CHAPTER V
DISCUSSION

As the cost of producing meat, milk, egg and fish, the protein foods of high biological values, increases, plant proteins offer ready and affordable solution to the problem of a growing protein gap. Of late, the enrichment or fortification of traditional cereal based diets with other protein sources such as oilseeds and legumes has received considerable attention. Legumes such as kidney beans (Phaseolus vulgaris) are one of the neglected tropical legumes which are grown and consumed widely throughout the world especially in developing countries, more often than not, without much dietary discretion or nutritional prudence. Their dietary and economic importance is globally appreciated and recognized. Kidney beans are being cultivated and widely consumed in Northern India since time immemorial. In India, they provide only high protein component on an average diet and over 10 million tonnes are consumed annually (Sood et al., 2002). Legume proteins are mainly used in food formulations to complement the protein in cereal grains to improve protein quality in a diet and provide vegetarians with potential meat substitutes (Enwere, 1998). They are also a cheap and valuable source of fat, complex carbohydrates, minerals, dietary fiber and vitamins (Fıratgil-Durmuş et al., 2010). They exceed other vegetables in phosphorus, potassium, calcium and magnesium content (Ximenez-Embun et al., 2004). Legume-cereal combination may be used as an alternate resource for individuals with lifestyle diseases. Studies have shown that intake of legumes have many health effects in controlling and preventing metabolic diseases such as diabetes mellitus and coronary heart disease (Liu et al., 1999). As kidney beans has a potential for curing a plethora of diseases as per ayurveda, blanched kidney beans can well be used as a salad ingredient with other vegetables including GLVs and fruits. Additionally, they are also good in soups, beverages and weaning foods (Charoenthaikij et al., 2010 and Giami, 2004). Apart from all these, kidney beans have an important medicinal value. Kidney beans can be partaken with other efficacious herbs which are useful for dropsy, sciatica and chronic rheumatism.
The present study was undertaken to explore kidney bean varieties for their nourishing potential as well as for product development application. The study was carried out in two phases; with first phase comprising nutrient, antioxidant and antinutrient analysis and effect of processing treatments (hot-water blanching) on aforesaid parameters. Second phase encompassed food product development of nineteen recipes for the different age groups; infants, preschoolers, schoolers, adolescents, adults, elderly, pregnant women and lactating mothers. In addition, food products have also been planned for some diseases like malnutrition, diabetes mellitus and coronary heart disease. Six variants each of standard recipes were prepared with incorporation of varying proportion of raw and processed (hot-water blanching) forms of kidney bean varieties. Sensory evaluation of food products was done by semi-trained panel members.

Moisture content of raw samples of kidney bean varieties was determined and found to be similar with other studies. In other studies moisture content of raw sample of three kidney bean varieties was found to be in the range of 10.1-12.7g/100g (Khatoon and prakash, 2004; Oonsivilai et al., 2011). The values of moisture content of three kidney bean varieties viz. RKB, WKB and PB revealed little inter varietal differences. These values were in agreement with that of Towo et al., 2003 who observed that the same values of moisture content in similar legume varieties. Different processing treatments affect moisture level on way or depending upon the type of processing. During blanching treatment, moisture content was found to be increased significantly which was similar to that reported by Ameru et al., 2010. This increase in moisture content is related to augmented water content during overnight soaking due to hydrolytic enzymes (Osman, 2007). Abu-Ghannam and McKenna (1997a) stated that blanching could enhance the hydration rate of kidney beans and the seed coat of beans is plasticized that allows faster moisture intake in beans. Similar findings have been reported by Khattack et al., 2007 in green gram and black gram dal that had highest moisture content which was obtained during pressure cooking followed by soaking and germination.

The ash content in raw kidney bean varieties was found to be in tune with the values given by Granito et al., 2002; Ejigui et al., 2005; Njintang et al., 2001;
Frias et al., 2002; Martin-cabrejas, 2004; Audu and Aremu, 2011 and falls within the range of 1.6-4.7g/100g. Further, there was no significant difference in ash content of blanched beans compared to the raw kidney bean varieties. Many authors (Osman, 2007 and Bhagya et al., 2007) also supported similar results which can be correlated with present findings. Processing treatment i.e. blanching is reported to decrease the ash content insignificantly may be due to the leaching out of both macro and micro elements into soaking water. A similar result was reported by another study (Kazanas and Fields, 1981). The values of ash content in raw kidney beans corresponded with values obtained by Winiarska-Mieczan and Koczmara (2006) who reported that the ash content in raw kidney beans was found to 4.65 g/100 g whereas blanched kidney beans had significantly lower ash content (3.8 g/100 g).

