

## NUTRITIONAL AND PHYSICOCHEMICAL ATTRIBUTES OF COWPEA AND MUNGBEAN BASED WEANING FOODS

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In current study, cowpea and mungbean were utilized in preparation of weaning foods. Roasting was carried out to enhance the nutritional profile of legumes and to reduce anti-nutritional factors. Afterwards, three cowpea or/and mungbean based weaning food treatments were prepared; W<sub>1</sub> (20% cowpea), W<sub>2</sub> (20% mungbean) and W<sub>3</sub> (10% cowpea+10% mungbean) along with control; W<sub>c</sub> (20% soybean). Results depicted significant decline of anti-nutritional factors in roasted legumes. Proximate analyses illustrated highest crude protein in W<sub>3</sub> (17.01±0.19%) and lowest in W<sub>c</sub> (14.09±0.27%). Moreover, highest calorific value and reconstitution index were observed in W<sub>3</sub> as 398.69±24.02 kcal/100g and 56.56±0.83 mL, respectively. Likewise, maximum viscosity was also viewed in W<sub>3</sub> (1985.27±21.84 cP). Additionally, loose & packed bulk densities were ranged from 0.46±0.04 & 0.52±0.04 (W<sub>c</sub>) to 0.59±0.01 & 0.66±0.02 g/mL (W<sub>3</sub>). In the nutshell, indigenous legumes have potential to formulate weaning foods with appreciable physicochemical and nutritional characteristics. Hence, these should be utilized to formulate nutritious and cost-effective weaning foods to combat the prevailing infant malnutrition.

**Keywords:** Cowpea, mungbean, weaning food, protein energy malnutrition, physicochemical properties, mineral profile.

### INTRODUCTION

Malnutrition is a growing impediment for human health. The prevalence of malnutrition in Pakistan is much higher among children as well as women. From the past two decades, three national nutritional surveys have been carried out focusing mainly on malnutrition in children. At the moment, malnutrition is also responsible for hidden retardation in the economic development of country. Deficiencies not only lead to increased disease burden but also result in loss of human capital. It has been reported that around 50% deaths under-five occur in response to malnutrition. Additionally, >25% children in the developing countries are moderately or severely malnourished. Moreover, the child nutrition is thought to be a major risk factor for the sickness and death of children, contributing >50% of child death over the globe (Cheah *et al.*, 2010). Of the leading nutritional problems, protein energy malnutrition (PEM) is affecting the masses significantly. In Pakistan, 9.6 million children under-five are malnourished. While, according to Global Nutrition Report (2016), 45% children are stunted in Pakistan.

Weaning/complementary foods are introduced in the mid period between breast-feeding and total solid food intake. Hence, nutritionally balanced, easily digestible and energy dense weaning foods are necessitated as a substitute to breast milk (Jirapa *et al.*, 2001). Traditional weaning foods are commonly consumed but unable to meet the criteria of energy, protein, micronutrient concentration and quality (Chang *et al.*, 2008). In order to overcome the existing

loopholes, well designed weaning food is the need of hour to ensure proper growth and healthy life of infants (Bond *et al.*, 2005). Normally, cereal flours are considered as the basic ingredient for infant formulations along with dry milk and indigenous legumes (Egli *et al.*, 2003). Not only the recipe, but also nutritional and functional properties matters a lot in the making of well-balanced weaning food (Nasirpour *et al.*, 2006).

Legumes belong to family "Leguminosae", also known as "Fabaceae". Legumes are important source of macro- and micro-nutrients, especially the low-cost vegetable proteins in contrast to expensive animal products that make them less favorable choice (Mubarak, 2005; Olivia and Ardythe 2013). Cowpea (*Vigna unguiculata*) belongs to family Fabaceae and commonly named as cow gram, lobia, china pea and black-eyed bean. It differs with respect to sizes, shape and color of seed coat (Appiah *et al.*, 2011; Ashogbon and Akintayo 2013). Likewise, cowpea is also an appropriate source of dietary protein with high bioavailability and relatively lower proportion of anti-nutritional factors (Papalamprou *et al.*, 2009). In spite of being a good protein source, it is also rich in soluble and insoluble dietary fiber, minerals and vitamins (Ashraduzzaman *et al.*, 2011).

Mungbean (*Vigna radiate*) is one of the main legumes consumed in sub-continental community. The protein content of mungbean is quite similar to chickpea however, it contains lesser amount of anti-nutrients (Dahiya *et al.*, 2013). It is an excellent source of macro- and micro-nutrients thus recommendable to the malnourished segments of the

population. Mungbean protein (20-30%) has balanced amino acid (A.A) profile; however, methionine is the first limiting A.A (Alsohaimy *et al.*, 2007). Mungbean is an iron rich and highly nutritional ingredient for infants besides high palatability and taste (Gulzar 2011). Thus, incorporation of legume based proteins in the weaning foods of low income countries could complement nutritionally the monotonous cereals, employed to prepare weaning foods or could easily replace proprietary soy based weaning foods (Khatab and Arntfield, 2009).

