EVALUATION OF PHYSICOCHEMICAL PROPERTIES AND BIOACTIVE COMPOUNDS OF FIVE MANGO (*Mangifera indica* L.) VARIETIES IN BANGLADESH

A THESIS

BY

MD. MAMUN OR RASHID

Registration No. 1705049

Semester: January-June/2018

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MASTER OF SCIENCE (MS)
IN
FOOD SCIENCE AND NUTRITION

DEPARTMENT OF FOOD SCIENCE AND NUTRITION
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

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DEDICATED
TO MY
BELOVED PARENTS

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The Author

ABSTRACT

Fruits and vegetables are important sources of nutrients for mankind. Among the various fruits available in Bangladesh, Mango occupies a vital place in the human nutrition for its delicious taste and higher nutritious value. This study was conducted to evaluate the quality of five different mango varieties (Fazli, Amrupali, Langra, Gopalbogh and Misribogh) available in Northern Bangladesh. Physiochemical characteristics including moisture, ash, total carbohydrates, total solids, total soluble solids (TSS), pH, acidity, total sugars and ascorbic acid contents were evaluated. The results showed that there were significant ($P < 0.05$) differences among mangoes of all varieties for physio-chemical parameters. In case of proximate composition, the mango variety Amrupali showed the highest ash content (2.34±0.15) and fat content (1.18±0.13). Protein content (0.94±0.12) and total fiber (2.67%) content was shown to be the highest by Gopalbogh and Misribogh, respectively. The selected mango varieties contained total soluble solids of 12.87~20.55^{o}Brix, pH of 4.45~4.67, titrable acidity of 0.07~0.42%, reducing sugar of 8.40~15.43%, non-reducing sugar of 9.24~10.48%, and total sugar of 18.88~25.12%. Bioactive compounds viz. vitamin C (28.63~40.92 mg/100g) and beta-carotene (0.01593 to 0.02028 mg/g) were found to be significantly varied among the mango varieties. It can be concluded from the results of this study that all the mango varieties are high in nutrition and beneficial compounds for the human health. The study findings would be helpful for the consumers, dietitian and industry policymakers.

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INTRODUCTION

Mango (*Mangifera indica* L.) is an economical crop in many countries, especially India, Bangladesh, Pakistan, Philippines, Indonesia, Malaysia, Thailand, Myanmar, Srilanka etc. (Islam *et al*., 2013). Mango ranks the third among the tropical fruits in the world with a complete production of 23.87 million tons (FAO, 2006), whereas Bangladesh produced 8,90,000 tons (BBS, 2013). Among the fruits, mango secures 1st place regarding the area, and third in terms of production in Bangladesh (BBS, 2012). Mango is now recognized as one of the best fruits of all indigenous fruits due to its excellent flavor, attractive fragrance, and beautiful shades of color, delicious taste and high nutritive value. Several hundred varieties are grown in the Indian sub-continent but a few specific varieties are commercialized according to preferences of different regions of the countries. About 250 varieties of mangoes are grown in Bangladesh (Shafique, 2006). Besides, having the delicious taste, exotic flavor, and many-shaded colors, it is a decent supplier of nutritions. As a supply of nutrient, mango occupies a considerable quantity of antioxidant, β-carotene, and dietary fiber further as soluble sugar and varied minerals (Pal, 1998). Among the main constituents of this fruit, carbohydrate and acid contribute a great deal to the food value of the fruit. High production of mango has been accompanied by high post-harvest loss of mango because of excess fruits in the market during the peak seasons. Post-harvest value addition technology would reduce these losses giving farmer high return for their crop. Mango is consumed worldwide as either whole fruit, fresh-cut produce, processed juice, pickle, dried fruit, chutney, pulp, paste, puree, jam, slices in brine or flour (Evans, 2008; Ntombela, 2012; IIRR, 2006). The stability of fresh-cut or dried mango during processing and storage depends primarily on fruit composition, ripening stage and certain post-harvest processing treatments. Fruits with high solid content are needed for mango puree, jam, pulp or paste to increase product yield.

