986)	1				17.2mg/seed		
Omueti and Singh (1987)	37	10.4-24.3	-	-	-	-	-
Latunde-Dada (1993)	12	10.03-20.1	-	0.90-1.28	-	-	-
Ajeigbe et al. (2008)	9	13.03-18.87	15.25-19.0/ 20g seeds	1.05-1.35	23.5-31.75ml/ 20g seeds	-	4.3-6.6
Sobukola and Abayomi (2010)	4	14.04-19.28					
Ileke et al. (2013)	31	10-33	-	-	-	-	2.0-4.07 (19.64-39.87N)
Improved varieties from Pantnagar, India (Erect type)							
Chaudhary (2009)	2	12.78-14.61	12.34-13.48	1.03-1.08			
Bhavana (2011)	4	13.64- 15.41	10.16- 14.83	1.04-1.35	15.09-17.12	-	7.74-9.92
Devi (2012)	3	11.44-14.85	8.33-13.5	1.1-1.54	12.33-16.37	0.83-1.28	-

- Values are not reported

Table 2: Comparative values of proximate composition of raw whole cowpea seeds

References	Cultivar studied	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)	Energy Kcal/100g
Improved varieties from Nigeria (Erect type)								
Phillips (1982)	-	13	-	-	-	-	-	-
Phillips and Mcwatters (1991)	-	12	-	24	1.3	-	60	340
Ajeigbe et al. (2008)	9	-	3.37-4.59	21.29-26.85	1.2-1.8	-	-	-
International studies (Botanical characters not reported)								
Longe (1980)	20	6-13	2-5	24-33	1-2	2-5	-	-
Rosario et al. (1981)	18	-	-	19.96-24.4	0.3-1.12	-	-	-
Ologhobo and Fetuga (1982)	-	7.1	4.24	25.21	1.96	3.21	-	-
Bressani (1985)	8	-	3.4-3.9	24.1-25.4	1.1-3.0	5.0-6.9	60.8-66.4	340
Bressani (1985)	-	11	3.4-3.9	22-24	1.3-1.5	-	54-66	-
Omueti and Singh (1987)	37	-	2.6-4.2	20.3-29.05	1.6-2.8	2.7-5.8	-	-
Kantha and Erdman (1987)	-	11.5	3.2	22.7	1.6	4.2	61	349
Farinu and Ingrao (1991)	13	10.1-10.84	4.09-4.49	21.8-28.38	-	-	52.65-59.31	-
Nugdallah (1996)	-	7.0-7.7	3.7-4.2	27.5-29.6	1.3-1.7	2.5-2.9	-	-
Richana and Damardjati (1999)	-	9.1	3.37	26.41	2.14	6.64	-	-
Towo et al. (2003)	-	9.7	-	21.7	2.4	-	-	-
Akinjayeju and Bisiriyu (2004)	-	9.4-9.8	-	-	-	-	-	-
Kabas et al. (2007)	8	-	9.42	20.31	-	-	-	-
Carvalho et al. (2012)	30	-	3.3-4.6	17.4-28.3	1.0-1.6	-	33.7-55	-
Indian studies (Botanical characters not reported)								
Khan et al. (1979)	-	-	3.0-3.3	25.7-27.4	3.1-3.5	4.8-6.1	48.3-52.4	-
Gopalan et al. (1989)	-	13.4	3.2	24.1	1	3.8	54.5	323
Preet and Punia (2000)	4	-	-	20.07-24.60	1.77-1.96	-	-	-
Tewari et al. (2004)	-	-	-	24.1	1	-	54	-
Ramchandra et al. (2004)	-	-	4.23	-	-	-	-	-
Improved varieties from Pantnagar, India (Erect type)								
Chaudhary (2009)	2	12.09-12.58	3.8-4.4	26.7-30.47	0.93-1.35	2.42-4.52	48.18-52.54	-
Devi (2012)	3	6.91-9.78	3.78-4.26	24.99-27.15	2.63-2.91	4.26-4.99	56.97-62.01	376-381

- Values are not reported

Table 3: Comparative values of mineral composition (ppm) of raw whole cowpea seeds