Earlier, a few efforts have been carried out to address PEM through development of specially designed infant formula using indigenous legume sources. There is a dire need to explore some plant based high protein sources to formulate nutritious and economical complementary foods. In the current study, weaning foods were prepared by using cowpea seeds and mungbeans. Furthermore, their nutritional and physicochemical properties were analyzed.

## MATERIALS AND METHODS

**Materials:** Cowpea and mungbean were procured from the Pulses Research Institute, Ayub Agricultural Research Institute Faisalabad, Pakistan. Cereal flours (wheat and rice) and remaining ingredients of the weaning food were purchased from local market, Faisalabad. Reagents were of analytical grade and procured from Merck (Merck KGaA, Darmstadt, Germany) and Sigma-Aldrich (Sigma-Aldrich Tokyo, Japan).

**Preparation of raw material:** Cowpea and mungbean were cleaned to remove dust and other foreign materials.

**Roasting:** Cowpea and mungbean were cleaned to remove dust and other foreign materials. Afterwards, whole legume seeds were roasted separately in a sand bath at  $200 \pm 2^\circ\text{C}$  for 2 min. The roasted samples were separated from sand by sieving, dehulled followed by grinding to make flour after attaining ambient temperature followed by final sieving. The resultant flour samples were kept in polyethylene bags under refrigeration storage until analyzed (Chitra *et al.*, 1997).

**Mineral profile:** The raw legume samples were probed for mineral profile (AOAC, 2006). For the purpose, wet digestion of dried sample (0.5 g) was carried out using di-acid mixture of nitric acid ( $\text{HNO}_3$ ) and perchloric acid ( $\text{HClO}_4$ ) in the ratio of 7:3 on hot plate till 1 to 2 mL solution left following dilution up to 100 mL. For the assessment of Zn and Fe, Atomic Absorption Spectrophotometer (Varian AA240, Victoria Australia) was used, whereas Na, K and Ca were determined using Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge, UK).

**Anti-nutrients:** The samples (raw & roasted) were homogeneously mixed with calcium hydroxide solution (20% w/w) to analyze the anti-nutrients present in legumes. Accordingly, standard procedures were adopted for hemagglutinin-lectin activity, trypsin inhibitor and phytates.

**Hemagglutinin-lectin activity:** Lectin activity was estimated by Rabbit Erythrocyte Agglutination Test. Lectin activity was determined in hemagglutinin units (HU) as indicated by Dry *et al.* (1983).

**Trypsin inhibitor activity:** Legume samples were mixed with 0.05N HCl in a Sorvall Omni Mixer (Ivan Sorvall, Inc., Newtown). The resultant slurry was centrifuged (M-3k30, Sigma, Germany) followed by addition of trichloroacetic acid (TCA) to the supernatant and recentrifuged. After neutralization, the enzyme inhibitory response was assessed (Decker 1977).

**Phytates:** Phytic acid content of legume samples was determined by following the protocol of Haug and Lantsch (1983). Prepared samples were heated with acidic ammonium iron-III sulphate solution of known concentration. The reduction in iron content of supernatant was indicated as phytate content using 2, 2 bipyridine at wavelength 519nm through spectrophotometer (CE 7200-7000 series, Cecil, UK).

**Preparation of weaning foods:** Selected legume flours were combined with rest of ingredients (soy bean, milk powder, rice flour, wheat flour, sugar, vegetable oil and multi-vitamins mixture) to formulate weaning food. Furthermore, control formulation was also prepared to compare with different treatments.

**Chemical analysis of legume based weaning foods:** The legume based weaning food samples were analyzed for moisture content, crude protein, ash contents, crude fat and crude fiber according to methods described below.

**Moisture content:** The moisture content in the weaning food samples was determined according to the AACC method no “44-15A Moisture-Air-Oven Methods” (AACC, 2000). Accurately weighed 5 g of sample was taken in pre-weighed china dish and placed in a hot air oven till dried at  $105^\circ\text{C}$  for 24 hrs. The sample was removed from the oven, cooled in a desiccator and moisture content was calculated according to the formula given below.

$$\text{Moisture (\%)} = \frac{\text{Wt. of original sample (g)} - \text{Wt. of dried sample (g)} \times 100}{\text{Wt. of original sample (g)}}$$

**Crude protein:** The nitrogen content in weaning food samples was estimated by using Kjeldahl apparatus (model: D-40599) based on Kjeldahl method “30-25b Crude Protein-Improved Kjeldahl Method” (AACC, 2000). The sample (50 g) was placed in a Kjeldahl digestion tube and digested with 25 mL concentrated  $\text{H}_2\text{SO}_4$  by using digestion tablets until the color was transparent or light greenish. The digested material was diluted to 250 mL in volumetric flask. The digested sample 10 mL was taken in the distillation apparatus and 10 mL of 40% NaOH was added. The liberated ammonia was collected in a beaker containing 4% boric acid solution and methyl red as an indicator. The resultant ammonium borate was titrated with 0.1 N  $\text{H}_2\text{SO}_4$  and volume of acid used was noted for nitrogen determination in sample.