Increased total soluble solids (TSS) content is important to juice and concentrates manufacturers. Some level of firmness is required for high consumer appreciation of the fresh-cut product. The flavor and color characteristics are virtually important to all end users of mango fruit. Fresh-cut mango was reported as a potential for the new product to the fresh produce sector (Djioua *et al*., 2010). However, during fresh-cut processing, the mango fruit experiences softening and decrease in overall appearance because of tissue browning on the cut surface (Plotto *et al*., 2004). Cultivars with higher phenolic content and higher polyphenol oxidase (PPO) activity will be highly susceptible to flesh browning during cutting operation (Vasquez-Caicedo *et al*., 2002). It is interesting to compare the quality parameters and bioactive compounds of mangoes of different varieties with other types knowing the potential of other alternative mango cultivars. This can open a new perspective to the farmers and local industries and will also benefit the consumer by offering a great source of vitamin A. Therefore, it is necessary to study the nutritional characteristics of different mango variety available in Bangladesh. This will help the consumers to choose the right variety with more nutritional value as well as the processed food manufacturers to predict the suitable variety for different mango products.

Therefore, this study was undertaken with the following objectives:

I. To analyze the physicochemical properties of selected five mango varieties of northern Bangladesh.
II. To analyze the bioactive compound's present in selected five mango varieties of northern Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 Mango

Mango is one of the popular and delicious fruits in Bangladesh. It grows all over the country, however, its production is usually focused within the northern region (BBS, 2006). The mango is named the king of fruits in our country. The leading districts are Chapai Nawabganj, Rajshahi, Khulna, Kushtia, Dinajpur, Sylhet, Panchagor, etc. The exceptional types of mango accessible in Bangladesh are Fazli, Langra, Alphonso, Himsagar, Khirshapat, Gopalbhog, Misribhog etc. (Shafique 2006). According to Jha *et al.* (2006), mango is consumed each as recent and in processed kind. The storage lifetime of the mango depends on the stage of maturity at that the fruit is harvested, mango fruits are typically harvested at the physiologically matured stage to urge optimum fruit quality.

2.2 Varieties of mango

There are many varieties of mangoes in Bangladesh. Among all the varieties, most important ones are the elite varieties (locally called Kalam Aam), which have been propagated through grafting and other vegetative means, another one Guti-aam that has been cultivated by mango seedling. The other varieties of mangoes that are very common in Bangladesh are given in Table 2.1.

Table 2.1 Varieties of mango

Name of varieties	Harvesting time	Examples
Early varieties	Mid-May to mid-June	Gopalbhog, Himsagar, Khirsapat Brindabani and BARI Aam-1
Mid-season varieties	Mid-June to late-June	Langra, Misribhog, Krisanbhog, Kohitoor, Lakhanbhog, Daseri and BARI Aam 2-3
Late varieties	July to mid-August	Fazli, Ashwina, Kuapahari, Mohanbhog, Chausa and BARI Aam-4.
Regular bearing varieties	Mid-June to mid-August	Neelum, Mollika, Amropali/BARI Aam-3

2.3 Production and trade of mango

Mangoes are one of the most important and popular Asian fruits. India is the main producer, growing more than half of the world's supply. They are widely available year-round as fresh fruit and in frozen and processed foods. The quantity of mangoes grown has doubled between 1971 and 1993, as markets developed in Europe and North America. India now produces over 50% of the world's crop. Ten and a half million tons were grown there in 2003, with Pakistan and Bangladesh producing over one million tons and 170,000 tons, respectively. There are thought to be 24 major cultivars in the Indian sub-continent, and possibly a thousand lesser-known varieties that are often only available locally and not widely marketed. Some of the more well-known varieties include alphonso, banganapalli, langra, malda, mulgoa, totapuri, chausa and dashehari. Table 2.2 shows the world top ten mango producing countries.

Table 2.2 World top 10 mango producing countries

Country	Production (in Tons)
India	15,188,000
China	4,350,000
Thailand	2,600,000
Indonesia	2,131,139
Pakistan	1,888,449
Mexico	1,827,314
Brazil	1,249,521
Bangladesh	889,176
Nigeria	850,000
Philippines	800,551

Source: FAOSTAT (2013)