Values for fat content of raw RKB, WKB & PB was found to be in agreement with previous data reported by Frias et al., 2002; Khatoon, 2004; Savoie, 2005; Mbofung, 2001; Granite et al., 2002; Towo et al., 2003, Oonsivilai et al, 2011; Bueno et al., 1980. The values of fat content in raw red kidney bean flour is higher than other legumes such as cowpea (2.10%), cream coat bambara groundnut (2.1%) but is lower than those of soybean (4.28%), lima bean (5.4%) and jack bean (9.5%) which was noticed by Aremu et al. in 2008. After blanching treatment, there was a no significant reduction in fat content in kidney bean varieties. The decrease in fat content in blanched-soaked beans vis-à-vis raw ones can be corroborated with the findings to other workers (Ramakrishna et al., 2006). The values showed the slight variation of fat content in three varieties of kidney beans. This difference was in agreement with that of Apata (1990). The similar result was obtained by Ghavidel and Prakash in 2007 indicating that fat content was reduced during different home based processing treatments. The reduction of fat content was probably due to break-down of the triglyceride into simple form due to high lipolytic enzyme activity during processing (Idouraine et al., 1980). Kidney beans having low fat content as compared to soybean, render it is a good food ingredient for diabetic, obese and hyperlipidemic people who are more vulnerable to metabolic disorders and degenerative diseases.
Fiber content in raw kidney beans varieties i.e. RKB, WKB and PB were found to be in line with a range of 4.0-6.5g/100g as quoted by Guerea, 2002; Khatoon and Prakash, 2004; Audu et al., 2011. Blanching of beans decreased the fiber content significantly in three kidney beans varieties. Similar results were reported by many other workers (Bressani and Sossa, 1990 and Beleia et al., 1993). The reduction in fiber content during processing may be due to the removal of the seed hull. Different processing methods affect the fiber content in different ways, which is exerting its beneficial effect in one or other way in keeping with different states of the health of people. Increased intake of dietary fiber exerts beneficial effects in the prevention or alleviation of degenerative maladies such as cardiovascular diseases, diabetes, diverticulitis and colon cancer in humans. By that reckoning, kidney beans qualify for being a nourishing and health promoting food stuff.

The protein content of three kidney bean varieties viz. RKB, WKB and PB indicates kidney bean as an ideal protein food. The similar observation was reported by other studies with a range of 20.9-26.9g/100g (Marin, 2005; Sharma et al., 2002; Ofuya and Akhidue, 2005; Martin-cabrejas et al., 2004; Martin-Cabrejas et al., 2009; Prakash, 2004; Ofuya, 2005). (Lauren et al., 2001) in context to amino acids profile of kidney beans reported that essential amino acids composition of kidney beans is good but with a limitation of methionine and tryptophan which can prudently be compensated with cereal pulse combination. Protein content of blanched beans of three varieties was decreased significantly. The similar findings were reported by Hassan et al. (2005). The reduction in protein content after processing could be attributed to the hydrolysis of protein into simpler compounds or leaching of soluble proteins into soaking water (Sharma et al., 2002). Many authors stated that soaking and cooking of kidney beans influence significantly the protein content of beans (Aguilera et al., 2009). A similar trend has been observed in this study. Protein content of raw kidney beans (Phaseolus vulgaris l.) is comparable to some commonly consumed plant proteins in Nigeria was found to be lower in selected legumes such as African locust bean (Parkia biglibosa) 31.0% (Omafuvbe et al., 2004); wild jack bean (Canavalia ensiformis) (28.9-35.0%) (Vadivel and
Janardhanan, 2001). During the processing treatment, protein content decreases with the consequent increase in amino acids, enhancing digestibility and facilitating the utilization of protein. Such processing methods also pave the way for cereal protein mutual supplementation of amino acids to ensure protein quality in developed product. Combined consumption of cereals and grain legumes could be helpful to overcome the amino acid deficiencies, thereby achieving complete protein balance and nutritional improvement in cereal-based diets.

The carbohydrate content of three kidney beans varieties viz. RKB, WKB and PB was found to be similar by various studies with a range of 54-63g/100g (Waldron, 2001; Ofuya and Akhidue, 2005, Martin-cabrejas, 2004, Hiran et al., 2011; Bueno et al., 1980; Laohakunjit, 2011. The values of carbohydrate content of kidney bean varieties were found to be similar when compared to different varieties of sesbania seeds and jack beans (Hossain and Becker, 2001) but the values are higher than those of soybean (26.3%) and cranberry beans (31.5%) and lower than lima bean (66.9%) and pigeon pea (66.8%) reported by (Aremu et al., 2006). Carbohydrate content of blanched beans of three varieties was found to be increased significantly. Since carbohydrate content of plant food is calculated by difference, decrease in dietary fiber, protein, fat and moisture content of kidney bean varieties after blanching will ultimately affect the value for carbohydrate content. There were significant increases in carbohydrate content during soaking, blanching, cooking, roasting or autoclaving. More or less, similar observations find place in our study. The carbohydrate content of these varieties showed that the kidney beans could become good supplement to scarce cereal grains as a source of energy and for feed formulations.

The calcium content of kidney bean varieties was found to be 221mg/100g for RKB; 208mg/100g for WKB and 261.6mg/100g for PB in raw samples which makes these beans fairly good source of calcium, as compared to other varieties of legumes. The similar findings was obtained by Ghavidel and Prakash (2007) and Sandberg (2007), who reported that calcium content was found to 220, 222 and 197 mg/100 g in dry matter of kidney beans respectively. This distinction could be due to the varietal difference. The calcium content was found to be lowest in white kidney
beans. Similar findings were concluded that white kidney beans have lower calcium content, accounting for 163 mg/100 g of dry seeds (Kunachowicz et al., 2005). Same observations were noticed by Viadel et al. (2006). But the contradictory observations were stated by Sangronis and Machado (2007). After blanching, the calcium content of three varieties of kidney beans was found to be increased significantly after this household treatment. The values for calcium content increased possibly due to the fact that the outer covering that got removed in the processing action might be low in calcium content. However, a possibility of interaction of calcium with other compounds such as phytate or polyphenols to form insoluble complexes cannot be ruled out. However, an abundant decrease in phytate during processing treatments could go to improve the bioavailability of minerals including calcium in human nutrition.