Nitrogen (%)

$$= \frac{\text{Volume of 0.1 N H}_2\text{SO}_4 \text{ used} \times 0.0014 \times 250 \times 100}{\text{Weight of sample} \times \text{Volume of sample (10 mL)}}$$

Crude protein (%) = Nitrogen (%) x factor

**Crude fat:** Each weaning food sample was tested for crude fat content by running samples through Soxtec System HT2, Extraction Unit, Tecator, Hoganas, Sweden (AACC, 2000). Five grams of moisture free sample was weighed into an extraction thimble and covered with absorbent cotton. Afterwards, 50 mL of petroleum ether was added to pre-weighed cup. Both thimble and cup were attached to the Soxhlet extraction unit and subjected to extraction with solvent for thirty minutes. The solvent was evaporated from the cup to the condensing column. Extracted fat in the cup was placed in an oven at 110°C for 1 hr and crude fat was calculated using following formula.

$$\text{Crude fat (\%)} = \frac{\text{Weight of petroleum ether extract} \times 100}{\text{Weight of sample (g)}}$$

**Crude fiber:** The weaning food samples were subjected to crude fiber analysis by method no. 32-10 Crude Fiber in Flours (AACC, 2000). Ten grams of sample was placed in a glass crucible and attached to the extraction unit. Subsequently, 150 mL of 1.25% H<sub>2</sub>SO<sub>4</sub> solution was added. The sample was digested for 30 min. Thereafter, alkali was drained out and the sample was washed with boiling water. Finally, the sample was placed in crucible and oven dried at 110°C overnight. The sample was cooled in a desiccator and weighed (w<sub>1</sub>). Afterwards, the resultant sample was placed in a muffle furnace for 2 hr at 550-600°C followed by cooling in a desiccator and reweighed (w<sub>2</sub>), subtracted w<sub>1</sub>-w<sub>2</sub> to attain loss in weight on ignition. The fiber was expressed as percentage of the original defatted sample.

$$\text{Crude fiber (\%)} = \frac{\text{Loss in weight on ignition (g)} \times 100}{\text{Weight of sample (g)}}$$

**Ash content:** The ash content in weaning food samples was measured by the method # “08-01 Ash-Basic Method” (AACC, 2000). Five grams of sample was weighed into a pre-weighed porcelain crucible and directly charred on flame in crucible until there were no fumes coming out and was ignited in muffle furnace maintained at temperature of 550-600°C for 5-6 hr or until greyish white residues were obtained from the muffle furnace, cooled in a desiccator, weighed and ash content was calculated as expressed below.

$$\text{Ash content (\%)} = \frac{\text{Weight of ash in sample (g)} \times 100}{\text{Weight of sample (g)}}$$

**Nitrogen Free Extracts (NFE):** The nitrogen free extract was calculated according to the expression given below;

$$\text{NFE (\%)} = 100 - (\% \text{ moisture} + \% \text{ crude protein} + \% \text{ crude fat} + \% \text{ crude fiber} + \% \text{ ash})$$

### Physicochemical properties

**Energy value:** Weaning foods as whole and per meal basis were analyzed for gross energy using Oxygen Bomb Calorimeter (C-2000, IKA WERKE) following the guidelines of AOAC (2006). The protein and fat energy were estimated by physiological fuel values adopting Atwater's conversion factors (4 x % Protein, 9 x % Fat) considering the protocol of Passmore and Eastwood, (1986). Additionally, nutrient density for respective macromolecules was calculated per 100kcal (FAO/WHO, 2007).

**Bulk density:** For loose bulk density was determined by pouring 50 g sample into 100 mL graduated cylinder, whereas packed density (tapped density) was measured by tapping the cylinder gently several times on a laboratory bench. The result for loose and packed bulk density was calculated using expressions sample weight to volume before & after tapping and expressed as g/mL (Siddiq *et al.*, 2010).

**Reconstitution index:** Weaning food samples were blended with boiling water for 90 sec and shifted to 250 mL volumetric cylinder. The volume of deposited material was checked after 10 min as reconstitution index (Osundhuns and Aworh, 2002).

**Viscosity:** Viscosity of weaning food slurry (40%) was measured using a DV-E Viscometer (LVDVE 230, Brookfield Viscometers Ltd., Harlow, UK) following the method of Thathola and Srivastava (2002).

**Statistical analysis:** The collected data was statistically analyzed using Statistical Package (Costat-2003, Co-Hort, v 6.1.). Accordingly, level of significance was estimated by analysis of variance techniques (ANOVA) using completely randomized design (CRD). Means were further compared through Tukey's HSD multiple comparison tests (Mason *et al.*, 2003).

## RESULTS AND DISCUSSION

Protein is one of the essential components of diet performing diversified role especially in repair, growth and maintenance of human body. Among plant sources, legumes are one of the most important contributors of protein in our daily diet. Accordingly, the present research was designed to formulate protein based weaning food using indigenous legumes *i.e.* cowpea seeds and mungbean. The formulated weaning foods were evaluated for proximate composition and physicochemical properties including energy value, bulk density, reconstitution index and viscosity. The under discussion parameters and their results are elaborated in the following section:

