NUTRITIONAL AND ORGANOLEPTIC EVALUATION OF VALUE ADDED PRODUCTS DEVELOPED FROM FABA BEAN (*VICIA FABA* L.)

By

VANDANA
2004HS207M

Thesis submitted to CCS Haryana Agricultural University in partial fulfilment of the requirements for the degree of :

MASTER OF SCIENCE

IN

FOODS AND NUTRITION

Department of Foods and Nutrition
I.C. College of Home Science
CCS Haryana Agricultural University
Hisar – 125004

2006

Dedicated

To

My Papa

&

Loving

Bhai Jagdeep

Acknowledgement

With limitless humility, I would like to praise and thank God, the supreme and merciful, who blessed me with all the favourable circumstances to go through this gigantic task and for bestowing me with such affectionate parents, without whom, my present thesis would not have materialized. The very idea of this work having been completed makes me ponder over the word to thank to all those who were incremental in the completion of this important milestone in my academic journey, through the gratitude cannot be expressed, yet can be felt deep in the heart and is beyond description.

Although thanks are poor expression of debt of gratitude one feel yet there is not better way to express it. With sincerity and immense pleasure. I feel great pride and privilege of express profound sense of gratitude and infinite indebtnes to my esteemed Major Advisor, Dr. (Mrs.) Saroj Dahiya, Professor and Head, Department of Foods and Nutrition under whose close supervision, sincere counsel and invaluable guidance, this study has been completed. For all this kind consideration, I am beholder to her in a special manner and no words can fully convey my feeling of respect and regards for her.

I wish to convey my heartiest appreciation for her patience, understanding and round the clock help extended to me by my Co-Major advisor Dr. (Mrs.) Asha Kawatra, Professor, Department of Foods and Nutrition.

I also honour and thank this same spark to the members of my advisory committee, Dr. (Mrs.) Sarla Malhotra, Professor, Department of Biochemistry, Dr. Lajpat Rai, Professor, Department of Mathematics and Statistic, Dr. Nerraj Kumar, Senior Scientist, Department of Pulses.

I am immensely indebted to Mr. Ramnivas, Computer Section, College of Basic Sciences for their valuable guidance and spirited cooperation all through my research work.

I am highly grateful to the teaching and non-teaching staff members of Department of Foods and Nutrition, especially Mr. Karnail

Singh, Mr. Sita Ram, Mr. Dalbir Singh, Mr. Surender Kumar for their ever willing help.

Words fail me in expressing the debt of gratitude to my mother, Smt. Snehlata and father Sh. O.P. Boora as I owe my identity. Silent wishes and blessing received from them to bring me to this level.

The love and affection liberally showed on me by my sister Deepika, jiju Sukhbir, Bhiya Jagdeep and Bhabhi Veenu who always kept me optimistic and embolden my resolve.

I have also express my heartily thanks to my mamaji Sh. Nathu Ram Arya for his invaluable blessings in my life.

Good friends are treasure of life. I would never be able to repay back the kind consideration support, affectionate help and prompt criticism from my friends Savita, Anita, Ila, Anu, Priya, Deepti, Shuchi, Tukku, Pooja, Sikandra, Kiran di, Arti di, Anuja di and Parvinder di, Vicky. The best thing happened to me during my sojourn at Hisar was my friendship with Chandni, Dimpu, Rubi whose company and help was a source of strength and encouragement during the course of my master's degree.

I also express my thanks to CCSHAU, Hisar for providing me fellowship and all facilities during this study.

Last, but not the least, I express my sincere thanks and heartful love to my little angel Nonu and Khushi.

Above all, I admire my Papa as the whole work is possible because of them which stood behind me as a strong pillar and provided me great energy and enthusiasm for work.

Hisar

June, 2006 **VANDANA**

CERTIFICATE – I

This is to certify that this thesis entitled, **"Nutritional and Organoleptic evaluation of value added products developed from Faba bean (*Vicia faba* L.)",** submitted for the degree of **Master of Science,** in the subject of **Foods and Nutrition** to the CCS Haryana Agricultural University, is a bonafide research work carried out by **Vandana** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

Dr. (Mrs.) Saroj Dahiya
Major Advisor
Professor and Head
Deptt. of Foods and Nutrition
CCS HAU, Hisar - 125004

CERTIFICATE – II

This is to certify that this thesis entitled**, "Nutritional and Organoleptic evaluation of value added products developed from Faba bean (*Vicia faba* L.)"**, submitted by **Vandana** to the CCS Haryana Agricultural University in partial fulfillment of the requirements for the degree of **Master of Science,** in the subject of **Foods and Nutrition**, has been approved by the Student's Advisory Committee after an oral examination on the same.

MAJOR ADVISOR **HEAD OF THE DEPARTMENT**

DEAN, POSTGRADUATE STUDIES

CONTENTS

List of Tables

List of Figures

Chapter 1

Introduction

Legumes are produced and widely consumed through out the world particularly in tropical and sub-tropical areas of Africa, Asia and Latin America (Gupta *et al.*, 2005).

Legumes are one of the richest and least expensive sources of protein in the human diet in many parts of the world. Faba bean (*Vicia faba* L.) is a non conventional legumes grown as minor vegetable crop in Himalayas (Naidu, *et al.*, 1984). As the requirement of pulses is increasing with population increase emphasis is being laid upon utilization of non conventional food legumes like faba bean (Sharma and Sehgal, 1992a).

Food legumes are characterized by a relatively large content of proteins and carbohydrates. In general pulses also contain significant amounts of crude fibre, lipids, minerals and vitamins (R. Alonso *et al.*,

2000). Faba bean ranks as the fourth most important pulse crop in the world after dry beans, dry peas and chickpea (Elsheikh *et al.*, 1999).

Leguminous crops are unique in the high protein content of their seeds and their ability to fix atmospheric nitrogen. Faba bean contain 28.6 – 29.3 per cent protein (Sharma, 1989). Faba bean a newly introduced crop in Indian agriculture is an active substitute after soybean products to replace the animal protein in diet (Youssef *et al.* 1987). Diet surveys show that there is a wide variation in the daily consumption of food legumes. In economically poor sections of population, the consumption of food legumes is far below the recommend levels. Daily recommended allowance of pulses in a balanced diet is around 50g (Gopalan *et al.* 1984). Thus there is a growing need for making more of grain legumes available to meet the protein requirements of people.

In Sudan, faba bean is mainly grown for human consumption. Faba bean like other beans are god sources of calories, protein, carbohydrates and fibre and the main characteristic of faba bean is the high protein content although it is low in sulphur-containing amino acid (EI Tinay *et al.,* 1993). A wide range of processing techniques could improve the protein and starch digestibility of legume and therefore their utilization (Alonso *et al.*, 1998). Domestic processing and cooking methods are known to reduce the antinutrients and thus improve the nutritive value of legume grains (Khokhar and Chauhan, 1986a). Domestic processing

techniques like soaking, sprouting, roasting and pressure cooking are able to decrease or destroy antinutrients present in legumes there by improving the protein quality (Bakar and Gawish, 1991).

Using these processing methods, a variety of legume products is prepared and consumed depending upon the cultural and taste preferences and it is of paramount importance to asses their nutritive value, which is lacking. A major obstacle in utilizing the faba beans is the tough nature of their seed coats and the presence of various autinutrients. Consequently long hours of cooking required to tenderized them. Faba bean seeds are highly nutritious yet its cultivation is not very common (Gupta *et al.*, 2005). Phytic acid lowers the bioavailability of minerals and inhibits enzymes like proteases and amylases. Removal of these antinutrients is therefore necessary for effective utilization of food legumes for human nutrition.

The faba bean contains appreciable levels of minerals and dietary fibre. Mineral availability from faba bean can be directly or indirectly affected by other legume components such as protein, other minerals, phytic acid and dietary fibre which may act as enhancers or inhibitors (Pilar *et al.,* 2004).

The favourable nutritional profile, together with the excellent quality of faba bean protein of the good availability of its carbohydrates, makes the use of this pulse suitable for human and animal nutrition under

diverse physiological and pathological situations (Hypertension, arteriosclerosis, diabetes etc.) (Pilar *et al.,* 2004).

Faba bean is a rich source of vegetable protein content (20.25%), moderately resistant to insects-pests and diseases and highly responsive to good management conditions. It has diversified uses as food, feed, fodder, fuel and adds nitrogen to soil thereby increases the soil fertility,

Keeping these facts in view, the present study was planned to standardize and develop various products from the high yielding variety of faba bean, their organoleptic acceptability and nutritional analysis of the developed products. The objectives of the study were as follows :

1. To study the physico-chemical properties and nutrient composition of faba bean.

2. To standardize value added products from faba bean and study their organoleptic evaluation.

3. To find out the nutritional composition and shelf life of acceptable products.

Chapter 2

Review of Literature

The availability of pulses, a major protein source for masses, is decreasing progressively due to stagnation in production and increase in population. The poor cannot have sufficient quantity of protein and fat in their daily diets owing to high prices. So, to meet the growing demands of population, the availability of pulses could be increased through effective utilization of unconventional pulses like, faba bean etc, through their use in development of different products.

Very few studies have been reported on incorporation of these pulses in different recipes. The literature available regarding the effect of different processing on nutrients and the development of different products from pulses and their nutritional evaluation has been suitably reviewed under the following heads and subheads :

3.1 Physico-chemical properties of unprocessed faba bean

3.2 Nutritional composition of unprocessed faba bean

3.2.1 Proximate composition

2.2.2 *In vitro* digestibilities

3.2.1.1 Protein digestibility

3.2.1.2 Starch digestibility

3.2.3 Antinutritional factors

3.2.3.1 Phytic acid

3.2.3.2 Tannins

3.2.4 Minerals composition

3.2.4.1 Total minerals

3.2.4.2 HCl extractable minerals

2.1 PHYSICO-CHEMICAL PROPERTIES OF UNPROCESSED FABA BEAN

Physico-chemical parameters such as density, hydration capacity, swelling capacity and cooking time of pulses are the important parameters for assessing consumer acceptability.

Soaking of legumes before cooking can provide many beneficial attributes to the final cooked products. Soaking removes foreign material, facilitates cleaning of beans, improves product tenderness and improves colour (Cain, 1950; Hoff and Nelson, 1966).

Ahmed and Shehta (1982) analyzed 93 faba bean samples and observed that hydration coefficient varied from 172 to 219. Both the consumers as well as processors prefer faba bean samples that have high hydration and swelling coefficients.

William *et al.* (1982) reported that hydration capacity was highly correlated with seed size in chickpea and the seed volume and swelling capacity per seed were related to cooking time. They reported that seed volume, density, swelling capacity and hydration capacity of kabuli type chickpea was 0.247 ml, 1.29 g/ml, 0.344 ml and 0.356 g, respectively.

Soaking reduced cooking time in faba beans. Cooking time of dry and soaked seeds was highly correlated in faba bean as reported by Singh *et al.* (1988).

Sharma (1989) reported that cooking time of two varieties of faba bean was 116 and 70 min. Cooking time of different pea varieties varied from 83 to 106 min.

Latunde-Dada (1991) revealed that swelling capacity and seed density of ten Nigerian soybean varieties ranged from 99.3 to 197.7 per cent and 1.82 to 2.36 g/cm^2, respectively, whereas swelling capacity and density of different varieties of peas was found to be ranged from 0.43 to 0.55 ml/seed and 1.18 to 1.30 g/ml, respectively (Bishnoi and Khetarpaul, 1993a).

Cooking time is defined as the time from commencement of boiling until 90-100 per cent seeds are cooked. Most of the legume require hours of cooking, if not soaked, so the cooking time is an important parameter.

2.2 NUTRITIONAL COMPOSITION OF UNPROCESSED FABA BEAN

2.2.1 Proximate composition

Brisson *et al.* (1950) reported fibre content to be 9.2 per cent on dry matter basis. Ash has been found out to be 3.8-4.0 per cent on dry matter basis. The crude fiber concentration of faba beans ranges from 6-11 per cent. However higher values of fibre content (15.4%) has also been reported (Hove *et al.*, 1978).

Fat and ash content in faba bean varied from 0.8 to 4.5 per cent and 2.5 to 3.5 per cent, respectively (Eden; 1968; Muberak *et al.*, 1988 and Sharma and Sehgal, 1991b).

Protein content in faba bean ranged from 23-35 per cent (Gorski, 1985; Sammour, 1987; Sharma and Sehgal, 1991b).

Cooking brought a slight decrease in crude protein, ether extract and fibre contents in chickpea grains as compared to raw grains (Kosson and Bakowski, 1986). Sotelo *et al.* (1987) reported no difference in cooked and raw chickpea grains with respect to protein, fat and fibre content. According to Savage and Deo (1989) cooked peas had slightly lower crude protein contents.

The contents of crude protein and fat in various legumes change during fermentation. In the cereal-legume blends using rice, barley, green gram dal and defatted Soya flour, fermentation either decreased or did not alter the crude protein content of blends (Goyal, 1991).

Some strains of micro-organism are known to be fat producing and their likely participation in fermentation may account for increased amount of fat in fermented products. Since no addition or deletion of mineral source is involved. Hence, no change in ash content during fermentation has been observed (Chaudhary, 1993).

Rani and Hira (1993) and Gupta *et al.* (2005) reported the crude protein content in raw faba bean to be 25.8 per cent and found no significant effect of various treatments i.e. roasting, pressure cooking and dehulling on the protein content of the faba bean.

2.2.2 *In vitro* digestibilities

2.2.2.1 Protein digestibility (*In vit*ro)

Cooking and heat treatment have been shown to increase the digestibility of legume proteins (Jaffe, 1950). Satwadhar *et al.* (1981) and EI-Faki *et al.* (1984) showed that cooking improved the protein digestibility of chickpea, horse gram and cowpea by destroying trypsin inhibitors. According to Laurena *et al.* (1987) simple wet heat treatment like boiling at atmospheric pressure and pressurized boiling above 100^0C temperature could increase protein digestibility by 6 to 26 per cent in cowpea (Laurena *et al.*, 1987). *In vitro* protein digestibility of mungbeans increased with increase in time of processing. Kataria *et al.* (1989b) established a correlation between period of processing and protein digestibility.

Legumes contain about 2-3 times more protein as compared with cereals but protein digestibility of legumes is poor (Liencer, 1962).

Due to presence of several factors like saponins, glycoside, tannins, oxalates, phytates, legumes possess low protein digestibility (*in vitro*) (Anon, 1973; Gupta, 1987). The low protein digestibility of legumes may alsobe attributed to the resistance of globulins, a major pulse seed protein to the proteolytic enzymes (Walker and Kochhar, 1983).

Various processing techniques have been reported to significantly improve the protein digestibility of several legumes including blackgram (Khan and Ghafoor, 1978), northern bean (Sathe and Salunkhe, 1981), cowpeas (Chavan *et al.*, 1989), field and vegetable peas (Bishnoi and Khetarpaul, 1994b), Pigeon pea (Duhan, 1992), faba bean (Sharma and Sehgal, 1991a), ricebean (Kaur, 1986) and soybean (Grewal, 1992).

Fermentation also improves the protein digestibility. The reason being the microflora during fermentation produce protinases which are responsible for proteolytic activity of microflora. During the fermentation the bacteria increased the proteolytic activity and degraded protein into peptides and amino acid which are readily utilizable by bacteria (Zamora and Fields, 1979). Synthesis of amino acids from metabolic intermediates during growth cycle of bacteria also occur.

Increased protein digestibility due to soaking is attributed to leaching of phytates, polyphenols and other factors affecting the protein content in seed (Deshpande and Cheryan, 1983; Reddy *et al.*, 1982).

Roasting of soybean for five and ten minutes caused only a slight increase in the *in vitro* digestibility of protein (Reddy *et al.,* 1985).

Antinutrients like phytic acid and polyphenols having an adverse effect on protein digestibility are decreased during fermentation (Lopez, *et al.,* 1983; Dhankar and Chauhan, 1987b; Khetarpaul and Chauhan, 1991; Gupta *et al.,* 1991) and may be responsible for an increase in protein digestibility.

An increase in protein digestibility due to fermentation has been observed in corn meal (Neumann *et al.,* 1984), pearl millet (Mahajan and Chauhan, 1988), wheat and barley flour (Gupta, 1989), sorghum meal (Kazanas and Fields, 1981), *rabadi* prepared from pearl millet (Dhankar and Chauhan, 1987b) and soybean (Grewal, 1992).

Khokhar and Chauhan (1986b) observed a variation of 58.7 to 62 per cent in protein digestibility among few varieties of mothbean. Griffiths and Moseley (1980) suggested that presence of polyphenols was responsible for low digestibility of field beans.

Protein digestibility was slightly enhanced in roasted bengal gram, maize and soybean (Shrivastava *et al.*, 1990). They showed that effect of time of roasting on protein digestibility value of bengal gram and maize was more than that of temperature of roasting whereas an opposite trend was observed in case of soybean.

The blends prepared from rice, bengal gram flours, barley and defatted soybean flours showed significant increase in temperature and period of fermentation (Goyal, 1991).

Alonso *et al.* (2002) and Saharan *et al.* (2002) reported that on dehulling, soaking and germination the protein digestibility (*in vitro*) of faba bean improved from 53.3 to 28.0 and 72.0 per cent respectively.

2.2.2.2. Starch digestibility (*In vitro)*

Among the legume carbohydrates, starch is the major constituent (Nigam and Giri, 1961) which possesses low digestibility (Geervani and Theophilus, 1980; EI-Faki *et al.*, 1984a).

Various processing methods are known to improve starch digestibility. Starch digestibility (*in vitro*) increased on cooking of chickpeas, green gram, cowpea, black gram and red gram (Rao, 1969 and Kumar and Venkataraman, 1978). EI Faki *et al.* (1984b) observed an increased starch digestibility during boiling, pressure cooking and germination. Boralkar and Reddy (1985) observed as significant improvement in starch digestibility after soaking soybean for 12 h.

The low starch digestibility in food legumes results from the presence of amylase inhibitors (Singh *et al.*, 1982), phytate and polyphenols (Thompson and Yoon, 1984). Starch digestibility among

different legume varies from 22 to 80 per cent (Khokhar and Chauhan, 1986; Sharma and Sehgal, 1991a; Yadav, 1992 and Chaudhary, 1993).

Heat treatment increases the rate of amylases by three times when compared to that of raw sample of mothbean and horse gram (Subhalakshmi *et al.*, 1976) and hence causes an enhancement in starch digestibility. An increase in starch digestibility on cooking has been observed incase of peas (Bishnoi and Khetarpaul, 1993b), cowpeas (Duhan, 1992) and in amphidiploids (Kataria *et al.*, 1990).

An increase in starch digestibility (*in vitro*) during fermentation in various food grains including sorghum (Kazanas and Fields, 1981), pearl millet (Khetarpaul and Chauhan, 1991), soybean (Grewal, 1992) has been reported. Chaudhary (1993) observed the beneficial effect of indigenous fermentation on starch digestibility of black gram sprouts.

Saharan (1994) reported that enhanced digestibility of cooked legume starch by alpha-amylase could be attributed to the swelling and rupturing of starch granules which facilitate more randomized configuration for alpha-amylase to affect hydrolysis, the disintegration of various bean components during cooking and inactivation of ∝-amylase inhibitors. Differences in starch digestibility during heat treatment may occur due to differences in extent of starch gelatinisation.

2.2.3 Antinutritional factors

2.2.3.1 Phytic acid

The biological role of phytic acid in seeds includes as a phosphorus store; as an energy store and possibly as an agent for preventing aflatoxin production in soybean seed by making zinc unavailable to the mold. Phytates are widely distributed in plant seeds. Erdman (1981) stated that phytic acid can form complexes with protein and mono and divalent cations.

Kumar *et al.* (1978) suggested that insoluble complexes between phytate and other components were formed during cooking and hence, the phytic acid content was decreased.

Phytate phosphorus is not generally available to humans and monogastric animals. Phytate is hydrolysed to inosital and few orthophophate by enzyme phytase. This enzyme has been reported in soybean, corn seed, faba bean, mungbean, triticale and wheat (Singh and Sedeh, 1979; Michael Eskin and Wiebe, 1983).

Phytic acid occurs primarily in the seed coat and germ of plant seeds. At acidic pH, phytate forms a binary protein-phytate complex by binding to basic residue of protein. In the presence of cations at alkaline pH, phytic acid forms a ternary protein-mineral-phytate complex (Cheryan, 1980) which inhibits enzymatic degradation of protein (Serranio *et al.*, 1985) and therefore affects the protein digestibility.

Phytic acid, a powerful chelating agent for divalent cations interferes with the mineral availability by formation of insoluble phytates (Reddy and Salunkhe, 1981).

A wide variation in phytic acid exists among different varieties of faba bean. Throw MS variety of faba bean contained 9.6 g/kg phytic acid whereas in variety Dylan, it was as high as 12.0 g/kg (Griffith and Thomas, 1981).

Duhan *et al.* (1989) reported that phytic acid content of chickpea and black gram ranged between 7.48 – 8.00 kg^{-1} respectively. Phytic acid content of black gram was reported to be 645 mg/100g and that of amphidiploids (green gram × black gram) to range from 697 to 750 mg/100g (Kataria, 1986). Carnovale *et al.* (1988) observed a variation of 0.71 to 1.15 per cent in faba beans. Phytic acid content of faba bean ranged from 977.7 to 980.0 mg/100g (Sharma and Sehgal, 1992b). Yadav (1992) observed the phytic acid content of black gram and green gram to be 1004.4 and 897.4 mg/100g, respectively.

The nutritive value of legume seeds could be improved if phytate is reduced or hydrolysed before consumption. Various domestic processing methods as soaking, germination and fermentation, etc., are known to reduce or eliminate phytic acid content (Duhan *et al.*, 1989;

Bishnoi *et al.*, 1994c; Yadav, 1992; Grewal, 1992). A longer cooking time is required to destroy phytate in dry beans (Tabekhia and Luh, 1980).

Saharan *et al.* (2002) reported that whole seed of faba bean and rice bean contained 1012.7 and 2018.2 mg/100g of phytic acid and tannin respectively. Further they reported that soaking and sprouting contributing significantly ($P<0.05$) towards reduction in phytic acid and tannin contents in faba bean and rice bean. Phytic acid content of faba bean was reduced from 1012.7 to 855.8 mg/100g and sprouting.

2.2.3.2 Tannins

Most of the tannins in the faba bean is found in the testa (Kadirvel and Clandinin, 1974). Digestibility has been reported to be reduced in faba beans with high tannin concentration (Bond, 1976; Marquardt *et al.*, 1978). Tannins are known to inhibit the proteolytic enzymes as they form insoluble complexes with food proteins which ultimately lower the digestibility and so also the protein quality. Digestibility has been reported to be reduced in faba bean with high tannin concentration (Bond, 1976; Marquardt *et al.,* 1978).

Salunkhe *et al.* (1982) have shown the harmful effect of polyphenols on the availability of minerals and vitamins. The availability of ionizable iron is decreased by tannins due to their natural iron chelating agent action (Rao and Prabhavathi, 1982). The tannin content in different

legumes can be reduced by various processing method e.g. dehulling, soaking, cooking etc.