2.4 Production of mango in Bangladesh

Mango is one of the important fruits of Bangladesh and grows in all parts of Bangladesh. However, juicy mangoes with good tastes and quality are mostly grown in the northwestern Rajshahi region, especially in Chapai Nawabganj district. Chapai Nawabganj known as the "mango capital" of Bangladesh, has a long tradition of producing around 150 varieties of sweet mangoes. Media reports quoting agriculture department sources said, there are almost two million mango trees on 23 thousand hectares of land in Chapai Nawabganj district. The district alone with around 50,000 mango groves produced a total of 172,000 tons of mango in 2010 (Saleque, 2013). Rajshahi zone especially Chapai Nawabganj, Meherpur, Dinajpur, districts are famous for mango production. The area under mango cultivation during 2003-04 was about 50991 hectares with a total production of about 242605 metric tons (BBS 2004). In

2012 mango was cultivated in 79066 acres and produced 8,89,176 tons (FAO, 2013). Table 2.3 shows the production of mango in Bangladesh.

Table 2.3 Production of mango in Bangladesh

Year	Production (Tons)
2012	889176
2011	868921
2010	863952
2009	828161
2008	802750
2007	766930

Source: FAOSTAT (2013)

2.5 Composition of mango

The composition, in general, differs with the cultivar and the stage of maturity. The unripe green mangoes are reported to have 82% moisture, 0.6% protein, 0.5% fat, 12.5% carbohydrate, 12 mg/100g calcium, 13 mg/100g phosphorus, 400µg/100g iron, carotene (as vitamin A) 3mg/100g, 40mg/100g ascorbic acid (Food-allergens, 2001). Various compositions of mango are shown in Table 2.4.

Table 2.4 Nutritional value of mango per 100g

Nutrients	Amount
Energy	250 KJ (60 kcal)
Carbohydrates	15 g
Sugars	13.7 g
Dietary fiber	1.6 g
Fat	0.38 g
Protein	0.82 g
Vitamin A equivalence	54 µg
β-carotene	640 µg
Thiamine (B1)	0.028 mg
Riboflavin (B2)	0.038 mg
Niacin (B3)	0.669 mg
Pantothenic acid (B5)	0.197 mg
Vitamin B6	0.119 mg
Folate (B9)	43 µg
Choline	7.6 mg
Vitamin C	36.4 mg
Vitamin E	0.9 mg
Vitamin K	4.2 µg
Calcium	11 mg
Iron	0.16 mg
Magnesium	10 mg
Phosphorus	14 mg
Potassium	168 mg
Sodium	1 mg
Zinc	0.09 mg

Source: USDA Nutrient Database (2013)

2.6 Utilization of mango

2.6.1 Utilization of fresh mango

- **Mango beverages:** The most important beverages prepared on a commercial scale are Mango juice, Nectar and Squash. Juice preparation is done by adding about to equal quantity of water and adjusting the total soluble solids (TSS) and acids. The mango nectar contains 20% pulp and mango squash contains 25% juice (Mathur and Purnanandam, 1976; Kumbhar, 1992).
- **Mango jam:** Mango jam is another important product prepared from mango by adding citric acid (Mathur and Purnanandam, 1976; Sagar and Khurdiya, 1998).
- **Mango yoghurt:** It is an excellent substitute for the high-calorie dessert pudding which contains a sufficient amount of curd with cream. Yoghurt made from milk containing 10% fat and 8% sugar and homogenized at 200 bars with the addition of mango pulp up to 4% of the milk, which resulted in excellent flavored and smoother consistency yoghurt (Balasubhramanyam and Kulkarni, 1992).
- **Mango ice-cream:** The mango ice-cream is so much appealing and non-conventional food product that is prepared by mixing mango powder and milk in the ratio of 3:10. The structured mango ice-cream pieces modified with natural ingredients has also been discussed by (Britnell, 1991).
- **Mango lassi:** This is a delicious and popular drink of summer, and it can be prepared with mango powder with curd and other ingredients. When the ratio of mango powder and curd 3:10 is obtained the highest score in respect of color, flavor and texture followed by mango lassi prepared from mango powder and curd in the ratio of 2:5 and 1:5 (Sagar and Khurdiya, 1996).
- **Mango shake:** It is very delicious food product preferred mostly in the summer when the mango is out of the market. Mango shake from spray dried product comprised of mango,

milk and sugar solids and sterilized in glass bottles had good consumer acceptability, (Grewal and Jain, 1982).