**Mineral profiling of cowpea and mungbean:** Mineral profile in the current study (Table 1) comprised of potassium, calcium, sodium, iron and zinc and their respective values were 28.19±0.89, 61.20±4.13, 45.75±1.05, 7.55±0.37 and 1.28±0.07 mg/100g for cowpea and 387.51±14.11, 78.33±2.52, 10.46±0.48, 5.31±0.81 and 2.17±0.14 mg/100g

for mungbean, respectively. The results for Zn, Fe, Ca, Na and K are in conformity with the earlier results of Owolabi *et al.* (2012) who measured these minerals in different cowpea samples which varied from 0.23 to 0.66, 0.48 to 2.65, 15.00 to 36.80, 0.41 to 0.60 and 16.21 to 18.69 mg/100g, respectively. Later, Osunbitan *et al.* (2016) determined manganese was in the range of 0.1264-0.171 mg/100g, iron 0.1314-0.2058 mg/100g, zinc 0.2302-0.252 mg/100g and copper contents were in the range of 0.0221-0.03 mg/100g. Sodium content was varying from 0.0573-0.237 mg/100g, potassium 109-116 mg/100g, calcium 7-9 mg/100g, magnesium 14-16 mg/100g and phosphorus content was from 33-35 mg/100g. These varieties contain higher content of essential mineral elements (calcium, iron, zinc, manganese, phosphorus and potassium) than those tested in this study. Thus, their consumption would reduce the occurrence of nutritional deficiency and its associated health problem in infants, children and pregnant women. Earlier, Dahiya *et al.* (2013) noted K ( $363 \pm 1.5$  to  $414 \pm 1.1$  mg/100g), Ca ( $81 \pm 1.2$  to  $114 \pm 1.0$  mg/100g), Na ( $8.8 \pm 0.3$  to  $13.2 \pm 0.3$  mg/100g), Zn ( $1.2 \pm 0.03$  to  $2.1 \pm 0.14$  mg/100g) and Fe ( $3.6 \pm 0.15$  to  $4.6 \pm 0.10$  mg/100g) in established and newly bred varieties of mungbean samples.

**Table 1. Mineral profiling of cowpea and mungbean.**

Minerals (mg/100g)	Cowpea	Mungbean
Potassium	$28.19 \pm 0.89^b$	$387.51 \pm 14.11^a$
Calcium	$61.20 \pm 4.13^b$	$78.33 \pm 2.52^a$
Sodium	$45.75 \pm 1.05^a$	$10.46 \pm 0.48^b$
Iron	$7.55 \pm 0.37^a$	$5.31 \pm 0.81^b$
Zinc	$1.28 \pm 0.07^b$	$2.17 \pm 0.14^a$

Values are expressed as means  $\pm$  standard deviation (n =3), Means sharing the same letter in a column are statistically alike

**Anti-nutritional factors:** Anti-nutrients present in the legumes causes hindrance in the bioavailability of certain dietary components. Legumes usually contain significant amount of anti-nutrients that negative impact on digestive enzymes activity, binding minerals ultimately making them unavailable to participate in physiological functioning of the body. Protease inhibitors in various legumes such as soybean, lima bean, common bean and chickpea have the ability to reduce proteolytic enzyme activity. Lectins are polymeric proteins, exist in beans as bound with monosaccharide units in glycoproteins of cell membrane and causation factors for lesions in the intestinal mucus membrane and also reduce nutrient absorption (Ma *et al.*, 2011). In this context, phytates, and hemagglutinin-lectin & trypsin inhibitor activities were analyzed for their anti-nutritional perspectives in tested legumes.

**Phytates:** Phytic acid is a chelator of important nutrients such as calcium, magnesium, iron and zinc. It interferes with their bioavailability thus causes mineral deficiency (Vasagam and

Rajkumar, 2011). It is evident from the statistical inference that phytate contents differed significantly in the treatments before and after heating.

Means (Fig. 1) revealed that more phytates were present in untreated cowpea ( $13.59 \pm 0.54$  mg/g) as compared to mungbean ( $6.51 \pm 0.82$  mg/g). Roasting disassociated phytate complexes efficiently thereby minimizing phytate content in respective legume samples. More reduction in this attribute was noticed due to roasting in cowpea ( $4.48 \pm 0.36$  mg/g) than that of mungbean ( $1.88 \pm 0.06$  mg/g).

Current finding are in accordance with Padmashree *et al.* (2016) who observed that mungbean contains 6.65 mg/g phytates. These results are also in conformity with earlier findings of Owolabi *et al.* (2012), who observed that cowpea contain phytates ranging from 3.00 to 8.50 mg/100g. Anjos *et al.* (2012) recorded 28.33% reduction in phytate content of cowpea samples on roasting at 120°C for 60 min. Phytic acid is recognized to block absorption not only of phosphorus, but also other minerals like magnesium, iron, calcium and zinc. It is also inversely related with the absorption of proteins and lipids (El-Adawy, 2003).

The phytates interact with metals to form insoluble complexes resulting in impaired protein solubility and subsequent lower absorption (Abdelrahman *et al.*, 2007). Moreover, roasting, germination, dehusking and cooking have been reported to produce valuable effects on nutritional significance of legumes. The most common procedure for preparing pulses for utilization at the household level is cooking specially in boiling water. Levels of anti-nutritional substances in beans are reported to decrease by boiling (Vadivel and Janardhanan, 2000). The boiling procedure indicates reduction of phytic acid up to 41 and 38% in brown tepary and white beans, respectively. Likewise, the reduction up to 7, 53 and 16% was observed in cowpea, fava bean and chick pea, respectively.

