NUTRITIONAL QUALITY EVALUATION OF SELECTED VARIETIES OF HORSE GRAM (*Macrotyloma uniflorum*)

THESIS

By

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(H-2009-30-09)

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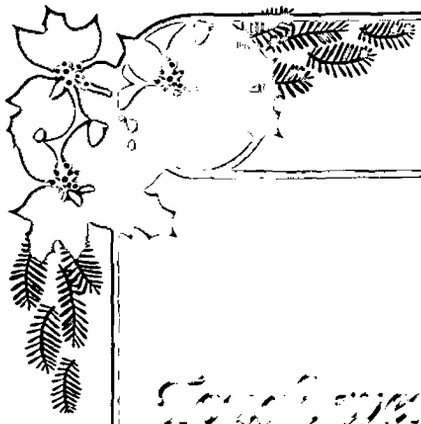


Together we've had days
Together we've had nights
I need your precious
love & care for my smiles

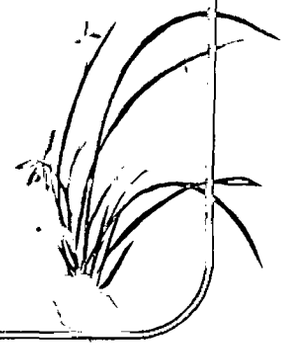
Affectionately Dedicated

To my

Revered Parents

And

'Husband



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CERTIFICATE – I

This is to certify that the thesis entitled, **"Nutritional quality evaluation of selected varieties of horse gram** (Macrotyloma uniflorum)**"**, submitted in partial fulfillment of the requirements for the award of the degree of **Master of Science (Home Science)** in the discipline of **Food Science and Nutrition** of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur is a bonafide research work carried out by **Ms Sonika (Admission No.H-2009-30-09)** daughter of Sh. Surjit Singh Guleria under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

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

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Major Advisor

Place: Palampur
Dated: 5th July, 2011

CERTIFICATE - II

This is to certify that the thesis entitled, **"Nutritional quality evaluation of selected varieties of horse gram (Macrotyloma uniflorum)"** submitted by **Sonika (Admission No.H-2009-30-09)** daughter of Sh. Surjit Singh Guleria to CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, in partial fulfillment of the requirements for the degree of **Master of Science (Home Science)** in the discipline of **Food Science and Nutrition**, has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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TABLE OF CONTENTS

Chapter	*Title*	*Pages*
1.	INTRODUCTION	1-3
2.	REVIEW OF LITERATURE	4-14
3.	MATERIALS AND METHODS	15-30
4.	RESULTS & DISCUSSION	31-63
5.	SUMMARY AND CONCLUSIONS	64-67
	LITERATURE CITED	68-76
	APPENDIX	77
	BRIEF BIODATA OF THE STUDENT	

LIST OF ABBREVIATIONS

cm	=	Centimeter
ml	=	Milliliter
g	=	Gram
mg	=	Milligram
kg	=	Kilogram
Fig	=	Figure
%	=	Per cent
g/ml	=	Gram per mililitre
tbl sp	=	Table spoon
tsp	=	Tea spoon
pcs	=	Pieces

LIST OF TABLES

Table No.	Title	Page
3.1	Ingredients and steps involved in the preparation of different products.	28-29
4.1	Physical characteristics of selected varieties of Horse gram.	32
4.2	Proximate composition of different varieties of horse gram.	37
4.3	Nutritional composition of selected five varieties of horse gram.	39
4.4	Colour scores of different products at various levels of supplementation.	48
4.5	Taste scores of different products at various levels of supplementation.	48
4.6	Texture scores of different products at various levels of supplementation.	49
4.7	Overall acceptability scores of different products at various levels of supplementation.	49
4.8	Chemical composition of *sev* at various levels of supplementation.	52
4.9	Chemical composition of *ladoo* at various levels of supplementation.	52
4.10	Chemical composition of biscuits at various levels of supplementation.	53
4.11	Chemical composition of *gulgule* at various levels of supplementation.	53
4.12	Chemical composition of *mathi* at various levels of supplementation.	57
4.13	Chemical composition of *chillay* at various levels of supplementation.	57
4.14	Chemical composition of *pakoru* at various levels of supplementation.	58
4.15	Crude protein content of the different prepared products.	59
4.16	Crude fat content of the different prepared products.	59
4.17	Calcium content of the different prepared products.	60

LIST OF FIGURES

Fig. No.	*Title*	*Page*
4.1	Colour scores of Products (*sev, ladoo, gulgule* and bisciuts).	44
4.2	Taste score of Products (*sev, ladoo, gulgule* and bisciuts).	44
4.3	Texture scores of Products (*sev, ladoo, gulgule* and bisciuts).	44
4.4	Overall acceptability scores of Products (*sev, ladoo, gulgule* and bisciuts).	44
4.5	Colour scores of Products (*mathi, chillay* and *pakoru*).	45
4.6	Taste scores of Products (*mathi, chillay* and *pakoru*).	45
4.7	Texture scores of Products (*mathi, chillay* and *pakoru*).	45
4.8	Overall acceptability scores of Products (*mathi, chillay* and *pakoru*).	45
4.9	Crude Protein content of the different preparations.	61
4.10	Crude fat content of the different preparations.	61
4.11	Calcium content of the different preparations.	61

LIST OF PLATES

Plate No.	*Title*	*Page*
4.1(a)	Whole seeds and powder of HPK-4 variety of horse gram.	33
4.1(b)	Whole seeds and powder of VLG-1 variety of horse gram.	33
4.1(c)	Whole seeds and powder of HPKC-2 variety of horse gram.	34
4.1(d)	Whole seeds and powder of Himganga variety of horse gram.	34
4.2(a)	Whole seeds and powder of local variety of horse gram.	35
4.2(b)	Sprouted & dehydrated seeds and their powder of local variety of horse gram.	35
4.3	*Sev* Preparations	42
4.4	*Ladoo* Preparations	42
4.5	Biscuits Preparations	42
4.6	*Gulgule* Preparations	42
4.7	*Mathi* Preparations	43
4.8	*Chillay* Preparations	43
4.9	*Pakoru* Preparations	43

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ABSTRACT

Selected varieties of horse gram (Macrotyloma uniflorum) were compared for their physical, proximate and nutritional composition. Product development was done using local variety of horse gram. Various preparations *viz. sev, ladoo*, biscuits, *gulgule, mathi, chillay* and *pakoru* were prepared and supplemented using horse gram sprouts as well as dehydrated powder of horse gram sprouts. Supplementation was done in different proportions i.e. (00:100), (10:90), (20:80), (30:70), (35:65), (50:50) and (100:0). Organoleptic evaluation of the products was done on 9 point Hedonic scale to assess the acceptability scores. Although all the control products were having maximum acceptability scores, supplemented products were also having scores in acceptable limits. Amount of crude protein, crude fiber, calcium, iron increased, whereas amount of crude fat decreased with increase in level of supplementation of horse gram in almost all the products with exception in few of the products. Locally available horse gram varieties can be easily supplemented in some traditional and locally consumed preparations to increase their nutritional value to little or significant extent. Inclusion of horse gram in daily dietaries as well as horse gram supplemented products can prove to improve the nutritional status of the affected population.

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Introduction

1. INTRODUCTION

Food legumes are nearly worldwide in distribution and one or more of them are consumed regularly in some form in almost every country in the world. They occupy an important place in human nutrition, especially for the low income groups of people in developing countries. Owing to the increase in population, daily per capita protein consumption has progressively decreased, showing alarming situation of malnutrition in the country (Ali Nawab 2004). Legume seeds have worldwide nutritional importance as they are easy to store, rich in protein, fiber and minerals like calcium, iron & phosphorus. These are important source of proteins in the vegetarian diet in developing countries. In general, the seeds contain 20-25 per cent protein, though soybean and winged bean have a concentration of 40-45 percent and 30-35 per cent, respectively. Horse gram (*Macrotyloma uniflorum*) has been identified as one of the potential food resource of the tropics by the National Academy of Sciences of the (USA 1979).

Legumes are consumed in the form of split, whole, boiled or roasted. The dehulled split cotyledons of legumes are termed as *"dhal"*. Legumes are cheapest source of supplementary proteins in Indian diets (Rao and Sampath 1979).

Horse gram is sown in the rainy season by resource-poor farmers in marginal, drought-prone areas of India. The whole seeds of horse gram are generally utilized as cattle feed. However, it is consumed as a whole seed, sprouts, or whole meal by a large population in many parts of India (Ghorpade *et al.* 1986). It is considered to be originated in South East Asia and probably in Peninsular India. It is mainly grown in states of Tamil Nadu, Karnataka, Maharashtra, Madhya Pradesh, Andhra Pradesh, Bihar, Himachal Pradesh, Gujrat and Uttar Pradesh in India. It occupies an area of 1,537 thousands hectares with an average productivity of 3.69 quintals per hectare (Bhan and Mishra 1998). In Himachal Pradesh it is the second important pulse crop next to

urad bean and occupies an area of 3,028 hectares with total production of 1,475 metric tons (Anonymous 2001).

The use of dry seeds of horse gram is limited due to poor cooking quality, presence of high levels of enzyme inhibitors and haemagglutinin activities.The seed is reported to be high in tannins and polyphenols compared to other legumes (Kadam and Salunkhe 1985).

Cooking quality is one of the important quality parameter of legumes. It results in improved texture, digestibility and palatability. Cooking is required to ensure acceptable sensory quality. Texture is a major factor responsible for influencing consumer acceptance of cooked legumes (Stanley *et al.* 1989). Presoaking facilitates cooking process in the legumes. The seed may be cooked for a set period of time or may be cooked until considered done based on an evaluation of texture. In both cases, the evaluation of texture is critical to the determination of the cooking quality (Arntfield *et al.* 2000).

Germination is a simple biochemical tool and significantly improves palatability, digestibility and the nutritive utilization of proteins. Genarally, grain legumes are soaked before they are germinated or cooked, in order to render them edible and ensure sensory quality. The soak water may or may not be discarded prior to cooking depending upon regional preference. During these operations, the seed undergoes important chemical changes resulting in much softer texture (Stanley and Aguilera 1985).

Legumes are known to have a lower protein digestibility, which is attributed to the presence of antinutritional factors (Liener 1994). Horse gram contains several natural constituents such as protease inhibitors, haemagglutinins, tannins and phytic acid which can interfere with protein digestion or distrupt physiological process. Dry matter of horse gram contains 24.89 per cent crude protein. Horse gram with husk has a protein digestibility of 32.6 percent whereas dehusking has improved the protein digestibility to 44.1per cent.

Rahman and Salariya (2005) reported protein digestibility of various raw legumes in the range of 33.8-37.8 per cent. Very low protein digestibility of raw horse gram could be due to presence of trypsin inhibitors and tannins compared to other legumes. Since, most of the seed tannins are present in the seed coat, removal of seed coat by dehulling increased the digestibility by 35 per cent.

Bravo *et al.* (1999) determined protein, fat, ash and polyphenols composition of Indian pulses along with total and resistant starch (RS), dietary fiber (DF) & soluble sugars and compared with other legumes. It was observed that all the legumes had a high content of non-digestible carbohydrates (37-48% of carbohydrates) and was suggested that moth bean and horse gram are of good nutritional quality, making them suitable for more extensive use.

Sharma *et al.* (1987) while studying the economic analysis of tribal agriculture of Himachal Pradesh reported that the people of tribal areas like Pangi, Bharmour, Kinnaur and Lahaul Spiti grow amaranthus, buckwheat and horse gram.

Based upon these considerations, the present research work on nutritional quality evaluation of selected varieties of horse gram was proposed with special reference to assess the influence of processing treatments on its nutritional quality attributes. Keeping in view the nutritional importance of the horse gram, the present study was undertaken with the following objectives:

- To assess the physico-chemical characteristics of selected varieties of Horse gram.
- To study the effect of different processing techniques on nutritional quality.

Review of Literature

2. REVIEW OF LITERATURE

Horse gram (*Macrotyloma uniflorum*), also known as Gahat, Kulath or Kulthi is a minor, under-exploited legume of tropics and subtropics, grown mostly under dry-land agriculture. The chemical composition is comparable with commonly cultivated legumes. Like other legumes, these are deficient in methionine and tryptophan. It is an important source of protein, iron and molybdenum.

Poor functional properties of horse gram are major limitations to use its flour in legume composite flours. Utilization of horse gram can be maximized through an understanding of its physical and chemical components and through the implementation of diverse processing strategies to facilitate the development of economically viable alternative products. There has been an increasing interest in recent years on the functional properties of plant proteins or their isolates for food use. Thus, information on the changes in the functional properties of Horse gram, as influenced by processing is needed. Nutritional value and consumption of horse gram could be improved by processing it into a new product or ingredient that can be used in food processing.

An attempt has been made to review literature available to comprehend the work done so far in India and abroad, as per objectives of the present investigation. The relevant review has been discussed under the following headings:

2.1 Importance of legumes/Pulses

2.2 Physical characteristics of horse gram

2.3 Chemical characteristics of horse gram

2.3.1 Proximate composition of horse gram

2.3.2 Ascorbic acid composition

2.3.3 Mineral composition

2.4 Effect of germination on Horse Gram

2.4.1 Effect on in vitro digestibility

2.4.2 Effect on antinutritional factors

2.4.3 Effect on ascorbic acid

2.4.4 Effect on other nutritional parameters

2.5 Effect of other processing techniques on Horse Gram

2.5.1 Effect on in vitro digestibility

2.5.2 Effect on antinutritional factors

2.5.3 Effect on other nutritional parameters

2.6 Others

The literature regarding the various aspects of present study is scanty, so the information regarding the other studies on horse gram is also given here, to support the study.

2.1 Importance of legumes/Pulses

India is the largest producer of pulses in the world with an annual production of about 14.46 million tones. Consequently with increasing population, the per capita availability of pulses which was 51.29 g/day in 1971 has declined to 35.1 g/day in 1998 (Agricultural Statistic, 1998) as against NIN recommendation of 80 g/day. Grain legumes or pulses are mostly dried and preserved for consumption throughout the year. Among the plant foods, pulses are the major sources of protein (18-32%) and are valuable in cereal-based diets because of their complementary character to cereal proteins.

Legumes are widely grown throughout the world and their dietary and economic importance is globally appreciated. Legumes not only add variety to human diet, but also serve as an economical source of supplementary proteins

for a large human population in developing countries like India where majority of population is vegetarian. (Bishnoi 1991)

Legumes play an important role in the agriculture and diet of many developing countries and are major source of dietary nutrients for many people. However, their role appears to be limited because of several factors including low protein and starch digestibility (Negi *et al.* 2001), poor mineral bioavailability, and high antinutritional factors (Das *et al.*1999).