References	Cultivar studied	Micro-minerals				Macro-minerals				
		Fe	Zn	Mn	Cu	P	K	Ca	Mg	Na
Improved varieties from Nigeria (Erect type)										
Omueti and Singh (1987)	37	80-160	-	-	-	3000-4400	7500-15500	280-680	1350-2650	400-1200
Latunde-Dada (1993)	12	47-75.5	-	-	-	-	-	-	-	-
Ojimelukwe et al. (1999)	2	-	-	-	4-6	4800-5600	5500-8000	7500	3000	-
Owolabi et al. (2012)	5	4.8-23.3	2.3-6.6	-	-	-	156.7-186.9	150-368	76.7-185	4.0-6.0
International studies (Botanical characters not reported)										
Khan et al. (1979)	3	58-69	-	-	-	5200-5400	-	1400-1600	-	-
Ologhobo and Fetuga (1982)		35-60	53-85	20-40	-	4000-4800	18800-21800	800-900	-	260-400
Aletor and Aladetimi (1989)	5	-	-	-	-	3.3-30.0	12600-16000	400-800	2200-2700	100-200
Akinyele and Akinlosotu (1991)	2	169	45	-	-	-	12360	446	905	-
Farinu and Ingrao (1991)	13	39.4-53.9	22.4-38.8	-	-	-	-	-	-	-
Prinyawiwatkul et al. (1996)[#]	-	83	34	-	8	4250	11100	1100	1840	162
Towo et al. (2003)	1	47.4	-	-	-	-	-	-	-	-
Asante et al. (2007)	30	-	nd-2082	10-57.5	nd-12.3	-	-	nd-2096	-	-
Alain et al. (2007)	2	123.8-193.9	8.9-93.3	-	-	-	-	68.3-73.5	-	-
Frota et al. (2008)	1	68	41	15	-	5100	14300	-	-	-
Mamiro et al. (2011)	15	9.24-23.79	17.09-28.34	-	-	-	-	320.47-1112.94	-	-
Boukar et al. (2011)	1541 accessions	33.6-79.5	22.1-58	-	-	3450-6750	11400-18450	310-1395	1515-2500	-
Madode et al. (2012)	20	55.7-104.3	36.7-54.1	-	-	-	-	661.6-1444.5	-	-
Ayan et al. (2012)	2	-	-	-	-	3400-3700	13600-16500	10400-13200	4600-5100	-
Carvalho et al. (2012)	30	61-81	27-44	17-24	20-22	-	9570-12510	290-510	1310-1690	84-177
Alayande et al. (2012)	2	56.6	-	-	5.8-6.0	-	7412.9-7680.5	1604-1820	1899.1-1953.3	781.5-846.5
Belane and Dakora (2012)	27	48-97	33-65	21-43	5-8	3800-4700	11400-16400	370-1130	1300-2400	-
Indian studies (Botanical characters not reported)										
Goplan et al. (1989)	-	86	46	13.4		4140	11310	770	2100	232
Sinha et al. (2005)	5	63.6-103.6	-	-	-	4305.5-5471.8	-	773.3-950.0	-	-
Improved varieties from Pantnagar (Erect type)										
Chaudhary (2009)	2	47.4-64.3	-	-	-	-	-	863.3-856.7	-	-
Devi (2012)	3	48.4-67.5	-	-	-	-	-	1059.9-1381.8	-	-

- Values are not reported; nd: below detection limit; #= values @12% moisture

Table 4: Comparative values of vitamin composition (mg/100g) of raw whole cowpea seeds

References	Cultivar studied	Thiamine	Riboflavin	Niacin	Folic acid	Beta-Carotene	Vitamin C	Alpha tocopherol	Delta tocopherol
Elias et al. (1964)	8	0.41-0.99*	0.29-0.76*	2.51-3.23*	-	-	-	-	-
Ogunmodede and Oyenuga (1969)	30	0.534-1.437	0.106-0.322	0.711-1.608	-	-	-	-	-
Ogunmodede and Oyenuga (1970)	30	-	-	-	0.135-0.189	-	-	-	-
Akpapunam and Markakis (1981)	1	0.91	0.1	2.3	-	-	-	-	-
Onayemi et al. (1986)	1	10.3	-	-	-	-	-	-	-
Nnanna and Phillips (1989)	1	1.70	0.16	2.97	-	-	-	-	-
Uzogara et al. (1991)	1	0.771	0.25	3.479	-	-	-	-	-
Akinlosotu and Akinyele (1991)	2	0.87	-	3.75	-	-	0-2.5	-	-
Prinyawiwatkul et al. (1996)	-	0.9	0.2	2.0	0.6	-	-	-	-
Ofuya (2006)	-	0.61 to 1.08	-	-	-	-	-	-	-
Carvalho et al. (2012)	7							0.02-0.38g/kg	0.79-1.90g/kg
Nielson et al. (1997)	-	1.05	0.21	2.2		0.02			
Indian studies (Botanical characters not reported)									
Gopalan *et al.* (1989)	-	0.51	0.2	1.3	133	12	0	-	-

- Values are not reported; *= values @10% moisture; #= values @12% moisture

Table 5: Comparative values of anti-nutritients content in raw whole cowpea seeds