**Hemagglutinin-lectin activity:** Heat sensitive hemagglutinin is a growth intoxicant even in a little amount in food hence recognized as a toxin at higher concentration (Liener, 1994). Mean squares for hemagglutinin-lectin of legume samples are depicted in Figure 1. It was reported from the statistical results that hemagglutinin-lectin activity were considerably decreased before and after heating. As evident more hemagglutinin-lectin activity were higher in mungbean ( $2.74 \pm 0.09$  Hg/mg) as compared to cowpea ( $0.61 \pm 0.03$  Hg/mg). Conclusively, it has been revealed from the current study that roasting reduced hemagglutinin-lectin significantly.

The current study is in corroboration with previous finding that observed higher reduction in mungbean  $0.59 \pm 0.02$  Hg/mg (Thorne *et al.*, 1983). These results are in conformity with earlier findings of Almeida *et al.* (2008), they showed that hemagglutinin-lectin activity ranged from 0.0513 to 0.0572 HU/mg. Furthermore, significant decrease was viewed in lectin activity after heating. It is well known that germination, soaking and roasting decrease hemagglutinin-

lectin in bean (Alonso *et al.*, 2000). Microwave heat treatment decreases hemagglutinin-lectin activity in legumes (El-Adawy, 2003). Hemagglutinins are the sugar-binding proteins that bind with red blood cells (RBCs). They bind with distinct receptors at intestinal epithelial cells, causing lesions and irregular microvillus development leading to abnormal absorption of nutrients. Additionally, El-Adawy *et al.* (2000) and Mubarak (2005) investigated hemagglutinin activity in mungbean.

**Trypsin inhibitor activity:** Among anti-nutrients, trypsin inhibitor has much importance and reported to retard growth, results in poor feed efficiency and inhibit the activity of digestive enzymes (Bahnassey *et al.*, 1986). However, it can be inactivated at higher temperature (Liener *et al.*, 1994). Significant variations in trypsin inhibitor activity were observed before and after heating in cowpea and mungbean samples. Mean values showed that maximum trypsin inhibitor activity was in mungbean ( $18.35 \pm 1.12$  TIU/mg) followed by cowpea ( $7.53 \pm 0.18$  TIU/mg) as shown in Figure 1.

The present results are in accordance with Olivera-Castillo *et al.* (2007) who also observed notable reduction in trypsin inhibitor activity in dry heated cowpea formulations. Highest reduction in trypsin inhibitor activity was detected in roasted cowpea followed by roasted mungbean. Previously, it has been reported that heat treatment reduces trypsin inhibitor activity in rice bran (Tashiro and Ikegami, 1996). Microwave heating, dry and moist heat treatments have also been reported to reduce trypsin inhibitor (Deolankar and Singh, 1979; Hernandez-Infante *et al.*, 1998). Likewise, pressure cooking of legumes can be used at household level to minimize the trypsin inhibitor activity (Seena *et al.*, 2006).

Conclusively, the present findings are in agreement with El-Adawy (2003) who reported that reduction in trypsin inhibitor activity depends on heating conditions provided to the legumes. Likewise, soaking of dry beans for 12 hr may also reduce trypsin inhibitor activity, phytates and total polyphenols up to 51, 35 and 43%, respectively (Ramakrishn *et al.*, 2008).

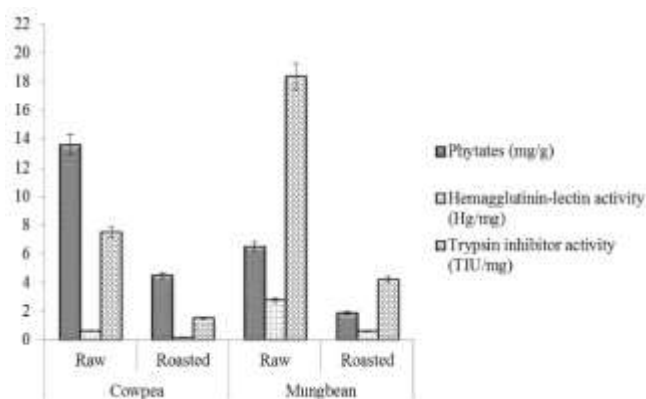


Figure 1. Anti-nutritional factors in raw and roasted legumes (n=3)

### Analysis of weaning foods

**Proximate analysis:** Mean squares regarding composition of weaning food samples showed non-significant variations for crude protein, crude fat, crude fiber, ash and NFE content. It is obvious from the results that prepared weaning foods were nutrient dense, considering the values of crude protein  $14.09 \pm 0.27$  to  $17.01 \pm 0.19\%$ , crude fat  $9.13 \pm 0.65$  to  $11.11 \pm 0.36\%$ , crude fiber  $1.73 \pm 0.26$  to  $4.57 \pm 0.37\%$ , ash  $1.23 \pm 0.21$  to  $2.67 \pm 0.39\%$  and NFE  $63.74 \pm 1.02$  to  $68.26 \pm 0.99\%$  (Table 2). Chemical composition of weaning food samples showed adequate amount of desired nutrients to meet the criteria defined by FAO *i.e.* supplementary foods for infants should be comprised of 10 to 25% fat, 15% protein and dietary fiber not more than 5% (FAO/WHO, 1991). Recently, Gibbs *et al.* (2011) explicated that in several developing countries, dietary staples specially legumes and cereals are utilized in infant formulations. In a few parts of the globe, animal foods are not so admired due to economic or religious concerns. In this situation, flour multi-mix with whole milk powder is commercially utilized to make weaning formulations. Multi-mix technology is often used in the preparation of infant weaning foods (Mosha and Vicent, 2004).