It has been reported that protein and thiamin (Sattar *et al.* 1989), mineral bioavailability, (Ghanem and Hussein 1999) and protein and starch digestibility (Preet and Punia 2000) increased, whereas phytic acid and tannin decreased during germination of legumes (Ayet *et al.* 1997).

2.2 Physical characteristics of horse gram

Kachru *et al.* (1994) while studying the gravimetric properties of legume reported the values for bulk density and 1000 kernel weight of horse gram as 0.829 g/cm^3 and 32.10 g respectively.

Sharma (2002) while studying effect of incorporation of full fat and defatted legume flours on the acceptability and nutritional quality of maize products reported the values of 1000 kernel weight, density and bulk density of horse gram as 38.86 g, 1.125 g/ml and 0.970 g/ml respectively.

Munde (2000) evaluated effect of moisture content on the physical properties of horse gram. It was studied that as moisture content increased 1000-grain weight also increased. Grain volume linearly increased from 20.21 to 26.10 mm^3 as moisture increased from 7.3 to 27.10 %. Kernel and bulk density also showed a linear increase with increasing moisture content.

2.3 Chemical characteristics of horse gram

2.3.1 Proximate composition of horse gram

Manage and Sohonie (1972), determined composition of dried, powdered red horse gram *(Macrotyloma uniflorum)* seeds and reported moisture, carbohydrate, fat, protein and ash as 8.3%, 59.3%, 4.8%, (N×6.25) 24.7%, 2.8% respectively.

Ray (1969) analyzed raw seeds of horse gram *(Macrotyloma uniflorum)*.Values examined were: moisture-10.25%, protein (N×6.25)-21.90%, carbohydrate-55.20%, fat-1.04%, fiber-4.90%, ash-3.10%.

Rao and Sampath (1979) studied chemical composition and nutritive value of horse gram. In dry matter of horse gram *(Macrotyloma uniflorum)* crude protein was 24.89%, ether extract 1.32%, crude fiber 5.69%, N-free extract 62.69%, ash 5.41%.

Bravo *et al.* (1999) characterized proximate composition of 2 legumes grown for consumption by the rural poor i.e. moth bean and horse gram and compared with other popular legumes in Asia. It was reported that horse gram contain (g/100g dry matter): 59.3 carbohydrate, 24.9 protein, 0.58 fat, 3.31 ash, 36.0 total starch (of which 30.8 was digestible) respectively.

Khatoon and Prakash (2004) analysed 8 legume samples including horse gram. Study was done for nutrients composition in cooked as well as raw horse gram samples. Amount of nutrients analyzed in 100 g cooked sample were: moisture 62.8-69.7%, protein 14.7-24.3%, fat-0.9-5.9%, and ash 1.7-4.6%.

Pore (1979) analyzed 27 varieties of horse gram for proximate composition and reported that range of values as for protein 16.5-26.9%, crude fat-0.56-0.96%, carbohydrate 71.84- 81.33% respectively.

Begum *et al.* (1977) reported the crude protein contents in seeds of *Macrotyloma uniflorum* ranged from 18.5-28.5%, the average being 23.1%.

In 20 varieties of *Macrotyloma uniflorum* protein content ranged from 22.02% to 31.16% and dietary fibre content from 9.27 to 12.49%.Murthy (1980)

2.3.2 Ascorbic acid composition

Gupta *et al.* (2002) conducted study to determine the nutritional status of genotypes of horse gram *(Macrotyloma uniflorum)* along with other pulses with respect to Vitamin C content. The highest amount of Vitamin C (13.3 mg/100 g) was produced in horse gram genotypes during the period of 48 hours

germination. It was concluded that cow pea *(Vigna catjang)* and horse gram genotype are superior to other genotypes with respect to germination period and Vitamin C content respectively.

2.3.3 Mineral composition

Pore (1979)[b] reported total mineral content in the meal of 27 varieties of *Macrotyloma uniflorum* varied from 2.2 % to 3.3 % and reported values were: Ca-191-430, P-292-495, Fe-13.0-70.6 mg/100 g flour. It was observed that all the varieties had high contents of Ca and P.

Rao and Sampath (1979) studied chemical composition and nutritive value of horse gram and reported dry matter of horse gram contain 0.27% Ca, 0.24% P and 0.19% Mg.

Borhade *et al.* (1984)[b] conducted study on horse gram *(Macrotyloma uniflorum)* and moth bean *(Phaseolus aconitifolius)* and reported that both legumes are rich source of iron. Iron content in horse gram was 9.6 mg/100g.

2.4 Effect of germination on Horse Gram

2.4.1 Effect on in vitro digestibility

Ramakrishna *et al.* (2007) studied ability of germination to increase the nutritional quality of storage proteins by germinating the Indian bean seeds for 0, 8, 16, 24 and 32 h and evaluated the nutritional quality through an in vitro protein digestibility (IVPD), protein efficiency ratio (PER), apparent and true digestibility. The in vitro digestibility increased appreciably with germination and marked increase was noticed in the early stage of germination. It was determined that germination is a simple biochemical enrichment tool and significantly improves palatability, digestibility and the nutritive utilization of proteins in Indian bean seeds, while Chopra and Sankhala (2004) reported that soaking grains for 8 and 16 hours and germinating the grains for 24 and 28 hours increases the iron bioavailability of legumes.

Faki *et al.* (1984) conducted studies on horse gram along with other pulses through processing by 6 methods: boiling, pressure cooking, puffing, frying, germination and germination + cooking. It was observed that for horse gram most treatments improved protein digestibility. Pressure cooking and germination/cooking gave the highest carbohydrate digestibility; germination alone reduced carbohydrate digestibility.

Satwadhar *et al.* (1981) reported free amino acid content and in vitro protein digestibility tended to increase during germination (for up to 48 hours) of horse gram.

Subbulakshmi *et al.* (1976) investigated effects of germination (for 0, 24 or 72 hours) on composition and nutritional value of horse gram and reported improved protein digestibility with increasing germination time.

Ismail *et al.* (2003) examined quantitative changes in protein and free amino acid contents in horse gram during germination. Result reveals that there was a progressive change in free amino acids content and in vitro protein digestibility which increase during germination and decreased at later stage of germination.

2.4.2 Effect on antinutritional factors

Chopra and Sankhala (2004) investigated the effect of simple processing techniques in 2 underutilized legumes horse gram *(Macrotyloma uniflorum)* and moth beam *(Phaseolus aconitifolius)*. Horse gram had higher amount of phytates and tannins. It was concluded that soaking grains for 8 and 16 hours and germinating the grains for 24 and 28 hours are significantly effective in reducing tannin and phytates.

Horse gram *(Macrotyloma uniflorum)* and moth beam *(Phaseolus aconitifolius)* were used in a study on effects of germination (at 30°c for up to 48 hours) and/or cooking (boiling until soft) on mineral and phytate concentration. It was determined that at the start phytate concentration in horse gram was 184 and at finish of germination period it was 65 mg/100g.Cooking decreased phytate

P content in both species, the decrease being greatest for germinated seeds (Borade *et al.* 1984b).

Satwadhar *et al.* (1981) reported decreased Polyphenol content during germination (for up to 48 hours) of horse gram while Subbulakshmi *et al.* (1976) determined haemagglutin and trypsin inhibitor activity decreased during germination and considerably reduced by cooking.

Diwaker *et al.* (2000) studied the level of antinutritional principle and in-vitro protein digestibility of different varieties of processed horse gram. It was reported that germination reduced markedly haemagglutinin activity and all processing techniques improved in-vitro protein digestibility.

Rodge *et al.* (2006) investigated effect of soaking and germination techniques on tannin and phytate contents in horse gram and moth bean. The processing techniques employed were soaking grain for 4,8,12 and 16 hours and germination grains for 20,25 and 30 hours. Results revealed that horse gram had higher tannin and phytate as compared to moth bean. Soaking both the legumes reduced the level of tannin and phytate as time of soaking progressed. The degradation of tannin and phytate was more pronounced after germination.

2.4.3 Effect on ascorbic acid

Dikshit (1992) studied effect of sprouting temperature on the ascorbic content of horse gram seeds. Sprouting was carried out at 4-5 degrees C (low temperature sprouting), 27 degrees C for 12 h followed by 12 h at 4-5 degrees C (mixed temperature sprouting), 27-28 degrees C (room temperature sprouting), or 33-34 degrees C (high temperature sprouting). Ascorbic content was determined at 24-h intervals for 192 h. It was determined that palatability decreased with increasing growth. Ascorbic acid value initially increased and then decreased. The number of days for which the content increased, decreased with increasing temperature.

2.4.4 Effect on other nutritional parameters

Sumathi *et al.* (1995) studied effect of germination up to 120 hours on malting lose (weight loss), amylase activity and viscosity of 9 common Indian legumes including horse gram. Seeds were germinated and sample withdrawn after 48, 72, 96 and 120 hours germination and processed into meal before analysis. It was investigated that amylase activity increased with progressive germination in horse gram and malted sample had lower cooked paste viscosity than native ones. Germination beyond 48 hours resulted in considerably higher malting losses without much effect on viscosity.

Arora (1997) determined chemical composition of 3 varieties (black, mixed and yellow) of *Macrotyloma Uniflorum* seeds after roasting, or soaking and sprouting. The seeds were rich in protein. It was observed that sprouting, but not roasting had a beneficial effect on the crude protein, ether extract and crude fiber content, but an adverse effect on nitrogen free extract.

Borade *et al.* (1984) reported decreased Ca content in non germinated seeds of horse gram and moth bean.

2.5 Effect of other processing techniques on Horse Gram

2.5.1 Effect on in vitro digestibility

Khader and Rao (1986) investigated effects of steaming, autoclaving, puffing, roasting and dehusking of horse gram along with other 2 legumes on their PER (Protein Effeciency Ratio) and digestibility coefficient. A significant improvement in PER was observed with dehusked horse gram. Roasting significantly enhanced the PER score of whole horse gram. The apparent digestibility of all the legumes improved on dehusking and puffing while Diwaker *et al.* (2000) concluded that all the processings improved in-vitro protein digestibility values of some varieties of horse gram maximally upon autoclaving and minimally after germination.

Effect of various processing treatments on the in vitro starch digestion rate and resistant starch formation in 2 little known Indian legumes horse gram *(Macrotyloma uniflorum)* and moth beam *(Phaseolus aconitifolius)* as compared with widely consumed pulse in Asian countries (black gram) was studied. It was determined that soaking significantly improved in vitro starch digestibility in the little known pulses but not in black gram (Bravo *et al.* 1999).

2.5.2 Effect on antinutritional factors

Diwaker *et al.* (2000) analyzed that autoclaving drastically suppressed the level of trypsin inhibitor, free polyphenols and haemagglutinins whilst bond polyphenols were slightly elevated in some varieties (red and brown) of horse gram. Roasting too decreased markedly the level of trypsin inhibitor and haemagglutinins.

Ghorpade *et al.* (1986) reported that germination did not affect trypsin inhibitor activity but cooking resulted in 90% decrease in trypsin inhibitor activity.

Ayyagari *et al.* (1989) examined various legumes along with horse gram for hemagglutinating activity using rabbit, rat, monkey and human. It was investigated that cooking, particularly method involving soaking of seeds in water, generally reduces the level of antinutrients.

2.5.3 Effect on other nutritional parameters

Annapurani and Murthy (1985) determined bioavailability of iron from cereals and pulses and effect of processing (dehulling, milling, cooking, roasting and germination) on possibility of improving bioavailability was investigated. Results revealed that absolute available iron in horse gram was 1.32 mg/100g.

Diwakar *et al.* (1996) studied effect of processing on functional properties of horse gram *(Macrotyloma uniflorum)* flour. Germinated and autoclaved seeds were oven dried at 50°c for 24 hours, powdered and passed through 60 mesh sieve. It was observed that heat processing reduced foam capacity and foam stability of horse gram, whereas germination increased foam capacity but did not alter foam stability.

Bravo *et al.* (1999) reported that oligosaccharide levels were high in horse gram (3.69/100g) but could be reduced by soaking and cooking etc.

2.6 Others

Kadam *et al.* (1981) reported reduction in cooking time from 145-27 minutes, improvement in protein digestibility (69-78%) of cooked horse gram after pretreatment with soak solution(1.5%NaHCO3 ,0.5% Na_2CO_3 and 0.75% citric acid for 12 hours) and had 35% less amount of polyphynols than that in untreated cooked sample.

Jogyabathi *et al.* (2001) studied effect of cooking media (salt, soda, tartaric acid and citric acid at one percent level) on cooking quality, in vitro protein and starch digestibilities of some legumes. It was concluded that cooking media have significant effects on in vitro protein and starch digestibilities of legumes as in vitro protein digestibility of controlled sample of horse gram sample was 85.8% which get reduced during cooking in different medias.

The influence of a mixture of eleven spices commonly consumed in India on the utilization of protein from boiled horse gram (*Macrotyloma uniflorum*) was studied at 10 and 20 percent level of protein intake in experimental rats. Addition of the spice mixture at 1.5% level of the diet significantly increased the Biological value and decreased the Total digestibility at both the levels of protein tested (Pradeep and Geervani 1992).

Kushwah *et al.* (2004) conducted a study on nutritional utilization of germinated and heat treated horse gram as a protein supplement in millet based diet and it was determined that these proved effective and indicated better result. Subsequent studies on digestibility co-efficient, biological value and net protein utilization also confirmed better biological utilization of millets supplemented with 50% heat treated dhal horse gram over raw or germinated grams supplementation.

Proximate nutrients, Ca and selected antinutrients (oxalic acid, tannins) in 16 varieties of whole horse gram and their dehulled seeds were estimated. It was determined that protein, carbohydrate and fat contents were higher in dehulled samples than in corresponding whole horse gram. Moisture, fiber, ash and Ca content of dehulled samples were lower. A significant portion of the antinutrients studied was removed by dehulling (Sudha *et al.*1995).

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled **"Nutritional Quality Evaluation of selected varieties of Horse Gram (*Mcrotyloma uniflorum*)"** was carried out in the Department of Food Science and Nutrition, College of Home Science, CSK Himachal Pradesh Krishi Vishvavidyalaya Palampur. This chapter contains relevant information regarding the research design and methodological steps. The research methodology and procedure to achieve the foregoing objectives have been described under the following heads:

3.1 Procurement of raw material

3.2 Preparation of sample

3.3 Physical characteristics of horse gram

3.4 Chemical analysis

3.5 Standardization of methods/recipes used for preparation of products supplemented with horse gram

3.6 Organoleptic evaluation of the prepared products

3.7 Chemical analysis of the prepared products

3.8 Statistical Analysis

In order to achieve objectives of the study and arrive at proper conclusions, standard techniques and methodologies were used.