References	Cultivar studied	Oligosaccharides (g/100g)				Phytic acid (mg/g)	Oxalate (mg/g)	Trypsin inhibitor activity (TIU/100g)	PIA (µmol tyr/ min/mg)	CIA (CIU/mg)	Alpha-amylase inhibitor	Lectins as HU activity	Tannins (mg/g)	Polyphenols (mg/g)	Cyanogenic glycoside (mg/kg)
		R	S	V	T										
Improved varieties from Nigeria (Erect type)															
Giami (2005)	4	-	-	-	-	1.15-2.1	-	-	-	-	-	-	-	0.99-1.96	-
International studies (Botanical characters not reported)															
Akpapunam and Achinewhu (1985)	1	-	-	-	-	5.9	-	-	-	-	-	-	-	-	-
Phillips and Abbey (1989)		0.29-0.47	1.65-2.23	0.38-0.6	-	-	-	-	-	-	-	-	-	-	-
Akinyele and and Akinlosotu (1991)	2	1.95	3.56	4.03	9.54	-	-	-	-	-	-	-	-	-	-
Farinu and Ingrao (1991)	13	-	-	-	-	5.1-10.3	-	-	-	-	-	-	-	-	-
Carnovale et al. (1991)	14	-	-	-	-	-	-	9.91-51.56 TIU/mg					Tr-3862 mg/100g		
Somiari and Balogh (1993)	3	2.2-2.8	3.3-4.8	-	-	-	-	-	-	-	-	-	-	-	-
Marconi et al. (1993)	22	-	-	-	-	-	-	9.01-46.7 TIU/mg	-	nd-55.8 CIU/mg	-	13-1173	-	-	-
Prinyawiwatkul et al. (1996)	-	0.4-1.2	2.0-3.6	0.6-3.1	-	-	-	-	-	-	-	-	-	-	-
Harijono et al. (2001)	1	-	-	-		332.08	-	31.5	61.87	-	-	100%	-	-	-
Ibrahim et al. (2002)	1	0.52	2.04	-		4.54 g/100g	-	29.65 TIU/mg	-	-	-	-	210.17 mg/100g	-	-
Egounlety and Aworh (2003)	1	0.78	3.53	-	-	-	-	-	-	-	-	-	-	-	-
Towo et al. (2003)	1	-	-	-	-	13.18 mg/g	-	-	-	-	-	-	-	-	-
Afiukwa et al. (2012)	101	-	-	-	-	2.58-3.91	0.57-0.99	14.98-27.93 TUI/mg	-	-	-	5.10-83.00 HU/mg	2.14-4.21	-	370.0-402.0
Aguilera et al. (2013)	1	-	-	-	-	-	-	3.4mg/g	-	1.6mg/g	nd	nd	-	-	-
Carvalho et al. (2012)	30	-	-	-	-	-	-	2.3-3.8 (TIU/mg)	-	2.2-4.2 (CIU/mg)	-	40000-360000 HU/kg flour	-	-	-
Indian studies (Botanical characters not reported)															
Preet and Punia (2000)	**4**	-	-	-	-	818.46-949.89 mg/100g	-	-	-	-	-	-	-	778.82-934.48 mg/100g	-
Ghavidel, and Prakash, (2007)	**1**	-	-	-	-	0.6 g/100g	-	-	-	-	-	-	0.47 g/100g	-	-
Sreerama et al. (2012)	**1**	1.03	1.78	0.36	3.17	14	-	6981TIU/g	-	-	-	-	-	10.8	-
Improved varieties from Pantnagar (Erect type)															
Devi (2012)	3	-	-	-	-	308.83-380.84 mg/100g		5.64-6.03 TIU/mg	-	-	-	-	-	-	-

- Values are not reported; nd: below detection limit; R=Raffinose; S=Stachyose, V=Verbascose; T= Total oligosaccharides; PIA= Protease inhibitor activity; tyr=tyrosine; HU= Haemagglutination; CIA= Chymotrypsin inhibitor activity; TIU=Trypsin inhibited units; CIU=Chymotrypsin inhibited units; Tr=Traces

Table 6: Culinary uses of cowpea

References	**Name of recipe**	**Cooking/ Processing method**	**Form of cowpea**
Goyal (1996)	Cowpea curry	Soaking and pressure cooking	Whole seeds
	Cowpea Cutlets	Soaking and frying	
	Cowpea *paneer* and cowpea *paneer* curry	Boiling, grinding and frying	
	Sprouted pulses salad	Soaking and sprouting	
	Cowpea kachori	Boiling, mixing, fryimg	
	Cowpea chutney	Roasting, grinding and tempering	
	Cowpea poshak mix	Roasting and grinding	
	Paustik khichdi	Soaking and cooking	
	Cowpea porridge/ dalia	Soaking, dehulling, coarse grinding, cooking	Cotyledons without hulls
	Cowpea poshak laddoo	Roasting, grinding, mixing	Whole cowpea flour
	Cowpea biscuits	Sifting. Mixing and baking.	
	Cowpea puri	Kneading into a dough, frying	
	Cowpea bati	Kneading and baking/ frying/ roasting	
	Stuffed cowpea parantha	Kneading, stuffing and shallow frying.	
	Muffin	Baking	
	Rabri	Boiling/ concentration	
	Cowpea chikki	Sauteing	
	Papad	Frying/ baking/ puffing/ flaking	
	Gatta curry	Kneading boiling and frying	
	Poshtik soup	Pressure cooking, grinding and boiling	
	Idli	Soaking, grinding, fermenting	
Prinyawiwatkul et al. (1996)	Bread	Baking	Cowpea flour
	Baby/ complementary food	Malting/ fermentation	
	Chips	Frying/ baking/ puffing/ flaking	
	Papad/ tortillas	Frying/ baking/ puffing/ flaking	
	Biscuits/ doughnuts/ muffins	Baking/ frying	
	Extruded snacks	Extrusion cooking	
	Noodles	Extrusion without high temperature/ pressure	
	Milk	Soaking, grinding	Whole seeds
	Patties	Soaking, grinding, cooking	
	Moin-moin	Soaking, grinding, steaming	
	Akara	Soaking, grinding, frying	
Kushwaha (2009)	Halwa	Soaking, grinding and frying	Whole seeds
	Dahi vada	Soaking, grinding and frying	
	Dhokla	Steaming	

CONCLUSION

Cowpea is an important food and feed crop traditionally grown in arid regions of the developing world and often considered as minor/ underutilized/ poor man's pulse. Its innate climate resilience suggests its scope as a suitable alternative in the present climate change era. It is a treasure trove of various therapeutic, bioactive compounds along with excellent nutritional quality makes it a wholesome food that should be added to diet on a regular basis. Furthermore, there are still great possibilities exist for this legume to be explored for its nutraceutical properties, toxicological consequences, innate health-promoting aspects and many undiscovered phytochemicals as well as there is need to promote and support the initiatives that make the most use of this indigenous underutilized legume to address food and nutritional security issues.

