

**NUTRITIONAL EVALUATION AND  
UTILIZATION OF *BER (ZIZIPHUS MAURITIANA  
LAMK.)* POWDER FOR THE DEVELOPMENT  
OF VALUE ADDED PRODUCTS**

By

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## CERTIFICATE – I

This is to certify that this dissertation entitled, “**Nutritional evaluation and utilization of ber (*Ziziphus Mauritiana* Lamk.) powder for the development of value added products**” submitted for the degree of **Doctor of Philosophy** in the subject **Foods and Nutrition** to the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by **Malika Bajaj (Admission No. 2009HS68D)** under my supervision and guidance and that no part of this thesis has been submitted for any other degree.

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

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You are the father and worthy of adoration, By worshipping you through performances  
Of ones natural duties, Does one attain perfection”.....(GEETA)*

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## CHAPTER-I

### INTRODUCTION

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Fruits are known as protective foods as they provide essential vitamins, minerals and fiber required for maintaining good health. Fruits have significant health promoting effects and also reduce the incidence of cardio vascular diseases, cancer and various degenerative diseases. Presence of phytochemicals in fruits and their strong antioxidant potential in scavenging free radicals has generated tremendous attention of the scientists (Kaur and Miani, 2001).

India is the second largest producer of fruits in the world with the production of 68.5 million tonnes in an area of 6.1 million hectare contributing to 11.2 percent in the world's share (Singh, 2010). But due to their perishable nature, fruits undergo a rapid transformation and results into spoilage. The post harvest lossess of fruits in India is between 17 to 35 per cent during different stages of handling, transportation, storage, processing and distribution (Gajanan and Hedge; 2009, Fageria *et al.*, 2007). The moisture content of fresh fruits is more than 80 per cent, so they are classified as perishable foods (Orsat *et al.*, 2006). The post harvest technologies in the area of fruits obviously have to match with the production of perishable foods to challenge that always keeps the scientists, the technologists and the engineers attentive in looking for innovative methodologies and the technologies towards making value added products and at the same time, encouraging the value addition and the byproduct utilization (Prakash, 2001).

Proper nutrition is essential for the maintenance of health and socio-economic development of the nation. For optimum health, the balanced diet is essential. This includes adequate amount of carbohydrates, proteins, fats, vitamins, minerals, roughage and water. Deficiency of micronutrients such as iron, iodine, vitamin A and folic acid affect nearly one-third of world's population. Micronutrient malnutrition prevents hundreds of millions of children from achieving their potential because of preventable blindness, mental retardation, physical handicaps and learning deficits. Micronutrient deficiencies have been reported due to inadequate intake of fruits and vegetables (Kennedy *et al.*, 2008). In spite of surplus amount of locally available fruits which are known to be the richest sources of these nutrients, the consumption of these fruits is less due to ignorance to some extent. India has a vast population and majority of this population resides in rural areas and suffer from under nutrition. On one side, the population is facing malnutrition and on the other hand, the produce is getting spoiled due to lack of storage and processing facilities.

There are a number of fruits in the world which are known to prevent hidden hunger and *ber* is one of them. The Indian jujube or *ber*, *Ziziphus Mauritiana* Lamk. is adapted to

warm climate and has different names in different countries and among different languages also. It has got numerous names like jujube, Chinese date, Berra, Putrea, Kul, Baher, Beri, Nakhi, Dara, Kunar, Gob, madadebara, Iradi, Kulvali, Widara, Nabig, Than, Epal, Siam, Bidaru, Zi, Zee-pen, Berwarter, Ilanda, Masaka, Bogori, Indian Plum, Indian Cherry etc but in India, it is commonly known as *ber*, especially in Gujrati, Hindi, Marathi, Punjabi, Sindhi and Urdu languages (Ali *et al.*, 2006).

*The ber (Ziziphus Mauritiana Lamk.)* is one of the most ancient and common fruit of India, particularly of Haryana. It is known for its drought tolerance and ability to perform and yield high returns even on low fertile marginal lands of India (Prasad *et al.*, 2004; Kumar *et al.*, 2008). It is an important fruit of tropical and subtropical regions (Pandey and Singh, 2012). During the last one decade, the cultivation of *ber* has received a great impetus in Northern India owing to its successful adaptability under such agro-climatic conditions (Aulakh *et al.*, 2005).

*Ber (Ziziphus Mauritiana Lamk.)* is widely cultivated in different states of India, i.e. Madhya Pradesh, Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Maharashtra and to limited extent in several other states (Samant *et al.*, 2008). There is a constant increase in the cultivated area of this crop due to better adaptability and higher returns in arid, semi-arid, rainfed and irrigated areas (Kumar and Reddy, 2004; Dayal *et al.*, 2010). Haryana, being an arid region, supports easy growth for *ber* fruits with low input requirements. In Haryana, *ber* orchards are found in all the districts. It is cultivated for its fresh fruits which are rich in vitamin C and B complex vitamins. It is popularly called as poor man's apple due to its high nutritional and medicinal value (Gajbhiya *et al.*, 2003), low cost of production (Singh *et al.*, 2007) and because it is easily available, delicious and nutritious as compared to apple and it not only adds to the income of the desert dwellers but also fortify their precarious diet (Prasad, 2005).

*Ber* has more protein, phosphorous, calcium, carotene and vitamin C than apple and also excels oranges in phosphorous, iron and vitamin C (Pareek, 2001). It is a rich source of vitamin C and also contains good amount of proteins, minerals like iron (Gill and Bal, 2006) and B complex vitamins especially thiamine and riboflavin. It contains good amount of vitamin C and vitamin P (bioflavonoids) which act together to help to maintain the thin walls of capillaries. Vitamin P also has antibacterial, anti-inflammatory and antioxidant properties, and is known to stimulate bile production, promote circulation and prevent allergies (GreatVista Chemicals, 2004). *Ber* leaves provide fodder which contains protein and is suitable for forage, hay and silage and its pruned twigs/stems are used as a fuel wood in rural areas (Kumar and Shukla, 2010).

Apart from these, *ber* has medicinal properties too. Its seeds, roots and stem also have medicinal uses. *Ber* leaves have prominent antimicrobial activity. The leaf extracts also have

wound healing properties and antioxidant activity (Kumar, 2011). *Ber* has also shown antifungal properties (Adamu *et al.*, 2006) and anti-cancer properties (Mishra *et al.*, 2011). The seed extract of *ber* exhibited significant free anti-inflammatory and nephroprotective activity (Komala, 2010). It also possessed free radicals scavenging activity (Bhatia and Mishra, 2009). *Ber* is also known to cure respiratory problems, intestinal disorders, urinary inflammation, insomnia, night sweats, stomachache, palpitations, nervous body movements etc. It has analgesic and anti-convulsive properties and anti-diabetic activity ([www.mdidea.com](http://www.mdidea.com), [www.amazonherbs.net](http://www.amazonherbs.net)).

*Ber* belongs to family Rhamnaceae which has about 50 genera and 600 species. Genus *Ziziphus* has 40 species. There are more than 125 cultivars grown in India. Several cultivars of *ber* have been mentioned in literature but commercially leading varieties in India are Gola, Umran, Sanaur-3, Sanaur-5, Kaithali, Banarasi Karaka, Seb, Dandan, Kathaphal, Muria Mahrara, Sandhura Narnaul, Meharun etc. *Ziziphus Mauritiana* Lamk. is a spreading tree with drooping branches and dark green leaves which are densely tomentose on their under surface. *Ziziphus Mauritiana* Lamk. is synonymous with *Z. jujube*.

Gola cultivar has got many variants and are named as Kala Gola, Kakrola Gola, Gurgaon Gola, Gurgaon Gola-I, Gurgaon Gola-II etc. It has a good keeping quality. It is a famous variety of Rohtak district in Haryana. Kaithali is a popular variety of Kaithal district (Haryana) and is grown commercially in Hisar, Jind and Rohtak. Among various *ber* cultivars, Umran is preferred by fruit growers in Haryana because it is an outstanding variety famous for high yield potential, big fruit size, attractive colour, good keeping quality and long shelf-life (15-20 days). It yields more income per unit area and has good nutritional qualities (Pareek, 2001; Lal *et al.*, 2003; Saran *et al.*, 2007). The cultivars Gola, Kaithali and Umran are the promising varieties of *ber* in North India (Kudachikar *et al.*, 2000). *Ber* fruits should be harvested at correct stage of maturity since they do not mature after picking and the organoleptic (taste and texture) and visual qualities of fruit decline with increased maturity. Immature fruits lack sweetness and have an acrid taste. Over-mature and fully ripe fruits turn from yellow and golden-yellow colour to red or dark brown. The texture changes from crisp and juicy to soft and slimy.

*Ber* fruits are relatively perishable and have short shelf-life at ambient temperature (25-35°C). Depending upon cultivar and storage conditions, fruits can be kept for 4 to 15 days without loss of organoleptic quality. Transportation of ripe fruits to different places is difficult and results in large post-harvest losses (Kudachikar *et al.*, 2000). Due to high temperature and low humidity during harvesting season, it ripens fast and gets spoiled easily. However, owing to their short shelf-life, fruits cannot be stored for longer period under ambient conditions (Bhat, 2004). The post harvest losses of *ber* are 25-35 per cent due to its perishable nature (Fageria *et al.*, 2007). The lack of knowledge of processing is also the main

hindrance in the utilization of the produce. These losses can be saved by incorporating fruits and processed fruit products in diet. This will solve two purposes, one is rectification of malnutrition among masses and other is avoidance of pollution caused due to wastage of produce.

With the advancement of technology, there is a rapid and tremendous change in the lifestyle of the people. Due to lack of time on the part of home-makers, refined, ready-to-eat foods are gaining entry into Indian markets. People of all age groups especially teenagers and working couples prefer more of these processed and convenience foods. The main ingredients used for these convenience foods generally contain appreciable amount of energy and protein but are depleted of fiber and other micro nutrient unless fortified or supplemented. Hence, processing of *ber* fruits into several products can solve this problem to a great extent.

The ripe fruits are mostly consumed fresh, but are sometimes processed (Singh *et al.*, 2007). In India, ripe *ber* fruits are mostly consumed raw but are sometimes stewed. The unripe fruits are often eaten with salt. *Ber* fruits are used to make a number of different products. One of the simplest forms of processing is dehydration. The dried fruits are sometimes ground in powder for prolonged storage and out-of-season use. Dried, fresh or powdered *ber* can be used further for processing. Traditionally *ber* fruits were washed, drained and sun-dried. The quality of dried products varies according to the different varieties of *ber*, the level of maturity at harvest, environmental and physical conditions during dehydration. Pre-treatments such as blanching or sulphuring before dehydration improve the product quality (Ali *et al.*, 2006).

In view of the nutraceutical properties of fruits and to avoid their spoilage, the fruits can be processed into various products like fruit powders, jams, jellies, bars, candy, preserves, syrups, squashes, ready to drink products etc. Nowadays, people are more health conscious and so, they prefer products containing less sugar. Hence, fruit powder is one of the best options as it can be utilized in bakery, confectionary, beverages and other traditional products without the addition of extra sugar. Apart from nutraceutical properties, fruit powders have nutritive value as such. Moreover, fruit powders have excellent flavour and very attractive colour.

Keeping in mind the above points, the present study was planned with the following objectives:

- To prepare *ber* (*Ziziphus Mauritiana* Lamk.) powder
- To study sensory, functional, nutritional and shelf-life properties of the developed powder
- To utilize *ber* (*Ziziphus Mauritiana* Lamk.) powder in value-added products and study their acceptability, nutritional and shelf-life properties

## CHAPTER-II

### REVIEW OF LITERATURE

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Fruits play a vital role in human diet. They are rich sources of essential vitamins, minerals and fibers. Fresh fruits contain 80 per cent water, which is responsible for their crunchy and crispy texture. This high content of water make fruits highly perishable, as does the fact that they are seasonal and reasonable products (Sinha, 1998). In order to have good quality fruits available throughout the year, several processing and preservation techniques have been employed and drying of fruits is one of them. Fruit powders have proven to be more versatile than purees or pulps. Hence, they can be used in low moisture products also. *The ber (Ziziphus Mauritiana Lamk.)* is one of the most ancient and common fruit of India. (2008). It is an important fruit of arid and semi-arid regions. It is a rich source of various vitamins and minerals.

An attempt has been made in this chapter to review the information available regarding processing of *ber* fruit and making various products from its powder. Extensive research work has been reported on processing and products formation from fruit crops. However, information regarding processing of *ber* is very scanty. Therefore, literature on these aspects of some other fruits related to present study has also been included. The literature pertaining to “Nutritional evaluation and utilization of *ber (Ziziphus Mauritiana Lamk.)* powder for the development of value added products” has been reviewed and presented under the following headings and subheadings:-

- 2.1 Development of powder
- 2.2 Sensory evaluation of developed powder
- 2.3 Physico-chemical properties of the fruit powder
- 2.4 Shelf-life studies of powder
- 2.5 Nutritional evaluation of powder
- 2.6 Development of value added products
- 2.7 Sensory evaluation of products
- 2.8 Nutritional evaluation of products
- 2.9 Shelf-life study of products

#### **2.1 DEVELOPMENT OF POWDER**

In earlier times, fruits were consumed for their flavour and appearance rather than their nutritive value. But with the advancement in science, technology and nutrition, fruits are now recognized as contributors of certain nutrients particularly vitamins like vitamin A and C, and some essential minerals, like magnesium, potassium and iron. Fruits are although rich in vitamins and minerals and some other nutrients but they have a high level of moisture which

makes them prone to spoilage by endogenous metabolism and microorganisms. The jujube (*Ziziphus spp.*) commonly known as *ber*, is a hardy fruit plant and can be grown even on poor and marginal soils and in adverse climatic conditions of salinity, drought and water logging, where other fruits fail to grow successfully. *Ber* fruit has a high nutritive value, especially carbohydrates and vitamin C with good amount of minerals like calcium, phosphorous and iron and a high sugar to acids ratio at ripe stage. These characteristics are ideal for a fruit to be used for dehydration. However, in India, *ber* fruits are mostly consumed as fresh. *Ber* fruits can be processed into canned, candy, pulp, jam, jelly, juice, powder, slices, *tutti frutti*, wine and can be preserved, bottled and dried using different dehydration techniques. Powder from *ber* fruits can be rehydrated into RTS beverage (Kadam, 2001; Thomas and Kulwal, 2001). Several techniques of processing and preservation have been used since time immemorial, and drying is one of them. It is the cheapest and most common technique known to man. The main feature of drying is that the moisture content is reduced to a level at which microorganisms cannot grow (Negi, 2003).

Sagar *et al.* (2000) prepared mango powder by dipping the mango slices in an equal weight of 70<sup>0</sup> Brix sugar syrup, containing 0.1 per cent potassium metabisulphite (KMS) and then heated for 2 minute at 90<sup>0</sup> C and soaked overnight in same solution. Then the slices were drained and loaded on aluminium trays and dried in a cabinet drier at 58-60<sup>0</sup>C to a moisture level of 5 per cent. Dried slices were then ground to pass through 30 mesh sieve.

Negi (2003) prepared guava powder by giving different pre-treatments to the fruit. The peeled, sliced and deseeded guava fruit was treated with different treatments before drying *i.e.* without any treatment (T<sub>1</sub>), with addition of preservatives (T<sub>2</sub>), water blanching (T<sub>3</sub>), and steam blanching (T<sub>4</sub>). The fruit was then spread on trays over polythene sheets and dried at 60 ± 2<sup>0</sup>C in a cabinet drier. The dried slices were ground to pass through 30 mesh sieve.

Shukla (2004) prepared papaya powder by cutting the fruits in 5mm thick slices and blanching the slices for 2-3 minutes. The slices were then spread on perforated polythene sheets and placed under direct sunlight at 45 angles. After drying, the slices were ground to powder. The powder was sieved through 40 mesh sieve and stored quickly in air-tight containers.

Chhabra (2006) prepared bael fruit powder by drying the pulp after addition of 2000 ppm SO<sub>2</sub> in the form of a thin sheet to 10 per cent moisture. The sheets were then cut into pieces and further dried to below 4 per cent moisture in a cabinet drier at 60 ± 5<sup>0</sup>C. The pieces were ground the pass through a 30 mesh sieve.

Ambriz *et al.* (2008) prepared banana flour from unripe preclimactric banana (*Musa ABB*) in Mexico. Fruits were peeled and cut into 1 cm slices and immediately rinsed in citric

acid solution (0.3per cent w/v). The slices were dried at 50<sup>0</sup>C, ground using a commercial grinder to pass a 0.028mm sieve and stored at 25<sup>0</sup>C in sealed plastic containers.

Sablani *et al.* (2008) prepared date powder from California Date fruits in Australia. Date flesh was minced in laboratory scale mincer (1400w, MG450/MG470 Kenwood Limited, Hampshire, UK) to make a smooth paste. Date paste of about 200 g along with the required amount of maltodextrin (dextrose equivalent, DE 6) was mixed using a laboratory scale mixer (K45SS, 250W, Kitchen Aid, Inc., MI). Three batches of four different proportions (35:65, 40:60, 45:55 and 50:50) of maltodextrin were used in the production of date powders. The mix was then spread on a Teflon coated tray to a thickness of 5 mm and kept inside an oven dryer at 70<sup>0</sup>C for about 18 hours. The dry product was ground in a hammer mill to produce date powder. The powder was immediately collected in plastic pouches to avoid moisture pick-up from the air.

Mishra *et al.* (2009) prepared aonla powder using different drying methods. The aonla fruits were cleaned and cut into small pieces and immediately pressed to obtain juice using a small laboratory manual press. For the preparation of spray dried powder, juice was evaporated to 50 per cent using rotary evaporator. Maltodextrin (5 per cent w/v of initial juice) was added to concentrated juice and stirred for 5 minutes using mechanical stirrer followed by spray drying at 200<sup>0</sup>C inlet and 150<sup>0</sup>C outlet temperature and 40 per cent aspiration speed to dry the sample. For freeze drying 200 ml of juice was subjected to freezing at -35<sup>0</sup>C for 3 hours followed by freeze dehydration in a freeze dryer at 60<sup>0</sup>C for 16 hours. Sun dried powder was prepared from grated aonla dried under sun followed by grinding in a mixer grinder and filtration using muslin cloth. The powder was also prepared by drying the grated aonla in a vacuum oven at 50<sup>0</sup>C and in a tunnel dryer at 70<sup>0</sup>C followed by grinding and filtration.

Ritthiruangdej *et al.* (2011) prepared banana flour using unripe bananas. The banana fruits were cut in 3 mm slices and immediately rinsed in 0.25 per cent w/v sodium metabisulphite. The slices were dried at 50<sup>0</sup>C and then ground to powder in a commercial grinder and stored at 25<sup>0</sup>C in sealed containers.

## **2.2 SENSORY EVALUATION OF DEVELOPED POWDER**

Negi (2003) prepared guava powder using different treatments and observed that the mean scores for colour, appearance and overall acceptability of control guava powder (T<sub>1</sub>) were significantly lower than the powders prepared with preservatives (T<sub>2</sub>) or water (T<sub>3</sub>) or steam blanching (T<sub>4</sub>). Among the powders, mean scores for overall acceptability was highest in T<sub>2</sub> (4.50) followed by T<sub>4</sub> (4.25), T<sub>3</sub> (4.23) and T<sub>1</sub> (3.92) using 6 point scale. The mean scores for overall acceptability of guava powder decreased significantly after 45 days.

Chhabra (2006) prepared powder of Bael fruit and observed that the mean scores of all the sensory parameters using 9 point hedonic scale were rated as 'liked very much' by the

panel of judges. The mean scores for colour, appearance, aroma, texture, taste and overall acceptability were 8.50, 8.40, 8.30, 8.20, 8.20 and 8.32, respectively.

Nehra (2011) prepared guava and aonla powders and observed that powders of both the fruits prepared by addition of 1000 ppm KMS were 'liked very much' in terms of their organoleptic characteristics.

### **2.3 PHYSICO-CHEMICAL PROPERTIES OF THE FRUIT POWDER**

Rai and Mishra (2001) investigated the quality of bael fruit pulp powder as influenced by drying methods. Non-enzymatic browning was found to range from 10.24 to 16.03. Significantly higher non-enzymatic browning was found in sun dried sample as compared to cabinet dried. After a storage period of 4 months, the non-enzymatic browning increased significantly in both sun dried and cabinet dried samples, further the increase was significantly higher in sun dried samples as compared to cabinet dried samples.

Singh *et al.* (2001) reported that different cultivars of *ber* differ significantly in respect to acidity content (0.240 per cent to 0.992 per cent). They reported the maximum acidity in Chinese *ber* (0.992 per cent) followed by Sanaur-3 (0.896 per cent) and minimum in ZG-3 (0.240 per cent) followed by Umran (0.256 per cent).

Negi (2003) prepared guava powder by using different treatments and found that non-enzymatic browning of guava powder prepared using various treatments ranged from 0.074 to 0.109. Significantly higher non-enzymatic browning (0.109) was observed in control guava powder. Non-enzymatic browning of guava powder decreased significantly after addition of preservatives or after water blanching and steam blanching. Whereas, the non-enzymatic browning of guava powder prepared with addition of preservative (0.074) was significantly lower than the guava powder prepared after water blanching (0.08) or steam blanching (0.087). Non-enzymatic browning of powder was increased from 0.074 to 0.088 when stored for 60 days.

Dhillon *et al.* (2004) evaluated the different cvs. of mango under Punjab conditions and reported that maximum level of acidity in S.B. Rampur (0.46) and Frazi (0.35) followed by Alphanso and B.G.Balda (0.34) and minimum was recorded in S.B. Chausa.

Kaushik *et al.* (2004) evaluated 47 cultivars of *ber* for acidity. Maximum acidity was observed in Kathaphal (0.76 per cent) and minimum was recorded in Banarasi Karaka (0.135 per cent).

Aulakh *et al.* (2005) analyzed the physico-chemical characteristics of different cvs. of *ber* and recorded maximum acid content in cv. ZG-2 and minimum in Sanaur-2 and Umran.

### **2.4 SHELF-LIFE STUDIES OF POWDER**

Sagar *et al.* (2000) studied the effect of storage temperature and period on the quality of ripe mango powder. The quality of the product was affected significantly by both temperature as well as period of storage. Ripe mango powder could be stored upto 6 months

at room temperature (33-33.5<sup>0</sup>C) in low density polythene (LDPI) pouches without losing its colour, flavour and texture. Low temperature helped in retaining higher level of ascorbic acid and total carotenoids in the powder.

Alam *et al.* (2001) reported that dehydrated aonla powder stored in high density polythene bags showed better retention of ascorbic acid and organoleptic characteristics irrespective of the treatments and storage method. High density polythene was better than ambient storage for maintaining the shelf-life of dehydrated aonla powder of 3 months.

Negi (2003) prepared papaya, guava and pear powders and stored for 60 days at room temperature (30 ± 2<sup>0</sup>C) in polythene bags. The mean scores for overall acceptability of powders showed that fruit powders could be stored up to 45 days of storage without any change in sensory characteristics. Non-enzymatic browning of papaya, guava and pear powder at 0 day was 0.057, 0.074 and 0.066, respectively which increased with an increase in storage period.

Chhabra (2006) reported the overall acceptability of bael powder on 0 day of storage as 8.32 which remain 8.14 up to 45 days of storage. On 60<sup>th</sup> day, mean scores of overall acceptability were reduced to 7.70.

Nehra (2011) reported that the overall acceptability of aonla and guava powders were liked very much upto 60<sup>th</sup> day of storage and after that it was 'liked moderately' till 90<sup>th</sup> day of storage period.

## **2.5 NUTRITIONAL EVALUATION OF POWDER**

Singh *et al.* (2001) evaluated twenty four cultivars of *ber* for ascorbic acid content and found the highest in cultivar ZG-3 (120 mg/100g of pulp) and minimum in case of Rohtaki Gola (55.50 mg/100g pulp).

Negi (2003) prepared guava powder and found that powder had 7.10 per cent moisture, 8.45 per cent crude protein, 4.24 per cent ash and 2.39 per cent crude fiber. Total soluble sugars and reducing sugar was 20.87 per cent and 19.76 per cent, respectively. The vitamin C content of papaya, guava and pear powders ranged from 2.90 and 45.50 mg/100g. *In-vitro* starch digestibility in guava powder was 39.80 mg maltose released/g flour.

Gupta *et al.* (2004) recorded highest ascorbic acid content (159.86 mg/100g) in the pulp of Illaichi and minimum (93.54 mg/100g) in the pulp of Dandan Gola cultivars of *ber*.

Kaushik *et al.* (2004) evaluated forty seven cultivars of *ber* for quality characteristics and recorded the highest ascorbic acid in cultivar Banarasi Peondi i.e 123 mg/100g.

Aulakh *et al.* (2005) analyzed the physico-chemical characteristics of different cvs. of *ber* and reported that maximum sugar was in Sanaur-2 (12.64 per cent) followed by Umran (10.12 per cent) and ZG-2 (10.01 per cent).

Hymavathi and Khader (2005) evaluated β-carotene, ascorbic acid, moisture, total and reducing sugars of mango powder viz. Baneshan powder (BE), Baneshan + Suvarnarekha

blend (BESR), Suvernarekha (SR) and Suvernarekha + Totapuri blend (SRTT) prepared from three varieties of mango *i.e.* Baneshan (BE), Suvernarekha (SR) and Totapuri (TT) and reported that  $\beta$ -carotene content of powder ranged from 2098 to 2790  $\mu\text{g}/100\text{g}$  being highest in Baneshan powder and lowest in Suvernarekha and Totapuri blend. Ascorbic acid was highest in SRTT (37.80 mg/100g) and lowest in SR (26.58 mg/100g). Total sugar content ranged from 36.10 to 36.66 per cent whereas reducing sugar content ranged from 4.38 to 6.85 per cent.

Kumar (2006) prepared *ber* powder by dehydrating ripe *ber* fruits using sun drying and oven drying techniques with different pre-treatments and reported that the powder contained total sugars 57.38 per cent, reducing sugars 36.98 per cent, non-reducing sugars 20.40 per cent and ascorbic acid 35.17 per cent.

Juarez-Garcia *et al.* (2006) prepared banana flour from unripe banana and reported that the total starch and total dietary fiber content of banana flour was 76.80 and 10.40 per cent, respectively. Of the total starch, available starch was 71.50 per cent and resistant starch was 30.40 per cent. Moisture, protein and ash content of banana flour were 6.0, 3.4 and 4.4 per cent, respectively.

Ajila *et al.* (2008) prepared mango peel powder. They reported that mango peel contained 51.2 per cent of total dietary fiber and 3092  $\mu\text{g}/\text{g}$  of carotenoids.

Costa *et al.* (2009) prepared dehydrated cashew apple and guava powder. Cashew apple powder contained 6.52 per cent moisture, 7.63 per cent protein, 5.91 per cent fiber, 1.42 per cent ash, 30.60 per cent total sugar, 30.60 per cent reducing sugar and 30.33 mg/100g vitamin C. Moisture, protein, fiber, ash, total sugar and reducing sugar content was 4.07, 11.47, 1.53, 8.69 and 8.44 per cent, respectively. Whereas vitamin C content of guava powder was 19.57 mg/100g.

Mishra *et al.* (2009) studied physico-chemical properties of aonla powder prepared from Chaikya variety by using different drying methods viz. sun drying, tunnel drying, vacuum drying, spray drying and freeze drying. Total ascorbic acid content ranged from 3.0 to 5.43 g/100g powder. The freeze dried powder contained highest ascorbic acid content followed by spray dried powder. Minimum amount of ascorbic acid was found in sun dried powder. Calcium (76.6 mg/100g), phosphorous (12.38 mg/100g) and iron (88.03 mg/100g) content was found maximum in freeze dried powder. Whereas sun dried aonla powder contained 70.3 mg/100g calcium, 7.90 mg/100g phosphorous and 54.20 mg/100g iron which was maximum as compared to other powders prepared. The moisture content of freeze-dried, sun-dried, vacuum dried, spray dried and tunnel dried aonla powder were 6.78, 5.76, 6.53, 5.05 and 5.59 per cent, respectively.

Ibrahim *et al.* (2010) studied the physico-chemical composition and anti-oxidant activities of underutilized *Mangifera pajang* Kosterm fruit pulp and fruit juice powder. The

composition revealed that *M. pajang* juice powder (MPJP) was high in protein, carbohydrate, ascorbic acid and ash. Additionally, MPJP extract also exhibited the high free radical scavenging activities. The antioxidant capacity of MPJP extracts were significantly correlated with the ascorbic acid content.

## 2.6 DEVELOPMENT OF VALUE ADDED PRODUCTS

Shukla (2004) prepared *kheer*, vermicelli and *ladoo* by incorporating papaya powder and reported them organoleptically acceptable.

Kumar and Manimegalai (2005) prepared whey based papaya fruit juice blended RTS beverage as per FPO specification by blending papaya juice at 10 per cent with whey. The TSS and acidity were maintained at 15<sup>0</sup> Brix and 0.3 per cent, respectively as per FPO specification. The RTS was stored at refrigeration temperature. Kumar (2006) prepared RTS using different concentrations of *ber* powder (5, 10 and 15 per cent). All the RTs prepared were organoleptically acceptable.

Kaikadi *et al.* (2006) prepared *ber* candy from umran cultivar by slow syrumping method. For this, mature *ber* fruits after pricking, destined and blanched in hot water for 5 minutes. Sulphur fumigation was done @ 2g/kg for 2 hours. Then sugar syrup of 40<sup>0</sup> Brix was prepared and fruit was added to it. At this stage, 1 per cent citric acid was added and stored for 24 hours. Next day the strength was increased by 10<sup>0</sup> Brix with addition of 1 per cent citric acid. The process was repeated till 70<sup>0</sup> Brix was reached with addition of 1 per cent citric acid. The fruits were stored for 7-8 days. The fruits were washed quickly and dried in shade until the moisture content was below 18 per cent. The candy was packed in polythene bags or plastic boxes which were stored either at room or refrigerated temperature up to 6 months.

Ajila *et al.* (2008) prepared biscuits by incorporating mango peel powder. Acceptable biscuits with mango flavour were obtained by incorporating 10 per cent mango peel powder.

Uchoa *et al.* (2009) prepared dehydrated fruit powders from cashew apple and guava residues and used it at different levels of wheat flour substitution for cookies formulation and observed that supplementation seemed to be suited for wheat flour substitution to obtain cookies with value added food ingredient within standards.

Dahiya and Grewal (2010) prepared high protein high fiber biscuits using soybean and *ber* by creaming method. Full fat soy flour or defatted soy flour at the concentration of 10 per cent was used along with 5, 10 or 15 per cent *ber* powder and refined wheat flour. All the prepared biscuits were organoleptically acceptable.

Nilguin and Mahendran (2010) prepared RTS beverage from Palmyrah fruit pulp using different concentrations of 8, 10, 12, 14 and 16 per cent. All the prepared RTS beverages were acceptable.

Ritthiruangdej *et al.* (2011) prepared banana flour using unripe bananas. They prepared noodles by substituting wheat flour with 10, 20, 30, 40 and 50 per cent banana flour.

Jakhar and Pathak (2012) prepared RTS by blending *ber* and *jamun* pulp. The different blending ratios of *ber* and *jamun* pulp were 75:25, 50:50, and 25:75, respectively. RTS using 100 per cent *ber* pulp and 100 per cent *jamun* pulp were also developed.

Kadam *et al.* (2012) prepared RTS using guava pulp. Twelve per cent of guava pulp was taken and pasteurized at 85<sup>0</sup>C for 3 minutes with the addition of 12 per cent sugar and 2.8 g/l citric acid. The remaining volume was adjusted with water. The RTS was filled in bottles and bottles were sterilized to 121<sup>0</sup>C for 15 minutes to control the microbial load.

## 2.7 SENSORY EVALUATION OF PRODUCTS

Kumar and Manimegalai (2005) prepared RTS beverage by blending 10 per cent papaya juice with whey. The beverage was stored at refrigeration temperature. The sensory attributes were highly acceptable even after storing the beverage for 3 months.

Chhabra (2006) reported significant increase in protein, ash, fiber, carbohydrate and mineral content in all extruded products prepared by incorporating the bael powder (5, 10 and 15 per cent).

Kaikadi *et al.* (2006) reported that the freshly prepared *ber* candy had an average organoleptic score of 9.00 for overall acceptability. A gradual decrease in the score of overall acceptability was observed during storage of *ber* candy. The refrigerator storage was found to maintain the organoleptic properties of *ber* candy up to six months.

Fang (2008) prepared wheat bread substituted with different percentages (5, 10 and 15 per cent) of Pumpkin flour (*Cucurbita moschata*). Sensory evaluation indicated that the 5 per cent Pumpkin Flour bread was the most acceptable.

Uchoa *et al.* (2009) prepared dehydrated fruit powders from cashew apple and guava residues and used it at different levels of wheat flour substitution for cookies formulation. The pH, fiber and protein content of the cookies were significantly affected. Biscuits with 15 g and 20 g/100g cashew apple and guava fruit powders showed highest scores for sensory attributes, respectively.

Nilguin and Mahendran (2010) prepared RTS beverage from Palmyrah fruit pulp in different concentrations. They reported that RTS prepared using 12 per cent palmyrah pulp was most acceptable among all followed by RTS prepared using 10 and 14 per cent pulp. Ritthiruangdej *et al.* (2011) prepared banana flour using unripe bananas and substituted this flour at concentrations of 10, 20, 30, 40 and 50 per cent with wheat flour to make noodles. All the prepared noodles were organoleptically acceptable as judged by panelists using 9 point hedonic scale.

Jakhar and Pathak (2012) prepared RTS by blending *ber* and *jamun* pulp in different proportions and found that RTS prepared using 25 per cent *ber* pulp and 75 per cent *jamun*

pulp scored highest mean scores followed by RTS prepared using *ber* and *jamun* pulp in the ratio of 50:50 and RTS prepared using 100 per cent *jamun* pulp. The RTS prepared using 100 per cent *ber* pulp and *ber* and *jamun* pulp in the ratio of 75:25 scored lowest scores. All the prepared RTS blends were organoleptically acceptable.

## 2.8 NUTRITIONAL EVALUATION OF PRODUCTS

Kumar and Nath (2002) studied dehydration of *ber* fruits and reported that there was non-significant difference in pretreatment and osmo-drying on fat content of *ber* fruits. The ash content of pre-treated air dried fruits was highest (0.63 per cent) as compared to untreated osmo dried fruits (0.51 per cent) and pre-treated osmo air dried (0.43 per cent).

Negi (2003) prepared baked products using papaya, guava and pear powder and reported that with addition of fruit powder, the crude protein, ash, crude fiber and mineral content increased in baked products. She also reported that the bulk density (Kg/lt) of ready to eat (RTE) and extruded products prepared with addition of papaya-guava or pear powder was significantly higher whereas the expansion ratio of RTE and extruded products was lower than the control.

Palodkar *et al.* (2003) reported that all the treatments except alkali treatment recorded non-significant difference in crude fat content of dehydrated aonla. There was a significant decrease in the fat content of alkali treated sample (0.50 per cent) over control (0.59 per cent).

Kumar and Manimegalai (2005) prepared RTS beverage by blending 10 per cent papaya juice with whey as per FPO specifications and stored it at refrigeration temperature. They reported that the acidity and reducing sugar content of the beverage increased during storage while the total sugar and ascorbic acid content decreased during storage.

Kaikadi *et al.* (2006) prepared *ber* candy, packed in polythene bags or plastic boxes and analyzed for contents of moisture, reducing sugar, total sugar and ascorbic acid. The moisture, reducing sugar, total sugar and ascorbic acid content was 19.8 per cent, 29.5 per cent, 77.0 per cent and 24.8 mg/100g, respectively. In all cases, storage container was not found to have significant influence on any chemical component of *ber* candy.

Kumar *et al.* (2007) prepared RTS using *ber* powder at different concentrations of 5, 10 and 15 per cent and recorded ascorbic acid from 2.02 to 6.03 per cent, reducing sugars from 3.87 to 4.36 per cent and non-reducing sugars from 6.28 to 6.77 per cent. The total sugars content was 10.64 per cent. All the RTS prepared could be stored safely up to 3 months and were liked moderately during storage.

Ajila *et al.* (2008) prepared biscuits by incorporating mango peel powder. The biscuits exhibited improved antioxidant properties and increased total dietary fiber from 6.5 to 20.7 per cent. The content of carotenoids also increased with 20 per cent incorporation of mango peel powder as compared to 10 per cent.

Fang (2008) prepared wheat bread substituted with different percentages (5, 10 and 15 per cent) of Pumpkin flour (*Cucurbita moschata*). He reported that the bread substitution from 5 per cent to 15 per cent Pumpkin Flour showed significant ( $p < 0.05$ ) increase in ash and crude fiber content. However, protein and fat content were found to decrease significantly ( $p < 0.05$ ) in the bread. Pumpkin Flour was noted to significantly increase the beta-carotene content in bread which resulted in significant increase ( $p < 0.05$ ) in the yellowness of the crust and crumb colour of the bread. The mineral (Ca, Na, K, Fe, P and Mg) contents increased significantly ( $p < 0.05$ ) with increased percentages of Pumpkin Flour in the bread.

Dahiya and Grewal (2010) prepared high protein high fiber biscuits by using different concentrations of soybean flour and *ber* powder with refined wheat flour. The protein content of all the combinations of biscuits ranged from 10.26 to 11.61 per cent while their fiber content ranged from 5.81 to 7.04 per cent.

Ritthiruangdej *et al.* (2011) prepared noodles substituting banana flour with wheat flour at different concentrations. They reported no change in fat content of noodles with addition of banana flour but ash content increased when amount of banana flour increased. The ash, moisture, protein, fat and fiber content of noodles ranged from 4.98 to 5.35, 8.67 to 10.07, 12.35 to 15.75, 0.04 to 0.14 and 4.44 to 5.94 per cent, respectively.

## **2.9 SHELF-LIFE STUDY OF PRODUCTS**

Kumar *et al.* (2001) found a gradual decrease in acceptability of aonla products during storage at ambient temperature. The acceptable quality of candy was maintained up to 9 months of storage.

Hashmi *et al.* (2007) studied the effect of chemical preservatives namely sodium benzoate, potassium metabisulphite and potassium sorbate used individually and in combination on the sensory quality of the mango pulp (packed in 1 kg plastic containers) stored at ambient temperature (30-36<sup>0</sup>C) for 90 days and evaluated in an interval of fifteen days. Mean scores for taste, colour, flavour and overall acceptability decreased significantly after storage.

Nilguin and Mahendran (2010) prepared RTS beverage from Palmyrah fruit pulp in different concentrations and stored it for 6 months at room temperature. They found that the formulated RTS beverages were safe for consumption for a minimum period of 6 months.

Jakhar and Pathak (2012) prepared RTS by blending *ber* and *jamun* pulp and stored it at room temperature for 6 months. They reported that organoleptic quality determines the storage stability of the products. There was a gradual decrease in organoleptic score of the blended RTS beverage during the storage period at room temperature. The RTS was found acceptable up to five months of storage.

## CHAPTER-III

### MATERIAL AND METHODS

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The present investigation entitled “Nutritional Evaluation and Utilization of *Ber* (*Ziziphus Mauritiana* Lamk.) Powder for the Development of Value Added Products”, was conducted in the Department of Foods and Nutrition, I.C. College of Home Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana.

The present investigation was undertaken to evaluate the different varieties of *ber* (*Ziziphus Mauritiana* Lamk.), namely ‘Gola’, ‘Kaithali’ and ‘Umran’, in the form of *ber* powder, for their nutritional composition, sensory, functional and shelf-life properties and to study the acceptability, nutritional and shelf-life properties of various value-added products developed from the best acceptable *ber* powder.

This chapter delineates information pertaining to the research design and methodological steps used for the present investigation. The research procedures to achieve the planned objectives have been distinctly described under following heads and subheads:

- 3.1 Selection of varieties**
- 3.2 Development of powder**
  - 3.2.1 Sensory evaluation of *ber* powder**
  - 3.2.2 Physico-chemical properties of the *ber* powder**
    - 3.2.2.1 Acidity
    - 3.2.2.2 Total soluble sugars (TSS)
    - 3.2.2.3 Total soluble sugars (TSS)/acid ratio
    - 3.2.2.4 Non-enzymatic browning
- 3.3 Shelf-life studies of *ber* powder**
- 3.4 Nutritional evaluation**
  - 3.4.1 Proximate composition**
    - 3.4.1.1 Moisture
    - 3.4.1.2 Crude protein
    - 3.4.1.3 Crude fat
    - 3.4.1.4 Crude fiber
    - 3.4.1.5 Ash
  - 3.4.2 Carbohydrates**
    - 3.4.2.1 Total soluble sugars (TSS)
    - 3.4.2.2 Reducing sugars
    - 3.4.2.3 Non-reducing sugars
  - 3.4.3 Minerals**
    - 3.4.3.1 Calcium

- 3.4.3.2 Iron
- 3.4.3.3 Magnesium
- 3.4.3.4 Zinc
- 3.4.4 Vitamins**
- 3.4.4.1 Ascorbic acid
- 3.4.4.2  $\beta$ -carotene
- 3.4.5 *In-vitro* digestibility**
- 3.4.5.1 *In-vitro* protein digestibility
- 3.4.5.2 *In-vitro* starch digestibility
- 3.5 Utilization of ber (*Ziziphus Mauritiana* Lamk.) powder**
- 3.5.1 Traditional Products**
- 3.5.1.1 Custard
- 3.5.1.2 *Kheer*
- 3.5.2 Baked Products**
- 3.5.2.1 Biscuits
- 3.5.2.2 Cake
- 3.5.3 Extruded Products**
- 3.5.3.1 Pasta
- 3.5.3.2 Noodles
- 3.5.4 Unfermented Beverages**
- 3.5.4.1 RTS
- 3.6 Sensory evaluation of value added products**
- 3.7 Nutritional evaluation of products**
- 3.7.1 Proximate composition**
- 3.7.1.1 Moisture
- 3.7.1.2 Crude protein
- 3.7.1.3 Crude fat
- 3.7.1.4 Crude fiber
- 3.7.1.5 Ash
- 3.7.2 Carbohydrates**
- 3.7.2.1 Total soluble sugars
- 3.7.2.2 Reducing sugars
- 3.7.2.3 Non-reducing sugars
- 3.7.3 Minerals**
- 3.7.3.1 Calcium
- 3.7.3.2 Iron
- 3.7.3.3 Magnesium
- 3.7.3.4 Zinc

### 3.7.4 Vitamins

3.7.4.1 Ascorbic acid

3.7.4.2  $\beta$ -carotene

### 3.7.5 *In-vitro* digestibility

3.7.5.1 *In-vitro* protein digestibility

3.7.5.2 *In-vitro* starch digestibility

### 3.8 Shelf-life study of products

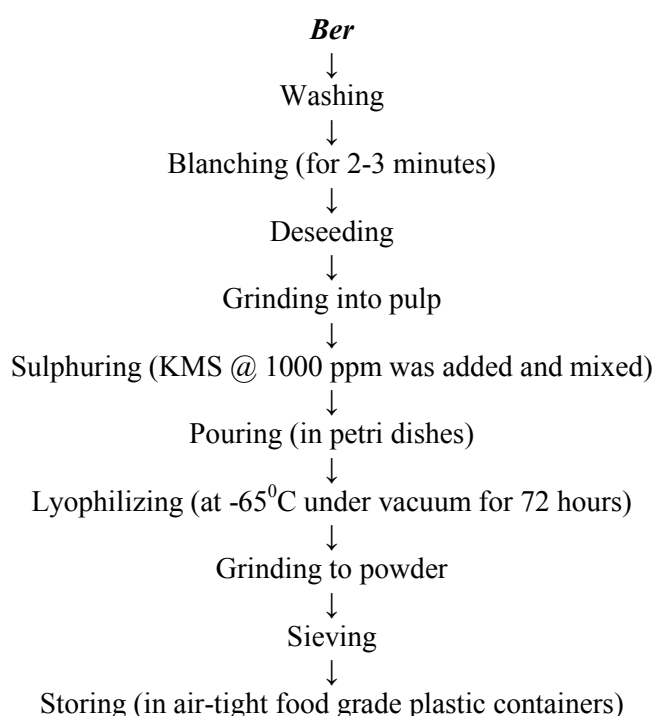
### 3.9 Statistical analysis

## 3.1 SELECTION OF VARIETIES

Fruits of different varieties of *ber* namely 'Gola', 'Kaithali' and 'Umran', were procured at ripe stage from the Horticulture Farm, CCSHAU, Hisar. *Gola* is early maturing, *Kaithali* is mid maturing and *Umran* is late maturing variety. The fruits obtained were thoroughly cleaned and screened to remove decayed, rotten and damaged fruits and other foreign material. The fruits were washed under running water to remove dirt and dust. The fruits were washed with double distilled water before development of powder.

## 3.2 DEVELOPMENT OF POWDER

The *ber* (*Ziziphus Mauritiana* Lamk.) fruits of selected varieties were blanched in boiling water for 2-3 minutes. Then they were deseeded and ground into pulp. Preservative i.e. potassium metabisulphite (KMS) @ 1000 ppm was added to the pulp. The pulp was then poured in petri dishes and kept in lyophilizer at  $-65^{\circ}\text{C}$  under vacuum for 72 hours. It was then taken out and ground to prepare powder. The powder was then sieved to pass through 30 mesh sieve. The powders were stored in air tight food grade plastic containers for further analysis and utilization. The flow sheet for preparation of powder is as below:-



**Fig 1: Flow sheet for preparation of *ber* powder**



**Plate 1: *Ber* varieties and their powder**

The prepared powders of all the varieties were evaluated for sensory characteristics using 9-point hedonic scale and physico-chemical properties (AOAC, 2000) as per methods given below:

### **3.2.1 Sensory Evaluation of *ber* powder**

For selecting the best acceptable powder for further study, the above mentioned powders were subjected to organoleptic evaluation by a panel of ten judges from the I.C. College of Home Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. The judges were asked to record the quality characteristics i.e. colour, appearance, aroma, texture and taste by employing a nine-point Hedonic Rating Scale as given in Annexure-I. Judges were asked to rinse their mouth before and after testing each product. Average of the scores for all these characteristics was expressed as overall acceptability.

### **3.2.2 Physico-chemical properties of *ber* powder**

The Acidity, Sugar/acid ratio (AOAC, 2000) and Non-enzymatic browning (Ranganna, 1986) of *ber* powders were analyzed as per method given below:

#### **3.2.2.1 Acidity**

##### **Reagents:**

- i) 0.1 N NaOH: Four g NaOH was dissolved in water and volume was made to one litre.
- ii) Phenolphthalein indicator: 1 per cent in 80 per cent ethyl alcohol.

**Procedure:** Five g of sample was taken in 250 ml conical flask. Boiling water was added to make the volume 100 ml and 5 drops of phenolphthalein indicator was added. It was titrated

slowly against NaOH until finally one drop gave a pink colour lasting for a minute or longer. The acidity was expressed in per cent of citric acid using the formula:

$$\text{Titration acidity (milliequivalent / 100 g)} = \frac{\text{ml} \times \text{N} \times 100}{\text{Wt. of sample}}$$

Per cent citric acid = Titration Acidity x 0.06404

ml = ml of NaOH used for titration

N = Normality of NaOH.

#### **3.2.2.2 Total soluble sugars (TSS)**

Total soluble sugars (TSS) content of *ber* powders was estimated as described in section 3.4.2.1.

#### **3.2.2.3 Total soluble sugars (TSS)/acid ratio**

The ratio of total soluble sugars (TSS) to acidity of *ber* powders was obtained by dividing the total soluble sugars content with total acidity.

#### **3.2.2.4 Non-enzymatic browning**

Five grams of sample was dissolved in 100 ml of 60 per cent alcohol (ethanol). The solution was kept overnight and filtered on the next day to obtain a clear solution. The colour of the solution was measured at 440 nm using 60 per cent alcohol as blank. The increase in absorbance of the sample at 440 nm was taken as a measure of non-enzymatic browning.

### **3.3 SHELF-LIFE STUDIES OF *BER* POWDER**

Powders of all the varieties were stored in air tight plastic containers (food grade) at ambient temperature for 0, 15, 30, 45 and 60 days. These powders were evaluated for the sensory characteristics at the end of each storage period, by a panel of 10 judges using 9-point hedonic scale.

### **3.4 NUTRITIONAL EVALUATION**

Powders of all the three varieties were analyzed for the following parameters:

#### **3.4.1 Proximate composition**

The proximate composition of best acceptable *ber* powder was determined by employing the standard method (AOAC, 2000).

##### **3.4.1.1 Moisture**

Five gram sample was weighed in the moisture box and dried in hot air oven at 105°C for six hours. The sample was weighed after cooling it in a desiccator. The moisture content was calculated as per the following formula:

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

##### **3.4.1.2 Crude protein**

Crude protein was estimated by KEL PLUS Automatic Nitrogen Estimation System.