3.1 Procurement of raw material

The research material for the present study comprised of five Horse gram varieties. Four varieties of horse gram viz. HPKC-2, HPK-4, VLG-1 and Himganga were procured from the Department of Crop Improvement, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The local variety and other ingredients required for product development were procured from the local market.

3.2 Preparation of sample (s)

3.2.1 Preparation of horse gram varieties

Dry mature seeds of horse gram varieties were cleaned of any extraneous substances such as dust, dirt or any foreign material and dried in a hot air oven at 60°± 5° C. The dried samples were ground in pestle and mortar and stored in airtight containers. These samples were properly labeled and kept in room temperature for further analysis. Analysis was performed in triplicates and results were presented on dry weight basis.

3.2.2 Germination

The seeds of local variety were soaked in water overnight. The excess water was drained off and seeds were kept tied in moist muslin cloth for 2 days for allowing germination. After germination seeds were dried at 60±5°c in the tray drier and then ground to the powder. Thereafter horse gram powder was stored in airtight container to equilibrate the moisture for further use in the product development.

3.3 Physical characteristics of horse gram

For physical characteristics, the seeds were selected randomly representing the whole lot of sample.

3.3.1 Colour

The colour of the Horse gram varieties was observed from their physical appearance.

3.3.2 Shape

The shape of the Horse gram varieties was observed from their physical appearance.

3.3.3 Length

Ten randomly selected seeds were taken and their length was measured with the help of vernier caliper and expressed in centimeters with the help of standard scale.

3.3.4 1000-Kernel Weight

One thousand seeds from each variety were taken randomly and weighed in triplicate separately. The mean seed weight was recorded, which represented the 1000 kernel weight.

3.3.5 Bulk Density

Bulk density of different samples of horse gram was determined by using the method given by Narain et al. (1978). A calibrated graduated cylinder (1000 ml) was filled with seeds up to the mark. The contents of the cylinder were weighed. The bulk density of individual sample was calculated by dividing the weight by 1000 and expressed as g/ml.

3.4 Chemical Analysis

3.4.1 Proximate Principles

The following proximate parameters were analyzed by using standard methods. The observations were made in triplicate.

3.4.1.1 Moisture (AOAC, 1990)

Moisture content in the samples of horse gram varieties was determined by following the oven drying method. Weighed sample was taken in a previously weighed, dried moisture dishes. These moisture dishes were kept in hot air oven at 60° ± 5° C for 8 hours. The moisture dishes were taken out from oven and kept in dessicator for cooling for 30 minutes, for attaining a constant weight. After cooling, samples were weighed with moisture cups. The loss in weight represented the moisture content of the sample.

Calculations

$$\text{Per cent moisture} = \frac{\text{Loss of weight}}{\text{Weight of sample}} \times 100$$

3.4.1.2 Ash (AOAC, 1990)

In a preweighed crucible, 5 g of oven dried sample was added. Sample was ignited on a burner till the smoke ended up and placed in a muffle furnace at 550°C for 4 hours. The crucible was removed from furnace, cooled in a dessicator and weighed.

Calculations

$$\text{Per cent Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.4.1.3 Crude protein (AOAC, 1990)

Protein was determined by using the micro-kjeldhal method using the factor 6.25 for converting nitrogen content into crude protein.

Reagents

1. Digestion mixture : One part of copper sulphate + 10 parts of potassium sulphate
2. Boric acid solution : 4.0 per cent
3. Sodium hydroxide : 40.0 per cent
4. Standard H_2SO_4 : 0.1 N
5. Mixed indicator : 0.1 (g) Methyl red and 0.5 (g) Bromocreasol green in 100ml of 95.0 percent ethanol

Procedure

Weighed sample (2 g) was digested with concentrated sulphuric acid (25 ml) and digestion mixture (5 g) in Kjeldahl digestion flask. The content were cooled and transferred to 250 ml volumetric flask. The volume was made up to the mark with distilled water and mixed. Measured aliquot (5 ml) was taken in a distillation flask followed by 40.0 per cent Sodium hydroxide and ammonium borate was collected through a condenser in a flask containing (10 ml) of 4.0 per cent boric acid solution. The distillate was titrated with 0.1 N sulphuric acid. A blank sample was also run along with the sample.

Calculations

$$\text{Nitrogen Per cent} = \frac{\text{Titre value x 0.00014 x Volume made}}{\text{Aliquot taken x Weight of sample}} \times 100$$

Crude protein Per cent = Nitrogen (%) x 6.25

3.4.1.4 Fat (AOAC, 1990)

Reagent

Petroleum ether (B.P. 60-80°C)

Procedure

Weighed samples of 5.0 g each in triplicate were extracted with petroleum ether in Soxhlet extraction apparatus for 18 hours. The ether extract was filtered through a sintered funnel in a pre-weighed beaker and was washed with small volume of petroleum ether 2-3 times. The petroleum ether was completely evaporated and the beakers were weighed. The increase in the weight of beakers represented the fat content present in the samples.

Calculations

$$\text{Per cent Fat} = \frac{\text{Amount of ether extract}}{\text{Weight of sample}} \text{X}100$$

3.4.1.5 Crude fiber (AOAC, 1990)

Reagents

Sulphuric acid : 1.25 per cent

Sodium hydroxide: 1.25 per cent

Procedure

Weighed defatted samples (5.0 g) each in triplicate were digested with 200 ml of 1.25 per cent sulphuric acid by gentle boiling for half an hour. The contents were filtered and the residue was washed free of acid using hot distilled water. Acid free residue was then transferred to the same flask to which 200 ml of 1.25 per cent sodium hydroxide was added. The contents were digested again

for half an hour, filtered and again washed free of alkali using hot distilled water. The residue was dried in an oven overnight at 105°C, weighed and then placed in the muffle furnace at 600°C for 4 hours. The loss in weight after ignition represented the crude fibre in the sample.

Calculations

$$\text{Crude fibre per cent} = \frac{\text{Wt. of sample (before ignition)} - \text{Wt. of sample (after ignition)}}{\text{Weight of sample}} \times 100$$

3.4.1.6 Carbohydrates

The values of moisture, crude protein, crude fat, crude fiber and ash were added and subtracted from 100. The difference gives the value of carbohydrates.

3.4.2 Nutritional Analysis

3.4.2.1 Acidity (AOAC, 1990)

Reagents

NaOH solution : 0.1 N NAOH

Phenolphthalein indicator: 1 per cent

Procedure

5 g sample was taken and transferred into a 50 ml volumetric flask. Added little water, mixed well and filtered. Then volume was made up to mark with distilled water. 5ml aliquot was taken and titrated with 0.1 N NaOH and phenolphthalein was used as an indicator. The end point was the development of faint pink colour which persisted for 15 seconds.

Calculations

$$\text{Acidity (\% as lactic acid)} = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{Volume made} \times 60.08}{\text{Aliquot of extract taken for estimation} \times \text{Weight / volume of sample taken for estimation} \times 1000} \times 100$$

3.4.2.2 Ascorbic acid (AOAC, 1990)

Ascorbic acid was estimated by using 2, 6-dichlorophenol indophenol dye and dye factor was calculated as:

Dye factor = A/B

A = mg of standard ascorbic acid solution

B = ml of dye used

Procedure

5 g sample was taken and blended with 3 per cent HPO_3 and made the volume to 50 ml with HPO_3 and filtered. Then 5 ml aliquot was taken and titrated with standard dye to a pink colour persisting for 15 seconds.

Calculations

$$\text{Ascorbic acid (mg/100 ml)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made}}{\text{Aliquot of extract taken for estimation} \times \text{Weight / volume of sample taken for estimation}} \times 100$$

3.4.2.3 Minerals (Piper, 1950)

Reagents- Diacid mixture of nitric acid and perchloric acid in the ratio of 5:1 was used for digesting the samples, taking care to prepare the reagent fresh before use.

Procedure- 1 g of sample was digested with 25 ml of diacid mixture in a conical flask (100-250 ml). The contents were kept overnight for slow digestion and then heated at low temperature on a hot plate till about 1 ml of clear, colourless liquid with precipitate was left. The contents were allowed to cool and then transferred with deionized water into a 50ml volumetric flask after repeated washing and then volume was made up to the mark. The digested samples were filtered through Whatman paper No.42 filter paper and stored in the decontaminated dried labeled air tight plastic bottles for the mineral determination.

The digested samples were analyzed for Calcium using flame photometer and Iron was determined by using atomic absorption spectrophotometer.

For blank, 25 ml of diacid mixture was digested as in case of sample and volume was made to 50 ml with deionized water.

Mineral content= Concentration of Sample (ppm) × Dilution Factor

3.5 Standardization of methods/recipes used for preparation of products supplemented with horse gram

The selected products *viz. sev, mathi, ladoo,* biscuits, *chillay, pakoru and gulgule* were prepared by supplementing the basic ingredient/ ingredients with horse gram at acceptable levels. The following products were standardized and prepared in present investigation.

3.5.1.1 *Sev*

Ingredients

Chickpea flour (*besan*) - 50g

Fat - 1 tbl sp

Cumin seed (ground) -1 pinch

Omum seeds - ½ tsp

Chilli powder - 1 pinch

Salt - To taste

Water - 25ml

0il - For frying

Method

Sieved the flour, added 1 tbl sp. oil, and rubbed well. Added cumin seeds, omum seeds, salt and chilli powder. Mixed into a stiff dough using sufficient water. Oil was heated in a *karahi* for frying. Dough was put into extruder machine. Hold the machine a few inches above the oil and passed the dough to

fall into hot oil, moving hands in a rotating motion so that *sev* do not fall into one place. Fried till golden crisp.

3.5.1.2 Proportion of horse gram and chickpea flour in different *sev* preparation

1. Control (00:100) = *Horse gram (0g) + *Besan* (50g)

2. *Horse gram: *Besan* (10:90) = *Horse gram (5g) + *Besan* (45g)

3. *Horse gram: *Besan* (20:80) = *Horse gram (10g) + *Besan* (40g)

***Horse gram- Powder of Dehydrated sprouts of Horse gram**

3.5.2.1 *Ladoo*

Ingredients

Chickpea flour (*Besan*) - 25 g

Ghee - 25 g

Powdered sugar - 15 g

Crushed raisins - 5 pcs

Crushed almonds - 3 pcs

Method

Ghee was heated in a pan. Then *besan* was added and roasted on a low flame stirring constantly till brown. When browned, kept for some time to allow cooling. Then powdered sugar, crushed raisin and almonds were added and material was shaped into *ladoos.*

3.5.2.2 Proportion of horse gram and Chickpea flour in different *ladoo* preparation

1. Control (00:100) = *Horse gram (0 g) + *Besan* (25g)

2. *Horse gram: *Besan* (10:90) = *Horse gram (2.5g) + *Besan* (22.5g)

3. *Horse gram: *Besan* (20:80) = *Horse gram (5g) + *Besan* (20g)

***Horse gram- Powder of Dehydrated sprouts of Horse gram**

3.5.3.1 Biscuits

Ingredients

Refined Flour (*Maida*) - 50g

Fat - 25g

Powdered sugar - 25g

Sodium bicarbonate - 1 pinch

Curd - 1 tsp

Green cardamom - 1 pc

Method

All the ingredients were mixed together and dough was made with optimum water. The dough was then cut into circular shapes of equal width with a cutter and kept in greased baking dish and baked at 220°C temperature for 8-10 minutes.

3.5.3.2 Proportion of horse gram and refined flour (*Maida*) in different biscuits preparation

1. Control (00:100) = *Horse gram (0 g) + *Maida* (50g)

2. *Horse gram: *Maida* (10:90) = *Horse gram (5g) + *Maida* (45g)

3. *Horse gram: *Maida* (20:80) = *Horse gram (10g) + *Maida* (40g)

***Horse gram- Powder of Dehydrated sprouts of Horse gram**

3.5.4.1 *Gulgule*

Ingredients

Wheat flour - 50g

Sugar - 30g

Yeast - 1 pinch

Grated coconut - 5 g

Water - 80 ml

Oil - for frying

Method

Yeast and water were added in flour and thick paste was made. This was kept for fermentation for 10-15 min Then 1 tsp. oil and sugar were added and mixed well. Deep fried the small portions in hot oil till done.

3.5.4.2 Proportion of horse gram and wheat flour in different *gulgule* preparation

1. Control (00:100) = *Horse gram (0 g) +Wheat flour (50g)

2. *Horse gram: wheat flour (10:90) = *Horse gram (5g) + Wheat flour (45g)

3. *Horse gram: wheat flour (20:80) =*Horse gram (10g) + Wheat flour (40g)

***Horse gram- Powder of Dehydrated sprouts of Horse gram**

3.5.5.1 *Mathi*

Ingredients

Refined flour *(Maida)* - 50 g

Fat - 3 tbl sp

Salt - ½ tsp

Omum seeds - ½ tsp

Black pepper - ¼ tsp

Water - For kneading

Oil - for frying

Method

Flour was sieved, added 3 tbl sp oil, and rubbed well. Then omum seeds, salt and black pepper were added and mixed into a stiff dough by addition water. The dough was divided into small portions, rolled and deep fried in the oil till done.

3.5.5.2 Proportion of horse gram and refined flour in different *mathi* preparation

1. Control (00:100) = *Horse gram (0 g) + *Maida* (50g)

2. *Horse gram: *Maida* (10:90) = *Horse gram (5g) + *Maida* (45g)

3. *Horse gram: *Maida* (30:70) = *Horse gram (15g) + *Maida* (35g)

***Horse gram- Powder of Dehydrated sprouts of Horse gram**

3.5.6.1 *Chillay*

Ingredients

Rice Flour - 50g

Salt - ¼ tbl sp.

Red chilli powder - ¼ tsp.

Water - 100ml

Chopped onions - 5g

Chopped tomatoes - 5g

Oil - for frying

Method

Water was added to rice flour and a batter was prepared. To this, all the other ingredients were added and mixed well. In a frying pan small amount of batter was poured and made a thin pancake and shallow fried from both sides.

3.5.6.2 Proportion of horse gram and rice flour in different *chillay* preparation

1. Control (00:100) = *Horse gram (0 g) +Rice flour (50g)

2. *Horse gram:Rice flour (50:50) = *Horse gram (25g) + Rice flour (25g)

3. *Horse gram:Rice flour (100:0) = *Horse gram (100g) + Rice flour (0g)

***Horse gram- Horse gram sprouts**

3.5.7.1 *Pakoru*

Ingredients

Bengal gram - 50g

Black gram - 50g

Red chilli powder - 0.5g

Salt- ½ tbl sp

Water - 50ml

Oil - for frying

Method

Dhal was soaked overnight in water and was ground to paste by adding water in it. Added salt and red chilli powder and mixed well. Then small portions fried in hot oil till done.