The iron content of kidney bean varieties in raw samples was found to be 5.3; 8.0 and 6.6 mg/100g iron for RKB, WKB and PB respectively while in various studies, iron content is reported to be in the range of 5.1-8.6mg/100g (Desrosiers, 2005; Doblado, 2002; Towo et al., 2003). This difference may be due to varietal differences. It was found that blanching causes an increase in iron content significantly in all three varieties of kidney beans. The values for iron content increased possibly due to the fact that the outer covering that got removed in the processing action might be low in iron content. This increase in iron content of kidney bean varieties during different processing treatments can be laid on the development of phytase activity. Since phytate phosphorus can reduce the availability of minerals to humans, this breakdown of phytate phosphorus by phytase enzyme during processing methods is desirable. The values of iron content of three kidney beans varieties proved to be good source for providing high iron and helpful to overcome some deficiencies.

The phosphorus content of kidney bean varieties was found to be 408; 426 and 412.3 mg/100g phosphorus in raw samples of RKB, WKB and PB respectively. This difference may be attributed to varietal differences. Processing significantly affected the mineral content in the seed flour. They have higher phosphorus content comparatively than other legume seeds (Aremu et al., 2008, 2010). After
processing, the phosphorus content was found to be increased significantly in all three varieties of kidney beans. The results indicated that phosphorus content increased possibly due to the fact that the outer covering that got removed in the processing action culminating, in low phosphorus content. The most abundant mineral in the kidney beans was calcium and phosphorus. The concentrated values of calcium and phosphorus would make the kidney beans was more suitable for bone, blood formation and supportive structure of the body for children (Ogunlade et al., 2005).

The extractable total phenolic of raw kidney bean varieties i.e. RKB, WKB and PB has been found to be 5.19; 4.7 and 14.56mg/100g respectively which is similar to the values reported by various studies (Iyer, 1980 (II); Cardador-martinez et al., 2002 (a); Yasmin et al., 2008; Towo et al., 2003; Hiran, 2011). Espinosa-Alonso et al., 2006 suggested that colored dry beans may be an important source of dietary antioxidants. A similar observation was reported by Troszynska and Ciska (2002) and Rocha-Guzma’n et al., 2007 that the colored beans have the greater antioxidant and antiradical properties especially in the seed hull due to higher concentration of phenolic compounds than less colored ones. The phenol content was variable in different legumes with various processing methods. In the present study, hot-water blanching significantly decreased the phenolic content in blanched samples of three kidney bean varieties (RKB, WKB, PB) to 4.12; 3.4 and 5.26mg/100g respectively which is validated from a study done by Xu and Chang (2009). This decrease in phenols could result from the activation of polyphenol oxidase enzyme resulting in degradation and consequent losses of polyphenols during soaking prior to dehulling (Khandelwal et al., 2010; Saxena et al., 2003; Singh et al., 2010). There was a decrease in phenols after soaking due to the leaching of water-soluble phenols into the soaking water was reported by Adb El-Hady and Habiba in 2003. Processing treatment increases the polyphenol content of foodstuff making it rich in antioxidant activity and increase the utilization of food stuff. Epidemiological studies have indicated that regular consumption of foods rich in phenol compounds such as fruits, vegetables, whole grain cereals, red wine and tea, is associated with reducing risks of cardiovascular disease, neuro-degenerative diseases and certain cancers (Miller et al., 2000).
In various studies tannins content of raw kidney bean varieties (RKB, WKB, PB) was found to be in the range of 2000-4560 mg/100g (Gonzalez de mejia et al., 2005; Yasmin et al., 2008; Ejigui, 2005; Granto, 2002, Towo et al., 2003). The processing treatment (hot-water blanching) significantly decreased the tannin content of kidney bean varieties may be due to the physical removal of seed coat of beans because most of the tannins are located in the testa of seeds (Reddy and Pierson, 1994). Similar findings were reported by Alonso et al., 2000; Boateng et al., 2008. Dehulling, germination, cooking and roasting have been shown to produce the beneficial effect on nutritional quality of legumes (Tinsley et al., 1985). Deshpande and Cheryan (1983) observed that the leaching losses during soaking of beans were highest for tannin among the antinutritional factors. Dehulling proved to be most effective processing method for reducing the tannin content in all three varieties of kidney beans. These results were in line with that of Rehman and Shah (2005) who stated that tannin content of black grams, red kidney beans and white kidney beans was significantly reduced after soaking and other processing treatments. As much as 60-70% reduction in the tannin content by dehulling after soaking and iron content will increased was reported by Akindahunsi (2004). It is thought to be responsible for antidiarrheal activity by increasing colonic water and electrolyte reabsorption (Palombo, 2006). Tannins interfere with iron by acting as a natural iron chelating agent and also interact with protein to form tannin-protein complexes resulting in the inactivation of digestive enzymes (Kumar and Singh, 1984). El-Hady and Habiba (2003) have reported that tannin content was reduced significantly during soaking for 16 hours of kidney beans. As blanching decreased the tannins in kidney beans which, as per recent reports of tannins acting as antioxidants, can also act to human advantage as some reports (Reddy et al., 2007; Koleckar et al., 2008) implicate tannins as antioxidants.