## Reagents

- i) Hydrochloric acid (0.1N)
- ii) Boric acid solution (4%): Dissolved 40 g of boric acid in distilled water and diluted to one litre.
- iii) Sodium hydroxide solution (40%): Dissolved 400 g of carbonate free sodium hydroxide (NaOH) in distilled water and diluted to one litre.
- iv) Copper sulphate catalyst: Mixed copper sulphate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ) and potassium sulphate in ratio of 1:9.
- v) Mixed indicator solution: Dissolved 0.5 g bromocresol green and 0.1 g methyl red in 100 ml 95% ethanol and stored in dark brown bottle.
- vi) Digestion mixture: 10 g potassium sulphate, 0.5 g copper sulphate and 2 g ferrous sulphate were mixed together and ground to a fine powder
- vii) Concentrated Sulphuric acid ( $\text{H}_2\text{SO}_4$ )

## Procedure

### Digestion:

Moisture free sample (500 mg) was transferred to the digestion tube. Twenty ml of conc. sulphuric acid and 3g of digestion mixture were added to the sample. Digestion tubes were loaded into the digester and manifold was placed over the tubes and the block was heated at 360-410°C. The water connection was turned on. Digestion was carried out for about 3-4 hours till contents of tubes turned slight bluish green in colour. After digestion, the insert rack containing tubes was removed from the block and was placed in the cooling stand for 15-20 minutes till the tubes got cooled to room temperature. Then finally, the water connection was closed. Then, the samples were ready for distillation in DISTYL-EM unit.

### Distillation:

The tube containing the digested sample was loaded in the space provided in apparatus. One empty conical flask was put on the receiver side. Boric acid (20 ml) dropped automatically into the conical flask mixed indicator (2-3 drops) was added to it to give it a pink colour. This flask was put on the receiver side and the programme of the equipment was run. Then 40 ml of 40 per cent NaOH in auto mode was added slowly in the order of 10 ml each time (till the colour in the test tube changed from bluish green to brown precipitate) and ammonia liberated was trapped in the boric acid till the volume increased 2-3 time. After few minutes, the colour in the conical flask changed from pink to green. This was the end point of distillation of the sample. The flask was taken out for titration.

### Titration:

Titrated the above solution with 0.1 N HCl till colour changed from green to permanent pale pink. This was the end point of titration. Titration value of a blank solution of boric acid and mixed indicator was also determined.

$$\text{Total N (\%)} = \frac{14 \times \text{Titrant value} \times \text{Normality of HCl}}{1000 \times \text{sample weight}} \times 100$$

Where,

Titrant value = Volume of HCl used for sample – volume of HCl used for blank

14 = 1.0 ml of 0.1 N HCl neutralize .00014 g of nitrogen.

The protein was calculated by multiplying the nitrogen content with a factor of 6.25.

#### 3.4.1.3 Crude fat

Crude fat was estimated by standard method of analysis (AOAC, 2000) using the Automatic Socs Plus Solvent Extraction System.

##### Procedure:

One gram of the moisture free sample was weighed and transferred to a pre-weighed extraction thimble and dried overnight. The beakers were washed thoroughly and dried in hot air oven at 60<sup>0</sup>C and weighed after cooling. The thimble along with the sample was inserted in the thimble holder and placed in the beaker. One hundred ml of petroleum ether (boiling pt. 60-80<sup>0</sup>C) was taken into the beaker. Loaded the beakers into the system and set the required temperature to 80<sup>0</sup>C (according to the boiling point of the solvent) in the controller. The extraction was carried out for one hour. After the completion of extraction period, the temperature was raised to 120<sup>0</sup>C. The stopper was closed in order to collect the solvent in the solvent compartment. The beakers along with the fat were removed and kept in hot air oven at 60<sup>0</sup>C temperature, till the liquid matter evaporated and a constant weight was obtained. The beaker was weighed again after cooling in a dessicator.

$$\text{Fat (\%)} = \frac{W_2 - W_1}{W} \times 100$$

W= weight of sample (g)

W<sub>1</sub>= weight of empty beaker

W<sub>2</sub>= weight of beaker with fat

#### 3.4.1.4 Crude fiber

##### Reagents:

- i) Sulphuric acid solution (1.25%): Dissolved 12.5ml of sulphuric acid in 200 ml distilled water and made the volume to one liter.
- ii) Sodium hydroxide solution (1.25%): Dissolved 12.5 g sodium hydroxide in distilled water and diluted to one liter.

**Procedure:** One gram of fat free sample was taken and put in weighed crucibles. The crucibles were fixed in apparatus. One fifty ml of 1.25 per cent H<sub>2</sub>SO<sub>4</sub> was filled in each of the beaker through funnels. The instrument was then connected to water supply. All the knobs

are set on closed mode and the instrument was switched on. The temperature was fixed to 550<sup>0</sup>C by pushing the set button. When solution in beakers started boiling, the temperature was reduced to 400<sup>0</sup>C and instrument was allowed to run for 45 minutes. After 45 minutes, the instrument was switched off. The water source was then changed from direct to via suction apparatus. All the knobs were put in open position and the big knob was changed from pressure to vacuum. The suction pump apparatus was also switched on. This whole process was repeated then twice with distilled water followed by NaOH solution and again two times with distilled water. After that, the instrument was switched off. The crucibles were taken off and put in hot air oven for some time and then transferred to muffle furnace at 550<sup>0</sup>C for 2 hours. After 2 hours, the crucibles were taken out, put in dessicator and weighed again.

$$\text{Crude Fiber (\%)} = \frac{\text{Weight of crucible with sample} - \text{final weight of crucible}}{\text{Weight of sample}} \times 100$$

#### **3.4.1.5 Ash**

Five gram of oven dried sample was weighed in a weighed crucible. It was ignited till no charred particles remained in the crucible. The crucible was put in muffle furnace (550° C) for 6 hrs or till a white ash was obtained. Then the crucible was cooled in a desiccator and weighed. The loss in weight represented the organic matter and residue being the ash content.

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

#### **3.4.2 Carbohydrates**

Total soluble sugars were extracted according to the procedure of Cerning and Guilhot (1973).

##### **Extraction**

Twenty five ml ethanol (80 per cent) was added to 500 mg sample in a round bottomed flask. The flask was connected to a condenser and kept on a heating mantle for 30 minute with occasional stirring. The extract was cooled, centrifuged at 8000 rpm for 15 min and supernatant was collected. The above procedure was repeated twice, each time extracting the residue in 25 ml 80% ethanol. The combined extract in the beaker was evaporated to dryness on a boiling water bath. The residue was dissolved in distilled water and made to 50 ml. The prepared sample was sugar free pellet.

##### **3.4.2.1 Total soluble sugars**

Total sugars were estimated by the method of Yemm and Willis (1954).

##### **Reagents**

- i) Standard sugar solution: Dissolved 25 mg glucose in water and made to 100 ml. This solution contained 250 µg glucose per ml. For obtaining the standard curve, 0.2 ml to 1.0 ml of this solution was added.
- ii) Anthrone Reagent (0.2% anthrone in 70% H<sub>2</sub>SO<sub>4</sub>): This reagent was prepared fresh daily and allowed to stand for 30-40 min before use.

### Estimation

Freshly prepared 10 ml anthrone reagent was pipetted in a test tube, chilled and kept in ice cold water. One ml of the sugar extract (as in 3.4.2) was taken and diluted to 10 ml with water. Out of the diluted sugar extract, one ml was taken and was layered on the anthrone reagent. After cooling for 3-5 min, the contents were thoroughly mixed, while still immersed in ice cold water. The contents in the tube were heated vigorously in a boiling water bath for 10 min and then immediately cooled in cold water. The absorbance was then read at 625 nm against blank. Amount of sugar was estimated by referring to standard curve prepared with glucose previously. The total soluble sugars were calculated by the formula:

$$\text{Total Soluble Sugars (g/100g)} = \frac{C \times V}{W \times V_1 \times 10^6} \times 100$$

Where,

C= concentration of glucose from curve (µg)

V= volume of extract made

W= weight of sample taken (g)

V<sub>1</sub>= volume of aliquot taken

### 3.4.2.2 Reducing sugars

Reducing sugars were estimated by Somogyi's modified method (Somogyi, 1945).

### Reagents

- i) Copper reagent A: Dissolved 25 g anhydrous sodium carbonate, 25 g potassium sodium tartarate, 20 g sodium bicarbonate and 200 g anhydrous sodium sulphate in about 800 ml distilled water and diluted to one litre.
- ii) Copper reagent B: Dissolved 15 g CuSO<sub>4</sub> in 100 ml distilled water containing two drops of HCl.
- iii) Arsenomolybdate reagent: Dissolved 25 g ammonium molybdate in 450 ml distilled water by warming. Added 21 ml conc. H<sub>2</sub>SO<sub>4</sub> with stirring. Three g sodium hydrogen arsenate dissolved in 25 ml distilled water was added with stirring. The solution was kept in an incubator at 37°C for 24 h before use. The reagent was kept in a glass stoppered brown bottle and stored in refrigerator.
- iv) Copper Reagent: A and B mixed in the ratio of 25:1 (V/V) before use.
- v) Standard sugar solution: Dissolved 25 mg glucose and made to 100 ml with water. This contained 250 µg glucose/ml.

### Estimation

One ml test extract obtained in 3.4.2 was taken in blood sugar tube graduated at 25 ml. One ml mixed copper reagent (iv) was added and then heated for 20 min in boiling water bath. To this one ml arsenomolybdate reagent was added, mixed thoroughly and the contents diluted to 25 ml. A stable blue colour appeared quickly which was read at 520 nm against blank. The amount of reducing sugar was then determined by referring to the glucose standard curve and using the following formula:

$$\text{Reducing sugar (g/100g)} = \frac{C \times V}{W \times V_1 \times 10^6} \times 100$$

Where,

C= concentration of glucose from curve ( $\mu\text{g}$ )

V= volume of extract made

W= weight of sample taken (g)

$V_1$ = volume of aliquot taken

#### 3.4.2.3 Non-reducing sugars

The amount of non-reducing sugars was calculated as the difference between total sugars and reducing sugars.

### 3.4.3 Minerals

#### Acid digestion

To one g ground sample in a 150 ml conical flask, 25-30 ml of diacid mixture ( $\text{HNO}_3:\text{HClO}_4::5:1$ , v/v) was added and kept overnight. The contents were digested by heating on a hot plate until clear white precipitates settled down at the bottom. The crystals were dissolved by adding double distilled water and volume was made to 50 ml. This was then used for determination of total minerals.

#### 3.4.3.1 Estimation of Calcium, Iron, Magnesium and Zinc

Calcium, Iron, Magnesium, Zinc in acid digested samples were determined by Atomic Absorption Spectrophotometer according to the method of Lindsey and Norwell (1969).

#### 3.4.4 Vitamins

Ascorbic acid and  $\beta$ -carotene in the sample were analysed by the standard method of analysis given by AOAC (2000).

##### 3.4.4.1 Ascorbic acid

#### Reagents

- i) Metaphosphoric acetic acid solution: Metaphosphoric ( $\text{HPO}_3$ ) pellets (15g) were dissolved in 40 ml glacial acetic acid and 200 ml distilled water and the volume was made to 500 ml with distilled water. It was filtered rapidly through filter paper

(Whatman # 1) in to glass stoppered bottle and stored in refrigerator. It could be stored for 7-10 days.

- ii) Ascorbic acid standard solution (1 mg ascorbic acid / ml): Fifty mg ascorbic acid reference standard (that had been stored in a dessicator away from direct sunlight) was weighed and transferred to 50 ml volumetric flask. It was diluted with metaphosphoric acetic acid solution to a final volume of 50 ml.
- iii) Indophenol standard solution: Fifty mg 2, 6-dichloroindophenol sodium salt (that had been stored in dessicator, away from sunlight) was dissolved in 50 ml distilled water, to which 42 mg sodium bicarbonate had been added. When the dye dissolved, it was diluted to 200 ml with distilled water and was filtered through filter paper Whatman # 1 in to amber glass stoppered bottle. The solution was stored away from direct sunlight in refrigerator.

#### **Extraction**

To five gram of sample, 25 ml metaphosphoric acetic acid solution was added. The sample was made to a fine paste in pestle and mortar until the suspension appeared one, mixed well and volume was made to 100 ml with metaphosphoric acetic acid solution. Filtered rapidly through Whatman # 1 filter paper.

#### **Estimation**

Two ml aliquot of ascorbic acid standard solution was taken in 50 ml conical flasks containing five ml metaphosphoric acetic acid solution. These standard samples were titrated rapidly against indophenol solution from a microburette until light but distinct rose pink colour persisted at least for five seconds. Similarly, blank containing seven ml metaphosphoric acetic acid solution was titrated against indophenol solution. For the sample, five ml metaphosphoric acetic acid solution was added to each of two ml of sample aliquots and titrated against indophenol solution as for blank and standard. Ascorbic acid contents (mg / 100 g) were calculated as follows:

#### **Calculations**

$$\text{Ascorbic acid (mg/100g)} = \frac{Y - B \times V}{X - B \times W} \times 100$$

Where,

Y = Volume of dye solution used against sample aliquot

B = Volume of dye solution used against blank

X = Volume of dye solution used against standard

V = Volume of aliquot made

W = Weight of sample (g)

#### **3.4.4.2 $\beta$ -carotene**

#### **Reagents**

- i) Acetone (3%) in petroleum ether
- ii) Alumina (aluminium oxide neutral)
- iii) Sodium sulphate anhydrous
- iv)  $\beta$ -carotene standard: carotene (50mg) was dissolved in 3 per cent acetone in petroleum ether and diluted to 50 ml (1 mg/ml).

### **Procedure**

#### **Preparation of chromatography column**

The chromatography column was filled with aluminium oxide neutral which has been dried at 70°C in a hot air oven. The absorbent was gently pressed down to a depth of 10 cm by tapping or suction. The absorbent was covered with a one cm layer of anhydrous sodium sulphate. The column wetted with 3 per cent acetone in petroleum ether. The column was not allowed to dry at any stage.

#### **Extraction of sample**

Weighed 10 g of sample and put it in a conical flask and to this added 30 ml 3 per cent acetone in petroleum ether and allowed it to stand overnight. The extract was then filtered through filter paper (Whatman No. # 1) and residue was washed with 3 per cent acetone petroleum ether until the filtrate was of clear yellow colour. The filtrate was pooled and taken in 500 ml separating funnel. It was then shaken with 50 ml water. Washings were discarded. It was repeated 2-3 times in order to make it acetone free. The solvent was then passed out over dried anhydrous sodium sulphate and was diluted to 100 ml by petroleum ether.

#### **Chromatographic separation of $\beta$ -carotene**

Ten ml extract was taken and concentrated to 2 ml. The condensed extract was poured in to adsorption column followed by 10 ml 3 per cent acetone petroleum ether. The elute containing all the  $\beta$ -carotene was collected and transferred to 25 ml volumetric flask. Volume was made with 3 per cent acetone petroleum ether.

#### **Standard curve**

Standard solution (0.1 to 1.0 ml) was taken in 25 ml volumetric flask and volume was made with acetone in petroleum ether. The colour intensity was read at 435 nm on Spectrophotometer. Concentration of  $\beta$ -carotene was calculated by referring to a standard curve prepared from  $\beta$ -carotene standard solution containing 1  $\mu$ g  $\beta$ -carotene/ml.

#### **Calculation**

$$\beta\text{-carotene(mg/100g)} = \frac{M \times V_1}{W \times V_2 \times 1000} \times 100$$

Where,

M = Concentration of elute extract obtained from graph

W = Weight of sample taken (g)

$V_1$  = Volume of extract made (ml)

$V_2$  = Volume of extract taken for elution (ml)

### 3.4.5 *In-vitro* digestibilities

*In-vitro* protein digestibility was carried out by the modified method of Mertz *et al.* (1983) while *in-vitro* starch digestibility was assessed by employing pancreatic amylase (Singh *et al.*, 1982).

#### 3.4.5.1 *In-vitro* protein digestibility

##### Reagents

- i) Pepsin reagent: 0.1 M  $\text{KH}_2\text{PO}_4$  (pH 2.0) containing 0.2 per cent pepsin; 13.6 g potassium phosphate was dissolved in 1 litre of water, pH of the solution was adjusted to 2.0 and 2 g pepsin (Sigma) was dissolved in the buffer.
- ii) TCA (50%): 50 g Trichloroacetic acid was dissolved in water and volume was made to 100 ml.

##### Procedure

Two hundred and fifty mg of sample was weighed and transferred to a centrifuge tube. To it 20 ml of pepsin reagent was added. The tube was stoppered and arranged in a shaker-incubator maintaining the water temperature at 37°C for 3 hours. The centrifuge tube was removed and cooled. Five ml of TCA (50 per cent) was added and the contents were centrifuged at 10,000 rpm for 10 minutes at room temperature and filtered. Ten ml of aliquot was taken and dried in hot air oven and digested for nitrogen determination by Micro kjeldahl method (AOAC, 2000). Digested protein of sample was determined. Protein digestibility was calculated by the following formula.

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

#### 3.4.5.2 *In-vitro* starch digestibility

##### Reagents

- i) Pancreatic amylase: Twenty mg pancreatic amylase (Sigma Chemical Company, USA) was dissolved in 50 ml phosphate buffer (pH 6.9).
- ii) 0.2 M Disodium hydrogen phosphate: Dissolved 35.598 g disodium hydrogen phosphate in distilled water and volume was made to one litre.
- iii) 0.2 M Potassium dihydrogen phosphate: Dissolved 27.28 g potassium dihydrogen phosphate in distilled water and volume was made to one litre.
- iv) Phosphate buffer (pH 6.9): Added 50 ml 0.2 M Potassium dihydrogen phosphate to 46.8 ml 0.2 M sodium hydrogen phosphate and volume was made upto 200 ml.
- v) Dinitrosalicylic reagent: 3,5-dinitrosalicylic acid (10 g), sodium potassium tartarate (300 g) and sodium hydroxide (16 g) were dissolved in carbon dioxide free water and volume was made to 1 litre. The reagent was stored in brown bottle and protected from carbon dioxide.
- vi) Standard maltose solution: Maltose monohydrate (100 mg) was dissolved in distilled water and volume was made upto 100 ml.

## Estimation

Fifty mg defatted sample was dispersed in 1.0 ml 0.2 M phosphate buffer (pH 6.9). Added 0.5 ml pancreatic amylase to sample and incubated in water bath at 37°C for 2 h with occasional shaking of the test tubes. After incubation, 2 ml dinitrosalicylic reagent was quickly added and heated for 5 minutes in a boiling water bath. After cooling, the solution was made to 25 ml with distilled water and filtered through an ordinary filter paper prior to measurement of absorbance at 550 nm.

A blank was run simultaneously by incubating the sample without enzyme. Dinitrosalicylic reagent was added before addition of the enzyme solution. Maltose was used as standard and values were expressed as mg maltose released/g defatted sample. Standard curve was prepared by taking 0.5 to 4.0 mg maltose from standard maltose solution. The starch digestibility was calculated as:

$$\text{In vitro starch digestibility} = \frac{\text{Concentration from graph (mg)}}{\text{Weight of sample (g)}}$$

### 3.5 UTILIZATION OF *BER (ZIZIPHUS MAURITIANA LAMK.)* POWDER

The best acceptable powder based on the desirable sensory characteristics, physico-chemical properties and nutritional evaluation was further utilized for the development of value-added products.

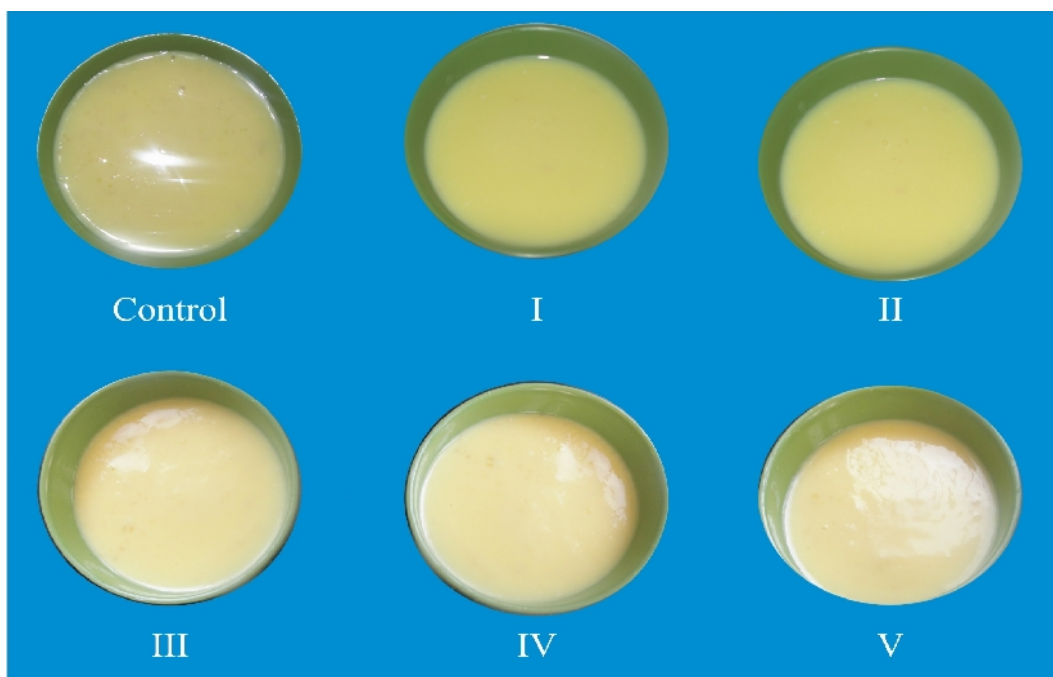
#### 3.5.1 Traditional Products

##### 3.5.1.1 Custard

Ingredients	Control	Types of custard				
		I	II	III	IV	V
Custard Powder (g)	20	18	16	14	12	10
<i>Ber</i> Powder (g)	-	2	4	6	8	10
Milk (ml)	500	500	500	500	500	500
Sugar (g)	50	50	50	50	50	50

#### Method

1. Mixed custard powder or custard powder and *ber* powder mixture with about 50 ml of milk and formed a smooth paste without lumps.
2. Rest of the milk was kept on flame for boiling.
3. Added custard paste in boiling milk with constant stirring.
4. Added sugar and stirred again.
5. Boiled till it became thick and removed from fire.



**Plate 2: Custard prepared using *ber* powder**

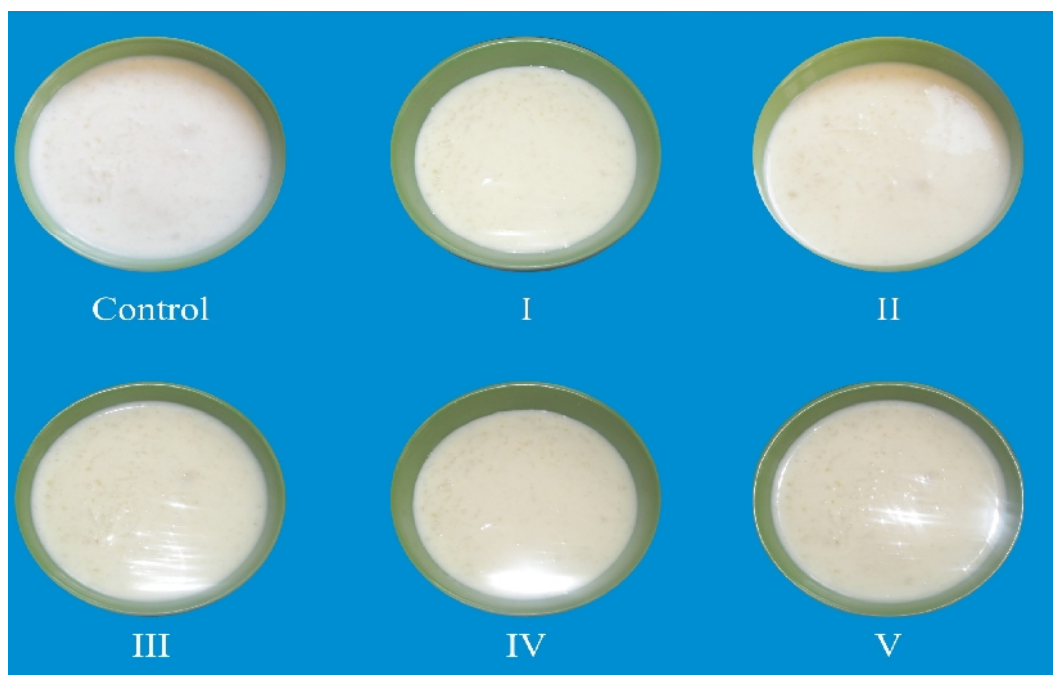
Control = 100 % CP      I= 10:90 (BP:CP)      II= 20:80 (BP:CP)  
 III= 30:70 (BP:CP)      IV= 40:60 (BP:CP)      V= 50:50 (BP:CP)  
 BP= *Ber* powder      CP= Custard Powder

### 3.5.1.2 *Kheer*

Ingredients	Types of <i>kheer</i>					
	Control	I	II	III	IV	V
Rice (g)	40	36	32	28	24	20
<i>Ber</i> Powder (g)	-	4	8	12	16	20
Milk (ml)	500	500	500	500	500	500
Sugar (g)	50	50	50	50	50	50

#### Method

1. Soaked rice in water for half an hour and strained.
2. Boiled milk and added rice or rice and *ber* powder mixture.
3. Cooked on slow flame with constant stirring until soft and thickened.
4. Added sugar and cooked further for 2-3 minutes.



**Plate 3: Kheer prepared using *ber* powder**

Control = 100 % R      I= 10:90 (BP:R)      II= 20:80 (BP:R)  
 III= 30:70 (BP:R)      IV= 40:60 (BP:R)      V= 50:50 (BP:R)  
 BP= *Ber* powder      R= Rice

### 3.5.2 Baked products

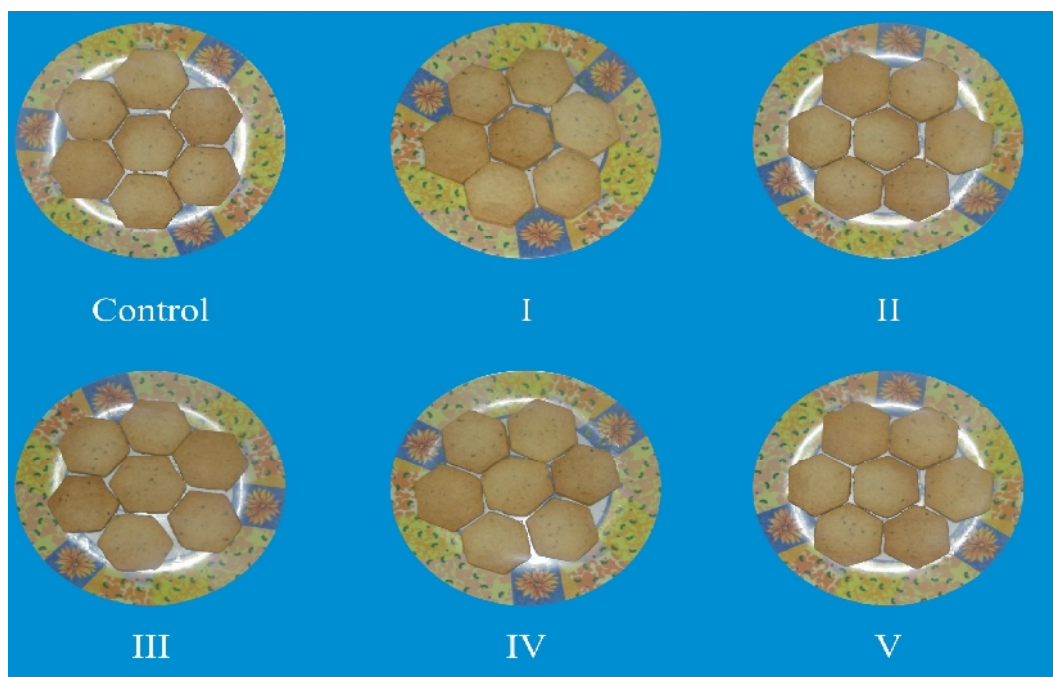
#### 3.5.2.1 Biscuits

Ingredients	Types of biscuit					
	Control	I	II	III	IV	V
Refined Flour (g)	100	90	80	70	60	50
<i>Ber</i> Powder (g)	-	10	20	30	40	50
Ghee (g)	40	40	40	40	40	40
Powdered Sugar (g)	25	25	25	25	25	25
Milk (ml)	40	40	40	40	40	40
Salt (g)	3.5	3.5	3.5	3.5	3.5	3.5
Cumin Seeds (g)	1.5	1.5	1.5	1.5	1.5	1.5
Ammonium Bicarbonate (g)	5	5	5	5	5	5
Sodium Bicarbonate (pinch)	1	1	1	1	1	1
Ajwain (g)	0.5	0.5	0.5	0.5	0.5	0.5

#### Method

1. Creamed ghee, sugar and milk.
2. Added cumin seeds, ajwain and salt.
3. Added ammonium bicarbonate and sodium bicarbonate.
4. Folded sieved refined flour or refined flour and *ber* powder mixture into it.

5. Rolled on flat board (1/4" thick).
6. Cut into shapes of biscuits with the help of biscuits cutter.
7. Baked in oven at 160°C till brown.



**Plate 4: Biscuits prepared using *ber* powder**

Control = 100 % RF      I= 10:90 (BP:RF)      II= 20:80 (BP:RF)  
 III= 30:70 (BP:RF)      IV= 40:60 (BP:RF)      V= 50:50 (BP:RF)  
 BP= *Ber* powder      RF= Refined Flour

### 3.5.2.2 Cake

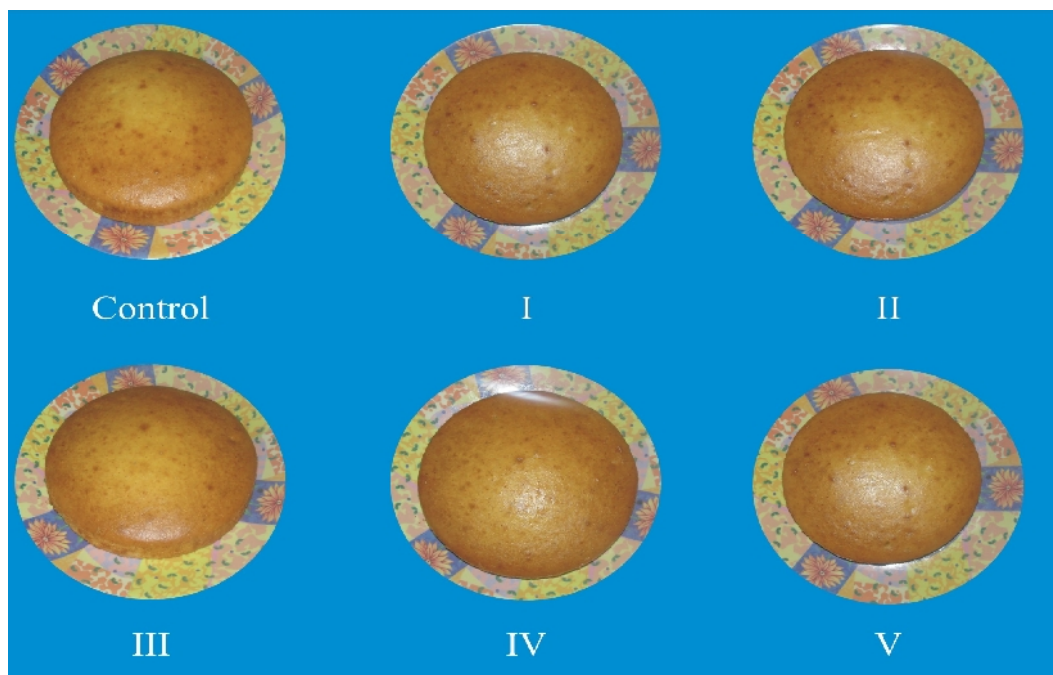
#### Types of cake

Ingredients	Control	I	II	III	IV	V
Refined Flour (g)	80	72	64	56	48	40
<i>Ber</i> Powder (g)	-	8	16	24	32	40
Egg (nos.)	3	3	3	3	3	3
Sugar (g)	80	80	80	80	80	80
Baking Powder (tsp)	¼	¼	¼	¼	¼	¼
Vanilla essence (tsp)	½	½	½	½	½	½
Oil (ml)	15	15	15	15	15	15

#### Method

1. Sieved flours and baking powder.
2. Beaten eggs and sugar till fluffy.
3. Added vanilla essence.
4. Beaten egg yolk and added to the batter.
5. Added oil and mixed.

6. Added refined flour or refined flour and *ber* powder mixture and mixed using cut and fold method.
7. Poured in greased baking dish.
8. Baked in oven at 160-170<sup>0</sup>C for 15-20 minutes.



**Plate 5: Cake prepared using *ber* powder**

Control = 100 % RF      I= 10:90 (BP:RF)      II= 20:80 (BP:RF)  
 III= 30:70 (BP:RF)      IV= 40:60 (BP:RF)      V= 50:50 (BP:RF)  
 BP= *Ber* powder      RF= Refined Flour

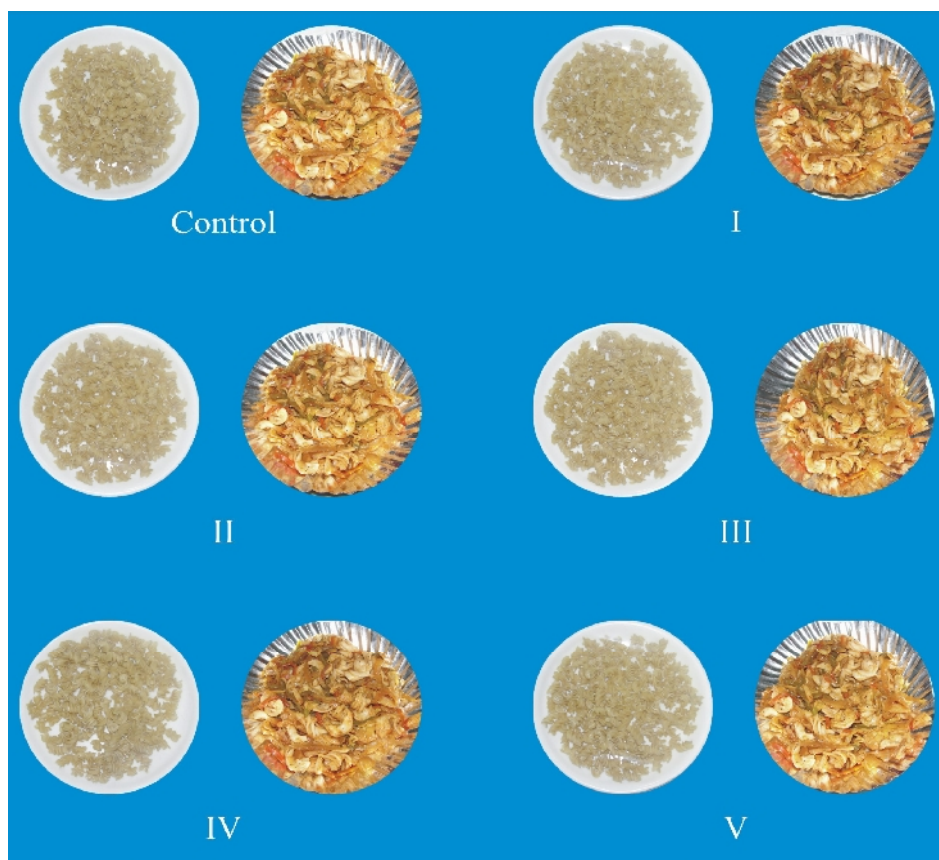
### 3.5.3 Extruded products

#### 3.5.3.1 Pasta

Ingredients	Types of pasta					
	Control	I	II	III	IV	V
Refined Flour (g)	100	90	80	70	60	50
<i>Ber</i> Powder (g)	-	10	20	30	40	50
Water (ml)	30	30	30	30	30	30

#### Method

1. Mixed refined flour or refined flour and *ber* powder mixture with water for 3-4 minutes in extruder chamber till the homogenous and stiff dough was obtained.
2. Passed the mixture through the extruder.
3. Collected pastas on the trays and dried at 40<sup>0</sup>C for 2 hours.
4. Packed dried pastas in air-tight food grade plastic containers for further use.



**Plate 6: Pasta prepared using *ber* powder**

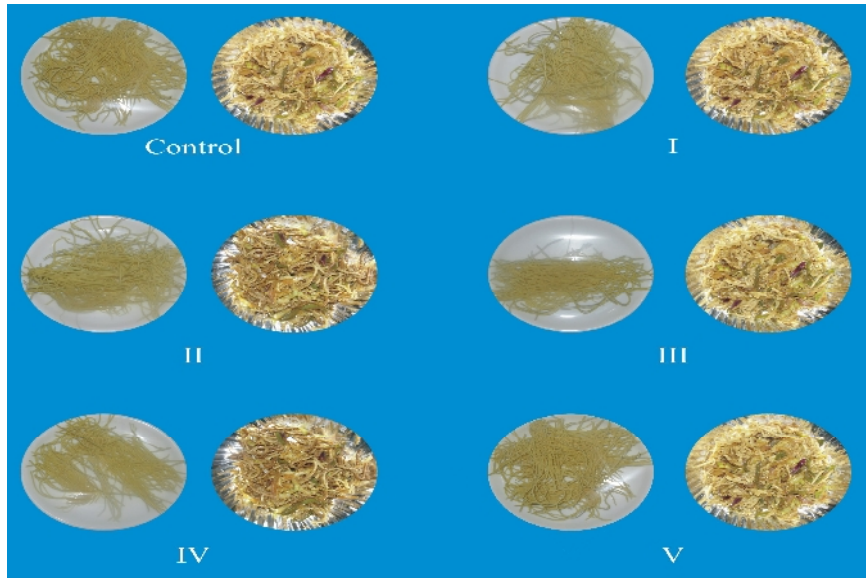
Control = 100 % RF      I= 10:90 (BP:RF)      II= 20:80 (BP:RF)  
 III= 30:70 (BP:RF)      IV= 40:60 (BP:RF)      V= 50:50 (BP:RF)  
 BP= *Ber* powder      RF= Refined Flour

### 3.5.3.2 Noodles

Ingredients	Control	Types of noodles				
		I	II	III	IV	V
Refined Flour (g)	100	90	80	70	60	50
<i>Ber</i> Powder (g)	-	10	20	30	40	50
Water (ml)	30	30	30	30	30	30

#### Method

1. Kneaded stiff dough with refined flour and water or refined flour and *ber* powder mixture and water.
2. Passed dough through the extruder.
3. Collected noodles in trays and kept in oven for drying at 50<sup>0</sup>C temperature for 2 hours.
4. Packed in air-tight plastic containers of food grade quality for further use.



**Plate 7: Noodles prepared using *ber* powder**

Control = 100 % RF      I= 10:90 (BP:RF)      II= 20:80 (BP:RF)  
 III= 30:70 (BP:RF)      IV= 40:60 (BP:RF)      V= 50:50 (BP:RF)  
 BP= *Ber* powder      RF= Refined Flour

### 3.5.4 Unfermented beverage

#### 3.5.4.1 RTS

The RTS was prepared using the standard method as specified by FPO (TSS 15<sup>0</sup>Brix and Acidity 0.3%). No control was prepared in case of RTS.

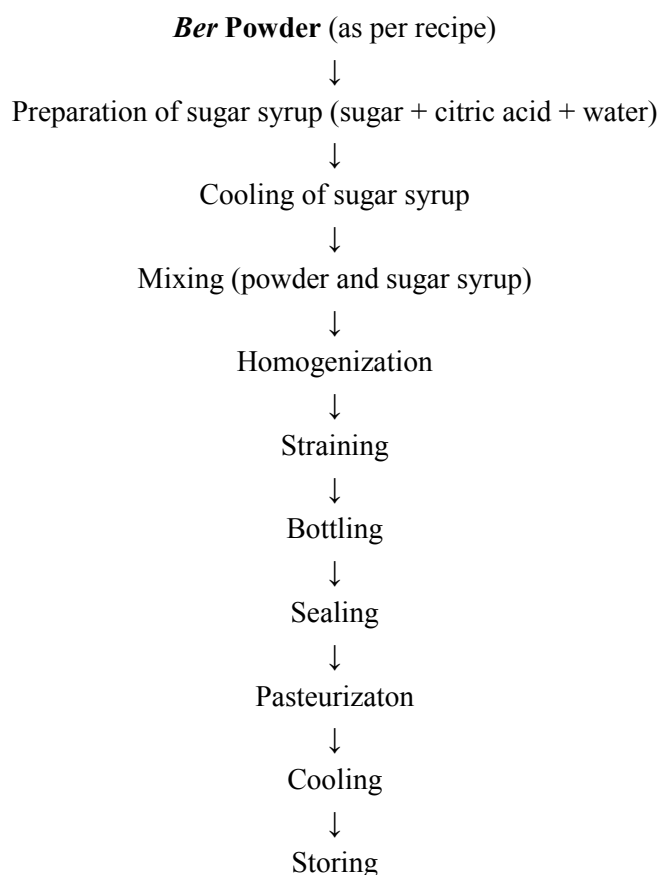
Contents	Types of RTS				
	I	II	III	IV	V
Powder Concentration (%)	10	20	30	40	50
TSS ( <sup>0</sup> Brix)	-	15	15	15	15
Acidity (%)	0.3	0.3	0.3	0.3	0.3



**Plate 8: RTS beverage prepared using *ber* powder**

I= 10 % BP      II= 20 % BP      III= 30 % BP      IV= 40 % BP  
 BP= *Ber* powder

The product with 50 per cent powder did not form. So, four RTS variants were used for further study. The flow chart for preparation of RTS is shown as under:-



**Fig 2: Flow chart for preparation of RTS**

### **3.6 SENSORY EVALUATION OF VALUE ADDED PRODUCTS**

All the prepared products were analyzed organoleptically for characteristics like colour, appearance, aroma, texture and taste. Mean of the scores of all these characteristics was expressed as overall acceptability. The products were evaluated by a panel of 10 judges from I.C. College of Home Science, CCSHAU, Hisar, Haryana, using 9 point Hedonic Scale as mentioned in Annexure-I.

### **3.7 NUTRITIONAL EVALUATION OF PRODUCTS**

All the prepared products from all the categories were nutritionally analyzed for all the parameters mentioned earlier for *ber* (*Ziziphus Mauritiana* Lamk.) powder in section 3.4.

All the prepared products from all the categories (except RTS) were dried in hot air oven at 60<sup>0</sup>C and ground to fine powder for further analysis. The powders were stored in air-tight food grade plastic containers. The RTS was used as fresh for analysis. The formulas used for RTS were on the basis of presence of nutrients per 100 ml.

### **3.8 SHELF-LIFE STUDY OF PRODUCTS**

The products from all the categories which were suitable for storage were stored at ambient temperature in air-tight food grade plastic containers for 2 months and were evaluated for sensory characteristics at 0, 15, 30, 45 and 60 days by a panel of 10 judges from I.C. College of Home Science, CCSHAU, Hisar, Haryana, India.

### **3.9 STATISTICAL ANALYSIS**

The data obtained were subjected to statistical analysis for analysis of variance in a complete randomized design using standard methods of Panse and Sukhatme (1961).

Fruits have long been valued as a part of nutritious and tasty diet. These are good sources of vitamins, minerals, fiber and are low in fat. They play a significant role in human nutrition, especially as source of vitamin C, A, thiamine, niacin, pyridoxine, folacin (folic acid), vitamin E, iron, magnesium etc. Fruits, being perishable in nature, have limited shelf-life because the moisture content of fresh fruits is more than 80 per cent (Orsat *et al.*, 2006). This leads to heavy losses of fruits. Keeping the product fresh is the best way to maintain its nutritional value, but most of the storage techniques require low temperatures, which are difficult to maintain throughout the distribution chain. On the other hand, drying is a suitable alternative for post management especially in country like India where there is poorly established low temperature distribution and handling facilities (Singh *et al.* 2006). It is noted that over 20 per cent of world's perishable crops are dried to increase shelf-life and promote food security (Grabowski *et al.*, 2003). So, processing is a means to avoid the wastage of produce and enhance its availability throughout the year. This, in turn, helps to ameliorate the malnutrition problem.

*Ber* is a delicious, refreshing and rich source of vitamin C. It is also rich in protein (0.8 g/100g) and minerals such as phosphorous (0.148 per cent) and iron (0.54 per cent) (Sharma *et al.*, 2002). Dried *ber* seeds are also rich in protein (36.10 g/100g), fiber (11.04 g/100g), lipids (27.40 g/100g) and minerals like sodium (154.79 per cent), potassium (589.08 per cent), and phosphorous (585.43 per cent). It also contain good amount of ash (2.78 g/100g), magnesium (6.23 per cent), zinc (3.52 per cent), manganese (1.15 per cent) and iron (1.21 per cent) (Yerima nd Adamu, 2011). The vitamin C and total sugar content of fresh *ber* fruit was 114.0 mg/100g and 6.32 per cent, respectively (Kumar, 2005).

The present investigation was conducted to nutritionally evaluate *ber* powders prepared from three varieties of *ber* namely, Gola, Kaithali and Umran and to study their shelf-life. The prepared powders were further utilized for development of various value-added products. These products were then nutritionally analyzed. Some of the selected products were studied for their shelf-life. The results of the present investigation are discussed under the following heads and sub-heads:

- 4.1 Development of *ber* powder, its sensory evaluation, physico-chemical properties and shelf-life
- 4.2 Nutritional evaluation of *ber* powders
- 4.3 Development of value added products and their sensory evaluation
- 4.4 Nutritional evaluation of value-added products

#### 4.5 Shelf-life studies of products

### 4.1 Development of *ber* powder, its sensory evaluation, physico-chemical properties and shelf-life

#### 4.1.1 Development of *ber* powders

The *ber* fruits of all the three varieties namely Gola, Kaithali and Umran were procured from the Horticulture Farm, CCS Haryana Agricultural University, Hisar. The fruits observed were thoroughly cleaned and screened to remove decayed, rotten and damaged fruits and other foreign material. The fruits were then washed and blanched in boiling water for 2-3 minutes. They were then deseeded and ground to pulp. KMS @ 1000 ppm was added to the pulp which was then freeze-dried in lyophilizer at  $-65^{\circ}\text{C}$  under vacuum for 72 hours. It was then ground to powder and allowed to pass through 30 mesh sieve.

#### 4.1.2 Sensory evaluation *ber* powders

Three varieties of *ber* were used for preparing the powder, namely, Gola, Kaithali and Umran. The powders were subjected to sensory evaluation by a panel of 10 judges using 9 point hedonic scale.

Mean scores of sensory characteristics indicated that powders prepared using Gola, Kaithali and Umran varieties was rated as ‘liked moderately’ by the panel of judges in terms of their colour, appearance and aroma (Table 4.1).

**Table 4.1:- Sensory evaluation of *ber* powders**

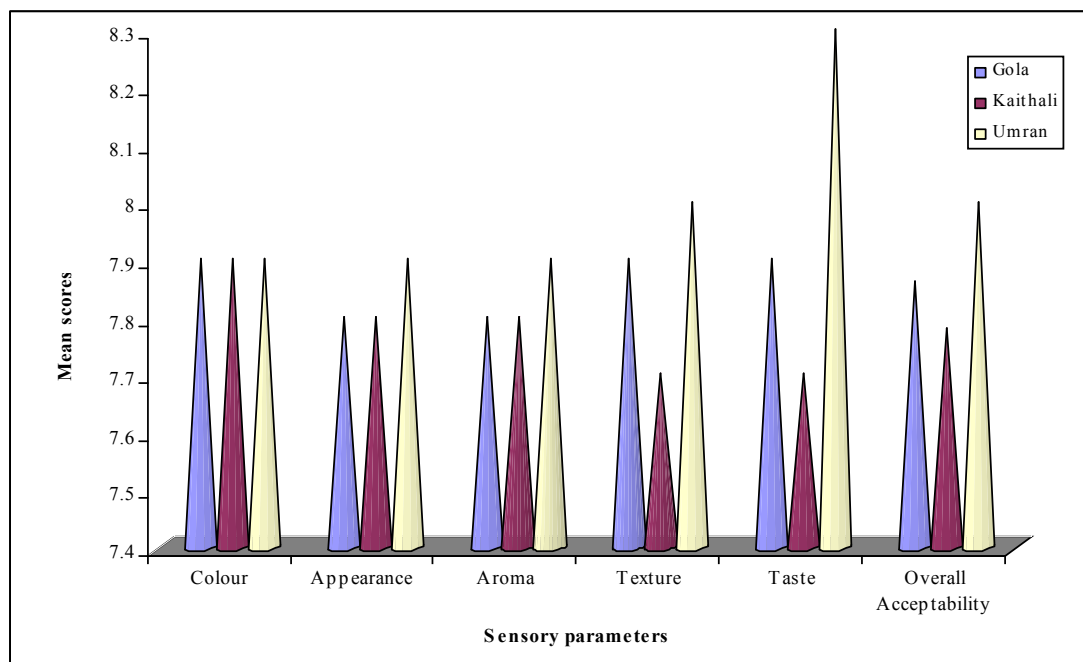
Varieties	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
Gola	7.90 ± 0.23	7.80 ± 0.25	7.80 ± 0.25	7.90 ± 0.26	7.90 ± 0.13	7.86 ± 0.20
Kaithali	7.90 ± 0.18	7.80 ± 0.20	7.80 ± 0.20	7.70 ± 0.21	7.70 ± 0.15	7.78 ± 0.17
Umran	7.90 ± 0.18	7.90 ± 0.23	7.90 ± 0.23	8.00 ± 0.25	8.30 ± 0.23	8.00 ± 0.19
CD (P≤0.05)	NS	NS	NS	NS	NS	NS

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant (P≤0.05)

The mean scores for colour, appearance, aroma, texture and taste of powder prepared from Gola variety were 7.90, 7.80, 7.80, 7.90 and 7.90, respectively, of Kaithali variety were 7.90, 7.80, 7.80, 7.70 and 7.70, respectively and of Umran variety were 7.90, 7.90, 7.90, 8.00 and 8.30, respectively. The texture, taste and overall acceptability of the powder from Umran variety was rated as ‘liked very much’ while the other two powders were rated as ‘liked moderately’ for these parameters. Non-significant (P≤0.05) differences were observed in the colour, aroma, appearance, texture, taste and overall acceptability of all the powders. The powder prepared using Umran variety scored slightly higher mean scores with regards to appearance, aroma, texture, taste and overall acceptability as compared to the powder prepared using Gola and Kaithali varieties. The colour of all the powders was liked equally

and moderately. Overall, the data revealed that *ber* powder prepared from Umran variety was liked most (8.00) followed by the powders prepared from Gola (7.86) and Kaithali (7.78) varieties. Fig. 3 showed the mean scores for sensory evaluation of *ber* powders.