3.5.7.2 Proportion of horse gram, Bengal gram and black gram in different *pakoru* preparation

1. Control (50:50:0)

   Bengal gram(50g)+black gram(50g)+*Horse gram (0g)

2. Bengal gram+black gram+*horse gram (35:35:30)

   Bengal gram(35g)+black gram(35g)+*horse gram(30g)

3. Bengal gram+black gram+*horse gram (0:0:100)

   Bengal gram(0g)+black gram(0g)+*horse gram(100g)

***Horse gram- Horse gram sprouts**

Table (3.1) Ingredients and steps involved in the preparation of different products

Products	Ingredients	Method of preparation
Sev	Chickpea flour (*besan*) - 50g Fat - 1 tbl sp Cumin seed (ground) - 1 pinch Omum seeds - ½ tsp Chilli powder - 1 pinch Salt - To taste Water - 25ml Oil - For frying	I. Seive the flour II. Addition of all the ingredients and mixing into a stiff dough. III. Putting the dough into *sev* machine. IV. Passing the dough to fall into hot oil and frying till golden crisp.
Ladoo	Chick pea flour (*Besan*) - 25 g Ghee - 25 g Powdered sugar - 15 g Crushed raisins - 5 pcs Crushed almonds - 3 pcs	I. Heat ghee in a pan II. Addition of *Besan* and frying on a low flame till brown. III. Keep for some time to allow cooling. IV. Addition of all the remaining ingredients and shaping into balls.
Biscuits	Refined Flour (*Maida*) -50g Fat - 25g Powdered sugar - 25g Sodium bicarbonate - 1 pinch Curd - 1 tsp Green cardamom - 1 pc	I. Mixing of all the ingredients together. II. Preparation of dough by addition of water. III. Cutting of dough into circular shapes with cutter. IV. Baking in the greased baking dish at 220°C temp. for 8-10 min.

Gulgule	Wheat flour - 50g Sugar - 30g Yeast - 1 pinch Grated coconut - 5 g Water - 80 ml Oil - for frying	I. Addition of yeast and water in flour. II. Preparation of thick paste. III. Keeping for fermentation for 10-15 min. IV. Addition of 1 tea spn.oil and sugar and mixing. V. Deep frying of small portions in hot oil till done.
Mathi	Refined flour *(Maida)* - 50 g Fat - 3 tbl sp Salt - ½ tsp Omum seeds - ½ tsp Black pepper - ¼ tsp Water - 23 ml Oil - for frying	I. Seive the flour II. Addition of 3 tbl sp oil and rubbing. III. Addition of all the other ingredients. IV. Mixing into a stiff dough by adding water. V. Dividing of dough into small portions. VI. Rolling and deep frying till done.
Chillay	Rice Flour - 50g Salt - ¼ tbl sp Red chilli powder - ¼ tsp Water - 100ml Chopped onions - 5g Chopped tomatoes - 5g Oil = for frying	I. Addition of water to rice flour. II. Preparation of batter. III. Addition of all the ingredients and mixing. IV. Preparation of pancakes by pouring of small amount of batter o n the frying pan. V. Shallow frying on both sides.
Pakoru	Bengal gram - 50g Black gram - 50g Salt- ½ tbl sp Red chilli powder - 0.5g Water - 50ml Oil - for frying	I. Soaking of dhal for overnight II. Ground to paste by addition of water. III. Addition of salt and pepper and mixing well. IV. Shaping into small portions and frying in hot oil till done.

3.6 Organoleptic evaluation

The prepared traditional products of different composition of horse gram supplementation were evaluated for colour, taste, flavor, texture and overall acceptability using a 9-point Hedonic scale, by the selected taste panel.

3.7 Chemical analysis of the prepared products

3.7.1 Moisture (AOAC,1990) as discussed in 3.4.1.1

3.7.2 Total Ash (AOAC, 1990) as discussed in 3.4.1.2

3.7.3 Crude Protein (AOAC, 1990) as discussed in 3.4.1.3

3.7.4 Crude Fat (AOAC, 1990) as discussed in 3.4.1.4

3.7.5 Crude Fiber (AOAC, 1990) as discussed in 3.4.1.5

3.7.6 Carbohydrate as discussed in 3.4.1.6

3.7.7 Minerals (Piper,1950) as discussed in 3.4.2.3

3.8 Statistical Analysis

The data obtained from various parameters were subjected to statistical analysis with the help of computer using CRBD design. The data was analyzed statistically using analysis of variance as per Senedecor and Cocharan (1988).

Results and Discussion

4. RESULTS AND DISCUSSION

The present study entitled, "Nutritional Quality Evaluation of selected varieties of Horse Gram" was carried out in the Department of Food Science and Nutrition, College of Home Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The study was conducted to assess the physico-chemical and nutritional quality characteristics of the five varieties of Horse Gram viz. HPK-4, VLG-1, HPKC-2, Himganga and local variety. Horse Gram varieties were cleaned and freed of any extraneous substances, dried, ground and stored in airtight containers and kept in room temperature for further analysis.

Horse gram sprouts and dried powder of the sprouted horse gram prepared from local variety was used for preparation of different horse gram supplemented products. The prepared products were evaluated for nutritional quality characteristics and consumer's acceptability using standard methods. The relevant results obtained from the present study have been discussed under the following heads:

4.1 Physical characteristics of Horse gram.

4.2 Chemical characteristics of Horse gram.

4.3 Organoleptic evaluation of the prepared products.

4.4 Chemical analysis of the prepared products.

4.1 Physical characteristics of Horse gram.

The data pertaining to physical characteristics of five varieties of Horse gram viz. HPK-4, VLG-1, HPKC-2, Himganga and local variety are given in Table 4.1.

The colour of HPK-4 and Himganga variety was observed as blackish brown, local and VLG-1 as reddish brown and for HPKC-2 as light brown. All the

varieties of horse gram were observed of flat shape and were found to be free from defects i.e. insect infestation etc.

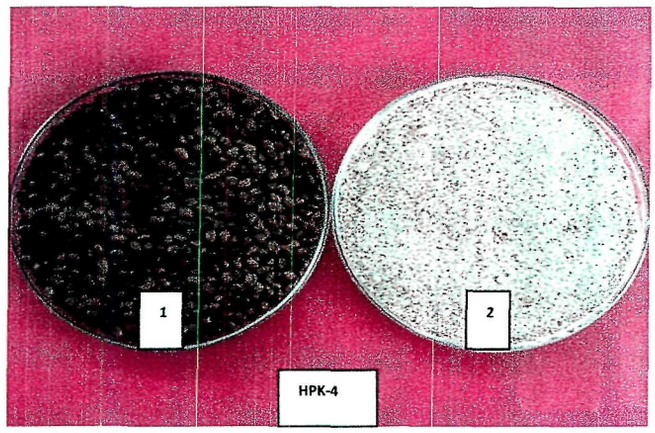
A critical look on the data reveals that the some values for physical parameters of five varieties of Horse gram varied significantly (P≤0.05) whether other vary non-significantly with the varieties. The values for 1000 kernel weight vary significantly whether the values for length and bulk density vary non-significantly. The values for length, bulk density and 1000 kernel weight for five varieties of horse gram ranged from 0.52 to 0.58 cm, 0.84 to 0.93 g/ml and 30.19 to 42.06 g respectively. Seeds of horse gram variety had the highest value of 1000 kernel weight i.e. 42.06g while the seeds of local variety were found having the lowest weight i.e. 30.19g.

Table 4.1 Physical characteristics of selected varieties of Horse gram

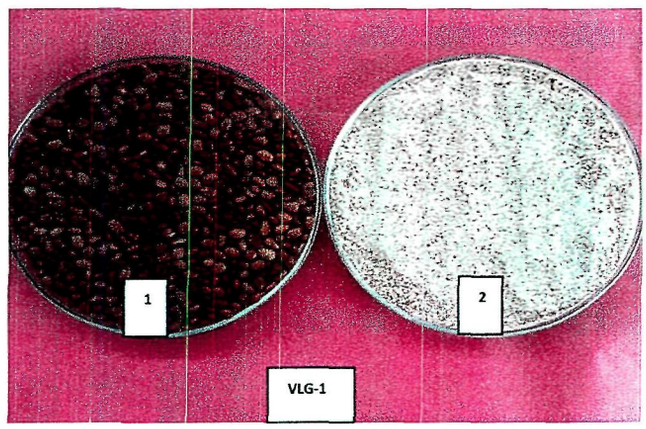
Parameters	Varieties					CD
	HPK-4	VLG-1	HPKC-2	Himganga	Local	(P≤0.05)
Colour	Blackish brown	Reddish brown	Light brown	Blackish brown	Reddish brown	-
Shape	Flat	Flat	Flat	Flat	Flat	-
Length(cm)	0.57	0.54	0.52	0.58	0.53	0.10
1000 kernel weight(g)	34.22	34.52	34.82	42.06	30.19	0.25
Bulk density(g/ml)	0.84	0.90	0.93	0.89	0.85	0.04

Data presented is mean of ten determinations.

Plate (4.1) Samples of selected varieties of Horse gram



4.1(a)

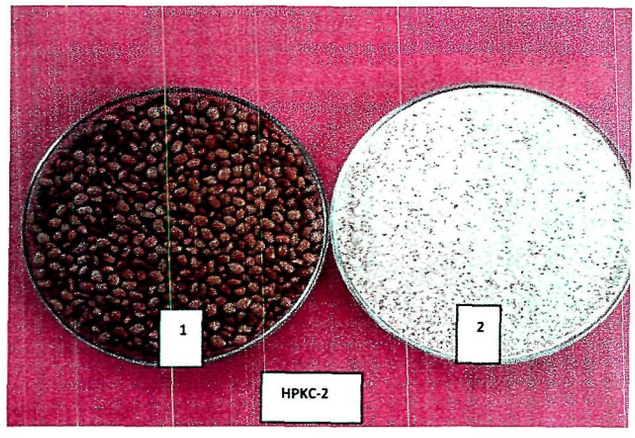


4.1(b)

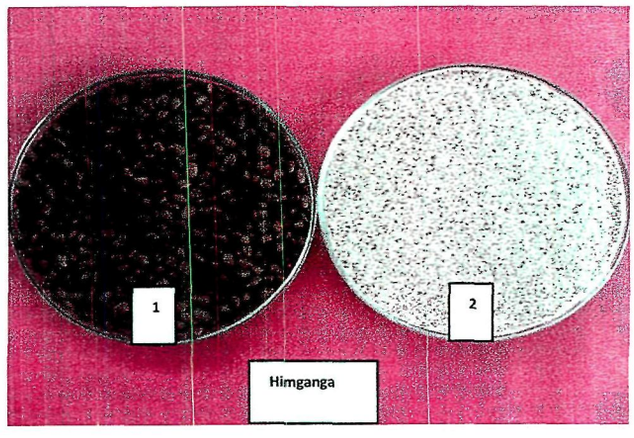
1. Whole seeds

2. Powdered seeds

Plate (4.1) Samples of selected varieties of Horse gram



4.1(c)

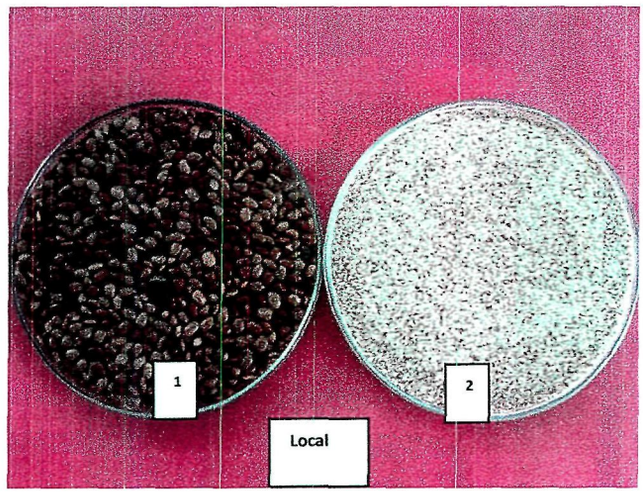


4.1(d)

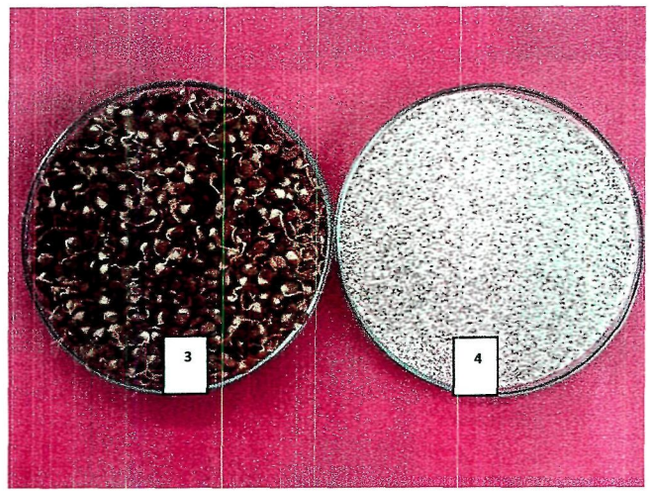
1. Whole seeds

2. Powdered seeds

Plate (4.2) Samples of local variety of Horse gram



4.2(a)



4.2(b)

1. Whole seeds 2. Powder of whole seeds

3.Sprouted & dehydrated seeds 4. Powder of sprouted & dehydrated seeds

Colour of different varieties of horse gram varies from light brown, reddish brown, and blackish brown and seeds of all the selected varieties were observed of flat shape. Sharma (2002) and Yogita (2006) observed colour of horse gram as brown and shape as flat. Similarly Sharma (2006) reported colours for different varieties of horse gram as brownish black, blackish brown, reddish brown and brown. The results are in line with present study.

Kachru *et al.* (1994) reported the values for bulk density and 1000 kernel weight of horse gram as 0.829 g/cm^3 and 32.10 g respectively which are at par with the present investigation.

Sharma (2002) reported the values of 1000 kernel weight, density and bulk density of horse gram as 38.86 g, 1.125 g/ml and 0.970 g/ml respectively. Similar findings are reported in the present investigation for 1000 kernel weight i.e.30.19 to 42.06, but the values for bulk density are lower for the present investigation. Slight variation may be due to varietal difference.

4.2 Chemical characteristics of Horse gram

4.2.1 Proximate Composition

The proximate composition of different varieties of horse gram is presented in table 4.2 showing moisture, ash, crude fat, crude protein and crude fiber contents of horse gram vary significantly ($P \leq 0.05$) amongst the five varieties.

