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Physico-chemical properties and nutritional composition of improved varieties of grain cowpea grown in Pantnagar

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Abstract
Cowpea (*Vigna unguiculata*) is an inexpensive, nutrient dense legume favoring health. Physical characteristics and nutritional composition of Pusa Komal (PK) was compared with improved grain cowpea varieties (PL-1, PL-2, PL-3, PL-4, PL-5, PGCP-11 and PGCP-13). Grain cowpea varieties were significantly larger in size, higher seed weight, higher hydration and swelling capacity than PK. PGCP-13 and PL-3 were significantly denser seeds than PK (1.167g/ml). Bulk density of grain cowpea varieties (0.714 - 0.76 g/ml) was significantly lower than PK (0.812g/ml). Leaching losses in PL-1, PL-4, PL-5 and PGCP-13 (11.72 -12.26 %) was significantly lower than PK (13.65%). The proximate composition of PK viz. ash (4.02%), crude fat (1.04%), crude protein (24.4%), crude fiber (3.63%) and carbohydrate (66.91%) were significantly lower in comparison to different grain cowpea varieties. Phytate content was significantly low in PGCP-11, PL-4 and PL-3 (ranged from 184.77 to 203.31 mg/100g) than PK (204.24 mg/100g). The tannic acid content of PL-1, PGCP-13 and PL-3 was significantly lower than PK (0.68%).

Keywords: Cowpea; *Vigna unguiculata*, physical properties, nutritional composition, antinutrients

Introduction
Adequate nutrition is a fundamental cornerstone of any individual's health but it is especially critical for women because inadequate nutrition not only destroys women's health but also of their children (Ravishankar 2012) [27]. In India, under nutrition continues to be a major problem with Chronic Energy Deficiency (CED) highly prevalent in women and Protein Energy Malnutrition (PEM) in children. Prevalence rate of CED is used as a measure of (adult) nutrition and health status for any region or country (Ramachandran *et al*. 2006) [24]. Prevalence of CED in India, among non pregnant non lactating (NPNL) tribal women was higher (56%) than rural women (36%) (Rao *et al*. 2010) [26].

The main reason of under nutrition is inadequate access to protein and energy dense foods to meet their daily requirement because of poverty and low purchasing power of poor population. The use of plants as food to meet the world's food needs is vital to human survival. On a global basis, over 65 % of food protein and over 80 % of food energy is supplied by plants (Onder and Kahraman 2009) [20].

Pulses form a major source of plant protein for a huge section of India particularly for the poor, backward classes and most of the traditionally vegetarian population (Reddy 2004) [28]. Pulses have double the protein content of wheat and three times that of rice and are valuable for the cropping system in maintaining and improving the productivity of soil due to the nitrogen fixation ability (CACP). Pulse protein is the cheapest source of protein available to mankind but unfortunately the protein is accompanied by antinutrients. The presence of these antinutrients makes plant protein (especially legumes) partially available and of poor quality (Odumodu 1992) [18]. Legumes represent one of the most important food categories that have been extensively used as staple foods to cover basic needs of protein and energy throughout the history of humanity. As a food group, pulses have several appealing attributes including their high nutritional value, low cost and long preservation periods outside the cold chain. Although India is the largest producer and consumer of pulses in the world (Jain *et al*. 2009) [13] but the per capita availability of pulses has declined in the past five decades due to increasing population and stagnant pulses production. Production of Pulses in India in 2017-18 was 25.23 million tonnes (MT). In conformity to the objective of FSA-2013 to ensure nutritional security, the per capita per day availability of pulses has risen to 53 g per head/day from a low level of 41-42 g between 1991 to 2013 (Min. of Agri. & FW, GOI 2018). Lack of high yielding and short duration varieties of pulses resulted in poor yield. Farmers were using local varieties of seeds, mostly their own. These seeds were used over a longer period and their productivity was lesser in comparison to the improved/new seeds (Banerjee *et al*. 2010). To mitigate the problem of CED, PEM and for increasing per capita availability of pulses, researchers are focusing on production and evaluation of physical characteristics and nutritional composition of uncommon pulses like cowpea.