2.6.2 Utilization of by-products of mango

- **Mango peel:** Peel is a major by-product during processing of mango contributes about 15-20% of the fruit (Beerh and Raghuramaiah, 1976). It is discarded as a waste and becoming a source of pollution, as the peel is not currently utilized for any commercial purpose. Peel is a good source of phytochemicals, such as polyphenols, carotenoids, vitamin E, dietary fibre and vitamin C and it also exhibited good antioxidant properties (Ajila *et al.,* 2007; Kim *et al.,* 2010).
- **Production of vinegar from mango waste:** Potentially the production of vinegar using mango (var. Totapuri) peels and stones was investigated (Ethiraj and Suresh, 1992). Alcoholic fermentation of these waste products is done by two methods. Peels or stone were mixed with (cold or hot water) and saccharin.
- **Mango seed kernel:** Mango kernel is a good source of fat and starch. The seed represents from 20% to 60% of the whole fruit weight depending on the mango type, variety and the kernel inside the seed, which represents from 45% to 75% of the whole seed (Maisuthisakul and Gordon, 2009).
- **Pectin from solid waste:** An observation was carried out to establish optimum extraction conditions for the extraction of pectin from mango solid waste. Highest pectin yield was occurred at pH-3, bleaching with alcohol and extraction of 60 minutes (Pedroza *et al.*, 1994).

2.7 Physiochemical composition of different mango varieties:

Naz. S *et al.* (2014) conducted a study on the paramount mango (*Mangifera indica* L.) cultivar in relation to its physical, chemical and sensorial attributes. Physiologically fully

mature fruits of eight mango cultivars were picked and subjected for physical and proximate analysis. Among the eight cultivars, Fazli produced the maximum green and ripe fruit weight, fruit length and perimeter, and physiological weight loss (453.0g, 403.0g, 13.80 cm, 21.57cm and 10.97% respectively). The higher softness values were noticed in Aman Dusahri. The mark variations were observed among all the cultivars for proximate composition. There is an increase in pH values (5.47, 5.40 and 5.33) among Samar Bahisht Chaunsa, Aman Dusahri and Anwar Ratual, respectively with a progressive decrease in ascorbic acid and titrable acidity during the ripening period. Likewise, maximum moisture and ash contents were observed in the mango pulp of Fazli and Sindhri (92.20 and 0.78%, respectively). Whereas, appreciably higher total sugar contents were observed in the pulp of Langra, Samar Bahisht Chaunsa, and Anwar Ratual (20.67%, 20.43% and 20.33%, respectively). TSS content of 19.83% and protein content of 0.64% were recorded in Langra while the Fazli contained higher fat contents. The sensorial attributes varied significantly according to cultivars. Out of eight cultivars, Langra obtained higher scores, while Anwar Ratual found to be highly satisfactory followed by Samar Bahisht Chunsa for flavor and taste. Both of these cultivars were equally acceptable for overall acceptability. However, none of the cultivars is rejected by the panellists regarding the sensory evaluation.

Hossain *et al.* (2014) performed a research to study the shelf life of mango fruits, and to investigate the changes in biochemical parameters and activities of ripening-associated enzymes of Ashwina hybrid mangoes at 4-day regular intervals during storage at -10 °C, 4 °C, and 30 ± 1 °C. Titratable acidity, vitamin C, starch content, and reducing sugar were higher at unripe state, and the values of those traits were gradually decreased with the increase of storage time at all storage temperatures while phenol content, total soluble solids, total sugar, and non-reducing sugar contents gradually increased.

Shafique *et al.* (2006) conducted a comparative study on the physiological and biochemical composition of ten varieties of mangoes at three maturity stages viz. immature, mature and ripe to find out the standard one. During the investigation, the whole weight of the mangoes, pulp content, weight of peel and stone, total soluble solids (TSS), pH, acidity, sugar content and vitamin C were determined at three maturity stages. It was observed that all the varieties at ripe stages had a higher sugar content as compared to immature and mature stages. Attractive flavor and pleasant taste were also developed in ripe stages and differed from one another due to varietal specific. This characteristics odor which appeared during ripening is due to ester and components of carbonyl types.