REFERENCES

Abbey, B.W. & Ibeh, G.O. (1988). Functional properties of raw and heat processed cowpea (*Vigna unguiculata*) flour. *Journal of Food Science*. *53*(6), 1775-1777.

Aguilera, Y., Díaz, M.F., Jimenez, T., Benítez, V., Herrera, T., Cuadrado, C., Martín-Pedrosa, M. & Martín-Cabrejas, M.A. (2013). Changes in non nutritional factors and antioxidant activity during germination of nonconventional legumes. *J. Agric. Food Chem*. *61*, 8120−8125.

Ahlawat, I.P.S. & Shivkumar, B.G. (2005). Kharif Pulses. In E. Prasad Ed. *Textbook of Field Crops Production* (pp. 264-266). New Delhi: Indian Council of Agricultural Research.

Ajeigbe, H.A., Ihedioha, D. & Chikoye, D. (2008). Variation in physico-chemical properties of seed of selected improved varieties of cowpea as it relates to industrial utilization of the crop. *African Journal of Biotechnology*. *7*(20), 3642-3647.

Akinjayeju, O. & Enude, O.T. (2002). Effects of dehulling on some properties of cowpea (*Vigna unguiculata* L. Walp) flours. *Italian Journal of Food Science*. *14*(1), 53-58.

Akinjayjeju, O. & Bisiriyu, K.T. (2004). Comparative studies of some properties of, undehulled, mechanically dehulled and manually dehulled cowpea (*Vigna unguiculata* (L) Walp) flours. *International Journal of Food Science & Technology*. *39*(4), 355-360.

Akpapunam, M.A & Markakis, P. (1981). Physiochemical & nutritional aspects of cowpea flour. *Journal of Food Science*, *46*, 72.

Alain, M.M.M., Israël, M.L. & René, M.S. (2007). Improving the nutritional quality of cowpea and Bambara bean flours for use in infant feeding. *Pakistan Journal of Nutrition*, *6*(6), 660-664.

Alayande, L.B., Mustapha, K.B., Dabak, J.D. & Ubom, G.A. (2012). Comparison of nutritional values of brown and white beans in Jos North local government markets. *African Journal of Biotechnology*, *11*(43), 10135-10140.

Aletor, V.A. & Aladetimi, O.O. (1989). Compositional evaluation of some cowpea varieties and some under-utilized edible legumes in Nigeria. *Die Nahrung 33*(10), 999-1007.

Allen, D.J. (1983). The Pathology of Tropical Food Legumes. Chichester: John Wiley & Sons.

Amonsou, E.O., Houssou, P.A., Sakyi-Dawson, E. & Saalia, F.K. (2009). Dehulling characteristics, sensory and functional properties of flours from selected cowpea varieties. *J Sci Food Agric*, *89*, 1587–1592.

Asante, I.K., Adu-Dapaah, H. & Acheampong, A.O. (2007). Determination of some mineral components of cowpea (*Vigna unguiculata* (L.) Walp) using instrumental neutron activation analysis. *West African Journal of Applied Ecology*, 11(1). 10.4314/wajae.v11i1.45721.

Asiamah K. (2004). Cowpea, The ‘poor man's meat' is now food for all. *African Journal of Food Agriculture Nutrition and Development*. *4*(2), 231-232.

Ayan I., Mut, H., Mut, H., Basaran, U., Acar, Z. & Onal, O. (2012). Forage potential of cowpea (*Vigna unguiculata* L. Walp). *Turkish Journal of Field Crops*, *17*(2),135-138.

Aykroyd, W. R. & Doughty, J. (1982). Legumes in human nutrition-food and nutrition paper. Rome, FAO.

Bhagirathi, L., Asna, U. , Puttaraj, S. (1992). Utilization of cowpea in the preparation of papad. *Journal of Food Quality*. *15*(5), 349-355.

Boukar, O., Massawe, F., Muranaka, S., Franco, J., Maziya-Dixon, B., Singh, B. & Fatokun, C. (2011). Evaluation of cowpea germplasm lines for protein and mineral concentrations in grains.

Plant Genetic Resources, Characterization and Utilization, *9*(4), 515–522.

Bressani, R. (1985). Nutritive value of Cowpea. In, S.R. Singh & K.O. Rachie (Eds.). *Cowpea Research, Production and Utilization* (pp 353), John Wiley & Sons Ltd.

Carvalho, A.F.U., de Sousa, N.M., Farias, D.F., da Rocha-Bezerra, Lady C.B., da Silva, R.M.P., Viana, M.P., Gouveia, S.T., Sampaio, S.S., de Sousa, M.B., de Lima, G.P.G., Morais, S.M., Maia de, S., Barros, C.C., Costa, C. & Filho, F.R.F. (2012). Nutritional ranking of 30 Brazilian genotypes of cowpeas including determination of antioxidant capacity and vitamins. *Journal of Food Composition and Analysis*, *26*, 81–88.