Phytic acid of raw kidney bean varieties (RKB, WKB PB) was found to be in the range of 330-550mg/100g which was similar with other studies (Iyer et al., 1980 (I); Yasmin et al., 2008; Rasha Mohamed et al., 2011; Ejigui, 2005; Hiran, 2011). The phytic acid concentration in the peas, cowpeas, lentil, kidney beans, and
chickpeas has been found to be 9.02, 6.83, 11.5, 10.99, and 8.40 mg/g respectively (Abd El-Hady and Habiba, 2003). Phytic acid content decreased significantly during the blanching treatment. The results indicate that the reduction in the phytate content is due to their water-soluble property or leaching. This process also enhances the action of naturally occurring phytase in legumes (Kumar et al., 2010; Shimelis and Rakshit, 2007). Studies on legumes, cereals and other oilseeds showed that phytic acid is generally stable under ordinary processing conditions (Thompson, 1990). Soaking and dehulling of legumes in distilled water was an effective way of removing phytic acid from legumes (Liang et al., 2009). Similar reduction pattern was found in phytic acid during soaking, cooking and germination as reported by (Alonso et al., 2000) for chinese legumes, pea, faba pea, dry bean, lentil and black bean respectively. It has been reported that dehulled beans, particularly after soaking, was reduce phytic acid in P. vulgaris (Ibrahim et al., 2002). Akindahunsi (2004) concluded that the red kidney beans and pinto beans soaked in distilled water for 18 hrs at room temperature reduced their phytate content by 51.7 and 52.7 % respectively. Osman (2007) has reported that soaking, cooking of presoaked beans and germination are potential methods for improving the nutritional value and enhancing the utilization of the kidney beans by reducing the phytic acid content. Phytic acid reduces the bioavailability of zinc, manganese, copper, molybdenum, calcium, magnesium, iron as well as protein (Khattak et al., 2007). When phytic acid becomes bound to protein, it induces a decrease in solubility and functionality of the protein (El Adawy, 2002). Reduction of phytic acid is very advantageous, due to its influence on nutrition; therefore scientific interest has grown to reduce its antinutritional effects.

Total cyanogens of raw kidney bean varieties viz. RKB, WKB and PB were found to be similar with that reported in the study of Yasmin et al., 2008. Cyanogen content has found to be insignificantly reduced during processing i.e. blanching of three kidney bean varieties. Regarding the kidney beans, similar results were found by Adeparusi (2001) who reported significant reduction in levels of cyanide to Lima beans (Phaseolus lunatus) after soaking treatments. The higher level of cyanide content in raw kidney beans was observed when compared to processed
beans. Similar findings was reported by Akindahunsi (2004) that a value of 3.7mg/kg in raw African oil beans after soaking and cooking was reduced to 2.2mg/kg.

Trypsin inhibitor activity of raw kidney bean varieties (RKB, WKB PB) was found to be in agreement with previous data reported by Mejia et al, 2005; Mbithi-mwikya et al., 2001; Iyer et al., 1980 (II); Ejigui, 2005; Granto, 2002. The trypsin inhibitor activity was significantly reduced (P>0.05) by different treatment methods, hot water blanching being the most effective. Hot-water blanching significantly reduced the trypsin inhibitor activity in processed sample of kidney bean varieties. Similar observations were reported by Osman (2007) in Dolichoslablabbean (Lablab purpureus (L) Sweet), chickpea, winged beans and Grewal and Jood(2006) in green gram dal. A similar reduction in trypsin inhibitor activity after soaking has been reported in cowpea, peas and kidney beans to 10.22–19.85% (Khattab et al.,2009). According to Ramakrishna et al.(2006), the raw Indian bean (Dolichoslablab L.) have a very high trypsin inhibitory activity which progressively decreases by 51% after the soaking for 12 hrs. Hot water blanching has been pin-pointed more effective in reducing the estimated antinutrients in this study than other processing treatments. It also enhances the utilization of nutrients along with increasing the bioavailability of minerals and improving the digestibility of proteins.