The current findings are similar to the work conducted by Ikujenlola (2008) and Ikujenlola and Adurotoye (2014). They illustrated that protein, fat, ash, fiber and moisture contents in weaning foods were ranging from 7.23 to 17.90, 3.45 to 18.10, 2.0 to 4.25, 2.05 to 5.0 & 4.0 to 9.0%, respectively. Protein contents of different weaning foods from maize and soy flour ranged from  $9.49 \pm 0.1$  to  $19.70 \pm 0.4\%$  (Osundahunsi and Aworh, 2002). The current findings are also in close proximity with the work of Modu *et al.* (2010). They reported that protein, moisture, fat, ash, fiber and carbohydrates in cowpea based supplemented foods were 14.96, 4.70, 4.60, 2.50, 5.60 and 67.64% accordingly.

Combination of legume and cereal based formulation exhibited  $15.0 \pm 0.1$  to  $16.0 \pm 0.3\%$  protein,  $3.4 \pm 0.5$  to  $4.0 \pm 0.4\%$  crude fiber,  $11.0 \pm 0.3$  to  $12.4 \pm 0.6\%$  fat,  $2.0 \pm 0.1$  to  $2.6 \pm 0.2\%$  ash and  $60.0 \pm 1$  to  $60.0 \pm 0.6\%$  carbohydrates as observed by Owino *et al.* (2007). The present findings are also comparable with the work of Onabanjo *et al.* (2008), depicted mean values for proximate composition of complementary foods as 4.14% moisture, 4.74% ash, 14.58% crude protein, 10.67% crude fat and 2.11% crude fiber.

Later, Munasinghe *et al.* (2012) formulated three weaning foods with different ratios of brown rice, soybean, mungbean and milk powder blend with yoghurt through extrusion process, to achieve the daily recommended intake of vitamins and minerals for children aged between 1-3 years. The three weaning foods were compared with a commercially available weaning food. They illustrated protein, fat, ash and fiber in weaning foods ranging from 15.22 to 16.19, 12.38 to 12.48, 1.66 to 1.70 and 0.54 to 0.93% respectively.

Work by Imtiaz *et al.* (2011) is also in close proximity to the

**Table 2. Proximate analysis of weaning foods.**

Components (%)	W <sub>1</sub>	W <sub>2</sub>	W <sub>3</sub>	W <sub>c</sub>
Moisture	3.10±0.14 <sup>b</sup>	4.58±0.24 <sup>a</sup>	4.20±0.35 <sup>a</sup>	3.82±0.41 <sup>ab</sup>
Crude protein	16.06±0.45 <sup>b</sup>	15.16±0.30 <sup>c</sup>	17.01±0.19 <sup>a</sup>	14.09±0.27 <sup>d</sup>
Crude fat	9.13±0.65 <sup>b</sup>	10.15±0.28 <sup>ab</sup>	9.25±0.41 <sup>b</sup>	11.11±0.36 <sup>a</sup>
Crude fiber	2.22±0.41 <sup>b</sup>	1.73±0.26 <sup>b</sup>	2.02±0.21 <sup>b</sup>	4.57±0.37 <sup>a</sup>
Ash	1.23±0.21 <sup>c</sup>	2.56±0.36 <sup>ab</sup>	1.69±0.40 <sup>bc</sup>	2.67±0.39 <sup>a</sup>
NFE	68.26±0.99 <sup>a</sup>	65.82±0.27 <sup>b</sup>	65.84±1.34 <sup>ab</sup>	63.74±1.02 <sup>c</sup>

Means sharing the same letter in a row are statistically alike (n=3), W<sub>1</sub>= Cowpea based weaning food; W<sub>2</sub>= Mungbean based weaning food; W<sub>3</sub>= Cowpea + Mungbean based weaning food; W<sub>c</sub> = Soybean based weaning food

current research, where proximate composition of weaning foods formulations prepared from germinated wheat and mungbean flour was analyzed. The moisture, protein, ash, fiber, fat and carbohydrates contents were reported as 5.26, 17.35, 2.60, 1.86, 1.23 and 61.73%, accordingly. Physiochemical properties

**Energy value:** Protein and fat are the most important nutrients of weaning foods to manage with the body needs of growing infants; lack of which may lead to malnutrition. The mean squares for percent and per meal calorific values (gross energy, protein and fat) elucidated non- significant differences among the weaning food samples. The gross energy of weaning food sample was directly obtained from its heat of combustion while the protein and fat energy were determined by physiological fuel values using Atwater's conversion factors (Passmore and Eastwood, 1986).