Udayasekhara and Deosthale (1982) reported that soaking of pigeon pea and chickpea overnight resulted in 50 per cent loss of tannin which was 25 per cent in green gram. Cooking also has pronounced effect on reduction of tannins. Kataria *et al.* (1989) reported a significant decrease in tannin content in pulses on cooking.

Tannin content of dry beans depends upon the bean species and colour of seed coat. Tannins are mainly, i.e. 81-85 per cent are located in the testa while only 15-18 per cent located in kernal (Barroga *et al.* 1985). Gorski (1985) showed that seed coat of coloured varieties of faba bean contained upto 6-8 per cent tannins.

Sharma and Sehgal (1992a) reported that polyphenol content of faba bean vried from 226.8 to 208.2 mg/100g.

The polyphenol contents of various legumes have been reported to range from 6.3 to 7.5 mg/g in beans (Tan *et al.,* 1983), 24-25 mg/kg ink peas (Sanage and Deo, 1989), 4.92 mg/kg in pigeon peas (Souza *et al.,* 1991), 122 mg/g in lime beans (Egbe and Akinyele, 1990) and 998.4 to 1000.5 mg/100g in black gram (Yadav, 1992; Chaudhary, 1993).

Alonso *et al.* (1998) and Alonso *et al.* (2000) found that different processing methods and extrusion cooking significantly reduced the level of condensed tannins, polyphenols and phytic acid.

2.2.4 Mineral composition

2.2.4.1 Total minerals

Faba bean are excellent sources of calcium, phosphorus and other essential minerals (Eden, 1968).

Different processing and cooking methods are known to have a pronounced effect on the mineral content of legumes. According to Meiners *et al.* (1976), minerals in cooked legumes are reduced to about one-third and one-half of the values in raw beans, with Mg, P and K leaching into cooking water.

Losses in calcium content of black gram, green gram and chickpea as a result of cooking were noticed by Kumar *et al.* (1978). The losses occurring during cooking may be because cooking involves a complex reaction system. Thereby the Ca^{++} which is concentrated in parenchymal cell migrates into the interior of cell and complexes with phytate ion. Father permeability of cell wall is altered by the presence of Ca^{++} and Mg^{++} ions. More soluble calcium salts might be formed during these changes which get leached out.

Faba bean are also the good soruce of some of the mineral elements (EI-Shimi, 1980). Kumar and Kapoor (1984) reported that calcium content and density of legumes varied from 109.6 to 281.9 mg/100g and 31.82 to 78.31 mg/100g calories, gram having the highest and lentil being the lowest in calcium content and density. The iron content ranged from 6.83 to 12.90 mg/100g in different legumes.

On the contrary, Chompreede and Fields (1984) reported non-significant changes in Mg, Fe and Zn content of legumes after cooking and autoclaving. It is generally believed that mineral are not sensitive to heat processing, but are susceptible to leaching into cooking water. Roasting brought only a slight change in Ca, Mn, Fe, Cu and Zn content of soybean (Ologhobo, 1989). Savage and Deo (1989) reported that cooked peas contained lower level of iron. Cooking of lentil kernels resulted in a marked increase of all minerals elements (Sanage, 1988).

Kakkar (1992) reported that roasted chickpea grains had significantly higher iron content as compared to raw grains.

Fermentation did not alter total mineral content of various cereals and legumes including pearl millet (Dhankar and Chauhan, 1990; Khetarpaul and Chauhan, 1989) and soybean (Grewal, 1992).

According to Hira and Rani (1993) pressure cooking and roasting resulted in significant loss of phosphorus in faba bean. Reduction in

phosphorus content might be due to leaching of minerals in cooking water. Iron content was also significantly reduced after pressure cooking and the Ca, P and Fe contents of raw faba bean were found to be 180, 424 and 4 mg/100g respectively.

2.2.4.2 HCl Extractable minerals

Extractable minerals in a food are those which are soluble in 1.03 N HCl, the concentration of HCl found in human stomach. The amount of HCl-extractable minerals in food is an index of their bioavailability from foods (Chompreeda and Fields, 1984a).

The improvement of HCl-extractability of minerals during fermentation has been reported in corn (Chompreeda and Fields, 1984a), soybean (Grewal, 1992), pearl millet (Dhankar and Chauhan, 1989; Khetarpaul and Chauhan, 1990), cereal legumes blends (Goyal, 1991), *rabadi* prepared from wheat and barley (Gupta, 1989), black gram (Chaudhary, 1993) and *wadi* (Yadav, 1992).

An increase in extractability of Ca, P, Fe, Zn, Cu and Mn with an increase in temperature and period of fermentation in various rice legume blends has been reported by Goyal (1991).

Fermentation brings conversion of bound forms of the minerals to free forms, thereby increasing the amount of extractable minerals (Ramakrishnan *et al.,* 1976; Nolan and Duffin, 1987).

The increased bioavailability of minerals may be attributed to the loss of phytates and tannins as a significant and negative correlation has been noticed between minerals extractability and these antinutrients by previous workers (Khetarpaul and Chauhan, 1990; Yadav, 1992; Grewal, 1992).

Chapter 3

Material and Methods

The present investigation entitled "Nutritional and organoleptic evaluation of value added products developed from Fababean (*Vicia faba* L.)" was conducted in Department of Foods and Nutrition, College of Home Science, CCS Haryana Agricultural University, Hisar.

This chapter contains relevant information pertaining to the research design and methodological steps used for the present investigation. The research procedures have been distinctly described under the following heads and sub-heads:

3.1 Procurement of material

3.2 Physico-chemical properties

3.2.1 Density

3.2.2 Hydration capacity

3.2.3 Swelling capacity

3.2.4 Cooking time

3.3 Nutritional evaluation of unprocessed faba bean

3.3.1 Proximate analysis

3.3.1.1 Moisture

3.3.1.2 Crude protein

3.3.1.3 Crude fat

3.3.1.4 Ash

3.3.1.5 Crude fibre

3.3.2 *In vitro* digestibilities

3.3.2.1 Protein digestibility

3.3.2.2 Starch digestibility

3.3.3 Antinutrients

3.3.3.1 Phytic acid

3.3.3.2 Tannins

3.3.4 Minerals composition

3.3.4.1 Total minerals (Ca, Fe, Zn and P)

3.3.4.2 HCl- extractable minerals (Ca, Fe, Zn, and P)

3.4 Development of products, their organoleptic and nutritional evaluation

3.5 Storage studies

3.3.1 Sensory evaluation of stored products

3.3.2 Chemical analysis

3.1 PROCUREMENT OF MATERIAL

Two high yielding and released variety of fababean namely Vikrant and HB-180 were procured from the department of Plant Breeding, CCSHAU, Hisar in a single lot.

The seeds of fababean varieties were than freed from extraneous material and stored in airtight plastic container under ambient conditions.

3.2 PHYSICO-CHEMICAL PROPERTIES

3.2.1. Density

Seeds (50 g) were weighed accurately and transferred to a measuring cylinder. Then 50 ml distilled water was added to it. Seed volume was recorded by subtracting 50 ml from the total volume (ml). Density was recorded as g/ml.

3.2.2 Hydration capacity

Seeds weighing 50 g were counted and transferred to a measuring cylinder and to this 150 ml water was added. The cylinder was covered with aluminum foil and left overnight at room temperature. Next day, seeds were drained, superfluous water removed with filter paper and swollen seeds reweighed. Hydration capacity per seed was determined by using the following formula :

$$\text{Hydration capacity (per seed)} = \frac{\text{Wt. of soaked seeds} - \text{Wt. of seeds before soaking}}{\text{No. of seeds}}$$

3.2.3 Swelling capacity

Seeds weighing 50g were counted, their volume was noted and soaked overnight. The volume of soaked seeds was noted in a graduated cylinder.

$$\text{Swelling capacity (ml/seed)} = \frac{\text{Volume of seeds after soaking} - \text{Volume of seeds before soaking}}{\text{Number of seeds}}$$

$$\text{Per cent solubility (Per seed)} = \frac{(W5 - W4) \times V_1}{V_2 \times 0.5\ g} \times \frac{100}{0.5\ g}$$

3.2.4 Cooking time

Seeds (100g) were taken in beakers of crude fibre apparatus. Water was added in a ratio of 1:3 (w/v). Beakers were connected with condensers to avoid evaporation of water during boiling. Samples were stirred at 2 min interval. After 45 min one seed was withdrawn without interrupting the boiling. Degree of cooking was tested by pressing seeds between the fingers. If seeds were felt uncooked, one seed was again tested after 5 min. This procedure continued until five seeds tested were found cooked. At this time, total cooking time was recorded.

3.3 NUTRITIONAL EVALUATION OF UNPROCESSED FABA BEAN

The samples of Vikrant and HB-180 varities of fababean were assessed for nutritional quality. The following parameters were studied:

3.3.1 Proximate analysis

3.3.1.1 Moisture

Moisture content was determined by employing the standard method of analysis (AOAC, 1995).

Procedure : Ten gram sample was weighed in a petridish and dried in an oven at 105^0C for six hours or till a constant weight was obtained. The sample was weighed after cooling it in a dessicator.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight (g) of sample}} \times 100$$

3.3.1.2 Crude protein

The total nitrogen was estimated by a standard method of AOAC (1995).

Reagents :

(i) N/100 HCl

(ii) Boric acid (4%)

(iii) NaOH (40%)

(iv) Digestion mixture : 10g K_2SO_4, 0.5g $CuSO_4.6H_2O$ and 2g $FeSO_4$.

(v) Mixed indicator solution : 0.5g of bromocresol green and 0.1 g of methyl red were taken and dissolved in 100 ml 95 per cent ethanol and the solution was adjusted with drops of dilute NaOH to bluish purple colour.

Procedure : 200 mg sample was taken and digested with 20 ml concentrated H_2SO_4 and a pinch of digestion mixture. The nitrogen, as ammonical salt, was distilled with 40 per cent NaOH in a Microkjeldahl apparatus. The ammonia thus liberated was absorbed in 10 ml boric acid solution containing a few drops of mixed indicator and was titrated against standard HCl (N/100). The end point was indicated by the change of colour from bluish-green to pink.

$$\text{Crude protein (\%)} = \frac{.00014 \times V \times (S\text{-}B) \times 100}{V_1 \times W} \times F$$

Where,

W = weight(g) of sample taken

V = volume(ml) of aliquot made

V_1 = volume(ml) of aliquot taken for distillation

S = volume(ml) of HCl (N/100) used in titration for sample

B = volume(ml) of HCl (N/100) used in titration for blank

.00014 = 10 ml of .1 N HCl neutralize .00014 g of nitrogen

F = factor for converting N to protein

3.3.1.3 Crude fat

Crude fat was estimated by employing the standard method of analysis (AOAC, 1995) using the soxhlet extraction apparatus.

Procedure : Five gram of moisture free sample was taken and transferred to an extraction thimble and then weighed. The thimble was placed in a Soxhlet extractor fitted with a condenser and flask containing sufficient petroleum ether. The extraction was carried out for six hours. After the extraction, thimble was removed with the sample from the extraction apparatus and dried in hot air oven to a constant weight. It was cooled in a dessicator and weighed. The loss in weight of the thimble was the estimate of the ether extract in the sample.

$$\text{Fat (\%)} = \frac{\text{Loss of weight (g)}}{\text{Sample weight (g)}} \times 100$$

3.3.1.4 Ash

Ash was estimated by employing the standard method of analysis (AOAC, 1995).

Procedure : Five gram of oven dried sample was weighed in the silica crucible. It was ignited till no charred particles remained in the crucible. The crucible was put in muffle furnace (550^0C) for 5-6 hours or till a white ash was obtained. The crucible was then cooled in a dessicator and weighed.

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

3.3.1.5 Crude fibre

Crude fibre in the sample was determined using the standard method of analysis (AOAC, 1995)

Reagents

(i) HCl (1%) v/v

(ii) Sulphuric acid stock solution (10%) v/v : 55 ml concentrated sulphuric acid was diluted to one litre.

(iii) Sulphuric acid working solution (1.25%) : Diluted 125 ml of stock solution to one litre.

(iv) Sodium hydroxide stock solution (10 %)w/v :Dissolved 100 g of NaOH in distilled water and diluted to one litre.

(v) Sodium hydroxide working solution (1.25%) : Diluted 125 ml of stock solution to one litre with distilled water.

(vi) Antifoam (2%) : Silicon antifoam in CCl_4.

Procedure : Two gram fat free dried sample was put in one litre tall beaker and 200 ml 1.25 per cent H_2SO_4 and a few drops of antifoam were added. The solution was kept for boiling for 30 minutes under bulb

condenser. Beaker was rotated occasionally to mix the contents and remove the particles from sides. The contents were filtered into the beaker through Buchner funnel. The sample was washed back into the tall beaker with 200 ml 1.25 per cent NaOH and again boiled for exactly 30 minutes. All the insoluble mass was transferred to the sintered crucible(G-1) by means of boiling distilled water till acid free. Washed twice with alcohol and thrice with acetone. And then dried at 100^0C to constant weight. The dried material was ashed in a muffle furnace at 550^0C for 1 hour. The crucible was cooled in a dessicator and weighed.

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,

W_1 = weight (g) of sample

W_2 = weight (g) of insoluble matter (wt. of crucible + insoluble matter – wt. of crucible)

W_3 = weight (g) of ash (crucible + ash – wt. of crucible)

3.3.2 *In vitro* digestibility

3.3.2.1 *In vitro* protein digestibility

In vitro protein digestibility was determined by the modified method of Mertz *et al.* (1983).

Reagents

(i) Pepsin reagent : 0.1 M KH_2PO_4 (pH 2.0) containing 0.2 per cent pepsin, 13.6g potassium phosphate was dissolved in 1 litre of distilled water, adjusted pH of the solution to 2.0 and then dissolved 2.0g pepsin in the buffer.

(ii) TCA (50%) : Fifty gram trichloroacetic acid was dissolved in water and made volume upto 100 ml.

Procedure : 250 mg of sample was weighed and transferred to a centrifuge tube. To it, 20 ml of pepsin reagent was added. The tube was stoppered and arranged in a shaker incubator maintaining the water temperature at 37^0C for 3 hours. Then the centrifuge tube was removed and cooled. Five ml of 50 per cent TCA was added and centrifuged the contents at 10,000 rpm for 10 minutes at room temperature and filtered. Ten ml of aliquot was taken and dried in hot air oven. Dried aliquot was digested for nitrogen determination by Microkjeldahl method (AOAC, 1995). Digested protein of sample was determined. Protein digestibility was calculated employing the following formula :

$$\text{Protein digestibility (\%)} = \frac{\text{Digested protein}}{\text{———————}} \times 100$$

Total protein

3.3.2.2 *In vitro* starch digestibility

In vitro starch digestibility was assessed as per the method of Singh *et al*. (1982).

Reagents

(i) Pancreatic amylase : Twenty mg pancreatic amylase was dissolved in 50 ml 0.2 M phosphate buffer (pH 6.9).

(ii) 0.2 M potassium dihydrogen phosphate : 27.28g potassium dihydrogen phosphate was dissolved in distilled water and the volume was made upto one litre.

(iii) 0.2 M disodium hydrogen phosphate : 35.59g disodium hydrogen phosphate was dissolved in distilled water and the volume was made to one litre.

(iv) 0.2 M phosphate buffer (pH 6.9) : Fifty ml 0.2 M potassium dihydrogen phosphate was added to 46.8 ml of 0.2 M disodium hydrogen phosphate and the volume was made upto 200 ml.

(v) Dinitrosalicylic reagent : 3, 5 dinitrosalicylic acid (10g), sodium potassium tartrate (300g) and sodium hydroxide (16g) were dissolved in carbon dioxide free water and volume made to one litre.

The reagent was stored in brown bottle and protected from carbon dioxide.

(vi) Standard maltose solution : One hundred mg maltose monohydrate was dissolved in distilled water and volume made to 100 ml.

Estimation : Fifty mg defatted sample was dispersed in 1.0 ml of 0.2 M phosphate buffer (pH 6.9), 0.5 ml of pancreatic amylase was added to the sample suspension and incubated in water bath at 37^0C for 2 hours with occasional shaking of test tubes. After incubation, 2 ml dinitrosalicylic reagent was added quickly and heated for 5 minutes in a boiling water bath. After cooling, the solution was made to 25 ml with distilled water and filtered. Absorbance was read at 550 nm.

A blank was run simultaneously by incubating the sample without enzyme. Dinitrosalicylic reagent was added before addition of enzyme solution. Maltose was used as standard and values were expressed as mg maltose released/g sample. Standard curve was prepared by taking 0.2 to 1.0 mg maltose from a standard maltose solution.

3.3.3 Antinutrients

3.3.3.1 Phytic acid

Phytic acid was determined by the method of Davies and Reid (1979).

Reagents

(i) 0.5 M HNO_3 : 15.96 ml of 69.5 per cent HNO_3 was diluted to 500 ml with distilled water.

(ii) Ferric ammonium sulphate : 216 mg ferric ammonium sulphate was dissolved in distilled water and made to 500 ml.

(iii) Ammonium thiocyanate : 10g ammonium thiocyanate was dissolved in distilled water and made to 100 ml.

(iv) Isoamyl alcohol.

(v) Sodium phytate : 30.54 mg sodium phytate was dissolved in 100 ml 0.5 M HNO_3, which gave a solution containing 20 mg phytic acid in 100 ml or 200 µg phytic acid/ml.

Estimation : For plotting a standard curve, different concentration i.e. 0.4 to 1.0 ml of standard sodium phytate solution containing 30-200 µg phytic acid, were taken and made to 1.4 ml with water.

Extraction : One gram of sample was extracted with 20 ml 0.5 M HNO_3 for 3 hours with continuous shaking on a shaker and centrifuged at 8000 rpm for 15 minutes.

Procedure : One ml supernatant was taken in a test tube and made to a final volume of 1.4 ml with water. Then one ml ferric ammonium sulphate

solution was added. The tubes were mixed thoroughly and placed in boiling water bath for 20 minutes. After cooling down to room temperature under running tap water, 5 ml Isoamyl alcohol was added. Immediately after mixing the tubes by inversion method, 0.1 ml ammonium thiocyanate solution was added. The tubes were shaken well and the contents were centrifuged at 3000 rpm for 10 minutes. Colour intensity was read at 465 nm against isoamyl alcohol blank exactly after 15 minutes of addition of ammonium thiocyanate.

(v)1.22 Tannin

Tannins were extracted by the method of Singh and Jambunathan (1981).

Extraction : 500 mg defatted sample was refluxed with 50 ml methanol containing one per cent HCl for four hours. The extract was concentrated by evaporating on a hot water bath and brought its volume to 25 ml with methanolic HCl. The amount of polyphenolic compounds was estimated as tannic acid equivalent according to Folin-Denis procedure.

Reagents

(i) Folin-Denis reagent : To 750 ml water, 100g sodium tungstate, 20g phosphomolybdic acid and 50 ml phosphoric acid were added and heated and then refluxed for 2 hours. It was cooled and diluted to one litre.

(ii) Tannic acid (stock solution) : 100 mg of tannic acid was dissolved in water and made upto one litre. In order to have working standard solution 20 ml stock solution was further diluted to 100 ml with water.

(iii) Saturated aqueous sodium carbonate solution.

Procedure : The extract (1.5 ml) was diluted to 8.5 ml with water in graduated test tube. The contents were well mixed. Then 0.5 ml Folin-Denis reagent was added and the tubes were thoroughly shaken. Exactly 3 minutes later, one ml saturated sodium carbonate solution was added and tubes were thoroughly shaken again. After one hour, the absorbance was read at 725 nm using a suitable blank.

A standard curve was plotted by taking different concentrations of 0.5 to 3.0 ml of working tannic acid standard solution containing 10 to 60 ug tannic acid.

3.3.4 Minerals

3.3.4.1 Total Minerals

Acid digestion

Two gram dried and ground sample was taken in a 150 ml conical flask. To this, added 20 ml diacid mixture (HNO_3 : $HClO_4$ :: 5:1, v/v) and kept overnight. Next day it was digested by heating till clear white precipitates settled down at the bottom. The crystals were dissolved in double distilled water. The contents were filtered through Whatman No. 42 filter paper. The filterate was made to 50ml with double distilled water.

This acid digested sample was used for the determination of calcium, phosphorous, magnesium, iron, zinc, copper and manganese. Iron, zinc, copper and manganese were determined by Atomic Absorption Spectrophotometer 2380, Perkin Elmer (USA) according to the method of Lindsey and Norwell (1969). Phosphorous, calcium and magnesium were determined colorimetrically.

Phosphorus

Phosphorus was determined colorimetrically by the method of Chen *et al.* (1956).

Reagents

i) Ascorbic acid (10%)

ii) Ammonium molybdate (2.5%)

iii) Reagent C : 6N H_2SO_4, water, 2.5 per cent ammonium molybdate and 10 per cent ascorbic acid were mixed in the ratio of 1:2:1:1 (v/v) respectively. This reagent was prepared fresh.

iv) Standard phosphorus solution : 0.351g pure and dry anhydrous monopotassium dihydrogen orthophosphate was dissolved in a few ml water and 10 ml 10N H_2SO_4. The volume was made to one litre with water. This stock contained 80 µg P/ml

v) Working standard phosphorus solution : Twenty five ml stock solution was diluted to one litre which served as working standard solution and contained 2 µg P/ml. Two or three drops of chloroform were added to preserve the solution.

Procedure

Mineral extract (0.1 ml) was pippeted in a test tube and volume was made to four ml with water. Four ml reagent C was added and mixed well.

The content was incubated at 37^0C in water bath for 90 minutes. It was removed and allowed to cool to room temperature and absorbance was read at 720 nm against a suitable blank. Standard curve was plotted using one to eight µg P. (0.246 O.D. corresponded to 2µg P).

Calcium

Total calcium in acid digested sample was determined by the method of Chopra and Kanwar (1979).

Reagents

(i) Standard solution of Ca (0.01 N) : 0.5g of well dried pure $CaCO_3$ was transferred to 400 ml beaker and added 10 ml of 1N HCl in it and boiled to expel CO_2. Cooled and 200 ml distilled water was added to dissolve the contents. It was transferred to 1 litre volumetric flask and made up the volume. Stored in a glass reagent bottle.

(ii) Standard solution of EDTA (0.01N) : 2g of EDTA-di-sodium salt was dissolved in sufficient volume of distilled water in a 400 ml beaker and was transferred to 1 litre volumetric flask. To this, 0.05g

of $MgCl_2$. $6H_2O$ was added and made up the volume to 1 litre. The normality of this solution was standardized as under.