Cowpeas (*Vigna unguiculata*) are an important grain legume in developing countries like India. Legumes such as soybeans and groundnuts are oil-protein seeds whereas cowpeas are starch-protein seeds. Grain cowpea varieties are high yielding, early maturing, well grown and fit in rice wheat cropping system in context of Uttarakhand, wherein the lands are marginal with low productivity and rain fed agriculture (Pandey and Singh 2006) [2]. Pantnagar University has developed many early maturing grain cowpea varieties under pulse improvement programme aiming to increase per capita availability of legumes in the state. Although legumes are main source of protein but unfortunately the protein is accompanied by anti-nutrients that reduces its quality and bioavailability. Therefore, evaluation of nutritional composition and physical characteristics of such improved varieties are essential to enhance their utilization. The present study was carried out with the objective to identify most promising lines for improved varieties of grain cowpea from nutritional point of view against conventionally grown vegetable cowpea (Pusa Komal).

Grain type improved varieties include three released varieties viz. Pant Lobia-1 (PL-1 released in 2008), Pant Lobia-2 (PL-2 released in 2010), Pant Lobia-6 (PL-5 released in 2012) and four other varieties that are under breeding trial at Pantnagar University viz. Pant Grain Cowpea -11(PGCP-11), Pant Grain Cowpea -12(PL-4), Pant Grain Cowpea -13(PGCP-13) and Pant Grain Cowpea -14(PL-3). These varieties were compared with PK as baseline. PK is an improved variety of cowpea developed by IARI, Karnal.

Materials and Methods

Cowpea samples were procured from Breeder Seed Production Centre, G.B. P. U.A &T., Pantnagar (Uttarakhand). All the samples were cleaned for dust and foreign materials and dried in an air oven at 40-50°C for 6-7 h to prevent deterioration by biological agents such as insects and moulds. The dried samples were stored in clean airtight containers and used for determination of physical characteristics of grains. For determination of nutritional composition, cowpea grains were subjected to grinding in Wiley mill and passed through 60 mesh sieve. Cowpea flours were stored in airtight container and subjected to analysis in triplicates for proximate composition (AOAC, 1995) and anti-nutritional factors viz. phytate, tannins and trypsin inhibitor (Ranganna 1986) [25].

Physical characteristics viz. seed size including dimensions, namely seed length, width and thickness was determined by the procedure given by Demooy and Demooy 1990; [7] whereas 100-seed weight, density, hydration capacity, hydration index and swelling capacity were determined by the method given by Sood *et al*. 2002 [33]. Swelling index, bulk density, seed coat and leaching losses were determined by the methods given by Williams *et al*. 1983; [38] Wang and Kinsella 1976; [37] Giami and Okwechime 1993 [10]; Akinyele *et al*., respectively. The data were analyzed by using complete randomized design to find out significant difference between cowpea samples (Snedecor and Cochran 1967) [32].

Results and Discussion

Physical Properties

The improved varieties of grain cowpeas can be processed into value added products that would be influenced by their physical and nutritional properties. Physical properties such as seed coat texture affect hydration characteristics while chemical composition (nutrients and anti-nutrients) affects cooking properties of seeds (Sefa-Dedeh *et al*. 1978) [30]. The results related to physical characteristics of eight varieties of cowpeas are presented in Table 1.

Seed Size

Seed size was determined by considering three linear dimensions viz. length, width and thickness. Data show that PK was significantly smaller in size than other grain cowpea varieties (except thickness of PL-2 which was not significantly higher than PK). Length, width and thickness of grain cowpea varieties varied from 7.33- 9.26 mm, 5.5- 6.2 mm and 4.02- 4.91 mm, respectively whereas it was 6.81 mm, 4.98 mm and 3.94 mm, accordingly for PK. Appiah *et al*. 2011 had also reported the length of locally grown grain cowpeas varieties ranged from 7.73-7.67mm.