The second phase of the study involved food product development and taking up sensory evaluation of the various products prepared by incorporating kidney bean varieties at different levels. The purpose of developing kidney bean based food products in the diet in combination with cereals and vegetables to make it nutritionally balanced appears to be the only feasible approach to eliminate “Protein Energy Malnutrition”-(PEM) in the near future. Kidney beans (Phaseolus vulgaris), a grain legume, is one such protein source that can be used in the fortification or enrichment of cereal–based diets and as functional ingredients in the formulation of a number of food products. Because of their nutritional and health-promoting properties, the development of value-added bean-based products for new market opportunities in the functional food and nutraceutical industry is being
promoted. These beans not only add variety to diet but also serve as an economical source of supplementary protein for a large human population. Quality protein is required by people of different life stages as well as in therapeutic conditions. In this phase, various recipes were developed for different age groups; for infants, preschoolers, schoolers, adolescents, adults, elderly, and some other physiological conditions i.e. pregnant women and lactating mothers. In addition food products have been planned for some diseases like- malnutrition, diabetes mellitus and cardio-vascular diseases. Six variants each of standard recipes were prepared with incorporation of varying proportions of raw and processed (hot-water blanching) forms of kidney bean varieties as per the following notations:

Standard= Food product developed without kidney beans, VAR: A1; VAR: B1; VAR: C1= Food product developed by incorporating raw red kidney beans, raw white kidney beans, raw pinto beans respectively, VAR:A2; VAR: B2, VAR: C2= Food product developed by incorporating blanched red kidney beans, blanched white kidney beans, blanched pinto beans respectively.

Various aspects related to the nutrition, health and acceptability potential of the products have been discussed below.

In developing countries, foods are rarely modified at the household level to increase nutrient density according to the need of infants. Traditional infant foods which are based on cereals or tubers may be low in several nutrients including protein, vitamin A, zinc and iron etc. Legume flours are incorporated with cereal and root flours to prepare infant feeds. In present study, two complementary foods i.e. wheat rajmah premix and chivra rajmah premix were developed by incorporating kidney bean varieties in flour form. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Based upon the processing method of kidney bean varieties, six variants of wheat rajmah premix were developed at 10%. Among standard and all variants, it was found that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among six variants, VAR: A1 was most
acceptable and VAR: C1 was least acceptable in terms of overall acceptability. Some attributes i.e. appearance, taste and flavor influence infant’s food choice as compared to others. Premix was highly energy dense and a good source of protein, fiber, carbohydrates, vitamins and minerals. There is a good choice for infants which is providing optimum nutrition and helping in growth spurts. One of the study conducted by Yewelsew et al. in 2006 reported that weaning food prepared by using corn flour in supplementation with kidney beans and pumpkin pulp improved protein and vitamin-A content. Corn: kidney bean: pumpkin (CBP) formulation provided 14.07g/100g crude protein, while the traditional corn based control premix had only 8.82 g/100 g. The pumpkin in CBP provided 54 μg RAE per 100g, increasing the Vitamin A value of the mixes by 25 times. There is improvement in the nutrient quality of the formulated complementary food with high acceptability ratings on 5-point hedonic scale compared to traditional formulation. Thus, addition of kidney beans and pumpkin is a potential way to increase the nutritive value of traditional complementary foods prepared from corn flour.

Likewise, six variants of chivra rajmah premix were prepared at 10%. It was found that standard was most acceptable followed by VAR: B2 and VAR: C2 was least acceptable in terms of all attributes. In this recipe protein content has been found to be increased due to the incorporation of kidney bean flour and would make complementary food more nutritious for infants. Anigo et al., (2010) developed complementary food gruels formulated from cereals (maize, sorghum), soybeans and groundnut by malting technique for infants and children. Complementary foods have good acceptability as well as improved nutrient profile and quality.

Two recipes for preschoolers i.e. blended boondi and rajmah-rice toffee have been supplemented with kidney bean varieties in flour form. Sensory analysis revealed that the recipes got acceptance in terms of various attributes.

Six variants of blended boondi were prepared at 50% by incorporation of raw and processed forms of kidney bean varieties in flour form. Among standard and six variants, it was found that standard was most acceptable in terms of all attributes. While among variants, VAR: A1 was most acceptable and VAR: B2 was least
acceptable in terms of overall acceptability as well as in terms of all attributes. During childhood, the demand of some nutrients is increased so this recipe fulfills the body requirement and aids in achieving growth spurts. It had good calorific value due to deep frying and highly rich in protein content because of supplementation with kidney beans flour. **Waghray and Gulla (2010)** has done a study to extend the shelf life of traditional snack foods such as *khara boondi* and *sev* using butylated hydroxyl anisole (BHA) as an antioxidant at 0.1% level. The products were examined for their physico-chemical and organoleptic changes during the storage period for 120 days. The products were found to be more acceptable only upto 90 days of storage at room temperature. The study demonstrates that the shelf life of traditional snacks can be extended from 60 to 90 days if treated with BHA.

Six variants of *rajmah-rice toffee* were prepared at 20% by the incorporation of raw and processed forms of kidney bean varieties in flour form. Among standard and six variants, it was found that standard was most acceptable in terms of all attributes. While among variants, VAR: B1 was most acceptable and VAR: B2 was least acceptable in terms of overall acceptability as well as among all attributes. Nutritionally, rice is full of starch carbohydrate and thus a good source of energy booster. It is an appealing handy food and the instant source of energy and provides good supplement of cereal-pulse combination which fulfills the nutrient demands during childhood. **Veena et al. (2004)** prepared cereal based traditional foods viz., *chakli* with the substitution of Barnyard millet at various levels. It was reported that the substitution of millet had improved the nutrients per serving in terms of dietary fiber and minerals. Results showed that protein and fat content were exceptionally higher among the developed product as compared to traditional *chakli*.