**Fig. 3: Mean scores for sensory evaluation of *ber* powders**

#### 4.1.3 Physico-chemical properties of *ber* powders

The acidity, total soluble sugar/acid ratio and browning of powders prepared from all the three varieties are presented in Table 4.2. The data revealed that the acidity content of powders prepared from Gola, Kaithali and Umran varieties was 2.19, 2.16 and 2.09 per cent, respectively. The acidity content of powders prepared from Gola and Kaithali varieties was similar and significantly ( $P \leq 0.05$ ) higher than the powder prepared from Umran variety.

**Table 4. 2:- Physico-chemical properties of *ber* powders (on dry matter basis)**

Varieties	Acidity (%)	Total Soluble Sugar (TSS)/acid ratio	Browning (OD at 440 nm)
Gola	2.19 <sup>a</sup> ± 0.01	8.93 <sup>b</sup> ± 0.13	0.09 <sup>a</sup> ± 0.00
Kaithali	2.16 <sup>a</sup> ± 0.01	8.82 <sup>b</sup> ± 0.05	0.08 <sup>a</sup> ± 0.00
Umran	2.09 <sup>b</sup> ± 0.01	9.66 <sup>a</sup> ± 0.15	0.08 <sup>a</sup> ± 0.00
CD ( $P \leq 0.05$ )	0.04	0.42	NS

Values are Mean ± SE of the three independent determinations.  
Mean values with same superscript are not significantly different.  
NS=Non-significant ( $P \leq 0.05$ )

The total soluble sugar/acid ratio of powder of Gola, Kaithali and Umran varieties was 8.93, 8.82 and 9.66, respectively. The data depicted that the total soluble sugar/acid ratio

of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher than other two powders whose total soluble sugar/acid ratio was almost similar and non-significantly ( $P \leq 0.05$ ) different from each other.

The browning content of powders prepared from Gola, Kaithali and Umran varieties was 0.09, 0.08 and 0.08 respectively, when the Optical Densities of powders were measured at 440 nanometers. The browning content of all the powders differed non-significantly ( $P \leq 0.05$ ) from each other.

#### 4.1.4 Shelf-life studies of *ber* powders

The powders prepared from Gola, Kaithali and Umran varieties of *ber* fruits were stored at room temperature in air-tight food grade plastic containers and were analyzed for sensory parameters by a panel of ten judges using 9-point hedonic scale. The powders were analyzed for two months at an interval of 15 days each. The results of shelf-life studies are depicted in Table 4.3 to Table 4.8.

The colour of all the powders was similar at 0 and 15<sup>th</sup> day of storage while it started changing thereafter (Table 4.3). Significant ( $P \leq 0.05$ ) differences were observed for all the varieties during storage. The colour of powders of all the varieties scored significantly ( $P \leq 0.05$ ) lower mean scores at 45<sup>th</sup> and 60<sup>th</sup> day of storage as compared to 0 day of storage. However, the colour of powder prepared from Umran variety was liked little more on 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup> day of storage than the powders prepared from Gola and Kaithali varieties. The colour of powders from Gola and Kaithali varieties was liked similarly at 60<sup>th</sup> day of storage. During the storage period the acceptability of colour of all the powders fell in the category of 'liked moderately' by the panel of judges.

**Table 4.3:-Effect of storage on colour of developed powders**

Varieties	Storage Period (days)				
	0	15	30	45	60
Gola	7.90 ± 0.74	7.80 ± 0.79	7.70 ± 0.79	7.50 ± 0.82	7.40 ± 0.42
Kaithali	7.90 ± 0.57	7.80 ± 0.63	7.60 ± 0.63	7.40 ± 0.65	7.40 ± 0.48
Umran	7.90 ± 0.57	7.80 ± 0.74	7.80 ± 0.74	7.60 ± 0.79	7.50 ± 0.74
CD ( $P \leq 0.05$ )	For variety= NS		For storage= 0.34		

Values are Mean ± SE of the ten independent mean scores.  
NS=Non-significant ( $P \leq 0.05$ )

The appearance of all the powders fell in the category of 'liked moderately' during the storage period (Table 4.4). Powders from all the varieties differed significantly ( $P \leq 0.05$ ), in terms of appearance, during their storage period. The appearance of powders of all the varieties scored significantly ( $P \leq 0.05$ ) lower mean scores at 45<sup>th</sup> and 60<sup>th</sup> day of storage as compared to 0 day of storage. However, the appearance of powder from Umran variety was

liked slightly more at 0 and 15<sup>th</sup> day of storage while the appearance of rest of the powders was same. At 30<sup>th</sup> day of storage, the appearance of powders from Gola and Umran varieties was similar and liked slightly more than powder from Kaithali variety. At 45<sup>th</sup> and 60<sup>th</sup> day of storage, the appearance of powder of Gola and Kaithali varieties was similar and like slightly less than powder of Umran variety.

**Table 4.4:-Effect of storage on appearance of developed powders**

	Storage Period (days)				
Varieties	0	15	30	45	60
Gola	7.80 ± 0.25	7.70 ± 0.21	7.60 ± 0.27	7.40 ± 0.22	7.30 ± 0.15
Kaithali	7.80 ± 0.20	7.70 ± 0.30	7.50 ± 0.31	7.40 ± 0.34	7.30 ± 0.26
Umran	7.90 ± 0.23	7.90 ± 0.21	7.60 ± 0.22	7.50 ± 0.31	7.40 ± 0.22
CD (P≤0.05)	For variety= NS		For storage= 0.37		

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant (P≤0.05)

The mean scores of aroma of powder prepared from Umran variety were liked slightly more than powders from Gola and Kaithali varieties whose mean scores for aroma were equal at 0 and 15<sup>th</sup> day of storage (Table 4.5). The aroma of powders from Gola and Umran varieties was liked equally and slightly more than the powder from Kaithali variety at 30<sup>th</sup> day of storage. At 45<sup>th</sup> and 60<sup>th</sup> day of storage, the aroma of powder prepared from Umran variety was preferred more followed by powder of Gola and Kaithali varieties. Overall, the mean scores of aroma indicated that the acceptability of all the powders were in the range of 'liked moderately' during the storage period. The aroma of all the powders differed significantly (P≤0.05) during storage period. The aroma of powders of all the varieties scored significantly (P≤0.05) lower mean scores at 45<sup>th</sup> and 60<sup>th</sup> day of storage as compared to 0 day of storage.

**Table 4.5:-Effect of storage on aroma of developed powders**

	Storage Period (days)				
Varieties	0	15	30	45	60
Gola	7.80 ± 0.25	7.70 ± 0.21	7.60 ± 0.27	7.40 ± 0.22	7.30 ± 0.15
Kaithali	7.80 ± 0.20	7.70 ± 0.21	7.50 ± 0.22	7.30 ± 0.34	7.20 ± 0.20
Umran	7.90 ± 0.23	7.80 ± 0.23	7.60 ± 0.22	7.50 ± 0.31	7.40 ± 0.21
CD (P≤0.05)	For variety= NS		For storage= 0.37		

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant (P≤0.05)

Mean scores of texture of *ber* powders indicated that the acceptability of texture of powder prepared from Umran variety was rated as ‘liked very much’ at the beginning of storage when the powders of other two varieties were rated as ‘liked moderately (Table 4.6). All the *ber* powders were ‘liked moderately’ at 15<sup>th</sup> day of storage and thereafter till the end of their storage period. The texture of all the powders differed significantly ( $P \leq 0.05$ ) during storage period. The texture of powders of all the varieties scored significantly ( $P \leq 0.05$ ) lower mean scores after one month of storage as compared to the beginning of storage period. However, the texture of powders from Gola and Kaithali varieties was liked slightly less than the texture of powder from Umran variety during the storage.

**Table 4.6:-Effect of storage on texture of developed powders**

Varieties	Storage Period (days)				
	0	15	30	45	60
Gola	7.90 ± 0.26	7.60 ± 0.22	7.50 ± 0.31	7.30 ± 0.21	7.20 ± 0.13
Kaithali	7.70 ± 0.21	7.40 ± 0.18	7.30 ± 0.34	7.20 ± 0.37	7.10 ± 0.23
Umran	8.00 ± 0.25	7.80 ± 0.21	7.70 ± 0.27	7.50 ± 0.27	7.40 ± 0.21
CD ( $P \leq 0.05$ )	For variety= NS		For storage= 0.36		

Values are Mean ± SE of the ten independent mean scores.  
NS=Non-significant ( $P \leq 0.05$ )

Mean scores of taste indicated that all the powders were acceptable during storage (Table 4.7). Significant ( $P \leq 0.05$ ) differences were observed for the taste of all the powders during storage period.

**Table 4.7:-Effect of storage on taste of developed powders**

Varieties	Storage Period (days)				
	0	15	30	45	60
Gola	7.90 ± 0.13	7.70 ± 0.21	7.50 ± 0.34	7.40 ± 0.21	7.30 ± 0.13
Kaithali	7.70 ± 0.15	7.60 ± 0.16	7.40 ± 0.31	7.30 ± 0.40	7.20 ± 0.23
Umran	8.30 ± 0.23	8.10 ± 0.21	7.90 ± 0.22	7.70 ± 0.31	7.50 ± 0.22
CD ( $P \leq 0.05$ )	For variety= NS		For storage= 0.39		

Values are Mean ± SE of the ten independent mean scores.  
NS=Non-significant ( $P \leq 0.05$ )

The taste of powders of all the varieties scored significantly ( $P \leq 0.05$ ) lower mean scores after one month of storage as compared to the beginning of storage period. However, the taste of powder prepared from Umran variety was ‘liked very much’ at 0 and 15<sup>th</sup> day of storage while the taste of other powders was ‘liked moderately’. The taste of powder prepared from Gola variety was preferred slightly more than the powder from Kaithali variety. The taste of powder of Umran variety was liked slightly more followed by the taste of powders of Gola

and Kaithali varieties at 0, 15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup> day of storage. Overall, it can be concluded from the results that the acceptability of all the powders was ‘liked moderately’ in terms of taste during the end of the storage period.

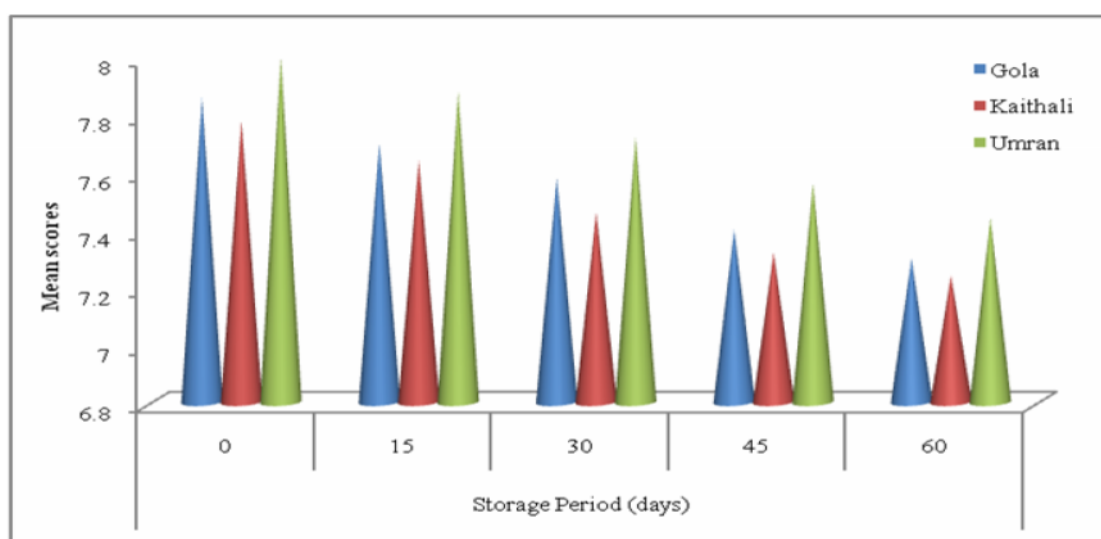
The data indicated that the overall acceptability of powder of Umran variety fell in the category of ‘liked very much’ in the beginning of storage while the other powders were in the range of ‘liked moderately’ during their storage period (Table 4.8). Significant ( $P \leq 0.05$ ) differences were observed in the overall acceptability of all the powders during their storage. The overall acceptability of powders of all the varieties scored significantly ( $P \leq 0.05$ ) lower mean scores after one month of storage as compared to the beginning of storage period. However, the overall acceptability of powder prepared from Umran variety was liked slightly more followed by powder of Gola and Kaithali varieties at 0, 15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup> day of storage. It was observed from the data that the powder of Umran variety was preferred more over the other two powders. Fig. 4 showed the mean scores for overall acceptability of *ber* powders after storage.

**Table 4.8:-Effect of storage on overall acceptability of developed powders**

Varieties	Storage Period (days)				
	0	15	30	45	60
Gola	7.86 ± 0.20	7.70 ± 0.18	7.58 ± 0.28	7.40 ± 0.21	7.30 ± 0.13
Kaithali	7.78 ± 0.17	7.64 ± 0.17	7.46 ± 0.27	7.32 ± 0.35	7.24 ± 0.21
Umran	8.00 ± 0.19	7.88 ± 0.18	7.72 ± 0.22	7.56 ± 0.30	7.44 ± 0.20
CD ( $P \leq 0.05$ )	For variety= NS		For storage= 0.35		

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant ( $P \leq 0.05$ )



**Fig 4: Mean scores for overall acceptability of *ber* powders after storage**

## 4.2 Nutritional evaluation of *ber* powders

All the three varieties of *ber* namely Gola, Kaithali and Umran were used for making powder. The powders from all the varieties were nutritionally analyzed for proximate composition (moisture, crude protein, crude fat, crude fiber and ash), carbohydrates (total soluble sugars, reducing sugars and non-reducing sugars), minerals (calcium, iron, magnesium and zinc), vitamins (ascorbic acid and  $\beta$ -carotene) and *in-vitro* digestibilities of protein and starch.

### 4.2.1 Proximate composition of *ber* powders

The moisture, crude protein, crude fat, crude fiber and ash content of *ber* powders are presented in Table 4.9. The moisture content of powders prepared from Gola, Kaithali and Umran varieties was 5.68, 5.35 and 5.21 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed for the moisture content among the powders of all the varieties.

**Table 4.9:- Proximate composition of the developed powders (g/100g, on dry matter basis)**

Varieties	Moisture	Crude Protein	Crude Fat	Crude fiber	Ash
Gola	5.68 <sup>a</sup> $\pm$ 0.11	6.92 <sup>b</sup> $\pm$ 0.17	1.03 <sup>b</sup> $\pm$ 0.02	3.75 <sup>b</sup> $\pm$ 0.04	4.49 <sup>a</sup> $\pm$ 0.27
Kaithali	5.35 <sup>a</sup> $\pm$ 0.14	7.17 <sup>b</sup> $\pm$ 0.08	0.99 <sup>c</sup> $\pm$ 0.01	3.52 <sup>c</sup> $\pm$ 0.05	4.27 <sup>a</sup> $\pm$ 0.06
Umran	5.21 <sup>a</sup> $\pm$ 0.11	7.83 <sup>a</sup> $\pm$ 0.17	1.07 <sup>a</sup> $\pm$ 0.01	3.91 <sup>a</sup> $\pm$ 0.03	4.31 <sup>a</sup> $\pm$ 0.05
CD ( $P \leq 0.05$ )	NS	0.51	0.04	0.14	NS

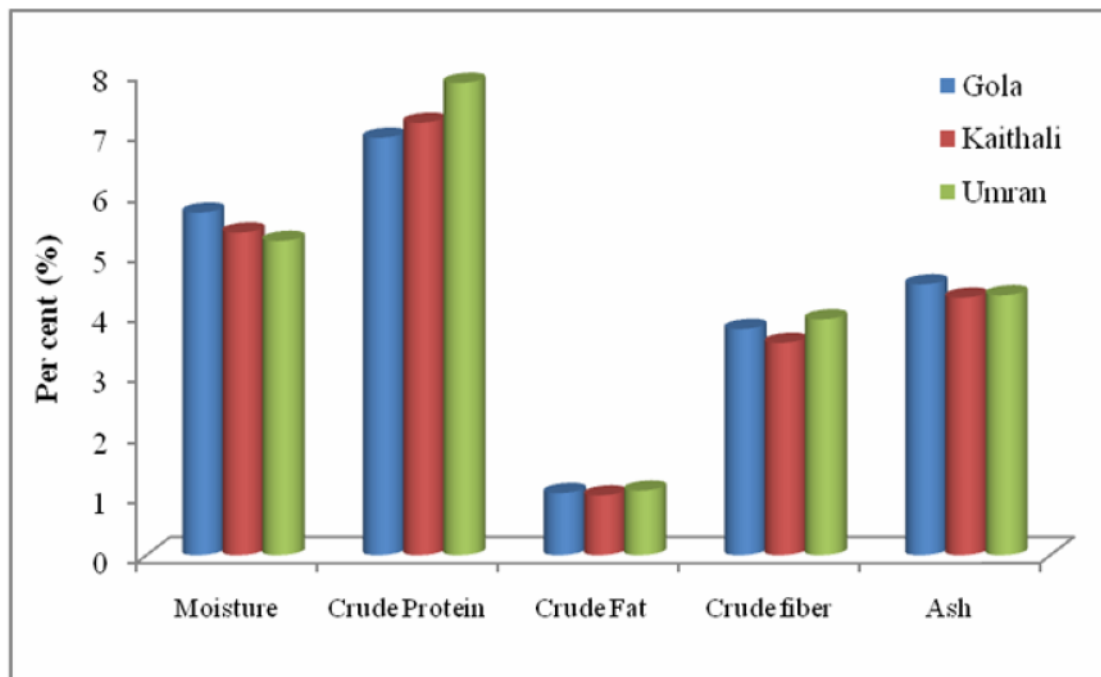
Values are Mean  $\pm$  SE of the three independent determinations.  
Mean values with same superscript are not significantly different.  
NS=Non-significant ( $P \leq 0.05$ )

The crude protein content of powder prepared from Gola, Kaithali and Umran variety was 6.92, 7.17 and 7.83 per cent, respectively. The crude protein content of powders prepared from Gola and Kaithali varieties was similar and non-significantly ( $P \leq 0.05$ ) different from each other while the crude protein content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher than the other two varieties.

The crude fat content of powders prepared from all the three varieties ranged from 0.99 to 1.07 per cent. The crude fat content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher while the crude fat content of powder prepared from Kaithali variety was significantly ( $P \leq 0.05$ ) lower among the three varieties. Significant ( $P \leq 0.05$ ) differences were observed in the crude fat content among powders of all the three varieties.

The crude fiber content of powders prepared from Gola, Kaithali and Umran varieties was 3.75, 3.52 and 3.91 per cent, respectively. The crude fiber content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher while the crude fiber content of powder of Kaithali variety was significantly ( $P \leq 0.05$ ) lower among the three varieties. Significant ( $P \leq 0.05$ ) differences were observed in the crude fiber content among all the three varieties.

The ash content of powders prepared from Gola, Kaithali and Umran varieties was 4.49, 4.27 and 4.31 per cent, respectively. The ash content of all the powders was similar and non-significantly ( $P \leq 0.05$ ) different from each other. Fig. 5 showed proximate composition of *ber* powders.



**Fig 5: Proximate composition of *ber* powders**

#### 4.2.2 Carbohydrate content of *ber* powders

The result about total soluble sugars, reducing sugars and non-reducing sugars content of powders prepared from Gola, Kaithali and Umran varieties are presented in Table 4.10. The total soluble sugars content of *ber* powders ranged from 19.08 to 20.17 g/100g. The total sugar content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher while the total soluble sugars content of powder prepared from Kaithali variety was significantly ( $P \leq 0.05$ ) lower among the three varieties. The total soluble sugars content of powder of Gola variety was non-significantly ( $P \leq 0.05$ ) different from the other two varieties.

**Table 4.10:- Carbohydrate content of the developed powders (g/100g, on dry matter basis)**

Varieties	Total soluble sugars	Reducing sugars	Non-reducing sugars
Gola	19.58 <sup>ab</sup> ± 0.17	3.80 <sup>a</sup> ± 0.28	15.78 <sup>ab</sup> ± 0.07
Kaithali	19.08 <sup>b</sup> ± 0.22	3.61 <sup>a</sup> ± 0.35	15.47 <sup>b</sup> ± 0.15
Umran	20.17 <sup>a</sup> ± 0.30	3.98 <sup>a</sup> ± 0.48	16.19 <sup>a</sup> ± 0.21
CD ( $P \leq 0.05$ )	0.83	NS	0.53

Values are Mean ± SE of the three independent determinations.  
Mean values with same superscript are not significantly different.  
NS=Non-significant ( $P \leq 0.05$ )

The reducing sugars content of powder of Gola, Kaithali and Umran varieties was 3.80, 3.61 and 3.98 g/100g, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed for the reducing sugars content among the powders of all the three varieties.

The non-reducing sugars content of powders prepared from all the three varieties ranged from 15.47 to 16.19 per cent. The non-reducing sugars content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher while the non-reducing sugars content of powder prepared from Kaithali variety was significantly ( $P \leq 0.05$ ) lower among powders of all the three varieties. The non-reducing sugars content of powder of Gola variety was similar and showed non-significant ( $P \leq 0.05$ ) differences from the other two varieties.

#### 4.2.3 Mineral content of *ber* powders

The calcium, iron, magnesium and zinc content of all the powders prepared using Gola, Kaithali and Umran varieties are presented in Table 4.11. The calcium content of powders prepared from Gola, Kaithali and Umran varieties was 148.56, 153.63 and 151.42 mg/100g, respectively. The calcium content of powder prepared from Kaithali and Umran varieties was significantly ( $P \leq 0.05$ ) higher than the calcium content of powder prepared from Gola variety. The calcium content of powder prepared from Kaithali variety was slightly more than the calcium content of powder of Umran variety but both of them differed non-significantly ( $P \leq 0.05$ ) from each other.

**Table 4.11:- Mineral content of the developed powders (mg/100g, on dry matter basis)**

Varieties	Calcium	Iron	Magnesium	Zinc
Gola	148.56 <sup>b</sup> ± 0.22	17.87 <sup>c</sup> ± 0.09	86.67 <sup>a</sup> ± 2.91	0.98 <sup>a</sup> ± 0.03
Kaithali	153.63 <sup>a</sup> ± 0.27	18.30 <sup>b</sup> ± 0.12	84.43 <sup>a</sup> ± 2.89	0.91 <sup>a</sup> ± 0.03
Umran	151.42 <sup>a</sup> ± 0.16	18.65 <sup>a</sup> ± 0.08	90.33 <sup>a</sup> ± 2.40	0.94 <sup>a</sup> ± 0.01
CD ( $P \leq 0.05$ )	2.78	0.35	NS	NS

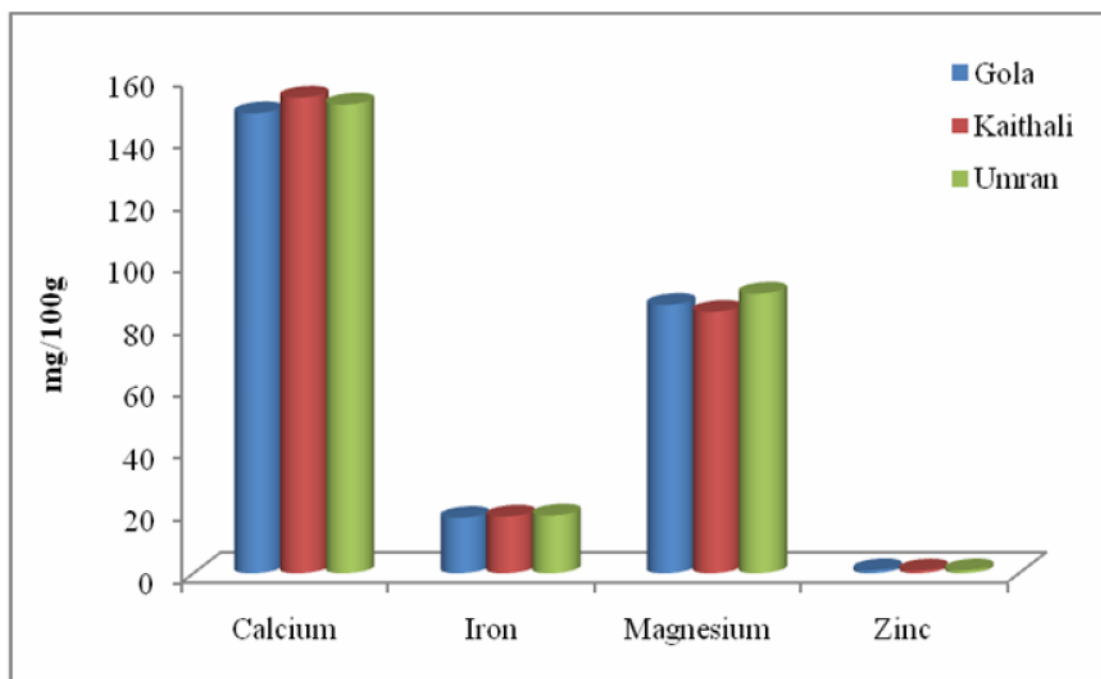
Values are Mean ± SE of the three independent determinations.  
Mean values with same superscript are not significantly different.  
NS=Non-significant ( $P \leq 0.05$ )

The iron content of powders varied from 17.87 to 18.65 mg/100g. The iron content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher and the iron content of powder of Gola variety was significantly ( $P \leq 0.05$ ) lower among the three varieties. The iron content of all the varieties differed significantly ( $P \leq 0.05$ ) from each other.

The magnesium content of powders prepared from Gola, Kaithali and Umran varieties was 86.67, 84.43, 90.33 mg/100g, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed for the magnesium content among the powders of all the varieties.

The zinc content of all the *ber* powders ranged from 0.91 to 0.98 mg/100g, being highest in powder of Gola variety followed by powders of Umran and Kaithali varieties. The

zinc content of all the powders was similar and non-significantly ( $P \leq 0.05$ ) different from each other. Fig. 6 showed mineral content of *ber* powders.



**Fig 6: Mineral content of *ber* powders**

#### 4.2.4 Vitamin content of *ber* powders

The ascorbic acid content of powders prepared from Gola, Kaithali and Umran varieties was 46.77, 47.20 and 48.23 mg/100g, respectively (Table 4.12). The ascorbic acid content of powder of Umran variety was significantly ( $P \leq 0.05$ ) higher than the powder of other two varieties whose ascorbic acid content were non-significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.12:- Vitamin content of the developed powders (mg/100g, on dry matter basis)**

Varieties	Ascorbic acid	$\beta$ -carotene
Gola	46.77 <sup>b</sup> $\pm$ 0.20	2.63 <sup>ab</sup> $\pm$ 0.12
Kaithali	47.20 <sup>b</sup> $\pm$ 0.23	2.38 <sup>b</sup> $\pm$ 0.09
Umran	48.23 <sup>a</sup> $\pm$ 0.23	2.94 <sup>a</sup> $\pm$ 0.06
CD ( $P \leq 0.05$ )	0.79	0.33

Values are Mean  $\pm$  SE of the three independent determinations.  
Mean values with same superscript are not significantly different.

The  $\beta$ -carotene content of powders prepared from all the three varieties of *ber* is presented in Table 4.12. The  $\beta$ -carotene content of powders ranged from 2.38 to 2.94 mg/100g. It was observed from the data that the  $\beta$ -carotene content of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher while that of powder prepared from Kaithali

variety was significantly ( $P \leq 0.05$ ) lower among the three varieties. The  $\beta$ -carotene content of powder of Gola variety was non-significantly ( $P \leq 0.05$ ) different from the other two varieties.

#### 4.2.5 *In-vitro* digestibilities of ber powders

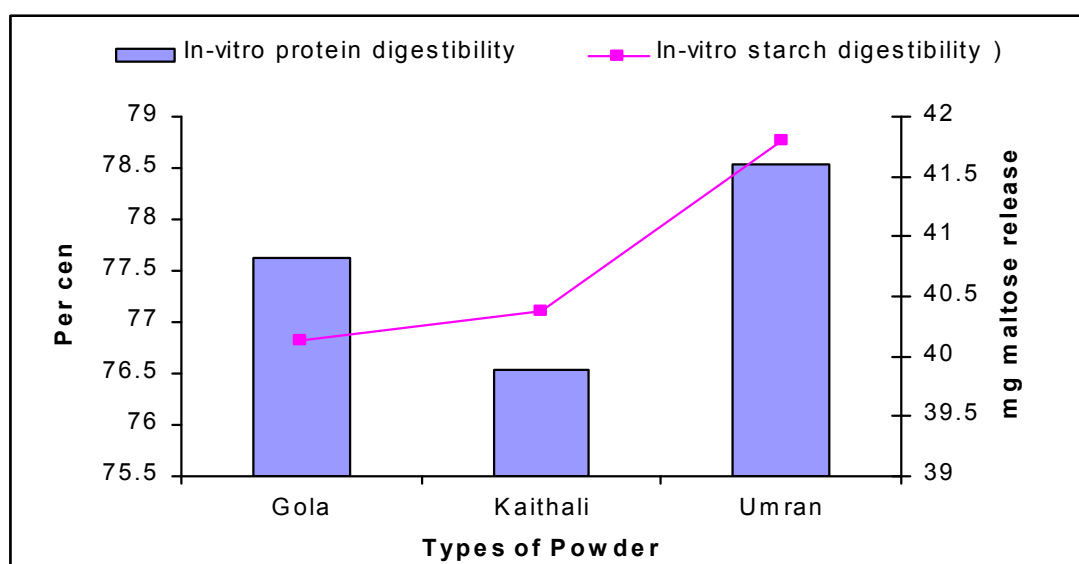
The *in-vitro* protein digestibility of powders prepared from Gola, Kaithali and Umran varieties ranged from 76.53 to 78.53 per cent (Table 4.13). The *in-vitro* protein digestibility of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher while that of Kaithali variety was significantly lower among the powders of all the three varieties. The *in-vitro* protein digestibility of powder prepared from Gola variety was non-significantly ( $P \leq 0.05$ ) different from the powders of other two varieties.

**Table 4.13:- *In-vitro* digestibilities of the developed powders (on dry matter basis)**

Varieties	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g powder)
Gola	77.63 <sup>ab</sup> $\pm$ 0.38	40.13 <sup>b</sup> $\pm$ 0.41
Kaithali	76.53 <sup>b</sup> $\pm$ 0.12	40.37 <sup>b</sup> $\pm$ 0.31
Umran	78.53 <sup>a</sup> $\pm$ 0.49	41.80 <sup>a</sup> $\pm$ 0.23
CD ( $P \leq 0.05$ )	1.29	1.15

Values are Mean  $\pm$  SE of the three independent determinations.  
Mean values with same superscript are not significantly different.

The *in-vitro* starch digestibility of powders prepared from Gola, Kaithali and Umran varieties of *ber* was 40.13, 40.37 and 41.80 mg maltose released/ g powder, respectively (Table 4.13). The *in-vitro* starch digestibility of powder prepared from Umran variety was significantly ( $P \leq 0.05$ ) higher than the other two varieties whose *in-vitro* starch digestibility was almost similar and non-significantly ( $P \leq 0.05$ ) different from each other. Fig. 7 showed *in-vitro* digestibilities of *ber* powders.



**Fig. 7: *In-vitro* digestibilities of ber powders**

### 4.3 Development of value added products and their sensory evaluation

Keeping in view, the good nutritive value especially the protein, calcium, iron, magnesium, vitamin C content and *in-vitro* digestibilities of *ber* powder, various value added products were developed using its powder. For the development of the products powder prepared from Umran variety was selected on the basis of its sensory evaluation, high total soluble sugars/acid ratio, high protein content, high carbohydrate content, high mineral content like calcium, iron and magnesium, high ascorbic acid content, high *in-vitro* protein and starch digestibility. The products developed included custard, *kheer*, biscuits, cake, pasta, noodles and RTS beverage. Different concentrations of *ber* powders were used for the formulation of products. Their sensory evaluation with respect to parameters like colour, appearance, aroma, texture, taste and overall acceptability was adjudged by panel of ten judges from I.C. College of Home Science, CCS Haryana Agricultural University using a 9 point hedonic scale.

#### 4.3.1 Sensory evaluation of Custard

Five types of custard namely type I, II, III, IV and V were prepared by incorporating 10, 20, 30, 40 and 50 per cent *ber* (Umran variety) powder, respectively, in place of custard powder in the basic standardized recipe. The custard prepared using custard powder and no *ber* powder served as control. Mean scores of sensory evaluation of custard are presented in Table 4.14.

**Table 4.14:- Sensory evaluation of Custard**

Type of Custard	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	7.90 ± 0.23	7.90 ± 0.23	7.90 ± 0.23	7.90 ± 0.23	7.90 ± 0.23	7.90 ± 0.23
I	7.90 ± 0.31	7.90 ± 0.31	8.00 ± 0.26	8.10 ± 0.28	8.20 ± 0.20	8.02 ± 0.26
II	7.90 ± 0.23	7.70 ± 0.29	7.80 ± 0.23	7.80 ± 0.29	7.70 ± 0.30	7.78 ± 0.26
III	7.80 ± 0.33	7.60 ± 0.36	7.60 ± 0.34	7.30 ± 0.40	7.30 ± 0.37	7.52 ± 0.33
IV	7.80 ± 0.25	7.40 ± 0.31	7.20 ± 0.30	6.40 ± 0.33	6.10 ± 0.31	6.98 ± 0.27
V	7.80 ± 0.29	7.30 ± 0.31	7.00 ± 0.36	6.10 ± 0.35	5.70 ± 0.30	6.78 ± 0.28
CD (P≤0.05)	NS	NS	0.61	0.88	0.97	0.74

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant (P≤0.05)

Control = 100 % CP

I= 10:90 (BP:CP)

II= 20:80 (BP:CP)

III= 30:70 (BP:CP)

IV= 40:60 (BP:CP)

V= 50:50 (BP:CP)

BP= *Ber* powder

CP= Custard Powder

The mean scores for colour, appearance, aroma, texture, taste and overall acceptability of all the types of custard ranged from 7.80 to 7.90, 7.30 to 7.90, 7.00 to 8.00, 6.10 to 8.10, 5.70 to 8.20 and 6.78 to 8.02, respectively. It was observed from the mean scores of colour that type III, IV and V custard were preferred slightly less than type I, II and control

custard. The appearance of type I custard was same as that of control custard while the appearance of type II custard was slightly less followed by type III, IV and V custard. Sensory characteristics namely aroma, texture, taste and overall acceptability of type I custard were rated as 'liked very much' while that of control, type II and III were rated as 'liked moderately'. The aroma of type IV and V custard was rated as 'liked moderately' while their texture and overall acceptability were rated as 'liked slightly'. The taste of type IV custard was rated as 'liked slightly' while the taste of type V custard was rated as 'neither liked nor disliked'. The mean scores indicated that the type I custard was liked most (8.02) followed by control (7.90), type II (7.78), III (7.52), IV (6.98) and V (6.78) custard. Non-significant ( $P \leq 0.05$ ) differences in mean scores were observed for colour and appearance of all types of custard while significant ( $P \leq 0.05$ ) differences were observed for aroma, texture, taste and overall acceptability of custard. The aroma, texture, taste and overall acceptability of type IV and V custard were significantly ( $P \leq 0.05$ ) lower than type I custard whose mean scores for all these sensory attributes were higher among all. However, all the types of custard were organoleptically acceptable as judged by the panel of judges.

#### 4.3.2 Sensory evaluation of *Kheer*

Five types of *kheer*, type I, II, III, IV and V were prepared using powder from Umran variety of *ber*. The rice in the standardized recipe of *kheer* was replaced using 10, 20, 30, 40 and 50 per cent *ber* powder, respectively. The mean scores of *kheer* are indicated in Table 4.15.

**Table 4.15:- Sensory evaluation of *Kheer***

Type of <i>Kheer</i>	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	8.00 ± 0.15	8.00 ± 0.15	8.00 ± 0.15	8.00 ± 0.15	8.20 ± 0.20	8.04 ± 0.15
I	8.00 ± 0.15	8.00 ± 0.15	8.00 ± 0.15	8.00 ± 0.15	8.10 ± 0.18	8.02 ± 0.15
II	7.90 ± 0.23	7.90 ± 0.18	7.70 ± 0.20	7.70 ± 0.20	7.60 ± 0.22	7.76 ± 0.19
III	7.90 ± 0.31	7.70 ± 0.29	7.50 ± 0.29	7.30 ± 0.26	7.10 ± 0.21	7.50 ± 0.27
IV	7.80 ± 0.36	7.60 ± 0.36	6.70 ± 0.30	6.50 ± 0.47	6.20 ± 0.44	6.96 ± 0.35
V	7.80 ± 0.42	7.50 ± 0.43	6.60 ± 0.35	6.10 ± 0.38	5.80 ± 0.37	6.76 ± 0.32
CD ( $P \leq 0.05$ )	NS	NS	0.78	0.93	1.28	0.85

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant ( $P \leq 0.05$ )

Control = 100 % R

I= 10:90 (BP:R)

II= 20:80 (BP:R)

III= 30:70 (BP:R)

IV= 40:60 (BP:R)

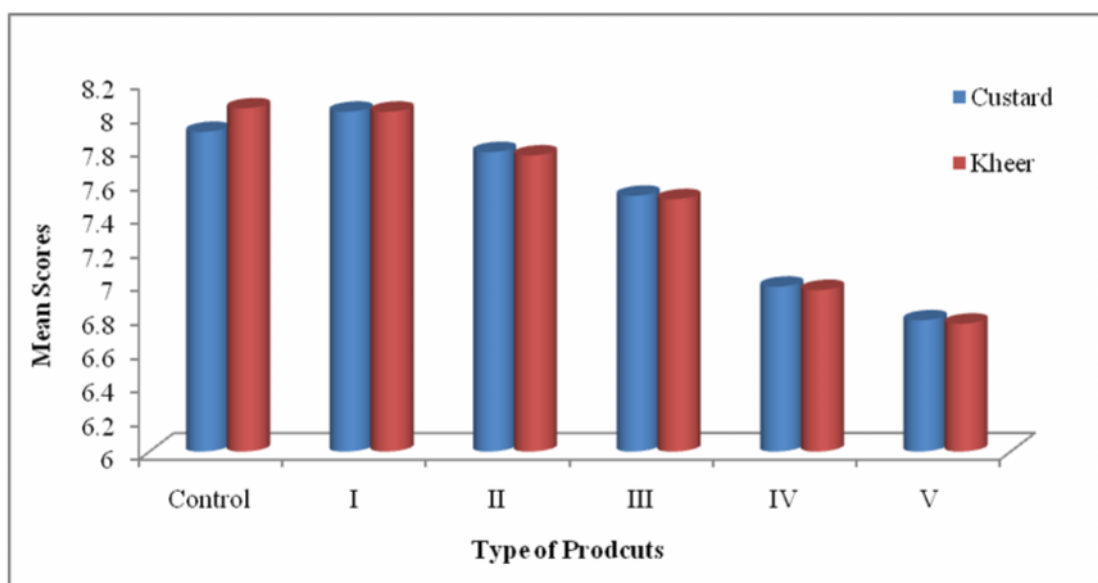
V= 50:50 (BP:R)

BP= *Ber* powder

R= Rice

The mean scores for colour, appearance, aroma, texture, taste and overall acceptability of all the types of *kheer* ranged from 7.80 to 8.00, 7.50 to 8.00, 6.60 to 8.00,

6.10 to 8.00, 5.80 to 8.20 and 6.76 to 8.04, respectively. Mean scores depicted that all the sensory characteristics like colour, appearance, aroma, texture, taste and overall acceptability of control and type I *kheer* were ‘liked very much’ by the panel of judges while all the sensory characteristics of type II and III *kheer* were recorded as ‘liked moderately’. The colour and appearance of type IV and V *kheer* were ‘liked moderately’ while their aroma, texture and overall acceptability were ‘liked slightly’ by the panel of judges. It was also observed from the data that the taste of type IV *kheer* was ‘liked slightly’ but the taste of type V *kheer* was ‘neither liked nor disliked’. Overall, it was inferred from the table that control *kheer* was preferred slightly more (8.04) over type I *kheer* (8.02) followed by type II (7.76), III (7.50), IV (6.96) and V (6.76) *kheer*. The mean scores for aroma, texture, taste and overall acceptability of control and type I *kheer* were found to be significantly ( $P \leq 0.05$ ) higher than type IV and V *kheer*. Fig. 8 showed the mean score for overall acceptability of traditional products.



**Fig. 8: Mean scores for overall acceptability of traditional products**

#### 4.3.3 Sensory evaluation of Biscuits

The control biscuits were prepared using refined wheat flour while the *ber* biscuits, type I, II, III, IV and V, were prepared by replacing refined wheat flour in the ratio of 10, 20, 30, 40 and 50 per cent, respectively. The organoleptic scores of biscuits are presented in Table 4.16.

Mean scores of biscuits for colour were 7.60 to 7.80, appearance were 7.50 to 7.80, aroma were 7.20 to 7.80, texture were 7.10 to 7.80, taste were 7.20 to 8.10 and overall acceptability were 7.30 to 7.86. The mean scores for all the sensory parameters of all the biscuits were rated as ‘liked moderately’ by the panel of judges except for the taste of type I biscuits which were rated as ‘liked very much’. The data indicated that type I biscuits scored

slightly higher (7.86) mean scores as compared to control (7.82) biscuits. The mean scores of overall acceptability of type II biscuits (7.66) were higher than type III (7.54), IV (7.42) and V (7.32) biscuits. The colour and aroma of all types of biscuits were observed to be non-significantly ( $P \leq 0.05$ ) different from each other while significant ( $P \leq 0.05$ ) differences were observed in the mean score for aroma, texture, taste and overall acceptability of all the biscuits. The aroma, texture, taste and overall acceptability of control and type I biscuits were significantly ( $P \leq 0.05$ ) higher than type IV and V biscuits. Overall, it was inferred that all the prepared *ber* powder biscuits were organoleptically acceptable.

**Table 4.16:- Sensory evaluation of Biscuits**

Type of Biscuits	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	7.80 ± 0.20	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25	7.90 ± 0.23	7.82 ± 0.23
I	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25	8.10 ± 0.23	7.86 ± 0.23
II	7.70 ± 0.30	7.70 ± 0.30	7.60 ± 0.31	7.60 ± 0.31	7.70 ± 0.30	7.66 ± 0.30
III	7.70 ± 0.34	7.60 ± 0.34	7.50 ± 0.37	7.40 ± 0.31	7.50 ± 0.16	7.54 ± 0.26
IV	7.60 ± 0.31	7.60 ± 0.31	7.30 ± 0.30	7.20 ± 0.33	7.40 ± 0.31	7.42 ± 0.27
V	7.60 ± 0.43	7.50 ± 0.43	7.20 ± 0.42	7.10 ± 0.46	7.20 ± 0.43	7.32 ± 0.39
CD ( $P \leq 0.05$ )	NS	NS	0.34	0.37	0.36	0.33

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant ( $P \leq 0.05$ )

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

#### 4.3.4 Sensory evaluation of Cake

Five different types of cake viz. type I, II, III, IV and V were prepared by supplementing 10, 20, 30, 40, and 50 per cent *ber* powder of Umran variety, respectively, with refined wheat flour in the standardized recipe of sponge cake. The control cake was prepared using 100 per cent refined wheat flour without addition of *ber* powder. The sensory attributes of cake are presented in Table 4.17.

The mean scores of all the types of cake for colour were 7.90 to 8.20, appearance were 7.80 to 8.20, aroma were 7.20 to 8.20, texture were 7.10 to 8.20 and taste were 7.10 to 8.40. Mean scores for colour, appearance, aroma, texture, taste and overall acceptability of control and type I cake were rated as 'liked very much' by the panel of judges. All the sensory parameters were rated as 'liked moderately' for type II, III, IV and V cake except for the colour of type II cake which was rated as 'liked very much'. The overall acceptability of cake ranged from 7.42 to 8.24, being highest in type I cake followed by control, type II, III, IV and V cake. Non-significant ( $P \leq 0.05$ ) differences were observed in the colour and appearance of all the prepared cake while significant ( $P \leq 0.05$ ) differences were observed in aroma, texture,

taste and overall acceptability. The aroma, texture and overall acceptability of type I cake were significantly ( $P \leq 0.05$ ) higher than type IV and V cake while the taste of type I cake was significantly ( $P \leq 0.05$ ) higher than type III, IV and V cake. However, all the cake prepared using *ber* powder were acceptable based on their sensory characteristics. Fig. 9 showed mean scores for overall acceptability of baked products.

**Table 4.17:- Sensory evaluation of Cake**

Type of Cake	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	8.20 ± 0.20	8.20 ± 0.20	8.20 ± 0.20	8.20 ± 0.20	8.20 ± 0.20	8.20 ± 0.20
I	8.20 ± 0.20	8.20 ± 0.20	8.20 ± 0.25	8.20 ± 0.25	8.40 ± 0.21	8.24 ± 0.21
II	8.00 ± 0.30	7.90 ± 0.23	7.90 ± 0.28	7.90 ± 0.28	7.80 ± 0.29	7.90 ± 0.23
III	7.90 ± 0.23	7.90 ± 0.23	7.60 ± 0.21	7.70 ± 0.21	7.50 ± 0.27	7.72 ± 0.20
IV	7.90 ± 0.20	7.80 ± 0.20	7.30 ± 0.22	7.20 ± 0.17	7.30 ± 0.21	7.50 ± 0.15
V	7.90 ± 0.23	7.80 ± 0.20	7.20 ± 0.21	7.10 ± 0.16	7.10 ± 0.25	7.42 ± 0.15
CD ( $P \leq 0.05$ )	NS	NS	0.67	0.68	0.69	0.54

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant ( $P \leq 0.05$ )

Control = 100 % RF

III= 30:70 (BP:RF)

BP= *Ber* powder

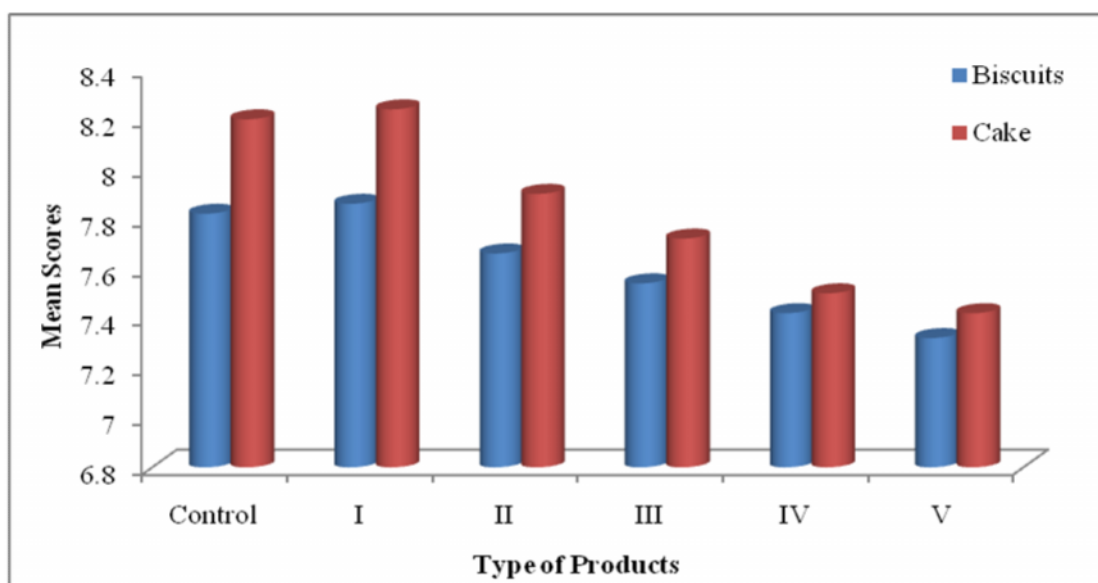
I= 10:90 (BP:RF)

IV= 40:60 (BP:RF)

RF= Refined Flour

II= 20:80 (BP:RF)

V= 50:50 (BP:RF)



**Fig. 9: Mean scores for overall acceptability of baked products**

#### 4.3.5 Sensory evaluation of Pasta

Five types of pasta were prepared using *ber* powder (Umran variety). Type I had 10 per cent, type II had 20 per cent, type III had 30 per cent, type IV had 40 per cent and type V

had 50 per cent *ber* powder. The *ber* powder replaced refined wheat flour in the standardized recipe of pasta. All the sensory parameters of Pasta are presented in Table 4.18.