4.2.1.1 Moisture

It is clear from the data given in Table 4.2 that the values for moisture of five varieties of horse gram varied significantly. The mean values for moisture ranged from 9.79 to 11.47 per cent, however the highest value for moisture was observed in Local (11.47%) followed by HPK-4 (10.99%), Himganga (10.73%), VLG-1 (10.56%), and HPKC-2 (9.79%). The variations in moisture content of five varieties may be due to the varietal differences. The moisture content was 8.3 per cent in dried, powdered red horse gram as reported by Manage and Sohonie

(1972) which was slightly lower than the results of the present study. The result of present investigation is supported by the work done by Ray (1969) as the moisture content examined was 10.25 percent. Value is in close agreement with the present investigation.

4.2.1.2 Ash

The Ash content of the food is defined as the inorganic residue left over after the incineration. It also represents the mineral constituents of the foods, which play an important role in the human nutrition. Table 4.2 indicates that the per cent ash content of three varieties of horse gram *viz.* HPK-4, VLG-1, HPKC-2, Himganga and local varied significantly and the values for ash were calculated as 4.25, 4.25, 4.31, 4.41 and 3.43 respectively.

Ash content was 3.31 per cent in horse gram as reported by Bravo *et al.* (1999). Khatoon and Prakash (2004) reported the per cent ash present in horse gram varied from 1.7-4.6 per cent. The results are in close agreement with the present study. It can be concluded that the variation in the ash content of five varieties may be due to the varietal difference.

4.2.1.3 Crude Protein

Protein is the indispensable component of the living matter, in foods protein supply essential amino acids, which are necessary to sustain life.

Table 4.2 Proximate composition of different varieties of horse gram

Parameters	Varieties					CD
(%)	HPK-4	VLG-1	HPKC-2	Himganga	Local	(P≤0.05)
Moisture	10.99	10.56	9.79	10.73	11.47	0.06
Ash	4.25	4.25	4.31	4.41	3.43	0.06
Crude Protein	18.25	24.41	22.18	20.96	22.40	0.32
Crude Fat	0.77	1.12	0.84	1.16	0.84	0.06
Crude Fiber	4.33	5.09	5.04	4.28	4.69	0.31
Total Carbohydrates	61.41	54.57	57.84	58.46	57.17	-

Data presented is mean of triplicate determinations.

The estimation of crude protein reflects the total nitrogenous and non-nitrogenous proteins present in the protein foods. It is clear from the data that values of crude protein varied significantly among the varieties (Table 4.2). The values for protein in five varieties were ranged from 18.25 to 24.41 per cent. The highest value for protein was found in VLG-1(24.41), followed by local(22.40), HPKC-2(22.18), Himganga(20.96) and HPK-4(18.25).

Manage and Sohonie (1972) reported per cent crude protein in horse gram as 24.7%. Similar findings were done from Rao and Sampath (1979) i.e. 24.89%. According to Ray (1969) per cent protein content in raw seeds of horse gram observed was 21.90%, whereas range for crude protein was 14.7-24.3% as reported by Khatoon and Prakash (2004). All the studies are comparable with the results of the present study.

4.2.1.4 Crude Fat

The crude fat content of a food represents the true fat (triglycerides) and other materials such as phospholipids, sterols, essential oils, fat and fat soluble pigments, waxes, carotenoids, chlorophyll and other pigments extractable with ether. The values of crude fat of five varieties ranged from 0.77 to 1.16 per cent (Table 4.2).

Bravo *et al.* (1999) observed the value of per cent fat present in horse gram was 0.58 per cent, whereas Khatoon and Prakash (2004) reported fat content in the horse gram ranged from 0.9-5.9 per cent, in range with the present results.

4.2.1.5 Crude Fiber

The crude fiber content represents the fibrous or viscous polysaccharides which gives plants, their structure, form and also used as an index of maturity, but are not digested by the human system as crude fiber includes all materials those are indigestible in humans and non-ruminants. As per the data the values varied significantly with the varieties. Table 4.2 illustrates the values of crude fiber for five different varieties and the values for crude fiber range from 4.28 to

5.09 per cent. The highest value of crude fiber was calculated in VLG-1(5.09) followed by for HPKC-2(5.04), Local(4.69), HPK-4(4.33) and Himganga(4.28) per cent. The slight variation might be due to the varietal difference as well as the stage of maturity.

The values of the crude fiber are in the range as reported by Ray (1969) and Rao and Sampath (1979) as they reported the per cent fiber present in horse gram as 4.90 per cent and 5.69 per cent respectively.

4.2.1.6 Total Carbohydrates

A look on data given in Table 4.2 reveals that the range of carbohydrate content in the selected varieties of horse gram was observed from 54.57 to 61.41 per cent. Highest content of carbohydrate was found in HPK-4, followed by Himganga(58.46), HPKC-2(57.84), local(57.17), and VLG-1(54.57) per cent respectively.

Manage and Sohonie (1972) reported the values for total carbohydrate present in the powdered red horse gram variety as 59.3 per cent. Similar values were reported by Bravo *et al.* (1999). These values are in close agreement with the present study.

4.2.2 Nutritional Composition.

Table 4.3 illustrates the data pertaining to acidity, ascorbic acid, and important mineral composition of five varieties of horse gram.

Table 4.3 Nutritional composition of selected five varieties of horse gram

Parameters	Varieties					CD
(mg/100g)	HPK-4	VLG-1	HPKC-2	Himganga	Local	(P≤0.05)
Ascorbic acid	4.53	3.62	3.63	3.62	4.50	NS
Acidity(%)	0.18	0.36	0.36	0.18	0.18	NS
Calcium	177.91	162.24	234.08	170.95	173.95	0.004
Iron	10.55	9.65	9.96	9.03	8.06	0.71

Data presented is mean of triplicate determinations.

4.2.2.1 Ascorbic Acid

It is clear from the data given in Table 4.3 that the values for ascorbic acid of five varieties of horse gram varied non-significantly. The mean values for ascorbic acid ranged from 3.62 to 4.53 mg/100 g. The value of ascorbic acid content of five varieties of horse gram *viz.* HPK-4, VLG-1, HPKC-2, Himganga and local variety were 4.53, 3.62, 3.63, 3.62 and 4.50 mg/100g, respectively. Gupta *et al.* (2002) reported 13.3 mg/100 g Vitamin C content in horse gram during the period of 48 hours germination, the values being higher as compared to the present investigation due to dehydration of the horse gram sprouts before analysis. So far no work has been reported on ascorbic acid content of horse gram on dry matter basis. Variations in ascorbic acid values may be attributed to varietal differences.

4.2.2.2 Acidity

Table 4.3 indicates that the values of acidity differed non-significantly with the varieties. The values of acidity ranged from 0.18 to 0.36 per cent. The values for per cent acidity in five varieties *viz.* HPK-4(0.18), VLG-1(0.36), HPKC-2(0.36), Himganga(0.18) and local(0.18) per cent as lactic acid. A variation in the values might be due to the varietal difference.

4.2.2.3 Mineral Composition

The mineral elements viz. Calcium and Iron were analyzed in five varieties of horse gram (Table 4.3). As from the data, the values for calcium varied significantly with the varieties. The highest value for Calcium was found in HPKC-2(234.08) followed by HPK-4(177.91), local(173.95), Himganga(170.95) and VLG-1(162.74) mg/100g. Iron content also varied significantly among the different varieties. The highest value for Iron was calculated in HPK-4(10.55) followed by HPKC-2(9.96), VLG-1(9.65), Himganga(9.03) and local(8.06) mg/100g.

Pore (1979) analyzed total mineral content in the meal of 27 varieties of *Macrotyloma uniflorum* and reported the values for Ca and Fe contents in the range of 191 to 430 and 13.0 to 70.6 mg/100 g flour respectively. These values for the Ca and Fe are on the higher side when compared with the present study whereas for Fe, present study is supported by the findings of Borhade *et al.* (1984) who reported Iron content in horse gram as 9.6 mg/100g. The difference in the mean values could be due to varietal difference and agro-climatic reasons.

4.3 Organoleptic evaluation of the prepared products.

Some locally consumed products were selected and various levels of fresh horse gram sprouts and powder of dried horse gram sprouts were supplemented in the products. These were evaluated organoleptically on a 9 point Hedonic scale for colour, taste, texture and overall acceptability.

4.3.1 Colour

The preparations supplemented at different levels are shown in Plates 4.3-4.9. Table 4.4 indicated the colour scores of *sev, ladoo,* biscuits, *gulgule, mathi, chillay* and *pakoru* at various levels of horse gram sprouts/dehydrated sprouts powder supplementation. The results revealed that supplementation of all the products with horse gram at different per cent levels had significant effect ($P \leq 0.05$) on colour of these products. The mean values of supplementation were the highest when compared with supplemented products i.e. *sev, ladoo*, biscuits, *gulgule, mathi, chillay* and *pakoru* and the score was 8.70, 8.50, 8.10, 8.50, 8.60, 8.20 and 8.40 respectively, whereas at maximum level supplementation these values were the lowest i.e. 7.00, 7.70, 7.20, 7.60, 7.20, 5,80 and 7.40 respectively

Plate (4.3) *Sev* Preparations

Plate (4.4) *Ladoo* Preparations

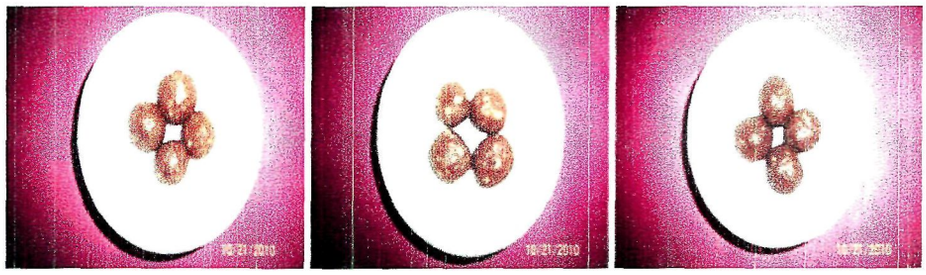


Plate (4.5) Biscuits Preparations

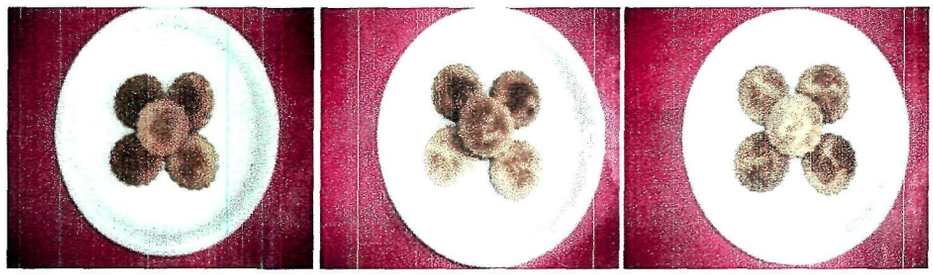


Plate (4.6) *Gulgule* Preparations

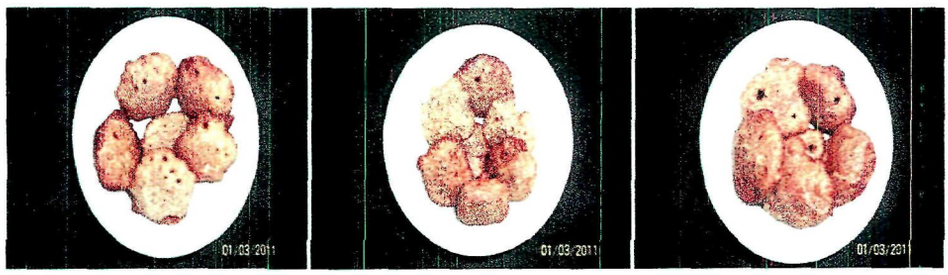


Plate (4.7) ***Mathi*** **Preparations**

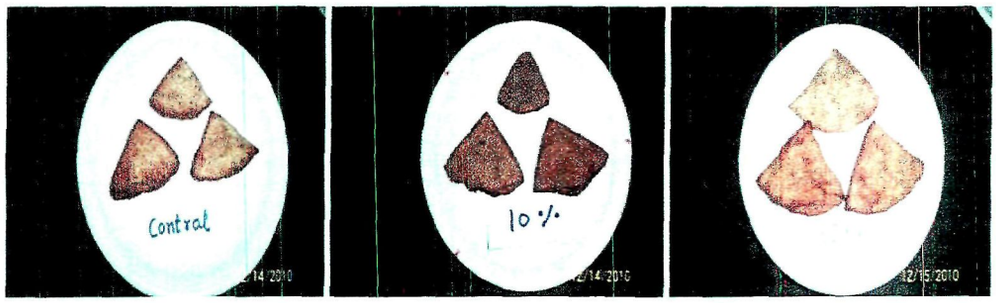


Plate (4.8) ***Chillay*** **Preparations**

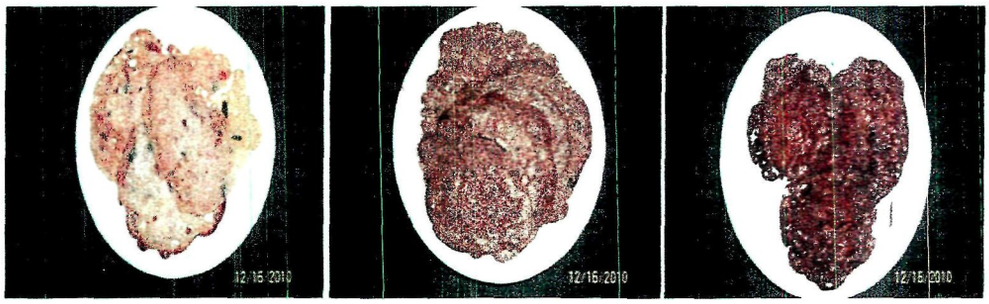
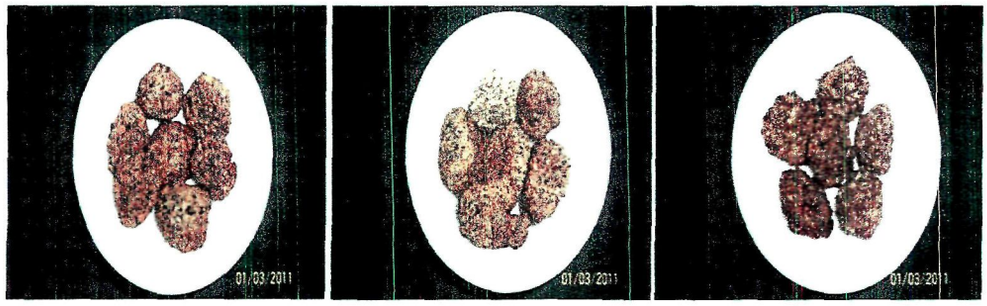