Standardization of EDTA solution : 5 ml of standard calcium solution (0.01N) was pipetted in 100 ml China-dish. It was diluted to 10 ml with distilled water. Ten drops each of NaCN and hydroxylamine hydrochloride solutions were added. Then 2.5 ml of NaOH solution and 10-15 drops of calcon indicator were added. Pink colour appeared. In another China dish, a blank solution was prepared in same manner, taking 5 ml of distilled water instead of standard calcium solution. The blank solution was blue in colour or it turned blue with the addition of 2-3 drops of EDTA solution. This blue blank was kept along side for comparing the end point. Then China dish containing the pink coloured standard calcium solution was placed on magnetic stirrer plate. A glass coated iron needle was put in it and stirred. Titrated the solution with EDTA until colour of the solution changed from pink to blue matching the blank. The volume of EDTA used was noted. On the basis of calculation, $N_1V_1 = N_2V_2$, necessary dilutions were made so that the normality of the EDTA solution was exactly equal to 0.01 N.

(iii) Calcon indicator solution (0.5%) : 0.5g of calcon reagent (solochrome dark blue and Erichrome blue black R) was dissolved in 100 ml 95 per cent ethanol. Stored in a plastic bottle.

(iv) Sodium hydroxide solution (16% or 4 N)

(v) Sodium cyanide solution (2%)

(vi) Hydroxylamine hydrochloride solution (5%)

Procedure : 5 ml of digested sample was poured in a 100 ml China dish and diluted to 10 ml with distilled water. To this 10 drops each of 2 per cent NaCN and 5 per cent hydroxylamine hydrochloride solution were added. Then added 2.5 ml of 4 N NaOH solution and 10-15 drops of calcon indicator. Pink colour appeared. In another China dish, a blank solution was prepared exactly in the same way, taking 5 ml of distilled water instead of the test solution. In blank blue colour appeared, if not, 2-3 drops of EDTA solution were added and this blue blank was used for comparing the end point of the test solution. Test solution was placed on magnetic stirrer top and glass coated iron needle was placed in it and stirred. The solution was titrated with 0.01 N EDTA till the pink colour changed to blue matching the blank.

Calculations

$$\textbf{Ca (me per 100g)} = \frac{\text{ml of EDTA used} \times \text{Normality of EDTA} \times \text{Dilution factor} \times 100}{\text{ml of aliquot taken for titration}}$$

3.3.4.2 HCl-extractable minerals

Procedure

Minerals including calcium, phosphorous, magnesium, zinc, iron, copper and manganese were extracted in 0.03N HCl (Peterson *et al.*, 1943).

To one g sample 50 ml 0.03N HCl was added and incubated at 37^0C in a water bath for 3 hours with constant stirring to stimulate condition of human stomach. At the end of incubation period the mixture was filtered through an ashless filter paper (Whatman No. 42) and the filtrate was analyzed for minerals including calcium, phosphorous, zinc and iron. Iron and zinc were determined by Atomic Absorption Spectrophotometer 2380, Perkin Elmer (USA) according to the method of Lindsey and Norwell (1969). Calcium and phosphorous were estimated colorimetrically by the methods described earlier at 3.8.4.1.

3.4 DEVELOPMENT OF PRODUCTS THEIR ORGANOLEPTIC AND NUTRITIONAL EVALUATION

Products viz. roasted *dal*, boiled *dal, missi roti*, *puri, halwa, ladoo, dhokla, dalia,* pasta, cake, biscuit were prepared from Vikrant variety. The

variety was selected on basis of its nutritional composition as compared to HB-180 variety. Standard recipe for each product served as control except roasted *dal* and boiled *dal*. The standard procedure, ingredients used and method of cooking for each product is given below :

ROASTED *DAL*

Method

i) Faba bean seeds were soaked in water for 4 h.

ii) Soaked water was discarded and the seeds were sun dried.

iii) Dried seeds were roasted in sand in an iron pan at about 250^0C for approximately 2 min.

iv) Then they were dehulled.

BOILED *DAL*

Method

i) Added faba bean *dal,* salt, turmeric powder and water in a pressure cooker.

ii) Pressure cooked *dals* till it became tender.

iii) Chopped the onions and fried the onions in ghee till light brown.

iv) Added chilli powder to it.

v) Added boiled *dal* to the above mixture and cooked for another 3 min.

MISSI *ROTI*

Ingredients

Flour	: 100 g
Water	: to knead the dough
Salt	: to taste
Fat	: to smear

Method :

i) Flour was mixed with salt and dough was prepared with water.

ii) Dough was divided into three equal rolls, rounded and rolled with rolling pin to uniform thickness and size of 15 cm diameter.

iii) *Roti* was then baked on both sides on a preheated hot plate.

iv) The *Roti* was then turned twice and than puffed on the hot plate itself by applying pressure with a cloth.

v) *Roti* was cooled to room temperature and then smeared with fat.

PURI

Ingredients

Wheat flour	: 100g
Water	: to knead
Salt	: to taste
Oil	: to fry

Method

i) Sieved wheat flour.

ii) Added salt and kneaded into a dough by using water.

iii) Took small amount of dough and rolled out in form of *puries*.

iv) Deep fried them till golden brown in colour.

HALWA

Ingredients

Wheat flour	: 100g
Sugar	: 25 g
Ghee	: 200g
Water	: 80 ml

Method

i) Sieved flour.

ii) Melted ghee in pan and added flour.

iii) Roasted till light brown colour by continuous stirring.

iv) Added water and sugar till the ghee started leaving sides of the pan.

LADOO

Ingredients

Flour	: 50 g
Ghee	: 40 g
Sugar	: 40 g

Method

i) Melted ghee in a pan and added flour.

ii) Roasted till light brown colour by continuous stirring.

iii) Removed from fire and added ground sugar and mixed well.

iv) Shaped into balls like *ladoos*.

DHOKLA

Ingredients

Chickpea flour	: 250 g
Semolina	: 250g

Citric acid	: 2 per cent
Sodium bicarbonate	: 1.5 per cent
Turmeric powder	: ¼ tsp
Salt	: to taste

Method

Chickpea flour and semolina (1:1) were mixed. In this mixture 2% citric acid, 1.5% sodium bicarbonate, turmeric powder and salt were added. This mixture (100g) was then packed in 200 gauge polythene bags and sealed.

Formulation of Instant *Dhokla* mix

Ingredients

Dhokla Mix	: 50 g
Water	: 90 ml

For water

Refined oil	: 1 tsp
Mustard seeds	: ½ tsp
Sugar	: 1 tsp
Lemon juice	: 1 tsp
Curry leaves	: few
Green chillies	: 2

Water	: 200 ml
Salt	: ¼ tsp

Method

i) Water was added to the *dhokla* mix.

ii) Batter was prepared with proper mixing.

iii) A pan was greased for steaming and poured the mixture into the greased pan.

iv) It was steamed for 20 minutes.

v) When ready took it out on plate and cut into 2"× 2" square pieces.

DALIA

Ingredients

Wheat *dalia*	: 50g
Sugar	: 50g
Water	: 500 ml

Method

i) *Dalia* was roasted in the frying pan until light brown in colour.

ii) Then, water was added to it.

iii) Mixture was cooked on a slow fire till soft and semi-solid.

iv) Sugar was added and mixed properly.

v) Then cooked for few minutes and served hot.

PASTA

Ingredients

Refined flour	: 100 g
Water	: 30 ml

Method :

i) Sieved flour.

ii) Water was added in flour gradually to make a tight dough.

iii) Kneaded the dough well.

iv) Passed the dough through the screw extruder to get the pasta.

v) Pasta were dried in hot air oven (40^0C, 2-3 hrs)

Note : The amount of water added should not be increased more then 30 ml to avoid stickiness of the dough.

Formulation of Extruded Pasta

Ingredients

Raw pasta	: 50 g
Water	: 300 ml

Onion	: 20 g
Tomato	: 10 g
Capsicum	: 30 g
Cabbage	: 20 g
Tomato sauce	: 1 tsp
Chilli sauce	: ½ tsp
Soya sauce	: ½ tsp
Vinegar	: ¼ tsp
Oil	: 10 ml
Salt	: to taste

Method

i) Water was boiled with salt.

ii) Pasta was added into boiled water and boiled for 5 minutes or till soft.

iii) Boiled water was strained and pasta was washed with cold water properly and then kept aside.

iv) Oil was heated in a pan, added chopped onion and fried slightly.

v) Chopped tomato, capsicum and cabbage were added to it and cooked till soft.

vi) Salt, tomato sauce, chilli sauce, soy sauce and vinegar were added and stirred properly.

vii) Boiled pasta was added to the vegetable mixture and cooked for 2-3 minutes.

viii) Served hot.

CAKES

Ingredients

Flour	: 80 g
Sugar	: 80 g
Eggs	: 3 Nos.
Baking powder	: ½ tsp
Vanilla essence	: few drops

Method :

i) Egg white and yolk was separated.

ii) The egg white was beaten with egg beater and sugar was added gradually followed by vanilla essence.

iii) The mixture was beaten until it become white and stiff.

iv) Flour mixture was sieved with baking power twice.

v) The egg yolk and sieved flour was folded in the above mixture.

vi) Cake mixture was poured into the muffins tray and cup cakes were baked at 180^0C for 15-20 minutes.

BISCUITS

Ingredients

Refined flour	: 150 g
Sugar	: 100 g
Hydrogenated fat	: 115 g
Egg	: 1
Baking powder	: ¼ tsp
Baking soda	: ¼ tsp
Vanilla essence	: Few drops

Method

i) The flour was sieved with baking power and baking soda twice.

ii) Ghee and sugar were creamed until light and fluffy.

iii) The egg was beaten with vanilla essence.

iv) The egg and sieved flour were added to ghee and sugar mixture.

v) The mixture was placed in refrigerator for 1 hour.

vi) Small balls were made and pressed with the help of palm.

vii) Biscuits were kept in greased baking tray and baked at 160^0C for 20 minutes.

Sensory Evaluation Of Products

All the products were subjected for organoleptic evaluation with respect to colour, appearance, flavour, taste, texture and overall acceptability by a panel of ten judges from the Department of Foods and Nutrition, CCS Haryana Agricultural University, Hisar using 9-point hedonic scale.

On the basis of mean scores of sensory evaluation obtained after feeding to the judges, the most acceptable products were selected for further nutritional and storage studies

Proportions Tried for Standardization of Recipes :

1. Roasted *dal* and Boiled *dal*

Treatment No.	**Proportions**
1	100% Faba bean

2. *Missi roti*

Treatment No.	**Proportions**

Control	80% Wheat flour + 20% Chickpea flour
1	80% Wheat flour + 20% Faba bean flour
2	60% Wheat flour + 40% Faba bean flour
3	40% Wheat flour + 60% Faba bean flour

3. *Puri*

Treatment No.	**Proportions**
Control	100% Wheat flour
1	90% Wheat flour + 10% Faba bean flour
2	80% Wheat flour + 20% Faba bean flour
3	70% Wheat flour + 30% Faba bean flour

4. *Halwa*

Treatment No.	**Proportions**
Control	100% Wheat flour
1	90% Wheat flour + 10% Faba bean flour
2	80% Wheat flour + 20% Faba bean flour
3	70% Wheat flour + 30% Faba bean flour

5. *Ladoo*

Treatment No.	**Proportions**
Control	100% Chickpea flour
1	90% Chickpea flour + 10 % Faba bean flour
2	80% Chickpea flour + 20 % Faba bean flour
3	70% Chickpea flour + 30 % Faba bean flour

6. *Dhokla*

Treatment No.	**Proportions**
Control	50% Semolina + 50% Chickpea flour
1	45% Semolina + 45% Chickpea flour + 10% Faba bean flour
2	40% Semolina + 40% Chickpea flour + 20% Faba bean flour

7. *Dalia*

Treatment No.	**Proportions**

Control	100% Wheat flour
1	90% Wheat flour + 10% Faba bean flour
2	80% Wheat flour + 20% Faba bean flour
3	70% Wheat flour + 30% Faba bean flour

8. Pasta

Treatment No.	**Proportions**
Control	100% Refined flour
1	90% Refined flour + 10% Faba bean flour
2	80% Refined flour + 20% Faba bean flour
3	70% Refined flour + 30% Faba bean flour

9. Cake

Treatment No.	**Proportions**
Control	100% Refined flour
1	80% Refined flour + 20% Faba bean flour
2	60% Refined flour + 40% Faba bean flour

3	40% Refined flour + 60% Faba bean flour

10. Biscuits

Treatment No.	**Proportions**
Control	100% Refined flour
1	90% Refined flour + 10% Faba bean flour
2	80% Refined flour + 20% Faba bean flour

Nutritional Evaluation

The organoleptically acceptable products were nutritionally evaluated for parameters as mentioned under nutrional analysis of unprocessed fababean.

3.5 STORAGE STUDIES

3.5.1 Sensory evaluation of stored products

The stored products viz. Biscuits, Pasta, *Ladoo* were drawn at intervals of 0, 15, 30, 45 and 60 days and evaluated organoleptically by a panel of 10 judges, using 9-point Hedonic Scale.

3.5.2 Chemical analysis

3.5.2.1 Moisture

Moisture content was determined by employing the standard method of analysis (AOAC, 1995).

Procedure : Ten gram sample was weighed in a petridish and dried in an oven at 105^0C for six hours or till a constant weight was obtained. The sample was weighed after cooling it in a dessicator.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight (g) of sample}} \times 100$$

3.5.2.2 Free fatty acids

Free fatty acids were determined by the standard method of AOAC (1995).

Reagents

(i) Chloroform

(ii) Methanol

(iii) 20 per cent magnesium chloride : 20g magnesium chloride was dissolved in distilled water and volume made upto 100ml with distilled water.

(iv) 1 per cent NaCl : One gram sodium chloride was dissolved in water and made upto 100 ml.

(v) Sodium sulphate (anhydrous)

(vi) Sodium hydroxide (0.25 N) : Ten gram sodium hydroxide was dissolved in water and made upto one litre with water .

(vii) Isopropyl alcohol (99%) : Isopropyl alcohol was neutralized with 0.1 N NaOH solution to a pink colour before adding to sample.

(viii) Phenolphthalein indicator solution : One gram phenolphthalein was dissolved in 95 per cent ethyl alcohol and made upto 100 ml volume .

Extraction : To five gram of sample, five ml chloroform, 10 ml methanol and 0.05 ml of 20 per cent $MgCl_2$ were added and mixed for two minutes on whirl mixer. Five ml chloroform was added and mixed for another two minutes. Then distilled water was added to bring total water content of sample to nine ml and mixed again for 30 seconds. Filtered through G-1 sintered crucible. Washed residues and crucible with 2.5 ml chloroform thrice .Centrifuged the tube contents at 1500 rpm for 5 minutes

and then removed the upper aqueous layer and added 10 ml of 1 per cent NaCl to chloroform extract. Mixed well by gentle inversions. Again, centrifuged at 1500 rpm for 5 minutes. The top aqueous layer was removed and added 1-2g anhydrous powdered Na_2SO_4, shaken vigorously and filtered through a Na_2SO_4 saturated filter paper. Washed the tube contents with 2.5 ml chloroform thrice. The chloroform extract was then transformed to pre weighed tube and placed in steam bath to evaporate chloroform, and then in an oven at 40^0C for 25 minutes .Cooled and reweighed.

Estimation : The weighed lipid sample was taken and to it added fifty ml neutralized isopropyl alcohol. Sample was dissolved completely. Phenolphthalein indicator was added and titrated against 0.25 N NaOH to pink colour end point which persisted for 30 seconds.

Calculations :

$$\% \text{ FFA} = \frac{\text{ml} \times \text{N} \times \text{F} \times 100}{\text{Sample wt.} \times 100}$$

Where,

ml = ml of NaOH required

N = Normality of NaOH

F = Equivalent weight (282) of FFA (oleic acid)

3.5.2.3 Peroxide value

Peroxide value was determined by the method of AOAC (1995).

Reagents

i) Acetic acid : Chloroform solution (3:2, v/v)

ii) Saturated potassium iodide solution

iii) 0.01 N sodium thiosulphate solution

iv) Starch solution : One g soluble starch was dissolved in cold distilled water to make thin paste, then boiling distilled water was added and boiled for one min while stirring. When completely dissolved, the volume was made to 100 ml.

Procedure

Twenty ml of lipid extract was made to 100 ml. To each flask 30 ml of acetic acid-chloroform mixture was added and swirled to dissolve. Then 0.5 ml of saturated potassium iodide solution was added, kept for one minute with occasional shaking and 30 ml of distilled water was added. This was slowly titrated with 0.01 N sodium thiosulphate with vigorous shaking until yellow colour almost disappeared. Then 0.5 ml of one per cent starch solution was added and titration continued shaking vigorously

to release all iodine from chloroform layer until blue colour just disappeared. The blank was run in the similar way.

Peroxide value (meq/kg sample) = S × N × 100 × g sample

Where,

S = ml sodium thiosulphate (blank corrected)

N = Normality of sodium thiosulphate solution

3.6 STATISTICAL ANALYSIS

The data were statistically analyzed by using analysis of variance technique and t-test.

Chapter 4

Results and Discussion

The present investigation was carried out to study the nutritional and organoleptic evaluation of value added products developed using faba bean.

Two varieties of faba bean i.e. HB-180 and Vikrant were evaluated for their physico-chemical properties and nutritional composition. The variety Vikrant was selected for the product development. The products were developed by incorporating various proportions of faba bean flour, chickpea flour, wheat flour and refined flour etc. and were evaluated for their nutritive value. The selected products were stored for two months determining their shelf- life.

The results pertaining to this study have been presented and discussed under the following headings:

iv).2 Physico- chemical properties of unprocessed faba bean

iv).3 Nutritional composition of unprocessed faba bean

iv).3.1 Proximate composition

4.2.2 *In vitro* digestibilities

iv).3.1.1 Protein digestibility

iv).3.1.2 Starch digestibility

iv).3.3 Antinutritional factors

iv).3.3.1 Phytic acid

iv).3.3.2 Tannins

iv).3.4 Mineral composition

iv).3.4.1 Total minerals

iv).3.4.2 HCl extractable minerals

iv).3 Sensory evaluation of value added products developed from faba bean

iv).4 Nutritional evaluation of acceptable products

iv).4.1 Proximate composition

iv).4.2 *In vitro* digestibilities

iv).4.2.1 Protein digestibility

iv).4.2.2 Starch digestibility

iv).4.3 Antinutritional factors

iv).4.3.1 Phytic acid

iv).4.3.2 Tannins

iv).4.4 Mineral composition

iv).4.4.1 Total minerals

iv).4.4.2 HCl extractable minerals

iv).5 Shelf life study of acceptable products

iv).5.1 Organoleptic evaluation

iv).5.2 Chemical analysis

4.1 PHYSICO-CHEMICAL PROPERTIES OF UNPROCESSED FABA BEAN

Physico- chemical properties such as density, hydration capacity, swelling capacity and cooking time of faba bean are given in Table 4.1.

It is clear from the table that density of Vikrant variety of faba bean was 0.85g/ml whereas that of HB-180 variety was 0.82g/ml. Hydration capacity per seed was 0.14 and 0.12g for Vikrant and HB-180 variety, respectively. Swelling capacity of Vikrant was more as compared to those of HB-180 variety of faba bean.

Cooking time is also an important parameter as most of the legumes need very long time for cooking. Cooking time of Vikrant variety was 90 minute where as HB-180 required108 minute cooking time. Vikrant variety had more swelling capacity and hydration capacity and less cooking time. Williams *et al.* (1982) also reported that swelling capacity per seed was negatively correlated with cooking time. The results of the present study are consistent with those mentioned by previous workers for faba bean (Sharma, 1989) peas (Bishnoi and Khetarpaul, 1993a) and

(Saharan, 1994). They also reported a significant negative correlation between swelling capacity and cooking time of legumes.

Table 4. 1 : Physico-chemical properties of Faba bean (on dry matter basis)

Varieties	Density (g/ml)	Hydration capacity (g/ seed)	Swelling capacity (ml/ seed)	Cooking time(min)
HB-180	0.82±0.05	0.12± 0.00	0.19±0.00	108±0.09
Vikrant	0.85±0.00	0.14±0.00	0.23±0.00	90±0.05
't' value	3.67*	2.44	3.16*	6.12*

Values are means ± SE of three independent determination

* Significant at 5% level

4.2 NUTRITIONAL COMPOSITION OF UNPROCESSED FABA BEAN

4.2.1 proximate composition

Moisture and fibre content of both the varieties was almost, similar and showed non-significant differences. The protein content of Vikrant variety was 30.66g/100g where as in HB-180 variety it was 28.82g/100g. Fat and ash content of HB-180 variety was higher than those of Vikrant variety shown in Table 4.2. Sammour (1987) reported that protein content of various *vicia* species ranged from 17-32 percent. Mubarak *et al.* (1988) reported that crude fibre content in faba beans was 7.2 percent. Youssef *et al.* (1987) observed non-significant differences in crude protein, fat and ash.

iv).5.2In vitro digestibilities

4.2.2.1 Protein digestibility (*in vitro)*

Table 4.3 contains results of protein digestibility and starch digestibility of faba bean varieties namely (Vikrant and HB-180). Results showed that protein digestibility of Vikrant variety was 51.43 percent and that of HB-180 was 48.51 percent. Krause *et al.* (1984) also observed that 49.8 percent of protein in raw faba bean was hydrolysable. The presence of large amount of globulins, which are resistant to action of digestive enzymes in the native state, may be responsible for low digestibility of raw legumes (Walker and Kochhar, 1982). Kataria *et al.* (1989a) also stated that with increase in duration of cooking protein digestibility of *mung* beans increased.

Table 4.2 : Proximate composition of Faba bean (g /100g ,on dry matter basis)

Variety	**Moisture**	Protein	**Fat**	**Ash**	**Crude fibre**
HB-180	9.08±0.02	28.82±0.06	2.56±0.08	3.56±0.02	1.30±0.12
Vikrant	9.11±0.02	30.66±0.03	2.00±0.01	2.79±0.01	1.53±0.16
't' value	1.02	27.26**	6.37**	30.73**	1.11

Values are means ± SE of three independent determinations
** Significant at 1% level

Table 4.3 : *In vitro* protein digestibility (%) and *in vitro* starch digestibility (mg maltose released /g meal)of Faba bean (on dry matter basis)

Variety	Protein digestibility	Starch digestibility
HB-180	48.51±0.01	33.00±0.57
Vikrant	51.43±0.02	34.63±0.66
't' value	148.57**	0.72

Values are means ± SE of three independent replications
** Significant at 1% level

4.2.2.2 Starch digestibility (*in vitro*)

Data on *in vitro* starch digestibility has been presented in Table 4.3. Non-significant difference was observed in both the varieties of faba bean i.e. starch digestibility of Vikrant was 34.63 and for HB-180 was 33.00 mg maltose released/g.

Various processing methods are known to increase starch digestibility (El faki *et al.*, 1984a). The improvement in the starch digestibility may be possibly due to reduction in level of antinutritional

factors like polyphenols and phytic acid (Table 4.3). These antinutrients are known to inhibit ∝- amylase activity (Deshpande and Cheryan, 1983).

4.2.3 Antinutritional factors

4.2.3.1 Phytic acid

Phytic acid is known to be the major storage form of phosphorus in legumes. The phytic acid content of Vikrant variety of faba bean was found to be significantly ($P<0.05$) lower than that of HB-180 as shown in Table 4.4.