100-Seed Weight

The seed weight could be a useful criterion for determining suitability for a particular end-use application of cowpea variety. For example, varieties with large seeds would be preferred for canning, since this would mean less quantity of beans would be required to attain a high cooked bean weight (Henshaw 2008) [12]. Results revealed that 100-seed weight of PK (9.96 g) was significantly lower than other grain cowpea varieties (13.38 g to 17.31 g). PGCP-13 showed higher seed weight followed by PL-4, PGCP-11, PL-1, PL-3, PL-5 and PL-2. Henshaw 2008 [12] reported that 100- seed weight of 28 cowpea varieties ranged between 11-26g.

On the basis of 100-seed weight, cowpea varieties are classified into size categories (Ogle *et al*. 1987). Varieties with seed weight between 10-15 g, 15.1-20 g and 20.1 -25 g are described as small, medium and large size seed, respectively whereas seed weight over 25 g are described as very large seeds. According to this classification grain cowpeas are described as medium size seeds whereas PK is small size seed.

Seed Volume

Seed volume of PK (85.67 ml/100g) was significantly lower than PL-1, PL-2, PL-5 and PL-4 whereas PGCP-13 and PL-3 had significantly lower volume than PK.

Seed Density

Grain cowpea varieties viz PGCP-13 and PL-3 were significantly denser seeds than PK (1.167g/ml) whereas PL-1, PL-2, PL-5 and PL-4 were less dense than PK.

Bulk Density

Bulk density of grains indicate the degree of kernel filling during growth and therefore an indicator of quality and predicated in breakage susceptibility and hardness studies, milling and baking qualities (Chang 1988) [6]. Results revealed that bulk density of grain cowpea varieties (ranging from 0.714 to 0.76 g/ml) was significantly lower than PK (0.812g/ml).

Leaching Losses

Soluble solid loss into cooking water generally decreases the nutritional and economic value of the final product and it is one of the quality indicators of the cooked legumes (Guzel and Sayar 2012). Leaching losses in PL-2, PGCP-11 and PL-3 (ranged from 13.74 to 15.1%) were significantly higher than PK (13.65%) whereas it was significantly lower in PL-1, PL-5, PL-4 and PGCP-13 (ranged from 11.72 to 12.26 %). The total solids loss was reported to be between 2 and 19% of the dry legume seeds during soaking and cooking, depending on the water temperature, physiochemical defects on seed and type of seed (Kon 1979; Wang *et al*. 1979; Seena and Sridhar 2005).

Seed Coat

Grain cowpea varieties viz. PL-2, PL-5 and PGCP-11(ranging from 6.16 to 6.73%) had significantly higher seed coat than PK (6.12%) whereas PL-1, PL-4, PGCP-13 and PL-3 had significantly lower seed coat percentage (ranging from 2.73 to 6.07 %) than PK.

Hydration Capacity and Hydration Index

Hydration capacity of PK (0.11 g/seed) was significantly lower than all grain cowpea varieties (0.13 to 0.22 g/seed). Hydration index of PK was 1.11 which was significantly lower than PL-1, PGCP-11, PL-4, PGCP-13 and PL-3 (ranged from 1.15 to 1.29) and higher than PL-5 (1.0).

Swelling Capacity and Swelling Index

Swelling capacity of PK (0.12 ml/seed) was significantly lower than all grain cowpea varieties (ranged from 0.14 to 0.26 ml/seed). Swelling index was significantly higher than PL-2 and PL-5 whereas it was significantly lower than PL-1, PL-4, PGCP-13 and PL-3.