Two recipes were developed for schoolers by incorporating kidney bean varieties in flour form i.e. *nutri-sickle* and *cookies-en-rajmah*. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Six variants of *nutri-sickle* were prepared at 20% by incorporation of raw and processed forms of kidney bean varieties in flour form. Among standard and all variants, it was found that standard was most acceptable followed by VAR: A2 and
VAR: A1 was least acceptable in terms of overall acceptability as well as among all attributes. It is a mouth-watering recipe especially for children’s. Singh et al., 2004 developed a product such as namakpara from dried spinach leaves. Moisture and protein content of namakpara ranged from 1.43 to 40.87g/100g and 9.61 to 16.62 g/100g respectively. Ascorbic acid and β-carotene were higher in developed product prepared from fresh spinach leaves as compared to that prepared from dried powder. Total iron content of spinach incorporated products ranged from 4.10 to 15.00 mg /100 g. Product developed by using fresh spinach leaves contained appreciable amount of iron and β-carotene content.

Cookies-en-rajmah was also made for school-going children at 15% level. It is a good source of energy and protein for growing children. It was found that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among all variants, VAR: B2 was most acceptable and VAR: A1 was least acceptable in terms of overall acceptability as well as of entire attributes. Since coconut has been used for preparing cookies-en-rajmah which is highly nutritious and rich in fiber, vitamins and minerals. So the developed recipe could be suitable for schoolers as it holds the benefits of coconut as well as kidney beans. Similar product was developed in the study of Hiroyuki et al., 2012 that sago flour was incorporated at 40% in wheat flour for cookies formulations to improve the quality of protein, fiber and mineral content. Results of the sensory evaluation showed the highest overall acceptability scores in terms of all attributes and found good consumer acceptance when compared to cookies containing 100 % wheat flour.

Two recipes were developed for adolescents by incorporating kidney bean flour i.e. rom-pom poli and nourishing churma. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Six variants of rom-pom poli, a stuffed snack item, were made at 15% by the incorporation of raw and processed forms of kidney bean flour. Among standard and all variants, it was found that standard was most acceptable followed by VAR: B1 and VAR: C2 was least acceptable in terms of overall acceptability and had lowest
scores for all the attributes of color, appearance, texture, taste, after taste, flavor. It is a good preparation having a mix of cereals, pulses and jaggery. It was highly nutritious and had good energy, iron and protein content. Khan et al., 2009 prepared mix dal (moong, arhaar and chana) based chiwada, poori and parantha. Among these recipes, it was found that parantha mix provides good amount of protein and iron followed by poori and chiwada mix. Whereas, dal chiwada mix contained more amount of fat and carbohydrate than poori and parantha mix.

Likewise, six variants of nourishing churma were prepared at 20%. After sensory analysis, it was found that standard was most acceptable in terms of overall acceptability and all attributes. While among six variants, VAR: A1 was most acceptable and VAR: C2 was least acceptable in terms of overall acceptability. Efforts were made to enrich traditional recipe by incorporating kidney bean flour and improving its protein quality and energy density for adolescents. A study conducted by UN to test the shelf life, nutrient composition, acceptability of 24 recipes by incorporating India mix (wheat 40: maize 40: full fat soybean 20/100g). The report revealed that almost all the recipes had mean scores more than 3 on 5 point hedonic scale and acceptability scores of churma for appearance, taste, color, flavor, palatability, overall acceptability, mean scores were 3.7, 4.0, 3.8, 3.9, 3.7, 3.7, 3.7 respectively.

Two recipes i.e. rajmah bati and raj-rasam were developed for adults by incorporation of kidney bean varieties in flour and whole form respectively. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Based upon processing method of kidney bean varieties, six variants of rajmah-bati were prepared at 20%. Among standard and six variants, it was found that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among six variants, VAR: A1 was most acceptable and VAR: C2 was least acceptable in terms of overall acceptability and all attributes. Since, whole wheat flour contains complex carbohydrates, though low in lysine content, and therefore provide substations fiber substrates. It is very low in saturated fat and cholesterol. By the incorporation of kidney beans, recipe would
become nutritionally sound emanating from increased bioavailability of deficient amino acids. In the study of Arora and Srivastava (2002), finger millet based bati was made along with roasted bengal gram flour and fenugreek seeds powder in the ratio of 60: 20: 20. Carbohydrate content in finger millet based bati provided 79.32 % of total energy than control recipe.

Six variants of raj-rasam were made at 15 % incorporation level of raw and processed forms of kidney bean varieties. Among standard and all variants, it was found that standard was most acceptable in terms of all attributes. While among variants, VAR: C1 was most acceptable and VAR: B2 was least acceptable in terms of overall acceptability as well as in terms of all attributes. Since four food groups (Pulses, Vegetables, Jaggery, Oil) have been used to prepare raj-rasam, so the product is nutritious signifying the concept of food groups and synergism and also improves the protein quality by incorporating kidney beans. It is highly nutritious and rich in protein and vitamin-mineral content.