4.2.3.2 Tannins

HB-180 variety of faba bean contained 395.33mg/100g and that of Vikrant was 382.00 mg/100g Vikrant variety contained significantly lower amount of tannin (Table-4.4).

Table 4. 4 : Antinutritional factors of Faba bean (mg/100g, on dry matter basis)

Variety	Phytic acid	Tannin
HB-180	971.60±0.61	395.33±1.45

Vikrant	952.46±3.89	382.00±1.15
't' value	4.85**	7.18**

Values are means ± SE of three independent determination

* Significant at 5% level

4.2.4 Mineral composition

4.2.4.1 Total minerals

Total calcium, iron, zinc and phosphorus contents of Vikrant variety were 176.97, 4.33, 5.80 and 4.18 mg/100g, respectively and that of HB-180 were 157.32, 4.21, 5.06 and 432.00 mg/100g, respectively. (Table 4.5). Non significant difference was observed in the total iron content of both varieties of faba bean.

The loss in mineral contents upon soaking may be attributed to leaching out of these minerals in to the soaking water (Kumar *et al.*, 1978).

4.2.4.2 HCl extractable minerals

The HCl extractability of calcium, iron, zinc and phosphorus content of Vikrant variety were 55.20, 73.42, 24.87 and 38.96 per cent, respectively and that of HB-180 were 52.31, 68.74, 22.30 and 38.11 per cent, respectively as has been given in Table 4.6.

4.3 SENSORY EVALUATION OF VALUE ADDED PRODUCTS DEVELOPED FROM FABA BEAN

Different faba bean products were organoleptically evaluated in terms of their colour, appearance, flavour, texture, taste and overall acceptability using 9-point Hedonic Scale. The overall acceptability of *halwa*, cake and biscuits prepared from faba bean showed non- significant ($p<0.05$) differences when compared with their respective controls (Table 4.7). *Missi roti, puri*, *dalia, ladoo*, pasta, *dhokla*

Table 4.5: Total minerals of Faba bean (mg/100g, on dry matter basis)

Variety	Calcium	Iron	Zinc	Phosphorus
HB-180	157.32±0.53	4.21±0.13	5.06±0.06	432.00±2.64
Vikrant	176.97±0.57	4.33±0.13	5.80±0.05	418.00±0.57
't' value	24.87**	0.65	8.19**	5.17**

Values are means ± SE of three independent determination
** Significant at 1% level

Table 4.6 : HCl extractable minerals of Faba bean (%, on dry matter basis)

Variety	Calcium	Iron	Zinc	Phosphorus
HB-180	52.31+0.016	68.74+0.21	22.30+0.12	38.11+0.34
Vikrant	55.20+0.80	73.42+1.05	24.87+0.20	38.26+0.71
't' value	6.14**	15.21**	10.13**	0.68

Values are means ± SE of three independent determination
** Significant at 1% level

Table 4.7 : Sensory evaluation of food products prepared from Faba bean

Products	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
Missi Roti						
80 WF:20 CF (Control)	8.10±0.10	8.00±0.00	8.10±0.10	7.80±0.20	8.00±0.14	8.00±0.09
80 WF:20 FB	8.10±0.10	8.00±0.00	8.10±0.10	7.80±0.20	7.70±0.21	7.94±0.11
60WF:40 FB	8.10±0.10	8.10±0.10	7.50±0.10	7.70±0.21	7.60±0.22	7.80±0.13
40WF: 60 FB	7.50±0.16	7.80±0.13	7.20±0.13	7.10±0.23	7.10±0.31	7.34±0.13
SE(m)	±0.12	±0.08	±0.10	±0.21	±0.23	±0.12
CD at 5%	0.34	NS	0.31	NS	NS	0.35
Poori						
100 WF:0 FB (Control)	7.80±0.13	7.30±0.15	7.70±0.15	7.10±0.23	7.50±0.16	7.48±0.12
90 WF:10 FB	7.60±0.16	7.70±0.15	7.70±0.15	7.50±0.22	7.80±0.13	7.66±0.11
80 WF:20 FB	7.10±0.18	7.20±0.24	7.20±0.20	7.10±0.27	6.90±0.27	7.10±0.17
70 WF:30 FB	6.80±0.29	6.90±0.18	6.70±0.21	5.90±0.56	5.70±0.55	6.40±0.28
SE(m)	±0.20	±0.18	±0.18	±0.35	±0.33	±0.18
CD at 5%	0.57	0.54	0.52	1.02	0.94	0.54
Halwa						
100 WF:0 FB(Control)	7.70±0.21	7.70±0.21	7.80±0.20	7.70±0.15	7.90±0.10	7.76±0.12
90 WF:10 FB	7.50±0.16	7.50±0.16	7.70±0.21	7.90±0.10	7.80±0.13	7.66±0.14
80 WF:20 FB	7.40±0.16	7.40±0.22	7.60±0.22	7.90±0.23	7.90±0.23	7.56±0.17
70WF:30 FB	6.90±0.27	7.00±0.25	7.30±0.30	7.70±0.26	7.28±0.23	7.28±0.23
SE(m)	0.21	±0.21	±0.23	±0.19	±0.19	±0.17
CD at 5%	NS	NS	NS	NS	NS	NS
Dhokla						
50 S:50 CF (Control)	7.80±0.13	7.90±0.10	7.70±0.15	7.70±0.15	7.60±0.16	7.74±0.09
45 S:45 CF:10 FB	7.50±0.22	7.40±0.22	7.40±0.16	7.40±0.22	7.10±0.18	7.36±0.17
40S:40CF:20FB	7.30±0.21	7.10±0.18	7.00±0.14	7.00±0.21	6.80±0.13	7.04±0.13
SE(m)	±0.19	±0.17	±0.15	±0.19	±0.16	±0.13
CD at 5%	NS	0.50	0.45	NS	0.46	0.40
Dalia						

50 WF:0 FB(Control)	7.60±0.16	7.70±0.21	7.60±0.16	7.60±0.16	7.60±0.26	7.62±0.17
45 WF:5 FB	7.50±0.16	7.20±0.20	7.30±0.15	7.40±0.22	7.50±016	7.38±0.14
40 WF:10 FB	7.30±0.15	7.20±0.24	7.20±0.24	6.90±0.18	7.10±0.18	7.14±0.16
35WF:15FB	6.50±0.22	6.60±0.22	6.60±0.30	6.20±0.32	6.20±0.35	6.42±0.25
SE (m)	±0.17	±0.22	±0.22	±0.23	±0.25	±0.18
CD at 5%	0.51	0.63	0.65	0.66	0.73	0.54
Ladoo						
100CF:0 FB(Control)	8.10±0.18	8.10±0.18	8.00±0.21	8.10±0.18	8.10±0.18	8.08±0.18
90 CF:10 FB	7.90±0.18	7.80±0.20	7.60±0.16	7.80±0.13	7.70±0.15	7.72±0.10
80 CF:20 FB	7.50±0.22	7.60±0.22	7.50±0.16	7.50±0.22	7.30±0.15	7.44±0.13
70CF:30FB	7.00±0.25	7.00±0.25	6.90±0.18	7.00±0.25	6.90±0.23	6.98±0.20
SE(m)	±0.21	±0.21	±0.18	±0.20	±0.18	±0.16
CD at 5%	0.61	0.62	0.52	0.58	0.52	0.46
Pasta						
100RF:0FB (Control)	7.90±0.10	7.80±0.13	8.30±0.15	7.60±0.16	7.80±0.13	7.88±0.08
90 RF:10FB	7.90±0.10	7.80±0.13	8.00±0.00	7.70±0.15	7.50±0.16	7.78±0.06
80RF:20FB	7.70±0.15	7.70±0.15	7.70±0.15	7.60±0.16	7.80±0.13	7.70±0.10
70RF:30FB	7.30±0.21	7.50±0.16	7.50±0.16	7.40±0.16	7.40±0.16	7.42±0.07
SE(m)	±0.14	±0.14	±0.13	±0.16	±0.15	±0.085
CD at 5%	0.42	NS	0.39	NS	NS	0.24
Cake						
100 RF:0 FB(Control)	7.50±0.16	7.50±0.16	7.70±0.26	7.70±0.26	7.70±0.26	7.62±0.22
80 RF:20 FB	7.80±0.13	7.90±0.23	7.90±0.23	7.90±0.23	7.90±0.23	7.88±0.20
60RF:40 FB	7.40±0.26	7.50±0.34	7.90±0.23	7.50±0.26	7.90±0.23	7.64±0.24
40RF: 60 FB	6.90±0.27	6.80±0.24	7.30±0.30	7.10±0.34	7.10±0.34	7.04±0.27
SE(m)	±0.22	±0.25	±0.25	±0.28	±0.27	±0.23
CD at 5%	0.63	0.73	NS	NS	NS	NS
Biscuit						
100 RF:0 FB(Control)	7.6±0.16	7.70±0.15	8.30±0.15	8.10±0.18	8.20±0.13	8.04±0.08
90RF:10FB	7.1±0.18	7.80±0.13	8.10±0.18	7.80±0.20	7.70±0.21	7.92±0.08
80 RF:20FB	6.8±0.13	7.50±0.22	8.20±0.20	7.70±0.15	7.90±0.23	7.84±0.12
SE(m)	±0.17	±0.18	±0.17	±0.17	±0.198	±0.10
CD at 5%	NS	NS	NS	NS	NS	NS
Roasted *dal*						
	7.6±0.16	7.7±0.15	7.0±0.00	7.40±0.16	7.3±0.15	7.4±0.07
Boiled *dal*						
	8.1±0.08	8.6±0.08	7.4±0.04	8.2±0.06	7.6±0.05	7.8±0.06

RF= Refined flour, CF = Chickpea flour, FB = Faba bean flour, WF = Wheat flour,
S = Semolina

NS-Non significant

Values are means ±SE of three independent determinations**.**

prepared from faba bean were acceptable but ($p<0.05$) differed from their controls. Roasted *dal* and boiled *dal* of faba bean were acceptable. In terms of colour and flavour, faba bean *missi roti* was significantly ($p<0.05$) different from the control whereas appearance, texture and taste did not differ significantly. Four types of *puri* were prepared by taking different proportions of wheat flour and faba bean flour. *Puri* prepared from wheat flour was served as the control *puri* containing 10 percent faba bean flour had significantly higher acceptability than the control and other types of *puri*. It was observed that all the types of *puri* prepared from faba bean significantly ($P< 0.05$) differed from their controls. *puri* containing 10 percent of faba bean flour was selected for further analysis shown in Table 4.7. .

*Dal*ia

Similarly, *dalia* was prepared by supplementing the faba bean flour at different levels i.e 10, 20 and 30 percent with wheat flour. Type I which

contained 100 percent wheat flour served as control (Table 4.7). Overall acceptability of different types of *dalia* differed significantly ($p<0.05$) and type I, II and III were in the category of 'moderately liked' and type IV was 'slightly liked' by judges. *Dalia* containing 10 percent of faba bean flour (type II) had significantly higher acceptability than other types of *dalia* prepared from faba bean.

Ladoo

Four types of *ladoo* were prepared by incorporating the faba bean flour with chickpea flour in different proportions i.e 10, 20 and 30 percent. Significant ($P<0.05$) differences were observed in colour, appearance, flavour, texture, taste and overall acceptability and was therefore selected for further analysis. (Table 4.7)

Pasta

Different types of pasta were prepared by mixing the faba bean flour and refined flour. The overall acceptability of pasta incorporating 10, 20 and 30 percent faba bean flour were in the category of 'moderately liked'. Pasta containing 10 percent proportions of faba bean flour had overall acceptability close to that of the control and hence, used for further analysis (Table 4.7)

Cake

Cake was prepared by adding faba bean flour to refined flour at different levels i.e 20, 40 and 60 percent. The cake prepared from refined flour served as control. Cakes incorporating faba bean flour up to 60 percent level were acceptable to the human palate. Colour and appearance of cake incorporating faba bean flour at the levels of 20, 40 and 60 percent significantly differed from each other while non- significant differences were observed in flavour, texture, taste and in overall acceptability. Among the cakes prepared from faba bean, in which 20 percent faba bean flour was added showed the highest overall acceptability score (Table 4.7).

Biscuits

Four types of biscuits were prepared by incorporating different proportions of faba bean flour and refined flour. Biscuits prepared from refined flour served as control. Non-significant differences were observed in colour, appearance, flavour, texture, taste and overall acceptability. Although all types of biscuits were found to be in the category ‘moderately liked’ to ‘very much liked’ but biscuits containing 10 percent of faba bean flour was selected for further analysis (Table 4.7)

Roasted *Dal* and Boiled *dal*

Roasted *dal* and boiled *dal* were prepared from 100 percent faba bean Organoleptic evaluation i.e colour, appearance, flavour, texture and taste showed that it was found to be in the category of 'moderately liked' to 'very much liked'. Both *dals* were selected for further analysis.

Different faba bean products getting the highest overall acceptability scores were selected for further chemical analysis (Table 4.7).

4.4 NUTRITIONAL EVALUATION OF ACCEPTABLE PRODUCTS

4.4.1 Proximate composition

Moisture content of raw faba bean was 8.05 per cent and after roasting it was reduced significantly while non-significant difference was observed in (**roasted *dal***) protein, fat, ash and fibre content.

In ***missi roti*** significant differences were observed. Moisture, protein, fat, ash and fibre content varied from 24.56, 10.03, 2.23, 2.23 and 1.00 g/100g to 25.75, 13.66, 2.76, 2.99 and 2.87 g/100g, respectively (Table 4.8).

Puri made by the wheat flour served as control and moisture content was observed to be 30.22 g/100g while after incorporating faba bean it was 32.12 g/100g. The protein, fat, ash and fibre content of control *puri* were 18.63, 6.03, 3.88 and 1.30 g/100g respectively and after adding faba bean flour it was increased to 20.40, 6.73, 4.20 and 1.78 g/100g, respectively (Table 4.8).

Frying did not bring any change in the crude protein, fat and ash contents of various faba bean products (Saharan, 1994). Supplementation of ricebean flour with wheat flour improved the crude protein and ash content in *chapaties*, and *paranthas* (Kaur, 1992). Similarly, supplementation of chickpea flour with wheat flour has been known to improve the crude protein and ash content of *chapati* (Gandhi and Bourne, 1988; Kaur and Hira, 1988). In ***halwa*** significant differences were observed in proximate composition. *Halwa* made from wheat flour served as control and moisture, protein, fat, ash and fibre content was 33.82, 23.81, 27.01, 3.88 and 1.21 g/100g, respectively and after incorporating faba bean values were 35.16, 24.51, 28.05, 4.19 and 1.33 g/100g, respectively.

In ***ladoo*****,** non significant difference was observed in the ash content while the moisture, protein, fat and fibre content of control *ladoo* made from bengal gram flour were 0.86, 17.60, 18.21 and 2.76 g/100g and after

adding faba bean flour it was 1.01, 20.06, 19.43 and 2.75 g/100g, respectively (Table 4.8).

The moisture, protein, fat, ash and fibre contents of ***dhokla*** were significantly different from control. The values were 61.12, 16.23, 4.82, 1.67 and 2.24 g/100g, respectively of control and when faba bean flour were added values were 63.52, 18.25, 6.37, 2.45 and 4.27 g/100g, respectively (Table 4.8).

According to Goyal (1991) fermentation either decreased or did not alter the crude protein of cereal legume blends. Ash and fat content of *wadi* (Yadav, 1992) and "soy-*rabadi*" an indigenous fermented product (Grewal, 1992) did not change after fermentation. Aliya and Geerwani (1980) observed a decrease in crude protein of bengal gram and green gram whereas Eka (1980) showed an increase in protein and fat during fermentation. Since no addition or deletion of mineral source is involved hence no change in ash content during fermentation is exerted (Chaudhary, 1993).

Table 4.8 : Proximate composition of Faba bean products (g/100g on dry matter basis)

Products	Treatments	Moisture	Protein	Fat	Ash	Fibre
Roasted *Dal*	Raw *dal*	8.05±0.01	27.4±1.0	3.0±0.4	3.2±0.2	6.5±0.4
	Roasted *Dal*	7.06±0.02	27.3±0.4	3.1±0.2	3.0±0.0	7.0±0.0
	't' value	4.47*	0.17	0.50	1.00	1.73
Missi roti	Control (100% WF)	24.56±0.02	10.03±0.01	2.23±0.01	2.23±0.01	1.00±0.01
	Supplemented (80 WF+20 FB)	25.75±0.01	13.66±0.08	2.76±0.08	2.99±0.01	2.87±0.01
	't' values	56.60**	40.95**	5.96**	71.46**	128.47**
Poori	Control (100% WF)	30.22±0.00	18.63±0.01	6.03±0.08	3.88±0.01	1.30±0.01
	Supplemented (90 WF+10 FB)	32.12±0.01	20.40±0.11	6.73±0.12	4.20±0.02	1.78±0.02
	't' value	142.25**	15.15**	4.69**	12.16**	21.08**
Halwa	Control (100% WF)	33.82±0.05	23.81±0.01	27.01±0.01	3.88±0.01	1.21±0.01
	Supplemented (90 WF+10 FB)	35.16±0.01	24.51±0.01	28.05±0.02	4.19±0.01	1.33±0.01
	't' value	103.79**	66.72**	54.97**	7.71**	15.08**

Ladoo	Control (100% CF)	0.86±0.01	17.60±0.05	18.21±0.01	0.99±0.01	2.16±0.08
	Supplemented (90 CF+10 FB)	1.01±0.01	20.06±0.01	19.43±0.08	1.01±0.01	2.76±0.08
	't' value	9.20**	41.78**	13.76**	1.54	5.96**
Dhokla	Control (50% S + 50% CF)	61.12±0.01	16.23±0.01	4.82±0.01	1.67±0.01	2.24±0.02
	Supplemented (45 S+45 CF + 10 FB)	63.52±0.01	18.25±0.02	6.37±0.01	2.45±0.03	4.27±0.01
	't' value	165.41**	89.20**	147.67**	26.27**	5.44**
Dalia	Control (100% WF)	17.06±0.02	9.61±0.02	18.81±0.00	2.86±0.01	1.68±0.01
	Supplemented (90 WF+10 FB)	18.05±0.01	10.66±0.01	21.52±0.01	3.53±0.01	1.86±0.02
	't' value	44.77**	43.96**	203.75**	29.48**	6.39**
Boiled *Dal*	Raw *dal*	27.04±0.01	25.7±0.3	6.8±0.2	3.7±0.2	2.5±0.01
	Boiled *dal*	28.05±0.01	27.7±0.3	7.0±0.4	4.2±0.2	2.6±0.01
	't' value	44.7**	10.00**	0.5	2.12	6.92**
Pasta	Control (100% RF)	51.51±0.01	7.64±0.01	2.62±0.01	2.24±0.14	2.54±0.02
	Supplemented (90 RF+10 FB)	53.99±0.01	8.87±0.01	3.11±0.01	2.35±0.02	2.70±0.02
	't' value	170.91**	74.00**	33.49**	0.80	6.93*

Cake	Control (100% RF)	23.37±0.02	12.25±0.00	10.31±0.01	2.63±0.00	1.02±0.01
	Supplemented (80 RF+20 FB)	24.19±0.01	20.16±0.02	11.41±0.01	2.73±0.17	1.12±0.02
	't' value	38.57**	287.76**	88.73**	0.56	4.52*
Biscuit	Control (100% RF)	1.89±0.01	9.32±0.01	18.40±0.05	0.78±0.01	1.15±0.01
	Supplemented (90 RF+10 FB)	2.57±0.03	10.31±0.01	21.20±0.01	1.14±0.01	1.33±0.01
	't' value	22.92**	94.23**	47.55**	24.15**	16.44**

RF= Refined flour, CF = Chickpea flour, FB = Fababean flour, WF = Wheat flour, S = Semolina

Values are means ±SE of three independent determinations.

Supplementation of faba bean grits with wheat flour improved moisture, protein, fat, ash and fibre of ***dalia***. In control *dalia* values were 17.06, 9.61, 18.81, 2.86 and 1.68 g/100g, respectively and increased in supplemented faba bean *dalia* upto 18.05, 10.66, 21.52, 3.53 and 1.86 g/100g, respectively. In **boiled *dal*** non-significant difference was observed in fat and ash content. Moisture, protein and fibre of raw *dal* was 27.04, 25.7 and 2.5 g/100g, respectively and after boiling *dal* it was 28.05, 27.7 and 2.6 g/100g, respectively (Table 4.8).

Pasta prepared from refined flour served as control. The moisture, protein, fat and fibre content noticed in control were 51.51, 7.64, 2.62 and 2.54 g/100g, respectively and after adding faba bean flour, it was observed to be 53.99, 8.87, 3.11 and 2.70 g/100g, respectively (Table 4.8). In pasta, non-significant difference was observed in ash.

In the baked products like **cake** and **biscuits**, an improvement of nutrient composition was noticed. The moisture, protein, fat, ash and fibre contents of control cake prepared from refined flour were observed to be 23.37, 12.25, 10.31, 2.63 and 1.02 g/100g, respectively. After incorporating faba bean flour, it was observed to be 24.19, 20.16, 11.41, 2.73 and 1.12 g/100g, respectively. In the biscuits moisture, protein, fat, ash and fibre content of control was 1.89, 9.32, 18.40, 0.78 and 1.15 g/100g, respectively and when faba bean flour was added 2.57, 10.31, 21.20, 1.14 and 1.33 g/100g, respectively (Table 4.8).

On the contrary baking and roasting of faba bean did not show any effect on the crude protein, fat and ash content (Hamilton and Thompson, 1992).

4.4.2 In vitro digestibilities

4.4.2.1 Protein digestibility (*in vitro*)

The protein digestibility of roasted and boiled *dal* was 55.0 to 58.0 per cent, respectively. Variation in protein digestibility in both types of *dals* may be because of the types and amount of ingredients used in their preparation (Table 4.9). Significant ($P<0.05$) differences were observed between the protein digestibility of roasted *dal* and boiled *dal*. As a result of cooking protein digestibility improved significantly ($P<0.05$) in comparison to raw *dal*. Significant improvement was observed after roasting and boiling the *dal* (6.30 and 6.27 %) respectively.

The increase in protein digestibility on cooking of faba bean may be due to inactivation of or destruction of trypsin inhibitors (Sharma and Sehgal, 1991a; Parihar *et al.,* 1993; Mehta *et al.*, 1993) and opening up of protein structure through denaturation. Reduction in the content of antinutritional factors like phytates, polyphenols and trypsin inhibitor activity was brought about by soaking and cooking as reported by pervious workers (Kataria *et al.,* 1989b; Bishnoi and Khetarpaul, 1994b and

Saharan, 1994) (Table 4.9) Reduction in antinutrient factors may also be responsible for increasing protein digestibility in the present study.

Improvement in protein digestibility occurred in *puri*, *halwa, ladoo*, *dhokla, dalia*, pasta, biscuit, and cake and *missi roti* also.