**Table 4.18:- Sensory evaluation of Pasta**

Type of Pasta	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25	7.80 ± 0.25
I	7.80 ± 0.25	7.80 ± 0.25	7.70 ± 0.26	7.70 ± 0.21	7.60 ± 0.22	7.72 ± 0.22
II	7.80 ± 0.29	7.60 ± 0.22	7.50 ± 0.22	7.40 ± 0.22	7.40 ± 0.22	7.54 ± 0.22
III	7.70 ± 0.21	7.60 ± 0.22	7.30 ± 0.21	7.20 ± 0.20	7.00 ± 0.21	7.36 ± 0.13
IV	7.70 ± 0.26	7.30 ± 0.30	7.00 ± 0.26	6.80 ± 0.29	6.70 ± 0.30	7.10 ± 0.21
V	7.70 ± 0.45	7.20 ± 0.47	6.90 ± 0.48	6.70 ± 0.22	6.60 ± 0.27	7.02 ± 0.28
CD (P≤0.05)	NS	0.36	0.65	0.68	0.70	0.58

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant (P≤0.05)

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

Mean scores indicated that the colour, appearance, aroma, texture, taste and overall acceptability of pasta ranged from 7.70 to 7.80, 7.20 to 7.80, 6.90 to 7.80, 6.70 to 7.80, 6.60 to 7.80 and 7.02 to 7.80, respectively. All the sensory parameters like colour, appearance, aroma, texture, taste and overall acceptability of all types of pasta were rated as 'liked moderately' by the panel of judges except for the aroma of type V pasta and texture and taste of type IV and V pasta which were rated as 'liked slightly'. All types of pasta were 'liked moderately' in terms of their overall acceptability. Non-significant (P≤0.05) differences were observed in the colour of all types of pasta while significant (P≤0.05) differences were observed in appearance, aroma, texture, taste and overall acceptability of pasta. The appearance, aroma, texture and overall acceptability of type IV and V pasta and the taste of type III, IV and V pasta were significantly (P≤0.05) lower than their control counterpart. The control pasta was preferred more followed by type I, II, III, IV and V pasta.

#### 4.3.6 Sensory evaluation of Noodles

Five different types of noodles viz. type I, II, III, IV and V were prepared by supplementing 10, 20, 30, 40, and 50 per cent *ber* powder of Umran variety, respectively, with refined wheat flour in the basic recipe. The mean score of organoleptic characteristics of noodles are presented in Table 4.19.

Mean scores of colour, appearance, aroma, texture and taste of noodles ranged from 7.60 to 7.90, 7.20 to 7.90, 6.90 to 7.90, 6.80 to 7.90 and 6.50 to 7.80. It was observed from the data that the acceptability of colour of all the types of noodles was rated as 'liked moderately' by the panel of judges. The colour of control and type I noodles was preferred

slightly more followed by type II and III and type IV and V noodles. The appearance of control and type I noodles was same and slightly higher than the other types of noodles. The aroma of all the noodles was 'liked moderately' except for the aroma of type V noodles which was rated as 'liked slightly'. The texture and taste of type IV and V noodles were 'liked slightly' while the texture and taste of all other noodles were 'liked moderately'. However, the overall acceptability of all the types of noodles fell in the category of 'liked moderately' being highest in control noodles (7.88) followed by type I (7.80), II (7.56), III (7.40), IV (7.06) and V (7.02) noodles. Non-significant ( $P \leq 0.05$ ) differences were observed in the colour of all the noodles while the appearance, aroma, texture, taste and overall acceptability of control noodles were significantly ( $P \leq 0.05$ ) higher than type IV and V noodles. Fig. 10 showed mean scores for overall acceptability of extruded products.

**Table 4.19:- Sensory evaluation of Noodles**

Type of Noodles	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	7.90 ± 0.21	7.90 ± 0.18	7.90 ± 0.18	7.90 ± 0.18	7.80 ± 0.21	7.88 ± 0.21
I	7.90 ± 0.20	7.90 ± 0.20	7.80 ± 0.20	7.80 ± 0.20	7.60 ± 0.21	7.80 ± 0.20
II	7.80 ± 0.22	7.70 ± 0.27	7.60 ± 0.27	7.40 ± 0.27	7.30 ± 0.26	7.56 ± 0.25
III	7.80 ± 0.34	7.60 ± 0.26	7.40 ± 0.26	7.20 ± 0.26	7.00 ± 0.33	7.40 ± 0.26
IV	7.60 ± 0.28	7.20 ± 0.40	7.00 ± 0.40	6.90 ± 0.37	6.70 ± 0.45	7.06 ± 0.36
V	7.60 ± 0.15	7.20 ± 0.21	6.90 ± 0.23	6.80 ± 0.21	6.50 ± 0.18	7.02 ± 0.18
CD ( $P \leq 0.05$ )	NS	0.40	0.67	0.70	0.76	0.63

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant ( $P \leq 0.05$ )

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

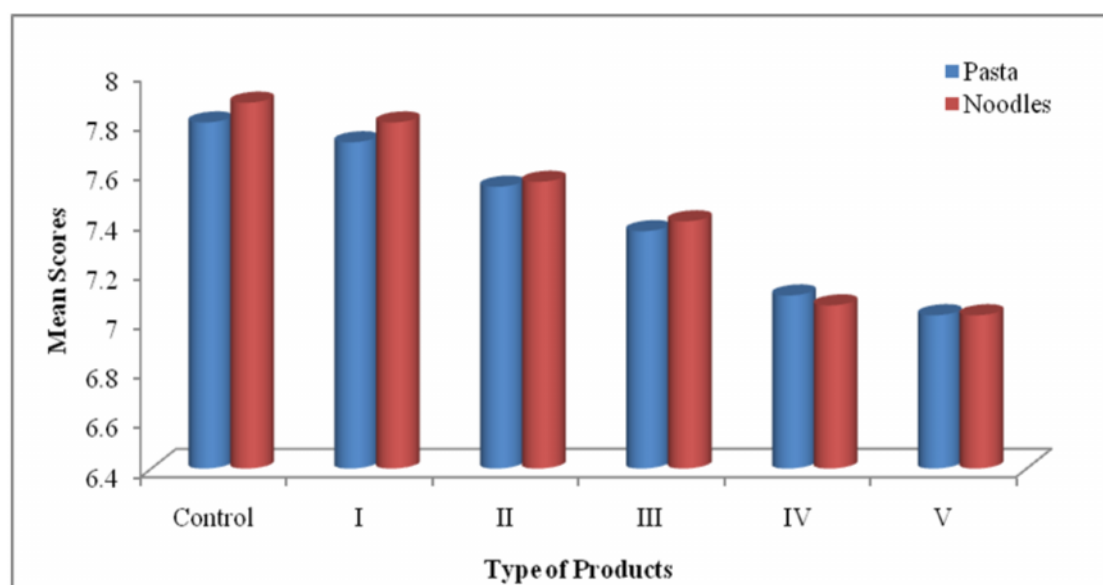
III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour



**Fig. 10: Mean scores for overall acceptability of extruded products**

#### 4.3.7 Sensory evaluation of RTS beverage

Four different types of RTS beverage, type I, II, III and IV were prepared using 10, 20, 30 and 40 percent *ber* powder. The sensory characteristics of RTS beverage are presented in Table 4.20.

The mean scores of colour, appearance, aroma, texture, taste and overall acceptability of RTS beverage ranged from 7.60 to 7.70, 6.90 to 7.70, 6.70 to 7.60, 5.90 to 7.60, 5.90 to 7.50 and 6.60 to 7.62, respectively. Mean scores for colour of RTS beverage indicated that the colour of type I and II RTS beverage were liked equally and slightly more than the colour of type III and IV RTS beverage. The appearance, aroma and overall acceptability of type I, II and III RTS beverage were rated as 'liked moderately' while that of type IV RTS beverage were rated as 'liked slightly'. The texture and taste of type I and II RTS beverage were 'liked moderately', type III were 'liked slightly' and type IV were 'neither liked nor disliked' by the panel of judges. The RTS beverage prepared using 10 per cent *ber* powder was preferred more followed by RTS beverage prepared using 20, 30 and 40 per cent *ber* powder. Non-significant ( $P \leq 0.05$ ) differences were observed in the colour of all the types of RTS beverage while the appearance, aroma, texture, taste and overall acceptability of type I and type IV RTS beverage differed significantly ( $P \leq 0.05$ ) from each other. The texture, taste and overall acceptability of type I RTS beverage were significantly ( $P \leq 0.05$ ) higher than type III and IV RTS beverage while the appearance and aroma of type IV RTS beverage was significantly ( $P \leq 0.05$ ) lower than type I RTS beverage. Fig. 11 showed mean scores for overall acceptability of unfermented beverage.

**Table 4.20:- Sensory evaluation of RTS beverage**

Types of RTS beverages	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
I	7.70 ± 0.26	7.70 ± 0.22	7.60 ± 0.22	7.60 ± 0.22	7.50 ± 0.22	7.62 ± 0.22
II	7.70 ± 0.22	7.60 ± 0.29	7.40 ± 0.29	7.30 ± 0.29	7.20 ± 0.13	7.44 ± 0.25
III	7.60 ± 0.15	7.30 ± 0.29	7.10 ± 0.13	6.60 ± 0.22	6.40 ± 0.22	7.00 ± 0.11
IV	7.60 ± 0.26	6.90 ± 0.29	6.70 ± 0.29	5.90 ± 0.22	5.90 ± 0.22	6.60 ± 0.22
CD ( $P \leq 0.05$ )	NS	0.70	0.75	0.90	0.86	0.67

Values are Mean ± SE of the ten independent mean scores.

NS=Non-significant ( $P \leq 0.05$ )

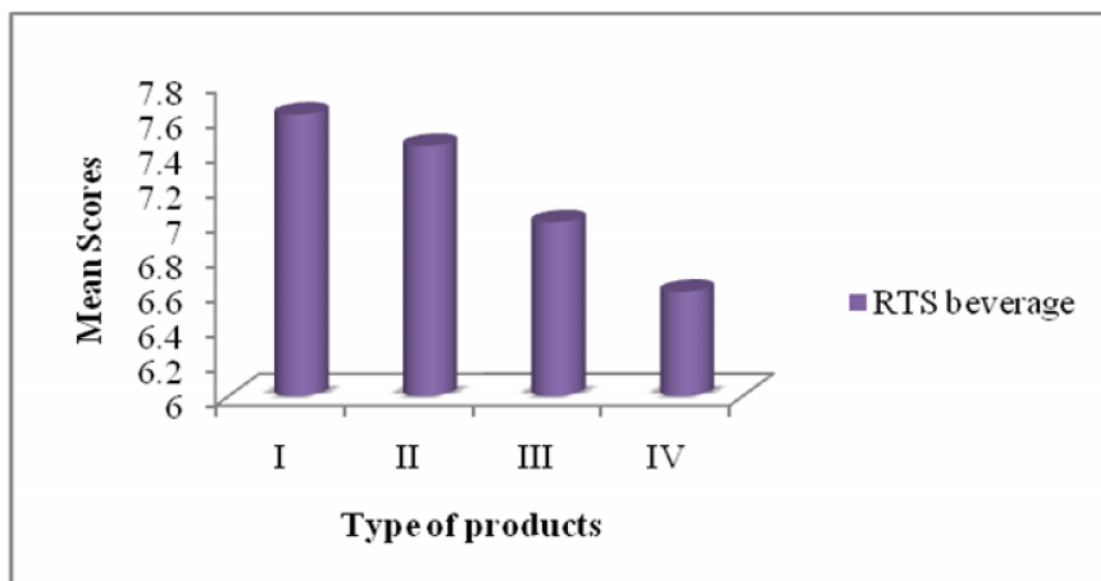
I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= *Ber* powder



**Fig. 11: Mean scores for overall acceptability of unfermented beverage**

#### **4.4 Nutritional evaluation of value-added products**

All the products prepared using powder of Umran variety of *ber* were analyzed for nutritional parameters which included proximate composition (moisture, crude protein, crude fat, crude fiber and ash), carbohydrates (total soluble sugars, reducing sugars and non-reducing sugars), minerals (calcium, iron, magnesium and zinc), vitamins (ascorbic acid and  $\beta$ -carotene) and *in-vitro* digestibilities of protein and starch. The value added products developed using *ber* powders were prepared using 10, 20, 30, 40 and 50 per cent incorporation of *ber* powder except in case of RTS beverage.

##### **4.4.1 Nutritional evaluation of Custard**

Five different types of custard were prepared using *ber* powder of Umran variety. Type I, II, III, IV and V consisted of 10, 20, 30, 40 and 50 per cent powder. The *ber* powder was replaced with custard powder in the basic standardized recipe. The custard prepared using custard powder and no *ber* powder served as control.

##### **4.4.1.1 Proximate composition of Custard**

The proximate composition of all the types of prepared custard is presented in Table 4.21. The moisture content of custard ranged from 76.53 in control to 77.00 per cent in custard prepared using 50 per cent *ber* powder. Non-significant ( $P \leq 0.05$ ) differences were observed in the moisture content of all the types of custard.

The crude protein content of control, type I, II, III, IV and V custard was 4.08, 4.21, 4.35, 4.50, 4.63 and 4.77 per cent, respectively. The crude protein content of type V custard was significantly ( $P \leq 0.05$ ) higher than the control, type I, II and III custard. Non-significant differences ( $P \leq 0.05$ ) were observed in the protein content of every two corresponding custard while rest were observed to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.21:- Proximate composition of Custard (g/100g, on dry matter basis)**

Types of Custard	Moisture*	Crude Protein	Crude Fat	Crude Fiber	Ash
Control	76.53 <sup>a</sup> ± 0.51	4.08 <sup>c</sup> ± 0.08	5.85 <sup>a</sup> ± 0.03	0.13 <sup>d</sup> ± 0.02	0.90 <sup>a</sup> ± 0.11
I	76.62 <sup>a</sup> ± 0.52	4.21 <sup>de</sup> ± 0.09	5.86 <sup>a</sup> ± 0.09	0.19 <sup>cd</sup> ± 0.04	0.97 <sup>a</sup> ± 0.13
II	76.73 <sup>a</sup> ± 0.56	4.35 <sup>cd</sup> ± 0.05	5.87 <sup>a</sup> ± 0.03	0.26 <sup>bcd</sup> ± 0.11	1.06 <sup>a</sup> ± 0.15
III	76.81 <sup>a</sup> ± 0.45	4.50 <sup>bc</sup> ± 0.12	5.87 <sup>a</sup> ± 0.10	0.32 <sup>abc</sup> ± 0.09	1.13 <sup>a</sup> ± 0.16
IV	76.91 <sup>a</sup> ± 0.49	4.63 <sup>ab</sup> ± 0.16	5.87 <sup>a</sup> ± 0.06	0.38 <sup>ab</sup> ± 0.12	1.21 <sup>a</sup> ± 0.13
V	77.00 <sup>a</sup> ± 0.50	4.77 <sup>a</sup> ± 0.10	5.88 <sup>a</sup> ± 0.13	0.45 <sup>a</sup> ± 0.16	1.29 <sup>a</sup> ± 0.18
CD (P≤0.05)	NS	0.26	NS	0.18	NS

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant (P≤0.05)

\*Moisture is determined on fresh weight basis

Control = 100 % CP

I= 10:90 (BP:CP)

II= 20:80 (BP:CP)

III= 30:70 (BP:CP)

IV= 40:60 (BP:CP)

V= 50:50 (BP:CP)

BP= *Ber* powder

CP= Custard Powder

The crude fat content of all the types of custard ranged from 5.85 to 5.88 per cent. The crude fat content did not increase much after addition of *ber* powder and observed to be almost similar and non-significantly (P≤0.05) different from each other in all the types of custard.

The crude fiber content of all the types of custard ranged from 0.13 to 0.45 per cent. The crude fiber content of control, type I and II, type I, II and III, type II, III and IV and type III, IV and V custard were almost similar and non-significantly (P≤0.05) different from each other. The crude fiber content of type V custard was significantly higher than control, type I and II custard.

The ash content of control, type I, II, III, IV and V custard was 0.90, 0.97, 1.06, 1.13, 1.21 and 1.29 per cent, respectively. Non-significant (P≤0.05) differences were observed in the ash content of all the types of custard.

#### 4.4.1.2 Carbohydrate content of Custard

The carbohydrate content of control, type I, II, III, IV and V custard are presented in Table 4.22. The total soluble sugars content of all the types of custard ranged from 20.17 to 21.77 g/100g, being highest in type V custard followed by type IV, III, II, I and control. Non-significant (P≤0.05) differences were observed in the total soluble sugars content of all the types of custard.

The reducing sugars content of all the types of custard ranged from 0.74 to 1.09 per cent. The reducing sugars content of type V custard was significantly higher than its control, type I, II and III counterparts. Non-significant differences were observed in the reducing sugars content of every three corresponding custard while the rest were observed to be significantly (P≤0.05) different from each other.

**Table 4.22:- Carbohydrate content of Custard (g/100g, on dry matter basis)**

Types of Custard	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
Control	20.17 <sup>a</sup> ± 0.50	0.74 <sup>d</sup> ± 0.07	19.43 <sup>a</sup> ± 0.45
I	20.39 <sup>a</sup> ± 0.53	0.79 <sup>cd</sup> ± 0.07	19.60 <sup>a</sup> ± 0.47
II	20.78 <sup>a</sup> ± 0.51	0.87 <sup>bcd</sup> ± 0.10	19.91 <sup>a</sup> ± 0.39
III	21.08 <sup>a</sup> ± 0.46	0.94 <sup>abc</sup> ± 0.12	20.14 <sup>a</sup> ± 0.44
IV	21.39 <sup>a</sup> ± 0.39	1.02 <sup>ab</sup> ± 0.06	20.37 <sup>a</sup> ± 0.38
V	21.77 <sup>a</sup> ± 0.51	1.09 <sup>a</sup> ± 0.13	20.68 <sup>a</sup> ± 0.46
CD (P≤0.05)	NS	0.23	NS

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant (P≤0.05)

Control = 100 % CP

I= 10:90 (BP:CP)

II= 20:80 (BP:CP)

III= 30:70 (BP:CP)

IV= 40:60 (BP:CP)

V= 50:50 (BP:CP)

BP= Ber powder

CP= Custard Powder

The non-reducing sugars content of control, type I, II, III, IV and V custard was 19.43, 19.60, 19.91, 20.14, 20.37 and 20.68 g/100g, respectively. Non-significant (P≤0.05) differences were observed in the non-reducing sugars content of all the types of custard.

#### 4.4.1.3 Mineral content of Custard

The data regarding the mineral content viz. calcium, iron magnesium and zinc content of all the types of custard is presented in Table 4.23. The calcium content of control, type I, II, III, IV and V custard was 217.88, 220.46, 223.32, 226.19, 228.85 and 231.52 mg/100g, respectively. The calcium content of type V custard was significantly (P≤0.05) higher and the calcium content of control custard was significantly (P≤0.05) lower than all the types of custard. All the types of custard were found to have significantly (P≤0.05) different calcium content.

**Table 4.23:- Mineral content of Custard (mg/100g, on dry matter basis)**

Types of Custard	Calcium	Iron	Magnesium	Zinc
Control	217.88 <sup>f</sup> ± 0.37	0.25 <sup>c</sup> ± 0.09	42.80 <sup>d</sup> ± 0.12	ND
I	220.46 <sup>e</sup> ± 0.20	0.51 <sup>de</sup> ± 0.12	42.96 <sup>cd</sup> ± 0.18	ND
II	223.32 <sup>d</sup> ± 0.21	0.78 <sup>cd</sup> ± 0.04	43.11 <sup>bcd</sup> ± 0.19	ND
III	226.19 <sup>c</sup> ± 0.21	1.04 <sup>bc</sup> ± 0.23	43.26 <sup>abc</sup> ± 0.18	ND
IV	228.85 <sup>b</sup> ± 0.21	1.32 <sup>ab</sup> ± 0.13	43.40 <sup>ab</sup> ± 0.19	ND
V	231.52 <sup>a</sup> ± 0.22	1.58 <sup>a</sup> ± 0.12	43.56 <sup>a</sup> ± 0.18	ND
CD (P≤0.05)	1.79	0.29	0.36	NS

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant (P≤0.05)

ND=Non Detected

Control = 100 % CP

I= 10:90 (BP:CP)

II= 20:80 (BP:CP)

III= 30:70 (BP:CP)

IV= 40:60 (BP:CP)

V= 50:50 (BP:CP)

BP= Ber powder

CP= Custard Powder

The iron content of all types of custard ranged 0.25 to 1.58 mg/100g, being highest in type V custard and lowest in control custard. The iron content of all the types of custard was found to be non-significantly ( $P \leq 0.05$ ) different from their consecutive custard but significantly ( $P \leq 0.05$ ) different from rest of the custard types. The iron content of type V custard was significantly higher than control, type I, II and III custard.

The magnesium content of control, type I, II, III, IV and V custard was 42.80, 42.96, 43.11, 43.26, 43.40 and 43.56 mg/100g, respectively. The magnesium content of type V custard was higher and that of control custard was lower among all the types of custard. The data depicted that there was non-significant ( $P \leq 0.05$ ) difference between the magnesium content of control, type I and II, type I, II and III, type II, III and IV and type III, IV and V custard while rest of the types of custard were observed to be significantly ( $P \leq 0.05$ ) different from each other.

The zinc content was not detected in any of the custard including control, type I, II, III, IV and V custard.

#### 4.4.1.4 Vitamin content of Custard

The ascorbic acid and  $\beta$ -carotene content were not detected in any of the custard including control, type I, II, III, IV and V custard.

#### 4.4.1.5 *In-vitro* digestibilities of Custard

The *in-vitro* digestibilities of protein and starch of all types of custard is presented in Table 4.24. The *in-vitro* protein digestibility of control, type I, II, III, IV and V custard was 85.49, 85.83, 86.15, 86.48, 86.89 and 87.09 per cent, respectively. The *in-vitro* protein digestibility of type V custard was significantly ( $P \leq 0.05$ ) higher than all the other custard except type IV. Similarly, the *in-vitro* protein digestibility of control and type I, type I and II, type II and III and type III and IV custard was similar and non-significantly ( $P \leq 0.05$ ) different from each other but significantly ( $P \leq 0.05$ ) different from rest of the types of custard.

**Table 4.24:- *In-vitro* digestibilities of Custard (on dry matter basis)**

Types of Custard	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g)
Control	85.49 <sup>e</sup> ± 0.36	55.93 <sup>e</sup> ± 0.16
I	85.83 <sup>de</sup> ± 0.29	56.13 <sup>de</sup> ± 0.12
II	86.15 <sup>cd</sup> ± 0.34	56.34 <sup>cd</sup> ± 0.11
III	86.48 <sup>bc</sup> ± 0.35	56.56 <sup>bc</sup> ± 0.19
IV	86.89 <sup>ab</sup> ± 0.32	56.77 <sup>ab</sup> ± 0.09
V	87.09 <sup>a</sup> ± 0.38	56.99 <sup>a</sup> ± 0.14
CD ( $P \leq 0.05$ )	0.45	0.38

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % CP

I= 10:90 (BP:CP)

II= 20:80 (BP:CP)

III= 30:70 (BP:CP)

IV= 40:60 (BP:CP)

V= 50:50 (BP:CP)

BP= Ber powder

CP= Custard Powder

The *in-vitro* starch digestibility of control, type I, II, III, IV and V custard was 55.93, 56.13, 56.34, 56.56, 56.77 and 56.99 mg maltose released/g powder, respectively. The *in-vitro* starch digestibility of all types of custard was significantly ( $P \leq 0.05$ ) different from each other except for every two consecutive custard.

#### 4.4.2 Nutritional evaluation of *Kheer*

Five different types of *kheer* were prepared using *ber* powder of Umran variety. Type I, II, III, IV and V consisted of 10, 20, 30, 40 and 50 per cent *ber* powder. The *ber* powder was replaced with rice in the basic standardized recipe of *kheer*. The *kheer* prepared using rice and no *ber* powder served as control.

##### 4.4.2.1 Proximate composition of *Kheer*

The proximate composition (moisture, crude protein, crude fat, crude fiber and ash) of all the types of prepared *kheer* is presented in Table 4.25. The moisture content of all the types of *kheer* ranged from 70.49 in control to 71.51 per cent in *kheer* prepared using 50 per cent *ber* powder. Non-significant ( $P \leq 0.05$ ) differences were observed in the moisture content of all the types of *kheer*.

**Table 4.25:- Proximate composition of *Kheer* (g/100g, on dry matter basis)**

Types of <i>Kheer</i>	Moisture*	Crude Protein	Crude Fat	Crude Fiber	Ash
Control	70.49 <sup>a</sup> ± 1.52	7.00 <sup>c</sup> ± 0.14	7.23 <sup>a</sup> ± 0.03	0.21 <sup>c</sup> ± 0.04	3.72 <sup>a</sup> ± 0.30
I	70.71 <sup>a</sup> ± 0.51	7.04 <sup>c</sup> ± 0.12	7.23 <sup>a</sup> ± 0.09	0.34 <sup>dc</sup> ± 0.06	3.85 <sup>a</sup> ± 0.26
II	70.91 <sup>a</sup> ± 1.14	7.11 <sup>bc</sup> ± 0.19	7.24 <sup>a</sup> ± 0.06	0.46 <sup>cd</sup> ± 0.05	4.00 <sup>a</sup> ± 0.32
III	71.13 <sup>a</sup> ± 0.55	7.24 <sup>abc</sup> ± 0.15	7.25 <sup>a</sup> ± 0.10	0.55 <sup>bc</sup> ± 0.07	4.15 <sup>a</sup> ± 0.38
IV	71.28 <sup>a</sup> ± 1.25	7.38 <sup>ab</sup> ± 0.21	7.25 <sup>a</sup> ± 0.13	0.66 <sup>ab</sup> ± 0.07	4.18 <sup>a</sup> ± 0.41
V	71.51 <sup>a</sup> ± 1.11	7.52 <sup>a</sup> ± 0.19	7.26 <sup>a</sup> ± 0.04	0.77 <sup>a</sup> ± 0.04	4.43 <sup>a</sup> ± 0.31
CD ( $P \leq 0.05$ )	NS	0.32	NS	0.18	NS

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

\*Moisture is determined on fresh weight basis

Control = 100 % R

I= 10:90 (BP:R)

II= 20:80 (BP:R)

III= 30:70 (BP:R)

IV= 40:60 (BP:R)

V= 50:50 (BP:R)

BP= *Ber* powder

R= Rice

The crude protein content of control, type I, II, III, IV and V *kheer* was 7.00, 7.04, 7.11, 7.24, 7.38 and 7.52 per cent, respectively. The crude protein content of type V *kheer* was significantly ( $P \leq 0.05$ ) higher than the control, type I and II *kheer*. The crude protein content of type II, III and IV *kheer* was almost similar and non-significantly ( $P \leq 0.05$ ) different from each other. Non-significant differences ( $P \leq 0.05$ ) were also observed in the crude protein content of control, type I, II and III *kheer*.

The crude fat content of *kheer* ranged from 7.23 to 7.26 per cent. The crude fat content of *kheer* did not increase much after addition of *ber* powder and observed to be almost similar and non-significantly ( $P \leq 0.05$ ) different from each other.

The crude fiber content of all types of *kheer* ranged from 0.21 to 0.77 per cent. The crude fiber content of control and type I, type I and II, type II and III, type III and IV and type IV and V *kheer* was almost similar and non-significantly ( $P \leq 0.05$ ) different from each other but significantly ( $P \leq 0.05$ ) different from rest of the *kheer* types. The crude fiber content of type V *kheer* was significantly higher than control and type I, II and III *kheer*.

The ash content of control, type I, II, III, IV and V *kheer* was 3.72, 3.85, 4.00, 4.15, 4.18 and 4.43 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the ash content of all the types of *kheer*.

#### 4.4.2.2 Carbohydrate content of *Kheer*

The carbohydrate (total soluble sugars, reducing sugars, non-reducing sugars) content of control, type I, II, III, IV and V *kheer* are presented in Table 4.26. The total soluble sugars content of all the types of *kheer* ranged from 22.58 to 25.67 g/100 g being highest in type V *kheer* followed by type IV, III, II, I and control *kheer*. The total soluble sugars of type III, IV and V *kheer* was similar and non-significantly ( $P \leq 0.05$ ) different from each other. Non-significant ( $P \leq 0.05$ ) differences were observed in the total soluble sugars content of control and type I, type I and II and type II and III *kheer*.

**Table 4.26:- Carbohydrate content of *Kheer* (g/100g, on dry matter basis)**

Types of <i>Kheer</i>	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
Control	22.58 <sup>d</sup> ± 0.26	0.70 <sup>c</sup> ± 0.07	21.88 <sup>e</sup> ± 0.25
I	23.22 <sup>cd</sup> ± 0.32	0.83 <sup>bc</sup> ± 0.10	22.39 <sup>de</sup> ± 0.26
II	23.84 <sup>bc</sup> ± 0.46	0.94 <sup>abc</sup> ± 0.06	22.90 <sup>cd</sup> ± 0.45
III	24.47 <sup>ab</sup> ± 0.16	1.06 <sup>abc</sup> ± 0.22	23.41 <sup>bc</sup> ± 0.29
IV	25.08 <sup>a</sup> ± 0.29	1.16 <sup>ab</sup> ± 0.27	23.92 <sup>ab</sup> ± 0.33
V	25.67 <sup>a</sup> ± 0.31	1.27 <sup>a</sup> ± 0.24	24.40 <sup>a</sup> ± 0.26
CD ( $P \leq 0.05$ )	0.81	0.41	0.80

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % R

I= 10:90 (BP:R)

II= 20:80 (BP:R)

III= 30:70 (BP:R)

IV= 40:60 (BP:R)

V= 50:50 (BP:R)

BP= *Ber* powder

R= Rice

The reducing sugars content of *kheer* ranged from 0.70 to 1.27 per cent. The reducing sugars content of type V *kheer* was significantly ( $P \leq 0.05$ ) higher than its control and type I counterparts. Non-significant differences were observed in the reducing sugars content of

every four corresponding *kheer* while the rest were observed to be significantly ( $P \leq 0.05$ ) different from each other.

The non-reducing sugars content of control, type I, II, III, IV and V *kheer* was 21.88, 22.39, 22.90, 23.41, 23.92 and 24.40 g/100g, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the non-reducing sugar content of every two consecutive *kheer* while rest of the types of *kheer* were found to be significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.2.3 Mineral content of *Kheer*

The data regarding the mineral content viz. calcium, iron magnesium and zinc content of *kheer* is presented in Table 4.27. The calcium content of control, type I, II, III, IV and V *kheer* was 228.61, 233.11, 237.42, 242.14, 246.44 and 251.05 mg/100g, respectively. The calcium content of type V *kheer* was significantly ( $P \leq 0.05$ ) higher and the calcium content of control *kheer* was significantly ( $P \leq 0.05$ ) lower among all the types of *kheer*. All the types of *kheer* were found to have significantly ( $P \leq 0.05$ ) different calcium content.

**Table 4.27:- Mineral content of *Kheer* (mg/100g, on dry matter basis)**

Types of <i>Kheer</i>	Calcium	Iron	Magnesium	Zinc
Control	228.61 <sup>f</sup> ± 0.33	1.02 <sup>e</sup> ± 0.44	57.21 <sup>f</sup> ± 0.21	ND
I	233.11 <sup>e</sup> ± 0.36	1.62 <sup>de</sup> ± 0.65	58.17 <sup>e</sup> ± 0.38	ND
II	237.42 <sup>d</sup> ± 0.31	2.17 <sup>cd</sup> ± 1.05	59.11 <sup>d</sup> ± 0.19	ND
III	242.14 <sup>c</sup> ± 0.46	2.73 <sup>bc</sup> ± 0.97	60.00 <sup>c</sup> ± 0.38	ND
IV	246.44 <sup>b</sup> ± 0.61	3.30 <sup>ab</sup> ± 2.09	60.85 <sup>b</sup> ± 0.27	ND
V	251.05 <sup>a</sup> ± 0.40	3.86 <sup>a</sup> ± 0.12	61.73 <sup>a</sup> ± 0.36	ND
CD ( $P \leq 0.05$ )	1.72	0.59	0.74	NS

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

ND=Non Detected

Control = 100 % R

I= 10:90 (BP:R)

II= 20:80 (BP:R)

III= 30:70 (BP:R)

IV= 40:60 (BP:R)

V= 50:50 (BP:R)

BP= *Ber* powder

R= Rice

The iron content of all types of *kheer* ranged 1.02 to 3.86 mg/100g, being highest in type V *kheer* and lowest in control *kheer*. The iron content of all the types of *kheer* was found to be non-significantly ( $P \leq 0.05$ ) different from their consecutive *kheer* but significantly different from rest of the *kheer* types.

The magnesium content of control, type I, II, III, IV and V *kheer* was 57.21, 58.17, 59.11, 60.00, 60.85 and 61.73 mg/100g, respectively. The magnesium content of type V *kheer* was significantly ( $P \leq 0.05$ ) higher and that of control *kheer* was significantly ( $P \leq 0.05$ ) lower among all the types of *kheer*. The data indicated that the magnesium content of all the types of *kheer* was significantly ( $P \leq 0.05$ ) different from each other.

The zinc content was not detected in any of the types of *kheer* including control, type I, II, III, IV and V *kheer*.

#### 4.4.2.4 Vitamin content of *Kheer*

The ascorbic acid and  $\beta$ -carotene content were not detected in any of *kheer*.

#### 4.4.2.5 *In-vitro* digestibilities of *Kheer*

The *in-vitro* digestibilities of protein and starch of all the types of *kheer* are presented in Table 4.28. The *in-vitro* protein digestibility of control, type I, II, III, IV and V *kheer* was 86.19, 86.51, 86.83, 87.15, 87.45 and 87.76 per cent, respectively. The *in-vitro* protein digestibility of type V custard was significantly ( $P \leq 0.05$ ) higher than all the other types of *kheer* except type IV *kheer*. Similarly, the *in-vitro* protein digestibility of control and type I, type I and II, type II and III and type III and IV *kheer* was similar and non-significantly ( $P \leq 0.05$ ) different from each other but significantly ( $P \leq 0.05$ ) different from rest of the types of *kheer*.

**Table 4.28:- *In-vitro* digestibilities of *Kheer* (on dry matter basis)**

Types of <i>Kheer</i>	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g)
Control	86.19 <sup>e</sup> $\pm$ 0.16	56.29 <sup>e</sup> $\pm$ 0.21
I	86.51 <sup>de</sup> $\pm$ 0.15	56.51 <sup>de</sup> $\pm$ 0.15
II	86.83 <sup>cd</sup> $\pm$ 0.29	56.71 <sup>cd</sup> $\pm$ 0.23
III	87.15 <sup>bc</sup> $\pm$ 0.24	56.92 <sup>bc</sup> $\pm$ 0.19
IV	87.45 <sup>ab</sup> $\pm$ 0.16	57.12 <sup>ab</sup> $\pm$ 0.24
V	87.76 <sup>a</sup> $\pm$ 0.22	57.33 <sup>a</sup> $\pm$ 0.18
CD ( $P \leq 0.05$ )	0.49	0.41

Values are Mean  $\pm$  SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % R

I= 10:90 (BP:R)

II= 20:80 (BP:R)

III= 30:70 (BP:R)

IV= 40:60 (BP:R)

V= 50:50 (BP:R)

BP= *Ber* powder

R= Rice

The *in-vitro* starch digestibility of control, type I, II, III, IV and V *kheer* was 56.29, 56.51, 56.71, 56.92, 57.12 and 57.33 mg maltose released/g *kheer*, respectively. The *in-vitro* starch digestibility was found to be non significantly ( $P \leq 0.05$ ) different among every two consecutive *kheer* but significantly ( $P \leq 0.05$ ) different from rest of the types of *kheer*.

#### 4.4.3 Nutritional evaluation of Biscuits

*Ber* powder of Umran variety was used for the development of sweet and salty biscuits. Five types of biscuits were prepared using *ber* powder in which the *ber* powder was used in the ratio of 10, 20, 30, 40 and 50 per cent by replacing the refined wheat flour in the basic standardized recipe. The biscuits prepared using refined wheat flour and no *ber* powder served as control.

#### 4.4.3.1 Proximate composition of Biscuits

The moisture, crude protein, crude fat, crude fiber and ash content of biscuits prepared using *ber* powder are presented in Table 4.29. The moisture content of biscuits ranged from 2.86 to 4.52 per cent being highest in type V biscuits followed by type IV, III, II, I and control biscuits. Non-significant ( $P \leq 0.05$ ) differences were observed in the moisture content of all types of biscuits.

**Table 4.29:- Proximate composition of Biscuits (g/100g, on dry matter basis)**

Types of Biscuits	Moisture*	Crude Protein	Crude Fat	Crude Fiber	Ash
Control	2.86 <sup>a</sup> ± 0.54	8.75 <sup>a</sup> ± 0.14	23.31 <sup>a</sup> ± 0.13	1.58 <sup>f</sup> ± 0.05	0.78 <sup>e</sup> ± 0.06
I	3.21 <sup>a</sup> ± 0.45	8.47 <sup>ab</sup> ± 0.24	23.32 <sup>a</sup> ± 0.19	1.92 <sup>e</sup> ± 0.10	1.12 <sup>d</sup> ± 0.12
II	3.53 <sup>a</sup> ± 0.39	8.21 <sup>abc</sup> ± 0.16	23.33 <sup>a</sup> ± 0.31	2.24 <sup>d</sup> ± 0.08	1.44 <sup>c</sup> ± 0.08
III	3.85 <sup>a</sup> ± 0.53	7.94 <sup>bcd</sup> ± 0.28	23.33 <sup>a</sup> ± 0.21	2.57 <sup>c</sup> ± 0.14	1.77 <sup>b</sup> ± 0.19
IV	4.18 <sup>a</sup> ± 0.50	7.66 <sup>cd</sup> ± 0.19	23.34 <sup>a</sup> ± 0.26	2.89 <sup>b</sup> ± 0.18	2.08 <sup>a</sup> ± 0.11
V	4.52 <sup>a</sup> ± 0.41	7.39 <sup>d</sup> ± 0.14	23.35 <sup>a</sup> ± 0.12	3.23 <sup>a</sup> ± 0.04	2.38 <sup>a</sup> ± 0.16
CD ( $P \leq 0.05$ )	NS	0.62	NS	0.26	0.31

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

\*Moisture is determined on fresh weight basis

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The crude protein content of control, type I, II, III, IV and V biscuits was 8.75, 8.47, 8.21, 7.94, 7.66, 7.39 g/100g, respectively. A decreasing trend was observed in the crude protein content of the biscuits as the supplementation of *ber* powder increased. The crude protein content of type III, IV and V biscuits was similar and non-significantly ( $P \leq 0.05$ ) different from each other. Similarly, the crude protein content of control, type I and II, type I, II and III and type II, III and IV biscuits was similar and non-significantly ( $P \leq 0.05$ ) different from each other but significantly ( $P \leq 0.05$ ) different from rest of the types of biscuits.

The crude fat content of control, type I, II, III, IV and V biscuits was 23.31, 23.32, 23.33, 23.33, 23.34 and 23.35 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the crude fat content of all the types of biscuits.

The crude fiber content of biscuits ranged from 1.58 per cent in control to 3.23 per cent in type V biscuits. Type V biscuits were found to have significantly ( $P \leq 0.05$ ) higher crude fiber content followed by type IV, III, II, I and control biscuits. Significant ( $P \leq 0.05$ ) differences were observed in the crude fiber content of all the types of biscuits.

The ash content of control, type I, II, III, IV and V biscuits was 0.78, 1.12, 1.44, 1.77, 2.08 and 2.38 per cent, respectively. The ash content of type IV and V biscuits was

significantly ( $P \leq 0.05$ ) higher than the other types of biscuits. The ash content of type III biscuits was significantly ( $P \leq 0.05$ ) higher than type II, I and control biscuits. The ash content of all the types of biscuits was recorded to be significantly ( $P \leq 0.05$ ) different from each other except the ash content of type IV and V biscuits which were found to be similar and non-significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.3.2 Carbohydrate content of Biscuits

The total soluble sugars, reducing sugars and non-reducing sugars of biscuits are presented in Table 4.30. The total soluble sugars content of control, type I, II, III, IV and V biscuits was 13.57, 15.13, 16.98, 19.05, 21.03 and 22.80 g/100g respectively. The total soluble sugars content of type V biscuits was significantly ( $P \leq 0.05$ ) higher than other types of biscuits while the total soluble sugars content of control biscuits was found to be significantly ( $P \leq 0.05$ ) lower than all the types of biscuits. The total soluble sugars content of all the types of biscuits was recorded to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.30:- Carbohydrate content of Biscuits (g/100g, on dry matter basis)**

Types of Biscuits	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
Control	13.57 <sup>f</sup> ± 0.51	0.54 <sup>f</sup> ± 0.04	13.03 <sup>d</sup> ± 0.48
I	15.13 <sup>e</sup> ± 0.50	0.89 <sup>e</sup> ± 0.04	14.24 <sup>d</sup> ± 0.47
II	16.98 <sup>d</sup> ± 0.49	1.50 <sup>d</sup> ± 0.15	15.38 <sup>c</sup> ± 0.37
III	19.05 <sup>c</sup> ± 0.52	1.63 <sup>c</sup> ± 0.06	17.42 <sup>b</sup> ± 0.43
IV	21.03 <sup>b</sup> ± 0.46	2.02 <sup>b</sup> ± 0.09	19.01 <sup>a</sup> ± 0.32
V	22.80 <sup>a</sup> ± 0.39	2.40 <sup>a</sup> ± 0.11	20.40 <sup>a</sup> ± 0.44
CD ( $P \leq 0.05$ )	1.55	0.23	1.42

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The reducing sugars content of all types of biscuits ranged from 0.54 per cent in control to 2.40 per cent in type V biscuits. The reducing sugars content of biscuits increased with increasing supplementation of *ber* powder. The reducing sugars content of all types of biscuits was found to be significantly ( $P \leq 0.05$ ) different from each other. Type V biscuits were observed to have significantly ( $P \leq 0.05$ ) higher reducing sugars content while control biscuits had significantly ( $P \leq 0.05$ ) lower reducing sugars content among all types of biscuits.

The non-reducing sugars content of control, type I, II, III, IV and V biscuits was 13.03, 14.24, 15.38, 17.42, 19.01 and 20.40 per cent, respectively. All the types of biscuits were observed to have significantly ( $P \leq 0.05$ ) different non-reducing sugars content except in type IV and V biscuits which were found to be similar and non-significantly ( $P \leq 0.05$ )

different from each other but significantly ( $P \leq 0.05$ ) higher than the other types of biscuits with regards to non-reducing sugars content.

#### 4.4.3.3 Mineral content of Biscuits

The calcium, iron, magnesium and zinc content of biscuits are presented in Table 4.31. The calcium content of control, type I, II, III, IV and V biscuits was 89.66, 102.76, 114.68, 127.22, 139.66 and 152.14 mg/100g, respectively. The calcium content of all the types of biscuits was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type V biscuits and significantly ( $P \leq 0.05$ ) lower in control biscuits.

**Table 4.31:- Mineral content of Biscuits (mg/100g, on dry matter basis)**

Types of Biscuits	Calcium	Iron	Magnesium	Zinc
Control	89.66 <sup>f</sup> ± 0.46	3.53 <sup>f</sup> ± 0.08	43.77 <sup>f</sup> ± 0.22	0.79 <sup>d</sup> ± 0.05
I	102.76 <sup>e</sup> ± 0.39	4.95 <sup>e</sup> ± 0.27	47.18 <sup>e</sup> ± 0.22	0.81 <sup>cd</sup> ± 0.03
II	114.68 <sup>d</sup> ± 0.32	6.44 <sup>d</sup> ± 1.14	50.48 <sup>d</sup> ± 0.31	0.84 <sup>bcd</sup> ± 0.02
III	127.22 <sup>c</sup> ± 0.56	7.85 <sup>c</sup> ± 1.38	53.74 <sup>c</sup> ± 0.21	0.87 <sup>abc</sup> ± 0.03
IV	139.66 <sup>b</sup> ± 0.24	9.25 <sup>b</sup> ± 0.48	56.99 <sup>b</sup> ± 0.19	0.89 <sup>ab</sup> ± 0.05
V	152.14 <sup>a</sup> ± 0.51	10.65 <sup>a</sup> ± 0.83	60.20 <sup>a</sup> ± 0.28	0.92 <sup>a</sup> ± 0.04
CD ( $P \leq 0.05$ )	2.59	0.61	0.64	0.07

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The iron content of biscuits ranged from 3.53 to 10.65 mg/100g. The iron content of type V biscuits was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II, I and control biscuits. The iron content of all the biscuits was found to be significantly ( $P \leq 0.05$ ) different from each other.

The magnesium content of control, type I, II, III, IV and V biscuits was 43.77, 47.18, 50.48, 53.74, 56.99 and 60.20 mg/100g, respectively. The magnesium content of all the biscuits was significantly ( $P \leq 0.05$ ) different from each other. The magnesium content of type V biscuits was significantly higher followed by type IV, III, II, I and control biscuits.

The zinc content of all the biscuits ranged from 0.79 to 0.92 mg/100g. Non-significant ( $P \leq 0.05$ ) differences were observed in the zinc content of every three consecutive biscuits prepared like control, type I and II, type I, II and III, type II, III and IV and type III, IV and V biscuits.

#### 4.4.3.4 Vitamin content of Biscuits

The ascorbic acid and  $\beta$ -carotene content of all the biscuits are presented in Table 4.32. The ascorbic acid content of all the biscuit ranged from 2.39 to 16.35 mg/100g while it

was not detected in the control biscuits. The ascorbic acid content of all the biscuits differed significantly ( $P \leq 0.05$ ) from each other. The ascorbic acid content of type V biscuits was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II and I biscuits.

**Table 4.32:- Vitamin content of Biscuits (mg/100g, on dry matter basis)**

Types of Biscuits	Ascorbic Acid	$\beta$ -carotene
Control	ND	ND
I	2.39 <sup>c</sup> $\pm$ 0.06	ND
II	5.85 <sup>d</sup> $\pm$ 0.10	ND
III	9.51 <sup>c</sup> $\pm$ 0.06	ND
IV	12.91 <sup>b</sup> $\pm$ 0.11	ND
V	16.35 <sup>a</sup> $\pm$ 0.07	ND
CD ( $P \leq 0.05$ )	0.20	NS

Values are Mean  $\pm$  SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

ND=Non Detected

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The  $\beta$ -carotene content was not detected in any type of prepared biscuits.

#### 4.4.3.5 *In-vitro* digestibilities of Biscuits

The *in-vitro* protein and starch digestibilities of all the types of biscuits are presented in Table 4.33. The *in-vitro* protein digestibility of control, type I, II, III, IV and V biscuits was 73.23, 73.55, 73.85, 74.17, 74.48 and 74.78 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the *in-vitro* protein digestibility of every three consecutive biscuits while rest of the biscuits were found to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.33:- *In-vitro* digestibilities of Biscuits (on dry matter basis)**

Types of Biscuits	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g)
Control	73.23 <sup>d</sup> $\pm$ 0.22	37.49 <sup>c</sup> $\pm$ 0.18
I	73.55 <sup>cd</sup> $\pm$ 0.37	37.68 <sup>bc</sup> $\pm$ 0.24
II	73.85 <sup>bcd</sup> $\pm$ 0.17	37.85 <sup>abc</sup> $\pm$ 0.20
III	74.17 <sup>abc</sup> $\pm$ 0.06	38.03 <sup>abc</sup> $\pm$ 0.15
IV	74.48 <sup>ab</sup> $\pm$ 0.21	38.19 <sup>ab</sup> $\pm$ 0.19
V	74.78 <sup>a</sup> $\pm$ 0.24	38.36 <sup>a</sup> $\pm$ 0.26
CD ( $P \leq 0.05$ )	0.69	0.56

Values are Mean  $\pm$  SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The *in-vitro* starch digestibility of all the biscuits ranged from 37.49 to 38.36 mg maltose released/g. The *in-vitro* starch digestibility of type V biscuits was significantly ( $P \leq 0.05$ ) higher than control and type I biscuits. Non-significant ( $P \leq 0.05$ ) differences were observed in the *in-vitro* starch digestibility of every four consecutive biscuits while rest of the biscuits were found to be significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.4 Nutritional evaluation of Cake

Five types of cake were prepared using *ber* powder where the ratio of *ber* powder was used as 10, 20, 30, 40 and 50 per cent by replacing the refined wheat flour in the basic standardized recipe. The cake prepared using refined wheat flour served as control.