Bean-bade and smridh upma were developed for old age persons by incorporating kidney bean varieties in flour and whole forms respectively. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Six variants of bean-bade was prepared at 30% incorporation level of raw and processed forms of kidney bean varieties. The results of sensory evaluation showed that standard was most acceptable in terms of all attributes. While among all variants, VAR: A1 was most acceptable and VAR: C1 was least acceptable in terms of overall acceptability. Bean-bade comprising of curd and kidney beans could be a source of good quality protein as it provides the protein of both plant and animal origin. Besides its protein configuration, calcium from curd could also be instrumental for aged people generally suffering from bone anomalies. Bean-bade was made by using the fermentation method. It is one of the beneficial methods that would increase the digestibility and absorption of the amino acids thus enhances the nutritional value of developed product. In the study of Dike and Odunfa (2003), that developed the fermented product soyavada, the results showed increased digestibility and absorption of amino acids due to fermentation process. Developed product has longer keeping quality as well as good in flavor.
Following the same trial, six variants of *smridh upma* were prepared at 30%. The results of sensory analysis showed that standard was most acceptable followed by VAR: A1 and VAR: B2 was least acceptable in terms of overall acceptability as well as in terms of all attributes. *Smridh upma*, being soft in texture, could be a suitable recipe for aged people with denture problems. Incorporation of bean flour might be one of the contributing factors to improve the protein quality of developed recipe. *Pathak and Srivastava (1998)* developed *dhokla, upma* and *laddu* mixed with foxtail millet in combination with fenugreek seeds and pulses. The products were found to have an excellent storage quality in terms of organoleptic evaluation when packed in polythene pouches and stored at ambient conditions for one month. Two recipes i.e. *paustik poha* and *augmented poppadoms* were developed for pregnant women by incorporation of kidney bean varieties in whole and flour forms respectively. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Based upon processing method of kidney bean varieties, six variants of *paustik poha* were prepared by the incorporation of kidney bean varieties at 20%. Among standard and all variants, it was found that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among six variants, VAR: A1 was most acceptable and VAR: C2 was least acceptable in terms of overall acceptability and all attributes. Rice flakes, being a good source of iron, incorporated with kidney beans could amplify the iron content of final product. So this recipe will be helpful to the women during expecting condition.

Six variants of *augmented poppadoms* were prepared at 10% with the incorporation of raw and processed forms of kidney bean varieties. The results of sensory analysis showed that standard was most acceptable followed by VAR: A1 and VAR: B2 was least acceptable in terms of overall acceptability as well as in terms of all attributes. They fulfill the extra need of bodily requirements during pregnancy. *Begum et al.(2003)* developed *papad* formulated from Finger millet (60%), sago (20%), black gram (20%). Results revealed that calcium content was found to be higher in papad with Finger millet (156 mg/100 g) as compared to traditional papad (82 mg/100 g) which corroborates with our study of kidney bean supplementation in *augmented poppadoms*. The protein content ranged from 9.8 g to
18.8 g/100g in papad. This could be well compared to the study reported by Khot et al. (1996) which revealed that the crude protein of moth beans usually was 14.93 g/100g. Similarly results were found in another study which was studied by Begum (1999).

Six variants of rustic *papdi* were prepared at 10% incorporation level of raw and processed forms of kidney bean varieties. The result of sensory evaluation revealed that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among six variants, VAR: C1 was most acceptable and VAR: A1 was least acceptable in terms of overall acceptability and among all attributes. Since, *til* was used which act as a galactogen helps to increase the milk production and provides optimum nutrition. Oil is used for deep frying which makes the recipe more energy dense. Incorporation of kidney beans will be helpful to enrich protein quality. So, developed value-added product could be a good supplement for expecting mothers to meet the nutritional requirements. One of the study conducted by Gupta, (2009) reported that *mathari* prepared from locally available ingredients such as- soybean, green leafy vegetables, peanuts, and sesame seeds improved the protein and mineral content. The protein and fat content was increased in mathari because of addition of soybean and using deep frying method respectively. The iron content of mathari ranged from 5.28 to 8.73 and calcium content from 13.5 to 227.28 mg/100g. Theresults revealed that the sensory scores of the developed products were highly acceptable. In another study done by Muyonga et al. in 2008, *mathari* was prepared by maize flour with the incorporation of amaranth flour at different levels which is commonly consumed as a snack item by children in Uganda. Results revealed that due to the substitution of amaranth with maize flour, the quality of protein as well as iron, zinc, calcium and B-vitamins content of the snacks was improved. Results showed more weight gain and improved school attendance among children aged 3-5 years snacking on amaranth-based snack compared to those fed on maize-based snacks. Amaranth has potential to contribute in the improvement of the nutritional status of vulnerable population.

Further, six variants of enriched *sev* were made at 50% incorporation level with kidney bean varieties in raw and processed forms. The results of sensory analysis revealed that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among all variants, VAR: B1 was most acceptable
and VAR: C1 was least acceptable in terms of overall acceptability as well as in terms of all attributes. It was highly rich in protein content and good for nursing mothers. The value added product namely sev was also developed in the study conducted by Punia, 2009 by using locally available food ingredients such as soybean, green leafy vegetables, peanuts, and sesame seeds which can improve the protein and mineral content of the recipe. The results revealed that the developed value-added product was highly acceptable and having higher scores of more than 7. Sev can meet up to one-third requirement of RDA of protein intake and fulfill about one-third requirement of RDA of iron during the physiological condition.