Table 1: Physical properties of eight cowpea varieties*

Components		PL-1	PL-2	PL-3	PL-4	PL-5	PGCP-11	PGCP-13	PK	$CD_{0.05}$
Seed Size	Seed length (mm)	7.85 ± 0.010^{d}	7.67 ± 0.006^{e}	8.35 ± 0.229^{b}	8.03 ± 0.017^{c}	7.63 ± 0.011^{ef}	7.33 ± 0.007^{g}	9.26 ± 0.065^{a}	6.81 ± 0.003^{h}	0.146
	Seed width (mm)	5.93 ± 0.024^{d}	5.50 ± 0.055^{g}	6.20 ± 0.007^{a}	5.62 ± 0.006^{f}	5.75 ± 0.009^{e}	6.06 ± 0.022^{cb}	6.07 ± 0.004^{b}	4.98 ± 0.062^{h}	0.055
	Seed thickness (mm)	4.59 ± 0.002^{dcb}	4.52 ± 0.008^{ed}	4.02 ± 0.015^{g}	4.31 ± 0.009^{f}	4.75 ± 0.010^{ba}	4.72 ± 0.004^{cb}	4.91 ± 0.275^{a}	3.94 ± 0.009^{hg}	0.169
100-seed weight (g)		14.29 ± 0.011^{d}	13.38 ± 0.115^{g}	14.16 ± 0.001^{e}	15.30 ± 0.017^{b}	13.78 ± 0.057^{f}	14.69 ± 0.001^{c}	17.31 ± 0.005^{a}	9.96 ± 0.006^{h}	0.078
Seed volume (ml/100 g)		90.17 ± 0.289^{cbc}	90.67 ± 1.155^{a}	81.17 ± 1.041^{g}	89.67 ± 0.577^{dabc}	90.17 ± 0.289^{bac}	85.50 ± 0.500^{fe}	80.67 ± 1.155^{hg}	85.67 ± 0.577^{e}	1.345
Seed density (gm/ml)		1.109 ± 0.004^{gef}	1.103 ± 0.014^{hefg}	$1.232\pm0.016b^{b}$	1.115 ± 0.007^{e}	1.109 ± 0.004^{fe}	1.170 ± 0.007^{c}	1.240 ± 0.018^{a}	1.167 ± 0.008^{dc}	0.019
Bulk density (gm/ml)		0.714 ± 0.000^{hfg}	0.723 ± 0.015^{gef}	0.760 ± 0.016^{dbc}	0.732 ± 0.015^{fbcde}	0.760 ± 0.016^{b}	0.760 ± 0.016^{cb}	0.750 ± 0.016^{ebcd}	0.812 ± 0.037^{a}	0.033
Hydration capacity (g/seed)		0.17 ± 0.0001^{dc}	0.15 ± 0.0005^{f}	0.16 ± 0.0001^{e}	0.18 ± 0.0000^{b}	0.13 ± 0.0002^{g}	0.17 ± 0.0001^{c}	0.22 ± 0.0002^{a}	0.11 ± 0.0001^{h}	0.001
Hydration index		1.23 ± 0.001^{b}	1.11 ± 0.002^{f}	1.15 ± 0.000^{d}	1.22 ± 0.004^{c}	1.00 ± 0.001^{h}	1.15 ± 0.000^{ed}	1.29 ± 0.001^{a}	1.11 ± 0.001^{gf}	0.003
Swelling capacity (ml/seed)		0.18 ± 0.001^{dc}	0.16 ± 0.002^{f}	0.18 ± 0.001^{c}	0.20 ± 0.001^{b}	0.14 ± 0.001^{g}	0.17 ± 0.001^{e}	0.26 ± 0.000^{a}	0.12 ± 0.000^{h}	0.002
Swelling index		1.44 ± 0.006^{d}	1.32 ± 0.015^{g}	1.59 ± 0.029^{b}	1.51 ± 0.024^{c}	1.11 ± 0.012^{h}	1.40 ± 0.014^{e}	1.86 ± 0.028^{a}	1.40 ± 0.008^{fe}	0.033
Seed coat (%)		2.73 ± 0.003^{h}	6.57 ± 0.005^{b}	3.74 ± 0.001^{g}	6.07 ± 0.001^{e}	6.16 ± 0.035^{c}	6.73 ± 0.004^{a}	5.78 ± 0.002^{f}	6.12 ± 0.018^{d}	0.024
Leaching losses (%)		11.92 ± 0.026^{f}	13.77 ± 0.006^{b}	15.10 ± 0.105^{a}	12.26 ± 0.037^{e}	11.72 ± 0.021^{hg}	13.74 ± 0.003^{cb}	11.74 ± 0.010^{g}	13.65 ± 0.021^{d}	0.073