##### 4.4.4.1 Proximate composition of Cake

The moisture, crude protein, crude fat, crude fiber and ash content of cake prepared using *ber* powder are presented in Table 4.34. The moisture content of cake ranged from 22.81 to 24.48 per cent being highest in type V cake followed by type IV, III, II, I and control cake. Non-significant ( $P \leq 0.05$ ) differences were observed in the moisture content of all types of cake.

**Table 4.34:- Proximate composition of Cake (g/100g, on dry matter basis)**

Types of Cake	Moisture*	Crude Protein	Crude Fat	Crude Fiber	Ash
Control	22.81 <sup>a</sup> ± 1.05	12.58 <sup>a</sup> ± 0.08	9.53 <sup>a</sup> ± 0.03	0.91 <sup>f</sup> ± 0.03	1.10 <sup>e</sup> ± 0.19
I	23.15 <sup>a</sup> ± 0.88	12.36 <sup>ab</sup> ± 0.11	9.54 <sup>a</sup> ± 0.05	1.16 <sup>e</sup> ± 0.13	1.39 <sup>de</sup> ± 0.15
II	23.50 <sup>a</sup> ± 0.64	12.13 <sup>bc</sup> ± 0.21	9.54 <sup>a</sup> ± 0.09	1.39 <sup>d</sup> ± 0.04	1.72 <sup>cd</sup> ± 0.14
III	23.84 <sup>a</sup> ± 1.04	11.91 <sup>cd</sup> ± 0.04	9.55 <sup>a</sup> ± 0.10	1.63 <sup>c</sup> ± 0.23	2.05 <sup>bc</sup> ± 0.19
IV	24.16 <sup>a</sup> ± 0.54	11.68 <sup>de</sup> ± 0.15	9.56 <sup>a</sup> ± 0.12	1.86 <sup>b</sup> ± 0.06	2.37 <sup>ab</sup> ± 0.24
V	24.48 <sup>a</sup> ± 0.48	11.47 <sup>e</sup> ± 0.19	9.57 <sup>a</sup> ± 0.19	2.09 <sup>a</sup> ± 0.04	2.68 <sup>a</sup> ± 0.16
CD ( $P \leq 0.05$ )	NS	0.25	NS	0.11	0.61

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

\*Moisture is determined on fresh weight basis

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The crude protein content of control, type I, II, III, IV and V cake was 12.58, 12.36, 12.13, 11.91, 11.68 and 11.47 g/100g, respectively. A decreasing trend was observed in the crude protein content of all the types of cake as the supplementation of *ber* powder increased. The crude protein content of type IV and V cake was similar and non-significantly ( $P \leq 0.05$ ) different from each other. Similarly, the crude protein content of control and type I; type II and III and type III and IV cake was similar and non-significantly ( $P \leq 0.05$ ) different from each other but significantly ( $P \leq 0.05$ ) different from rest of the types of cake.

The crude fat content of control, type I, II, III, IV and V cake was 9.53, 9.54, 9.54, 9.55, 9.56 and 9.57 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the crude fat content of all the types of cake.

The crude fiber content of cake ranged from 0.91 per cent in control to 2.09 per cent in type V cake. Type V cake was found to have significantly ( $P \leq 0.05$ ) higher crude fiber content followed by type IV, III, II, I and control cake. Significant ( $P \leq 0.05$ ) differences were observed in the crude fiber content of all the types of cake.

The ash content of control, type I, II, III, IV and V cake was 1.10, 1.39, 1.72, 2.05, 2.37 and 2.68 per cent, respectively. The ash content of type V cake was significantly ( $P \leq 0.05$ ) higher than control, type I, II and III cake. The ash content of type III cake was significantly ( $P \leq 0.05$ ) higher than type I and control cake. The ash content of every two consecutive cake was found to be non-significantly ( $P \leq 0.05$ ) different from each but significantly ( $P \leq 0.05$ ) different from rest of the types of cake.

#### 4.4.4.2 Carbohydrate content of Cake

The total soluble sugars, reducing sugars and non-reducing sugars of all the types of cake are presented in Table 4.35. The total soluble sugars content of control, type I, II, III, IV and V cake was 32.66, 34.17, 35.67, 37.20, 38.74 and 40.26 g/100g respectively. The total soluble sugars content of type V cake was significantly ( $P \leq 0.05$ ) higher other types of cake while the total soluble sugars content of control cake was found to be significantly ( $P \leq 0.05$ ) lower than all the types of cake. The total soluble sugars content of all the types of cake was recorded to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.35:- Carbohydrate content of Cake (g/100g, on dry matter basis)**

Types of Cake	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
Control	32.66 <sup>f</sup> ± 0.32	0.44 <sup>f</sup> ± 0.04	33.22 <sup>f</sup> ± 0.43
I	34.17 <sup>e</sup> ± 0.33	0.71 <sup>e</sup> ± 0.06	33.46 <sup>e</sup> ± 0.36
II	35.67 <sup>d</sup> ± 0.23	1.02 <sup>d</sup> ± 0.10	34.65 <sup>d</sup> ± 0.37
III	37.20 <sup>c</sup> ± 0.29	1.33 <sup>c</sup> ± 0.09	35.87 <sup>c</sup> ± 0.48
IV	38.74 <sup>b</sup> ± 0.32	1.62 <sup>b</sup> ± 0.04	37.12 <sup>b</sup> ± 0.29
V	40.26 <sup>a</sup> ± 0.21	1.93 <sup>a</sup> ± 0.13	38.33 <sup>a</sup> ± 0.38
CD ( $P \leq 0.05$ )	1.01	0.28	1.16

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The reducing sugars content of all types of cake ranged from 0.44 per cent in control to 1.93 per cent in type V cake. The reducing sugars content of all the types of cake increased with increasing supplementation of *ber* powder. The reducing sugars content of all types of

cake was found to be significantly ( $P \leq 0.05$ ) different from each other. Type V cake was observed to have significantly ( $P \leq 0.05$ ) higher reducing sugars content while control cake had significantly ( $P \leq 0.05$ ) lower reducing sugars content among all types of cake.

The non-reducing sugars content of control, type I, II, III, IV and V cake was 33.22, 33.46, 34.65, 35.87, 37.12 and 38.33 per cent, respectively. All the types of cake were observed to have significantly ( $P \leq 0.05$ ) different non-reducing sugars content from each other. The non-reducing sugars content of type V cake was significantly ( $P \leq 0.05$ ) higher and that of control cake was significantly ( $P \leq 0.05$ ) lower among all the types of cake.

#### 4.4.4.3 Mineral content of Cake

The calcium, iron, magnesium and zinc content of cake are presented in Table 4.36. The calcium content of control, type I, II, III, IV and V cake was 92.49, 102.43, 112.31, 122.23, 132.13 and 141.94 mg/100g, respectively. The calcium content of all the types of cake was significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type V cake and significantly ( $P \leq 0.05$ ) lower in control cake.

**Table 4.36:- Mineral content of Cake (mg/100g, on dry matter basis)**

Types of Cake	Calcium	Iron	Magnesium	Zinc
Control	92.49 <sup>f</sup> ± 0.56	4.40 <sup>f</sup> ± 0.24	51.60 <sup>f</sup> ± 0.29	0.55 <sup>c</sup> ± 0.02
I	102.43 <sup>e</sup> ± 0.54	5.49 <sup>e</sup> ± 0.13	54.29 <sup>e</sup> ± 0.34	0.57 <sup>c</sup> ± 0.03
II	112.31 <sup>d</sup> ± 0.66	6.58 <sup>d</sup> ± 0.13	56.91 <sup>d</sup> ± 0.39	0.60 <sup>bc</sup> ± 0.02
III	122.23 <sup>c</sup> ± 0.49	7.73 <sup>c</sup> ± 0.11	59.56 <sup>c</sup> ± 0.44	0.63 <sup>ab</sup> ± 0.04
IV	132.13 <sup>b</sup> ± 0.63	8.85 <sup>b</sup> ± 0.70	62.12 <sup>b</sup> ± 0.49	0.65 <sup>ab</sup> ± 0.04
V	141.94 <sup>a</sup> ± 0.53	9.89 <sup>a</sup> ± 0.34	64.71 <sup>a</sup> ± 0.59	0.67 <sup>a</sup> ± 0.03
CD ( $P \leq 0.05$ )	1.26	1.01	1.32	0.06

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The iron content of all the types of cake ranged from 4.40 to 9.89 mg/100g. The iron content of type V cake was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II, I and control cake. The iron content of all the types of cake was significantly ( $P \leq 0.05$ ) different from each other.

The magnesium content of control, type I, II, III, IV and V cake was 51.60, 54.29, 56.91, 59.56, 62.12 and 64.71 mg/100g, respectively. The magnesium content of all the types of cake was significantly ( $P \leq 0.05$ ) different from each other. The magnesium content of type V cake was significantly higher followed by type IV, III, II, I and control cake.

The zinc content of all the types of cake ranged from 0.55 to 0.67 mg/100g. Non-significant ( $P \leq 0.05$ ) differences were observed in the zinc content of every three consecutive

cake prepared like control, type I and II, type I, II and III, type II, III and IV and type III, IV and V cake.

#### 4.4.4.4 Vitamin content of Cake

The ascorbic acid and  $\beta$ -carotene content of all the types of cake are presented in Table 4.37. The ascorbic acid content of all the cake ranged from 3.49 to 17.24 mg/100g while it was not detected in the control cake. The ascorbic acid content of all the types of cake differed significantly ( $P \leq 0.05$ ) from each other. The ascorbic acid content of type V cake was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II and I cake.

**Table 4.37:- Vitamin content of Cake (mg/100g, on dry matter basis)**

Types of Cake	Ascorbic Acid	$\beta$ -carotene
Control	ND	ND
I	3.49 <sup>e</sup> $\pm$ 0.03	ND
II	6.67 <sup>d</sup> $\pm$ 0.25	ND
III	10.39 <sup>c</sup> $\pm$ 0.04	ND
IV	13.82 <sup>b</sup> $\pm$ 0.11	ND
V	17.24 <sup>a</sup> $\pm$ 0.15	ND
CD ( $P \leq 0.05$ )	0.32	NS

Values are Mean  $\pm$  SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

ND=Non Detected

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The  $\beta$ -carotene content was not detected in any of the cake prepared.

#### 4.4.4.5 In-vitro digestibilities of Cake

The *in-vitro* protein and starch digestibilities of all the types of cake are presented in Table 4.38. The *in-vitro* protein digestibility of control, type I, II, III, IV and V cake was 84.44, 84.76, 85.06, 85.37, 85.67 and 85.93 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the *in-vitro* protein digestibility of every two consecutive cake while rest were found to be significantly ( $P \leq 0.05$ ) different from each other.

The *in-vitro* starch digestibility of all the cake ranged from 48.11 to 49.14 mg maltose released/g. The *in-vitro* starch digestibility of type V cake was significantly ( $P \leq 0.05$ ) higher than control, type I, II and III cake. Non-significant ( $P \leq 0.05$ ) differences were observed in the *in-vitro* starch digestibility of every two consecutive cake while rest were found to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.38:- In-vitro digestibilities of Cake (on dry matter basis)**

Types of Cake	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g)
Control	84.44 <sup>e</sup> ± 0.17	48.11 <sup>e</sup> ± 0.11
I	84.76 <sup>de</sup> ± 0.24	48.32 <sup>de</sup> ± 0.15
II	85.06 <sup>cd</sup> ± 0.15	48.52 <sup>cd</sup> ± 0.19
III	85.37 <sup>bc</sup> ± 0.26	48.72 <sup>bc</sup> ± 0.09
IV	85.67 <sup>ab</sup> ± 0.11	48.94 <sup>ab</sup> ± 0.12
V	85.93 <sup>a</sup> ± 0.15	49.14 <sup>a</sup> ± 0.16
CD (P≤0.05)	0.52	0.33

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

#### 4.4.5 Nutritional evaluation of Pasta

Five different types of pasta were prepared using *ber* powder by supplementing 10, 20, 30, 40 and 50 per cent *ber* powder with refined wheat flour. Pasta prepared using only refined wheat flour served as control.

##### 4.4.5.1 Proximate composition of Pasta

The moisture, crude protein, crude fat, crude fiber and ash content of all the types of pasta prepared are presented in Table 4.39. The moisture content of control, type I, II, III, IV and V pasta was 2.74, 2.97, 3.18, 3.40, 3.60 and 3.81 per cent, respectively. Non-significant (P≤0.05) differences were observed in the moisture content of all the types of pasta prepared using *ber* powder and the control pasta.

**Table 4.39:- Proximate composition of Pasta (g/100g, on dry matter basis)**

Types of Pasta	Moisture*	Crude Protein	Crude Fat	Crude Fiber	Ash
Control	2.74 <sup>a</sup> ± 0.64	9.25 <sup>a</sup> ± 0.63	0.91 <sup>a</sup> ± 0.05	0.33 <sup>f</sup> ± 0.04	0.63 <sup>f</sup> ± 0.15
I	2.97 <sup>a</sup> ± 0.59	8.98 <sup>ab</sup> ± 0.29	0.92 <sup>a</sup> ± 0.10	0.67 <sup>e</sup> ± 0.13	0.97 <sup>e</sup> ± 0.04
II	3.18 <sup>a</sup> ± 0.54	8.71 <sup>bc</sup> ± 0.64	0.93 <sup>a</sup> ± 0.06	1.03 <sup>d</sup> ± 0.08	1.29 <sup>d</sup> ± 0.15
III	3.40 <sup>a</sup> ± 0.48	8.44 <sup>cd</sup> ± 0.26	0.93 <sup>a</sup> ± 0.02	1.34 <sup>c</sup> ± 0.15	1.63 <sup>c</sup> ± 0.16
IV	3.60 <sup>a</sup> ± 0.64	8.17 <sup>de</sup> ± 0.69	0.94 <sup>a</sup> ± 0.07	1.66 <sup>b</sup> ± 0.06	1.95 <sup>b</sup> ± 0.18
V	3.81 <sup>a</sup> ± 0.46	7.90 <sup>e</sup> ± 0.58	0.95 <sup>a</sup> ± 0.12	1.99 <sup>a</sup> ± 0.05	2.26 <sup>a</sup> ± 0.16
CD (P≤0.05)	NS	0.48	NS	0.14	0.22

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant (P≤0.05)

\*Moisture is determined on fresh weight basis

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The crude protein content of all the types of pasta ranged from 7.90 to 9.25 g/100g. The crude protein content of type V pasta was significantly ( $P \leq 0.05$ ) lower as compared to control pasta whose protein content was found to be significantly ( $P \leq 0.05$ ) higher than type II, III, IV and V pasta. Non-significant ( $P \leq 0.05$ ) differences were observed in the crude protein content of every two consecutive pasta while rest were found to be significantly ( $P \leq 0.05$ ) different from each other.

The crude fat content of control, type I, II, III, IV and V pasta was 0.91, 0.92, 0.93, 0.93, 0.94 and 0.95 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the crude fat content of all the types of pasta.

The crude fiber content of all the types of pasta ranged from 0.33 in control pasta to 1.99 in type V pasta. The crude fiber content of all the types of pasta was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type V pasta and significantly ( $P \leq 0.05$ ) lower in control pasta.

The ash content of control, type I, II, III, IV and V pasta was 0.63, 0.97, 1.29, 1.63, 1.95 and 2.26 per cent, respectively. The ash content of type V pasta was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II, I and control pasta. The ash content of all the types of pasta was found to be significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.5.2 Carbohydrate content of Pasta

The total soluble sugars, reducing sugars and non-reducing sugars content of pasta are presented in Table 4.40. The total soluble sugars content of control, type I, II, III, IV and V pasta was 3.90, 5.35, 6.92, 8.53, 10.20 and 11.75 g/100g, respectively. The total soluble sugars content of type V pasta was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II, I and control pasta. The total soluble sugar content of all the types of pasta was significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.40:- Carbohydrate content of Pasta (g/100g, on dry matter basis)**

Types of Pasta	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
Control	3.90 <sup>f</sup> ± 0.11	0.63 <sup>f</sup> ± 0.04	3.27 <sup>f</sup> ± 0.08
I	5.35 <sup>e</sup> ± 0.17	0.93 <sup>e</sup> ± 0.09	4.42 <sup>e</sup> ± 0.02
II	6.92 <sup>d</sup> ± 0.09	1.26 <sup>d</sup> ± 0.16	5.66 <sup>d</sup> ± 0.06
III	8.53 <sup>c</sup> ± 0.13	1.60 <sup>c</sup> ± 0.10	6.93 <sup>c</sup> ± 0.07
IV	10.20 <sup>b</sup> ± 0.19	1.92 <sup>b</sup> ± 0.05	8.23 <sup>b</sup> ± 0.08
V	11.75 <sup>a</sup> ± 0.20	2.26 <sup>a</sup> ± 0.04	9.49 <sup>a</sup> ± 0.06
CD ( $P \leq 0.05$ )	0.51	0.28	0.24

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The reducing sugars content of all the prepared pasta ranged from 0.63 to 2.26 per cent. The reducing sugars content of control pasta was found to be significantly ( $P \leq 0.05$ ) lower and that of type V pasta was found to be significantly ( $P \leq 0.05$ ) higher among all the types of pasta. The reducing sugars content of all the types of pasta was observed to be significantly ( $P \leq 0.05$ ) different from each other.

The non-reducing sugars content of control, type I, II, III, IV and V pasta was 3.27, 4.42, 5.66, 6.93, 8.23 and 9.49 g/100g, respectively. The non-reducing sugars content of type V pasta was significantly ( $P \leq 0.05$ ) higher among all the types of pasta followed by type IV, III, II, I and control pasta. All the types of pasta were found to be significantly ( $P \leq 0.05$ ) different from each other in terms of their non-reducing sugars content.

#### 4.4.5.3 Mineral content of Pasta

The calcium, iron, magnesium and zinc content of all the types of pasta are presented in Table 4.41. The calcium content of control, type I, II, III, IV and V was 21.42, 34.04, 46.65, 59.28, 71.90 and 84.51 mg/100g, respectively. The calcium content of type V pasta was significantly ( $P \leq 0.05$ ) higher while the calcium content of control pasta was significantly ( $P \leq 0.05$ ) lower among all the types of pasta. The calcium content of all the types of pasta was found to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.41:- Mineral content of Pasta (mg/100g, on dry matter basis)**

Types of Pasta	Calcium	Iron	Magnesium	Zinc
Control	21.42 <sup>f</sup> ± 0.67	2.73 <sup>f</sup> ± 0.07	46.35 <sup>f</sup> ± 0.21	0.43 <sup>d</sup> ± 0.02
I	34.04 <sup>e</sup> ± 0.88	4.14 <sup>c</sup> ± 0.14	49.68 <sup>e</sup> ± 0.31	0.45 <sup>cd</sup> ± 0.03
II	46.65 <sup>d</sup> ± 0.94	5.53 <sup>d</sup> ± 0.11	52.93 <sup>d</sup> ± 0.24	0.47 <sup>bcd</sup> ± 0.02
III	59.28 <sup>c</sup> ± 1.02	6.94 <sup>c</sup> ± 0.18	56.15 <sup>c</sup> ± 0.15	0.50 <sup>abc</sup> ± 0.02
IV	71.90 <sup>b</sup> ± 0.97	8.36 <sup>b</sup> ± 0.21	59.41 <sup>b</sup> ± 0.26	0.53 <sup>ab</sup> ± 0.04
V	84.51 <sup>a</sup> ± 0.88	9.76 <sup>a</sup> ± 0.62	62.69 <sup>a</sup> ± 0.22	0.55 <sup>a</sup> ± 0.03
CD ( $P \leq 0.05$ )	1.81	0.44	0.67	0.07

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The iron content of all the types of pasta ranged from 2.73 to 9.76 mg/100g. The iron content of all the types of pasta was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly higher in type V pasta followed by type IV, III, II, I and control pasta.

The magnesium content of control, type I, II, III, IV and V pasta was 46.35, 49.68, 52.93, 56.15, 59.41 and 62.69 mg/100g, respectively. The magnesium content of type V pasta

was significantly ( $P \leq 0.05$ ) higher and the magnesium content of control pasta was significantly ( $P \leq 0.05$ ) lower among all the types of pasta. The magnesium content of all the types of pasta was found to be significantly ( $P \leq 0.05$ ) different from each other.

The zinc content of all the types of pasta ranged from 0.43 to 0.55 mg/100g. The zinc content of type V pasta was significantly ( $P \leq 0.05$ ) higher than control, type I and II pasta. Non-significant ( $P \leq 0.05$ ) differences were observed in the zinc content of every three consecutive pasta while rest were found to be significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.5.4 Vitamin content of Pasta

The ascorbic acid and  $\beta$ -carotene content of all the prepared pasta are presented in Table 4.42. The ascorbic acid content of all the prepared pasta ranged from 3.31 to 18.19 mg/100g while it was not detected in the control pasta. The ascorbic acid content of all the types of pasta differed significantly ( $P \leq 0.05$ ) from each other. The ascorbic acid content of type V pasta was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II and I pasta.

**Table 4.42:- Vitamin content of Pasta (mg/100g, on dry matter basis)**

Types of Pasta	Ascorbic Acid	$\beta$ -carotene
Control	ND	ND
I	3.31 <sup>e</sup> $\pm$ 0.08	ND
II	7.43 <sup>d</sup> $\pm$ 0.06	ND
III	11.34 <sup>c</sup> $\pm$ 0.04	ND
IV	14.56 <sup>b</sup> $\pm$ 0.06	ND
V	18.19 <sup>a</sup> $\pm$ 0.06	ND
CD ( $P \leq 0.05$ )	0.18	NS

Values are Mean  $\pm$  SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

ND=Non Detected

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The  $\beta$ -carotene content was not detected in any type of the pasta.

#### 4.4.5.5 In-vitro digestibilities of Pasta

The *in-vitro* protein and starch digestibilities of all the types of pasta are presented in Table 4.43. The *in-vitro* protein digestibility of control, type I, II, III, IV and V pasta was 70.75, 71.14, 71.74, 72.11, 72.46 and 72.79 per cent, respectively. The *in-vitro* protein digestibility of all the types of pasta was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type V pasta and significantly ( $P \leq 0.05$ ) lower in control pasta.

The *in-vitro* starch digestibility of all the types of pasta ranged from 35.64 to 36.69 mg maltose released/g. The *in-vitro* starch digestibility of type V pasta was significantly

( $P \leq 0.05$ ) higher than control, type I, II, III and IV pasta. Significant ( $P \leq 0.05$ ) differences were observed in the *in-vitro* starch digestibility of all the types of pasta.

**Table 4.43:- *In-vitro* digestibilities of Pasta (on dry matter basis)**

Types of Pasta	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g)
Control	70.75 <sup>f</sup> ± 0.07	35.64 <sup>f</sup> ± 0.12
I	71.14 <sup>c</sup> ± 0.13	35.86 <sup>e</sup> ± 0.17
II	71.74 <sup>d</sup> ± 0.10	36.06 <sup>d</sup> ± 0.24
III	72.11 <sup>c</sup> ± 0.13	36.28 <sup>c</sup> ± 0.09
IV	72.46 <sup>b</sup> ± 0.08	36.49 <sup>b</sup> ± 0.10
V	72.79 <sup>a</sup> ± 0.12	36.69 <sup>a</sup> ± 0.12
CD ( $P \leq 0.05$ )	0.22	0.17

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

#### 4.4.6 Nutritional evaluation of Noodles

Five different types of noodles were prepared using *ber* powder by supplementing 10, 20, 30, 40 and 50 per cent *ber* powder with refined wheat flour. Noodles prepared using only refined wheat flour served as control.

##### 4.4.6.1 Proximate composition of Noodles

The moisture, crude protein, crude fat, crude fiber and ash content of all the types of noodles are presented in Table 4.44. The moisture content of control, type I, II, III, IV and V noodles was 2.70, 2.91, 3.10, 3.35, 3.59 and 3.80 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the moisture content of all the types of noodles prepared using *ber* powder and the control noodles.

**Table 4.44:- Proximate composition of Noodles (g/100g, on dry matter basis)**

Types of Noodles	Moisture*	Crude Protein	Crude Fat	Crude Fiber	Ash
Control	2.70 <sup>a</sup> ± 0.41	9.33 <sup>a</sup> ± 0.08	0.90 <sup>a</sup> ± 0.08	0.38 <sup>f</sup> ± 0.15	0.60 <sup>f</sup> ± 0.02
I	2.90 <sup>a</sup> ± 0.43	9.05 <sup>b</sup> ± 0.13	0.91 <sup>a</sup> ± 0.12	0.71 <sup>c</sup> ± 0.05	0.91 <sup>e</sup> ± 0.04
II	3.10 <sup>a</sup> ± 0.48	8.79 <sup>c</sup> ± 0.15	0.92 <sup>a</sup> ± 0.02	1.04 <sup>d</sup> ± 0.18	1.22 <sup>d</sup> ± 0.03
III	3.35 <sup>a</sup> ± 0.45	8.51 <sup>d</sup> ± 0.09	0.93 <sup>a</sup> ± 0.15	1.37 <sup>c</sup> ± 0.23	1.58 <sup>c</sup> ± 0.06
IV	3.59 <sup>a</sup> ± 0.39	8.24 <sup>e</sup> ± 0.05	0.94 <sup>a</sup> ± 0.20	1.69 <sup>b</sup> ± 0.15	1.88 <sup>b</sup> ± 0.04
V	3.80 <sup>a</sup> ± 0.36	7.97 <sup>f</sup> ± 0.11	0.94 <sup>a</sup> ± 0.27	2.01 <sup>a</sup> ± 0.06	2.19 <sup>a</sup> ± 0.03
CD ( $P \leq 0.05$ )	NS	0.26	NS	0.05	0.09

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

\*Moisture is determined on fresh weight basis

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The crude protein content of noodles ranged from 7.97 to 9.33 g/100g. The crude protein content of type V noodles was significantly ( $P \leq 0.05$ ) lower as compared to control noodles whose crude protein content was found to be significantly ( $P \leq 0.05$ ) higher than type I, II, III, IV and V noodles. Significant ( $P \leq 0.05$ ) differences were observed in the crude protein content of all the types of noodles.

The crude fat content of control, type I, II, III, IV and V noodles was 0.90, 0.91, 0.92, 0.93, 0.94 and 0.94 per cent, respectively. Non-significant ( $P \leq 0.05$ ) differences were observed in the crude fat content of all the types of noodles.

The crude fiber content of noodles ranged from 0.38 per cent in control noodles to 2.01 per cent in type V noodles. The crude fiber content of all the types of noodles was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type V noodles and significantly ( $P \leq 0.05$ ) lower in control noodles.

The ash content of control, type I, II, III, IV and V noodles was 0.60, 0.91, 1.22, 1.58, 1.88 and 2.19 per cent, respectively. The ash content of type V noodles was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II, I and control noodles. The ash content of all the types of noodles was found to be significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.6.2 Carbohydrate content of Noodles

The total soluble sugars, reducing sugars and non-reducing sugars content of noodles are presented in Table 4.45. The total soluble sugars content of control, type I, II, III, IV and V noodles was 3.76, 5.27, 6.86, 8.43, 10.08 and 11.72 g/100g, respectively. The total soluble sugars content of type V noodles was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II, I and control noodles. The total soluble sugars content of all the types of noodles was significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.45:- Carbohydrate content of Noodles (g/100g, on dry matter basis)**

Types of Noodles	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
Control	3.76 <sup>f</sup> ± 0.16	0.54 <sup>f</sup> ± 0.05	3.22 <sup>f</sup> ± 0.21
I	5.27 <sup>e</sup> ± 0.15	0.85 <sup>e</sup> ± 0.06	4.42 <sup>e</sup> ± 0.20
II	6.86 <sup>d</sup> ± 0.19	1.19 <sup>d</sup> ± 0.03	5.67 <sup>d</sup> ± 0.26
III	8.43 <sup>c</sup> ± 0.12	1.53 <sup>c</sup> ± 0.06	6.90 <sup>c</sup> ± 0.19
IV	10.08 <sup>b</sup> ± 0.15	1.84 <sup>b</sup> ± 0.08	8.24 <sup>b</sup> ± 0.20
V	11.72 <sup>a</sup> ± 0.13	2.19 <sup>a</sup> ± 0.04	9.53 <sup>a</sup> ± 0.18
CD ( $P \leq 0.05$ )	0.46	0.16	0.62

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The reducing sugars content of all the prepared noodles ranged from 0.54 to 2.19 per cent. The reducing sugars content of control noodles was found to be significantly ( $P \leq 0.05$ ) lower and that of type V noodles was found to be significantly ( $P \leq 0.05$ ) higher among all the types of noodles. The reducing sugars content of all the types of noodles was observed to be significantly ( $P \leq 0.05$ ) different from each other.

The non-reducing sugars content of control, type I, II, III, IV and V noodles was 3.22, 4.42, 5.67, 6.90, 8.24 and 9.53 g/100g, respectively. The non-reducing sugars content of type V noodles was significantly ( $P \leq 0.05$ ) higher among all the types of noodles followed by type IV, III, II, I and control noodles. All the types of noodles were found to be significantly ( $P \leq 0.05$ ) different from each other in terms of their non-reducing sugar content.

#### 4.4.6.3 Mineral content of Noodles

The calcium, iron, magnesium and zinc content of all the types of noodles are presented in Table 4.46. The calcium content of control, type I, II, III, IV and V noodles was 22.19, 34.80, 47.43, 60.02, 72.64 and 85.26 mg/100g, respectively. The calcium content of type V noodles was significantly ( $P \leq 0.05$ ) higher while the calcium content of control noodles was significantly ( $P \leq 0.05$ ) lower among all the types of noodles. The calcium content of all the types of noodles was found to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.46:- Mineral content of Noodles (mg/100g, on dry matter basis)**

Types of Noodles	Calcium	Iron	Magnesium	Zinc
Control	22.19 <sup>f</sup> ± 0.22	2.16 <sup>f</sup> ± 0.19	46.12 <sup>f</sup> ± 0.30	0.45 <sup>d</sup> ± 0.02
I	34.80 <sup>e</sup> ± 0.65	3.58 <sup>e</sup> ± 0.06	49.48 <sup>e</sup> ± 0.34	0.47 <sup>cd</sup> ± 0.03
II	47.43 <sup>d</sup> ± 0.58	4.97 <sup>d</sup> ± 0.16	52.76 <sup>d</sup> ± 0.23	0.49 <sup>bcd</sup> ± 0.02
III	60.02 <sup>c</sup> ± 0.72	6.39 <sup>c</sup> ± 0.14	56.02 <sup>c</sup> ± 0.19	0.52 <sup>abc</sup> ± 0.04
IV	72.64 <sup>b</sup> ± 0.48	7.78 <sup>b</sup> ± 0.14	59.31 <sup>b</sup> ± 0.31	0.54 <sup>ab</sup> ± 0.02
V	85.26 <sup>a</sup> ± 0.70	9.20 <sup>a</sup> ± 0.11	62.62 <sup>a</sup> ± 0.27	0.56 <sup>a</sup> ± 0.02
CD ( $P \leq 0.05$ )	1.68	1.32	0.95	0.06

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The iron content of all the types of noodles ranged from 2.16 to 9.20 mg/100g. The iron content of all the types of noodles was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly higher in type V noodles followed by type IV, III, II, I and control noodles.

The magnesium content of control, type I, II, III, IV and V noodles was 46.12, 49.48, 52.76, 56.02, 59.31 and 62.62 mg/100g, respectively. The magnesium content of type V noodles was significantly ( $P \leq 0.05$ ) higher and the magnesium content of control noodles was

significantly ( $P \leq 0.05$ ) lower among all the types of noodles. The magnesium content of all the types of noodles was found to be significantly ( $P \leq 0.05$ ) different from each other.

The zinc content of all the types of noodles ranged from 0.45 to 0.56 mg/100g. The zinc content of type V noodles was significantly ( $P \leq 0.05$ ) higher than control, type I and II noodles. Non-significant ( $P \leq 0.05$ ) differences were observed in the zinc content of every three consecutive noodles while rest were found to be significantly ( $P \leq 0.05$ ) different from each other.

#### 4.4.6.4 Vitamin content of Noodles

The ascorbic acid and  $\beta$ -carotene content of all the types of noodles are presented in Table 4.47. The ascorbic acid content of all the types of noodles ranged from 3.26 to 18.21 mg/100g while it was not detected in the control noodles. The ascorbic acid content of all the types of noodles differed significantly ( $P \leq 0.05$ ) from each other. The ascorbic acid content of type V noodles was significantly ( $P \leq 0.05$ ) higher followed by type IV, III, II and I noodles.

The  $\beta$ -carotene content was not detected in any type of the noodles.

**Table 4.47:- Vitamin content of Noodles (mg/100g, on dry matter basis)**

Types of Noodles	Ascorbic Acid	B-carotene
Control	ND	ND
I	3.26 <sup>c</sup> $\pm$ 0.08	ND
II	7.39 <sup>d</sup> $\pm$ 0.07	ND
III	11.31 <sup>c</sup> $\pm$ 0.04	ND
IV	15.53 <sup>b</sup> $\pm$ 0.06	ND
V	18.21 <sup>a</sup> $\pm$ 0.03	ND
CD ( $P \leq 0.05$ )	0.16	NS

Values are Mean  $\pm$  SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

ND=Non Detected

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

#### 4.4.6.5 *In-vitro* digestibilities of Noodles

The *in-vitro* protein and starch digestibilities of all the types of noodles are presented in Table 4.48. The *in-vitro* protein digestibility of control, type I, II, III, IV and V noodles was 71.00, 71.38, 71.74, 72.11, 72.46 and 72.79 per cent, respectively. The *in-vitro* protein digestibility of all the types of noodles was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type V noodles and significantly ( $P \leq 0.05$ ) lower in control noodles.

**Table 4.48:- *In-vitro* digestibilities of Noodles (on dry matter basis)**

Types of Noodles	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/g)
Control	71.00 <sup>f</sup> ± 0.16	35.92 <sup>f</sup> ± 0.03
I	71.38 <sup>e</sup> ± 0.19	36.14 <sup>e</sup> ± 0.06
II	71.74 <sup>d</sup> ± 0.22	36.34 <sup>d</sup> ± 0.04
III	72.11 <sup>c</sup> ± 0.26	36.55 <sup>c</sup> ± 0.04
IV	72.46 <sup>b</sup> ± 0.17	36.75 <sup>b</sup> ± 0.07
V	72.79 <sup>a</sup> ± 0.19	36.96 <sup>a</sup> ± 0.11
CD (P≤0.05)	0.23	0.18

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= *Ber* powder

RF= Refined Flour

The *in-vitro* starch digestibility of all types of noodles ranged from 35.92 to 36.96 mg maltose released/g. The *in-vitro* starch digestibility of type V noodles was significantly (P≤0.05) higher than control, type I, II, III and IV noodles. Significant (P≤0.05) differences were observed in the *in-vitro* starch digestibility of all the types of noodles.

#### 4.4.7 Nutritional evaluation of RTS beverage

Four different types of RTS beverage were prepared using *ber* powder. The type I, II, III and IV RTS beverage consisted of 10, 20, 30 and 40 per cent *ber* powder.

##### 4.4.7.1 Proximate composition of RTS beverage

The moisture, crude protein, crude fat, crude fiber and ash content of RTS beverage are presented in Table 4.49. The moisture content of all the types of RTS beverage ranged from 75.48 to 92.13 g/100ml being significantly (P≤0.05) higher in type I RTS beverage and significantly lower in type IV RTS beverage. The moisture content of all the types of RTS beverage was found to be significantly (P≤0.05) different from each other.

The crude protein content of type I, II, III and IV RTS beverage was 0.69, 1.34, 1.93 and 2.51 g/100ml, respectively. The crude protein content of type IV RTS beverage was significantly (P≤0.05) higher followed by type III, II and I RTS beverage. The crude protein content of all the types of RTS beverage was found to be significantly (P≤0.05) different from each other.

The crude fat content of all the types of RTS beverage ranged from 0.09 to 0.31 g/100ml. The crude fat content of type IV RTS beverage was significantly (P≤0.05) higher among all the types of RTS beverage. The crude fat content of all the types of RTS beverage was observed to be significantly (P≤0.05) different from each other.

**Table 4.49:- Proximate composition of RTS beverage (g/100ml)**

Types of RTS beverages	Moisture	Crude Protein	Crude Fat	Crude Fiber	Ash
I	92.13 <sup>a</sup> ± 0.16	0.69 <sup>d</sup> ± 0.02	0.09 <sup>d</sup> ± 0.02	0.34 <sup>d</sup> ± 0.02	0.39 <sup>d</sup> ± 0.02
II	86.72 <sup>b</sup> ± 0.13	1.34 <sup>c</sup> ± 0.06	0.15 <sup>c</sup> ± 0.04	0.60 <sup>c</sup> ± 0.04	0.74 <sup>c</sup> ± 0.06
III	81.19 <sup>c</sup> ± 0.21	1.93 <sup>b</sup> ± 0.03	0.22 <sup>b</sup> ± 0.05	0.85 <sup>b</sup> ± 0.03	1.12 <sup>b</sup> ± 0.07
IV	75.48 <sup>d</sup> ± 0.12	2.51 <sup>a</sup> ± 0.04	0.31 <sup>a</sup> ± 0.04	1.09 <sup>a</sup> ± 0.03	1.48 <sup>a</sup> ± 0.04
CD (P≤0.05)	1.53	0.15	0.06	0.09	0.15

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The crude fiber content of type I, II, III and IV RTS beverage was 0.34, 0.60, 0.85 and 1.09 g/100ml, respectively. The crude fiber content of type IV RTS beverage was significantly (P≤0.05) higher followed by type III, II and I RTS beverage. The crude fiber content of all the types of RTS beverage was observed to be significantly (P≤0.05) different from each other.

The ash content of all the types of RTS beverage ranged from 0.39 to 1.48 g/100ml. Significant (P≤0.05) differences were observed in the ash content of all the types of RTS beverage. The ash content of type IV RTS beverage was significantly (P≤0.05) higher and type I RTS beverage was significantly (P≤0.05) lower among all the types of RTS beverage prepared.

#### 4.4.7.2 Carbohydrate content of RTS beverage

The total soluble sugars, reducing sugars and non-reducing sugars content of all the types of RTS beverage are presented in Table 4.50. The total soluble sugars content of all the types of RTS beverage ranged from 18.70 g/100ml in type I RTS beverage to 23.64 g/100 ml in type IV RTS beverage. The total soluble sugars content of all the types of RTS beverage was found to be significantly (P≤0.05) different from each other. The total soluble sugars content of type IV RTS beverage was significantly (P≤0.05) higher followed by type III, II and I RTS beverage.

**Table 4.50:- Carbohydrate content of RTS beverage (g/100ml)**

Types of RTS beverages	Total Soluble Sugars	Reducing Sugars	Non-Reducing Sugars
I	18.70 <sup>d</sup> ± 0.13	7.19 <sup>d</sup> ± 0.08	11.51 <sup>d</sup> ± 0.06
II	20.35 <sup>c</sup> ± 0.24	7.54 <sup>c</sup> ± 0.13	12.81 <sup>c</sup> ± 0.09
III	21.95 <sup>b</sup> ± 0.15	7.91 <sup>b</sup> ± 0.18	14.04 <sup>b</sup> ± 0.08
IV	23.64 <sup>a</sup> ± 0.23	8.25 <sup>a</sup> ± 0.10	15.39 <sup>a</sup> ± 0.11
CD (P≤0.05)	0.58	0.29	0.29

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The reducing sugars content of type I, II, III and IV RTS beverage was 7.19, 7.54, 7.91 and 8.25 g/100 ml, respectively. The reducing sugars content of all the types of RTS beverage was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type IV RTS beverage and significantly ( $P \leq 0.05$ ) lower in type I RTS beverage.

The non-reducing sugars content of all the types of RTS beverage varied from 11.51 to 15.39 g/100ml. The non-reducing sugars content of type IV RTS beverage was observed to be significantly ( $P \leq 0.05$ ) higher followed by type III, II and I RTS beverage. Significant ( $P \leq 0.05$ ) differences were observed in the non-reducing sugars content of all the types of RTS beverage.

#### 4.4.7.3 Mineral content of RTS beverage

The calcium, iron, magnesium and zinc content of all the types of RTS beverage are presented in Table 4.51. The calcium content of type I, II, III and IV RTS beverage was 14.26, 29.23, 44.34 and 58.68 mg/100ml. The calcium content of type IV RTS beverage was significantly ( $P \leq 0.05$ ) higher among all the types of RTS beverage. Significant ( $P \leq 0.05$ ) differences were observed in the calcium content of all the types of RTS beverage.

**Table 4.51:- Mineral content of RTS beverage (mg/100ml)**

Types of RTS beverages	Calcium	Iron	Magnesium	Zinc
I	14.26 <sup>d</sup> ± 0.12	1.27 <sup>d</sup> ± 0.14	7.97 <sup>d</sup> ± 0.09	0.08 <sup>d</sup> ± 0.03
II	29.23 <sup>c</sup> ± 0.25	2.95 <sup>c</sup> ± 0.04	16.59 <sup>c</sup> ± 0.17	0.15 <sup>c</sup> ± 0.07
III	44.34 <sup>b</sup> ± 0.13	4.71 <sup>b</sup> ± 0.23	24.78 <sup>b</sup> ± 0.22	0.24 <sup>b</sup> ± 0.08
IV	58.68 <sup>a</sup> ± 0.19	6.32 <sup>a</sup> ± 0.26	33.86 <sup>a</sup> ± 0.16	0.31 <sup>a</sup> ± 0.04
CD ( $P \leq 0.05$ )	2.45	0.62	0.55	0.13

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The iron content of RTS beverage varied from 1.27 mg/100ml in type I RTS beverage to 6.32 mg/100ml in type IV RTS beverage. The iron content of all the types of RTS beverage was found to be significantly ( $P \leq 0.05$ ) different from each other being significantly ( $P \leq 0.05$ ) higher in type IV RTS beverage and significantly ( $P \leq 0.05$ ) lower in type I RTS beverage.

The magnesium content of all the types of RTS beverage ranged from 7.97 to 33.86 mg/100ml. The magnesium content of type IV RTS beverage was significantly ( $P \leq 0.05$ ) higher among all the types of RTS beverage followed by type III, II and I RTS beverage. Significant ( $P \leq 0.05$ ) differences were observed in the magnesium content of all the types of RTS beverage.

The zinc content of all the types of RTS beverage ranged from 0.08 to 0.31 mg/100ml. The zinc content of all the types of RTS beverage was significantly ( $P \leq 0.05$ )

different from each other being significantly ( $P \leq 0.05$ ) higher in type IV RTS beverage and significantly lower in type I RTS beverage.

#### 4.4.7.4 Vitamin content of RTS beverage

The ascorbic acid and  $\beta$ -carotene content of all the types of RTS beverage are presented in Table 4.52. The ascorbic acid content of type I, II, III and IV RTS beverage was 3.42, 7.25, 11.17 and 16.13 mg/100ml. The ascorbic acid content of type IV RTS beverage was found to be significantly ( $P \leq 0.05$ ) higher followed by type III, II and I RTS beverage. The ascorbic acid content of all the types of RTS beverage was found to be significantly ( $P \leq 0.05$ ) different from each other.

**Table 4.52:- Vitamin content of RTS beverage (mg/100ml)**

Types of RTS beverages	Ascorbic Acid	B-carotene
I	3.42 <sup>d</sup> ± 0.09	ND
II	7.25 <sup>c</sup> ± 0.15	ND
III	11.17 <sup>b</sup> ± 0.21	ND
IV	16.13 <sup>a</sup> ± 0.11	ND
CD ( $P \leq 0.05$ )	0.40	NS

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

NS=Non-significant ( $P \leq 0.05$ )

ND=Not Detected

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The  $\beta$ -carotene content was not detected in any of the RTS beverage.

#### 4.4.7.5 *In-vitro* digestibilities of RTS beverage

The *in-vitro* protein and starch digestibility of all the types of RTS beverage are presented in Table 4.53.

**Table 4.53:- *In-vitro* digestibilities of RTS beverage**

Types of RTS beverages	<i>In-vitro</i> protein digestibility (%)	<i>In-vitro</i> starch digestibility (mg maltose released/ml)
I	76.87 <sup>d</sup> ± 0.17	39.61 <sup>d</sup> ± 0.15
II	77.49 <sup>c</sup> ± 0.16	40.08 <sup>c</sup> ± 0.09
III	78.09 <sup>b</sup> ± 0.12	40.41 <sup>b</sup> ± 0.13
IV	78.60 <sup>a</sup> ± 0.13	40.71 <sup>a</sup> ± 0.10
CD ( $P \leq 0.05$ )	0.34	0.27

Values are Mean ± SE of the three independent determinations.

Mean values with same superscript are not significantly different.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The *in-vitro* protein digestibility of all the types of RTS beverage ranged from 76.87 to 78.60 per cent. The *in-vitro* protein digestibility of type IV RTS beverage was significantly ( $P \leq 0.05$ )

higher and that of type I RTS beverage was significantly ( $P \leq 0.05$ ) lower among all the types of RTS beverage. The *in-vitro* protein digestibility of all the types of RTS beverage was found to be significantly ( $P \leq 0.05$ ) different from each other.

The *in-vitro* starch digestibility of all the types of RTS beverage ranged from 39.61 to 40.71 mg maltose released/ml. The *in-vitro* starch digestibility of type IV RTS beverage was significantly ( $P \leq 0.05$ ) higher than type I, II and III RTS beverage. Significant ( $P \leq 0.05$ ) differences were observed in the *in-vitro* starch digestibility of all the types of RTS beverage.

#### 4.5 Shelf-life studies of products

The products which were suitable for storage were stored at ambient room temperature in air tight food grade plastic containers. They were evaluated for sensory parameters, by a panel of 10 judges using 9 point hedonic scale, at an interval of 15 days for 2 months. The products kept for storage were biscuits, pasta, noodles and RTS beverage.

##### 4.5.1 Effect of storage on sensory parameters of biscuits

Mean scores of the colour of control, type I, II, III, IV and V biscuits indicated that their acceptability for colour fell in the category of 'liked moderately' throughout their storage period (Table 4.54). Non-significant ( $P \leq 0.05$ ) differences were observed among the all the biscuit types for their colour while significant ( $P \leq 0.05$ ) differences were observed for colour during storage.

**Table 4.54:- Effect of storage on colour of Biscuits**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.20	7.80 ± 0.20	7.70 ± 0.21	7.60 ± 0.16	7.50 ± 0.22
I	7.80 ± 0.25	7.80 ± 0.25	7.60 ± 0.31	7.50 ± 0.27	7.40 ± 0.22
II	7.70 ± 0.30	7.60 ± 0.27	7.50 ± 0.27	7.40 ± 0.31	7.20 ± 0.33
III	7.70 ± 0.34	7.60 ± 0.34	7.40 ± 0.31	7.30 ± 0.40	7.20 ± 0.29
IV	7.60 ± 0.31	7.50 ± 0.27	7.30 ± 0.30	7.20 ± 0.25	7.10 ± 0.31
V	7.60 ± 0.43	7.40 ± 0.40	7.20 ± 0.39	7.10 ± 0.38	7.00 ± 0.39
CD ( $P \leq 0.05$ )	For product= NS		For storage= 0.34		

Values are Mean ± SE of the three independent determinations.

NS=Non-significant ( $P \leq 0.05$ )

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The acceptability of appearance of all the types of biscuits was rated as 'liked moderately' by the panel of judges during their storage (Table 4.55). Though the mean scores of biscuits were slightly higher in the beginning of storage and started declining thereof. Non-significant ( $P \leq 0.05$ ) differences were observed among the all the biscuit types for their appearance while significant ( $P \leq 0.05$ ) differences were observed for appearance during storage.

**Table 4.55:- Effect of storage on appearance of Biscuits**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.80 ± 0.25	7.60 ± 0.22	7.50 ± 0.27	7.40 ± 0.27
I	7.80 ± 0.25	7.80 ± 0.25	7.60 ± 0.27	7.50 ± 0.31	7.30 ± 0.34
II	7.70 ± 0.30	7.60 ± 0.27	7.50 ± 0.27	7.40 ± 0.22	7.20 ± 0.25
III	7.60 ± 0.34	7.50 ± 0.34	7.40 ± 0.31	7.30 ± 0.34	7.20 ± 0.33
IV	7.60 ± 0.31	7.50 ± 0.27	7.30 ± 0.30	7.20 ± 0.25	7.00 ± 0.26
V	7.50 ± 0.43	7.40 ± 0.40	7.20 ± 0.42	7.10 ± 0.38	7.00 ± 0.41
CD (P≤0.05)	For product= NS		For storage= 0.34		

Values are Mean ± SE of the three independent determinations.

NS=Non-significant (P≤0.05)

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The acceptability of aroma of control, type I, II and III biscuits was rated as 'liked moderately' during the storage (Table 4.56). The aroma of type IV and V biscuits was rated as 'liked moderately' till one month of storage and thereafter they were rated as 'liked slightly' for their aroma. Significant (P≤0.05) differences were observed for aroma of all the biscuits during their storage.