In the control *puri,* protein digestibility was 51.51 per cent and after incorporating faba bean flour it increased to 54.49 per cent. The protein digestibility of *halwa* and *ladoo* were also increased significantly when faba bean flour was added. The protein digestibility of control *halwa* and control *ladoo* was 62.00 and 55.52 per cent, respectively and after cooking by incorporating faba bean, it was increased to 64.37 and 57.02 per cent respectively (Table 4.9).

An enhancement in protein digestibility of *daila* was observed. The protein digestibility of control *dalia* prepared from wheat *daila* was 70.01 per cent and after adding faba bean, the protein digestibility of cooked *dalia* was 76.12 per cent.

Same trend was observed in pasta also. The protein digestibility of control pasta was 65.73 per cent and of faba bean pasta was 69.46 per cent.

Different processing techniques involved in preparation of fermented products (*dhokla*) from faba bean whether used in isolation or in combination, significantly enhanced the protein digestibility.

High proteinase activity has been reported by various workers in protein fermented foods (Wang *et al.*, 1975; Steinkaus, 1983). An increase in the amino nitrogen by fermentation signifies partial breakdown of protein to peptide and amino acid resulting in improved protein digestibility (Kao and Robinson, 1978). Phytic acid known to inhibit the proteolytic enzyme (Tan *et al.*, 1983; Knuckles *et al.*, 1985) is considerably reduced during fermentation which may explain increase in protein digestibility during fermentation.

The improvements in protein digestibility as observed in fried, baked and roasted products may be due to inactivation and destruction of trypsin inhibitors (Kataria *et al.*, 1989b) and opening up of protein structure through denaturation. Reduction in the levels of antinutrients during heat treatment may also be responsible for the increase in protein digestibility (Jood *et al.*, 1987; Kataria *et al.*, 1989b). Previous workers have also been reported the beneficial effect of heating on protein digestibility (*in vitro*) of various legumes including peas (Bishnoi and Khetarpaul, 1994b), rice bean (Kaur and Kapoor, 1990b), soybean (Shrivastav *et al.*, 1990; Grewal, 1992) and faba bean (Sharma and Sehgal, 1991a, Parihar *et al.*, 1993).

4.4.2.2. Starch digestibility (*in vitro*)

The starch digestibility of roasted faba bean *dal* was 35.9 mg maltose released/g meal, respectively. Pressure cooking as well as

ordinary cooking brought a significant ($P<0.05$) improvement in starch digestibility. The increase in starch digestibility of boiled *dal* was 48.40 mg maltose released/g meal, over the raw *dal* (35.90 mg maltose released/g meal).

Table 4.9 : *In vitro* protein digestibility (%) and *in vitro* starch digestibility (mg maltose released /g meal) of Faba bean products (on dry matter basis)

Products	Treatments	Protein digestibility	Starch digestibility
Roasted *dal*	Raw *dal*	55.0±1.90	47.7±1.03
	Roasted Faba bean	63.0±2.01	65.1±1.80
	't' value	4.01*	18.59*
Boiled *dal*	Raw *dal*	58.0±1.10	35.9±0.60
	Boiled Faba bean	62.7±1.40	48.4±1.10
	't' value	13.03**	21.67**
Missi roti	Control (100% WF)	74.8±0.01	46.73±0.16
	Supplemented (80% WF + 20% FB)	73.20±0.01	44.33±0.01
	't' value	111.26**	14.35**
Poori	Control (100% WF)	51.510.01	28.74±0.01
	Supplemented (90% WF + 10% FB)	54.49±0.02	29.77±0.04
	't' value	153.49**	25.57**

Halwa	Control (100% WF)	62.0±0.01	27.84±0.01
	Supplemented (90% WF + 10% FB)	64.37±0.01	31.09±0.01
	't' value	222.31*	398.04**
Ladoo	Control (100% CF)	55.52±0.01	23.82±0.01
	Supplemented (90% CF + 10% FB)	57.02±0.01	25.8±0.01
	't' value	103.46**	137.42**
Dhokla	Control (50% S + 50% CF)	71.53±0.02	46.37±0.01
	Supplemented (45 S + 45 % CF + 10% FB)	74.91±0.01	51.22±0.01
	't' value	176.51**	388.59**
Dalia	Control (100% WF)	70.01±0.02	26.19±0.01
	Supplemented (90% WF + 10% FB)	76.12±0.02	27.19±0.01
	't' value	225.50**	60.40**
Pasta	Control (100% RF)	65.73±0.01	32.88±0.01
	Supplemented (90% RF + 10% FB)	69.46±0.01	38.25±0.01
	't' value	200.62**	343.89**
Cake	Control (100% RF)	64.78±0.01	28.30±0.12
	Supplemented (80% RF + 20% FB)	65.84±0.01	30.81±0.01
	't' value	62.16**	21.71**
Biscuits	Control (100% RF)	57.20±0.01	29.98±0.01
	Supplemented (90% RF + 10% FB)	61.88±0.01	33.64±0.00
	't' value	286.59**	215.13**

RF= Refined flour, CF = Chickpea flour, FB = Faba bean flour, WF = Wheat flour, S = Semolina

Values are means ±SE of three independent determinations.

The starch digestibility of control *dalia* prepared from wheat porridge was 26.19 and *dalia* incorporated with faba bean had significantly higher starch digestibility i.e. 27.19 mg maltose released/g meal (Table 4.9).

The starch digestibility of control cake prepared from refined wheat flour was 28.30 mg maltose released/g meal which increased to 30.81 mg maltose released /g meal after baking. Similar trend for improvement in starch digestibility was observed in faba bean based biscuits. In control biscuits it was 29.98 mg maltose released/g meal while after incorporating

faba bean flour to refined wheat flour it increased to 33.64 mg maltose released/g in faba bean based biscuits (Table 4.9).

The starch digestibility of control *missi roti* was 46.73 which was decreased significantly ($P<0.05$) to 44.33 mg maltose released/g meal (Table 4.9).

The *in vitro* starch digestibility of control *puri* was observed to be 28.74 whereas after incorporating faba bean it was significantly increased i.e. 29.77 mg maltose released/g meal.

The starch digestibility (*in vitro*) of *halwa* prepared from faba bean increased from 27.84 in the control mixture to 31.09 mg maltose released/g meal in faba bean *halwa*.

The *in vitro* starch digestibility of *ladoo* prepared from chickpea flour served as control was 23.82 and when faba bean was incorporated, it was increased significantly i.e. 25.80 mg maltose released/g meal.

The *in vitro* starch digestibility of control *dhokla* was 46.37 mg maltose released/g while *dhokla* prepared by incorporating faba bean flour was 51.22 mg maltose released/g meal (Table 4.9).

The extruded product pasta prepared by incorporating faba bean was found to have significantly higher starch digestibility i.e. 38.25 as compared to control i.e. 32.88 mg maltose released/g.

In roasted product like roasted *dal*, it was observed that roasting improved the starch digestibility. Starch digestibility of raw *dal* was 47.70 and after roasting it was 65.10 mg maltose released/g meal.

The cumulative effect of different treatments used in preparation of products from faba bean increasing the starch digestibility has been reported. The breakdown of starch to oligosaccharides by fermenting microflora (Cronk *et al.*, 1977) or by the enzyme inherent in legume grains may be responsible for improvement in starch digestibility during fermentation.

Amylolysis has been reported to be inhibited by phytic acid (Thompson and Yoon, 1984) and hence the reduction in the phytate content of fermented products during fermentation was observed in this study (Table 4.9) shows improvement in starch digestibility of the fermented products. A significant ($P<0.05$) and negative relationship has been found between autinutrients and starch digestibility in all the fermented products prepared from faba bean (Table 4.9).

Increase in starch digestibility on boiling and pressure cooking was reported by earlier workers in different legumes including amphidiploids (Kataria *et al.*, 1990), ricebean (Kaur and Kapoor, 1990b), pigeon peas (Duhan, 1992), faba bean (Sharma and Sehgal, 1992; Parihar *et al.*, 1993) and peas (Bishnoi and Khetarpaul, 1993b).

Enhanced digestibility of cooked legumes starches by alpha-amylase could be attributed to the swelling and rupturing of starch granules which facilitates more randomized configuration of ∝-amylase to affect hydrolysis, the disintegration of various bean components during cooking and inactivation of ∝-amylase inhibitors. Differences in starch digestibility during heat treatment may occur due to differences in the extent of starch gelatinisation.

An increase in *in vitro* starch digestibility during fermentation was reported in soybean (Boralkar and Reddy, 1985; Grewal, 1992), cereal legume blends (Goyal, 1991), tef (Ramachandran and Bolodia, 1984) and black gram (Chaudhary, 1993). Soni and Sandhu (1990) reported a higher amylase activity in conventional black gram *wadi* dough after 3 days fermentation.

During drying, baking and roasting, the heat treatment involved increases the activity of alpha-amylases as a result of which the rate of amylosis in increased which ultimately leads to higher starch digestibility of fried, baked and roasted products. The rate of amylosis in cooked mothbean and horse gram was about 3 times than that observed in uncooked samples (Subhulakshmi *et al.*, 1976). Significant difference in amylosis rates in processed legume seeds, as compared to raw has been reported (Geervani and Theophilus, 1980; EI-Faki *et al.*, 1984).

4.4.3 Antinutritional factors

4.4.3.1 Phytic acid

Data or values of antinutrients of processed faba bean have been given in Table 4.10. Data shows that phytic acid content of *dal* was 312.10 mg/100g which was decreased to 240.90 mg/100g on roasting. Reduction in the phytic acid content was observed in *puri* also, as in control *puri* prepared from wheat flour it was 540.22 mg/100g and after incorporating faba bean, it was 532.11 mg/100g.

Similar trend in reduction of phytic acid content of other faba bean based products was observed. The phytic acid content of control *halwa* and *ladoo* was 258.66 mg/100g and 166.33 mg/100g, respectively. After incorporating faba bean flour phytic acid content was decreased to 240.66 mg/100g and 120.33 mg/100g in *halwa* and *ladoo* respectively.

Phytic acid content of boiled *dal* and control *dalia* was observed to be 357.80 mg/100g and 272.00 mg/100g and after boiling process phytic acid content was 284.50 and 261.00 mg/100g, respectively (Table 4.10). Pressure cooking and boiling brought a significant ($P<0.05$) decrease in the level of antinutrients.

An obvious decrease noticed in phytic acid content of boiled products due to ordinary and pressure cooking and dry heat treatment like baking may be attributed to the formation of insoluble complexes between

phytates and other components (Kumar *et al.*, 1978). Similar reduction during cooking has been reported in various legumes like ricebean (Kaur and Kapoor, 1990a), faba bean (Sharma and Sehgal, 1992b) and peas (Bishnoi *et al.*, 1994a).

Phytic acid content of the fermented product i.e. *dhokla* was also analyzed. The control *dhokla* prepared from semolina and chickpea flour had 226.00 mg/100g phytic acid while faba bean flour incorporated *dhokla* had 218.33 mg/100g phytic acid.

Decrease in phytic acid content during fermentation has been reported in various fermented food including temph (Riet *et al.*, 1987; Suparma, 1987) and *rabadi* (Duhan *et al.*, 1989; Gupta, *et al.,* 1991; Grewal, 1992).

Buckle (1985) reported that phytic acid content was halved during temph fermentation and deep fat frying further decreased the phytic acid. A wide range of microflora has been known to posses phytase activity (Daniels and Fisher, 1981; Lopez *et al.*, 1983) which may partly be responsible for decrease in phytic acid content.

Table 4.10 : Antinutritional factors of Faba bean products (mg/100g, on dry matter basis)

Products	Treatment	**Tannin**	**Phytic acid**
Roasted *dal*	Raw *dal*	250.00±4.20	312.10±8.10
	Roasted Faba bean	217.90±1.20	240.90±3.60
	't' value	9.70*	17.10*
Boiled *dal*	Raw *dal*	357.80±4.20	543.90±4.80
	Boiled Faba bean	284.50±3.30	488.60±3.80
	't' value	30.74**	14.78**
Missi roti	Control (100% WF)	279.66±1.45	210.32±0.12
	Supplemented (80% WF + 20% FB)	325.33±1.45	332.86±0.03
	't' value	22.22**	999.11**
Poori	Control (100% WF)	262.66±0.33	540.22±0.03
	Supplemented (90% WF + 10% FB)	259.00±0.57	532.11±0.03
	't' value	5.50**	167.89**
Halwa	Control (100% WF)	258.66±0.66	410.72±0.32
	Supplemented (90% WF + 10% FB)	240.66±1.20	386.52±0.05
	't' value	13.09**	73.84**
Ladoo	Control (100% CF)	166.33±0.88	251.65±0.04

	Supplemented (90% CF + 10% FB)	120.33±2.03	241.07±0.47
	't' value	20.80**	22.10**
Dhokla	Control (50% S + 50% CF)	226.00±1.15	325.17±0.59
	Supplemented (45 S + 45 % CF + 10% FB)	218.33±0.088	302.22±0.41
	't' value	5.27**	31.74**
Dalia	Control (100% WF)	272.00±1.73	258.39±0.01
	Supplemented (90% WF + 10% FB)	261.00±0.57	222.31±0.01
	't' value	6.02**	342.16**
Pasta	Control (100% RF)	382.33±1.20	294.89±33.34
	Supplemented (90% RF + 10% FB)	277.00±0.57	240.63±0.01
	't' value	79.00**	1.63
Cake	Control (100% RF)	271.33±0.88	322.59±0.11
	Supplemented (80% RF + 20% FB)	257.66±1.45	278.46±0.33
	't' value	8.04**	127.97**
Biscuit	Control (100% RF)	308.00±1.52	276.30±0.15
	Supplemented (90% RF + 10% FB)	289.66±0.88	211.75±0.05

	't' value	10.39**	390.99***

RF= Refined flour, CF = Chickpea flour, FB = Faba bean flour,
WF = Wheat flour, S = Semolina

Values are means ±SE of three independent determinations.

The phytic acid content of control *missi roti* was 210.32 mg/100g and of faba bean supplemented *roti* was 332.86 mg/100g. Reduction in phytic acid content was observed in control pasta i.e. 382.33 mg/100g when faba bean pasta was compared which 277.00 mg/100g was.

Cake and biscuits prepared from refined flour served as control had 271.33 and 308.00 mg/100g of phytic acid respectively while supplemented faba bean cake and biscuit had 257.66 and 289.66 mg/100g phytic acid respectively. After baking significant ($P<0.05$) reduction in phytic acid content was noticed.

Significant decrease was observed during frying, baking and roasting due to heat treatment in different products.

Phytic acid is heat stable, reduction may not be due to destruction of the compound but perhaps to its ability to form complex with proteins and minerals (Kratzer, 1965) which may not be extractable in 0.5 M HNo_3. So the decrease observed is apparent and not true. Various cooking methods

involved in preparing foods like baking (Tangkogchitr *et al.* 1981), roasting (Ayatse *et al.*, 1983), fat frying (Khan *et al.*, 1986) are known to reduce the level of phytic acid in the food products.

4.4.3.2 Tannins

Tannin content among all products of faba bean ranged from 120-320.33 mg/100g respectively. The tannin content of raw faba bean was 250.0 which were decreased to 217.9 mg/100g on roasting. Significant decrease in polyphenol occurred after roasting (Kakkar 1992). The tannin content observed in the control p*uri* was 262.66 and after supplementing with faba bean, it was 259.00 mg/100g (Table 4.10)

Similar trend in reduction of tannin content of various faba bean product was noticed. The tannin content of control *halwa* and *ladoo* was 258.66 and 166.33 mg/100g and after incorporating faba bean flour, tannin content was decreased significantly and found to be 240.66 and 120.33 mg/100g, respectively. Binding of polyphenols with other organic substances and proteins or to alterations in the chemical structure of polyphenols which cannot be extracted by available methods may explain a decrease in tannin of legume grain during cooking. Moist heating involved in ordinary or pressure cooking, may be responsible for destruction of polyphenols. The results of present study are in line with those reported by earlier worker for ricebean (Kaur and Kapoor,1990a),

faba bean (Sharma and Sehgal, 1992b) and peas (Bishnoi *et al.*, 1994a and Saharn, 1994).

Tannin content of the fermented product i.e control *dhokla* had more amount i.e 226.00 mg/100g when compared to the supplemented faba bean *dhokla* which was 218.33 mg/100g. Saharn (1994) also observed reduction in the tannin content in various fermented products. A decrease in polyphenolic content during fermentation was reported earlier for diffeent fermented foods including *rabadi* (Dhankar and Chauhan, 1987a), pearl millet fermented by pure culture of yeast and lactobacilli (Khetarpaul and Chauhan, 1990b), *wadi* prepared from black gram and green gram *dal* (Yadav, 1992). And in fermented black gram (Chaudhary, 1993). Contrary to these results, some workers (Gupta, 1989; Goyal, 1991; Grewal, 1992) reported no increase in polyphenolic content of fermented foods.

The tannin content of control *missi roti* was 279.66 mg/100g and after incorporating faba bean, it increased significantly to 325.33 mg/100g.

Reduction in tannin content was observed in faba bean supplemented pasta (277.00 mg/100g) in comparison to control pasta (382.33 mg/100g).

Cake and biscuits prepared out of refined flour served as control had 271.33 and 308.00 mg/100g of tannin content respectively and when with

supplemented faba bean a significant decreased was observed in cake and biscuits found to be 257.66 and 289.66 mg/100g respectively.

Baking and roasting were found to lower the polyphenol content in faba bean products. A decreased amount of polyphenols in cooked heat treated products could results from their reduced extractability or change in chemical reactivity (Satwadhar *et al.*, 1981). It may also be due to formation of some insoluble complex between proteins and tannins (Jood *et al.* 1987). Udayasekhara and Deosthale (1982) and Kataria *et al.* (1989a) also reported a significant decrease in tannin contents in pulses on cooking.

Loss of polyphenols during cooking may be attributed to presence of polyphenol oxidase and enzyme hydrolysis (Jood *et al.*, 1987).

4.4.4 Mineral Composition

4.4.4.1 Total minerals

In the roasted *dal* and boiled *dal*, the amount of total calcium, iron, zinc and phosphorus varied in these products due to differences in type and amount of ingredients used in their preparation. The amount of total Ca, Fe, Zn and P in 177.30, 5.20, 2.86 and 255.20 mg/100g in comparison to raw *dal* for which values were 174.70, 4.90, 2.09, and 250.90 mg/100g, respectively.

In boiled *dal*, the amount of total Ca, Fe, Zn and P in raw *dal* was 163.30, 5.00, 2.28 and 247.10 mg/100g and after boiling *dal* it was 167.0, 5.40, 2.58 and 250.30 mg/100g respectively. Non significant differences were observed in the Zinc and phosphorus of boiled *dal*.

Pressure cooking or boiling did not change the contents of total calcium, Iron, Zn and phosphorous in various boiled products prepared from ricebean and faba bean (Saharan 1994).

In *missi roti*, non- significant difference was observed in the iron content. *Missi roti* prepared from wheat flour and chickpea flour served as control and had total Ca, Fe, Zn and P as 50.66, 6.01, 2.15 and 188.66mg/100g, respectively while when 20 per cent of faba bean flour was added the amount of all minerals increased significantly and were found to be 54.54, 6.21, 2.83 and 191.33 mg/100g, respectively. In the control *puri* made from wheat flour the amount of total Ca, Fe, Zn and P was observed to be 7.51, 5.76, 2.78 and 291.00 mg/100g, respectively and after incorporating faba bean flour it was 90.23, 6.89, 2.83 and 315.33 mg/100g respectively.

Table 4.11 : Mineral contents of Faba bean products (mg/100g, on dry matter basis)

Products	Treatments	Calcium	Iron	Zinc	Phosphorus
Roasted *dal*	Raw dal	174.7±2.30	4.9±0.02	2.09±0.01	250.9±1.6
	Roasted Faba bean	177.3±1.60	5.20±0.04	2.86±0.01	255.2±1.4
	't' value	4.93**	1.00	73.36**	19.18**
Boiled *dal*	Raw dal	163.3±2.40	5.0±0.06	2.28±0.08	247.1±2.1
	Boiled Faba bean	167.0±1.60	5.4±0.05	2.58±0.07	250.3±3.1
	't' value	3.26*	2.72*	2.05	1.60
Missi roti	Control (100% WF)	50.66±0.31	6.01±0.12	2.15±0.01	188.66±2.03
	Supplemented (80% WF + 20% FB)	54.54±0.13	6.21±0.02	2.83±0.03	191.33±0.88
	't' value	35.01**	1.63	17.80**	3.18*
Poori	Control (100% WF)	87.51±0.03	5.76±0.01	2.78±0.01	291.00±1.15
	Supplemented (90% WF + 10% FB)	90.23±0.01	6.89±0.01	2.83±0.02	315.33±0.88
	't' value	87.09**	77.54**	12.05**	16.74**
Halwa	Control (100% WF)	78.07±0.01	3.01±0.01	2.03±0.01	212.00±1.73
	Supplemented (90% WF + 10% FB)	81.78±0.02	3.21±0.01	2.28±0.01	224.66±2.40
	't' value	203.21**	13.01**	20.84**	4.27*
Ladoo	Control (100% CF)	50.12±0.06	5.64±0.02	1.96±0.02	208.66±0.81
	Supplemented (90% CF + 10% FB)	62.42±0.08	5.80±0.03	2.11±0.03	211.33±1.20

	't' value	121.29**	4.93**	4.21*	1.78
Dhokla	Control (50% S + 50% CF)	88.76±0.01	3.33±0.01	2.94±0.02	231.08±0.57
	Supplemented (45 S + 45 % CF + 10% FB)	89.15±0.01	3.42±0.02	3.11±0.02	265.00±1.53
	't' value	26.38**	3.78*	6.12**	20.82**
Dalia	Control (100% WF)	40.15±0.01	5.42±0.02	2.58±0.02	200.00±1.15
	Supplemented (90% WF + 10% FB)	43.25±0.02	5.85±0.01	2.81±0.01	206.00±1.15
	't' value	48.80**	23.55**	11.05**	3.67*
Pasta	Control (100% RF)	50.21±0.01	5.77±0.01	2.09±0.01	187.00±1.15
	Supplemented (90% RF + 10% FB)	55.41±0.02	6.13±0.01	2.86±0.01	191.00±1.15
	't' value	289.68**	26.75**	73.36**	12.01**
Cake	Control (100% RF)	58.31±0.005	5.18±0.03	2.04±0.01	191.00±1.73
	Supplemented (80% RF + 20% FB)	64.17±0.02	6.16±0.06	2.49±0.04	208.66±1.45
	't' value	101.73**	14.75**	9.78**	4.27*
Biscuit	Control (100% RF)	54.47±0.34	5.68±0.03	2.38±0.02	179.66±2.02
	Supplemented (90% RF + 10% FB)	62.59±0.18	5.86±0.02	3.09±0.01	199.00±1.15
	't' value	54.24**	4.56*	21.52**	8.28**

RF= Refined flour, CF = Chickpea flour, FB = Fababean flour, WF = Wheat flour, S = Semolina

Values are means ±SE of three independent determinations.