Charanjeet, K., Jasbir, H., Kanwar, K., Gupta, N. & Kochhar, A. (1988). Nutritional evaluation of the rice-bean (*Vigna umbellata*). *Journal of Food Science and Technology*. *25*(3), 133-136.

Chaudhary, P. (2009). Nutritional quality of improved varieties of cowpea and acceptability of cowpea incorporated extruded snack. (M.Sc. thesis). G.B. Pant University of Agriculture and Technology, Pantnagar.

Chinma, C.E., Alemede, I.C. & Emelife, I.G. (2008). Physicochemical and functional properties of some Nigerian cowpea varieties. *Pakistan Journal of Nutrition*. *7*(1), 186-190.

Chinnan, M. S., McWatters, K. H., Beuchat, L. R., Phillips, R. D. & Worthington, R. E. (1985). Cowpea processing, utilization and nutrition. Workshop on utilization of grain legumes and grain, groundnut, bean, sorghum, millet. University of Georgia.

Desikachar, H.S.R. (1989). Development of weaning foods with high calorie density and low hot- paste viscosity using traditional technologies. *Food Nutrition Bull*, *4*,21-23.

Devi, C.B. (2012). Evaluation of nutrient composition and acceptability of sprouts of selected cowpea (*Vigna unguiculata*) genotypes. (M.Sc. thesis). G.B. Pant University of Agriculture and Technology, Pantnagar.

Elias, L.G., Bressani, R. and Colindre, R. (1964). Nutritive value of 8 varieties of cowpea (*Vigna sinensis*). *Journal of Food Science*, *29*, 118-122.

Erskine, W., Williams, P. C. & Nakoul, H. (1985). Genetic and environmental variation in the seed size, protein, yield and cooking quality of lentils. *Field Crops Research*, *12*, 153-161.

Farinu, G.O. & Ingrao, G. (1991). Gross composition, amino acid, phytic acid and trace elements content of thirteen cowpea cultivars and their nutritional significance. *J. Sci. Agric*. 55, 401-410.

Farzana, C., Shivaleela, H.B., Gouramma, T.S. and Surendra, H.S. (1996). Physico chemical and functional characteristics of cowpea varieties. *Current Research*, *25*, 125-127.

Frota, K. de M.G., Soares, R.A.M. & Areas, J.A.G. (2008). Chemical composition of cowpea (*Vigna unguiculata* L. Walp), BRS-Milênio cultivar. *Ciênc. Tecnol. Aliment.*, *28*(2), 470-476.

Ghadge, P.N., Vairagar, P.K., Prasad, K. (2008). Physical properties of chickpea splits (*Cicer arietinum* L.). *Agricultural Engineering International*, *10*, 200-208.

Ghavidel, R.A. & Prakash, J. (2007). The impact of germination and dehulling on nutrients, antinutrients, *in vitro* iron and calcium bioavailability and *in vitro* starch and protein digestibility of some legume seeds. *LWT Food Science & Technology* , *40*,1292–1299.

Giami, S.Y. (2005). Compositional and nutritional properties of selected newly developed lines of cowpea (*Vigna unguiculata* L. Walp). *Journal of Food Composition and Analysis*, *18*(7), 665-673.

Gopalan, C., Ramashastri, B.V. and Balasubramanium, S.C. (1989). Nutritive Value of Indian Foods.

National Institute of Nutrition. ICMR, Hyderabad.

Haq, N. (2011). Underutilized food legumes, Potential for multipurpose uses. In A. Pratap & J. Kumar (Eds., pp. 335-336), *Biology & Breeding of Food Legumes*. Oxfordshire, CABI.

Harijono, Mutiara, T. & Rakhmadiono, S. (2001). Some changes on enzymic activities, compositional and antinutritional factors of an Indonesian cowpea (*Vigna unguiculata* (L) Walp) cultivar undergoes germination and a mild heating process, *Jurnel Teknologi Pertanian, 2*(3), 164-171.

Harper, J.M. (1981). Extrusion of Foods. (Vol.1). Boca Raton, CRC Press.

Henshaw, F.O. (2008). Varietal Differences in Physical Characteristics and proximate composition of cowpea (*Vigna unguiculata*). *World Journal of Agricultural Sciences*, *4*(3), 302-306.

https://farmers.gov.in and

https://mkisan.gov.in

https://plantvillage.psu.edu/topics/cowpea/infos

Ileke, K.D., Odeyemi, O.O. & Ashamo, M.O. (2013). Varietal resistance of some cowpea cultivars to cowpea bruchid, callosobruchus maculatus (Fab.) [coleoptera: chrysomelidae] infestation. *FUTA Journal of Research in Sciences*, *1*, 72- 81.

Kabas, O., Yilmaz, E., Ozmerzi, A. & Akinci, I. (2007). Some physical and nutritional properties of cowpea seed (*Vigna sinensis* L.). *Journal of Food Engineering 79*, 1405–1409.

Kantha, S. S. & Erdman, J. W. (1987). Legume carotenoids. *Critical Reviews in Food Science and Nutrition*. *26*(2), 137-139.

Kay, D. E. (1979). Food Legumes. London, Tropical Development and Research Institute.