**Table 4.56:- Effect of storage on aroma of Biscuits**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.80 ± 0.25	7.60 ± 0.22	7.40 ± 0.27	7.30 ± 0.30
I	7.80 ± 0.25	7.80 ± 0.25	7.50 ± 0.31	7.40 ± 0.34	7.20 ± 0.39
II	7.60 ± 0.31	7.60 ± 0.31	7.40 ± 0.27	7.20 ± 0.33	7.10 ± 0.35
III	7.50 ± 0.37	7.40 ± 0.37	7.30 ± 0.40	7.20 ± 0.39	7.10 ± 0.41
IV	7.30 ± 0.30	7.20 ± 0.29	7.10 ± 0.23	6.90 ± 0.28	6.70 ± 0.30
V	7.20 ± 0.42	7.10 ± 0.38	7.00 ± 0.36	6.60 ± 0.31	6.50 ± 0.34
CD (P≤0.05)	For product= 0.39		For storage= 0.36		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

Mean scores of the texture indicated that the acceptability of texture of control, type I, II and III biscuits fell in the category of 'liked moderately' during the storage period (Table 4.57). The texture of type IV and V biscuits was rated as 'liked moderately' till 30<sup>th</sup> day of storage and they were rated as 'liked slightly' at 45<sup>th</sup> and 60<sup>th</sup> day of storage. Significant (P≤0.05) differences were observed for the texture among all the biscuits during storage.

**Table 4.57:- Effect of storage on texture of Biscuits**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.80 ± 0.25	7.70 ± 0.26	7.50 ± 0.22	7.30 ± 0.30
I	7.80 ± 0.25	7.70 ± 0.26	7.60 ± 0.31	7.40 ± 0.27	7.20 ± 0.29
II	7.60 ± 0.31	7.50 ± 0.27	7.40 ± 0.27	7.20 ± 0.25	7.00 ± 0.33
III	7.40 ± 0.31	7.30 ± 0.26	7.20 ± 0.25	7.20 ± 0.25	7.00 ± 0.26
IV	7.20 ± 0.33	7.10 ± 0.28	7.00 ± 0.26	6.80 ± 0.25	6.70 ± 0.26
V	7.10 ± 0.46	7.00 ± 0.42	7.00 ± 0.31	6.70 ± 0.37	6.50 ± 0.34
CD (P≤0.05)	For product= 0.36		For storage= 0.34		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The acceptability of taste indicated that control, type I, II and III were rated as 'liked moderately' during the storage period (Table 4.58). The taste of type IV biscuits was 'liked moderately' till 45<sup>th</sup> day of storage while the taste of type V biscuits was 'liked moderately' till one month of storage and were 'liked slightly' thereafter. Significant (P≤0.05) differences were observed for taste among all the biscuits during storage.

**Table 4.58:- Effect of storage on taste of Biscuits**

	Storage period (days)				
	0	15	30	45	60
Control	7.90 ± 0.23	7.80 ± 0.20	7.70 ± 0.21	7.50 ± 0.27	7.40 ± 0.31
I	8.10 ± 0.23	8.00 ± 0.21	7.90 ± 0.23	7.70 ± 0.37	7.50 ± 0.40
II	7.70 ± 0.30	7.60 ± 0.27	7.50 ± 0.27	7.40 ± 0.31	7.30 ± 0.34
III	7.50 ± 0.17	7.30 ± 0.21	7.20 ± 0.25	7.10 ± 0.23	7.00 ± 0.21
IV	7.40 ± 0.27	7.20 ± 0.20	7.10 ± 0.23	7.00 ± 0.21	6.90 ± 0.23
V	7.20 ± 0.36	7.10 ± 0.31	7.00 ± 0.37	6.90 ± 0.31	6.60 ± 0.22
CD (P≤0.05)	For product= 0.33		For storage= 0.32		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

Mean scores of overall acceptability of biscuits indicated that the acceptability of control, type I, II and III fell in the category of 'liked moderately' during their storage period (Table 4.59). The overall acceptability of type IV biscuits was rated as 'liked moderately' till 45<sup>th</sup> day of storage while that of type V biscuits was rated as 'liked moderately' till one month of storage. Significant (P≤0.05) differences were observed for the overall acceptability among all the biscuits during storage.

**Table 4.59:- Effect of storage on overall acceptability of Biscuits**

	Storage period (days)				
	0	15	30	45	60
Control	7.82 ± 0.23	7.80 ± 0.22	7.66 ± 0.20	7.50 ± 0.21	7.38 ± 0.18
I	7.86 ± 0.23	7.82 ± 0.23	7.64 ± 0.26	7.50 ± 0.66	7.32 ± 0.25
II	7.66 ± 0.30	7.58 ± 0.26	7.46 ± 0.26	7.36 ± 0.29	7.16 ± 0.23
III	7.54 ± 0.26	7.42 ± 0.23	7.30 ± 0.19	7.22 ± 0.25	7.10 ± 0.17
IV	7.42 ± 0.27	7.30 ± 0.21	7.16 ± 0.19	7.02 ± 0.22	6.88 ± 0.19
V	7.32 ± 0.37	7.20 ± 0.32	7.08 ± 0.32	6.88 ± 0.24	6.72 ± 0.26
CD (P≤0.05)	For product= 0.30		For storage= 0.28		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

#### 4.5.2 Effect of storage on sensory parameters of pasta

Five types of pasta prepared incorporating *ber* powder at different concentrations and the control pasta were studied for their shelf-life. Their sensory parameters are presented in Table 4.60 to 4.65.

Mean scores of colour indicated that the acceptability of control, type I, II and III pasta fell in the category of 'liked moderately' during the storage period (Table 4.60). The colour of type IV and V pasta was rated as 'liked moderately till 45<sup>th</sup> day of storage and was rated as 'liked slightly' thereafter. Significant (P≤0.05) differences were observed for the colour among all the types of pasta during storage.

**Table 4.60:- Effect of storage on colour of Pasta**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.80 ± 0.25	7.60 ± 0.22	7.60 ± 0.22	7.50 ± 0.27
I	7.80 ± 0.25	7.80 ± 0.25	7.60 ± 0.22	7.50 ± 0.22	7.40 ± 0.27
II	7.80 ± 0.29	7.60 ± 0.22	7.40 ± 0.22	7.40 ± 0.22	7.20 ± 0.29
III	7.70 ± 0.21	7.50 ± 0.17	7.40 ± 0.22	7.30 ± 0.15	7.10 ± 0.23
IV	7.70 ± 0.26	7.50 ± 0.22	7.30 ± 0.26	7.20 ± 0.29	6.90 ± 0.31
V	7.70 ± 0.45	7.40 ± 0.40	7.30 ± 0.34	7.00 ± 0.39	6.70 ± 0.34
CD (P≤0.05)	For product= 0.26		For storage= 0.30		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The acceptability of appearance of control, type I, II and III pasta fell in the category of ‘liked moderately’ during their storage (Table 4.61). The acceptability of appearance of type IV and V pasta was rated as ‘liked moderately till one month of storage and was rated as ‘liked slightly’ after that. Significant ( $P \leq 0.05$ ) differences were observed for the appearance among all the types of pasta during storage.

**Table 4.61:- Effect of storage on appearance of Pasta**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.70 ± 0.21	7.70 ± 0.21	7.60 ± 0.22	7.50 ± 0.27
I	7.80 ± 0.25	7.70 ± 0.26	7.60 ± 0.22	7.50 ± 0.27	7.40 ± 0.34
II	7.60 ± 0.22	7.50 ± 0.22	7.40 ± 0.27	7.30 ± 0.21	7.20 ± 0.20
III	7.60 ± 0.22	7.40 ± 0.16	7.20 ± 0.20	7.10 ± 0.23	7.00 ± 0.21
IV	7.30 ± 0.30	7.20 ± 0.29	7.00 ± 0.30	6.90 ± 0.23	6.70 ± 0.30
V	7.20 ± 0.47	7.10 ± 0.43	7.00 ± 0.42	6.80 ± 0.23	6.60 ± 0.37
CD ( $P \leq 0.05$ )	For product= 0.34		For storage= 0.32		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

Mean scores of the aroma indicated that control, type I and II pasta were rated as ‘liked moderately’ during their storage (Table 4.62). The aroma of type IV pasta was rated as ‘liked moderately’ in the beginning of storage, was rated as ‘liked slightly’ at 15<sup>th</sup>, 30<sup>th</sup> and 45<sup>th</sup> day of storage and was rated as ‘neither liked nor disliked’ at the end of storage period. The aroma of type V pasta was rated as ‘liked slightly’ till 45<sup>th</sup> day of storage and after that it was rated as ‘neither liked nor disliked’. Significant ( $P \leq 0.05$ ) differences were observed for the aroma among all the types of pasta during storage.

**Table 4.62:- Effect of storage on aroma of Pasta**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.70 ± 0.21	7.60 ± 0.22	7.30 ± 0.30	7.30 ± 0.21
I	7.70 ± 0.26	7.60 ± 0.31	7.60 ± 0.27	7.30 ± 0.37	7.20 ± 0.20
II	7.50 ± 0.22	7.40 ± 0.16	7.30 ± 0.26	7.20 ± 0.20	7.00 ± 0.21
III	7.30 ± 0.21	7.20 ± 0.20	7.10 ± 0.23	7.00 ± 0.21	6.90 ± 0.23
IV	7.00 ± 0.26	6.90 ± 0.23	6.70 ± 0.21	6.40 ± 0.22	5.90 ± 0.17
V	6.90 ± 0.48	6.80 ± 0.44	6.50 ± 0.43	6.20 ± 0.37	5.70 ± 0.34
CD ( $P \leq 0.05$ )	For product= 0.34		For storage= 0.33		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The texture of control, type I and II pasta was rated as ‘liked moderately’ during their storage (Table 4.63). The texture of type III pasta was rated as ‘liked moderately’ till 30<sup>th</sup> day of storage and was rated as ‘liked slightly’ after that. The texture of type IV and V pasta was rated as ‘liked slightly’ during their storage. Significant ( $P \leq 0.05$ ) differences were observed for the texture among all the types of pasta during storage.

**Table 4.63:- Effect of storage on texture of Pasta**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.70 ± 0.21	7.60 ± 0.22	7.30 ± 0.30	7.20 ± 0.29
I	7.70 ± 0.21	7.60 ± 0.22	7.50 ± 0.27	7.30 ± 0.30	7.10 ± 0.31
II	7.40 ± 0.22	7.30 ± 0.21	7.20 ± 0.25	7.10 ± 0.18	7.00 ± 0.15
III	7.20 ± 0.20	7.10 ± 0.18	7.00 ± 0.21	6.80 ± 0.20	6.60 ± 0.27
IV	6.80 ± 0.29	6.70 ± 0.26	6.50 ± 0.31	6.40 ± 0.22	6.20 ± 0.26
V	6.70 ± 0.52	6.60 ± 0.48	6.40 ± 0.45	6.20 ± 0.42	6.10 ± 0.35
CD ( $P \leq 0.05$ )	For product= 0.35		For storage= 0.35		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF) V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

Mean scores of taste of pasta indicated that the control, type I and II pasta fell in the category of ‘liked moderately’ during their storage (Table 4.64). The taste of type III pasta was rated as ‘liked moderately’ at the beginning of storage and was rated as ‘liked slightly’ at 15<sup>th</sup> day till the end of storage period. The taste of type IV and V pasta was rated as ‘liked slightly’ since the beginning of storage till 45<sup>th</sup> day and after that they were rated as ‘neither liked nor disliked’ for their taste. Significant ( $P \leq 0.05$ ) differences were observed for the taste among all the types of pasta during storage.

**Table 4.64:- Effect of storage on taste of Pasta**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.70 ± 0.21	7.50 ± 0.27	7.30 ± 0.21	7.20 ± 0.25
I	7.60 ± 0.22	7.60 ± 0.22	7.40 ± 0.27	7.20 ± 0.20	7.10 ± 0.23
II	7.40 ± 0.22	7.30 ± 0.15	7.20 ± 0.25	7.10 ± 0.18	7.00 ± 0.15
III	7.00 ± 0.21	6.90 ± 0.18	6.70 ± 0.21	6.60 ± 0.16	6.50 ± 0.17
IV	6.70 ± 0.30	6.50 ± 0.27	6.40 ± 0.22	6.10 ± 0.21	5.90 ± 0.20
V	6.60 ± 0.67	6.50 ± 0.64	6.30 ± 0.47	6.00 ± 0.36	5.70 ± 0.33
CD ( $P \leq 0.05$ )	For product= 0.36		For storage= 0.36		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The overall acceptability of control, type I and II pasta was rated as 'liked moderately' during their storage period (Table 4.65). The overall acceptability of type III pasta was rated as 'liked moderately' till one month of storage and after that it was rated as 'liked slightly'. The overall acceptability of type IV and V pasta was rated as 'liked moderately' in the beginning of storage period but after that it was rated as 'liked slightly' till the end of storage. Significant ( $P \leq 0.05$ ) differences were observed for the overall acceptability among all the types of pasta during storage.

**Table 4.65:- Effect of storage on overall acceptability of Pasta**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.25	7.72 ± 0.22	7.60 ± 0.22	7.42 ± 0.16	7.34 ± 0.15
I	7.72 ± 0.22	7.68 ± 0.21	7.54 ± 0.26	7.36 ± 0.20	7.24 ± 0.24
II	7.54 ± 0.22	7.42 ± 0.21	7.30 ± 0.25	7.22 ± 0.20	7.08 ± 0.17
III	7.36 ± 0.13	7.22 ± 0.12	7.08 ± 0.18	6.96 ± 0.17	6.82 ± 0.14
IV	7.10 ± 0.21	6.96 ± 0.16	6.78 ± 0.17	6.60 ± 0.17	6.32 ± 0.23
V	7.02 ± 0.48	6.88 ± 0.37	6.70 ± 0.34	6.44 ± 0.20	6.16 ± 0.18
CD ( $P \leq 0.05$ )	For product= 0.28		For storage= 0.27		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

#### 4.5.3 Effect of storage on sensory parameters of noodles

All the types of noodles prepared using different combination of *ber* powder along with the control noodles were studied for shelf-life. Their sensory parameters are presented in Table 4.66 to 4.71.

Mean scores of colour indicated that the acceptability of control, type I, II and III noodles fell in the category of 'liked moderately' during the storage period (Table 4.66).

**Table 4.66:- Effect of storage on colour of Noodles**

	Storage period (days)				
	0	15	30	45	60
Control	7.90 ± 0.18	7.90 ± 0.18	7.70 ± 0.15	7.60 ± 0.27	7.50 ± 0.31
I	7.90 ± 0.23	7.80 ± 0.20	7.60 ± 0.27	7.50 ± 0.22	7.40 ± 0.22
II	7.80 ± 0.25	7.70 ± 0.21	7.60 ± 0.22	7.40 ± 0.16	7.30 ± 0.21
III	7.80 ± 0.36	7.60 ± 0.34	7.40 ± 0.34	7.30 ± 0.40	7.10 ± 0.31
IV	7.60 ± 0.37	7.50 ± 0.34	7.30 ± 0.37	7.20 ± 0.33	6.90 ± 0.33
V	7.60 ± 0.43	7.50 ± 0.40	7.30 ± 0.42	7.00 ± 0.39	6.80 ± 0.33
CD ( $P \leq 0.05$ )	For product= 0.29		For storage= 0.34		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The colour of type IV and V noodles was rated as 'liked moderately till 45<sup>th</sup> day of storage and was rated as 'liked slightly' thereafter. Significant ( $P \leq 0.05$ ) differences were observed for the colour among all the types of noodles during storage.

The acceptability of appearance of control, type I, II and III noodles fell in the category of 'liked moderately' during their storage (Table 4.67). The acceptability of appearance of type IV and V noodles was rated as 'liked moderately till one month of storage and was rated as 'liked slightly' after that. Significant ( $P \leq 0.05$ ) differences were observed for the appearance among all the types of noodles during storage.

**Table 4.67:- Effect of storage on appearance of Noodles**

	Storage period (days)				
	0	15	30	45	60
Control	7.90 ± 0.18	7.90 ± 0.18	7.70 ± 0.21	7.50 ± 0.31	7.50 ± 0.31
I	7.90 ± 0.23	7.70 ± 0.21	7.60 ± 0.16	7.50 ± 0.22	7.40 ± 0.22
II	7.70 ± 0.30	7.50 ± 0.27	7.40 ± 0.22	7.30 ± 0.26	7.20 ± 0.25
III	7.60 ± 0.31	7.40 ± 0.31	7.20 ± 0.29	7.10 ± 0.35	7.00 ± 0.30
IV	7.40 ± 0.50	7.20 ± 0.47	7.00 ± 0.42	6.90 ± 0.43	6.70 ± 0.40
V	7.30 ± 0.50	7.10 ± 0.46	7.00 ± 0.26	6.70 ± 0.34	6.60 ± 0.31
CD ( $P \leq 0.05$ )	For product= 0.39		For storage= 0.36		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

Mean scores of the aroma indicated that control, type I and II noodles were rated as 'liked moderately' during their storage (Table 4.68).

**Table 4.68:- Effect of storage on aroma of Noodles**

	Storage period (days)				
	0	15	30	45	60
Control	7.90 ± 0.18	7.80 ± 0.20	7.60 ± 0.27	7.50 ± 0.31	7.40 ± 0.27
I	7.80 ± 0.20	7.70 ± 0.21	7.50 ± 0.22	7.40 ± 0.22	7.30 ± 0.26
II	7.60 ± 0.31	7.50 ± 0.27	7.30 ± 0.30	7.20 ± 0.25	7.00 ± 0.26
III	7.40 ± 0.31	7.30 ± 0.30	7.10 ± 0.28	7.00 ± 0.21	6.80 ± 0.20
IV	7.10 ± 0.57	6.90 ± 0.57	6.70 ± 0.42	6.30 ± 0.31	5.90 ± 0.34
V	6.90 ± 0.55	6.70 ± 0.50	6.50 ± 0.37	6.10 ± 0.37	5.70 ± 0.36
CD ( $P \leq 0.05$ )	For product= 0.40		For storage= 0.38		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The aroma of type IV noodles was rated as ‘liked moderately’ in the beginning of storage, was rated as ‘liked slightly’ at 15<sup>th</sup>, 30<sup>th</sup> and 45<sup>th</sup> day of storage and was rated as ‘neither liked nor disliked’ at the end of storage period. The aroma of type V noodles was rated as ‘liked slightly’ till 45<sup>th</sup> day of storage and after that it was rated as ‘neither liked nor disliked’. Significant ( $P \leq 0.05$ ) differences were observed for the aroma among all the types of noodles during storage.

The texture of control, type I and II noodles was rated as ‘liked moderately’ during their storage (Table 4.69). The texture of type III noodles was rated as ‘liked moderately’ till 30<sup>th</sup> day of storage and was rated as ‘liked slightly’ after that. The texture of type IV and V noodles was rated as ‘liked slightly’ during their storage period. Significant ( $P \leq 0.05$ ) differences were observed for the texture among all the types of noodles during storage.

**Table 4.69:- Effect of storage on texture of Noodles**

	Storage period (days)				
	0	15	30	45	60
Control	7.90 ± 0.18	7.80 ± 0.20	7.60 ± 0.22	7.50 ± 0.22	7.30 ± 0.26
I	7.80 ± 0.20	7.60 ± 0.27	7.40 ± 0.22	7.30 ± 0.21	7.30 ± 0.21
II	7.40 ± 0.27	7.30 ± 0.21	7.20 ± 0.20	7.10 ± 0.23	7.00 ± 0.21
III	7.20 ± 0.33	7.10 ± 0.28	7.00 ± 0.26	6.90 ± 0.23	6.70 ± 0.21
IV	6.90 ± 0.46	6.70 ± 0.40	6.50 ± 0.34	6.40 ± 0.31	6.20 ± 0.25
V	6.80 ± 0.51	6.60 ± 0.31	6.40 ± 0.34	6.30 ± 0.34	6.00 ± 0.21
CD ( $P \leq 0.05$ )	For product= 0.35		For storage= 0.35		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

Mean scores of taste of noodles indicated that the control, type I and II noodles fell in the category of ‘liked moderately’ during their storage (Table 4.70).

**Table 4.70:- Effect of storage on taste of Noodles**

	Storage period (days)				
	0	15	30	45	60
Control	7.80 ± 0.20	7.80 ± 0.20	7.60 ± 0.16	7.40 ± 0.22	7.20 ± 0.33
I	7.60 ± 0.22	7.50 ± 0.17	7.40 ± 0.16	7.30 ± 0.21	7.10 ± 0.23
II	7.30 ± 0.26	7.20 ± 0.20	7.10 ± 0.18	7.10 ± 0.18	7.00 ± 0.21
III	7.00 ± 0.39	6.90 ± 0.35	6.80 ± 0.25	6.60 ± 0.27	6.50 ± 0.22
IV	6.70 ± 0.54	6.60 ± 0.50	6.40 ± 0.37	6.30 ± 0.40	5.90 ± 0.39
V	6.50 ± 0.45	6.40 ± 0.40	6.30 ± 0.26	6.10 ± 0.28	5.80 ± 0.21
CD ( $P \leq 0.05$ )	For product= 0.36		For storage= 0.37		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

The taste of type III noodles was rated as ‘liked moderately’ at the beginning of storage and was rated as ‘liked slightly’ at 15<sup>th</sup> day till the end of storage period. The taste of type IV and V noodles was rated as ‘liked slightly’ since the beginning of storage till 45<sup>th</sup> day and after that they were rated as ‘neither liked nor disliked’ for their taste. Significant ( $P \leq 0.05$ ) differences were observed for the taste among all the types of noodles during storage.

The overall acceptability of control, type I and II noodles was rated as ‘liked moderately’ during their storage period (Table 4.71). The overall acceptability of type III noodles was rated as ‘liked moderately’ till one month of storage and after that it was rated as ‘liked slightly’. The overall acceptability of type IV and V noodles was rated as ‘liked moderately’ in the beginning of storage period but after that it was rated as ‘liked slightly’ till the end of storage. Significant ( $P \leq 0.05$ ) differences were observed for the overall acceptability among all the types of noodles during storage.

**Table 4.71:- Effect of storage on overall acceptability of Noodles**

	Storage period (days)				
	0	15	30	45	60
Control	7.88 ± 0.16	7.84 ± 0.17	7.64 ± 0.20	7.50 ± 0.25	7.38 ± 0.20
I	7.80 ± 0.20	7.66 ± 0.18	7.50 ± 0.17	7.40 ± 0.23	7.30 ± 0.26
II	7.56 ± 0.25	7.44 ± 0.19	7.32 ± 0.18	7.22 ± 0.24	7.10 ± 0.22
III	7.40 ± 0.29	7.26 ± 0.23	7.10 ± 0.36	6.98 ± 0.28	6.82 ± 0.29
IV	7.14 ± 0.45	6.98 ± 0.40	6.78 ± 0.39	6.62 ± 0.36	6.32 ± 0.30
V	7.02 ± 0.43	6.86 ± 0.38	6.70 ± 0.38	6.44 ± 0.29	6.22 ± 0.25
CD ( $P \leq 0.05$ )	For product= 0.35		For storage= 0.34		

Values are Mean ± SE of the three independent determinations.

Control = 100 % RF

I= 10:90 (BP:RF)

II= 20:80 (BP:RF)

III= 30:70 (BP:RF)

IV= 40:60 (BP:RF)

V= 50:50 (BP:RF)

BP= Ber powder

RF= Refined Flour

#### 4.5.4 Effect of storage on sensory parameters of RTS

Four type of RTS beverage prepared using *ber* powder were stored at room temperature and studied for their shelf-life. Their sensory parameters are presented in Table 4.72 to 4.77.

Mean scores of colour indicated that the colour of all the types of RTS beverage was rated as ‘liked moderately’ during the storage period (Table 4.72). Non-significant ( $P \leq 0.05$ ) differences were observed among the all the types of RTS beverage for their colour while significant ( $P \leq 0.05$ ) differences were observed for colour during storage.

The acceptability of appearance of type I and II RTS beverage fell in the category of ‘liked moderately’ during their storage (Table 4.73). The acceptability of appearance of type III RTS beverage was rated as ‘liked moderately till one month of storage and was rated as ‘liked slightly’ after that. The appearance of type III RTS beverage was rated as ‘liked

slightly' during the storage period. Significant ( $P \leq 0.05$ ) differences were observed for the appearance among all the types of RTS beverage during storage.

**Table 4.72:- Effect of storage on colour of RTS beverage**

	Storage period (days)				
	0	15	30	45	60
I	7.70 ± 0.26	7.60 ± 0.22	7.50 ± 0.22	7.40 ± 0.22	7.30 ± 0.29
II	7.70 ± 0.26	7.60 ± 0.27	7.40 ± 0.22	7.40 ± 0.30	7.30 ± 0.31
III	7.60 ± 0.27	7.50 ± 0.27	7.40 ± 0.22	7.30 ± 0.25	7.20 ± 0.18
IV	7.60 ± 0.34	7.50 ± 0.31	7.30 ± 0.34	7.30 ± 0.29	7.20 ± 0.30
CD ( $P \leq 0.05$ )	For product= NS		For storage= 0.36		

Values are Mean ± SE of the three independent determinations.

NS=Non-significant ( $P \leq 0.05$ )

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

**Table 4.73:- Effect of storage on appearance of RTS beverage**

	Storage period (days)				
	0	15	30	45	60
I	7.70 ± 0.21	7.60 ± 0.22	7.50 ± 0.27	7.30 ± 0.30	7.20 ± 0.29
II	7.60 ± 0.22	7.30 ± 0.26	7.20 ± 0.29	7.10 ± 0.23	7.00 ± 0.33
III	7.30 ± 0.15	7.10 ± 0.18	7.00 ± 0.15	6.80 ± 0.13	6.20 ± 0.25
IV	6.90 ± 0.46	6.70 ± 0.34	6.50 ± 0.23	6.20 ± 0.29	6.10 ± 0.30
CD ( $P \leq 0.05$ )	For product= 0.35		For storage= 0.43		

Values are Mean ± SE of the three independent determinations.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

Mean scores of the aroma indicated that type I and II RTS beverage were rated as 'liked moderately' during their storage (Table 4.74). The aroma of type III RTS beverage was rated as 'liked moderately' till one month of storage and was rated as 'liked slightly' after that. The aroma of type IV RTS beverage was rated as 'liked slightly' till 30<sup>th</sup> day of storage and after that it was rated as 'neither liked nor disliked'. Significant ( $P \leq 0.05$ ) differences were observed for the aroma among all the types of RTS beverage during storage.

**Table 4.74:- Effect of storage on aroma of RTS beverage**

	Storage period (days)				
	0	15	30	45	60
I	7.60 ± 0.21	7.60 ± 0.22	7.40 ± 0.27	7.30 ± 0.30	7.20 ± 0.29
II	7.40 ± 0.27	7.30 ± 0.26	7.20 ± 0.29	7.10 ± 0.23	7.00 ± 0.26
III	7.10 ± 0.28	7.00 ± 0.26	7.00 ± 0.21	6.90 ± 0.18	6.70 ± 0.15
IV	6.70 ± 0.28	6.50 ± 0.30	6.20 ± 0.28	5.80 ± 0.30	5.40 ± 0.31
CD ( $P \leq 0.05$ )	For product= 0.32		For storage= 0.46		

Values are Mean ± SE of the three independent determinations.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The texture of type I and II RTS beverage was rated as ‘liked moderately’ during their storage (Table 4.75). The texture of type III RTS beverage was rated as ‘liked slightly’ till 30<sup>th</sup> day of storage and was rated as ‘neither liked nor disliked’ after that. The texture of type IV RTS beverage was rated as ‘neither liked nor disliked’ during their storage period. Significant ( $P \leq 0.05$ ) differences were observed for the texture among all the types of RTS beverage during storage.

**Table 4.75:- Effect of storage on texture of RTS beverage**

	Storage period (days)				
	0	15	30	45	60
I	7.60 ± 0.21	7.60 ± 0.22	7.40 ± 0.31	7.30 ± 0.30	7.20 ± 0.33
II	7.30 ± 0.26	7.20 ± 0.29	7.20 ± 0.29	7.10 ± 0.18	7.00 ± 0.33
III	6.60 ± 0.34	6.30 ± 0.21	6.10 ± 0.28	5.80 ± 0.36	5.60 ± 0.31
IV	5.90 ± 0.41	5.70 ± 0.26	5.50 ± 0.22	5.40 ± 0.27	5.20 ± 0.29
CD ( $P \leq 0.05$ )	For product= 0.36		For storage= 0.43		

Values are Mean ± SE of the three independent determinations.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

Mean scores of taste of RTS beverage indicated that the type I and II RTS beverage fell in the category of ‘liked moderately’ during their storage (Table 4.76). The taste of type III RTS beverage was rated as ‘liked slightly’ till one month of storage period and was rated as ‘neither liked nor disliked’ after that. The taste of type IV RTS beverage was rated as ‘neither liked nor disliked’ during the storage period. Significant ( $P \leq 0.05$ ) differences were observed for the taste among all the types of RTS beverage during storage.

**Table 4.76:- Effect of storage on taste of RTS beverage**

	Storage period (days)				
	0	15	30	45	60
I	7.50 ± 0.26	7.60 ± 0.31	7.40 ± 0.34	7.30 ± 0.030	7.20 ± 0.29
II	7.20 ± 0.27	7.30 ± 0.26	7.20 ± 0.29	7.10 ± 0.31	7.00 ± 0.33
III	6.40 ± 0.22	6.20 ± 0.20	6.00 ± 0.30	5.90 ± 0.31	5.70 ± 0.26
IV	5.90 ± 0.41	5.70 ± 0.34	5.40 ± 0.22	5.20 ± 0.21	5.00 ± 0.23
CD ( $P \leq 0.05$ )	For product= 0.36		For storage= 0.41		

Values are Mean ± SE of the three independent determinations.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= Ber powder

The overall acceptability of type I and II RTS beverage was rated as ‘liked moderately’ during their storage period (Table 4.77).

**Table 4.77:- Effect of storage on overall acceptability of RTS beverage**

	Storage period (days)				
	0	15	30	45	60
I	7.62 ± 0.21	7.60 ± 0.22	7.44 ± 0.22	7.32 ± 0.19	7.22 ± 0.25
II	7.44 ± 0.24	7.36 ± 0.24	7.24 ± 0.17	7.16 ± 0.22	7.06 ± 0.20
III	7.00 ± 0.18	6.82 ± 0.10	6.70 ± 0.10	6.54 ± 0.20	6.28 ± 0.15
IV	6.60 ± 0.28	6.42 ± 0.26	6.08 ± 0.24	5.88 ± 0.27	5.78 ± 0.26
CD (P≤0.05)	For product= 0.27		For storage= 0.38		

Values are Mean ± SE of the three independent determinations.

I= 10 % BP

II= 20 % BP

III= 30 % BP

IV= 40 % BP

BP= *Ber* powder

The overall acceptability of type III RTS beverage was rated as 'liked moderately' in the beginning of storage and was rated as 'liked slightly' after that till the end of storage period. The overall acceptability of type IV RTS beverage was rated as 'liked slightly' till one month of storage and after that it was rated as 'neither liked nor disliked' till the end of storage. Significant ( $P \leq 0.05$ ) differences were observed for the overall acceptability among all the types of RTS beverage during storage.

Fruits have long been valued as a part of nutritious and tasty diet. They contain number of vitamins and minerals. They are good sources of vitamin C, A thiamine, niacin, pyridoxine, folacin (folic acid), vitamin E and dietary fiber. But their perishable nature and glut in the market may result in spoilage of large quantities (Parkash *et al.*, 2004). To avoid glut spoilage, fruits can be processed into various products and preserved. Drying is one of the ancient methods of preservation. The preservation through drying was based on solar drying techniques earlier but the poor quality and product contamination lead to alternate drying techniques (Bezyma and Kutovoy, 2005). The most applicable method of drying includes freezing, vacuum, osmotic, cabinet or tray, fluidized bed, spouted bed, ohmic microwave and combination thereof (George *et al.*, 2004). Drying can be used to form powder of fruits which can be stored for further use.

In the present study, fruit powders were prepared from three varieties of *ber* namely, Gola, Kaithali and Umran. Various value added products were also prepared using the best powder among the three varieties based on their sensory and nutritional evaluation. The products were also studied for sensory and nutritional parameters. All the powders and products were studied for their shelf life for a period of two months. The results on the same are discussed under the following heads and subheads:-

- 5.1 Development of *ber* powders
- 5.2 Sensory evaluation of *ber* powders
- 5.3 Physico-chemical properties of the *ber* powders
- 5.4 Shelf-life of *ber* powders
- 5.5 Nutritional evaluation of *ber* powders
- 5.6 Sensory evaluation of value-added products
  - 5.6.1 Sensory evaluation of traditional products
  - 5.6.2 Sensory evaluation of baked products
  - 5.6.3 Sensory evaluation of extruded products
  - 5.6.4 Sensory evaluation of unfermented beverage
- 5.7 Nutritional evaluation of value-added products
  - 5.7.1 Nutritional evaluation of custard
  - 5.7.2 Nutritional evaluation of *kheer*
  - 5.7.3 Nutritional evaluation of biscuits
  - 5.7.4 Nutritional evaluation of cake
  - 5.7.5 Nutritional evaluation of pasta

- 5.7.6 Nutritional evaluation of noodles
- 5.7.7 Nutritional evaluation of RTS beverage
- 5.8 Shelf-life of products
  - 5.8.1 Shelf-life of biscuits
  - 5.8.2 Shelf-life of pasta
  - 5.8.3 Shelf-life of noodles
  - 5.8.4 Shelf-life of RTS beverage

### **5.1 Development of *ber* powders**

Powders were prepared from three varieties of *ber* namely Gola, (early maturing), Kaithali (mid maturing) and Umran (late maturing) by blanching the fruits, deseeding, grinding to pulp and addition of potassium metabisulphite. The pulp was lyophilized and then ground to prepare powder. Powders were prepared using method as prescribed by Sagar *et al.* (2000) using mango fruits, Negi (2003) using papaya, guava and pear fruits and Nehra (2011) using aonla and guava fruits. Fruit powders were also prepared by Shukla (2004) using papaya fruits, Chhabra (2006) using bael fruits, Ambriz *et al.* (2008) using banana fruits, Sablani *et al.* (2008) using California date fruits, Mishra *et al.* (2009) using aonla fruits and Ritthiruangdej *et al.* (2011) using banana fruits.

### **5.2 Sensory evaluation of *ber* powders**

Results presented in Table 4.1 indicated that the mean scores of colour, appearance, aroma, texture, taste and overall acceptability of all the *ber* powders prepared from Gola, Kaithali and Umran varieties were in 'liked moderately' category except the mean scores of texture, taste and overall acceptability of powder prepared from Umran variety which were in 'liked very much' category. However, non-significant differences in the mean scores of all the sensory parameters of all the powders were observed. Similar observations have also been reported by Negi (2003) and Nehra (2011) for higher acceptability of guava, papaya and pear and guava and aonla powders, respectively which were prepared by addition of potassium metabisulphite. Chhabra (2006) also reported similar results in bael powder.

### **5.3 Physico-chemical properties of the *ber* powders**

The acidity content of *ber* powders ranged from 2.09 to 2.19 per cent (Table 4.2). The acidity content of powder of Umran variety was significantly lower than the powder of other two varieties. Singh *et al.* (2001) reported the acidity content of fresh *ber* cultivars ranged from 0.240 to 0.992 per cent while Kaushik *et al.* (2004) reported the range from 0.135 to 0.760 per cent. Dhillon *et al.* (2004) reported the acidity of different fresh mango cultivars to be 0.35 to 0.46 per cent. Chhabra (2006) observed 0.61 per cent acidity in fresh bael pulp. The high acidity of powder as compared to fresh fruits might be due to the loss of moisture from fresh fruits during preparation of powder and hence concentrating the soluble solids. Negi (2003) observed higher acidity content of papaya powder (4.50 to 4.69 per cent), guava

powder (4.02 to 4.25 per cent) and pear powder (4.00 to 4.17 per cent). Kumar (2005) found the acidity content of *ber* fruits after blanching and addition of KMS was 1.38 per cent on dry weight basis while Kumar (2006) found the acidity content of *ber* powder to be 2.04 per cent which is similar to the result observed in present study.

The data presented in Table 4.2 depicted that the total soluble sugars to acid ratio of powders of Gola, Kaithali and Umran varieties was 8.93, 8.82 and 9.66, respectively. The total soluble sugars/acid ratio of powder of Umran variety was significantly higher than the other two powders.

The Optical Densities at 440 nanometers for the browning content of powders prepared from Gola, Kaithali and Umran varieties were 0.09, 0.08 and 0.08, respectively (Table 4.2). The browning content of all the powders was similar and non-significantly different from each other. Optical densities at 440 nm for non-enzymatic browning content were also observed by Negi (2003) in papaya powder (0.057 to 0.323), guava powder (0.087 to 0.109) and pear powder (0.066 to 0.090) after various treatments whereas Kumar (2005) found the optical density for browning content of *ber* fruits after blanching and addition of KMS to be 0.27. Rai and Mishra (2001) found the browning content of bael fruit pulp to range from 10.24 to 16.03.

#### **5.4 Shelf-life of *ber* powders**

Data regarding the mean scores of sensory characteristics of all the *ber* powders presented in Table 4.3 to Table 4.8 revealed that the colour, appearance and aroma of all the powders were in the range of 'liked moderately' during the storage period. The texture, taste and overall acceptability of powder prepared from Umran variety was 'liked very much' in the beginning of storage but was 'liked moderately' at 15<sup>th</sup> day of storage and thereafter while the texture, taste and overall acceptability of the other two powders were in the range of 'liked moderately' during storage. Significant differences were observed for all the sensory parameters in all the powders during storage. The colour, appearance, aroma, texture, taste and overall acceptability of all the powders were significantly lower after one month of storage. Mean scores for overall acceptability of *ber* powders prepared from Gola, Kaithali and Umran varieties ranged from 7.86 to 7.30, 7.78 to 7.24 and 8.00 to 7.44 since the beginning of storage to the end of 2 months, respectively. Mean scores of all the sensory parameters were found to be higher in powder of Umran variety as compared to powder of Gola and Kaithali varieties during storage period though the mean scores were found to be decreased during storage for all the sensory characteristics of all the powders.

The results obtained are in confirmation with the findings of Sagar *et al.* (2000) and Alam *et al.* (2001) who reported that ripe mango powder could be stored safely for 6 months and dehydrated aonla powder could be stored safely for 3 months, respectively. Similar

results were also obtained by Negi (2003) for papaya, guava and pear powders, Chhabra (2006) for bael powder and Nehra (2011) for aonla and guava powders.

### **5.5 Nutritional evaluation of *ber* powders**

Data presented in Table 4.9 indicated that the moisture content of *ber* powders prepared from Gola, Kaithali and Umran varieties was 5.68, 5.35 and 5.21 per cent, respectively. The moisture content of powder of all the varieties was non-significantly different from each other. Mishra *et al.* (2009) also reported similar values of moisture content (5.05 to 6.78 per cent) in different cultivars of dried aonla. The moisture content of aonla and guava powder ranged from 5.44 to 5.60 and 6.89 to 7.06 per cent, respectively as reported by Nehra (2011). Chhabra (2006) found 5.20 per cent moisture in bael powder. Negi (2003) reported the moisture content of papaya, guava and pear powders to be 6.47, 7.10 and 6.92 per cent, respectively. Costa *et al.* (2009) reported the moisture content of 6.52 and 4.07 per cent in cashew apple and guava powder, respectively.

The crude protein content of powder prepared from Gola, Kaithali and Umran variety was 6.92, 7.17 and 7.83 per cent, respectively (Table 4.9). The crude protein content of powder prepared from Umran variety was significantly higher than the powder of other two varieties. Negi (2003) observed slightly higher values for crude protein content of papaya, guava and pear powders. Chhabra (2006) reported less amount of protein (5.40 per cent) in bael powder. Costa *et al.* (2009) found the crude protein content of 7.63 and 11.47 in cashew apple and guava powders, respectively. The crude protein content of aonla and guava powders as reported by Nehra (2011) ranged from 2.57 to 2.74 and 8.94 to 9.46 per cent, respectively.

Data presented in Table 4.9 indicated that the crude fat content of powders prepared from all the three varieties ranged from 0.99 to 1.07 per cent. The crude fat content of powder prepared from Umran variety was significantly higher among the three varieties. Significant differences in the crude fat content were observed in all the three varieties. Negi (2003) reported the crude fat content of 1.41, 1.22 and 1.56 per cent in papaya, guava and pear powders, respectively. Chhabra (2006) reported slightly less amount of fat i.e. 0.62 per cent in bael powder.

The crude fiber content of powders prepared from Gola, Kaithali and Umran varieties was 3.75, 3.52 and 3.91, per cent, respectively (Table 4.9). The crude fiber content of powder prepared from Umran variety was significantly higher among the three varieties. Significant differences in the crude fiber content were observed in all the three varieties. Negi (2003) reported 5.06, 2.39 and 4.25 per cent crude fiber content in papaya, guava and pear powders, respectively. Chhabra (2006) found slightly higher crude fiber content in bael powder (5.34 per cent). The crude fiber content of 9.57 and 1.47 was observed in KMS treated aonla and guava powder, respectively (Nehra, 2011). Higher values for crude fiber content were observed by Juarez-Garcia *et al.* (2006) in banana flour (10.40 per cent) and Ajila *et al.*

(2008) in mango peel powder. Costa *et al.* (2009) reported the fiber content of 5.91 and 40.98 per cent in cashew apple and guava powder, respectively.

The ash content of powders prepared from Gola, Kaithali and Umran varieties was 4.49, 4.27 and 4.31 per cent, respectively (Table 4.9). The ash content of all the powders was similar and non-significantly different from each other. Similar values of ash content were observed by Negi (2003) in papaya, guava and pear powders, Chhabra (2006) in bael powder and Nehra (2011) in aonla and guava powders. However, lower ash content was observed in cashew apple and guava powders i.e. 1.42 and 1.53 per cent, respectively by Costa *et al.* (2009). A high content of ash was observed in *Magnifera Pajang* juice powder (Ibrahim *et al.*, 2010).

Results for carbohydrates presented in Table 4.10 revealed that the total sugar content of *ber* powders ranged from 19.08 to 20.17 g/100g. The total sugar content of powder prepared from Umran variety was significantly higher than powder of Kaithali variety while the total sugar content of powder of Gola variety was non-significantly different from the other two varieties. Kumar (2005) found 33.48 per cent total sugars in dried *ber* cultivar Umran. Results for total soluble sugar content of *ber* powders were in range with those reported earlier by Nehra (2011) in guava powder where she reported slightly higher total soluble sugars in aonla powder (25.24 per cent). Negi (2003) recorded 22.43, 20.87 and 25.86 per cent total soluble sugars in papaya, guava and pear powders, respectively. Chhabra (2006) reported very less content of total soluble sugar in bael powder i.e. 89.60 mg/100g. Aulakh *et al.* (2005) found 10.01 to 12.64 per cent total sugar in different cultivars of *ber* fruits while Hymavathi and Khader (2005) reported 36.10 to 36.66 per cent total sugars in different mango cultivars. The total soluble sugar content of 30.60 and 8.69 was recorded in cashew apple and guava powders by Costa *et al.* (2009). Kumar (2006) reported very high content of total sugars in *ber* powder i.e. 57.38 per cent.

The reducing sugar content of powder of Gola, Kaithali and Umran variety was 3.80, 3.61 and 3.98 g/100g, respectively (Table 4.10). Non-significant differences were obtained for reducing sugar content among the powders of all the three varieties. Higher content of reducing sugars were obtained by Negi (2003) in papaya, guava and pear powders, Nehra (2011) in aonla and guava powders, Kumar (2005) in dried *ber* cultivar Umran and Costa *et al.* (2009) in cashew apple and guava powders whereas lower content for reducing sugars was observed by Chhabra (2006) in bael powder (18.64 mg/100g). Kumar (2006) reported high reducing sugars content of 36.98 per cent in *ber* powder.

From the results presented in Table 4.10, it was revealed that the non-reducing sugar content of powders prepared from all the three varieties ranged from 15.47 to 16.19 per cent. The non-reducing sugar content of powder prepared from Umran variety was significantly higher than the non-reducing sugar content of powder prepared from Kaithali variety. The

non-reducing sugar content of powder of Gola variety was similar and showed non-significant differences from the other two varieties. Results of present study were in accordance with those evidenced by Kumar (2006) in *ber* powder. Lower content of reducing sugars was observed by Negi (2003) in papaya, guava and pear powders, Chhabra (2006) in bael powder and Nehra (2011) in aonla and guava powders. High content of 29.81 to 31.72 per cent reducing sugars was observed by Hymavathi and Khader (2005) in different cultivars of mango. Costa *et al.* (2009) reported no non-reducing sugar content in cashew apple powder and very less (0.25 per cent) in guava powder.

It was inferred from the data presented in Table 4.11 that the calcium content of powders prepared from Gola, Kaithali and Umran varieties was 148.56, 153.63 and 151.42 mg/100g, respectively. The calcium content of powder prepared from Kaithali and Umran varieties was significantly higher than the calcium content of powder prepared from Gola variety. Powder prepared from Kaithali variety contained highest calcium content among all the three powders. Similar results were obtained by Negi (2003) in papaya powder while lower calcium was observed in guava and pear powders. Mishra *et al.* (2009) and Nehra (2011) also reported lower calcium in dehydrated aonla (70.3 to 76.6 mg/100g) and aonla powder (75.33 to 77.66 mg/100g), respectively. Chhabra (2003) reported higher amount of calcium in bael powder i.e. 234 mg/100g.

The iron content of powders varied from 17.87 to 18.65 mg/100g (Table 4.11). The iron content of powder prepared from Umran variety was significantly higher followed by powder of Kaithali and Gola varieties. The iron content of all the varieties differed significantly from each other. Similar results were observed by Nehra (2011) in aonla and guava powders and Negi (2003) in guava powder. Chhabra (2003) reported higher amount of iron in bael powder (106.6 mg/100g) while Mishra *et al.* (2006) reported lower amount (7.90 to 12.38 mg/100g) in dehydrated aonla cultivar Chakaiya.

Data presented in Table 4.11 indicated that the magnesium content of powders prepared from Gola, Kaithali and Umran varieties was 86.67, 84.43, 90.33 mg/100g, respectively. Non-significant differences for the magnesium content were observed among the powders of all the varieties. The magnesium content of dehydrated aonla fruits as reported by Mishra *et al.* (2009) ranged from 54.20 to 88.03 mg/100g. Negi (2011) reported 8.08 mg/100g magnesium in aonla powder and 12.72 mg/100g in guava powder.

The zinc content of all the *ber* powders ranged from 0.91 to 0.98 mg/100g, being highest in powder of Gola variety followed by powders of Umran and Kaithali varieties (Table 4.11). The zinc content of all the powders was similar and non-significantly different from each other. Negi (2003) reported 0.70, 0.81 and 0.50 mg/100g zinc in papaya, guava and pear powders, respectively. Nehra (2011) reported 0.88 mg/100g zinc in guava powder.

The ascorbic acid content of powders prepared from Gola, Kaithali and Umran varieties was 46.77, 47.20 and 48.23 mg/100g, respectively (Table 4.12). The ascorbic acid content of powder prepared from Umran variety was significantly higher than the other two powders whose ascorbic acid content were similar and non-significantly different from each other. Similar results were observed by Negi (2003) and Nehra (2011) in guava powder. Ascorbic acid in different *ber* cultivars was 55.50 to 120 mg/100 pulp (Singh *et al.*, 2001), 93.54 to 159.86 mg/100g pulp (Gupta *et al.*, 2004), 123 mg/100g powder (Kaushik *et al.*, 2004) and 35.17 mg/100g powder (Kumar (2006). Hymavathi and Khader observed 26.58 to 37.80 mg/100g ascorbic acid in different mango cultivars. Mishra *et al.* (2009) and Chhabra (2003) reported lower content of 3.0 to 5.43 mg/100g in aonla powder.

The  $\beta$ -carotene content of powders ranged from 2.38 to 2.94 mg/100g (Table 4.12). The  $\beta$ -carotene content of powder prepared from Umran variety was significantly higher than powder of Kaithali variety. The  $\beta$ -carotene content of powder of Gola variety was non-significantly different from the other two varieties. Results obtained were in accordance with those observed by Nehra (2011) in aonla and guava powder and Hymavathi and Khader (2005) in different mango cultivars. Negi (2003) recorded similar results in guava powder (2.90 mg/100g) while higher content (12.36 mg/100g) was observed in papaya powder and lower content (1.11 mg/100g) in pear powder. Chhabra (2006) reported the  $\beta$ -carotene content of bael powder to be 5.20 mg/100g.

It was inferred from the data presented in Table 4.13 that the *in-vitro* protein digestibility of powders prepared from Gola, Kaithali and Umran varieties ranged from 76.53 to 78.53 per cent. The *in-vitro* protein digestibility of powder prepared from Umran variety was significantly higher than powder of Kaithali variety. The *in-vitro* protein digestibility of powder prepared from Gola variety was non-significantly different from the powders of other two varieties. Similar results for *in-vitro* protein digestibility were observed by Chhabra (2003) in bael powder and Nehra (2011) in aonla and guava powder.