*****Means ± SD (n=3); Average values in rows with same superscript differs non-significantly ($p<0.05$)

Proximate Composition

Proximate assay is an important criterion to assess the overall composition and nutritional status of any ingredient intended for food use. The data on proximate composition (dry weight basis) of eight varieties of cowpea are summarized in Table 2.

Ash content of a foodstuff is inorganic residue which remains after destruction of organic matter. It may not necessarily be exactly equivalent to the mineral matter as some changes may occur due to volatilization or some interaction between constituents (Ranganna 1986) [25]. The mineral content in PL-1, PGCP-11 and PL-3 (3.23 to 3.83%) was significantly lower than PK (4.02%) whereas PL-5 (4.47%) had significantly higher ash content.

The crude fat represents, besides the true fat (triglycerides), other materials extractable with ether such as phospholipids, sterols, essential oils and fat soluble pigments (Ranganna 1986) [25]. Fat provides energy and aids in transport of fat soluble vitamins, insulates and protects internal tissues and contributes to important cell processes (Jones *et al*. 1985 and Pamela *et al*. 2005) [14, 21]. Crude fat content of PL-1 and PL-2 was significantly higher than PK (1.04%) whereas other grain cowpea varieties viz. PL-5, PL-4 and PL-3 contain significantly low crude fat. Crude fat values reported by Preet *et al*. 2000 [23] in brown cowpea varieties ranged from 1.77-1.96%.

Substances, such as enzymes, hormones, and antibodies are protein in nature and are necessary for the proper functioning of an organism. Lysine is the limiting amino acid in cereal proteins whereas legumes contained adequate amount of lysine. Therefore, it is recommended to enhance the protein quality of the diet through easily available and accessible plant protein sources especially legumes to improve the nutritional status of the low income group of population (Khattab and Arntfield 2009) [15].

The crude protein measures the total nitrogen content of a product, and from that, estimates the amount of the protein within that product. It is calculated from the determined nitrogen content by multiplying with a factor (as 6.25 for many foods and 5.7 for wheat).

Results of present study revealed that the crude protein content in PL-1, PL-2 and PL-5 was significantly higher than PK (24.4%) whereas protein content was significantly lower in PGCP-11, PL-4 and PL-3. Crude protein values reported by Preet *et al*. 2000 [23] in brown cowpea varieties ranged from 20.07 to 24.60%.

Crude fiber is the organic residue which remains after the food sample has been treated under standardized conditions with petroleum spirit, boiling dilute sulphuric acid, boiling dilute sodium hydroxide solution and alcohol. The crude fiber consists largely of cellulose together with a little lignin. Except PL-1(3.57%), crude fiber content of grain cowpea (4.08 to 4.53%) was significantly greater than PK (3.63%). Preet *et al*. 2000 [23] reported crude fiber contents in brown cowpea varieties varied from 4.27 to 4.95%.

Carbohydrates are main source of energy and provide the ideal fuel (glucose) for body to function optimally. The carbohydrate content in PGCP-11(67.76 %) was significantly higher than PK. Grain cowpea varieties *viz*. PL-1, PL-2, PL-5 and PGCP 13 had significantly less carbohydrate content.