Khan, M.A., Jacobsen, I. & Eggum, B.O. (1979). Nutritive value of some improved varieties of legumes. *J. Sci. Food Agric*. *30*, 395-400.

Kushwaha, A. (2009). Income generation in food services through sale of cowpea products. *Defense Food Science Magazine*. *17*, 52-54.

Kushwaha, A., Rajawat, P. & Kushwaha, H. (2002). Nutritional evaluation of extruded faba bean (*Vicia faba* L.) as a protein supplement in cereals based diets in rats. *Journal of Experimental Biology*. *40*(1), 49-52.

Latunde- Dada, G.O. (1993). Iron content and some physical component of twelve cowpea cultivars. *International Journal of Food Science and Nutrition*. *43*(4), 193-197.

Madode, Y.E., Houssou, P.A., Linnemann, A.R., Hounhouigan, D.J., Nout, M.J.R. & van Boekel, M.A.J.S. (2011). Preparation, consumption, and nutritional composition of West African cowpea dishes. *Ecology of Food and Nutrition, 50*(2), 115-136.

Madode, Y.E., Linnemann, A.R., Nout, M.J.R., Vosman, B., Hounhouigan, D.J., van Boekel, M.A.J.S. (2012). Nutrients, technological properties and genetic relationships among twenty cowpea landraces cultivated in West Africa. *International Journal of Food Science and Technology*. doi,10.1111/j.1365-2621.2012.03146.x

Magbagbeola, J.A.O., Adetoso, J.A. & Owolabi O.A. (2010). Neglected and underutilized species (NUS), A panacea for community focused development to poverty alleviation/poverty reduction in Nigeria. *J. Economics and International Finance*, *2*(10), 208-211.

Mamiro, P.S., Mbwaga, A.M., Mamiro, D.P., Mwanri, A.W. & Kinabo, J.L. (2011). Nutritional quality and utilization of local and improved cowpea varieties in some regions in Tanzania. *African Journal of Food, Agriculture, Nutrition and Development*, *11*(1), 4490-4506.

Marconi, E, Lombardi- Baccia, G., Carnovale, E. & Ng, N.Q. (1990). Nutritional evaluation of wild and cultivated species of cowpea. In N.Q. Ng & Monti, L.M. (Eds., pp. 101-110), *Cowpea Genetic Resources*, IITA, Nigeria.

Marconi, E., Ng, N.Q. & Carnovale, E. (1993). Protease inhibitors and lectins in cowpea. *Food Chemistry* 47, 37-40.

Meiners, C.R., Derise, N.L., Lau, H.C., Crews, M.G., Ritchey, S.J. & Murphy, E.W. (1976). The content of nine mineral elements in raw and cooked mature dry legumes. *Journal of Agricultural and Food Chemistry*. *24*, 1126-1130.

Millamena, A.A. & Lopez, P.L. (1986). Cowpea (*Vigna unguiculata* Walp) as potential substitute for soyabean oil meal. *Phillipine J. Vet. Ani. Sci.* 12(2-3), 63-64.

Ng, N.Q. & Marechal, R. (1985). Cowpea taxonomy, origin and germplasm. In S.R. Singh & K.O. Rachie (Eds., pp 11-12), *Cowpea Research, Production and Utilization*. Britain: John Wiley & Sons.

Nielson, S.S., Ohler, T.A., Mitchell, C.A. (1997). Cowpea leaves for human consumption, production, utilization and nutritional composition. In, Advances in Cowpea Research. Singh, B.B., Raj, D.R.M., Dashiell, K.E. & L.E.N. Jackai (Eds., pp. 326-332), Ibadan, Nigeria: IITA.

Nugdullah, G.A. (1996). Protein fractions and the effect of cooking on cowpea proteins (Sudan). Khartoum (Sudan). pp63.

Nwoji, V.C. (2004). Effect of processing on the storage stability and functional properties of cowpea (*Vigna unguiculata*) flour in the production of cowpea bean (akara) and paste (moin-moin). In, Proced. 29th Annual Conference of Nigeria Institute of Food Science and Tech. (NIFST). pp 199.

Nyankori, J.C.O, Wabukawo, V., Sakyi-Dawson, Esther & Sefa-Dedah, S. (2002). Product Life Cycle Model of Cowpea Based Products in Ghana. South Carolina Agricultural Experiment Station, Clemson University, Clemson.

Ogle, W.L., Witcher, W. & Barnett, O. (1987). Descriptors for the Southern peas of South Carolina, Bulletin 659, South Carolina Agricultural Experiment Station, Clemson University, Clemson.

Ogun, P.O., Markakis, P. & Chenoweth, W. (1989). Effect of processing on certain antinutrients in cowpeas (*Vigna unguiculata* (L) Walp). *Journal of Food Science*. *54*(2), 102-105.

Ojimelukwe, P., Onweluzo, J. & Okechukwu, E. (1999). Effects of infestation on the nutrient content and physiocochemical properties of two cowpea (*Vigna unguiculata*) varieties. *Plant Foods Hum Nutr* 53, 321–332.

Olapade, A.A, Okafor, G.I., Ozumba, A.U. & Olatunji O. (2002). Characterization of common Nigerian cowpea (*Vigna unguiculata* L. Walp) varieties. *Journal of Food Engineering*, *55*, 101–105.