Plate (4.9) ***Pakoru*** **Preparations**



Scores of different products at various levels of supplementation

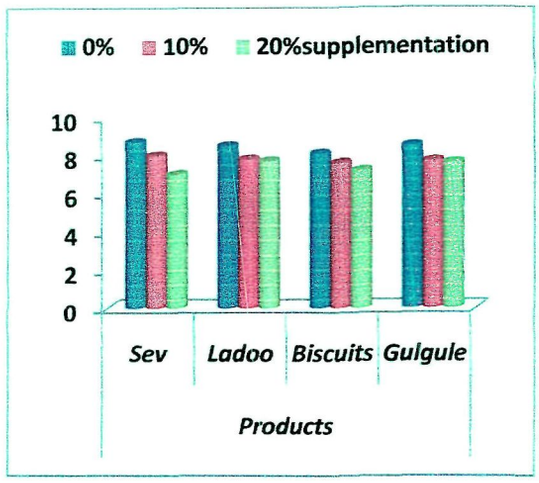


Fig.4.1 Colour scores of Products

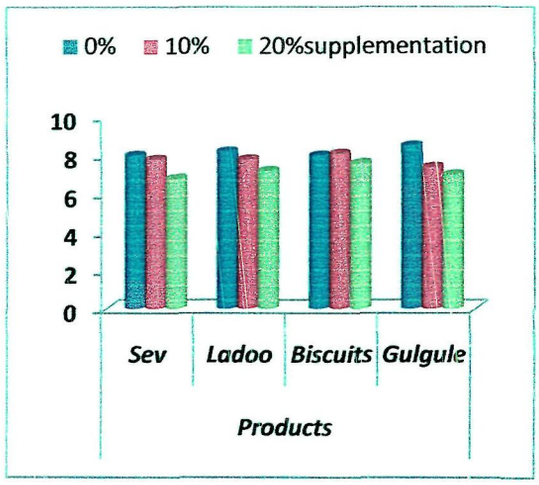


Fig.4.2 Taste score of Products

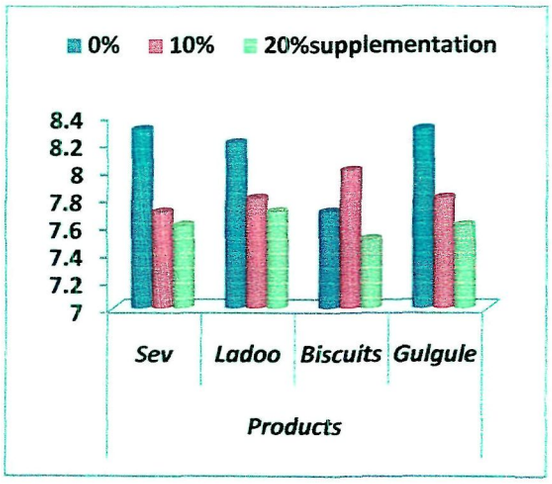


Fig.4.3 Texture scores of Products

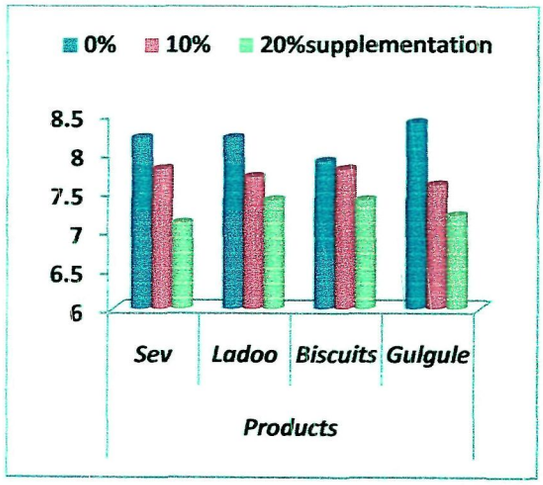


Fig.4.4 Overall acceptability score

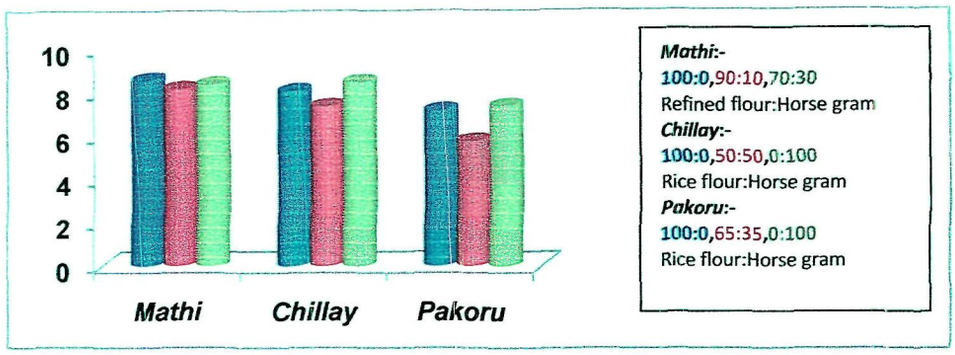


Fig.4.5 Colour scores of Products

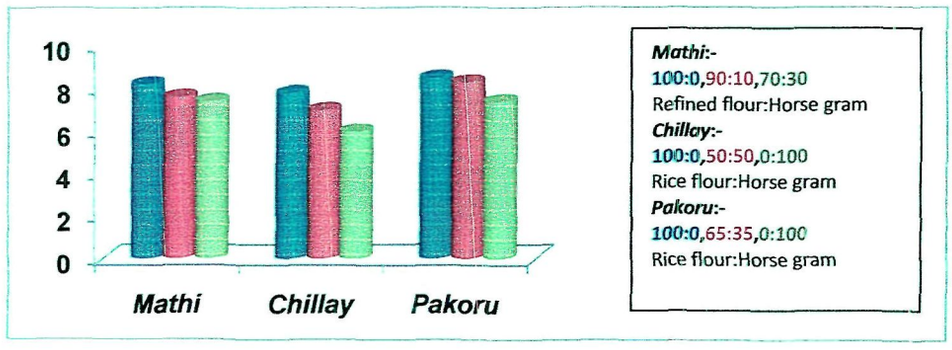


Fig.4.6 Taste scores of Products

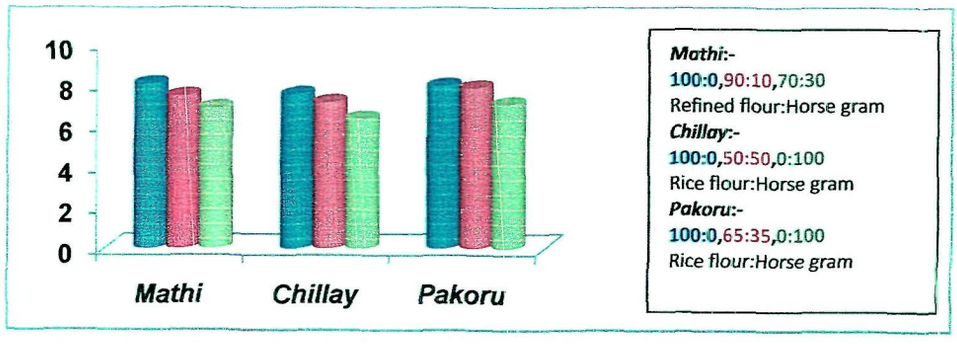


Fig.4.7 Texture scores of Products

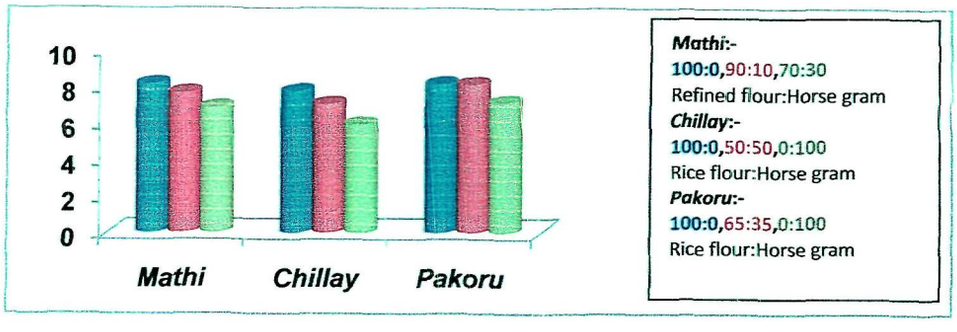


Fig.4.8 Overall acceptability scores of Products

As shown in Fig.4.1.1 and Fig. 4.1.5 in control products *sev* had the highest mean value of colour i.e. 8.70 followed by *mathi* (8.60), *ladoo* and *gulgule* (8.50 each), *pakoru* (8.40), *chillay* (8.20) and biscuits (8.10). The highest colour score observed at maximum level of supplementation was in case of ladoo (7.70), followed by *gulgule* (7.60), *pakoru* (7.40), biscuits and *mathi* (7.20 each), *sev* (7.00) and *chillay* (5.80) respectively.

4.3.2 Taste

Level of supplementation by horse gram affected the taste of various products. Data presented in Table 4.5 showed that for taste, control sample of *sev* scored 8.00, whereas *ladoo* scored 8.20, biscuits (8.10), *gulgule* (8.50), *mathi* (8.20), *chillay* (7.80) and *pakoru* (8.50). For control samples *gulgule* and *pakoru* had the highest mean value for taste followed by *mathi, chillay, ladoo* and biscuits. At maximum level of supplementation, highest taste score was observed in biscuits (7.60), followed by *mathi* and *pakoru*(7.40 each), *ladoo* (7.20), *gulgule* (7.00), *sev* (6.80) and *chillay* (6.00).

The taste scores at various levels of supplementation in all the products differed significantly ($P \leq 0.05$), except in case of biscuits where there was no significant difference between control, 10 and 20 per cent level of supplementation.

A general decreasing trend was observed (as shown in Fig. 4.1.2 and Fig, 4.1.6) among all the samples as there was an increase in per cent level of supplementation of horse gram. The reason was probably that there was a mild off flavor present in horse gram meal due to presence of peculiar flavor.

4.3.3 Texture

Texture scores of the products at various levels of supplementation are given in Table 4.6. As indicated in the Fig. 4.1.3 and 4.1.7, the highest texture score in control sample was observed in case of *sev* and *gulgule* (8.30 each) followed by *ladoo* (8.20), *mathi* (8.10), *pakoru* (8.00), biscuits

(7.70) and *chillay* (7.60). The highest score in maximum levels of supplementation was observed in *ladoo* (7.70) followed by *gulgule* and *sev* (7.60 each), biscuits (7.50), *pakoru* (7.10) and *mathi* (6.90).

The texture scores at various levels of supplementation in the *gulgule, mathi, chillay* and *pakoru* differed significantly ($P \leq 0.05$), whereas no significant difference was observed in case of *sev, ladoo* and biscuits.

4.3.3 Overall Acceptability

Overall acceptability data of various products at different levels of supplementation with horse gram has been summarized in data given in Fig. 4.1.4 and Fig.4.1.8, a perusal of which indicated that on addition of horse gram, the mean value of overall acceptability of *sev* decreased from a level of 8.29, at 0 per cent to 7.10 per cent at 20 per cent. The same trend was observed in all the products. In *ladoo* at 0 per cent level value for overall acceptability was 8.26, at 10 per cent this value decreased to 7.80 and at 20 per cent to 7.46. Biscuits had the values of 7.91, 7.83 and 7.42 at the level of 0, 10 and 20 percent respectively. For *gulgule* these values were 8.44, 7.60 and 7.26 for 0, 10 and 20 per cent level of supplementation. In *mathi* at 0 percent level the mean value was 8.29, at 10 per cent level value decreased to 7.71 and finally to 6.98 at 30 per cent level of supplementation. *Chillay* followed the same trend showing the mean value at 0 per cent supplementation as 7.18, at 50 per cent level value decreased to 7.18 and finally to 6.04 at 100 per cent horse gram supplementation. For *pakoru* also maximum overall acceptability score was found in control i.e. 8.27, and then values decreased to 8.22 and 7.28 at 35 per cent and 100 per cent horse gram supplementation respectively.

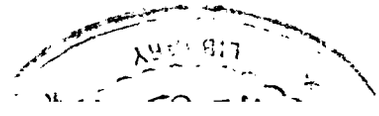


Table 4.4 Colour scores of different products at various levels of supplementation

Product	Per cent supplementation			CD
	0	**10**	**20**	**P≤0.05**
Sev	8.70	8.00	7.00	0.61
Ladoo	8.50	7.80	7.70	0.61
Biscuits	8.10	7.60	7.20	0.63
Gulgule	8.50	7.70	7.60	0.68
	0	**10**	**30**	
Mathi	8.60	8.10	7.20	0.58
	0	**50**	**100**	
Chillay	8.20	7.40	5.80	0.69
	0	**35**	**100**	
Pakoru	8.40	8.50	7.40	0.47

Table 4.5 Taste scores of different products at various levels of supplementation

Product	Per cent supplementation			CD
	0	**10**	**20**	**P≤0.05**
Sev	8.00	7.80	6.80	0.85
Ladoo	8.20	7.80	7.20	0.63
Biscuits	8.00	8.10	7.60	0.77
Gulgule	8.50	7.40	7.00	0.52
	0	**10**	**30**	
Mathi	8.20	7.60	7.40	0.51
	0	**50**	**100**	
Chillay	7.80	7.00	6.00	0.65
	0	**35**	**100**	
Pakoru	8.50	8.30	7.40	0.52

Table 4.6 Texture scores of different products at various levels of supplementation

Product	Per cent supplementation			CD
	0	**10**	**20**	**P≤0.05**
Sev	8.30	7.70	7.60	0.62
Ladoo	8.20	7.80	7.70	0.69
Biscuits	7.70	8.00	7.50	0.71
Gulgule	8.30	7.80	7.60	0.50
	0	**10**	**30**	
Mathi	8.10	7.50	6.90	0.61
	0	**50**	**100**	
Chillay	7.60	7.20	6.40	0.56
	0	**35**	**100**	
Pakoru	8.00	7.90	7.10	0.49

Table 4.7 Overall acceptability scores of different products at various levels of supplementation

Product	Per cent supplementation			CD
	0	**10**	**20**	**P≤0.05**
Sev	8.29	7.81	7.10	0.57
Ladoo	8.26	7.76	7.46	0.48
Biscuits	7.91	7.83	7.42	0.58
Gulgule	8.44	7.60	7.26	0.38
	0	**10**	**30**	
Mathi	8.29	7.71	6.98	0.51
	0	**50**	**100**	
Chillay	7.84	7.18	6.04	0.53
	0	**35**	**100**	
Pakoru	8.27	8.22	7.28	0.31

All the products supplemented at different levels of horse gram supplementation were significantly different from each other except in case of biscuits which were non-significant at 0, 10 and 20 per cent level of supplementation. However the score was the higher for the control products, all the supplemented products were also within acceptable limits indicating that horse gram may be successfully supplemented in the products. The reason for decreasing trend observed in all the characteristics, in all the products with increase in percentage of horse gram could be because of the distinct colour and peculiar taste of horse gram.