Table 2: Proximate composition of Cowpea grains*

Cowpea varieties	Ash (%)	Crude Fat (%)	Crude Protein (% on dry wt)	Crude Fiber (%)	Carbohydrate (%)
PL-1	3.83±0.10^{fde}	1.39±0.08^{a}	29.27±0.37^{ba}	3.57±0.34^{hg}	61.94±0.24^{gf}
PL-2	4.22±0.04^{ba}	1.23±0.16^{ba}	29.69±0.74^{a}	4.51±0.18^{ba}	60.35±0.66^{hfg}
PL-5	4.47±0.06^{a}	1.0±0.02^{fcde}	28.91±0.65^{cab}	4.08±0.06^{fe}	61.54±0.70^{f}
PGCP-11	3.23±0.07^{h}	1.15±0.24^{cb}	23.74±0.31^{hdefg}	4.12±0.04^{ed}	67.76±0.33^{a}
PL-4	4.07±0.07^{dbc}	0.99±0.02^{gcdef}	23.95±0.7^{gdef}	4.48±0.03^{cab}	66.51±0.63^{cab}
PGCP-13	4.16±0.02^{cb}	1.05±0.06^{dbc}	24.56±0.61^{d}	4.53±0.04^{a}	65.7±0.63^{ebcd}
PL-3	3.62±0.05^{gf}	0.89±0.07^{hdefg}	24.19±1.02^{fde}	4.39±0.03^{dabc}	66.91±0.90^{ba}
PK	4.02±0.41^{ebcd}	1.04±0.05^{ecd}	24.4±0.52^{ed}	3.63±0.26^{g}	66.91±0.94^{dbc}
$CD_{0.05}$	0.268	0.190	1.121	0.295	1.161

*Means ± SD (n=3); Average values in rows with same superscript differs non-significantly (p<0.05)

Anti-Nutrients in Cowpea

The presence of antinutritional factors is one of the major drawbacks limiting the antinutritional and food qualities of the legumes (Salunkhe 1982) [29]. Phytic acid reduces the bioavailability of some essential minerals and tannins inhibit the digestibility of protein. (Duhan *et al*. 1989 and Van der Poel 1990) [9, 35]. The data related to anti-nutrients are summarized in Table.3.

Phytic acid decreases the bioavailability of essential minerals and turns into insoluble compounds whose absorption and digestion is less in the small intestine (Desphande and Cheryan 1984) [8]. Phytate content was significantly low in PGCP-11, PL-4 and PL-3 (ranged from 184.77 to 203.31 mg/100g) than PK (204.24 mg/100g) and remaining varieties (except PL-5) had significantly high phytate content than PK. Variation in PL-5 with PK was not statistically significant.

Tannin (Polyphenol) forms complexes with proteins under certain pH conditions and thus responsible for low protein digestibility, decreased amino acid availability and increased faecal nitrogen (Jain *et al.* 2009) [13]. The tannic acid content of PL-1, PGCP-13 and PL-3 was significantly lower than PK (0.68%). Tannic acid content was significantly high in PL-2, PL-5, PGCP-11 and PL-4 than PK.

Tripsin inhibitor, when ingested in large quantity disrupts the digestive process and may lead to undesirable physiological reactions (Booth *et al*. 1960) [5]. No significant variation was observed in trypsin inhibitor content of grain cowpea varieties (ranged from 13.26-14.58 TIU/mg Protein) when compared with PK (14.12 TIU/mg Protein). These varieties have very low amount of trypsin inhibitor activity as reported by Udensi *et al*. 2007 [34] in raw seeds of vegetable cowpea (1113 TIU/g).

Table 3: Anti-nutrients in Cowpea grains*

Cowpea varieties	Phytate (mg/100g)	Tannic acid (%)	Trypsin inhibitor activity (TIU/mg Protein)
PL-1	211.57±1.51^{b}	0.51±0.02^{h}	13.89±0.83
PL-2	208.77±0.83^{c}	0.81±0.01^{b}	13.65±0.11
PL-5	203.31±1.01 ^{ed}	0.84±0.02^{a}	14.37±0.43
PGCP-11	184.77±0.83^{hg}	0.74±0.02^{c}	14.58±0.25
PL-4	196.63±1.05^{f}	0.74±0.02^{dc}	14.16±0.25
PGCP-13	223.17±0.83^{a}	0.63±0.01^{f}	13.6±0.35
PL-3	195.17±0.85^{g}	0.60±0.01^{g}	13.26±0.4
PK	204.24±1.06^{d}	0.68±0.01^{e}	14.12±0.74
$CD_{0.05}$	1.764	0.024	NS