Ologhobo, A. D. & Fetuga, B.L. (1982). Chemical composition of promising cowpea (*Vigna unguiculata*) varieties. *Nutr. Rep. Int.*, *25*(6), 913-919.

Ologhobo, A.D. & Fetuga, B.L. (1983). Effect of processing on the trypsin inhibitor, heamagglutinin, tannic acid and phytic acid contents of seeds of ten cowpea varieties. *Tropical Agriculture*. *61* (4), 261-264.

Omueti, O. & Singh, B.B. (1987). Nutritional attributes of improved varieties of cowpea (*Vigna unguiculata* (L.) walp). *Human Nutrition, Food Sciences and Nutrition*. *41*(2), 103-112.

Onayemi, O., Osibogum, O. A. & Obembe, O. (1986). Effect of different storage and cooking methods on biochemical, nutritional and sensory characteristics of cowpea (*Vigna unguiculata* L.). *Journal of Food Science*. *51*(1), 153-156.

Owolabi, A.O., Ndidi, U.S., James, B.D. & Amune, F.A. (2012). Proximate, antinutrient and mineral composition of five varieties (improved and local) of cowpea, *Vigna unguiculata*, commonly consumed in Samaru community, Zaria-Nigeria. *Asian Journal of Food Science and Technology*, *4*(2), 70-72.

Oxarekua, M.A, & Adeyeye, E.I. (2009). Comparative evaluation of nutritional quality, functional properties and amino acid profile of co-fermented maize/cowpea and sorghum/cowpea Ogi as infant complementary food. *Asian Journal of Clinical Nutrition*, *1*(1), 31-39.

Pandey, I. D. & Singh, B. B. (2006). Identification of early maturing grain type cowpea varieties for wheat-cowpea-rice based intensive crop system. *Pantnagar Journal of Research*. *4*(2), 65-71.

Pani, M., Bhattacharya, L., Sharma, S., & Raghuvanshi, R. S. (1994). Interrelationship between physical characteristics and cooking time of lentil genotypes. *Journal of Dairying Foods and Home Science*. *13* (3), 161-166.

Pattee, H. E., Salunkhe, D. K., Sathe, S. K., Reddy, N. R. (1982). Legume lipids. CRC *Critical Reviews in Food Science and Nutrition*. *17*(2), 104.

Phillips, R.D. & Abbey, B.W. (1989). Composition and flatulence-producing potential of commonly eaten Nigerian and American legumes. *Food Chemistry*, *33*, 271-280.

Phillips, R.D. & Adams, J.G. (1983). Nutritional and physiological response of rats to diets containing whole, decorticated and decorticated and steamed cowpeas. *Nutr. Rep. Int*. *27*, 949.

Phillips, R.D. & McWatters, K.H. (1991). Contribution of Cowpeas to Nutrition and Health. *Food Technology*. *45*, 127-130.

Phillips, R.D. (1982). Preparation and composition of a dry milled flour from cowpeas. *J. American Oil Chemists-Society*. *59*(8), 351-353.

Preet, K. & Darshan, P. (2000). Proximate composition, phytic acid, polyphenol and digestibility (*in vitro*) of flour brown cowpea varieties. *International Journal of Food Science and Nutrition*. *51*(3), 189-193.

Prinyawiwatkul, W., McWatters, K.H., Beuchat, L.R., & Phillips, R.D. (1996). Cowpea flour, a potential ingredient in food products. *CRC Critical Review of Food Science and Nutrition*. *36*, 413-436.

Ramchandra, B., Nagabhushana, V., Prakash, N. & Appannavar, M.M. (2004). Mineral composition of grains from cereal and pulse crops grown in agro climatic zone-1 of Karnataka state. *Indian Veterinary Journal*. *81*, 1358-1360.

Rao, B. S. N. & Prabhavathi, T. (1982). Tannin content of food commonly consumed in India and its influence on ionizable iron. *Journal of Science of Food and Agriculture*. *33*, 88-96.

Reddy, N. R., Pierson, M. D., Sathe, S. K. & Salunkhe, D. K. (1984). Chemical, nutritional and physiological aspects of dry bean carbohydrates- a review. *Journal of Food Chemistry*. *13*, 25-68.

Reddy, N.K., Sathe, S.K., Salunkhe, D.K. (1982). Phytates in legumes and cereals. *Advan. Food Res. 28*, 1-92.

Richana, N. & Damardjati, D.J. (1999). Physicochemical characteristics of cowpea seeds (*Vigna unguiculata* (L) Walp) and its use "Tempe". *Penelitian-pertanian (Indonesia)*. *18*(1), 71-77.

Rosario, R.R. , Lozano, V. & Noel, M.G. (1981). The chemical and biochemical composition of legume seeds. *Phillipine – Agriculturist (Phillipines)*. *64*(1), 49-57.

Sathe, S. K., Deshpande, S.S. & Salunkhe, D.K. (1984). Dry bean of *Phaseolus*, a review. CRC *Critical Reviews in Food Science and Nutrition*. *20*, 1.

Sefa-Dedeh, S. (1978). Protein Utilization in Africa. Util Protein Resour.