Islam *et al*. (2013) conducted an experiment on two popular mango varieties in Bangladesh (*viz*., Langra and Khirshapat) and four different levels of Gibberellic acid (GA3) solution, namely, control, 100, 200 and 400 ppm. The results revealed that Khirshapat showed better performance in achieving higher quantity of moisture, progressively lost physiological weight, increased pulp pH, TSS after 6th day of storage, and produced more quantity of sugar (total reducing and non-reducing sugar), as well as extended shelf life and delayed skin color changes than Langra at all the storage duration. Different levels of GA3 solution subjected to the investigation demonstrated significant variation in most of the physicochemical properties and shelf life of mango at different days after storage. The results explored that some physicochemical properties *viz.,* physiological weight loss, moisture content, pulp pH, TSS, sugar (total, reducing and non-reducing), were rapidly increased from untreated mangoes. GA3 at 400 ppm showed better performance in delaying the changes in physicochemical properties and extended shelf life.

Chovatiya *et al.* (2015) investigated the biochemical properties of mango (*Mangifera indica* L.) cv. Kesar at Saurashtra region at the Department of Horticulture and Food Testing Laboratory, College of Agriculture, Junagadh Agricultural University, Junagadh during the

year 2013-14. Nine different locations from Saurashtra region were selected for this experiment viz., Una, Mendarda, Bheshan, Junagadh (Sakkarbaug), Talala, Vanthali, Dhari, Aadityana and Ghogha. From the conducted experiment over nine different locations, they concluded that the Talala is more congenial for mango cv. Kesar or it can truly say that mango orchards located at/near Talala region produce better quality fruits as compared to others.

Islam *et al*. (2013) was carried out a detailed study with the postharvest mangoes (namely, the Langra and the Khirshapat) treated with different levels of Bavistin DF (BDF) solution (namely, 250, 500, and 750 ppm) for obtaining results on biochemical changes as well as storability of postharvest mango. The results of the experiments exhibited that only the single effect of varieties was found to be significant in most of the parameters studied. The Langraenriched a greater quantity of titratable acidity and total soluble solids (TSS) at 3rd day, over the Khirshapat. On the other hand, Khirshapat showed increased pulp pH and TSS at all the storage duration. The results explored that some physicochemical properties, namely, pulp pH, TSS, sugar (total, reducing, and non-reducing), and titratable acidity along with shelf life drastically decreased from untreated mangoes. Bavistin DF with the doses of 750 ppm showed better results in delaying the changes in physicochemical properties and extended shelf life.

Ara, *et al.* (2014) carried out a research to evaluate the nutritional properties of ten varieties (Amrapali, Chausa, Fazlee, Gopalbhog, Guti, Himsagor, Khirsapat, Kohitoor, Langra, and Mallika) of mango. Nutritional properties were significantly ($p < 0.05$) varied among the different mango varieties. The highest edible portion (79.49%), titratable acidity (0.75%) and calcium (30.56 mg/100 gm) were found in Gopalbhog. The highest amount of potassium (64.04 mg/100 gm) and magnesium (7.54 mg/100 gm) were found in Chausa while highest protein (1.18 gm/100 gm), crude fiber (4.78 gm/100 gm) and sodium (91.15 mg/100 gm)

were found in Langra. Mango varieties contain a significant amount of vitamin C (46.53-26.53 mg/100 gm), total sugar (5.48-4.27%) and total carbohydrate (27.33-4.49 gm/100 gm). The maximum calorific value (112.12 kcal/100 gm) was found in Amrapali. The heavy metal analysis was also done but no significant amounts were found. They strongly suggest that different varieties of mango can provide a higher amount of vitamin C and important minerals that will be a sustainable health benefit.

Abdualrahman, (2013) evaluated the physicochemical characteristic of different types of mango fruits grown in Darfur regions and its use in jam processing. For this, different types of mango fruits were carried out in term of physicochemical analysis. The physical characteristics results indicated that KMF had higher contents of flesh, length, width and volume (82.4±0.04, 125±0.01, 95±0.02 and 300±0.01), respectively. The proximate analysis of mango fruits was crude protein (0.74± 0.02-0.82±0.03%), ash (1.35±0.01-1.7±0.02%), crude fat (0.29±0.02-0.38±0.01%), crude fiber (4.2±0.01-4.5±0.01%) and total carbohydrates (14.1±0.01-15.4±0.01%). The NMJF, EMJF and KMJF contained 67, 67 and 66.8% TSS, respectively. The contents of total and reducing sugars of NMJF, EMJF and KMJF were (12.3, 12.8 and 12.8%) and (4.6, 4.8 and 4.5%), respectively. On other hand, the titratable acidity and pH values were (0.35, 0.37 and 0.34%) and (3.5, 3.6 and 3.4%), respectively; while, the contents of moisture and ash were (45.8, 46 and 45.6%) and (0.32, 0.34 and 0.33%) respectively.