* Mean± S.D. (n=3); NS=Not significant; Average values in rows with same superscript differs non-significantly (p<0.05)

Conclusion

Cowpea meal is a valuable protein source which can contribute towards overcoming the predicted protein shortage by supplying protein. Grain cowpea varieties like PL-1, PL-2 & PL-5 have high protein content and can be used for improving the quality of diet. Thus, these grain cowpea varieties can play a potential role in increasing per capita availability of pulses as well as maintaining good nutrition and human health.

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References

1. Akinyele IO, Onigbinde AO, Hussain MA, Omololu A. Physicochemical Characteristics of 18 Cultivars of Nigerian Cowpeas (V. Uniguiculafa) and Their Cooking Properties. J of Food Sci. 1986; 51(6):1483 - 1485.
2. Appiah F, Asibuo JY, Kumah P. Physicochemical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. Walp) varieties in Ghana. African J of Food Science. 2011; 5(2):100 -104.
3. AOAC. Official methods of Analysis.16th ed, Association of Official Analytical Chemists, Washington D.C, 1995.
4. Banerjee G, Palke LM. Economics of pulses production and processing of India. Department of Economic Analysis and Research, NABARD, Mumbai, Occasional paper. 2010; 51:12.
5. Booth AN, Robbins DJ, Kibellin WF. Effect of raw soybean meal and amino acids on pancreatic hypertrophy in rats. Proc. Soc. Expt. Biol. Med. 1960; 104:68-72.
6. Chang CS. Porosity and density of grain kernels. Cereal Chemistry. 1988; 65:13.
7. Demooy BE, Demooy CJ. Evaluation of cooking time and quality of seven diverse cowpea (*Vigna unguiculata* (L) Walp.) varieties. Int J Food Sci and Technol. 1990; 25:202-212.
8. Desphande S, Cheryan M. Effect of phytic acid, divalent cations and their interactions on alfa-amilase activity. J Food Sci. 1984; 49:516-519.
9. Duhan ABM, Chauhan D and Kapoor AC. 1989. Phytic acid contents of chickpea and black gram. Varietal difference and effect of domestic processing and cooking methods. J of the Science of Food and Agriculture 49:449-455.