International Symposium on Protein Utilization, Guelph, Ontario. pp 32-72

Sefa-Dedeh, S., Kluvitsae, Y. & Afoakwa, E.O. (2001). Influence of fermentation and cowpea steaming on some quality characteristics of maize-cowpea blends. *A.J.S.T, 2*(2), 71-80.

Sefa-Dedeh, S., Stanley, D.W. & Voisey P.W. (1978). Effects of soaking time and cooking conditions on texture and microstructure of cowpeas (*Vigna unguiculata*). *Journal of Food Science*. *43*, 1832-1838.

Siegal, A. & Fawcett, B. (1976). Food legume processing and utilization. Agriculture, Food and Nutrition Science Division. Ottawa, Canada., Bull. IDRC-TSI.

Singh, B.B. Chambliss, O.L. & Sharma, B. (1997). Recent advances in cowpea breeding. In, B. B. Singh, D.R. Mohan Raj, K. E. Danishiell, & L. E. N. Jackai (Eds., pp. 30-49), *Advances in Cowpea Research*. Co-publication of IITA & JIRCAS. IITA, Ibadan, Nigeria.

Singh, S. (2010). Physiological and quality characteristic in seed of cowpea (*Vigna unguiculata* (L.) Walp) cultivars. *International Journal of Agricultural Sciences*, *6*(2), 412-414.

Singh, U. (1999). Cooking quality of pulses. *Journal of Food Science and Technology*. *36*(1), 1-14.

Sinha, R., Kawatra, A. & Sehgal, A. (2005). Nutritional evaluation of five white cowpea cultivars. *Legume Res*., *28*(3), 206 - 209.

Sobukola, O.P. & Abayomi, H.T. (2010). Physical properties and rehydration characteristics of different varieties of maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L. Walp) seeds. *Journal of Food Processing and Preservation 35*, 299–307.

Somiari, R.I. & Balogh, E. (1993). Effect of soaking, cooking and crude alpha-galactosidase treatment on the oligosaccharide content of cowpea flours. *Journal of the Science of Food and Agriculture*, 61, 339-343.

Sood, D. R., Hooda, J. S. & Arora, S. K. (1992). Nutritional profile of some cowpea (*Vigna unguiculata* L.). *Legume Research*. *15*(4), 173-178.

Sreerama, Y.N., Sashikala, V. B., Pratape, V. M. & Singh, V. (2012). Nutrients and antinutrients in cowpea and horse gram flours in comparison to chickpea, Evaluation of their flour functionality, *Food Chemistry, 131*, 462-468.

Summerfield, R. J., Huxley P. A. & Steel, W. (1974). Cowpea (*Vigna unguiculata* L.). *Field Crop Abstracts*. *27*, 301-312.

Taiwo, K.A. (1998). The potential of cowpea as human food in Nigeria. *Technovation*, *18* (6/7), 469–481.

Tchiagam, Jean-Baptiste N., Bell, J.M., Ngakeu, D.F., Njintang, N.Y. & Youmbi, E. (2011). Diallel analysis of cowpea (*Vigna unguiculata* (L.) Walp.) for some physical properties of seed under the Sudano-guinean conditions. *Agriculture and Biology Journal of North America*, *2*(4), 698-707.

Tewari, P., Choudhary, S. & Shekhawat, N. (2004). Cowpea utilization in India. In, D. Kumar & N.B. Singh (Eds., pp.256-257), *Cowpea in India*. Scientific Publishers (India).

Tewari, S.R., Sharma, R.D. & Ram N. (1977). Mineral contents of some high yielding varieties of Bengal gram (*Cicer arietinum*). *Journal of Agriculture and Food Chemistry*. *25* (2), 420-421.

Tindall, H. D. (1983). Vegetables in the Tropics. London. Macmillan Press.

Towo, E., Svanberg, U. & Kamala, A. (2003). Phenolic compounds, phytate, citric acid and the in-vitro iron accessibility of cowpeas, mung beans and four varieties of kidney beans. *African Journal of Food, Agriculture, Nutrition and Development*. *3*(1), 1024-1032.

Tuan, Y.H & Phillips, R.D. (1991). Effect of hard-to-cook defect and processing on protein and starch digestibility of cowpea. *Cereal Chemistry*. *68*, 413.

Udensi, E. A., Ekwu, F. C. & Isinguzo, J. N. (2007). Antinutrient factors of vegetable cowpea (sesquipedalis) seeds during thermal processing. *Pakistan Journal of Nutrition*. *6*(2), 194-197.

Uzogara, S.G. & Ofuya, Z.M. (1992). Processing and utilization of cowpeas in developing countries, a review. *Journal of Food Processing and Preservation*. *16* (2), 105-147.

Uzogara, S.G., Morton I.D. & Daniel, J.W. (1991). Thiamin, riboflavin and niacin retention in cooked cowpeas as affected by Kanwa treatment. *Journal of Food Science*. *56*(2), 592-593.

Viera, R. F., Romeiro, E. N. C., Desouza, L. R. P., Danzelli, M. F. & Viera, C. (1989). Cooking time for dried beans of the genera *Vigna phaseolus* food yield and acceptability. *Revista Ceres*. *35*, 525.

Williams, P.C., Nakoul, H. & Singh, K.B. (1983). Relationship between cooking time and some physical characteristics of chickpea (*Cicer arietinum* L.). *Journal of Food Science and Agriculture*. *34*, 492-495.