The *in-vitro* starch digestibility of powders prepared from Gola, Kaithali and Umran varieties of *ber* was 40.13, 40.37 and 41.80 mg maltose released/ g powder, respectively (Table 4.13). The *in-vitro* starch digestibility of powder prepared from Umran variety was significantly higher than the other two varieties whose *in-vitro* starch digestibility was almost similar and non-significantly different from each other. Similar results were obtained by Nehra (2011) in aonla and guava powders. Chhabra (2006) reported lower content of *in-vitro* starch digestibility (32.40 mg maltose released/g) in bael powder. Negi (2003) reported similar content of *in-vitro* starch digestibility in guava powder but higher in pear powder and lower in papaya powder, respectively.

Differences in the moisture, crude protein, crude fat, crude fiber, ash, total soluble sugars, reducing sugars, non-reducing sugars, calcium, iron, magnesium, zinc, ascorbic acid,

$\beta$ -carotene, and *in-vitro* digestibilities of protein and starch contents of the different varieties of *ber* fruits may be due to composition differences of different varieties. The high nutritional content of powder as compared to fresh fruits might be due to the loss of moisture from fresh fruits during preparation of powder and hence concentrating the soluble solids.

## **5.6 Sensory evaluation of value-added products**

Different types of value added products were prepared using *ber* powder of Umran variety. The powder of Umran variety was found to be more acceptable for all the sensory parameters and also nutritionally better in terms of its high total soluble sugars/acid ratio, high protein content, high carbohydrate content, high mineral content like calcium, iron and magnesium, high ascorbic acid content, high *in-vitro* protein and starch digestibility. The products were prepared under four categories namely traditional products (custard and *kheer*), baked products (biscuits and cake), extruded products (pasta and noodles) and unfermented beverage (RTS beverage). Different proportions of *ber* powder were used for the development of value-added products.

### **5.6.1 Sensory evaluation of traditional products**

It was evident from the data presented in Table 4.14 that the mean scores that the acceptability of colour and appearance of all the types of custard fell in the category of 'liked moderately'. Sensory characteristics namely aroma, texture, taste and overall acceptability of type I custard were rated as 'liked very much' while that of control, type II and III were rated as 'liked moderately'. The aroma of type IV and V custard was rated as 'liked moderately' while their texture and overall acceptability were rated as 'liked slightly'. The taste of type IV custard was rated as 'liked slightly' while the taste of type V custard was rated as 'neither liked nor disliked'. The mean scores indicated that the type I custard was liked most followed by control, type II, III, IV and V custard. Non-significant differences in mean scores were observed for colour and appearance of all types of custard while the aroma, texture, taste and overall acceptability of type IV and V custard were significantly lower than type I custard. However, all the types of custard were organoleptically acceptable as judged by the panel of judges.

Results presented in Table 4.15 indicated that the mean scores for colour, appearance, aroma, texture, taste and overall acceptability of control and type I *kheer* were 'liked very much' by the panel of judges while all the sensory characteristics of type II and III *kheer* were recorded as 'liked moderately'. The colour and appearance of type IV and V *kheer* were 'liked moderately' while their aroma, texture and overall acceptability were 'liked slightly' by the panel of judges. The taste of type IV *kheer* was 'liked slightly' but the taste of type V *kheer* was 'neither liked nor disliked'. Overall, it was inferred from the table that control *kheer* was preferred slightly more (8.04) over type I *kheer* (8.02) followed by type II (7.76), III (7.50), IV (6.96) and V (6.76) *kheer*. The mean scores for aroma, texture, taste and overall

acceptability of control and type I *kheer* were found to be significantly higher than type IV and V *kheer*. Shukla (2004) prepared *kheer* using papaya powder and reported it organoleptically acceptable.

### **5.6.2 Sensory evaluation of baked products**

The data presented in Table 4.16 inferred that the mean scores for all the sensory parameters of all the biscuits were rated as 'liked moderately' by the panel of judges except for the taste of type I biscuits which were rated as 'liked very much'. The data indicated that type I biscuits scored slightly higher (7.86) mean scores as compared to control (7.82) biscuits. The mean scores of overall acceptability of type II biscuits (7.66) were higher than type III (7.54), IV (7.42) and V (7.32) biscuits. The colour and aroma of all types of biscuits were observed to be non-significantly different from each other while the aroma, texture, taste and overall acceptability of control and type I biscuits were significantly higher than type IV and V biscuits.

It was inferred from the data presented in Table 4.17 that mean scores for colour, appearance, aroma, texture, taste and overall acceptability of control and type I cake were rated as 'liked very much' whereas all the sensory parameters were rated as 'liked moderately' for type II, III, IV and V cake except for the colour of type II cake which was rated as 'liked very much'. The overall acceptability of cake ranged from 7.42 to 8.24, being highest in type I cake followed by control, type II, III, IV and V cake. Non-significant differences were observed in the colour and appearance of all the types of cake while the aroma, texture and overall acceptability of type I cake were significantly higher than type IV and V cake and the taste of type I cake was significantly higher than type III, IV and V cake.

Negi (2003) prepared baked products like cake, bread and biscuits using different concentrations of papaya, guava and pear powders and found them acceptable. Chhabra (2006) prepared biscuits, bread, cake, *nan khatai* and soupsticks using 10 and 20 per cent bael powder and found them organoleptically acceptable. Fang (2008) prepared bread using 5, 10 and 15 per cent pumpkin flour and found that bread prepared using 5 per cent powder was most acceptable. Uchoa *et al.* (2009) prepared cookies using different concentrations of cashew apple and guava powders and observed that cookies prepared with 15 g cashew apple powder and 20 g guava powder showed highest scores. Nehra (2011) prepared different types of biscuits, breads and cake using fruit powders and found them organoleptically acceptable.

### **5.6.3 Sensory evaluation of extruded products**

It was evident from the data presented in Table 4.18 that all the sensory parameters like colour, appearance, aroma, texture, taste and overall acceptability of all types of pasta were rated as 'liked moderately' except for the aroma of type V pasta and texture and taste of type IV and V pasta which were rated as 'liked slightly'. Although, all types of pasta were 'liked moderately' in terms of their overall acceptability. Non-significant differences were

observed in the colour of all types of pasta while the appearance, aroma, texture and overall acceptability of type IV and V pasta and the taste of type III, IV and V pasta were significantly lower than their control counterpart. The control pasta was preferred more followed by type I, II, III, IV and V pasta.

It was observed from the data indicated in Table 4.19 that the colour, appearance and aroma of all the types of noodles were rated as 'liked moderately' except for the aroma of type V noodles which was rated as 'liked slightly'. The texture and taste of type IV and V noodles were 'liked slightly' while the texture and taste of all other noodles were 'liked moderately'. However, the overall acceptability of all the types of noodles fell in the category of 'liked moderately' being highest in control noodles (7.88) followed by type I (7.80), II (7.56), III (7.40), IV (7.06) and V (7.02) noodles. Non-significant differences were obtained in the colour of all the noodles while the appearance, aroma, texture, taste and overall acceptability of control noodles differed significantly from type IV and V noodles.

All the extruded products were found to be acceptable. Similar results for acceptability of extruded products prepared with fruit powders were reported by Negi (2003) who prepared ready to eat extruded products, pasta products (macroni and noodles) using different concentrations of powders of papaya, guava and pear fruits and found them acceptable based on sensory characteristics. Shukla (2004) prepared vermicelli using papaya powder and reported it organoleptically acceptable. Chhabra (2006) prepared vermicelli, pasta and macroni by incorporating 10 and 20 per cent bael powder and found all of them acceptable. Ritthiruangdej *et al.* (2011) prepared noodles by incorporating banana flour at concentrations of 10, 20, 30, 40 and 50 per cent with wheat flour and found all of them to be organoleptically acceptable.

#### **5.6.4 Sensory evaluation of unfermented beverage**

Mean scores of RTS beverage indicated that the colour, appearance, aroma and overall acceptability of all the types of RTS beverage were rated as 'liked moderately' except the appearance, aroma and overall acceptability of type IV RTS beverage which were rated as 'liked slightly' (Table 4.20). The texture and taste of type I and II RTS beverage were rated as 'liked moderately', type III were rated as 'liked slightly' and type IV were rated as 'neither liked nor disliked'. The RTS beverage prepared using 10 per cent *ber* powder was preferred more followed by RTS beverage prepared using 20, 30 and 40 per cent *ber* powder. Non-significant differences were obtained in the colour of all the types of RTS beverage while the appearance, aroma, texture, taste and overall acceptability of type I and type IV RTS beverage differed significantly from each other. Overall, all the types of RTS beverage were acceptable.

The results obtained for the acceptability of RTS beverage were in accordance with those observed by Kumar and Manimegalai (2005) who prepared RTS beverage by blending

10 per cent papaya juice with whey and found that highly acceptable. Kumar (2006) prepared RTS beverage using 5, 10 and 15 per cent *ber* powder and found all of them to be organoleptically acceptable. Nilguin and Mahendran (2010) prepared RTS beverage using palmyrah fruit pulp at different concentrations and observed that RTS with 12 per cent fruit pulp was most acceptable followed by 10 and 14 per cent pulp. Jakhar and Pathak (2012) prepared RTS beverage using *jamun* and *ber* pulp in different blends and found them acceptable.

## **5.7 Nutritional evaluation of value-added products**

Different types of value added products were prepared using *ber* powder of Umran variety namely custard, *kheer*, biscuits, cake, pasta, noodles and RTS beverage. They were prepared by incorporating different concentrations of *ber* powder. All the products prepared were nutritionally analyzed for proximate composition, carbohydrate, mineral and vitamin content and *in-vitro* digestibilities of protein and starch.

### **5.7.1 Nutritional evaluation of custard**

It was inferred from the data depicted in Table 4.21 that the moisture content of all the types of custard ranged from 76.53 to 77.00 per cent. Non-significant differences were obtained in the moisture content of all the types of custard. However, the moisture content of type V custard was higher and that of control custard was lower among all the types of custard. The moisture content of all the types of custard increased as the supplementation with *ber* powder increased.

The crude protein content of control, type I, II, III, IV and V custard was 4.08, 4.21, 4.35, 4.50, 4.63 and 4.77 per cent, respectively (Table 4.21). Non-significant differences were obtained in the protein content of every two corresponding custard while rest were observed to be significantly different from each other. The crude protein content of all the types of custard increased as the supplementation with *ber* powder increased. This might be due to the fact that the protein content of *ber* powder was more as compared to custard powder. Hence, the crude protein content increased when custard powder was replaced with *ber* powder.

The crude fat content of all the types of custard ranged from 5.85 to 5.88 per cent (Table 4.21). The crude fat content of all the types of custard did not increase much after addition of *ber* powder and observed to be non-significantly different from each other. The crude fat content of all the types of custard increased to a smaller extent as the supplementation with *ber* powder increased. This might be due to the fact that the fat content of *ber* powder was less but it was more as compared to custard powder. Hence, a little increase was observed in the crude fat content after the addition of *ber* powder.

It was evident from the Table 4.21 that the crude fiber content of all the types of custard ranged from 0.13 to 0.45 per cent. Non-significant differences were observed for the crude fiber content of every two consecutive custard while rest were found to be significantly

different from each other. The crude fiber content of type V custard was significantly higher than control, type I and II custard. The crude fiber content of all the types of custard increased as the supplementation with *ber* powder increased. This might be due to the fact that the fiber content of *ber* powder was more as compared to custard powder. Hence, the crude fiber content increased when custard powder was replaced with *ber* powder.

The ash content of control, type I, II, III, IV and V custard was 0.90, 0.97, 1.06, 1.13, 1.21 and 1.29 per cent, respectively (Table 4.21). Non-significant differences were obtained in the ash content of all the types of custard. The ash content did not increased significantly after the addition of *ber* powder. The ash content of all the types of custard increased as the supplementation with *ber* powder increased. This might be due to the fact that the mineral content of custard increased after incorporation of *ber* powder leading to increase in ash content.

From Table 4.22, it was revealed that the total soluble sugars content of all the types of custard ranged from 20.17 to 21.77 g/100g. , being highest in type V custard followed by type IV, III, II, I and control. Non-significant differences were obtained in the total soluble sugars content of all the types of custard. The total soluble sugars content of all the types of custard increased as the supplementation with *ber* powder increased. This might be due to the fact that the total sugars content of *ber* powder was more as compared to custard powder. Hence, the total soluble sugars content increased when custard powder was replaced with *ber* powder.

The reducing sugars content of all the types of custard ranged from 0.74 to 1.09 per cent (Table 4.22). Non-significant differences were obtained in the reducing sugars content of every three corresponding custard while the rest were observed to be significantly different from each other. An increase in reducing sugars content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the reducing sugars content of *ber* powder was more as compared to custard powder. Hence, an increase in reducing sugars content was observed after replacing custard powder with *ber* powder.

It was inferred from the data presented in Table 4.22 that the non-reducing sugars content of control, type I, II, III, IV and V custard was 19.43, 19.60, 19.91, 20.14, 20.37 and 20.68 g/100g, respectively. Non-significant differences were obtained in the non-reducing sugars content of all the types of custard. An increase in non-reducing sugars content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the non-reducing sugars content of *ber* powder was more as compared to custard powder. Hence, an increase in non-reducing sugars content was observed after replacing custard powder with *ber* powder.

The calcium content of control, type I, II, III, IV and V custard was 217.88, 220.46, 223.32, 226.19, 228.85 and 231.52 mg/100g, respectively (Table 4.23). The calcium content

of type V custard was significantly higher and the calcium content of control custard was significantly lower among all the types of custard. All the types of custard were found to have significantly different calcium content. The calcium content of all the types of custard increased as the supplementation with *ber* powder increased. This might be due to the fact that the calcium content of *ber* powder was more as compared to custard powder. Hence, the calcium content increased when custard powder was replaced with *ber* powder.

It was evident from the data presented in Table 4.23 that the iron content of all types of custard ranged 0.25 to 1.58 mg/100g, being highest in type V custard and lowest in control custard. The iron content of all the types of custard was found to be non-significantly different from their consecutive custard but significantly different from rest of the custard types. An increase in iron content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the iron content of *ber* powder was more as compared to custard powder. Hence, an increase in iron content was observed after replacing custard powder with *ber* powder.

The magnesium content of control, type I, II, III, IV and V custard was 42.80, 42.96, 43.11, 43.26, 43.40 and 43.56 mg/100g, respectively (Table 4.23). The magnesium content of type V custard was higher and that of control custard was lower among all the types of custard. Non-significant differences were observed between the magnesium content of control, type I and II, type I, II and III, type II, III and IV and type III, IV and V custard while rest of the types of custard were observed to be significantly different from each other. The magnesium content of all the types of custard increased as the supplementation with *ber* powder increased. This might be due to the fact that the magnesium content of *ber* powder was more as compared to custard powder. Hence, the magnesium content increased when custard powder was replaced with *ber* powder.

It was evident from the data presented in Table 4.23 that the zinc content was not detected in any of the custard including control, type I, II, III, IV and V custard. This could be attributed to the less zinc content of *ber* powder and negligible zinc content of custard powder and milk. Moreover, the amount of *ber* powder added for the preparation of custard was small. That might have caused no detection of zinc content in all the types of custard.

The ascorbic acid was not detected in any of the custard including control, type I, II, III, IV and V custard. The reason for this might be the less amount of *ber* powder which was added for the preparation of different types of custard. Moreover, this could be attributed to the fact that the ascorbic acid was lost during constant boiling of custard. Uckiah *et al.* (2009) reported similar results of destruction of ascorbic acid after direct heat processing.

The  $\beta$ -carotene content was also not detected in any type of the custard. This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is

lost by oxidation and heat. Emmanuel *et al.* (2005) and Anjum *et al.* (2008) reported similar results for loss of  $\beta$ -carotene after heating and storage.

The data depicted in Table 4.24 reported that the *in-vitro* protein digestibility of control, type I, II, III, IV and V custard was 85.49, 85.83, 86.15, 86.48, 86.89 and 87.09 per cent, respectively. The *in-vitro* protein digestibility of every two consecutive types of custard was non-significantly different while rest were found to be significantly different from each other. An increase in the *in-vitro* protein digestibility of all the types of custard was observed as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* protein digestibility of *ber* powder was higher than the custard powder. Hence, an increase in *in-vitro* protein digestibility was observed after replacing custard powder with *ber* powder.

The *in-vitro* starch digestibility of control, type I, II, III, IV and V custard was 55.93, 56.13, 56.34, 56.56, 56.77 and 56.99 mg maltose released/g powder, respectively (Table 4.24). The *in-vitro* starch digestibility of all types of custard was significantly different from each other except for every two consecutive custard types. The *in-vitro* starch digestibility of all the types of custard increased as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* starch digestibility of *ber* powder was higher than the custard powder. Hence, *in-vitro* starch digestibility increased when custard powder was replaced with *ber* powder.

### 5.7.2 Nutritional evaluation of *kheer*

The moisture content of all the types of *kheer* ranged from 70.49 to 71.51 per cent (Table 4.25). Non-significant differences were obtained in the moisture content of all the types of *kheer*. An increase in the moisture content of *kheer* was observed as the amount of incorporation of *ber* powder increased.

The crude protein content of control, type I, II, III, IV and V *kheer* was 7.00, 7.04, 7.11, 7.24, 7.38 and 7.52 per cent, respectively (Table 4.25). The crude protein content of every three consecutive *kheer* types was found to be non-significantly different from each other but significantly different from the other types of *kheer*. The crude protein content of the *kheer* increased as the supplementation with the *ber* powder increased. The crude protein content of all the types of *kheer* increased as the supplementation with *ber* powder increased. This might be due to the fact that the protein content of *ber* powder was more as compared to rice. Hence, the crude protein content increased.

From the Table 4.25, it was depicted that the crude fat content of *kheer* ranged from 7.23 to 7.26 per cent. The crude fat content of *kheer* did not increase much after addition of *ber* powder and observed to be almost similar and non-significantly different from each other. A slight increase in fat content observed after supplementation with *ber* powder could be attributed to the fact that the fat content of *ber* powder was less but it was more as compared

to rice. Hence, a little increase was observed in the crude fat content after the addition of *ber* powder.

The crude fiber content of all types of *kheer* ranged from 0.21 to 0.77 per cent (Table 4.25). The crude fiber content of every two consecutive types of *kheer* was observed to be non-significantly different from each other but significantly different from rest of the *kheer* types. The crude fiber content of all the types of *kheer* increased as the supplementation with *ber* powder increased. This might be due to the fact that the fiber content of *ber* powder was more as compared to rice. Hence, the crude fiber content of all the types of *kheer* prepared using *ber* powder increased.

The ash content of control, type I, II, III, IV and V *kheer* was 3.72, 3.85, 4.00, 4.15, 4.18 and 4.43 per cent, respectively (Table 4.25). Non-significant differences were obtained in the ash content of all the types of *kheer*. An increase in ash content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the mineral content of *kheer* increased after incorporation of *ber* powder leading to increase in ash content.

It was revealed from the data presented in Table 4.26 that the total soluble sugars content of all the types of *kheer* ranged from 22.58 to 25.67 g/100 g being highest in type V *kheer* followed by type IV, III, II, I and control *kheer*. An increase in total soluble sugars content observed after supplementation with *ber* powder could be attributed to the fact that the total sugars content of *ber* powder was more as compared to rice. Hence, the total soluble sugars content of the *kheer* increased after the addition of *ber* powder.

The reducing sugars content of *kheer* ranged from 0.70 to 1.27 per cent (Table 4.26). The reducing sugars content of type V *kheer* was significantly higher than its control and type I counterparts. Non-significant differences were obtained in the reducing sugars content of every four corresponding *kheer* while the rest were observed to be significantly different from each other. The reducing sugars content of all the types of *kheer* increased as the supplementation with *ber* powder increased. This might be due to the fact that the reducing sugars content of *ber* powder was more as compared to rice. Hence, the reducing sugars content increased when rice was replaced with *ber* powder.

From the Table 4.26, it was revealed that the non-reducing sugars content of control, type I, II, III, IV and V *kheer* was 21.88, 22.39, 22.90, 23.41, 23.92 and 24.40 g/100g, respectively. Non-significant differences were obtained in the non-reducing sugar content of every two consecutive *kheer* while rest of the types of *kheer* was found to be significantly different from each other. An increase in non-reducing sugars content observed after supplementation with *ber* powder could be attributed to the fact that the non-reducing sugars content of *ber* powder was more as compared to rice. Hence, the non-reducing sugars content of the *kheer* increased after the addition of *ber* powder.

The calcium content of control, type I, II, III, IV and V *kheer* was 228.61, 233.11, 237.42, 242.14, 246.44 and 251.05 mg/100g, respectively (Table 4.27). The calcium content of type V *kheer* was significantly higher and the calcium content of control *kheer* was significantly lower among all the types of *kheer*. All the types of *kheer* were found to have significantly different calcium content. The calcium content of all the types of *kheer* increased as the supplementation with *ber* powder increased. This might be due to the fact that the calcium content of *ber* powder was more as compared to rice leading to increase calcium content of the *kheer* increased after the addition of *ber* powder.

It was depicted from the data presented in Table 4.27 that the iron content of all types of *kheer* ranged 1.02 to 3.86 mg/100g, being highest in type V *kheer* and lowest in control *kheer*. The iron content of all the types of *kheer* was found to be non-significantly different from their consecutive *kheer* but significantly different from rest of the *kheer* types. An increase in iron content observed after supplementation with *ber* powder could be attributed to the fact that the iron content of *ber* powder was more as compared to rice. Hence, the iron content of the *kheer* increased.

The magnesium content of control, type I, II, III, IV and V *kheer* was 57.21, 58.17, 59.11, 60.00, 60.85 and 61.73 mg/100g, respectively (Table 4.27). The magnesium content of type V *kheer* was significantly higher and that of control *kheer* was significantly lower among all the types of *kheer*. The data indicated that the magnesium content of all the types of *kheer* was significantly different from each other. The magnesium content of all the types of *kheer* increased as the supplementation with *ber* powder increased. This might be due to the fact that the magnesium content of *ber* powder was more as compared to rice leading to the increase in magnesium content of supplemented *kheer*.

It was evident from the data presented in Table 4.27 that the zinc content was not detected in any of the *kheer* including control, type I, II, III, IV and V *kheer*. This could be attributed to the less zinc content of *ber* powder and negligible zinc content of milk. Moreover, the amount of *ber* powder added for the preparation of *kheer* was also small. That might have caused no detection of zinc content in all the types of *kheer*.

The ascorbic acid was not detected in any of the *kheer* including control, type I, II, III, IV and V *kheer*. The reason for this might be the less amount of *ber* powder which was added for the preparation of different types of *kheer*. Moreover, this could be attributed to the fact that the ascorbic acid was lost during constant boiling of *kheer*. Uckiah *et al.* (2009) reported similar results of destruction of ascorbic acid after direct heat processing.

The  $\beta$ -carotene content was also not detected in any type of the *kheer*. This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is lost by oxidation and heat. Emmanuel *et al.* (2005) and Anjum *et al.* (2008) reported similar results for loss of  $\beta$ -carotene after heating and storage.

The data depicted in Table 4.28 reported that the *in-vitro* protein digestibility of control, type I, II, III, IV and V *kheer* was 86.19, 86.51, 86.83, 87.15, 87.45 and 87.76 per cent, respectively. The *in-vitro* protein digestibility of every two consecutive types of custard was non-significantly different while rest were found to be significantly different from each other. An increase in the *in-vitro* protein digestibility of all the types of *kheer* was observed as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* protein digestibility of *ber* powder was higher than rice. Hence, an increase in *in-vitro* protein digestibility was observed after supplementation.

The *in-vitro* starch digestibility of control, type I, II, III, IV and V *kheer* was 56.29, 56.51, 56.71, 56.92, 57.12 and 57.33 mg maltose released/g *kheer*, respectively (Table 4.28). The *in-vitro* starch digestibility was found to be non-significantly different among every two consecutive *kheer* but significantly different from rest of the types of *kheer*. The *in-vitro* starch digestibility of all the types of *kheer* increased as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* starch digestibility of *ber* powder was higher than rice. Hence, *in-vitro* starch digestibility increased when rice was replaced with *ber* powder.

### 5.7.3 Nutritional evaluation of biscuits

The moisture content of biscuits ranged from 2.86 to 4.52 per cent being highest in type V biscuits followed by type IV, III, II, I and control biscuits (Table 4.29). Non-significant differences were obtained in the moisture content of all types of biscuits. An increase in moisture content was observed as the supplementation increased. Negi (2003) and Chhabra (2006) recorded similar results for non-significant increase in moisture content of biscuits after fruit powder supplementation.

It was evident from the data in Table 4.29 that the crude protein content of control, type I, II, III, IV and V biscuits was 8.75, 8.47, 8.21, 7.94, 7.66, 7.39 g/100g, respectively. Non-significant differences were observed for the crude protein content of every three consecutive biscuits while rest were found to be significantly different. The crude protein content of all the types of biscuits decreased as the supplementation with *ber* powder increased. This might be due to the fact that the crude protein content of *ber* powder was less as compared to refined wheat flour. Hence, the crude protein content decreased when refined wheat flour was replaced by *ber* powder. Similar result of significant decrease of protein content was reported by Fang (2008) in baked bread supplemented with pumpkin flour. Negi (2003) and Chhabra (2006) found significant increase in protein content of biscuits after fruit powders supplementation. Dahiya and Grewal (2010) also observed increase in protein content of biscuits prepared using soybean and *ber* powder.

From the Table 4.29, it was revealed that the crude fat content of control, type I, II, III, IV and V biscuits was 23.31, 23.32, 23.33, 23.33, 23.34 and 23.35 per cent, respectively.

Non-significant differences were obtained in the crude fat content of all the types of biscuits. The crude fat content of all the types of biscuits increased to a smaller extent as the supplementation with *ber* powder increased. This might be due to the fact that the fat content of *ber* powder was less but it was slightly more than refined wheat flour leading to increase in crude fat content. Non-significant increase in fat content of biscuits prepared using fruit powders was observed (Negi, 2003; Chhabra, 2006). Fang (2008) reported significant decrease in fat content of baked bread supplemented with pumpkin flour.

The crude fiber content of biscuits ranged from 1.58 to 3.23 per cent (Table 4.29). Type V biscuits were found to have significantly higher crude fiber content followed by type IV, III, II, I and control biscuits. Significant differences were obtained in the crude fiber content of all the types of biscuits. The crude fiber content of all the types of biscuits increased as the supplementation with *ber* powder increased. This might be due to the fact that the fiber content of *ber* powder was more as compared to refined wheat flour. Hence, the crude fiber content increased. Significant increase in crude fiber content was observed in biscuits supplemented with fruit powders and fruit peel powders by Negi (2003), Chhabra (2006), Ajila *et al.* (2008) and Grewal and Dahiya (2010). Fang (2008) also reported significant increase in fiber of baked bread prepared using pumpkin flour.

Data presented in Table 4.29 indicated that the ash content of control, type I, II, III, IV and V biscuits was 0.78, 1.12, 1.44, 1.77, 2.08 and 2.38 per cent, respectively. The ash content of all the types of biscuits was recorded to be significantly different from each other except the ash content of type IV and V biscuits which were found to be similar and non-significantly different from each other. The ash content of all the types of biscuits increased as the supplementation with *ber* powder increased. This might be due to the fact that the mineral content of biscuits increased after incorporation of *ber* powder leading to increase in ash content. Significant increase in ash content was observed by Negi (2003) and Chhabra (2006) in biscuits prepared with fruit powders. Fang (2008) reported significant increase in ash content of baked bread prepared using pumpkin flour.

The total soluble sugars content of control, type I, II, III, IV and V biscuits was 13.57, 15.13, 16.98, 19.05, 21.03 and 22.80 g/100g respectively (Table 4.30). The total soluble sugars content of all the types of biscuits was recorded to be significantly different from each other being significantly higher than type V biscuits and significantly lower in control biscuits. The total soluble sugars content of all the types of biscuits increased as the supplementation with *ber* powder increased. This might be due to the fact that the total sugars content of *ber* powder was more than refined wheat flour leading to increase in total soluble sugars content. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in biscuits prepared using fruit powders.

The data presented in Table 4.30 indicated that the reducing sugars content of all types of biscuits ranged from 0.54 to 2.40 per cent. The reducing sugars content of biscuits increased with increasing supplementation of *ber* powder. The reducing sugars content of all types of biscuits was found to be significantly different from each other. The increase in reducing sugars content might be due to the fact that the reducing sugars content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in reducing sugars content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in biscuits prepared using fruit powders.

The non-reducing sugars content of control, type I, II, III, IV and V biscuits was 13.03, 14.24, 15.38, 17.42, 19.01 and 20.40 per cent, respectively (Table 4.30). All the types of biscuits were observed to have significantly different non-reducing sugars content except in type IV and V biscuits which were found to be similar and non-significantly different from each other. An increase in non-reducing sugars content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the non-reducing sugars content of *ber* powder was more than refined wheat flour leading to increase in non-reducing sugars content. Significant increase in non-reducing sugars content was observed by Negi (2003) and Chhabra (2006) in biscuits prepared with fruit powders.

It was evident from the data in Table 4.31 that the calcium content of control, type I, II, III, IV and V biscuits was 89.66, 102.76, 114.68, 127.22, 139.66 and 152.14 mg/100g, respectively. The calcium content of all the types of biscuits was found to be significantly different from each other being significantly higher in type V biscuits and significantly lower in control biscuits. The calcium content of all the types of biscuits increased as the supplementation with *ber* powder increased. This might be due to the fact that the calcium content of *ber* powder was more as compared to refined wheat flour. Hence, the calcium content increased. Significant increase in calcium content was observed by Negi (2003) and Chhabra (2006) in biscuits prepared with fruit powders. Fang (2008) also reported significant increase in calcium content of baked bread prepared using pumpkin flour.

The data presented in Table 4.31 revealed that the iron content of biscuits ranged from 3.53 to 10.65 mg/100g. The iron content of type V biscuits was significantly higher followed by type IV, III, II, I and control biscuits. The iron content of all the biscuits was found to be significantly different from each other. An increase in iron content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the iron content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in iron content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in

biscuits prepared using fruit powders. Fang (2008) also reported significant increase in iron content of baked bread prepared using pumpkin flour.

The magnesium content of control, type I, II, III, IV and V biscuits was 43.77, 47.18, 50.48, 53.74, 56.99 and 60.20 mg/100g, respectively (Table 4.31). The magnesium content of all the biscuits was significantly different from each other. The magnesium content of type V biscuits was significantly higher followed by type IV, III, II, I and control biscuits. The magnesium content of all the types of biscuits increased as the supplementation with *ber* powder increased. This might be due to the fact that the magnesium content of *ber* powder was more as compared to refined wheat flour. Chhabra (2006) reported non-significant increase in the magnesium content of biscuits prepared using bael powder. Fang (2008) also reported significant increase in magnesium content of baked bread prepared using pumpkin flour.

From the Table 4.31, it was revealed that the zinc content of all the biscuits ranged from 0.79 to 0.92 mg/100g. Non-significant differences were observed in the zinc content of every three consecutive biscuits while rest were found to be significantly different from each other. The zinc content of all the types of biscuits increased as the supplementation with *ber* powder increased. This might be due to the fact that the zinc content of *ber* powder was more as compared to refined wheat flour leading to increase in zinc content. Negi (2003) reported significant increase in zinc content of biscuits prepared using fruit powders while Chhabra (2006) reported non-significant increase in the zinc content of biscuits prepared using bael powder.

The data presented in Table 4.32 indicated that the ascorbic acid content of all the biscuit ranged from 2.39 to 16.35 mg/100g while it was not detected in the control biscuits. The ascorbic acid content of all the biscuits differed significantly from each other. The ascorbic acid content of type V biscuits was significantly higher followed by type IV, III, II and I biscuits. An increase in ascorbic acid content was observed after supplementation with *ber* powder. A loss of 30 to 40 per cent was observed in ascorbic acid content after baking by Lathrop and Leung (2006) and Chaudhary (2008). Negi (2003) and Chhabra (2006) prepared biscuits using fruit powders and observed significant increase in ascorbic acid content as the supplementation was increased.

The  $\beta$ -carotene content was not detected in any type of prepared biscuits (Table 4.32). This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is lost by oxidation and heat. Similar results for loss of  $\beta$ -carotene after heating and storage was observed by Emmanuel *et al.* (2005) and Anjum *et al.* (2008). Negi (2003) and Chhabra (2006) observed significant increase in  $\beta$ -carotene content of biscuits using fruit powders.

The data presented in Table 4.33 indicated that the *in-vitro* protein digestibility of control, type I, II, III, IV and V biscuits was 73.23, 73.55, 73.85, 74.17, 74.48 and 74.78 per cent, respectively. Non-significant differences were observed in the *in-vitro* protein digestibility of every three consecutive biscuits while rest of the biscuits were found to be significantly different from each other. An increase in the *in-vitro* protein digestibility of all the types of biscuits was observed as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* protein digestibility of *ber* powder was higher than the refined wheat flour leading to increase in *in-vitro* protein digestibility of all the types of biscuits. Chhabra (2006) also reported significant increase in *in-vitro* protein digestibility of biscuits after supplementation with bael powder.

The *in-vitro* starch digestibility of all the biscuits ranged from 37.49 to 38.36 mg maltose released/g (Table 4.33). Non-significant differences were observed in the *in-vitro* starch digestibility of every four consecutive biscuits while rest of the biscuits were found to be significantly different from each other. The *in-vitro* starch digestibility of all the types of biscuits increased as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* starch digestibility of *ber* powder was higher than the refined wheat flour. Hence, *in-vitro* starch digestibility increased. Similar results of significant increase in *in-vitro* starch digestibility were observed by Negi (2003) and Chhabra (2006) in biscuits prepared using fruit powder.

#### **5.7.4 Nutritional evaluation of cake**

The moisture content of cake ranged from 22.81 to 24.48 per cent being highest in type V cake followed by type IV, III, II, I and control cake (Table 4.34). Non-significant differences were obtained in the moisture content of all types of cake. An increase in moisture content was observed as the supplementation increased. Negi (2003) and Chhabra (2006) reported similar results for non-significant increase in moisture content of cake after fruit powder supplementation.

It was evident from the data in Table 4.34 that the crude protein content of control, type I, II, III, IV and V cake was 12.58, 12.36, 12.13, 11.91, 11.68 and 11.47 g/100g, respectively. The crude protein content of every two consecutive cake was similar and non-significantly different from each but significantly different from rest of the types of cake. A decreasing trend was observed in the crude protein content of all the types of cake as the supplementation of *ber* powder increased. This might be due to the fact that the crude protein content of *ber* powder was less as compared to refined wheat flour. Hence, the crude protein content decreased when refined wheat flour was replaced by *ber* powder. Similar result of significant decrease of protein content was reported by Fang (2008) in baked bread supplemented with pumpkin flour. Negi (2003) and Chhabra (2006) found significant increase in protein content of cake after fruit powders supplementation.

From the Table 4.34, it was revealed that the crude fat content of control, type I, II, III, IV and V cake was 9.53, 9.54, 9.54, 9.55, 9.56 and 9.57 per cent, respectively. Non-significant differences were obtained in the crude fat content of all the types of cake. The crude fat content of all the types of cake increased to a smaller extent as the supplementation with *ber* powder increased. This might be due to the fact that the fat content of *ber* powder was less but it was slightly more than refined wheat flour leading to increase in crude fat content. Non-significant increase in fat content of cake prepared using fruit powders was also observed by Negi (2003) and Chhabra (2006). Fang (2008) reported significant decrease in fat content of baked bread supplemented with pumpkin flour.

The crude fiber content of cake ranged from 0.91 to 2.09 per cent (Table 4.34). Type V cake was found to have significantly higher crude fiber content followed by type IV, III, II, I and control cake. Significant differences were obtained in the crude fiber content of all the types of cake. The crude fiber content of all the types of cake increased as the supplementation with *ber* powder increased. This might be due to the fact that the fiber content of *ber* powder was more as compared to refined wheat flour. Hence, the crude fiber content increased. Significant increase in crude fiber content was observed in cake supplemented with fruit powders by Negi (2003) and Chhabra (2006). Fang (2008) also reported significant increase in fiber of baked bread prepared using pumpkin flour.

Data presented in Table 4.34 indicated that the ash content of control, type I, II, III, IV and V cake was 1.10, 1.39, 1.72, 2.05, 2.37 and 2.68 per cent, respectively. The ash content of every two consecutive cake was found to be non-significantly different from each but significantly different from rest of the types of cake. The ash content of all the types of cake increased as the supplementation with *ber* powder increased. This might be due to the fact that the mineral content of cake increased after incorporation of *ber* powder leading to increase in ash content. Significant increase in ash content was observed by Negi (2003) and Chhabra (2006) in cake prepared with fruit powders. Fang (2008) reported significant increase in ash content of baked bread prepared using pumpkin flour.

The total soluble sugars content of control, type I, II, III, IV and V cake was 32.66, 34.17, 35.67, 37.20, 38.74 and 40.26 g/100g respectively (Table 4.35). The total soluble sugars content of type V cake was significantly higher while the total soluble sugars content of control cake was found to be significantly lower among all the types of cake. The total soluble sugars content of all the types of cake was recorded to be significantly different from each other. The total soluble sugars content of all the types of cake increased as the supplementation with *ber* powder increased. This might be due to the fact that the total sugars content of *ber* powder was more than refined wheat flour leading to increase in total soluble sugars content. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in cake prepared using fruit powders.

The data presented in Table 4.35 indicated that the reducing sugars content of all types of cake ranged from 0.44 to 1.93 per cent. The reducing sugars content of all types of cake was found to be significantly different from each other. Type V cake was observed to have significantly higher reducing sugars content while control cake had significantly lower reducing sugars content among all types of cake. The reducing sugars content of all the types of cake increased with increasing supplementation of *ber* powder. The increase in reducing sugars content might be due to the fact that the reducing sugars content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in reducing sugars content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in cake prepared using fruit powders.

The non-reducing sugars content of control, type I, II, III, IV and V cake was 33.22, 33.46, 34.65, 35.87, 37.12 and 38.33 per cent, respectively (Table 4.35). All the types of cake were observed to have significantly different non-reducing sugars content from each other. An increase in non-reducing sugars content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the non-reducing sugars content of *ber* powder was more than refined wheat flour leading to increase in non-reducing sugars content of cake. Significant increase in non-reducing sugars content was observed by Negi (2003) and Chhabra (2006) in cake prepared with fruit powders.

It was evident from the data in Table 4.36 that the calcium content of control, type I, II, III, IV and V cake was 92.49, 102.43, 112.31, 122.23, 132.13 and 141.94 mg/100g, respectively. The calcium content of all the types of cake was significantly different from each other being significantly higher in type V cake and significantly lower in control cake. . The calcium content of all the types of cake increased as the supplementation with *ber* powder increased. This might be due to the fact that the calcium content of *ber* powder was more as compared to refined wheat flour. Hence, the calcium content increased. Significant increase in calcium content was observed by Negi (2003) and Chhabra (2006) in cake prepared with fruit powders. Fang (2008) also reported significant increase in calcium content of baked bread prepared using pumpkin flour.

The data presented in Table 4.36 indicated that the iron content of all the types of cake ranged from 4.40 to 9.89 mg/100g. The iron content of type V cake was significantly higher followed by type IV, III, II, I and control cake. The iron content of all the types of cake was significantly different from each other. An increase in iron content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the iron content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in iron content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in cake

prepared using fruit powders. Fang (2008) also reported significant increase in iron content of baked bread prepared using pumpkin flour.

The magnesium content of control, type I, II, III, IV and V cake was 51.60, 54.29, 56.91, 59.56, 62.12 and 64.71 mg/100g, respectively (Table 4.36). The magnesium content of all the types of cake was significantly different from each other. The magnesium content of type V cake was significantly higher followed by type IV, III, II, I and control cake. The magnesium content of all the types of cake increased as the supplementation with *ber* powder increased. This might be due to the fact that the magnesium content of *ber* powder was more as compared to refined wheat flour. Chhabra (2006) reported non-significant increase in the magnesium content of cake prepared using bael powder. Fang (2008) also reported significant increase in magnesium content of baked bread prepared using pumpkin flour.

From the Table 4.36, it was revealed that the zinc content of all the types of cake ranged from 0.55 to 0.67 mg/100g. Non-significant differences were observed in the zinc content of every three consecutive cake while significant differences were observed in other types of cake. The zinc content of all the types of cake increased as the supplementation with *ber* powder increased. This might be due to the fact that the zinc content of *ber* powder was more as compared to refined wheat flour leading to increase in zinc content. Negi (2003) reported significant increase in zinc content of cake prepared using fruit powders while Chhabra (2006) reported non-significant increase in zinc content of cake prepared using bael powder.

The data presented in Table 4.37 indicated that the ascorbic acid content of all the cake ranged from 3.49 to 17.24 mg/100g while it was not detected in the control cake. The ascorbic acid content of all the types of cake differed significantly from each other. An increase in ascorbic acid content was observed after supplementation with *ber* powder. A loss of 30 to 40 per cent was observed in ascorbic acid content after baking by Lathrop and Leung (2006) and Chaudhary (2008). Negi (2003) and Chhabra (2006) prepared cake using fruit powders and observed significant increase in ascorbic acid content as the supplementation was increased.

The  $\beta$ -carotene content was not detected in any type of prepared cake (Table 4.37). This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is lost by oxidation and heat. Similar results for loss of  $\beta$ -carotene after heating and storage was observed by Emmanuel *et al.* (2005) and Anjum *et al.* (2008). Negi (2003) and Chhabra (2006) observed significant increase in  $\beta$ -carotene content of cake using fruit powders.

The data presented in Table 4.38 indicated that the *in-vitro* protein digestibility of control, type I, II, III, IV and V cake was 84.44, 84.76, 85.06, 85.37, 85.67 and 85.93 per cent, respectively. Non-significant differences were observed in the *in-vitro* protein

digestibility of every two consecutive cake while rest were found to be significantly different from each other. An increase in the *in-vitro* protein digestibility of all the types of cake was observed as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* protein digestibility of *ber* powder was higher than the refined wheat flour leading to increase in *in-vitro* protein digestibility of all the types of cake. Chhabra (2006) also reported significant increase in *in-vitro* protein digestibility of cake after supplementation with bael powder.

The *in-vitro* starch digestibility of all the cake ranged from 48.11 to 49.14 mg maltose released/g (Table 4.38). The *in-vitro* starch digestibility of type V cake was significantly higher than control, type I, II and III cake. Non-significant differences were observed in the *in-vitro* starch digestibility of every two consecutive cake while rest were found to be significantly different from each other. The *in-vitro* starch digestibility of all the types of cake increased as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* starch digestibility of *ber* powder was higher than the refined wheat flour. Hence, *in-vitro* starch digestibility increased. Similar results of significant increase in *in-vitro* starch digestibility were observed by Negi (2003) and Chhabra (2006) in cake prepared using fruit powder.

#### **5.7.5 Nutritional evaluation of pasta**

The moisture content of control, type I, II, III, IV and V pasta was 2.74, 2.97, 3.18, 3.40, 3.60 and 3.81 per cent, respectively (Table 4.39). Non-significant differences were observed in the moisture content of all the types of pasta prepared using *ber* powder and the control pasta. An increase in moisture content was observed as the supplementation increased. Negi (2003) and Chhabra (2006) recorded similar results for non-significant increase in moisture content of pasta after fruit powder supplementation.

It was evident from the data in Table 4.39 that the crude protein content of all the types of pasta ranged from 7.90 to 9.25 g/100g. The crude protein content of type V pasta was significantly lower as compared to control pasta whose protein content was found to be significantly higher than type II, III, IV and V pasta. Non-significant differences were observed in the crude protein content of every two consecutive pasta while significant differences were observed in other types of pasta. A decreasing trend was observed in the crude protein content of all the types of pasta as the supplementation of *ber* powder increased. This might be due to the fact that the crude protein content of *ber* powder was less as compared to refined wheat flour. Hence, the crude protein content decreased when refined wheat flour was replaced by *ber* powder. Negi (2003) and Chhabra (2006) found significant increase in protein content of pasta after fruit powders supplementation.

From the Table 4.39, it was revealed that the crude fat content of control, type I, II, III, IV and V pasta was 0.91, 0.92, 0.93, 0.93, 0.94 and 0.95 per cent, respectively. Non-

significant differences were observed in the crude fat content of all the types of pasta. The crude fat content of all the types of pasta increased to a smaller extent as the supplementation with *ber* powder increased. This might be due to the fact that the fat content of *ber* powder was less but it was slightly more than refined wheat flour leading to increase in crude fat content. Non-significant increase in fat content of pasta prepared using fruit powders was observed (Negi, 2003; Chhabra, 2006).

The crude fiber content of all the types of pasta ranged from 0.33 in control pasta to 1.99 in type V pasta (Table 4.39). The crude fiber content of all the types of pasta was found to be significantly different from each other being significantly higher in type V pasta and significantly lower in control pasta. The crude fiber content of all the types of pasta increased as the supplementation with *ber* powder increased. This might be due to the fact that the fiber content of *ber* powder was more as compared to refined wheat flour. Hence, the crude fiber content increased. Negi (2003) and Chhabra (2006) also reported significant increase in crude fiber content was observed in pasta supplemented with fruit powders.

Data presented in Table 4.39 indicated that the ash content of control, type I, II, III, IV and V pasta was 0.63, 0.97, 1.29, 1.63, 1.95 and 2.26 per cent, respectively. The ash content of type V pasta was significantly higher followed by type IV, III, II, I and control pasta. The ash content of all the types of pasta was found to be significantly different from each other. The ash content of all the types of pasta increased as the supplementation with *ber* powder increased. This might be due to the fact that the mineral content of pasta increased after incorporation of *ber* powder leading to increase in ash content. Significant increase in ash content was observed by Negi (2003) and Chhabra (2006) in pasta prepared with fruit powders.

The total soluble sugars content of control, type I, II, III, IV and V pasta was 3.90, 5.35, 6.92, 8.53, 10.20 and 11.75 g/100g, respectively (Table 4.40). The total soluble sugars content of type V pasta was significantly higher followed by type IV, III, II, I and control pasta. The total soluble sugar content of all the types of pasta was significantly different from each other. The total soluble sugars content of all the types of pasta increased as the supplementation with *ber* powder increased. This might be due to the fact that the total sugars content of *ber* powder was more than refined wheat flour leading to increase in total soluble sugars content. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in pasta prepared using fruit powders.

The data presented in Table 4.40 indicated that the reducing sugars content of all the prepared pasta ranged from 0.63 to 2.26 per cent. The reducing sugars content of control pasta was found to be significantly lower and that of type V pasta was found to be significantly higher among all the types of pasta. The reducing sugars content of all the types of pasta was observed to be significantly different from each other. The reducing sugars content of all the

types of pasta increased with increasing supplementation of *ber* powder. The increase in reducing sugars content might be due to the fact that the reducing sugars content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in reducing sugars content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in pasta prepared using fruit powders.

The non-reducing sugars content of control, type I, II, III, IV and V pasta was 3.27, 4.42, 5.66, 6.93, 8.23 and 9.49 g/100g, respectively (Table 4.40). The non-reducing sugars content of type V pasta was significantly higher among all the types of pasta followed by type IV, III, II, I and control pasta. All the types of pasta were found to be significantly different from each other in terms of their non-reducing sugars content. An increase in non-reducing sugars content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the non-reducing sugars content of *ber* powder was more than refined wheat flour leading to increase in non-reducing sugars content of pasta. Significant increase in non-reducing sugars content was observed by Negi (2003) and Chhabra (2006) in pasta prepared with fruit powders.

It was evident from the data in Table 4.41 that the calcium content of control, type I, II, III, IV and V was 21.42, 34.04, 46.65, 59.28, 71.90 and 84.51 mg/100g, respectively. The calcium content of type V pasta was significantly higher while the calcium content of control pasta was significantly lower among all the types of pasta. The calcium content of all the types of pasta was found to be significantly different from each other. The calcium content of all the types of pasta increased as the supplementation with *ber* powder increased. This might be due to the fact that the calcium content of *ber* powder was more as compared to refined wheat flour. Hence, the calcium content increased. Significant increase in calcium content was observed by Negi (2003) and Chhabra (2006) in pasta prepared with fruit powders.

The data presented in Table 4.41 indicated that the iron content of all the types of pasta ranged from 2.73 to 9.76 mg/100g. The iron content of all the types of pasta was found to be significantly different from each other being significantly higher in type V pasta followed by type IV, III, II, I and control pasta. An increase in iron content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the iron content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in iron content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in pasta prepared using fruit powders.

The magnesium content of control, type I, II, III, IV and V pasta was 46.35, 49.68, 52.93, 56.15, 59.41 and 62.69 mg/100g, respectively (Table 4.41). The magnesium content of all the types of pasta was found to be significantly different from each other. The magnesium

content of all the types of pasta increased as the supplementation with *ber* powder increased. This might be due to the fact that the magnesium content of *ber* powder was more as compared to refined wheat flour. Chhabra (2006) reported non-significant increase in the magnesium content of pasta prepared using bael powder.