Similarly, one recipe developed for malnourished children by the incorporation of kidney bean varieties in whole form was mix. veg.-bean khichdi. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Six variants of mix. veg.-bean khichdi were made at 10% with the incorporation of raw and processed forms of kidney bean varieties. Among standard and all variants, it was found that standard was most acceptable in terms of overall acceptability. While among six variants, VAR: C1 was most acceptable and VAR: B1 was least acceptable in terms of overall acceptability as well as all attributes. Mix veg.-bean khichdi was especially made for malnourished children. It was rich in protein, vitamins and had high energy value. Similar findings were found in another study that supplementary product khichdi were prepared using green gram dal and rice as control while for test samples, rice was supplemented with oats at different percent (20:25:30). The results revealed that all the sensory parameters of khichdisupplemented with oats at 25 % had the highest scores. Supplementation of developed recipe with oats increased the moisture, protein and fat content in comparison to the normal preparations (Sharma, 2011). Cereal-based items along with small amount of vegetables or fruits are highly nutritious and had higher protein, carbohydrate, vitamins and mineral content (Jani et al., 2009). (Anonymous, 2003) developed khichdi with chana and moong dal by incorporation of underutilized leafy vegetables like amaranth leaves and drumstick leaves at 10% level. Enhanced nutritive value of khichdi mix tremendously provides
23 g/100g protein, 396 Kcal of energy, 194 mg/100g of Calcium and 4260 mg/100g of ß-carotene as compared to traditional khichdi.

In the same vein, a recipe developed for diabetic patients by incorporating kidney bean flour was rissi-missi roti. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Six variants of rissi-missi roti were developed by incorporating raw and processed forms of kidney beans at 10%. It was found that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among variants, VAR: A2 was most acceptable and VAR: C1 was least acceptable in terms of overall acceptability as well as of all attributes. They will be helpful in regulating the blood glucose level. Protein and calcium of traditional wheat-based products can be potentially increased by incorporating kidney bean flour in product preparation. Almost similar recipe was made by Khetarpaul etal., 2009 by using cereal such as- wheat flour which was supplemented with different cereals and dals (partially defatted soy dhal, sorghum, rice, maize and pearl millet) at different levels which would be helpful to improve the nutritional value of chapattis in terms of moisture, protein and crude Fiber contents when compared with only wheat flour chapatti. Organoleptic evaluation of developed chapattis indicated that they were highly acceptable in terms of various sensory parameters.

Finally, a recipe named double-do sag was developed for cardiac disease patients by incorporating kidney bean varieties in whole form. Sensory analysis revealed that the recipes were accepted in terms of various attributes.

Six variants of double-do sag were made at 10% by incorporating raw and processed forms of kidney beans. Among standard and six variants, it was found that standard was most acceptable in terms of overall acceptability as well as in terms of all attributes. While among all variants, VAR: C1 was most acceptable and VAR: A1 was least acceptable in terms of overall acceptability as well as in terms of all attributes. They will be helpful for controlling the blood cholesterol level. Modification of traditional recipe of double-do sag was done to increase its vitamin and mineral content by adding spinach. The presence of greens like- spinach might be one of the contributing factors for high iron content among the product. They
were rich in protein and fiber content also. Developed innovative food product was incorporated with drumstick leaves (*moringa olifera*) in traditional Indian recipes by **Nambiar and Parnami, 2007.** Freshly blanched drumstick leaves were incorporated in three pulse based recipes commonly consumed in India such as boiled and seasoned mung (*phaseolus aureus*), kabuli chana (*cicer arietinum*) and desi chana (*cicer aritinum*). The study showed that all the three recipes (mung, kabuli chana and desi chana) were found to be acceptable by the panel of judges with an overall composite score ranging from 3.06 to 3.53 (on a scale of 1 to 5 point) for the three test recipes. The overall composite scores for desi chana were highest at 3.53±0.71 followed by kabuli chana at 3.4±0.49 and mung at 3.06±0.57.

In terms of sensory evaluation, most of the test recipes (incorporating different versions of kidney bean varieties) were as acceptable as their respective standards. Food products developed by incorporating raw kidney bean varieties were found the most, and those from blanched kidney beans as least acceptable, in terms of acceptability evaluation outcomes. Among developed food products, *cookies-en-rajmah* was most and *chivra rajmah premix* was least acceptable products among the whole range of products evaluated through ranking.

The present study revealed that hot-water blanching positively affects the nutrient profile of kidney bean varieties. Hot-water blanching has been found to be much better and suitable processing method than other household treatments in analytical aspects such as proximate, antioxidant and antinutrients. Blanching being found to be better in respect of effect on mineral content. On the product development front, nineteen recipes were developed by incorporating kidney bean in raw and processed forms at various levels for different life stages and therapeutic conditions. Results revealed that all the products were acceptable in terms of all attributes of respective recipes. Standard were most acceptable followed by VAR: A1, VAR: B1, VAR: C1 in most of the cases. Apparently, the recipes and their most acceptable variants which were well accepted can become beneficial in terms of normal and therapeutic nutrition as this study goes to validate kidney bean varieties as nourishing and healthy food stuff.