4.4 Chemical analysis of the prepared products.

4.4.1 Chemical composition of *sev*

Chemical composition of *sev* supplemented with sprouted horse gram powder at 0, 10 and 20 per cent levels, is presented in Table 4.8, a perusal of which showed that crude protein, crude fiber, ash, calcium and iron contents increased with increase in percentage of horse gram powder, whereas the percentage of crude fat decreased. Moisture, crude protein, crude fat, crude fiber, ash, calcium differed significantly ($P \leq 0.05$) at 0, 10 and 20 per cent levels of supplementation. Moisture content in the control *sev* sample was observed as 3.59 per cent, at 10 per cent level supplementation it was found as 2.52 per cent and at 20 per cent supplementation it was found as 3.46 per cent respectively. Ash content of *sev* in the control sample was 4.15 per cent, at 10 per cent level supplementation it was 4.39 per cent and at 20 per cent level ash content observed was 4.52. Crude protein content in the control sample was 13.63 and at 10 and 20 per cent level supplementation, it was found 13.79 and 14.14 per cent respectively. A little increase was found in the total carbohydrate content with increasing level of supplementation as 48.07, 49.58 and 53.60 respectively. Crude fiber content at 0, 10 and 20 per cent

level supplementation of horse gram was found as 0.20, 0.27, 0.39 per cent respectively. For iron content also a little increase in the values was observed with increase in the supplementation, however this increase was found non-significant ($P \leq 0.05$). Where for all the parameters an increase in the values was observed with increase in per cent level of horse gram supplementation, there was decrease in the crude fat contents in the supplemented products with increasing in supplementation of horse gram. The increase in crude protein, crude fiber, calcium and iron, whereas decrease in the crude fat content was due to higher content of crude protein, crude fiber, calcium and iron, whereas low content of fat in the sprouted horse gram powder.

4.4.2 Chemical composition of *ladoo*

Chemical composition of *ladoo* is shown in the Table 4.4.2. An increase in the crude protein, crude fiber, total carbohydrates, calcium and iron content, whereas decrease in the crude fat content was observed with increased levels of supplementation of horse gram. However same trend of increase with increase in supplementation was not found in the analyzed values of total ash contents. Moisture contents observed in the 0, 10 and 20 per cent supplementation of horse gram was found as 2.53, 2.06 and 1.32 per cent respectively. Crude protein in the control sample of *ladoo* was found as 14.84 per cent, it was found 14.40 in the 10 per cent levels of supplementation and 14.96 in the 20 per cent levels of supplementation. Total carbohydrates in the control, 10 and 20 per cent level supplementation were found as 52.31, 55.00 and 60.79 per cent respectively. A decreasing trend was found in the values of crude fat due to less absorption of fat of horse gram as in the control sample crude fat present was 27.07 per cent, it was found 24.69 per cent in the 10 per cent level of supplementation and 17.73 per cent in the 20 per cent level of horse gram supplementation.

Table 4.8 Chemical composition of *sev* at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	10:90	20:80	P≤0.05
Moisture	03.59	02.52	03.46	0.07
Ash	04.15	04.39	04.52	0.08
Crude Protein	13.63	13.79	14.14	0.12
Crude Fat	30.26	26.09	22.93	0.60
Crude Fiber	00.20	00.27	00.39	0.02
Total Carbohydrates	48.17	52.94	54.56	-
Calcium mg/100g	53.29	74.50	100.72	4.82
Iron mg/100g	05.94	06.41	06.64	NS

Data presented is mean of triplicate determinations.

Table 4.9 Chemical composition of *ladoo* at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	10:90	20:80	P≤0.05
Moisture	02.53	02.06	01.32	0.07
Ash	01.17	01.57	01.34	NS
Crude Protein	14.84	14.40	14.96	NS
Crude Fat	27.07	24.69	17.73	0.88
Crude Fiber	02.08	02.28	03.86	0.14
Total Carbohydrates	52.31	55.00	60.79	-
Calcium mg/100g	61.84	83.53	105.00	2.50
Iron mg/100g	06.56	06.82	06.85	NS

Data presented is mean of triplicate determinations.

Table 4.10 Chemical composition of biscuits at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	10:90	20:80	P≤0.05
Moisture	01.50	02.52	01.71	0.07
Ash	00.44	00.61	01.03	0.03
Crude Protein	07.26	09.34	10.90	0.07
Crude Fat	05.63	04.55	04.25	0.39
Crude Fiber	00.18	00.39	00.53	0.003
Total Carbohydrates	84.99	82.59	81.58	-
Calcium mg/100g	26.40	51.30	76.22	0.91
Iron mg/100g	01.86	02.60	02.49	NS

Data presented is mean of triplicate determinations.

Table 4.11 Chemical composition of *gulgule* at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	10:90	20:80	P≤0.05
Moisture	14.57	13.53	14.29	0.11
Ash	04.16	04.21	04.22	0.04
Crude Protein	08.02	08.83	09.55	0.17
Crude Fat	13.63	17.45	24.28	1.46
Crude Fiber	01.21	01.24	01.51	0.007
Total Carbohydrates	58.41	54.74	46.15	-
Calcium mg/100g	40.07	62.14	86.34	2.29
Iron mg/100g	05.94	06.08	06.38	0.55

Data presented is mean of triplicate determinations.

Crude fiber content observed in the control sample was 2.08, whereas 2.28 and 3.86 per cent respectively in the 10 and 20 per cent level of supplementation. This was because of the higher content of crude fiber in the horse gram as compared to chickpea flour. Same trend of increase in values were observed in calcium and iron content i.e. 61.84, 83.53, 105.00 and 6.56, 6.82, 6.85 respectively as horse gram has higher content of calcium and iron as compared to the basic ingredient used in the preparation. For *ladoo* values of moisture, crude fat, crude fiber and calcium differed significanty ($P \leq 0.05$) at 0, 10 and 20 per cent levels whereas values of ash, crude protein and iron were found non-significant ($P \leq 0.05$).

4.4.3 Chemical composition of biscuits

Data related to chemical characteristics of biscuits in control sample and at 10 and 20 per cent level of supplementation presented in Table 4.10 revealed moisture content observed of the samples were as 1.50, 2.52 and 1.71 per cent respectively for different mentioned supplementations. Ash content of control product was 0.44, at 10 per cent supplementation it was found 0.61 and 1.03 per cent at 20 per cent level of supplementation of horse gram. Protein content in the control product was found 7.26, whereas 9.34 and 10.90 for 10 and 20 per cent level of supplementation. Similar trend of increase in the values were observed for crude fiber i.e. 0.18, 0.39 and 0.53 per cent respectively for control, 10 and 20 per cent level supplementation, whereas a decreasing trend was observed in the values for crude fat as 5.63, 4.55 and 4.25 respectively for different mentioned supplementation. For total carbohydrates values observed for control, 10 and 20 per cent supplementation were as 84.99, 82.59 and 81.58 respectively. For calcium observed values for control,10 and 20 per cent supplementation were 26.40, 51.30 and 76.22 mg/100g respectively. For iron values found were 1.86, 2.60 and 2.49 mg/100g for control, 10 per cent and 20 per cent level supplementation respectively. Values observed for iron differed non-significantly ($P \leq 0.05$) with the control, 10 and 20 per cent level supplementation whereas all

the other compositions i.e. moisture, ash, crude protein, crude fat, crude fiber and calcium differed significantly (P≤0.05) at different per cent level supplementation.

4.4.4 Chemical composition of *gulgule*

Chemical composition of *gulgule* at various levels of supplementation of horse gram is shown in the Table 4.11. Data revealed that all the chemical characteristics *viz.* moisture, ash, crude protein, crude fat, crude fiber and calcium differed significantly (P≤0.05) except iron content which differed non-significantly at different levels of supplementation i.e. 0, 10 and 20 per cent of horse gram. Moisture content observed in the sample was as 15.57, 13.53 and 14.29 per cent respectively for different levels of supplementation. Ash content observed in control sample was 4.16 whereas 4.21 and 4.23 respectively in the different levels of supplementation. Crude protein content in the 0, 10 and 20 per cent level supplementation was found as 8.02, 8.83 and 9.55 respectively. Crude fat content was found as 13.63, 17.45 and 24.28 respectively for control, 10 and 20 per cent levels of supplementation respectively. Crude fiber contents were found as 1.21, 1.24 and 1.51 per cent for the different levels of supplementation. A decreasing trend in the values of total carbohydrates was found as 58.41, 54.74 and 46.14 per cent respectively for different levels of supplementation. Calcium content was observed as 40.07, 62.14 and 86.34mg/100g, whereas iron content as 5.94, 6.08 and 6.38 mg/100g respectively for the control, 10 and 20 per cent levels of supplementation.

4.4.5 Chemical composition of *mathi*

Chemical characteristics of *mathi* are presented in the Table 4.12. Moisture content in the control sample was observed as 3.69 per cent, 6.28 per cent in the 10 per cent supplementation and 4.42 in the 30 per cent supplementation. Ash content observed for different mentioned samples was

as 3.68, 2.93 and 5.30 per cent respectively. Crude protein content found was as 7.10, 9.27 and 10.14 per cent respectively in control, 10 and 30 per cent level supplementation. Crude fat content observed was 32.63, 29.60 and 24.66 per cent respectively for different levels of supplementation. Crude fiber contents analyzed were 0.18, 0.40 and 0.58 per cent in different supplementation. Total carbohydrate content was found as 56.41, 51.52 and 54.90 respectively for mentioned levels of supplementations. Calcium and iron contents analyzed were as 27.63, 54.26, 102.39 and 1.47, 2.05, 3.27 mg/100g respectively for different levels of supplementation i.e. 0, 10 and 30 per cent levels of supplementation. It was observed that values for moisture, crude protein, crude fat, crude fiber, calcium and iron were significant ($P \leq 0.05$), whereas values for ash were found non-significant at different levels of supplementation i.e. control, 10 and 20 per cent.

4.4.6 Chemical composition of *chillay*

The data of Table 4.13 pertaining to the chemical composition of *chillay* in the control sample and samples supplemented with horse gram at 50 per cent and 100 per cent horse gram sample showed that there was significant difference ($P \leq 0.05$) between all these samples in relation to their moisture, ash, crude protein, crude fat, crude fat, calcium and iron content. Moisture content of *chillay* at 0 per cent supplementation was 2.60, whereas 2.80 and 1.25 per cent at 50 per cent and 100 per cent horse gram product. Ash content observed was as 3.35, 3.84 and 4.23 respectively for mentioned supplementation. Crude protein content observed as 7.48, 10.14, 13.19 per cent respectively for different supplementation. A decrease in the crude fat content was observed among the control and supplemented products as 25.04, 21.02 and 12.26 per cent respectively. Crude fiber contents found in the control and supplemented products was noted as 0.14, 0.35 and 0.42 per cent respectively. Carbohydrate content calculated was 61.69, 61.85 and 68.65 respectively for different levels of supplementation. Calcium and iron

content observed was 15.07, 142.49, 246.76 and 1.20, 3.65, 6.55 respectively in the control and supplemented products at different mentioned levels.

Table 4.12 Chemical composition of *mathi* at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	10:90	30:70	P≤0.05
Moisture	03.69	06.28	04.42	0.04
Ash	03.68	02.93	05.30	NS
Crude Protein	07.10	09.27	10.14	0.02
Crude Fat	32.63	29.60	24.66	0.34
Crude Fiber	00.18	00.40	00.58	0.01
Total Carbohydrates	52.72	51.52	54.90	-
Calcium mg/100g	27.63	54.26	102.39	1.87
Iron mg/100g	01.47	02.05	03.27	0.24

Data presented is mean of triplicate determinations.

Table 4.13 Chemical composition of *chillay* at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	50:50	100:0	P≤0.05
Moisture	02.60	02.80	01.25	0.10
Ash	03.35	03.84	04.23	0.06
Crude Protein	07.48	10.14	13.19	0.09
Crude Fat	25.04	21.02	12.26	0.41
Crude Fiber	00.14	00.35	00.42	0.03
Total Carbohydrates	61.39	61.85	68.65	-
Calcium mg/100g	15.07	142.49	246.76	1.92
Iron mg/100g	01.20	03.65	06.55	0.16

Data presented is mean of triplicate determinations.

Table 4.14 Chemical composition of *pakoru* at various levels of supplementation

Parameters	Per cent Supplementation			CD
(%)	0:100	35:65	100:0	P≤0.05
Moisture	09.34	10.29	08.31	0.12
Ash	0.58	00.89	00.74	0.005
Crude Protein	14.12	12.49	12.44	0.38
Crude Fat	28.65	25.65	18.16	0.48
Crude Fiber	00.34	00.35	00.40	0.01
Total Carbohydrates	46.97	50.33	59.95	-
Calcium mg/100g	100.19	158.41	268.33	4.63
Iron mg/100g	04.57	05.69	08.07	0.15

Data presented is mean of triplicate determinations.

4.4.7 Chemical composition of *pakoru*

Data pertaining to the chemical composition of *pakoru* in the control sample and horse gram supplemented products i.e. 35 per cent supplementation and 100 per cent horse gram supplementation is shown in the Table 4.14. Data revealed that all the estimated chemical characteristics of the *pakoru* differed significantly (P≤0.05) at control and different mentioned supplementation of horse gram. It was observed that ash content in the control sample was 0.58, it was 0.89 at 35 per cent supplementation and 0.74 in the pure 100per cent horse gram product. Values observed for crude protein were 14.127, 12.49 and 12.44 per cent, respectively for control and different supplemented products. A decrease in the crude fat values was observed with increase in per cent supplementation of horse gram and the values found were 28.65, 25.65 and 18.16 per cent at different levels of supplementation. Crude fiber composition found was 0.34, 0.35 and 0.40 per cent, respectively for control and different levels of horse gram supplementation. Calcium content analyzed in the different supplementations was as 100.19, 158.41 and 268.33 mg/100g respectively. Iron

content in the control and supplemented products was found as 4.57, 5.69, 8.07 mg/100g respectively.