* significant at 5% level

** significant at 1% level

Similar trend was observed in *halwa*. The amount of total Ca, Fe, Zn and P was 78.07, 3.01, 2.03 and 212.00 mg/100g, respectively while when faba bean was added the mineral content increased to 81.78, 3.21, 2.28, 224.66 mg/100g respectively.

In *ladoo*, non significant difference was observed in phosphorous content. The amount of Ca, Fe, Zn was 50.12, 5.64, 1.96 mg/100g, respectively and after incorporating faba bean, it was found to be 62.42, 5.80, 2.11 and 211.33 mg/100g respectively.

In *dhokla*, the amount of total Ca, Fe, Zn and P were more or less the same. The amount of total mineral content of *dhokla* was 88.76, 3.33, 2.94 and 231.08 mg/100g, respectively while after incorporating faba bean flour it was 89.15, 3.42, 3.11 and 265.00 mg/100g, respectively.

In *dal*ia and pasta, significant difference was observed in total minerals i.e Ca, Fe, Zn and P and amount of minerals in control *dal*ia was 40.15, 5.42, 2.58 and 200.00 mg/ 100g, respectively and after adding faba bean it was 43.25, 5.85,2.81 and 206.00 mg/100g, respectively.

In the baked product like cake and biscuit, non significant difference in mineral content was observed. The amount of total Ca, Fe, Zn and P was 58.31, 5.18, 2.04 and 191.00 mg/100g in control cake were significantly increased after adding faba bean flour and observed to be 64.17, 6.16, 2.49 and 208.66 mg/100g respectively while in biscuit 54.47,

5.68, 2.38 and 179.66 mg/100g respectively while after adding faba bean flour values were 62.59, 5.86, 3.09 and 199.00 mg/100g respectively (Table 4.11).

4.4.4.2 HCl extractable minerals

Table 4.12 gives the data related to HCl extractability. In the roasted *dal* and boiled *dal* the amount of HCl extractable calcium, iron, zinc and phosphorus content varied in the products due to differences in type and amount of ingredients used in their preparations.

In roasted *dal*, the amount of HCl extractable Ca, Fe, Zn and P was 62.51, 80.62, 41.56, 41.01 mg/100g, respectively in comparison to raw *dal* for which values were 56.01, 76.81, 40.12, 40.56 mg/100g, respectively (Table 4.12).

The amount of HCl extractable Ca, Fe, Zn and P in raw *dal* were 57.69, 72.78, 38.13 and 39.02mg/100g, respectively and after boiling *dal* the content of HCl extractable minerals increased significantly to 64.62, 78.92, 40.26 and 42.03 mg/100g, respectively. Non- significant difference was observed in the zinc and phosphorus content of boiled *dal*.

Pressure coking or boiling did not change the contents of HCl extractable calcium, Iron, Zinc and phosphorus in various boiled products prepared from rice bean and faba bean (Saharn 1994).

In *missi roti* non- significant difference was observed in the iron content. *Missi roti* prepared from wheat flour and chickpea flour served as control and had HCl extractable Ca, Fe, Zn and P as 69.06, 63.20, 77.00 and 82.06mg/100g, respectively and when faba bean flour was added HCl extractable contents of all minerals increased significantly and were found to be 71.35,64.46,78.82 and 84.29mg/100g, respectively. In control *puri* made from wheat flour, the amount of HCl extractable Ca, Fe, Zn and P were 72.06, 69.00, 70.32 and 66.39 mg/100g respectively and after incorporating faba bean flour values were 73.16, 70.13, 73.38 and 68.03 mg/100g respectively (Table 4.12).

Similar trend was observed in *halwa* (Table 4.12). The amount of HCl extractable Ca, Fe, Zn and P were 80.11, 72.06, 76.74, 62.40mg/100g, respectively while incorporating faba bean flour it was 82.09, 74.09, 79.38 and 65.43 mg/100g, respectively. In *ladoo* non significant difference was observed in phosphorus content. The amount of HCl extractability of Ca, Fe and Zn was 54.35, 47.13, 20.53 mg/100g and after incorporating faba bean flour, it was found to be 58.85,49.28 and 22.28 mg/100g, respectively. In *dhokla* the amount of HCl extractability mineral content was 50.38, 58.16, 40.14 and 44.81 mg/100g, respectively while in faba bean supplemented sample it was 57.68, 62.78, 45.24 and 50.16mg/100g, respectively. In *dal*ia and pasta, significant difference was observed in HCl extractable minerals i.e Ca, Fe, Zn and P and amount of control *dal*ia was 83.07, 71.05, 77.47 and 67.60 mg/100g, respectively. After adding faba

bean it was 85.80, 73.16,79.38 and 69.94 mg/100g, respectively. Amount of control pasta was 45.20, 53.12, 54.19 and 35.21mg/100g, respectively while after adding faba bean it was 46.22, 55.19, 56.21 and 37.26mg/100g, respectively.

Table 4.12: HCl extractability of minerals of Faba bean products (%, on dry matter basis)

Products	**Treatments**	**Calcium**	**Iron**	**Zinc**	**Phosphorus**
Roasted *dal*	Raw *dal*	56.01±1.71	76.81±2.50	40.12±1.13	40.56±0.89
	Faba bean roasted *dal*	62.51±2.10	80.62±2.11	41.56±0.98	41.01±0.05
	T value	9.01**	NS	NS	NS
Boiled *dal*	Raw *dal*	57.69±1.89	72.78±0.90	38.13±2.16	39.02± 0.03
	Faba bean boiled *dal*	64.62±1.68	78.92±2.40	40.26±1.08	42.03±0.01
	T value	5.87**	5.01**	7.81**	2.23
Missi roti	Control	69.06±0.10	63.20±0.09	77.00±0.08	82.06±0.07
	Faba bean *missi roti*	71.35±0.13	64.46±0.03	78.82±0.04	84.29±0.11
	T value	0.32	0.25	0.31	0.35
Poori	Control	72.06±0.08	69.00±0.03	70.32±0.01	66.39±0.01
	Faba bean *poori*	73.16±0.10	70.13±0.15	73.38±0.03	68.03±0.05
	T value	0.69	1.81	0.67	0.92
Halwa	Control	80.11±0.07	72.06±0.01	76.74±0.06	62.40±0.13
	Faba bean	82.09±0.03	74.09±0.06	79.38±0.09	65.43±0.10

	halwa				
	T value	0.38	0.32	0.32	0.58
Ladoo	Control	54.35±0.10	47.13±0.06	20.53±0.08	59.24±0.13
	Faba bean *ladoo*	58.85±0.09	49.28±0.09	22.28±0.06	61.33±0.20
	T value	0.41	0.25	0.28	0.54
Dhokla	Control	50.38±2.89	58.16±0.16	40.14±0.43	44.81±1.11
	Faba bean *dhokla*	57.68±3.21	62.78±0.20	45.24±0.47	50.16±2.00
	T value	5.18**	6.13**	8.79**	5.56**
Dalia	Control	83.07±0.14	71.05±0.07	77.47±0.06	67.60±0.15
	Faba bean *dalia*	85.80±0.13	73.16±0.08	79.38±0.09	69.94±0.19
	T value	0.39	0.28	0.40	0.38
Pasta	Control	45.20±0.03	53.12±0.10	54.19±0.06	35.21±0.21
	Faba bean pasta	46.22±0.07	55.19±0.12	56.21±0.03	37.26±0.26
	T value	0.80	1.42	1.68	8.82**
Cake	Control	47.40±2.30	56.22±0.56	54.88±0.46	34.24±0.21
	Faba bean cake	49.24±2.56	56.86±1.02	56.98±0.30	38.26±0.25
	T value	1.16	0.80	1.28	11.67**
Biscuit	Control	46.21±2.30	51.23±0.31	53.20±1.30	36.26±0.28
	Faba bean biscuit	48.23±2.71	53.15±1.02	55.19±0.34	38.25±0.29
	T value	1.26	0.91	0.68	10.66**

Values are means ±SE of three independent determinations.

* significant at 5% level

** significant at 1% level

NS = Non significant

In the baked products like cake and biscuit, non- significant difference was observed. The amount of HCl extractable Ca, Fe, Zn and P was 47.40, 56.22, 54.88 and 34.24 mg/100g, respectively of cake and after adding faba bean, it was 49.24, 56.86, 56.98 and 38.26 mg/100g, respectively. And in biscuit 46.21, 51.23, 53.20 and 36.26 mg/100g, respectively while after adding faba bean flour it was 48.23, 53.15, 55.19 and 38.25mg/100g, respectively (Table 4.12).

As the divalent catious are generally present in association with phytic acid in processed legumes and therefore may be responsible for lower extractability of these divalent cations in faba bean. Decrease in the level of phytic acid during different processing may party account for improved extractability of these minerals. A significant negative correlation between the ant nutrients, viz., phytic acid, tannin and extractability of minerals further strengthens our findings. Present findings

are in line with those reported by previous workers (Kaur, 1986) Grewal, 1992; Chaudhary 1993; Bishnoi and Khetarpaul 1994c and Saharan (1994).

4.5 SHELF LIFE STUDY OF ACCEPTABLE PRODUCTS

4.5.1 Organoleptic evaluation

Stored products were organoleptic evaluated at a interval of 0,15, 30, 45 and 60 days during the storage period by panel of 10 judges using 9 point hedonic rating scale. The results of sensory evaluation are presented in Table 4.13 to 4.15.

Biscuits

Colour:- Colour of the control biscuits and supplemented faba bean biscuits was 'very much liked' up to 15 days of storage and while at 45th day control and supplemented faba bean biscuits were 'liked moderately' and up to 60th day colour of the biscuit was "slightly liked" by the judges.

Appearance: Appearance of the control biscuit and other supplemented biscuits was 'very much liked' up to 15 days of storage while at 45th day ' liked moderately' and on the 60th day 'slightly liked' by the judges.

Flavour :- Flavour of control biscuit and other supplemented biscuit was 'very much liked' up to 15 days of storage while at 45th day 'liked moderately' and on the 60th day 'liked slightly' by the judges.

Texture: Texture of control and supplemented biscuit was very much liked up to 15 days while at 45th day 'liked moderately' and on the 60th day 'slightly liked' during the whole storage period.

Taste : Taste of control and supplemented biscuit was 'very much liked' up to 15 days while at 45th day 'liked moderately' and on the 60th day 'slightly liked'.

Table 4.13 : Effect of storage on the organoleptic characteristics of biscuit

Biscuit	Storage period in days					Mean
	0	15	30	45	60	
Colour						
Control (100% RF)	8.0	8.1	7.3	7.1	7.1	7.4
Supplemented (90% RF + 10% FB)	8.0	8.0	7.4	7.0	6.8	7.5
Mean	8.0	8.1	7.3	7.0	6.9	

CD for product – 0.25 CD for storage period – NS CD for interaction – NS						
Appearance						
Control (100% RF)	8.0	8.2	7.3	7.2	7.0	7.4
Supplemented (90% RF + 10% FB)	8.5	8.0	7.3	7.0	6.9	7.5
Mean	8.2	8.0	7.3	7.1	6.9	
CD for product – 0.28 CD for storage period – NS CD for interaction – NS						
Flavour						
Control (100% RF)	8.6	8.1	7.4	7.0	7.0	7.4
Supplemented (90% RF + 10% FB)	8.0	8.0	7.4	7.0	6.9	7.4
Mean	8.3	8.0	7.4	7.0	6.9	
CD for product - 0.25 CD for s storage period –NS CD for interaction - 0.358						
Texture						
Control (100% RF)	8.0	8.1	7.4	7.1	6.9	7.2
Supplemented (90% RF + 10% FB)	8.0	8.1	7.1	7.2	6.7	7.3
Mean	8.0	8.1	7.2	7.1	6.8	

CD for product – 0.21 CD for storage period – NS CD for interaction – 0.309						
Taste						
Control (100% RF)	8.0	8.0	7.3	7.3	7.0	7.3
Supplemented (90% RF + 10% FB)	8.0	8.1	7.3	7.4	6.6	7.3
Mean	8.0	8.0	7.3	7.3	6.8	
CD for product – 0.25 CD for storage period – NS CD for interaction – NS						
Overall acceptability						
Control (100% RF)	8.1	8.0	7.3	7.1	7.0	7.3
Supplemented (90% RF + 10% FB)	8.1	8.1	7.3	7.1	6.8	7.3
Mean	8.1	8.0	7.3	7.1	6.9	
CD for product – 0.11 CD for storage period – NS CD for interaction – NS						

RF= Refined flour, FB = Faba bean flour

NS-Non significant

Values are means ±SE of three independent determinations.

Overall acceptability : Storage of varying periods had significant effect on overall acceptability of biscuits. Overall acceptability score which was

the mean score of different organoleptic characteristics i.e colour, appearance, flavour, texture and taste revealed that control and supplemented biscuits were ‘very much liked’ up to 15 days and ‘liked moderately’ up to 45 days after that they fell in the category of ‘liked slightly’ (Table 4.13).

Ladoo

Colour : Colour of the control and supplemental *ladoo* was ‘very much liked’ at 0 day while at 15th day of storage *ladoo* were ‘liked moderately’ and after that they fall in the category of ‘liked slightly’.

Appearance : Appearance of control and supplemented *ladoo* was 'very much liked' at 0 day and 'liked moderately' on the 15th day and after that appearance was 'slightly liked' by the judges.

Flavour : Flavour of control *ladoo* was 'very much liked' at 0 day and supplemented *ladoo* was 'liked moderately' up to 15 days of storage. Flavour of control *ladoo* was in the category of liked moderately on the 30th day while at 45th day it was 'slightly liked' and the supplemented *ladoo* was 'liked slightly' on the 45th day of storage.

Texture : Texture of control and supplemented *ladoo* was 'liked moderately' up to 15 days of storage while at 45th day *ladoo* was 'slightly liked' by judges.

Table 4.14 : Effect of storage on the organoleptic acceptability of *ladoo*

Ladoo	**Storage period in days**				**Mean**
	0	**15**	**30**	**45**	
Colour					
Control (100% CF)	8.1	7.3	6.7	6.7	7.2
Supplemented (90% CF + 10% FB)	8.1	7.5	6.7	6.6	7.2
Mean	8.1	7.4	6.7	6.6	

CD for product = 0.32 CD for storage period = NS CD for interaction = NS					
Appearance					
Control (100% CF)	8.1	7.4	6.7	6.7	7.2
Supplemented (90% CF + 10% FB)	8.1	7.0	6.9	6.8	7.2
Mean	8.1	7.2	6.8	6.7	
CD for product = 0.33 CD for storage period = NS CD for interaction = NS					
Flavour					
Control (100% CF)	8.1	7.5	7.0	6.7	7.3
Supplemented (90% CF + 10% FB)	7.9	7.0	6.8	6.3	7.0
Mean	8.0	7.2	6.9	6.5	
CD for product = 0.28 CD for storage period = 0.20 CD for interaction = 0.409					
Texture					
Control (100% CF)	7.8	7.2	6.9	6.4	7.0
Supplemented (90% CF + 10% FB)	7.6	7.3	6.6	6.9	7.1
Mean	7.7	7.2	6.7	6.6	
CD for product = 0.30 CD for storage period = NS CD for interaction = 0.424					

Taste					
Control (100% CF)	7.8	7.4	6.8	6.6	7.1
Supplemented (90% CF + 10% FB)	7.9	7.3	6.7	6.9	7.2
Mean	7.8	7.3	6.7	6.7	
CD for product = 0.27 CD for storage period = NS CD for interaction = NS					
Overall acceptability					
Control (100% CF)	7.9	7.1	7.0	6.6	7.1
Supplemented (90% CF + 10% FB)	7.9	7.0	6.9	6.6	7.1
Mean	7.9	7.0	6.9	6.6	
CD for product = 0.19 CD for storage period = NS CD for interaction = NS					

CF = Chickpea flour, FB = Faba bean

NS-Non significant

Values are means ±SE of three independent determinations

Taste : Taste of control and supplemented *ladoo* was 'liked moderately' upto 15 days and 'liked slightly' on the 30th day of storage.

Overall acceptability :- Of control *ladoo* was 'liked moderately' up to 30 days while at 45th day it was ' liked slightly' and overall acceptability of

supplemented *ladoo* was ‘ liked moderately’ up to 15 days and ‘liked slightly’ on the 45th day of storage (Table 4.14).

Pasta

Colour :- At 0 day, colour of control pasta was ‘extremely liked’ while at 15 days of storage control and supplemented pasta was ‘very much liked’ and on the 45 days ‘liked moderately’ and after that it was ‘liked slightly’ significant difference were found in colour of all treatments at different internal of storage period.

Appearance :- Appearance of control pasta was ‘very much liked’ up to 15 days and supplemented pasta was in the same category at 0 day while at 45th day of storage control and supplemental pasta was ‘liked moderately’ and after that it was ‘slightly liked’.

Flavour :- Flavour of control and supplemented pasta was ‘very much liked’ upto 15 days of storage while at 45th day it was ‘‘liked moderately’ and after that pasta was slightly liked’ by judges.

Texture :- Texture of control and supplemented pasta were ‘very much liked’ up to 15 days while 45th day it was ‘liked moderately’ and after that ‘liked slightly’.

Table 4.15 : Effect of storage on organoleptic acceptability of Pasta

Pasta	0	15	30	45	60	Mean
Colour						
Control (100% RF)	9.0	8.0	7.4	7.0	6.2	7.5
Supplemented (90% RF + 10% FB)	8.6	8.5	7.0	7.3	6.7	7.6
Mean	8.8	8.2	7.2	7.1	6.4	
CD for product – 0.23 CD for storage period – NS CD for interaction – 0.339						
Appearance						
Control (100% RF)	8.0	8.3	7.1	7.1	6.5	7.4
Supplemented (90% RF + 10% FB)	8.0	7.7	7.0	7.0	6.6	7.2
Mean	8.0	8.0	7.0	7.0	6.5	
CD for product – 0.25 CD for storage period – 0.15 CD for interaction – NS						
Flavour						
Control (100% RF)	8.6	8.1	7.3	7.1	6.0	7.4
Supplemented (90% RF + 10% FB)	8.5	8.0	7.0	7.0	6.1	7.3
Mean	8.5	8.0	7.1	7.0	6.0	
CD for product– 0.26 CD for storage period – 0.16 CD for interaction – 0.378						
Texture						
Control (100% RF)	8.8	8.3	7.1	7.0	6.3	7.5
Supplemented (90% RF + 10% FB)	8.7	8.2	7.0	7.1	6.5	7.5
Mean	8.7	8.2	7.0	7.0	6.4	
CD for product – 0.9 CD for storage period – NS CD for interaction – NS						

Taste						
Control (100% RF)	8.7	8.3	7.0	7.0	6.2	7.4
Supplemented (90% RF + 10% FB)	8.3	8.2	7.0	7.1	6.4	7.4
Mean	8.5	8.2	7.0	7.0	6.3	
CD for product – 0.29 CD for storage period – NS CD for interaction – NS						
Overall acceptability						
Control (100% RF)	8.5	8.4	7.0	7.1	6.2	7.4
Supplemented (90% RF + 10% FB)	8.4	8.5	7.1	7.0	6.4	7.4
Mean	8.5	8.5	7.0	7.0	6.3	
CD for product – 0.13 CD for storage period – 0.08 CD for interaction – 0.190						

RF= Refined flour, FB = Fababean flour

NS-Non significant

Values are means ±SE of three independent determinations

Taste :- Taste of control and supplemented pasta was 'very much liked' up to 15 days and 'liked moderately' on the 45 days and after that 'liked slightly'.

Overall acceptability :- Control and supplemented pasta were found to be organoleptically acceptable to human palate during the whole storage period which was up to two months. However, control and supplemented pasta were 'very much liked' up to 15 days of storage and 'liked moderately' on the 45 days and then 'liked slightly' by the judges (Table 4.15).

4.5.2 Chemical Analysis

The developed products including biscuits, pasta, roasted *dal* and *ladoo* were stored at room temperature in polythene bags. The products were chemically analyzed for two months at an interval of 0,15,30,45 and 60 days during their storage (Table 4.16 to 4.18).

Moisture

Biscuits

Moisture of control biscuits at 0 day of storage was 1.86 per cent while of supplemented biscuits was 1.87 per cent. On 60th day of storage, moisture content of control and supplemented biscuits were observed to be 5.15 per cent and 5.14 per cent, respectively. There was an increase in moisture content with the advancement of storage period (Table 4.16).

Table 4.16 : Effect of storage on Moisture content of Faba bean (% , on dry matter basis)

	Storage period in days					
Products	**0**	**15**	**30**	**45**	**60**	**Mean**
Biscuit						
Control (100% RF)	1.86	3.87	4.43	4.91	5.15	4.04
Supplemented (90% RF + 10% FB)	1.87	3.98	4.78	5.03	5.14	4.16
Mean	1.87	3.92	4.60	4.97	5.15	
CD for product = 0.04 CD for storage period = 0.02 CD for interaction = 0.063						
Pasta						
Control (100% RF)	0.86	1.84	2.53	3.66	3.82	2.54
Supplemented (90% RF + 10% FB)	1.12	2.30	3.11	4.16	4.26	2.99
Mean	0.99	2.07	2.82	3.91	4.04	
CD for product = 0.04 CD for storage period = 0.02 CD for interaction = 0.064						

Ladoo	**0**	**15**	**30**	**45**	**Mean**
Control (100% CF)	1.96	3.95	4.50	5.11	3.88
Supplemented (90% CF + 10% FB)	2.02	4.10	4.61	5.15	3.97
Mean	1.99	4.02	4.55	5.13	
CD for product = 0.04 CD for storage period = 0.03 CD for interaction = NS					

RF= Refined flour, CF = Chickpea flour, FB = Fababean flour

NS-Non significant

Values are means ±SE of three independent determinations.

Pasta

Moisture of control past**a** at 0 day of storage was 0.86 per cent and that of supplemented pasta was 1.12 per cent. On the 15th and 30th day of storage moisture content of control and supplemented pasta was 1.84, 2.53 per cent and 2.30, 3.11 per cent, respectively. On the 45th day moisture content of control pasta was 3.66 per cent while supplemented pasta was 4.16 per cent. On he 60th day of storage supplemented pasta was 4.26 per cent which was significantly higher than control (3.82%) respectively (Table 4.16).

Ladoo

Moisture content of control *ladoo* was 1.96 per cent on 0 day of storage and significantly higher than supplemented faba bean *ladoo* 2.02 per cent. A significant increase in moisture of *ladoo* with progression of storage was noticed. Moisture at 45th day of storage in control was 5.11 and 5.15 per cent supplemented *ladoo*, respectively (Table 4.16).

Free fatty acids

The developed products including biscuits, pasta, roasted *dal* and *ladoo* were stored at room temperature in polythene bags. The products were analyzed for free fatty acids at an interval of 0, 15, 30, 45 and 60 days during their storage period. These findings for all selected products are presented in Table 4.17.