10. Giami, SY Okwechime UI. Physicochemical properties and cooking quality of four new cultivars of Nigerian cowpea (*Vigna unguiculata* L. Walp.). J Sci Food Agric. 1993; 63:281-286.
11. Guzel D, Sayar S. Effect of cooking methods on selected physicochemical and nutritional properties of barlotto bean, chickpea, faba bean, and white kidney bean. J Food Sci Technol. 2012; 49(1):89-95.
12. Henshaw FO. Varietal Differences in Physical Characteristics and Proximate Composition of Cowpea (*Vigna unguiculata*). World J of Agricultural Sciences. 2008; 4(3):302-306.
13. Jain AK, Kumar S, Panwar JDS. Antinutritional factors and their detoxification in pulses- a review. Agric. Rev. 2009; 30(1):64-70.
14. Jones MM, Johnson DO, Netlerville JT, Wood JI, Joesten MD. Chemistry and Society. 5th ed., Saunders College Publishers U. S. A, 1985, 521-577.
15. Khattab RY, Arntfield SD. Nutritional Quality of Legume Seeds as Affected by Some Physical Treatments: Part 2. Antinutritional Factors. LWT-Food Science and Technology. 2009; 42:1113-1118.
16. Kon S. Effect of soaking temperature on cooking and nutritional quality of beans. J Food Sci. 1979; 44:1329-1335
17. Min. of Agri. & FW (DAC&FW), GOI.2018. Pulses Revolution from Food to Nutritional Security (accesses on 19/2/2019; https://farmer.gov.in/SucessReport2018-19.pdf).
18. Odumodu CU. Antinutrients content of some locally available legumes and cereals in Nigeria. Trop Geogr Med. 1992; 44(3):260-263.
19. Ogle WL, Witcher W, Barnett O. Descriptors for the Southern peas of South Carolina, Bulletin 659, South Carolina Agricultural Experiment Station, Clemson University, Clemson, 1987.
20. Onder M, Kahraman A. Antinutritional Factors in Food Grain Legumes. In: 1st International Syposium on Sustainable Development, Sarajevo, 2009, 40.
21. Pamela CC, Richard AH, Denise RF. Lippincotts illustrated Reviews Biochemistry 3rd ed., Lippincott Williams and Wilkins, Philadelphia, 2005. 335-388 (for lipid).
22. Pandey B, Singh JV. Combining ability for yield over environment in cowpea [*Vigna unguiculata* (L.) walp.]. Legume Research. 2006, 33(3):190-195.
23. Preet K, Punia D. Proximate composition, phytic acid, polyphenols and digestibility (*in vitro*) of four brown cowpea varieties. Int J of Food Sciences and Nutrition. 2000; 51(3):189-193.
24. Ramachandran M, Kavi Kumar KS, Viswanathan B. Vulnerability to Chronic Energy Deficiency: An Empirical Analysis of Women in Uttar Pradesh, India. Working Paper, Madras School of Economics, Chennai, 2006.
25. Ranganna S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products, 2ndedn, Tata McGraw Hill Publ. Co., New Delhi, 1986.
26. Rao KM, Balakrishna N, Arlappa N, Laxmaiah A, Brahmam GNV. Diet and Nutritional Status of Women in India. J Hum Ecol. 2010; 29(3):165-170.
27. Ravishankar AK. The Consequence of Chronic Energy Deficiency (CED) On Children's Nutritional Status in Tamil Nadu: Evidence from NFHS-II. Senior Lecturer, Population Studies, DDE wing, Annamalai University, Tamil Nadu, 2012. (http://paa2006.princeton.edu; dt. 09.11.2014).
28. Reddy A, Amarender. Consumption pattern, trade and production potential of pulses. Economic and Political Weekly. 2004; 34(44):4854-4860.
29. Salunkhe DK. Legumes in human nutrition: Current status and future research needs. Current Sci, 1982, 51, 387.
30. Sefa-Dedeh S, Stanley DW, Voisey PW. Effects of soaking time and cooking conditions on texture and microstructure of cowpeas. J Food Science. 1978; 43(6):1832-1838.
31. Seena S, Sridhar KR. Physicochemical, functional and cooking properties of under explored legumes, Canavalia of the southwest coast of India. Food Res Int. 2005; 38:803-814.
32. Snedecor GW, Cochran WG. Statistical methods.6th ed. Oxford IBH Publishing Co., Calcutt, 1967.
33. Sood M, Malhotra SR, Sood BC. Effect of processing and cooking on proximate composition of chick pea (Cicer arietinum) varieties. J Food Sci Technol. 2002; 39:69-71.
34. Udensi EA, Ekwu FC, Isinguzo JN. Antinutrient factors of vegetable cowpea (Sesquipedalis) seeds during thermal processing. Pakistan J of Nutrition. 2007; 6(2):194-197.
35. Van der Poel AFB. Effect of processing on antinutritional factors and protein nutritional value of dry beans. Animal Feed Science and Technology. 1990; 2:179-208.
36. Wang HL, Swain EW, Hesseltine CW, Heath HD. Hydration of whole soybeans affects solids losses and cooking quality. J Food Sci. 1979; 44:1510-1513.
37. Wang JC, Kinsella JE. Functional properties of alfalfa leaf protein: foaming. J Food Sci. 1976; 41:498-501.
38. Williams PC, Nakoul H, Singh KB. Relationship between cooking time and some physical characteristics in chickpeas (*Cicer arietinum* L.). J Sci Food Ag. 1983; 34: 492-496.