The mean gross calorific values were 397.88±21.61, 398.04±22.81, 398.31±28.31, and 398.69±24.02 kcal/100g for W<sub>2S</sub> (mungbean based food), W<sub>C</sub> (soy control based food), W<sub>1S</sub> (cowpea based food) and W<sub>3S</sub> (cowpea + mungbean based food) samples, respectively. The maximum calorific value was contributed by fat (127.71±9.49 to 130.16±9.36 kcal/100g) followed by protein (58.42±5.01 to 58.91±4.38 kcal/100g) as mentioned in Table 3. Formulations in the current study were suitable for delivering 121.11±11.25, 122.13±9.47, 122.38±7.70 and 123.72 ± 10.08 kcal gross energy per single meal for W<sub>2S</sub>, W<sub>C</sub>, W<sub>1S</sub> and W<sub>3S</sub>, respectively from which 37.01±3.14 to 37.78±3.63 kcal/100g energy was acquired from fat whilst, protein contributed about 16.48±1.31 to 16.58±1.49 kcal (Table 4).

From the present explorations, it is understandable that weaning preparations based upon legumes protein are capable of fulfilling infant energy needs. Rate of reappearance of meals per day and quantity of tested weaning foods per single meal can be adjusted according to infant age and caloric requirements. The present results are in accordance with the findings of Modu *et al.* (2010), it was estimated that the energy value of cowpea based supplemented weaning food was about 371.80 kcal/100g. Likewise, the energy value of mungbean based weaning food was about 376.60 kcal/100g (Imtiaz *et al.*, 2011).

The calorific value of weaning supplements based on cereal and legume combinations are ranged from 372 to 397 kcal/100g (Baskaran and Bhattacharaya, 2004). The current results are corroborated by the outcomes of Tizazu *et al.* (2010), observed that energy value of weaning foods ranged from 369.85 to 371.93 kcal/100g. In another study, energy values of weaning food blends prepared from sorghum, legumes and oil seeds were recorded as 405.8-413.2 kcal/100g. It is deduced that weaning formulations in the current study are in accordance with the guidelines of FAO/WHO to fulfill the infant energy requirements (Asma *et al.*, 2006).

**Table 3. Percent calorific value of weaning food samples.**

Weaning foods	Gross energy (kcal/100g)	Fat (kcal/100g)	Protein (kcal/100g)
W <sub>1</sub>	398.31±28.31	128.94±10.38	58.65±3.48
W <sub>2</sub>	397.88±21.61	127.71±09.49	58.42±5.01
W <sub>3</sub>	398.69±24.02	129.38±11.89	58.91±4.38
W <sub>C</sub>	398.04±22.81	130.16±09.36	58.56±4.88

Means sharing the same letter in a row are statistically alike (n=3), W<sub>1</sub>= Cowpea based weaning food; W<sub>2</sub>= Mungbean based weaning food; W<sub>3</sub>= Cowpea + Mungbean based weaning food; W<sub>c</sub> = Soybean based weaning food

**Table 4. Per meal calorific value of weaning food samples.**

Weaning foods	Gross value (kcal)	Fat (kcal)	Protein (kcal)
W <sub>1</sub>	122.38±07.70	38.69±2.83	16.61±1.21
W <sub>2</sub>	121.11±11.25	38.53±3.89	16.63±1.68
W <sub>3</sub>	123.72±10.08	37.44±3.49	16.58±1.49
W <sub>C</sub>	122.13±09.47	37.78±3.63	16.50±1.37

Means sharing the same letter in a row are statistically alike (n=3), W<sub>1</sub>= Cowpea based weaning food; W<sub>2</sub>= Mungbean based weaning food; W<sub>3</sub>= Cowpea + Mungbean based weaning food; W<sub>c</sub> = Soybean based weaning food

**Reconstitution index:** The basic concept behind reconstitution index is to work out the ease of weaning food preparation before consumption. Precooked weaning formulations are considered as instant foods that are prepared with warm water and do not need extensive cooking before

utilization. Mean squares (Table 5) showed significant variations in reconstitution index of various legume based complementary foods.

Means for this trait were  $56.56 \pm 0.83$ ,  $55.44 \pm 0.86$  and  $54.36 \pm 0.75$  mL for W<sub>3S</sub>, W<sub>1S</sub> and W<sub>2S</sub>, respectively while  $53.83 \pm 0.74$  mL for the control (Table 5). The weaning foods in the present study were made through several steps like drum drying that effect the physicochemical characteristics resulting in improved reconstitution index of the end product. The resultant weaning formulations have uniform texture that assist spoon feeding to the preschoolers (FAO/WHO, 2007). In a previous study, it has been observed that steam blanched pre-gelatinized maize flour has improved reconstitution index of weaning mix as compared to unrefined flour (Adeyemi et al., 1988). Reconstitution index normally ranges from 60 to 80 mL for the combinations of cereal and legumes (Sanni et al., 2001). Moreover, composite blends of fermented cereals and soy based complementary food have reconstitution index of 46 to 56 mL (Onilude et al., 1999).