Biscuits

It is clear from Table 4.17 that free fatty acids value of control biscuit at 0 day of storage was 151.33 mg/100g. Significant differences were found in free fatty acids values of all the supplemented biscuits during storage period. Control biscuit was found to have lower content of free fatty acids value when compared with supplemented faba bean flour. On 15th day of storage, free fatty acids value was 197.19 and 207.08 mg/100g in control biscuits and biscuits supplemented with 10 per cent

faba bean flour, respectively. On 30th day the free fatty acids content of control biscuits and supplemented biscuits was 242.62 and 284.41 mg/100g, respectively. On 45th day free fatty acids value of control biscuits increased to 320.13 mg/100g while that of supplemented biscuits was 385.02 mg/100g, respectively. On the 60th day free fatty acids value was observed to be maximum. The control biscuits had 365.27 and supplemented biscuits 399.05 mg/100g free fatty acids respectively.

Period of storage greatly influenced the free fatty acids value. Increase in free fatty acids value might be due to the hydrolysis of glycosides resulting in formation of free fatty acids.

Pasta

Free fatty acids value of control pasta and supplemented pasta at 0 day was 210.18 and 24.02 mg/100g, respectively (Table 4.17). Free fatty acids value at 15th day and 30th day of storage was 270.07 and

Table 4.17 : Effect of storage on free fatty acid of Faba bean products (mg/100g fat, as oleic acid)

	Storage period in days					
Products	**0**	**15**	**30**	**45**	**60**	**Mean**
Biscuit						
Control (100% RF)	151.33	197.19	242.62	320.13	365.27	255.31
Supplemented (90% RF + 10% FB)	181.33	207.08	284.41	385.02	399.05	291.37
Mean	166.33	202.13	263.51	352.57	382.16	

CD for product = 0.65 CD for storage period = 0.41 CD for interaction = 0.930						
Pasta						
Control (100% RF)	210.18	270.07	305.32	380.02	418.07	316.73
Supplemented (90% RF + 10% FB)	244.02	285.06	330.46	398.03	442.33	339.98
Mean	227.10	277.56	317.89	389.02	430.20	
CD for product = 0.31 CD for storage period = 0.19 CD for interaction = 0.438						
Ladoo	**0**	**15**	**30**	**45**	**Mean**	
Control (100% CF)	191.36	210.05	294.35	355.05	262.70	
Supplemented (90% CF + 10% FB)	211.88	240.13	318.04	394.13	291.04	
Mean	201.62	225.09	306.10	374.59		
CD for product = 0.74 CD for storage period = 0.52 CD for interaction = 1.048						

RF= Refined flour, CF = Chickpea flour

NS-Non significant

Values are means ±SE of three independent determinations

305.32 mg/100g of control pasta while for supplemented pasta 285.06 and 330.46 mg/100g of free fatty acids value was observed respectively. At 45^{th} day 380.02 mg/100g for control and 398.03 mg/100g for free fatty acids supplemented pasta was noticed. At 60^{th} day free fatty acids value of control and supplemented pasta was maximum and observed to be

418.07 and 442.33 mg/100g, respectively. A significant increase in free fatty acids value of pasta with progression of storage was noticed.

Ladoo

Free fatty acids value of control *ladoo* at 0 day of storage was 191.36 mg/100g. Significantly difference were found in free fatty acids value of all the supplemented *ladoo*. Control *ladoo* had lower free fatty acids value than those supplemented with faba bean flour. On the 15th day of storage, free fatty acids value was 210.05 mg/100g and 240.13 mg/100g in control *ladoo* and *ladoo* supplemented with 10 per cent faba bean flour, respectively. On 30th day the free fatty acids content of control *ladoo* and supplemented *ladoo* was 294.35 and 318.04 mg/100g, respectively while on 45th day of storage free fatty acids value of control *ladoo* increased to 355.05 mg/100g and free fatty acids value of supplemented *ladoo* was 394.13 mg/100g.

Similarly free fatty acids value of stored products increased significantly with increase in storage periods. On comparing the overall mean, the free fatty acids value increased from 0 day to 60th day of storage period. A significant increase in free fatty acids value might be due to the hydrolysis of fat which gives free fatty acids.

Peroxide value

Biscuits

Peroxide value of control biscuits at 0 day of storage was 2.5 meq/kg while of supplemented biscuits was 2.6 meq/kg. Non-significant difference was found in peroxide value of biscuits. On 60th day of storage, peroxide value of control and supplemented biscuits were observed to be 3.8 and 4.2 meq/kg respectively. There was an increase in peroxide value with the advancement of storage period due to increase in amount of polyunsaturated fatty acids which lead to flavour development (Table 4.18).

Pasta

Peroxide value of control pasta at 0 day of storage was 1.6 meq/kg and that of supplemented pasta was 1.7 meq/kg. Peroxide value of control and supplemented pasta was found to be 3.5 and 3.7 meq/kg, respectively. Non significant difference was observed between control and supplemented pasta at 0 day of storage. Peroxide value of faba bean supplemented pasta was significantly higher in comparison to control pasta from 15th day of storage. The increase in peroxide value with the advancement of storage period might be due to the oxidation of polyunsaturated fatty acids which leads to flavour development (Table 4.18).

Table 4.18 : Effect of storage on peroxide value (meq/kg ,on dry matter basis) of Faba bean products

	Storage period in days					
Products	**0**	**15**	**30**	**45**	**60**	**Mean**
Biscuits						
Control (100% RF)	2.5	2.8	3.1	3.4	3.8	3.1
Supplemented (90% RF + 10% FB)	2.6	2.9	3.5	3.9	4.2	3.4
Mean	2.5	2.8	3.3	3.6	4.0	
CD for product = 0.16 CD for storage period = 0.10 CD for interaction = NS						
Pasta						
Control (100% RF)	1.6	2.1	2.8	3.3	3.5	2.7
Supplemented (90% RF + 10% FB)	1.7	2.2	2.9	3.3	3.7	2.8
Mean	1.7	2.1	2.8	3.3	3.6	
CD for product = 0.06 CD for storage period = 0.04 CD for interaction = 0.092						
Ladoo	**0**	**15**	**30**	**45**	**Mean**	
Control (100% CF)	2.6	2.9	3.5	4.0	3.3	
Supplemented (90% CF + 10% FB)	2.5	2.8	3.3	3.9	3.1	
Mean	2.5	2.9	3.4	3.9		
CD for product= 0.02 CD for storage period = 0.02 CD for interaction = 0.04						

RF= Refined flour, CF = Chickpea flour, FB = Fababean flour

NS-Non significant

Values are means $\pm$SE of three independent determinations.

Ladoo

Peroxide value of control *ladoo* was 2.6 meq/kg on 0 day of storage and was significantly higher than supplemented faba bean *ladoo* 2.5 meq/kg. A significant increase in peroxide value of *ladoo* with progression of storage was noticed. Peroxide value at 45^{th} day of storage was detected in control 4.0 meq/kg and 3.9 meq/kg in supplemented *ladoo*. The peroxide value of all products differed significantly which might be due to the oxidation of polyunsaturated fatty acids which lead to the rancidity and off flavour development. Overall, during storage period significant increase in peroxide value of all products were noticed. Increase in peroxide value with advancement of storage period might be due to oxidation of polyunsaturated fatty acids which lead to flavour development (Table 4.18).

Chapter 5

Summary and Conclusion

. The present study was conducted to develop the different value added products involving processing techniques viz., soaking, boiling and fermentation, frying, baking and roasting from high yielding varieties of faba bean (HB-180 and Vikrant) and to find out their physico-chemical properties, organoleptic charters tics and nutritional composition. Storage studies of most acceptable products were also conducted.

Results of physico-chemical properties indicated that Hydration capacity and swelling capacity of Vikrant variety of raw faba bean was significantly higher then those of HB-180 variety. Hence the time for cooking Faba bean of Vikrant variety was also less (90 min.) than that of HB-180 variety (108 min). Non-significant differences were observed in the moisture content of both the varieties of faba bean. However crude protein, fat and ash contents of Vikrant variety were 30.6, 2.00 and 2.79g/100g, respectively whereas those of HB-180 variety were 28.82,

2.56 and 3.56 g/100g respectively. Non-significant difference was observed in the fibre content of both the varieties. Phytic acid and tannin content of Vikrant variety was found to be 952.46 and 382.00 mg/100g, respectively whereas those of HB-180 variety were 971.60 and 395.33 mg/100g, respectively.

Due to soaking, dehulling, a significant ($P<0.05$) improvement occurred in *in vitro* starch and *in vitro* protein digestibility of raw faba bean. The total calcium, iron, zinc and phosphorus content of Vikrant variety were 176.97, 4.33, 5.80 and 418.00 mg/100g and whereas those of HB-180 were 157.32, 4.21, 5.06 and 432.00 mg/100g respectively. The HCl extractable mineral calcium, iron, zinc and phosphorus content of Vikrant variety were 55.20, 73.42, 24.87 and 38.26 percent and whereas those of HB-180 were 52.31, 68.74, 22.30 and 38.11 percent respectively. A significant and negative correlation was found between *in vitro* protein and starch digestibility and in levels of antinutrients (phytic acid and tannins) in faba bean.

Among two varieties of faba bean (HB-180 and Vikrant), Vikrant was found to be the better variety because of its high protein content than that of HB-180. *In vitro* protein and *in vitro* starch digestibility of Vikrant was also significantly ($P<0.05$) higher due to lowering of antinutritional factors (tannin and phytic acid). Regarding mineral composition it was

found that Ca, Zn and P were significantly ($P<0.05$) higher in Vikrant variety. So this variety was selected for preparing value added products.

Different types of products involving various domestic, processing and cooking methods i.e boiling, fermentation, frying, baking and roasting etc. were prepared by incorporating faba bean in different proportions of 20, 40 and 60 % and 10, 20, 30 % in different products. Products standardized included boiled *dal,* roasted *dal, missi roti, puri, halwa, ladoo, dhokla, dalia*, pasta*,* cake and biscuits

All the products were organoleptically evaluated using 9 Point Hedonic Scale by a panel of 10 judges. The products having the highest acceptability scores were selected for further nutritional evaluation. Nutritional evaluation indicated that the moisture content of different products, prepared from faba bean ranged from 1.01 to 63.52 per cent, respectively. Crude protein content of products ranged from 8.87 to 24.51 g/100g. Crude fibre, ash and fat were in the range of 1.12 to 7.0, 1.01 to4.2 and 2.76 to28.05 g/100g in all the products respectively.

Starch digestibility (*in vitro*) was significantly ($P<0.05$) higher in all the products as compared to their respective controls. The protein digestibility (*in vitro*) of all the cooked products were significantly higher ($p<0.05$) as compared to their respective controls. The level of antinutrients of various faba bean based products differed because of the

differences in the amount and type of ingredients used in development of these products. Significant ($P<0.05$) reduction was observed in the level of phytic acid and tannin in various faba bean supplemented products.

The total Ca, Fe, Zn and P contents of different faba bean based products ranged from 43.25 to 175.00, 3.21 to 6.21, 1.96 to 3.11 and 188.00 to 315.00 mg/100g, respectively. The HCl extractable minerals Ca, Fe, Zn and P contents of different faba bean based products ranged from 46.22 to 85.80, 49.29 to 80.62, 22.28 to 79.38 and 37.26 to 84.29 per cent respectively.

Shelf life of acceptable products having good storability was stored for two months in polythene bags at room temperature. The stored products were drawn at intervals of 0, 15, 30, 45 and 60 days and evaluated organoleptically by a panel of 10 judges, using 9 Point Hedonic Scale. Results showed that biscuits and pasta stored were acceptable upto 45 days and slightly acceptable upto 60 days, *ladoo* were found to be acceptable upto 15 days and slightly acceptable upto 30 and 45 days. Chemical analysis of stored products showed that increase in storage period increased the moisture, free fatty acid and peroxide value content.

It can be concluded from the present study that unconventional pulses like faba bean was found to be quite acceptable in development of value added products like boiled, fired, baked, roasted, fried and extruded

products. As the protein, fiber, calories and minerals content of faba bean was higher. Faba bean can be used as a potential source in the development of micronutrients rich recipes to raise the nutritional status. Consumption of products incorporating can decrease the incidence of PEM in our country.

Hence it can be recommended that such value added products using faba bean should be encouraged to be prepared by mothers for inclusion in the home diets. This would go a long way for ensuring food and nutrition security and for providing balanced nutrition to the families.

Literature cited

Ahmad, M. and Shehata, E. L. T. 1982. Cooking quality of faba beans. In 'Faba bean Improvement" (Hawtin, G. and Webb, C. ed.). ICARDA, Aleppo, Syria, pp. 355-362.

Aliya, S. and Geervani, P. 1981. An assessment of protein quality and vitamin B contents of commonly used fermented products of legumes and millets. *J. Sci.Food Aric.* **32** : 837-841.

Alonso, R., Aguirre, F., Marzo, F. 2000. Effect of extrusion and traditional processing methods on antinutrients and *in vitro* digestibility of protein and starch in faba and kidney beans. *Food Chem.* **68** : 159-165.

Alonso, R., Saharan, K., Khetarpaul, N. and Bishnoi, S. 2002. Antinutrients and protein digestibility of faba bean and ricebean as affected by soaking, dehulling and germination. *J. Food Sci. Technol.* **39** (4) : 418-422.

Anonymous. 1973. Nutritional improvement of food legumes by breeding. Ed. Max. Milner, PAG, Italy, pp. 61-68.

AOAC. 1995. Official Methods of Analysis of the Association of Official Agricultural Chemists. *Association Analytical Chemists*, Washington, D.C.

Ayatse, J. O., Eka, O. V. and Ifon, E. T. 1983. Chemical evaluation of the effect of roasting on the nutritive value of maize (*Zea mays* Linn). *Food Chem.* **12** : 135-147.

Barroga, C. F., Laurena, A. C. and Mendona, E. M. T. 1985. Polyphenols in moong bean (*Vigna radiata* (L.) Wilczek) : Determination and removal. *J. Agric. Food Chem.* **33** : 1006-1008.

Bishnoi, S. and Khetarpaul, N. 1993a. Variability in physico-chemical properties and nutrient composition of different pea cultivars. *Food Chem.* **47** : 371-373.

Bishnoi, S. and Khetarpaul, N. 1993b. Effect of domestic processing and cooking methods on starch digestibility of different pea cultivars. *Food Chem.* **47 :** 177-182.

Bishnoi, S. and Khetarpaul, N. 1994a. Saponin content and trypsin inhibitor activity of pea cultivars (*Pisum sativum*). *J. Food Sci. Technol.* **31** (1) : 73-76.

Bishnoi, S. and Khetarpaul, N. 1994b. Protein digestibility of vegetable and field peas (*Pisum sativum*) : Varietal differences and effect of domestic processing and cooking methods. *Plant Food Human Nutr.* (In Press).

Bishnoi, S. and Khetarpaul, N. 1994c. HCl-extractability of minerals as affected by various domestic processing and cooking methods. Abstracts of International Symposium on Pulses Research held at Delhi from April 2-6, 1994, pp. 242-243.

Bond, D. A. 1976. Field bean. In "Evaluation of crop plants". [Simmonds, N. W. (ed.)]. Longman, London, pp. 179-182.

Boralkar, M. and Reddy , S. N. 1985. Effect of roasting, germination and fermentation on digestibility of starch and protein in soybean. *Nutr. Rep. Int.* **31** (4) : 833-835.

Brisson, N., Germain, J. and Maw, W.A. 1950. Feeding value of horse bean for chicks. *Scientific Agriculture.* **30** : 364.

Buckle, K. A. S. 1985. Reduction in phytic acid levels in soybeans durng *tempeh* production, storage and frying. *J. Food Sci.* **50** (1) : 260-261.

Cain, R. F. 1950. Relation of time and temperature of blanch to tenderness. *The canner.* **111** : 10.

Carnovale, E., Lugaro, E. and Lombardi-Boccia, G. 1988. Phytic acid in fababean and per : effect on protein availability. *Cereal Chem.* **65** (2) : 114-117.

Chaudhary, K. 1993. Nutritional evaluation and utilization of germinated and fermented black gram (*Phaseolus mungo*). M. Sc. Thesis, CCS Haryana Agricultural University, Hisar, India.

Chavan, J. K. and Kadam, S.S. 1989. Nutritional improvement of cereals by fermentation. *Crit. Rev. Food Sci. Nutr*. **28** : 249-351.

Chen, P.S.; Tosibara, T.Y. and Warner, H. 1956. Micro-determination of phosphorus. *Anal. Chem.* 28 : 1756-1759.

Cheryan, M. 1980. Phytic acid interaction in food systems. *CRC Crit. Rev. Food Sci. Nutr.* **13** : 297-335.

Chompreeda, P.T. and Fields, M. L. 1984a. Effect of heat and fermentation on the extractability of minerals from soybean meal and corn meal blends. *J. Food Sci.* **49** : 566-568.

Cronk, T. C., Steinkraus, K. H., Hackler, L. R. and Mattick, L. R. 1977. Indonesian *tape ketan* fermentation. *Appl. Environ. Microbiol*. **33** : 1067-1073.

Daniels, D. G. H. and fisher, N. 1981. Hydrolysis of the phytate of wheat flour during bread making. *Brit. J. Nutr.* **46** : 1-6.

Davies, N. T. and Reid, H. 1979. An evaluation of phytate, zinc, copper, iron and manganese content of, and zinc availability from soy based textured vegetable protein meat substitutes of meat extenders. *Brit. J. Nutr*. 41 : 570.

Deshpande, S. S. and Cheryan, M. 1983. Changes in the phytic acid, tannins and trypsin inhibitor activity on soaking of dry beans (*P. vulgaris* L.). *Nutr. Rep. Int.* **27** : 371-378.

Dhankar, N. and Chauhan, B. M. 1987a. Effect of temperature and fermentation time on phytic acid and polyphenol content of *rabadi* – a fermented pearl millet food. *J. Food Sci.* **52** : 828-830.

Dhankar, N. and Chauhan, B. M. 1987b. Effect of temperature and period of fermentation on protein and starch digestibility (*in vitro*) of *rabadi* – A pearl millet fermented food. *J. Food Sci.* **52** : 489-490.

Dhankar, N. and Chauhan, B. M. 1989. Effect of fermentation on HCl-extractability of minerals in *rabadi* – An indigenous fermented food of India. *J. Sci. Food Agric.* **49** : 467-469.

Duhan, A. 1992. Nutritional evaluation of pigeon pea (*Cajanus cajan*) : Varietal differences and effects of different domestic processing methods. M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Duhan, A., Chauhan, B. M., Punia, D. and Kapoor, A. C. 1989. Phytic acid content of chickpea (*Cicer arietinum*) and black gram (*Vigna mungo*) : Varietal differences and effect of domestic processing and cooking methods. *J. Sci. Food Agric.* **49** : 449-452.

Eden, A. 1968. A survey of analytical composition of fields beans (*Vicia faba* L.) harvested in 1968. *J. Agri. Sci.* **76** : 257-259.

Egbe, I. A. and Akinyele, I. O. 1990. Effect of cooking on the antinutritional factors of lima beans. *Food Chem.* **35** (2) : 81-87.

EI-Faki, H. A., Bhavanishanag, T. N., Tharanathan, R. N. and Desikachar, H. S. R. 1984a. Flatus effect of chickpea (*Cicer arietinum*), cowpea (*vigna sinensis*) and horse gram (*Dolichos biflorus*) and their isolated carbohydrate fractons. *Nutr. Rep. Int.* **27** : 921-924.

EI-Faki, H. A., Venkataraman, L. V. and Desikachar, H. S. R. 1984b. Effect of processing on the *in vitro* digestibility of protein and

carbohydrates in some Indian legumes. *Plant Foods Human Nutr.* **34** : 127-133.

EI-Shimi. 1980. Changes in nutritional value and micro-structure of fababean seeds during germination. Ph. D. Thesis, Faculty of Agriculture, University of Alexandria, Alexandria, Egypt.

Eka, O. V. 1980. Effect of fermentation on the nutrient status of locust beans. *Food Chem.* **5** : 303-308.

Elsheikh, E. A. E., EI Tinay, A. H. and Fadul, I. A. 1999. Effect of nutritional status of faba bean on proximate composition antinutritional factors and *in vitro* digestibility (IVPD). *Food Chem.* **67** : 379-383.

Erdman, J. W., JR. 1981. Bioavailability of trace minerals from cereals and legumes. *Cereal Chem.* **58** : 21.

Gandhi, A. P. and Bourne, M. C. 1988. Effect of added soybean paste and instant soydhal on toughness and rate of staling of *chapattis. Int. J. Food Sci. Technol.* **23** (4) : 411-414. Cited from *Food Technol. Abst*. 1989. **24** (4) : 930.

Geervani, P. and Theophilus, F. 1980. Studies on digestibility of selected legumes carbohydrates and its impact on the pH of the gastro intestinal tract in rats. *J. Sci. Food Agric.* **32** : 71-75.

Gopalan, C., Ramasastri, B. V. and Balasubramanian, S. C. 1984. Nutritive value of Indian foods. Indian Council of Medical Research, New Delhi, pp. 131.

Gorski, P. M. 1985. Variation in tannin content of fababean (*Vicia faba*) seed cost. *FABIS, News Letter*. **11** : 26-28.

Goyal, M. and Mathews, S. 1985. A study on the effect of cooking on protein, lysine, tryptophan and sugar content of cereals and pulses with special reference to cereal pulse combination preparation. *Indian J. Nutr. Dietet.* **22** : 73-79.

Goyal, R. 1991. Nutritional improvement and utilization of cereal legume blends through fermentation. M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Grewal, R. 1992. Nutritional improvement of soybean through fermentation and its utilization in traditional foods of India. Ph. D. Thesis, Haryana Agricultural University, Hisar, India.

Griffiths, D. W. and Moseley, G. 1980. The effects of diets containing field beans of high or low polyphenolic contents on the activity of digestive enzymes in the intestine or rats. *J. Sci. Food Agri.* **31** : 235-359.

Griffiths, D. W. and Thomas, T. A. 1981. Phytate and total phosphorus content of field beans (*Vicia faba* L.). *J. Sci. Food Agri.* **32** : 187-192.

Gupta, M. 1989. A study on nutritional and sensory evaluation of *rabadi* from cereals. M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Gupta, M., Khetarpaul, N. and Chauhan, B. M. 1991. *Rabadi* fermentation on wheat, changes in phytic acid content and *in vitro* digestibility. *Plant Foods Human Nutr.*

Gupta, V., Modgil, R., Kalia, M. 2005. Effect of domestic processing on the *in vitro* protein quality of faba bean (*Vicia faba*). *J. Food Sci. Technol.* **42** (6) : 501-503.

Gupta, Y. P. 1987. Antinutritional and toxic factors in food legumes. *Plant Foods Human Nutr.* **37** : 201-204.

Hamilton, R. M. G. and Thompson, K. 1992. Chemical and nutrient content of corn (*Zea mays*) before and after being flame roasted. *J. Sci. Food Agric.* **58** : 425.

Hoff, J. E. and Nelson, P. E. 1966. Methods for accelerating the processing of dry beans. Eighth Dry Bean Research Conference. Bellair, M. I. Aug. 11-13.