Table 4.15 Crude protein content of the different preparations

Product	Per cent supplementation			CD
	0	10	20	P≤0.05
Sev	13.63	13.79	14.14	0.12
Ladoo	14.84	14.40	14.96	0.51
Biscuits	07.26	09.34	10.90	0.07
Gulgule	08.02	08.83	09.55	0.17
	0	**10**	**30**	
Mathi	07.10	09.27	10.14	0.02
	0	**50**	**100**	
Chillay	07.48	10.14	13.19	0.09
	0	**35**	**100**	
Pakoru	14.12	12.49	12.44	0.38

Data presented is mean of triplicate determinations.

Table 4.16 Crude fat content of the different preparations

Product	Per cent supplementation			CD
	0	10	20	P≤0.05
Sev	30.26	26.09	22.93	0.60
Ladoo	27.07	24.69	17.73	0.88
Biscuits	05.63	04.55	04.25	0.39
Gulgule	13.63	17.45	24.28	1.46
	0	**10**	**30**	
Mathi	32.63	29.60	24.66	0.34
	0	**50**	**100**	
Chillay	25.04	21.02	12.26	0.41
	0	**35**	**100**	
Pakoru	28.65	25.65	18.16	0.48

Data presented is mean of triplicate determinations.

Table 4.17 Calcium content of the different preparations

Product	Per cent supplementation			CD
	0	**10**	**20**	**P≤0.05**
Sev	53.29	74.50	100.72	4.82
Ladoo	61.84	83.53	105.00	2.50
Biscuits	26.40	51.30	076.22	0.91
Gulgule	40.07	62.14	86.34	2.29
	0	**10**	**30**	
Mathi	27.63	54.26	102.39	1.87
	0	**50**	**100**	
Chillay	15.07	142.49	246.76	1.92
	0	**35**	**100**	
Pakoru	100.19	158.41	268.33	4.63

Data presented is mean of triplicate determinations.

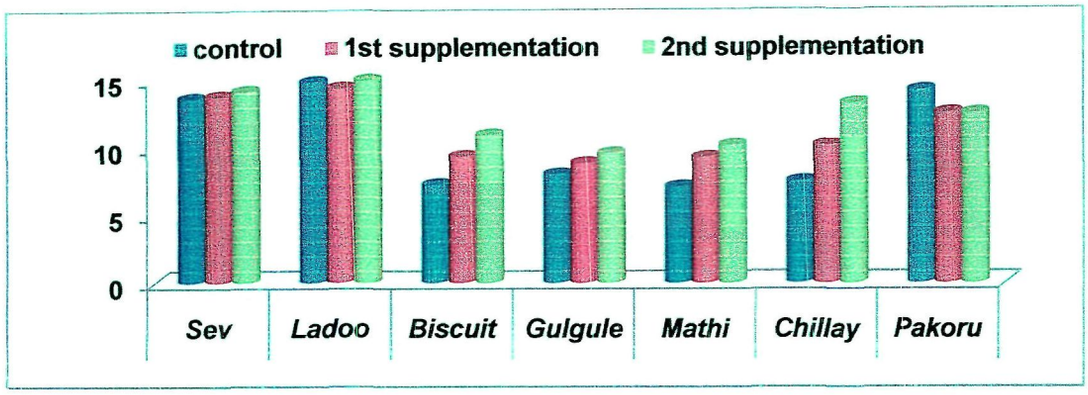


Fig.4.9 Crude Protein content of the selected preparations

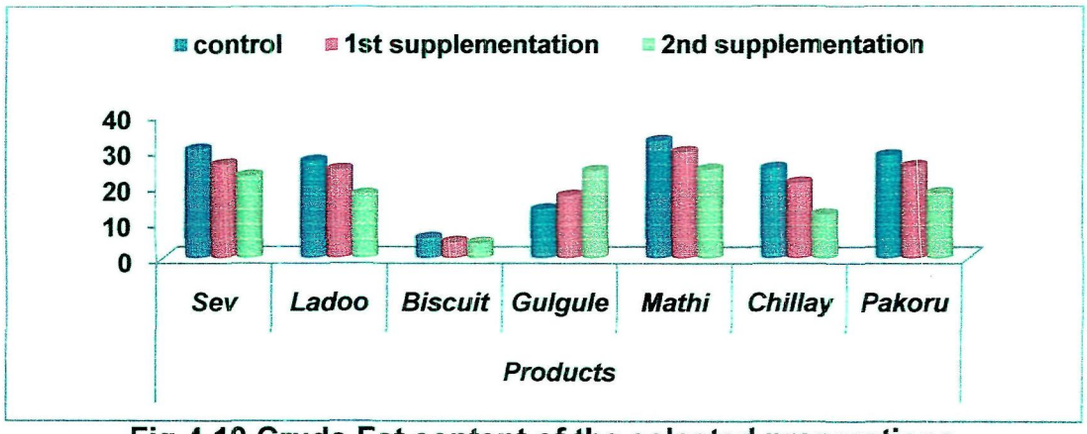


Fig.4.10 Crude Fat content of the selected preparations

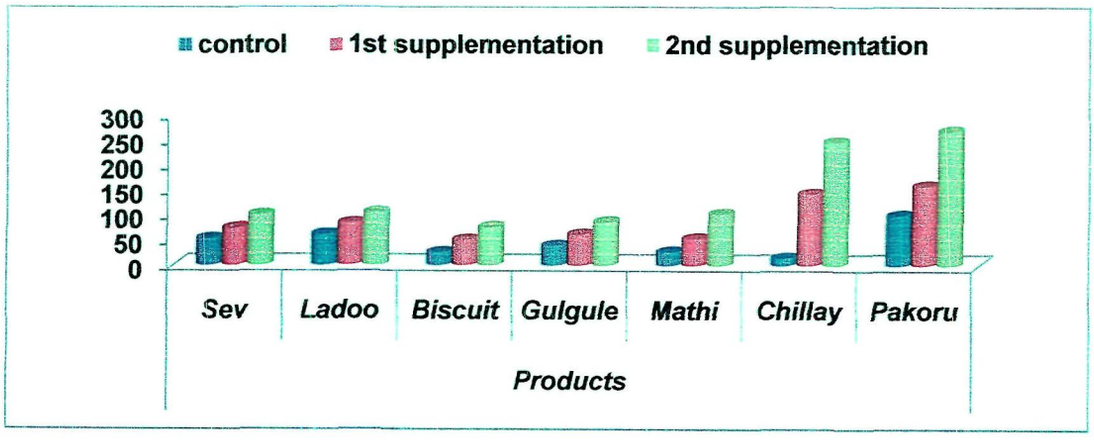


Fig.4.11 Calcium content of the selected preparations

4.4.8 Variation in protein content of the different prepared products

Protein content of different prepared products is presented in the Table 4.15. An increasing trend of per cent protein was observed (as shown in Fig.4.2) in almost all the supplemented preparations except in *pakoru*, reason being the basic ingredients i.e. black gram and bengal gram are rich source of protein, are used in the control product, whereas there is a single basic ingredient (wheat flour, rice flour or chickpea flour) used for all the other preparations. Among the control products the highest protein content was found in the *ladoo* (14.84 per cent), whereas it was found the lowest in *mathi* (7.1 per cent). For the highest level of supplementation, highest protein content was again observed in *ladoo* (14.96 per cent) and it was found the lowest in *gulgule* (9.5 per cent). The higher content of protein in *ladoo* is due to higher content of protein in the chickpea flour and the ingredients used i.e. almonds and raisins in its preparation. The lower content of protein in *mathi* and *gulgule* is due to comparatively lower content of protein in the wheat which is used as a basic ingredient in both the preparations.

4.4.9 Variation in fat content of the different prepared products

Fat content of the prepared products is shown in the Table 4.16. A decreasing trend in the fat content is observed in almost all the preparations with increase in per cent supplementation of horse gram except in *gulgule* where there is an increase in the per cent fat content with increase in level of supplementation. The highest fat content was found in *mathi* (32.63 per cent) whereas, it was found minimum in biscuits (5.63 per cent) among the control products. Among the supplemented products, the highest fat content was observed in *mathi* (24.66 per cent) whereas, it was observed minimum in biscuits (4.25 per cent). The higher fat content in *mathi* may be due to deep frying as well as use of fat in its dough making.

The decrease in the per cent fat content may be due to less absorption of fat by horse gram during product preparation as compared to the basic ingredient such as wheat flour, rice flour and chickpea flour. On the contrary, in *gulgule* the fat content was found to be more, due to thin consistency of batter used for its preparation leading to more of fat absorption.

4.4.10Variation in calcium content of the different prepared products

Data pertaining to the calcium content of different products is shown in the Table 4.17. Content of calcium increased with increase in the level of per cent supplementation of horse gram in all the products (as shown in the Fig.4.4). Increase in the calcium content of the products is due to the higher content of calcium in the horse gram as compared to the basic ingredients i.e. wheat flour, rice flour and chickpea flour used in the preparation of products.

Summary and Conclusions

5. SUMMARY AND CONCLUSIONS

The present study, **"Nutritional Quality Evaluation of selected varieties of Horse Gram"** was undertaken to assess the physical and chemical characteristics of some selected varieties of horse gram *viz.* HPK-4, VLG-1, HPKC-2, Himganga and local variety. By keeping in view the significance of horse gram the present study was planned with the following objectives to assess the physico-chemical characteristics of selected varieties of horse gram as well as to study the effect of different processing techniques on nutritional quality.

Research work of the present study was performed in Department of Food Science and Nutrition, College of Home Science, CSK Himachal Pradesh Krishi Vishvavidyalaya Palampur. Quality Evaluation of five varieties of horse gram was done by using standard/ approved methods. Recipes were standardized and horse gram was supplemented at various levels in locally consumed preparations *viz. sev, ladoo,* biscuits, *gulgule, mathi, chillay* and *pakoru.* The prepared products were analyzed for the organoleptic evaluation along with chemical and nutritional composition. In general, all the nutrients increased with increased level of supplementation of horse gram in all the preparations with a slight variation which was probably due to difference in ingredients used in preparations. The conclusions drawn from this investigation are summarized below:

1. Comparison of physical characteristics of five varieties of horse gram seeds showed that one thousand Kernel weight and length value was found maximum in the Himganga as 42.06g and 0.58cm respectively. Maximum bulk density was observed in variety HPKC-2 i.e.0.93 g/ml. Values for one thousand Kernel weight differed significantly, whereas length and bulk density values differed non significantly ($P \leq 0.05$) among the five selected varieties.

2. The highest value for per cent protein was found in VLG-1 (24.41), followed by local (22.40), HPKC-2 (22.18), Himganga (20.96) and HPK-4 (18.25) per cent respectively. The values of crude fat of five varieties ranged from 0.77 to 1.16 per cent. The highest value of crude fiber was observed in VLG-1(5.09), and was found the lowest in Himganga (4.28) per cent.

3. Maximum value for Calcium was found in HPKC-2 (234.08) followed by HPK-4 (177.91), local (173.95), Himganga (170.95) and VLG-1 (162.74) mg/100g, whereas the highest value for Iron was found in HPK-4 (10.55) followed by HPKC-2 (9.96), VLG-1 (9.65), Himganga (9.03) and local (8.06) mg/100g. All the values varied significantly ($P \leq 0.05$) with the varieties.

4. Supplementation of horse gram in *sev, ladoo*, biscuits, *gulgule, mathi, chillay* and *pakoru* brought out a noticeable difference in its colour, taste and texture. Colour scores decreased with increase in supplementation percentage because of dark colour of Horse gram. Maximum colour and texture acceptability scores were observed in *ladoo* after horse gram supplementation. Taste scores also decreased with increase in percentage of horse gram. This change in taste was probably due to peculiar taste of horse gram. Maximum scores for taste were observed in biscuits, whereas overall acceptability scores were maximum in *ladoo* at maximum level of supplementation of horse gram.

5. However the score was the higher for the control products, all the supplemented products were also within acceptable limits indicating that horse gram may be successfully supplemented in the products. The reason for decreasing trend observed in all the characteristics, in all the products as the percentage of horse gram increased could be because of the distinct colour and peculiar taste of horse gram.

6. Chemical composition of these products showed that on an average, values of crude protein, crude fiber, calcium and iron increased whereas value of fat decreased with increasing the level of supplementation of horse gram which is probably due to higher content of crude protein, crude fat, calcium, iron and less absorption of fat of horse gram as compared to basic ingredient used in the preparation.

7. The cooking quality of legumes which is dependent upon textural softness is very important in terms of consumer acceptance. Thermal processing has previously been suggested to improve the texture, palatability and inactivation of heat labile toxic compounds and enzyme inhibitors in legumes.

8. Utilization of horse gram and its flour in legume composite flours and products is limited due to the presence of antinutritional components, poor functional and expansion properties. Its utilization can be maximized through an understanding of its physical and chemical components and by implementing diverse processing strategies to facilitate the development of economically viable alternative products.

7. Consumption of horse gram can be popularised by value addition and using various pre-preparations and processing techniques such as soaking, germination and steaming etc. thereby improving the nutritional value of horse gram.

8. Soaking is generally done in water, which reduces the cooking time. In fact soaking is often, if not always, a prelude to cooking legume seeds. This is a long process, which requires varying lengths of time depending on the type of legume. The seed hardness starts declining with the commencement of soaking and continues to do so during the process of cooking.

9. Locally available horse gram varieties can be easily supplemented in some traditional and locally consumed preparations like *pakoru, chillay,*

besan ladoo, bean sev, biscuits, mathi and *gulgule* to increase their nutritional value to little or significant extent. Proper utilization of Horse gram seeds by supplementing it in different preparations, can be very useful for domestic, agricultural and industrial consumption.

It can be concluded that the five varieties of horse gram viz. HPK-4, VLG-1, HPKC-2, Himganga and local variety are nutritionally important and can be supplemented into different products. Hence horse gram can be supplemented to improve the protein and calcium content. The protein supplemented preparations may help to improve the nutritional status and combating with the problem of Protein Energy Malnutrition prevalent in our country.

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Appendices

Appendix-1

Evaluation Card For Hedonic Rating For Food Products

Name of Product:----------
Name of the evaluator:----------

Sample Code	Colour	Taste	Texture/ Consistency	Overall Acceptability	Remarks (if any)

Signature:----------

Hedonic Scale

Expression	Points to be assigned
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Brief Biodata of student

Name : Sonika

Father's Name : Sh.Surjit Singh Guleria

Mother's Name : Smt.Usha Guleria

Date of Birth : 16-11-1986

Permanent Address : C/o Mrs.Kaushlya Thakur.VPO-Tripal,
Tehsil-Dehra,District-Kangra.HP
Pin code-176029

Academic Qualifications:

Examination passed	Month	Year	School/Board/ University	Marks (%)	Division
10th Class	March	2002	H.P.B.S.E Dharamshala	64.71	First
12th Class	March	2004	H.P.B.S.E Dharamshala	64.20	First
B.Sc. (Home Science)	July	2008	CSKHPKV. Palampur	77.80	First