**Viscosity:** Viscosity plays an important role in the final product acceptability. Paste like consistency is favored in reconstituted baby foods as compared to watery mouth feel in less sticky weaning foods. Mean squares regarding viscosity of weaning foods indicated non-significant variations (Table 5). However, the mean values for viscosity were  $1968.52 \pm 104.08$ ,  $1973.15 \pm 109.42$ ,  $1984.85 \pm 104.55$  and  $1985.27 \pm 105.47$  cps for W<sub>c</sub>, W<sub>2</sub>, W<sub>1</sub> and W<sub>3</sub>, respectively (Table 5).

Commonly, mothers prefer an easily spoonable viscosity of infant foods in the range of 1000-3000 cP. Higher viscosity may lessen quantity to be utilized by infants, while lower viscosity specifies a final low bulk of reconstituted product (Mosha and Svanberg, 1993). Lower viscosity of fruit based complementary food is due to decrease in swelling property of starch (Bukusuba et al., 2008). Normally, thin weaning porridges of low energy density are given in a feeding bottle resulting poor growth during this period. To counter this practice, thick porridges of high energy density fed by spoon are advocated, with expectation that energy intake will increase along with decrease in risk of food borne diarrheal pathogens (Islam et al., 2008).

Starch is a main element responsible for viscosity of weaning mix that may undergo some variations during processing thus changing the final paste characteristics. Appropriate viscosity with improved nutrition is desired attribute of processed weaning foods (Suhasini and Malleshi, 2003). Data pertaining to present work are in agreement with Zanna and Milala (2004); cowpea based mixtures had viscosity within the range of 1630-2056 cP. Similarly, viscosity of sorghum enriched weaning food ranged from 2700-2900 cP (Lalude and Fashakin, 2006; Chakravarthi and Kapoor, 2003).

Former studies have explained diverse ranges of viscosity from high to low and thick to thin. Thick viscosity of amylose rich flour porridge was reported indigestible however, it was

energy dense. Furthermore, a comparison was made between thick and thin traditional porridges and recorded less energy intake in case of thin porridge. There is a possibility that children fed on thin low density porridge do not have sufficient energy from diet (Stephenson et al., 1994).

Earlier, a relative study was carried out for weaning foods in developing countries including Peru, India and Tanzania. It was concluded that reducing viscosity of thick energy-dense weaning food do not improve energy intake due to poor digestibility. Hence, it is suggested to develop weaning foods with less stability by adding oil, peanut butter etc. to give an energy density of 4.18 kJ/g i.e. a more feasible option to get better energy intake (Paul et al., 2008).

**Table 5. Reconstitution index and viscosity of weaning food samples.**

Weaning foods	Reconstitution index(mL)	Viscosity (cP)
W <sub>1</sub>	$55.44 \pm 0.86^a$	$1984.85 \pm 104.55$
W <sub>2</sub>	$54.36 \pm 0.75^{ab}$	$1973.15 \pm 109.42$
W <sub>3</sub>	$56.56 \pm 0.83^a$	$1985.27 \pm 105.47$
W <sub>c</sub>	$53.83 \pm 0.74^b$	$1968.52 \pm 104.08$

Means sharing the same letter in a row are statistically alike (n=3), W<sub>1</sub>= Cowpea based weaning food; W<sub>2</sub>= Mungbean based weaning food; W<sub>3</sub>= Cowpea + Mungbean based weaning food; W<sub>c</sub> =Soybean based weaning food

**Bulk density:** In the developing world, cereal based formulations are generally used as basic weaning formulations carrying starchy materials. Bulk density is important in weaning foods than normal dry mixes as it indicates product suitability for babies. However, means regarding packed and loose bulk density ranged from  $0.57 \pm 0.04$  to  $0.66 \pm 0.02$  and  $0.51 \pm 0.05$  to  $0.59 \pm 0.01$  g/mL, respectively (Table 6).

**Table 6. Loose and packed Bulk density of weaning food samples.**

Weaning food	Bulk density (loose) (g/mL)	Bulk density (packed) (g/mL)
W <sub>1</sub>	$0.51 \pm 0.05$	$0.57 \pm 0.05$
W <sub>2</sub>	$0.54 \pm 0.02$	$0.59 \pm 0.03$
W <sub>3</sub>	$0.59 \pm 0.01$	$0.66 \pm 0.02$
W <sub>c</sub>	$0.46 \pm 0.04$	$0.52 \pm 0.04$

Means sharing the same letter in a row are statistically alike (n=3), W<sub>1</sub>= Cowpea based weaning food; W<sub>2</sub>= Mungbean based weaning food; W<sub>3</sub>= Cowpea + Mungbean based weaning food; W<sub>c</sub> =Soybean based weaning food

**Conclusions:** In the current study, legumes based weaning food; W<sub>3</sub> (10% cowpea+10% mungbean) demonstrated better nutritional and physicochemical attributes. Therefore, cowpea and mungbean should be incorporated in the

development of weaning foods to overcome the prevailing malnutrition. This information should be disseminated by the nutritionist and dieticians for general awareness amongst the mothers alongside, food technologists and stakeholders should participate in the propagation of this notion so that cost-effective protein enriched formulations could be available to the vulnerable infants of the developing economies to cope up their protein-energy demands.

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