Hove, E, L., King, S. and Hill, G. D. 1978. composition, protein quality and toxins of seed of the grain legumes, *Glycine max, lupinus* spp., *Phaseolus* spp., *Pisum sativum* and *Vicia faba*. *New Zealand Journal of Agricultural Research*. **21** : 457-462.

Jaffe, W.G. 1950. Estudio sobre ia inhicicon del erecimiento de ratas esusade per algunas semillas de leguminosas Acta Cient Venezolana 1: 62 (Citied from Liener, 1976).

Jood, S., Chauhan, B. M. and Kapoor, A. C. 1987. Polyphenols in chickpea and black gram as affected by domestic processing and cooking methods. *J. Sci. Food Agric.* **38** : 145-149.

Kadirvel, R. and Clandinin, D. R. 1974. The effect of fababeans on the performance of turkey poults and broiler chicks from 0-4 weeks of age. *Poultry Science*. **53**: 1810-1816.

Kakkar, S. 1992. Bioavailability of minerals in chickpea : Effect of domestic processing and level of the antinutrients. Ph. D. Thesis, Haryana Agricultural University, Hisar, India.

Kao, C. and Robinson, R. J. 1978. Nutritional aspect of fermented foods from chickpea, horsebean and soybean. *Cereal Chem.* **55** : 512-516.

Kataria, A. 1986. Studies on nutrient composition and antinutritional factors of amphidiploids (green gram × black gram). M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Kataria, A., Chauhan, B. M. and Punia, D. 1989a. Antinutrients in amphidiploids (black gram × mung bean) : Varietal differences and effects of domestic processing and cooking. *Plant Foods Human Ntur*. **39** (3) : 257-266.

Kataria, A., Chauhan, B. M. and Punia, D. 1989b. Antinutrients and protein digestibility (*in vitro*) of mungbean as affected by domestic processing and cooking. *Food Chem*. **32** : 9-17.

Kataria, A., Chauhan, B. M. and Punia, D. 1990. Effect of domestic processing and cooking methods on the contents of carbohydrates of amphidiploids (black gram × mung bean). *Food Chem.* **36** (1) : 63-67.

Kaur, D. 1986. Studies on nutrient composition and nutritional factors of ricebean (*Vigna umbellate*). M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Kaur, D. and Kapoor, A. C. 1990a. Some antinutritional factors in recebean (*Vigna umbellate*) : Effects of domestic processing and cooking methods. *Food Chem.* **37** : 171-179.

Kaur, D. and Kapoor, A. C. 1990b. Starch and protein digestibility of ricebean (*Vigna umbellate*). *Food Chem*. **38** : 263-272.

Kaur, M. 1992. Nutritional and organoleptic evaluation of selected ricebean products. M. Sc. Thesis, Punjab Agricultural University, Ludhiana, India.

Kaur, R. D. and Hira, C. K. 1988. Supplementary effect of aestivum wheat (*Triticum aestivum* L.), bengal gram (*Cicer arietinum* L.) and soybean (*Glycine max* L.) on protein quality of Durum wheat (*Triticum durum* Desf.). *J. Sci. Food Agric.* **46** : 201-209.

Kazanas, H. and Fields, M. L. 1981. Nutritional improvement of sorghum by fermentation. *J. Food Sci.* **46** : 819-820.

Khan, N. A. and Ghafoor, A. 1978. The effect on soaking, germination and cooking on the protein quality of mash bean (*Phaseolus mungo*). *J. Sci. Food Agric.* **29** : 461-463.

Khan, N., Zaman, R. and Elahi, M. 1986. Effect of processing on the phytic acid content of wheat products. *J. Agric. Food Chem.* **34** (6) : 1010-1012.

Khetarpaul, N. and Chauhan, B. M. 1990. Improvement of HCl-extractability of mineral from pearl millet by natural fermentation. *Food Chem.* **37** (1) : 69-76.

Khetarpaul, N. and Chauhan, B. M. 1990b. Effect of germination and pure culture fermentation on phytic acid and polyphenols contents of pearl millet. *J. Food Sci.* **55** (4) : 1180-1182.

Khetarpaul, N. and Chauhan, B. M. 1991. Effect of natural fermentation on antinutrients and *in vitro* digestibility of starch and protein of pearl millet. *J. Sci. Food Agric.*

Khokhar, S. and Chauhan, B. M. 1986a. Antinutritional factors in mothbean (*Vigna aconitifolia*) : Varietal differences and effects of methods of domestic processing and cooking. *J. Food Sci.* **51** (3) : 591-594.

Khokhar, S. and Chauhan, B. M. 1986b. Effect of domestic processing and cooking on *in vitro* protein digestibility of mothbean. *J. Food Sci.* **51** (41) : 1083-1084.

Knuckles, B. E., Kuzmicky, D. D. and Batachart, A. A. 1985. Effect of phytate and partially hydrolyzed phytate on *in vitro* protein digestibility. *J. Food Sci.* **50** (4) : 1080-1082.

Kosson, R. and Bakowski, J. 1986. The effect of processing on nutritional quality of bean seeds (*Phaseolus vulgaris* L.). *Acta Alimentaria Polonica*. **12** : 197.

Kratzer, F. N. 1965. Soybean protein-mineral interrelationship. *Fed. Proc.* **24** : 1498.

Krause, W., Ludwing, E. and Schneider, H. 1984. *In vitro* digestibility of original and modified protein isolates from field beans. *Nahrung*. **28** (8) : 889-894.

Kumar, K. G. and Venkataraman, L. V. 1976. Studies on the *in vitro* digestibility of starch in some legumes before and after germination. *Nutr. Rep. Int.* **13** : 115.

Kumar, K. G., Venkataraman, L. V., Jaya, T.V. and Krishnamurthy, K. S. 1978. Cooking characteristics of some germinated legumes : Changes in phytins, Ca^{++}, Mg^{++} and pectins. *J. Food Sci.* **43** : 85-93.

Kumar, V. and Kapoor, A. C. 1984. Trace mineral composition of different varieties of cereal and legumes. *Indian J. Nutr. Dietet.* **21** : 137-143.

Latunde-Dada, G.O. 1991. Some physical properties on ten soybean varieties and effect of processing on iron levels and availability. *Food Chem.* **42** : 89-98.

Laurena, A. C., Garcia, V. V. and Mendoza, E. M. T. 1987. Effect of heat on the removal of polyphenols and *in vitro* protein digestibility of cowpea (*Vigna unguiculata* L.). *Plant Foods Human Nutr.* **37** (2) : 183-192.

Liener, I. E. 1962. Toxic factors in legume of their elimination. *Am. J. Clin. Nutri.* **77** : 281-286.

Lindsey, W. L. and Norwell, M. A. 1969. A new DPTA-TEA soil test for zinc and iron. *Agron. Absts*. 61 : 84.

Lopez, Y., Gordon, D. T. and Fields, M. L. 1983. Release of phosphorus from phytate by natural lactic acid fermentation. *J. Food Sci.* **48** : 953-954.

Mahajan, S. and Chauhan, B. M. 1988. Improvement of protein and starch digestibility and mineral extractability of pearl millet through lactic fermentation. Paper presented at 2nd International Food Conference IFCON held at CFTRI, Mysore, India, Feb. 18-23, 1988.

Marquardt, R. R., Mckirky, J. A. and Ward, A. T. 1978. Comparative cell wall constituent levels of tannin free and tannin containing cultivars of field beans (*Vicia faba* L.). *Can. J. Plant. Sci*. **58** : 753-760.

Mehta, U., Verma, P. and Singh, I. 1993. Effect of cooking, sprouting and dehulling on the nutritional quality and protein digestibility of ricebean (RBL-1) *Vigna umbellate* in comparison to mungbean (*Phaseolus aureus*). *J. Dairying Foods Home Sci.* **12** (4) : 165-172.

Mertz, E. T. Kirleis, A. W. and Aretell, J. D. 1983. *In vitro* digestibility of proteins in major food cereals. *Fed. Proc.* 42 (5) : 6026.

Michael Eskin, N. A. and Wiebe, S. 1983. Changes in phytase activity and phytate during germination of two fababean cultivars. *J. Food Sci.* **24** : 270-271.

Mubarak, A. A. El., Salih, F. A., Huda Abdual Galiel, N. E. L. and Ghorashi, Am. 1988. Effect of time and harvest on physical and chemical composition, cookability and yield of fababean. FABIS Newsletter. **20** : 30-36.

Naidu, M. R., Singh, V. P., Chhabra, A. 1984. Performance of some faba bean genotypes under North India conditions. Fabis News Letter. **9** : 20-21.

Neumann, P. E., Walker, C. E. and Wang, H. L. 1984. Fermentation of corn gluten meal with *Aspergillus oryzae* and *rhizopus oligosporus. J. Food Sci.* **49** : 1200-1201.

Nigam, V. N. and Giri, K. V. 1961. Sugar in pulses. *Can. J. Biochem. Physiol.* **39** : 1847-1853.

Nolan, K. B. and Duffin, P. A. 1987. Effect of phytate on mineral bioavailability. *In vitro* studies on Mg^{2+}, Ca^{2+}, F^{3+}, Cu^{2+} and Zn^{2+} Solubilities in the presence of phytate. *J. Sci. Food Agric*. **40** : 79-83.

Ologhobo, A. D. 1989. Improving the nutritive value of soybean (*Glycine max* L. Merr.) through processing : Biochemical and protein quality studies. *Trop. Agric.* **66** : 290.

Ologhobo, A. D. and Fetuga, B. L. 1984. Distribution of phosphorus and phytate in some Nigerian varieties of legumes and some effects of processing. *J. Food Sci.* **49** (1) : 199-201.

Parihar, R. S., Gupta, O. P., Singh, V. P. and Parihar, M. S. 1993. Effect of different processing treatments on *in vitro* digestibility of fababean seeds. J. *Dairying Foods Home Sci.* **12** (3) : 149-152.

Ramachandran, K. and Bolodia, G. 1984. The effect of fermentation on the iron, phosphorus and zinc content of *tef* (*Eragrostis tef*). *Ethiopian Med. J.* **22** : 45-48.

Ramakrishnana, C.V., Parekh, L. J., Aliokar, P. N., Rao, G. S. and Bhandari, S. D. 1976. Studies on soy *idli* fermentation. *Plant Foods Man.* **2** : 15.

Rani, N. and Hira, C. K. 1993. Effect of various treatments on nutritional quality of fababean (*Vicia faba*). *J. Food Sci. Technol*. **30** (6) : 423-416.

Rao, B. S. N. and Prabhavathi, T. 1982. Tannin content of food commonly consumed in India and it influence on ionisable iron. *J. Sci. Food Agric.* **33** : 89-96.

Rao, P. S. 1969. Studies on digestibility of carbohydrates in pulses. *Ind. J. Med. Res.* **57** (11) : 2151.

Reddy, N. R. and Salunkhe, D. K. 1981. Interactions between phytate, protein and minerals in whey fractions of black gram. *J. Food Sci. Adv. Food Res.* **28** : 1-9.

Reddy, N. R., Pierson, M. D., Sathe, S. K. and Salunkhe, D. K. 1995. Dry bean tannin : A review of nutritional implications. *J. Am. Oil Chem. Soc.* **62** : 541-549.

Reddy, N. R., Sathe, S. K. and Salunkhe, D. K. 1982. Phytates in legumes and cereals. *Adv. Food Res.* **28** : 1-9.

Riet, W. B. Wander, Wight, A. W., Gilliers, J. J. L. and Datel, J. M. 1987. Food chemical analysis of *tempeh* prepared from Sough African grown soybeans. *Food Chem.* **25** (3) : 176-206.

Saharan, K. 1994. Studies on the development of products from rice bean and faba bean. This sensory and nutritional evaluation. Ph. D. Thesis, CCS Haryana Agricultural University, Hisar, India.

Saharan, K., Khetarpaul, N. and Bishnoi, S. 2002. Antinutrients and protein digestibility of faba bean and ricebean as affected by soaking, dehulling and germination. *J. Food Sci. Techno.* **39** (4) : 418-422.

Salunkhe, D. K., Chavan, J. K., Kadam, S.S. and Chavan, J. K. 1982. Chemical, biochemical and biological significance of

polyphenols in cereals and legumes. *Crit. Rev. Food Sci. Nutr*. **17** : 277-280.

Sammour, R. H. 1987. Chemical constituents and electrophersis of seed protein of some species of Vicia. FABIS Newsletter. **18** : 30-32.

Sathe, S. K. and Salunkhe, D. K. 1981. Studies on trypsin and chymotrypsin inhibitor activities, haemagglutinating activity and sugars in the Great North beans (*Phaseolus vulgaris*). *J. Food Sci*. **46** : 626.

Satwadhar, P. N., Kadam, S. S. and Salunkhe, D.K. 1981. Effects of germination and cooking on polyphenols and *in vitro* protein digestibility of horse gram and moth bean. *Plant Food Human Nutr*. **31** : 71-76.

Savage, G. P. and Deo, S. 1989. The nutritional value of mungbean and urd (*Vigna radiata* var. aureus and var. mungo). *Nutr. Abst. Rev.* (Series A). **59** : 640-662.

Serraino, M. R., Thompson, L. U., Savoie, L. and Parent, G. 1985. Effect of phytic acid on the *in vitro* rate of digestibility of rapeseed protein and amino acids. *J. Food Sci.* **50** : 1689-1692.

Sharma, A. 1989. Effect of processing and cooking methods on nutrient composition and antinutritional factors of Bakla (*Vicia faba*). M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Sharma, A. and Sehgal, S. 1991a. Protein and starch digestibility of fababean as affected by domestic processing and cooking methods. *DieNahrung*. **35** (8) : 891-893.

Sharma, A. and Sehgal, S. 1991b. Proximate compositionand protein fractions of fababean (*Vicia faba*). *Bull. Grain Technol.* **29** (2) : 104-107.

Sharma, A. and Sehgal, S. 1992. Effect of processing and cooking on the antinutritional factors of faba bean (*Vicia faba*). *Food Chemistry.* **43** : 383-385.

Sharma, A. and Sehgal, S. 1992a. Effect of domestic processing, cooking and germination on the trypsin inhibitor activity and tannin content of fababean (*Vicia faba*). *Plant Food Human Nutr.* **42** : 127-133.

Sharma, A. and Sehgal, S. 1992b. Effect of processing and cooking on the antinutritional factors of fababean (*Vicia faba*). *Food Chem.* **43** (5) : 383-385.

Shrivastava, P. P., Das, H. and Prasad, S. 1990. Effect of roasting process variables on *in vitro* protein digestibility of bengal gram, maize and soybean. *Food Chem.* **35 :** 31-37.

Singh, B. and Sedeh, H. G. 1979. Characteristics of phytase and its relationship to acid phosphatase and certain minerals in triticale. *Cereal Chem.* **56** : 267-269.

Singh, K. B., Erskine, W., Robertson, L. D., Nokoul, H. and Williams, P. C. 1988. Influence of pretreatment on cooking quality parameters of dry legumes. *J. Sci. Food Agric.* **44** : 135-142.

Singh, U. and Jambunathan, R. 1981. Studies on *desi* and *kabuli* chickpea (*cicer arietrium* L.) cultivars. Level of protease inhibitors, levels of polyphenolic components and *in vitro* protein digestibility. J. *Food Sci.* 46 : 1364-1367.

Singh, U., Kherdekar, M. S. and Jambunathan, R. 1982. Studies on desi and kabuli chickpea cultivars. The levels of amylase inhibitors, levels of oligosaccharides and *in vitro* starch digestibility. *J. Food Sci.* **47** : 510.

Singh, U.; Khedekar, M. S. and Jambunathan, R. 1982. Studies on *desi* and *kabuli* chickpea cultivars. The level of amylase inhibitors, levels of oligosaccharides and *in vitro* starch digestibility. *J. Fd. Sci*. 47 : 510.

Soni, S. K. and Sandhu, D. K. 1990. Biochemical and nutritional changes associated with Indian Punjabi *warri* fermentation. *J. Food Sci. Technol.* **27** : 82-85.

Sotelo, A., Flores, F. and Hernandes, M. 1987. Chemical composition and nutritional value of Mexican varieties of chickpea (*Cicer arietinum* L.). *Plant Foods Human Nutr.* **37** : 299-305.

Souza, P. A. de, Souuza, H. B. de, Santos, J. E. dos and Freites, O. de. 1991. Physico-chemical and nutritional evaluation of pigeonpeas (*Cajanus cajan*). *Alimentose Nutricao*. **3**(2):51-62.

Steinkraus, K. H. 1983. Handbook of Indigenous Fermented Foods : Microbiological Series, Vol. 9, Marcel Decker, New York.

Subhulakshmi, G., Kumar, K. G. and Venkataraman, L. V. 1976. Effect of germination on the carbohydrates, proteins, trypsin inhibitors, amylase inhibitors and haemagglutinins in horse gram and moth bean. *Nutr. Rep. Int.* **13** : 19-31.

Suparmo, Markakis, P. 1987. *Tempeh* prepared from germinated soybeans. *J. food Sci.* **52** (6) : 1736-1737.

Tabekhia, M. M. and Luh, B. S. 1980. Effect of germination, cooking and canning on phosphorus and phytate retention in dry beans. *J. Food Sci.* **45** : 406-408.

Tan, N., Rahim, Z. H. A., Khar, H. and Wong, K. C. 1983. Winged bean (*Psophocarpus tetragonolobus*) tanning level, phytate content and hemagglutinin activity. *J. Agric. Food Chem*. **31** : 916-917.

Tangkongohitr, U. Sleh, P. A. and Hoseney, R.C. 1981. Phytic acid III. Its fate during bread making. *Cereal Chem.* **58** : 229-233.

Thompson, L. U. and Yoon, J. H. 1984. Starch digestibility as affected by polyphenols and phytic acid. *J. Food Sci.* **49** (4) : 1228-1229.

Walker, A. F. and Kochhar, N. 1983. Effect of processing including domestic cooking on nutritional quality of legumes. *Proc. Nutr. S*oc. **41** : 41-51.

Wang, H. L., Swain, E. W., Wallen, L. L. and Hesseltine, C. W. 1975. Free fatty acids identified as anti tryptic factor in soybean fermented by *Rhizopus oligasporus*. *J. Nutr.* **105** : 1351.

Wein, E. M. and Schwartz, R. 1983. Comparison of *in vitro* and *in vivo* measurement of dietary calcium changeability and bioavailability. *J. Nutr.* **113** : 338.

Williams, P. C., Nekoul, H. and Singh, K. B. 1982. International centre for Agricultural Research in the Dry Areas (ICARDA). Aleppo, Syria.

Williams, P.C.; Nakaul, H. and Singh, K. B. 1983. Relationship between cooking time and some physical characteristics in chickpea. *J. Sci. Food Agric.* 34 : 492-496.

Yadav, S. 1992. The preparaton, acceptability and nutritional evaluation of *wadi* – an indigenous legume fermented product. M. Sc. Thesis, Haryana Agricultural University, Hisar, India.

Youssef, M. M., Abd-El-Acl, M. H., Lalita, A. E. S. and Ziens, H. M. 1987. Effect of dehulling, soaking and germination on chemical composition, mineral element and protein pattern of fababean (*Vicia faba* L.). *Food Chem.* **23** : 129-138.

Zamora, A. F. and Fields, M. L. 1979. Nutritive quality of fermented cowpeas (*Vigna sinensis*) and Chickpeas (*Cicer arietinum*). *J. Food Sci.* **44** : 234.

APPENDIX- I

9-Hedonic Rating Scale

Name ---------- **Dated ----------**

Products ----------

Test these samples and check how much you like or dislike each one. Use appropriate scale to show your attitude by assigning points that best describe your feelings about the sample. An honest expression of your feelings will help us.

Sr. No.	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability	Remarks

Rate	Organoleptic score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

Abstract

1.	Title of thesis	:	Nutritional and organoleptic evaluation of value added products developed from Faba bean (*Vicia faba* L.).
2.	Full name of degree holder	:	**VANDANA**
3.	Admission No.	:	2004HS207M
4.	Title of degree	:	Master of Science
5.	Name and address of Major Advisor	:	Dr.(Mrs.) Saroj Dahiya Professor and Head Deptt. of Foods and Nutrition I.C. College of Home Science CCS Haryana Agricultural University Hisar-125004
6.	Degree awarding University/ Institute	:	CCS Haryana Agricultural University, Hisar-125004
7.	Year of award of degree	:	2006
8.	Major subject	:	Foods and Nutrition
9.	Total No. of pages in thesis	:	123 + xix
10.	No. of words in the abstract	:	418 Approximately

(An abstract of the dissertation submitted to the CCS Haryana Agricultural University in partial fulfilment of the requirements for the degree of M.Sc.)

Keywords: Fababean, nutritional composition, protein digestibility, antinutrients, mineral composition, product development, organoleptic evaluation, shelf life.

The present study was carried out for the nutritional and organoleptic evaluation of value added products developed from fababean. Among two varieties viz HB-180

and Vikrant, Vikrant was found to be nutritionally superior and was selected for product development. In physico-chemical properties, Vikrant variety of raw fababean had significantly higher ($p<0.05$) values of density, swelling capacity and low cooking time. Protein, crude fibre, *in vitro* protein digestibility was significantly higher in vikrant variety. Antinutritional factors like phytic acid and tannin observed to be lower in Vikrant variety of fababean. Total mineral and HCl extractable content Ca, Fe, Zn and P were also higher in Vikrant variety.

Value added products like *roasted dal, boiled dal, missi roti, puri, halwa, ladoo, dhokla, dalia, pasta, cake* and *biscuit* were preopared using Vikrant variety of fababean in different proportions.Organoleptic evaluation of products showed that all the products were organolepticallyacceptable and analysed nutritionally. Shelf life of acceptable products was also assessed in terms of organoleptic evaluation and chemical analysis.

Nutritional evaluation of products showed that supplemented products had higher amount of protein, fat, ash, crude fibre, *in vitro* digestibility and minerals content as compared to their controls. The supplementation also decreased the antinutrients like phytic acid and tannin significantly in all products except *missi roti* .

The products like *roasted dal*, pasta*, ladoo* and biscuits were stored in polyethylene bags at room temperature for two months. Shelf life of *roasted dal,* pasta, *ladoo* and biscuits were found to be quite satisfactory upto 60 days of storage. Ladoo was 'liked moderately' upto 30 days and 'liked slightly' upto 45 days. Pasta was found to be acceptable upto two months i.e. 60 days and roasted *dal* was in the category of 'liked slightly' upto 60 days of storage. Fababean supplemented products were found to be as acceptable as their controls.It is therefore concluded that unconventional pulses like fababean was found to be quite acceptable in development of value added products like boiled, fired, baked, roasted, fried & extruded products. As the protein, fiber, calories & minerals content of fababean was higher. Fababean can be used as a potential source in the development of micronutrients rich recipes to raise the nutritional status. Consumption of products incorporating can decrease the incidence of PEM in our country.s Therefore, these value added products

should be include in the diet of vulnerable groups (women and children) in order to improve their nutritional status.

MAJOR ADVISOR **DEGREE HOLDER**

HEAD OF THE DEPARTMENT