From the Table 4.41, it was revealed that the zinc content of all the types of pasta ranged from 0.43 to 0.55 mg/100g. Non-significant differences were observed in the zinc content of every three consecutive pasta while significant differences were observed for other types of pasta. The zinc content of all the types of pasta increased as the supplementation with *ber* powder increased. This might be due to the fact that the zinc content of *ber* powder was more as compared to refined wheat flour leading to increase in zinc content. Negi (2003) reported significant increase in zinc content of pasta prepared using fruit powders while Chhabra (2006) reported non-significant increase in zinc content of pasta prepared using bael powder.

The data presented in Table 4.42 indicated that the ascorbic acid content of all the prepared pasta ranged from 3.31 to 18.19 mg/100g while it was not detected in the control pasta. The ascorbic acid content of all the types of pasta differed significantly from each other. An increase in ascorbic acid content was observed after supplementation with *ber* powder. A loss of 12 to 30 per cent was observed in ascorbic acid content after extrusion cooking by Lathrop and Leung (2006) and Chaudhary (2008). Negi (2003) and Chhabra (2006) prepared pasta using fruit powders and observed significant increase in ascorbic acid content as the supplementation was increased.

The  $\beta$ -carotene content was not detected in any type of prepared pasta (Table 4.42). This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is lost by oxidation and heat. Similar results for loss of  $\beta$ -carotene after heating and storage was observed by Emmanuel *et al.* (2005) and Anjum *et al.* (2008). Negi (2003) and Chhabra (2006) observed significant increase in  $\beta$ -carotene content of pasta using fruit powders.

The data presented in Table 4.43 indicated that the *in-vitro* protein digestibility of control, type I, II, III, IV and V pasta was 70.75, 71.14, 71.74, 72.11, 72.46 and 72.79 per cent, respectively. The *in-vitro* protein digestibility of all the types of pasta was found to be significantly different from each other being significantly higher in type V pasta and significantly lower in control pasta. An increase in the *in-vitro* protein digestibility of all the types of pasta was observed as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* protein digestibility of *ber* powder was higher than the refined wheat flour. Chhabra (2006) also reported significant increase in *in-vitro* protein digestibility of pasta after supplementation with bael powder.

The *in-vitro* starch digestibility of all the types of pasta ranged from 35.64 to 36.69 mg maltose released/g (Table 4.43). The *in-vitro* starch digestibility of type V pasta was significantly higher than control, type I, II, III and IV pasta. Significant differences were observed in the *in-vitro* starch digestibility of all the types of pasta. The *in-vitro* starch digestibility of all the types of pasta increased as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* starch digestibility of *ber* powder was higher than the refined wheat flour. Hence, *in-vitro* starch digestibility increased. Similar results of significant increase in *in-vitro* starch digestibility were observed by Negi (2003) and Chhabra (2006) in pasta prepared using fruit powders.

#### **5.7.6 Nutritional evaluation of noodles**

The moisture content of control, type I, II, III, IV and V noodles was 2.70, 2.91, 3.10, 3.35, 3.59 and 3.80 per cent, respectively (Table 4.44). Non-significant differences were observed in the moisture content of all the types of noodles prepared using *ber* powder and the control noodles. An increase in moisture content was observed as the supplementation increased. Similar results for non-significant increase in moisture content of noodles after fruit powder supplementation was observed by Negi (2003) and Chhabra (2006) while Ritthiruangdej *et al.* (2011) reported significant decrease in moisture content of noodles prepared using banana flour.

It was evident from the data in Table 4.44 that the crude protein content of noodles ranged from 7.97 to 9.33 g/100g. The crude protein content of type V noodles was significantly lower as compared to control noodles. Significant differences were observed in the crude protein content of all the types of noodles. A decreasing trend was observed in the crude protein content of all the types of noodles as the supplementation of *ber* powder increased. This might be due to the fact that the crude protein content of *ber* powder was less as compared to refined wheat flour. Hence, the crude protein content decreased when refined wheat flour was replaced by *ber* powder. Results obtained were in accordance with those reported by Ritthiruangdej *et al.* (2011) who reported significant loss of crude protein content of noodles prepared using banana flour while Negi (2003) and Chhabra (2006) found significant increase in protein content of noodles after fruit powders supplementation.

From the Table 4.44, it was revealed that the crude fat content of control, type I, II, III, IV and V noodles was 0.90, 0.91, 0.92, 0.93, 0.94 and 0.94 per cent, respectively. Non-significant differences were observed in the crude fat content of all the types of noodles. The crude fat content of all the types of noodles increased to a smaller extent as the supplementation with *ber* powder increased. This might be due to the fact that the fat content of *ber* powder was less but it was slightly more than refined wheat flour leading to increase in crude fat content. Non-significant increase in fat content of noodles prepared using fruit powders was also observed by Negi (2003) and Chhabra (2006) while significant increase in

fat content of noodles prepared using banan flour was observed by Ritthiruangdej *et al.* (2011).

The crude fiber content of noodles ranged from 0.38 per cent in control noodles to 2.01 per cent in type V noodles (Table 4.44). The crude fiber content of all the types of noodles was found to be significantly different from each other being significantly higher in type V noodles and significantly lower in control noodles. The crude fiber content of all the types of noodles increased as the supplementation with *ber* powder increased. This might be due to the fact that the fiber content of *ber* powder was more as compared to refined wheat flour. Hence, the crude fiber content increased. Negi (2003), Chhabra (2006) and Ritthiruangdej *et al.* (2011) also reported significant increase in crude fiber content was observed in noodles supplemented with fruit powders.

Data presented in Table 4.44 indicated that the ash content of control, type I, II, III, IV and V noodles was 0.60, 0.91, 1.22, 1.58, 1.88 and 2.19 per cent, respectively. The ash content of type V noodles was significantly higher followed by type IV, III, II, I and control noodles. The ash content of all the types of noodles was found to be significantly different from each other. The ash content of all the types of noodles increased as the supplementation with *ber* powder increased. This might be due to the fact that the mineral content of noodles increased after incorporation of *ber* powder leading to increase in ash content. Significant increase in ash content was observed by Negi (2003), Chhabra (2006) and Ritthiruangdej *et al.* (2011) in noodles prepared with fruit powders.

The total soluble sugars content of control, type I, II, III, IV and V noodles was 3.76, 5.27, 6.86, 8.43, 10.08 and 11.72 g/100g, respectively (Table 4.45). The total soluble sugars content of all the types of noodles was significantly different from each other. The total soluble sugars content of all the types of noodles increased as the supplementation with *ber* powder increased. This might be due to the fact that the total sugars content of *ber* powder was more than refined wheat flour leading to increase in total soluble sugars content. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in noodles prepared using fruit powders.

The data presented in Table 4.45 indicated that the reducing sugars content of all the prepared noodles ranged from 0.54 to 2.19 per cent. The reducing sugars content of all the types of noodles was observed to be significantly different from each other. The reducing sugars content of all the types of noodles increased with increasing supplementation of *ber* powder. The increase in reducing sugars content might be due to the fact that the reducing sugars content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in reducing sugars content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in noodles prepared using fruit powders.

The non-reducing sugars content of control, type I, II, III, IV and V noodles was 3.22, 4.42, 5.67, 6.90, 8.24 and 9.53 g/100g, respectively (Table 4.45). The non-reducing sugars content of type V noodles was significantly higher among all the types of noodles followed by type IV, III, II, I and control noodles. All the types of noodles were found to be significantly different from each other in terms of their non-reducing sugar content. An increase in non-reducing sugars content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the non-reducing sugars content of *ber* powder was more than refined wheat flour leading to increase in non-reducing sugars content of noodles. Significant increase in non-reducing sugars content was observed by Negi (2003) and Chhabra (2006) in noodles prepared with fruit powders.

It was evident from the data in Table 4.46 that the calcium content of control, type I, II, III, IV and V noodles was 22.19, 34.80, 47.43, 60.02, 72.64 and 85.26 mg/100g, respectively. The calcium content of type V noodles was significantly higher among all the noodles. The calcium content of all the types of noodles was found to be significantly different from each other. The calcium content of all the types of noodles increased as the supplementation with *ber* powder increased. This might be due to the fact that the calcium content of *ber* powder was more as compared to refined wheat flour. Hence, the calcium content increased. Significant increase in calcium content was observed by Negi (2003) and Chhabra (2006) in noodles prepared with fruit powders.

The data presented in Table 4.46 indicated that the iron content of all the types of noodles ranged from 2.16 to 9.20 mg/100g. The iron content of all the types of noodles was found to be significantly different from each other being significantly higher in type V noodles followed by type IV, III, II, I and control noodles. An increase in iron content was observed as the supplementation with *ber* powder increased. This might be due to the fact that the iron content of *ber* powder was more as compared to refined wheat flour. Hence, an increase in iron content was observed after replacing refined wheat flour with *ber* powder. Results obtained were in accordance with those evidenced by Negi (2003) and Chhabra (2006) in noodles prepared using fruit powders.

The magnesium content of control, type I, II, III, IV and V noodles was 46.12, 49.48, 52.76, 56.02, 59.31 and 62.62 mg/100g, respectively (Table 4.46). The magnesium content of type V noodles was significantly higher and the magnesium content of control noodles was significantly lower among all the types of noodles. The magnesium content of all the types of noodles was found to be significantly different from each other. The magnesium content of all the types of noodles increased as the supplementation with *ber* powder increased. This might be due to the fact that the magnesium content of *ber* powder was more as compared to refined wheat flour. Chhabra (2006) reported non-significant increase in the magnesium content of noodles prepared using bael powder.

From the Table 4.46, it was revealed that the zinc content of all the types of noodles ranged from 0.45 to 0.56 mg/100g. The zinc content of type V noodles was significantly higher than control, type I and II noodles. Non-significant differences were observed in the zinc content of every three consecutive noodles. The zinc content of all the types of noodles increased as the supplementation with *ber* powder increased. This might be due to the fact that the zinc content of *ber* powder was more as compared to refined wheat flour leading to increase in zinc content. Negi (2003) reported significant increase in zinc content of noodles prepared using fruit powders while Chhabra (2006) reported non-significant increase in zinc content of noodles prepared using 10 and 20 per cent bael powder.

The data presented in Table 4.47 indicated that the ascorbic acid content of all the types of noodles ranged from 3.26 to 18.21 mg/100g while it was not detected in the control noodles. The ascorbic acid content of all the types of noodles differed significantly from each other. The ascorbic acid content of type V noodles was significantly higher followed by type IV, III, II and I noodles. An increase in ascorbic acid content was observed after supplementation with *ber* powder. A loss of 12 to 30 per cent was observed in ascorbic acid content after extrusion cooking by Lathrop and Leung (2006) and Chaudhary (2008). Negi (2003) and Chhabra (2006) prepared noodles using fruit powders and observed significant increase in ascorbic acid content as the supplementation was increased.

The  $\beta$ -carotene content was not detected in any type of prepared noodles (Table 4.47). This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is lost by oxidation and heat. Similar results for loss of  $\beta$ -carotene after heating and storage was observed by Emmanuel *et al.* (2005) and Anjum *et al.* (2008). Negi (2003) and Chhabra (2006) observed significant increase in  $\beta$ -carotene content of noodles using fruit powders.

The data presented in Table 4.48 indicated that the *in-vitro* protein digestibility of control, type I, II, III, IV and V noodles was 71.00, 71.38, 71.74, 72.11, 72.46 and 72.79 per cent, respectively. The *in-vitro* protein digestibility of all the types of noodles was found to be significantly different from each other being significantly higher in type V noodles and significantly lower in control noodles. An increase in the *in-vitro* protein digestibility of all the types of noodles was observed as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* protein digestibility of *ber* powder was higher than the refined wheat flour. Chhabra (2006) also reported significant increase in *in-vitro* protein digestibility of noodles after supplementation with bael powder.

The *in-vitro* starch digestibility of all types of noodles ranged from 35.92 to 36.96 mg maltose released/g (Table 4.48). The *in-vitro* starch digestibility of type V noodles was significantly higher than control, type I, II, III and IV noodles. Significant differences were observed in the *in-vitro* starch digestibility of all the types of noodles. The *in-vitro* starch

digestibility of all the types of noodles increased as the supplementation with *ber* powder increased. This may be due to the fact that the *in-vitro* starch digestibility of *ber* powder was higher than the refined wheat flour. Hence, *in-vitro* starch digestibility increased. Similar results of significant increase in *in-vitro* starch digestibility were observed by Negi (2003) and Chhabra (2006) in noodles prepared using fruit powders.

#### **5.7.7 Nutritional evaluation of RTS beverage**

The moisture content of all the types of RTS beverage ranged from 75.48 to 92.13 g/100ml (Table 4.49). The moisture content of all the types of RTS beverage was found to be significantly different from each other. A decreasing trend was observed in the moisture content of all the types of RTS beverage as the supplementation of *ber* powder increased. This might be due to the fact that the solid matter of powder replaces the liquid matter in total volume leading to decrease in moisture content.

It was evident from the data in Table 4.49 that the crude protein content of type I, II, III and IV RTS beverage was 0.69, 1.34, 1.93 and 2.51 g/100ml, respectively. The crude protein content of type IV RTS beverage was significantly higher followed by type III, II and I RTS beverage. The crude protein content of all the types of RTS beverage was found to be significantly different from each other. An increase in crude protein content was observed as the supplementation of *ber* powder increased.

From the Table 4.49, it was revealed that the crude fat content of all the types of RTS beverage ranged from 0.09 to 0.31 g/100ml. The crude fat content of type IV RTS beverage was significantly higher among all the types of RTS beverage. The crude fat content of all the types of RTS beverage was observed to be significantly different from each other. The crude fat content of all the types of RTS beverage increased to a smaller extent as the supplementation with *ber* powder increased.

The crude fiber content of type I, II, III and IV RTS beverage was 0.34, 0.60, 0.85 and 1.09 g/100ml, respectively (Table 4.49). The crude fiber content of all the types of RTS beverage was observed to be significantly different from each other. The crude fiber content of all the types of RTS beverage increased as the supplementation with *ber* powder increased.

Data presented in Table 4.49 indicated that the ash content of all the types of RTS beverage ranged from 0.39 to 1.48 g/100ml. Significant differences were observed in the ash content of all the types of RTS beverage. The ash content of type IV RTS beverage was significantly higher and type I RTS beverage was significantly lower among all the types of RTS beverage prepared. The ash content of all the types of RTS beverage increased as the supplementation with *ber* powder increased.

The total soluble sugars content of all the types of RTS beverage ranged from 18.70 to 23.64 g/100 ml (Table 4.50). The total soluble sugars content of all the types of RTS beverage was found to be significantly different from each other. The total soluble sugars

content of type IV RTS beverage was significantly higher followed by type III, II and I RTS beverage. The total soluble sugars content of all the types of RTS beverage increased as the supplementation with *ber* powder increased. Kumar (2006) also reported increase in total sugars content of RTS prepared with different concentrations of *ber* powder.

The data presented in Table 4.50 indicated that the reducing sugars content of type I, II, III and IV RTS beverage was 7.19, 7.54, 7.91 and 8.25 g/100 ml, respectively. The reducing sugars content of all the types of RTS beverage was found to be significantly different from each other. The reducing sugars content of all the types of RTS beverage increased with increasing supplementation of *ber* powder. Kumar (2006) also reported increase in reducing sugars content of RTS prepared with different concentrations of *ber* powder.

The non-reducing sugars content of all the types of RTS beverage varied from 11.51 to 15.39 g/100ml (Table 4.50). The non-reducing sugars content of type IV RTS beverage was observed to be significantly higher followed by type III, II and I RTS beverage. Significant differences were observed in the non-reducing sugars content of all the types of RTS beverage. An increase in non-reducing sugars content was observed as the supplementation with *ber* powder increased. Kumar (2006) also reported increase in non-reducing sugars content of RTS prepared with different concentrations of *ber* powder.

It was evident from the data in Table 4.51 that the calcium content of type I, II, III and IV RTS beverage was 14.26, 29.23, 44.34 and 58.68 mg/100ml. The calcium content of type IV RTS beverage was significantly higher among all the types of RTS beverage. Significant differences were observed in the calcium content of all the types of RTS beverage. The calcium content of all the types of RTS beverage increased as the supplementation with *ber* powder increased.

The data presented in Table 4.51 indicated that the iron content of RTS beverage varied from 1.27 mg/100ml in type I RTS beverage to 6.32 mg/100ml in type IV RTS beverage. The iron content of all the types of RTS beverage was found to be significantly different from each other being significantly higher in type IV RTS beverage and significantly lower in type I RTS beverage. An increase in iron content was observed as the supplementation with *ber* powder increased.

The magnesium content of all the types of RTS beverage ranged from 7.97 to 33.86 mg/100ml (Table 4.51). The magnesium content of type IV RTS beverage was significantly higher among all the types of RTS beverage followed by type III, II and I RTS beverage. Significant differences were observed in the magnesium content of all the types of RTS beverage. The magnesium content of all the types of RTS beverage increased as the supplementation with *ber* powder increased

From the Table 4.51, it was revealed that the zinc content of all the types of RTS beverage ranged from 0.08 to 0.31 mg/100ml. The zinc content of all the types of RTS beverage was significantly different from each other being significantly higher in type IV RTS beverage. The zinc content of all the types of RTS beverage increased as the supplementation with *ber* powder increased.

The data presented in Table 4.52 indicated that the ascorbic acid content of type I, II, III and IV RTS beverage was 3.42, 7.25, 11.17 and 16.13 mg/100ml. The ascorbic acid content of type IV RTS beverage was found to be significantly higher followed by type III, II and I RTS beverage. The ascorbic acid content of all the types of RTS beverage was found to be significantly different from each other. An increase in ascorbic acid content was observed after supplementation with *ber* powder.

The  $\beta$ -carotene content was not detected in any type of prepared RTS beverage (Table 4.52). This might be due to the less amount of  $\beta$ -carotene in *ber* powder and also due to the fact that  $\beta$ -carotene is lost by oxidation and heat. Similar results for loss of  $\beta$ -carotene after heating and storage was observed by Emmanuel *et al.* (2005) and Anjum *et al.* (2008).

The data presented in Table 4.53 indicated that the *in-vitro* protein digestibility of all the types of RTS beverage ranged from 76.87 to 78.60 per cent. The *in-vitro* protein digestibility of type IV RTS beverage was significantly higher and that of type I RTS beverage was significantly lower among all the types of RTS beverage. The *in-vitro* protein digestibility of all the types of RTS beverage was found to be significantly different from each other. An increase in the *in-vitro* protein digestibility of all the types of RTS beverage was observed as the supplementation with *ber* powder increased.

The *in-vitro* starch digestibility of all the types of RTS beverage ranged from 39.61 to 40.71 mg maltose released/ml (Table 4.53). The *in-vitro* starch digestibility of type IV RTS beverage was significantly higher than type I, II and III RTS beverage. Significant differences were observed in the *in-vitro* starch digestibility of all the types of RTS beverage. The *in-vitro* starch digestibility of all the types of RTS beverage increased as the supplementation with *ber* powder increased.

## **5.8 Shelf-life of products**

The products which were suitable for storage were stored at room temperature in air tight food grade plastic containers. They were evaluated for sensory parameters, by a panel of 10 judges using 9 point hedonic scale, at an interval of 15 days for 2 months. The products kept for storage were biscuits, pasta, noodles and RTS beverage.

### **5.8.1 Shelf-life of biscuits**

Mean scores indicated that the colour of all the types of biscuits fell in the category of 'liked moderately' throughout their storage period (Table 4.54). A gradual decrease in acceptability of colour was observed during storage. Non-significant differences were

observed among the all the biscuit types for their colour while significant differences were observed for colour during storage.

It was evident from the Table 4.55 that the appearance of all the types of biscuits was rated as 'liked moderately' by the panel of judges during their storage. Though the mean scores of biscuits were slightly higher in the beginning of storage and started declining thereof. Non-significant differences were observed among the all the biscuit types for their appearance while significant differences were observed for appearance during storage.

Table 4.56 indicated that the mean scores of aroma of control, type I, II and III biscuits were rated as 'liked moderately' during the storage. The aroma of type IV and V biscuits was rated as 'liked moderately' till one month of storage and thereafter they were rated as 'liked slightly' till the end of storage period. Significant differences were observed for aroma of all the biscuits during their storage.

The data presented in Table 4.57 that the mean scores of the texture indicated that the acceptability of texture of control, type I, II and III biscuits fell in the category of 'liked moderately' during the storage period. The texture of type IV and V biscuits was rated as 'liked moderately' till 30<sup>th</sup> day of storage and they were rated as 'liked slightly' at 45<sup>th</sup> and 60<sup>th</sup> day of storage. Significant differences were observed for the texture among all the biscuits during storage.

The mean scores of taste indicated that control, type I, II and III were rated as 'liked moderately' during the storage period (Table 4.58). The taste of type IV biscuits was 'liked moderately till 45<sup>th</sup> day of storage while the taste of type V biscuits was 'liked moderately' till one month of storage and were 'liked slightly' thereafter. Significant differences were observed for taste among all the biscuits during storage.

The data presented in Table 4.59 revealed that the mean scores of overall acceptability of biscuits indicated that the acceptability of control, type I, II and III fell in the category of 'liked moderately during their storage period. The overall acceptability of type IV biscuits was rated as 'liked moderately' till 45<sup>th</sup> day of storage while that of type V biscuits was rated as 'liked moderately' till one month of storage. Significant differences were observed for the overall acceptability among all the biscuits during storage.

It was inferred from the data that all the types of biscuits were acceptable during storage. The acceptability of biscuits prepared using 10, 20 and 30 per cent *ber* powder was higher than the others during the storage period. Negi (2003) prepared biscuits using papaya, guava and pear powders and observed that the acceptability of biscuits was rated as 'liked moderately' during one month of storage. Chhabra (2006) also prepared biscuits using bael powder and stored them for 2 months. She reported that the biscuits and found that the biscuits were highly acceptable till 45 days of storage. Nehra (2011) also prepared biscuits

using aonla and guava powders and recorded them to be acceptable after a storage period of 3 months.

### **5.8.2 Shelf-life of pasta**

Mean scores indicated that the colour of control, type I, II and III pasta fell in the category of 'liked moderately' during the storage period (Table 4.60). The colour of type IV and V pasta was rated as 'liked moderately till 45<sup>th</sup> day of storage and was rated as 'liked slightly' thereafter. Significant differences were observed for the colour among all the types of pasta during storage.

It data presented in Table 4.61 indicated that the appearance of control, type I, II and III pasta fell in the category of 'liked moderately' during their storage. The acceptability of appearance of type IV and V pasta was rated as 'liked moderately till one month of storage and was rated as 'liked slightly' after that. Significant differences were observed for the appearance among all the types of pasta during storage.

Mean scores of the aroma indicated that control, type I and II pasta were rated as 'liked moderately' during their storage (Table 4.62). The aroma of type IV pasta was rated as 'liked moderately' in the beginning of storage, was rated as 'liked slightly' at 15<sup>th</sup>, 30<sup>th</sup> and 45<sup>th</sup> day of storage and was rated as 'neither liked nor disliked' at the end of storage period. The aroma of type V pasta was rated as 'liked slightly' till 45<sup>th</sup> day of storage and after that it was rated as 'neither liked nor disliked'. Significant differences were observed for the aroma among all the types of pasta during storage.

From the Table 4.63, it was revealed that the texture of control, type I and II pasta was rated as 'liked moderately' during their storage. The texture of type III pasta was rated as 'liked moderately' till 30<sup>th</sup> day of storage and was rated as 'liked slightly' after that. The texture of type IV and V pasta was rated as 'liked slightly' during their storage. Significant differences were observed for the texture among all the types of pasta during storage.

The data in Table 4.64 revealed that the mean scores of taste of control, type I and II pasta fell in the category of 'liked moderately' during their storage. The taste of type III pasta was rated as 'liked moderately' at the beginning of storage and was rated as 'liked slightly' at 15<sup>th</sup> day till the end of storage period. The taste of type IV and V pasta was rated as 'liked slightly' since the beginning of storage till 45<sup>th</sup> day and after that they were rated as 'neither liked nor disliked' for their taste. Significant differences were observed for the taste among all the types of pasta during storage.

The data depicted in Table 4.65 revealed that the overall acceptability of control, type I and II pasta was rated as 'liked moderately' during their storage period. The overall acceptability of type III pasta was rated as 'liked moderately' till one month of storage and after that it was rated as 'liked slightly'. The overall acceptability of type IV and V pasta was rated as 'liked moderately' in the beginning of storage period but after that it was rated as

'liked slightly' till the end of storage. Significant differences were observed for the overall acceptability among all the types of pasta during storage.

It was inferred from the data that all the types of pasta were acceptable during storage. The acceptability of pasta prepared using 10 and 20 per cent *ber* powder was higher than the others during the storage period. Negi (2003) stored Ready-To-Eat Extruded products prepared using papaya, guava and pear powders for one month and found them highly acceptable.

### **5.8.3 Shelf-life of noodles**

Mean scores of indicated that the colour control, type I, II and III noodles fell in the category of 'liked moderately' during the storage period (Table 4.66). The colour of type IV and V noodles was rated as 'liked moderately till 45<sup>th</sup> day of storage and was rated as 'liked slightly' thereafter. Significant differences were observed for the colour among all the types of noodles during storage.

The data presented in Table 4.67 revealed that the appearance of control, type I, II and III noodles fell in the category of 'liked moderately' during their storage. The acceptability of appearance of type IV and V noodles was rated as 'liked moderately till one month of storage and was rated as 'liked slightly' after that. Significant differences were observed for the appearance among all the types of noodles during storage.

It was revealed from the data presented in Table 4.68 that the aroma of control, type I and II noodles were rated as 'liked moderately' during their storage. The aroma of type IV noodles was rated as 'liked moderately' in the beginning of storage, was rated as 'liked slightly' at 15<sup>th</sup>, 30<sup>th</sup> and 45<sup>th</sup> day of storage and was rated as 'neither liked nor disliked' at the end of storage period. The aroma of type V noodles was rated as 'liked slightly' till 45<sup>th</sup> day of storage and after that it was rated as 'neither liked nor disliked'. Significant differences were observed for the aroma among all the types of noodles during storage.

The texture of control, type I and II noodles was rated as 'liked moderately' during their storage (Table 4.69). The texture of type III noodles was rated as 'liked moderately' till 30<sup>th</sup> day of storage and was rated as 'liked slightly' after that. The texture of type IV and V noodles was rated as 'liked slightly' during their storage period. Significant differences were observed for the texture among all the types of noodles during storage.

From the data presented in Table 4.70, it was revealed that the mean scores of taste of control, type I and II noodles fell in the category of 'liked moderately' during their storage (Table 4.70). The taste of type III noodles was rated as 'liked moderately' at the beginning of storage and was rated as 'liked slightly' at 15<sup>th</sup> day till the end of storage period. The taste of type IV and V noodles was rated as 'liked slightly' since the beginning of storage till 45<sup>th</sup> day and after that they were rated as 'neither liked nor disliked' for their taste. Significant differences were observed for the taste among all the types of noodles during storage.

The data depicted in Table 4.71 revealed that the overall acceptability of control, type I and II noodles was rated as 'liked moderately' during their storage period (Table 4.71). The overall acceptability of type III noodles was rated as 'liked moderately' till one month of storage and after that it was rated as 'liked slightly'. The overall acceptability of type IV and V noodles was rated as 'liked moderately' in the beginning of storage period but after that it was rated as 'liked slightly' till the end of storage. Significant differences were observed for the overall acceptability among all the types of noodles during storage.

It was inferred from the data that all the types of noodles were acceptable during storage. The acceptability of noodles prepared using 10 and 20 per cent *ber* powder was higher than the others during the storage period. Negi (2003) stored Ready-To-Eat Extruded products prepared using papaya, guava and pear powders for one month and found them highly acceptable.

#### **5.8.4 Shelf-life of RTS beverage**

Mean scores indicated that the colour of all the types of RTS beverage was rated as 'liked moderately' during the storage period (Table 4.72). Non-significant differences were observed among the all the types of RTS beverage for their colour while significant differences were observed for colour during storage.

It was revealed from the Table 4.73 that the appearance of type I and II RTS beverage fell in the category of 'liked moderately' during their storage. The acceptability of appearance of type III RTS beverage was rated as 'liked moderately till one month of storage and was rated as 'liked slightly' after that. The appearance of type III RTS beverage was rated as 'liked slightly' during the storage period. Significant differences were observed for the appearance among all the types of RTS beverage during storage

The data presented in Table 4.74 indicated that the mean scores of the aroma of type I and II RTS beverage were rated as 'liked moderately' during their storage. The aroma of type III RTS beverage was rated as 'liked moderately' till one month of storage and was rated as 'liked slightly' after that. The aroma of type IV RTS beverage was rated as 'liked slightly' till 30<sup>th</sup> day of storage and after that it was rated as 'neither liked nor disliked'. Significant differences were observed for the aroma among all the types of RTS beverage during storage.

From the Table 4.75, it was revealed that the texture of type I and II RTS beverage was rated as 'liked moderately' during their storage. The texture of type III RTS beverage was rated as 'liked slightly' till 30<sup>th</sup> day of storage and was rated as 'neither liked nor disliked' after that. The texture of type IV RTS beverage was rated as 'neither liked nor disliked' during their storage period. Significant differences were observed for the texture among all the types of RTS beverage during storage.

Mean scores of taste of RTS beverage indicated that the type I and II RTS beverage fell in the category of 'liked moderately' during their storage (Table 4.76). The taste of type

III RTS beverage was rated as 'liked slightly' till one month of storage period and was rated as 'neither liked nor disliked' after that. The taste of type IV RTS beverage was rated as 'neither liked nor disliked' during the storage period. Significant differences were observed for the taste among all the types of RTS beverage during storage.

The data presented in Table 4.77 indicated that the overall acceptability of type I and II RTS beverage was rated as 'liked moderately' during their storage period (Table 4.77). The overall acceptability of type III RTS beverage was rated as 'liked moderately' in the beginning of storage and was rated as 'liked slightly' after that till the end of storage period. The overall acceptability of type IV RTS beverage was rated as 'liked slightly' till one month of storage and after that it was rated as 'neither liked nor disliked' till the end of storage. Significant differences were observed for the overall acceptability among all the types of RTS beverage during storage.

It was inferred from the data that all the types of RTS beverage were acceptable during storage except the RTS beverage prepared using 40 per cent *ber* powder. The acceptability of RTS prepared using 10 and 20 per cent *ber* powder was higher than the others during the storage period. Kumar (2006) prepared RTS using *ber* powder and found it acceptable after 3 months of storage. Kumar and Manimegalai (2005) found higher acceptability of RTS prepared using 10 per cent papaya pulp with whey during 3 months of storage. Nilguin and Mahendran (2010) reported that RTS prepared using palmyrah fruit pulp in different concentration could be stored safely for 6 months. Jakhar and Pathak (2012) reported that RTS prepared using different blends of *jamun* and *ber* pulp could be stored safely up to 5 months.

The present investigation was carried out to develop powders from three varieties of *ber* namely Gola, Kaithali and Umran, to study sensory, physico-chemical, nutritional and shelf-life properties of powder, to utilize the developed powder for the development of value-added products and study their nutritional, sensory and shelf-life properties. The powder was prepared by blanching *ber* fruits for 2-3 minutes followed by deseeding, grinding to pulp and addition of potassium metabisulphite at the concentration of 1000 ppm. After that, pulp was lyophilized and then ground to powder. The developed powder was evaluated for sensory parameters using 9-point hedonic scale by a panel of 10 judges. Results indicated that the overall acceptability of powder of Umran variety was rated as 'liked very much' while the other powders fell in the category of 'liked moderately'.

The acidity, total soluble sugars/acid ratio and browning content of powders ranged from 2.09 to 2.19 per cent, 8.82 to 9.66 and 0.08 to 0.09, respectively. All the powders were kept for storage and were analyzed for sensory parameters after every 15 days for 2 months. Results of sensory evaluation of stored powders indicated that the colour, appearance, aroma, texture, taste and overall acceptability of all the powders were rated as 'liked moderately' at the end of storage period though significant differences were observed during storage. Non-significant differences were observed for varieties when compared to each other during storage.

The moisture, crude protein, crude fat, crude fiber and ash content of *ber* powders varied from 5.21 to 5.68, 6.92 to 7.83, 0.99 to 1.07, 3.52 to 3.91 and 4.27 to 4.49 per cent, respectively. The total soluble sugars, reducing sugars and non-reducing sugars content of powders ranged from 19.08 to 20.17, 3.61 to 3.98 and 15.47 to 16.19 per cent, respectively. The calcium, iron, magnesium and zinc content of all the powders varied from 148.56 to 153.63, 17.87 to 18.65, 84.43 to 90.33 and 0.91 to 0.98 mg/100g, respectively. The ascorbic acid content of powders prepared from Gola, Kaithali and Umran varieties was 46.77, 47.20 and 48.23 mg/100g, respectively, while their  $\beta$ -carotene content ranged from 2.38 to 2.94 mg/100g. The *in-vitro* protein digestibility of powders ranged from 76.53 to 78.53 per cent and their *in-vitro* starch digestibility of powders ranged from 40.13 to 41.80 mg maltose released/ g powder.

Non-significant differences were observed for total soluble sugars/acid ratio, browning, moisture, ash, reducing sugars, magnesium and zinc content of powders while the crude protein, crude fat, crude fiber, iron, ascorbic acid and *in-vitro* starch digestibility of powder of Umran variety was significantly higher than the other powders.

Powder of Umran variety of *ber* was used for the development of value-added products based on its sensory evaluation and better nutritional content. The products were

developed under four categories which included traditional (custard and *kheer*), baked (biscuits and cake), extruded (pasta and noodles) and unfermented beverage (RTS beverage). Different concentrations of *ber* powders were used for the development of products i.e. 10, 20, 30, 40 and 50 per cent except in RTS beverage where up to 40 per cent supplementation was done. The products were studied for sensory evaluation by a panel of 10 judges using 9 point hedonic scale and were also analyzed for various nutrient contents.

The overall acceptability of type I custard fell in the category of 'liked very much' while control, type II and type III custard were in 'liked moderately' category. The overall acceptability of type IV and V custard was rated as 'liked slightly'. The overall acceptability of control and type I *kheer* was rated as 'liked very much', type II and type III *kheer* was rated as 'liked moderately' and type IV and V *kheer* was rated as 'liked slightly'. The overall acceptability of all the types of biscuits fell in the category of 'liked moderately'. The overall acceptability of control and type I cake was rated as 'liked very much' while the other types of cake were rated as 'liked moderately'. The overall acceptability of all the types of pasta and noodles fell in the category of 'liked moderately'. The overall acceptability of type I, type II and type III RTS beverage fell in the category of 'liked moderately' while type IV fell in the category of 'liked slightly'. All the baked products showed good organoleptic acceptability. The traditional products and extruded products were best acceptable up to 30 per cent supplementation and RTS beverage up to 20 per cent supplementation with *ber* powder.

The moisture, crude protein, crude fat, crude fiber and ash content of all the types of custard ranged from 76.53 to 77.00, 4.08 to 4.77, 5.85 to 5.88, 0.13 to 0.45 and 0.90 to 1.29 per cent, respectively, while their total soluble sugars, reducing sugars and non-reducing sugars content ranged from 20.17 to 21.77, 0.74 to 1.09 and 19.43 to 20.68 g/100g, respectively. The calcium, iron and magnesium content of all the types of custard varied from 217.88 to 231.52, 0.25 to 1.58 and 42.80 to 43.56 mg/100g, respectively. The zinc, ascorbic acid and  $\beta$ -carotene content were not detected in any of the custard types. The *in-vitro* digestibilities of protein and starch of all types of custard ranged from 85.49 to 87.09 per cent and 55.93 to 56.99 mg maltose released/g powder, respectively. An increase in all the nutrients was observed with the increase in supplementation level. Non-significant differences were observed for moisture, crude fat, ash, total soluble sugars and non-reducing sugars content among the custard types while significant differences were observed for other nutrients.

All the types of *kheer* were observed to have 70.49 to 71.51 per cent moisture, 7.00 to 7.52 per cent crude protein, 7.23 to 7.26 per cent crude fat, 0.21 to 0.77 per cent crude fiber and 3.72 to 4.43 per cent ash, 22.58 to 25.67 per cent total soluble sugars, 0.70 to 1.27 per cent reducing sugars, 21.88 to 24.40 per cent non-reducing sugars, 228.61 to 251.05 mg/100g calcium, 1.02 to 3.86 mg/100g iron and 57.21 to 61.73 mg/100g magnesium. The zinc, ascorbic acid and  $\beta$ -carotene content were not detected in any of the *kheer* types. The *in-vitro*

digestibilities of protein and starch of all the types of *kheer* varied from 86.19 to 87.76 per cent and 56.29 to 57.33 mg maltose released/g *kheer*, respectively. All the nutrients increased as the supplementation increased. Non-significant differences were observed for moisture, crude fat and ash content of the *kheer* types while significant differences were observed for other nutrients.

The content of moisture, crude protein, crude fat, crude fiber and ash in all the types of biscuits ranged from 2.86 to 4.52, 7.39 to 8.75, 23.31 to 23.35, 1.58 to 3.23 and 0.78 to 2.38 per cent, respectively, while their total soluble sugars, reducing sugars and non-reducing sugars content ranged from 13.57 to 22.80, 0.54 to 2.40 and 13.03 to 20.40 per cent, respectively. The calcium, iron, magnesium and zinc content of biscuits varied from 89.66 to 152.14, 3.53 to 10.65, 43.77 to 60.20 and 0.79 to 0.92 mg/100g, respectively. The ascorbic acid content of biscuits ranged from 2.39 to 16.35 mg/100g while it was not detected in the control biscuits. The  $\beta$ -carotene content was not detected in any type of prepared biscuits. The *in-vitro* protein and starch digestibilities of all the types of biscuits ranged from 73.23 to 74.78 per cent and 37.49 to 38.36 mg maltose released/g, respectively. An increase in all the nutrients was observed with the increase in supplementation level except for the crude protein content. Non-significant differences were observed for moisture and crude fat content of the biscuit types while significant differences were observed for other nutrients.

The moisture, crude protein, crude fat, crude fiber and ash content of all the types of cake ranged from 22.81 to 24.48, 12.58 to 11.47, 9.53 to 9.57, 0.91 to 2.09 and 1.10 to 2.68 per cent, respectively. The total soluble sugars, reducing sugars and non-reducing sugars varied from 32.66 to 40.26, 0.44 to 1.93 and 33.22 to 38.33 per cent, respectively. The calcium, iron, magnesium and zinc content of cake varied from 92.49 to 141.94, 4.40 to 9.89, 51.60 to 64.71 and 0.55 to 0.67 mg/100g, respectively. The ascorbic acid content of all the cake ranged from 3.49 to 17.24 mg/100g while it was not detected in the control cake. The  $\beta$ -carotene content was not detected in any of the cake. The *in-vitro* protein and starch digestibilities of cake ranged from 84.44 to 85.93 per cent and 48.11 to 49.14 mg maltose released/g, respectively. All the nutrients increased as the supplementation increased except for the protein content. Non-significant differences were observed for moisture and crude fat content of the cake while significant differences were observed for other nutrients

All the types of pasta were observed to have 2.74 to 3.81 per cent moisture, 7.90 to 9.25 per cent crude protein, 0.91 to 0.95 per cent crude fat, 0.33 to 1.99 per cent crude fiber, 0.63 to 2.26 per cent ash, 3.90 to 11.75 per cent total soluble sugars, 0.63 to 2.26 per cent reducing sugars, 3.27 to 9.49 per cent non-reducing sugars, 21.42 to 84.51 mg/100g calcium, 2.73 to 9.76 mg/100g iron, 46.35 to 62.69 mg/100g magnesium, 0.43 to 0.55 mg/100g zinc and 3.31 to 18.19 mg/100g ascorbic acid. The ascorbic acid was not detected in the control pasta. The  $\beta$ -carotene content was not detected in all the types of pasta. The *in-vitro* protein and starch digestibilities of pasta ranged from 70.75 to 72.79 per cent and 35.64 to 36.69 mg maltose released/g, respectively. An increase in all the nutrients was observed with the

increase in supplementation level except for the crude protein content. Non-significant differences were observed for moisture and crude fat content of the cake while significant differences were observed for other nutrients.

The moisture, crude protein, crude fat, crude fiber and ash content of noodles ranged from 2.70 to 3.80, 7.97 to 9.33, 0.90 to 0.94 per cent, 0.38 to 2.01 and 0.60 to 2.19 per cent, respectively. The total soluble sugars, reducing sugars and non-reducing sugars content ranged from 3.76 to 11.72, 0.54 to 2.19 and 3.22 to 9.53 g/100g, respectively. The calcium, iron, magnesium and zinc content of noodles varied from 22.19 to 85.26, 2.16 to 9.20, 46.12 to 62.62 and 0.45 to 0.56 mg/100g, respectively. The ascorbic acid content of noodles ranged from 3.26 to 18.21 mg/100g while it was not detected in the control noodles. The  $\beta$ -carotene content was not detected in all the types of noodles. The *in-vitro* protein and starch digestibilities of noodles ranged from 71.00 to 72.79 per cent, and 35.92 to 36.96 mg maltose released/g, respectively. All the nutrients increased as the supplementation increased except for the protein content. Non-significant differences were observed for moisture and crude fat content of the cake while significant differences were observed for other nutrients.

The content of moisture, crude protein, crude fat, crude fiber and ash in all the types of RTS beverage varied from 75.48 to 92.13, 0.69 to 2.51, 0.09 to 0.31, 0.34 to 1.09 and 0.39 to 1.48 g/100ml, respectively. The total soluble sugars, reducing sugars and non-reducing sugars content varied from 18.70 to 23.64, 7.19 to 8.25 and 11.51 to 15.39 g/100ml, respectively. The calcium, iron, magnesium and zinc content of RTS beverage ranged from 14.26 to 58.68, 1.27 to 6.32, 7.97 to 33.86 and 0.08 to 0.31 mg/100ml, respectively. The ascorbic acid content ranged from 3.42 to 16.13 mg/100ml. The  $\beta$ -carotene content was not detected in any of the RTS beverage. The *in-vitro* protein and starch digestibility of RTS beverage varied from 76.87 to 78.60 per cent and 39.61 to 40.71 mg maltose released/ml, respectively. An increase in all the nutrients was observed with the increase in supplementation level. Significant differences were observed in all the nutrients among all types of the RTS beverage.

The products suitable for storage were stored for two months and analyzed for sensory parameters at every 15 day interval. It was observed from the mean scores of overall acceptability of the biscuits that all the biscuits were in 'liked moderately' category during storage except type IV and type V biscuits which fell in the category of 'liked slightly' at 60<sup>th</sup> and 45<sup>th</sup> day of storage, respectively. The overall acceptability of control, type I and II of both extruded products was rated as 'liked moderately' during storage. The acceptability of type IV and type V extruded products was rated as 'liked slightly' at 15<sup>th</sup> day of storage while type III extruded products were 'liked slightly' after one month of storage. The overall acceptability of type I and type II RTS beverage was rated as 'liked moderately' during storage period. Type III RTS beverage was rated as 'liked slightly' at 15<sup>th</sup> to the end of storage period. Type IV RTS beverage was rated as 'liked slightly' up to one month of storage and after that it was

rated as 'neither liked nor disliked' up to 60<sup>th</sup> day of storage. Significant differences were observed for all the sensory characteristics of all the products during storage.

### **Conclusion**

From the present study, it may be concluded that low cost, easily available, low input requiring and high yielding fruits i.e. *ber* can be formed into powder. The *ber* powder could be stored safely for two months. Powder of Umran variety was found to be nutritionally and organoleptically superior to other powders. The fruit powder can be incorporated in the preparation of food products for development of value added products. All the products prepared using powder of Umran variety were organoleptically acceptable. The nutritional content of all the supplemented products increased with increase in supplementation except the protein content of baked and extruded products. All the products were organoleptically acceptable till the end of storage period except RTS beverage prepared with 40 per cent *ber* powder. Biscuits prepared with 10, 20 and 30 per cent and pasta, noodles and RTS beverage prepared with 10 and 20 per cent *ber* powder were best acceptable among all during storage.

Processing of fruits to powder can decrease seasonal losses and increase their utilization for value addition in various products. Processing also enhances its palatability and availability throughout the year. Consumption of such products can ameliorate the micronutrient deficiencies prevalent among vulnerable section of the society. In addition, these may also provide extra fiber and nutraceuticals to the affluent section of the society. The present study welcomes a scope for the commercialization of various developed products. It further provides a platform for diversifying the use of powders for other value added products. Sincere efforts can be made to popularize the development of powders and their use in formulating value-added products. This also would help to enhance the country's economy and avoid wastage of produce which can be utilized in a better way after processing. It would not only add to the income of growers but also fortify the diet of the masses.

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**ANNEXURE –I**

**HEDONIC RATING SCALE**

Name \_\_\_\_\_

Dated \_\_\_\_\_

Product \_\_\_\_\_

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

<b>Sr No.</b>	<b>Colour</b>	<b>Appearance</b>	<b>Aroma</b>	<b>Texture</b>	<b>Taste</b>	<b>Overall acceptability</b>	<b>Total remarks</b>

**Rate**

**Organoleptic score**

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

## ABSTRACT

1. Title of the thesis : **Nutritional evaluation and utilization of *ber* (*Ziziphus Mauritiana* Lamk.) powder for the development of value added products.**
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9. Total Number of pages in thesis : 142 + vi + I
10. Number of words in the abstract : 507

**Keyword:** *Ber* powder, nutritional evaluation, sensory evaluation, traditional products, baked products, extruded products, unfermented beverage, shelf-life

The present investigation was carried out to develop powders from three varieties of *ber* namely Gola, Kaithali and Umran, to study sensory, physico-chemical, nutritional and shelf-life properties of powder, to utilize the prepared powder for the development of value-added products and study their nutritional, sensory and shelf-life properties. The acidity, total soluble sugars/acid ratio and browning of powders ranged from 2.09 to 2.19 per cent, 8.82 to 9.66 and 0.08 to 0.09, respectively. The moisture, crude protein, crude fat, crude fiber and ash content of *ber* powders varied from 5.21 to 5.68, 6.92 to 7.83, 0.99 to 1.07, 3.52 to 3.91 and 4.27 to 4.49 per cent, respectively. The total soluble sugars, reducing sugars and non-reducing sugars content of powders ranged from 19.08 to 20.17, 3.61 to 3.98 and 15.47 to 16.19 per cent, respectively. The calcium, iron, magnesium and zinc content of powders varied from 148.56 to 153.63, 17.87 to 18.65, 84.43 to 90.33 and 0.91 to 0.98 mg/100g, respectively. The ascorbic acid and  $\beta$ -carotene content of powders varied from 46.77 to 48.23 and 2.38 to 2.94 mg/100g, respectively. The *in-vitro* protein and starch digestibility of powders ranged from 76.53 to 78.53 per cent and 40.13 to 41.80 mg maltose released/ g powder, respectively. Significant differences were observed for acidity, total soluble sugars/acid ratio, crude protein, crude fat, crude fiber, total soluble sugars, non-reducing sugars, calcium, iron, ascorbic acid,  $\beta$ -carotene and *in-vitro* protein and starch digestibility. All the powders were studied for shelf-life for two months and were found to be organoleptically acceptable during storage. Powder of Umran variety of *ber* was used for the development of value-added products based on its sensory evaluation, high total soluble sugars/acid ratio, high protein content, high carbohydrate content, high mineral content like calcium, iron and magnesium, high ascorbic acid content, high *in-vitro* protein and starch digestibility. The products were developed under four categories which included traditional (custard and *kheer*), baked (biscuits and cake), extruded (pasta and noodles) and unfermented beverage (RTS beverage). The products were developed using 10, 20, 30, 40 and 50 per cent *ber* powder except in RTS beverage where supplementation level was up to 40 per cent only. All the products were organoleptically acceptable. All the baked products had good acceptability scores. The traditional products and extruded products were best acceptable up to 30 per cent supplementation while and unfermented beverage up to 20 per cent supplementation with *ber* powder. All the developed products were nutritionally analyzed. Results of nutritional analysis indicated that all the nutrients content increased as the supplementation level of powder increased except the protein content of baked and extruded products. Significant differences in various nutrients content were observed after increased supplementation. The products like biscuits, pasta, noodles and RTS beverage were studied for shelf-life. All the stored products were organoleptically acceptable except RTS beverage prepared using 40 per cent *ber* powder. Biscuits prepared with 10, 20 and 30 per cent and pasta, noodles and RTS beverage prepared with 10 and 20 per cent *ber* powder were best acceptable among all during storage.

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### Paper presented and abstracted

Bajaj, M., Sehgal, S. and Kawatra, A. 2009. Content of nutrients and antinutrients in rice bean (*Vigna Umbellata*) varieties as effected by soaking and pressure cooking. In: National seminar on nutritional strategies for improving quality of life. GBPUA&T, Pant Nagar. Sept. 11-12, 2009. Pp. 100.

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## UNDERTAKING OF THE COPY RIGHT

“I **Malika Bajaj**, Adm. No. **2009HS68D** undertake that I give copy right to the CCS HAU, Hisar of my dissertation entitled “**Nutritional evaluation and utilization of *ber* (*Ziziphus Mauritiana* Lamk.) powder for the development of value added products**”.

I also undertake that, patent, if any, arising out of the research work conducted during the program shall be filed by me only with due permission of the competent authority of CCS HAU, Hisar.

**Signature of student**