Two mangoes (*Mangifera indica* L.) fruit varieties, Dodo and Viringe, from two localities of Eastern Tanzania, (Muheza in Tanga and Ifakara in Morogoro), were harvested as mature green fruits during early, mid and late season and allowed to ripen while stored at room temperature. The fruits were analyzed for their proximate composition (ash, titrable acidity, crude fat, crude fibre, moisture), reducing and total sugars content, ascorbic acid and total soluble solids content. The results showed that the mango fruits had high moisture content

(>65%), moderate acidity (0.20 - 1.30% c.a.), low crude fat content (0.20 g/100 g-fw), low crude fibre content (0.85 g/100 g-fw), low ash content of 0.55 g/100 g-fw, high reducing sugars amounts (10.5 – 21.3%), high total sugars content (10.5 – 21.3%), high soluble solids content (14.2 – 26.5%) and high ascorbic acid content (15.8-25.1%). (Othman OC and Mbogo GP, 2009)

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods used to carry out the present research work. The materials and methods used to determine the biochemical component of different mango grown in Rajshahi region.

3.1 Experimental site

The experiment was conducted in the Food and Process Engineering Lab-1 and Laboratory of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.2 Sample collection

Fresh and mature mangoes of different varieties viz. Fazli, Langra, Amrupali, Gopalbogh and Misribogh, were collected from Rajshahi district during the harvesting season (June-July 2017). These mangoes were brought into the laboratory and stored in a refrigerator at 3-5^{o}C for further use.

Figure 3.1: Freshly collected mangoes

3.3 Proximate analysis

The proximate chemical composition represents the gross content of important chemical constituents such as moisture, fat, protein, ash, total carbohydrate. The study of the proximate composition serves as an important base to study the nutritive quality of mango.

3.3.1 Determination of moisture content

The moisture content of mango pulp was determined in accordance to the moisture measurement method of AOAC (2000).

Procedure

The weight of previously dried (1 hr at 100°C) empty petridish was taken and 10g of mango sample was placed in each. Then the petridish with samples were dried in an air oven at 100-105°C for 24 hours or more till constant weight. After drying the petridish was removed from the oven and cooled in desiccators and weighed soon after reaching room temperature. The losses are taken as the moisture loss of the sample. From these weights the percent of moisture in the samples were calculated as follows:

$$\% \text{ Moisture} = \frac{\text{Loss of moisture}}{\text{weight of sample}}$$

3.3.2 Estimation of protein

Principle

The modified Kjeldahl method is used to determine the total nitrogen consisting of organic and ammonium forms. It is a wet oxidation procedure, where the complex form of nitrogen in plant protein is converted to nitrogen. Three steps are involved in this method.

1. Digestion
2. Distillation
3. Titration

Apparatus required:

1. Kjeldahl flask
2. Kjeldahl digestion stand
3. Conical flask
4. Volumetric flask
5. Measuring cylinder
6. Burette
7. Distillation apparatus
8. Electrical balance

Chemical required:

1. Sulphuric acid
2. Potassium sulphate
3. Copper sulphate
4. Selenium powder
5. Sodium hydroxide
6. Boric acid

Preparation of different reagents:

1. **Boric acid solution (4%):** Boric acid (H_3BO_3) of 20g was taken in a 250ml beaker about 150ml distilled water was added to it and heated until the solution clear and cooled. Then the solution was transferred to a 500ml volumetric flask and made the volume up to the mark with distilled water.
2. **Mixed indicator:** Bromocresol green of 0.5g and 0.1g methyl red was taken in a 150ml beaker 30-40ml ethanol was added to it and was dissolved. Then the solution

was transferred in a 100ml volumetric flask, volume was made up to the mark with ethanol.

3. **Sodium hydroxide (NaOH) solution (40%):** NaOH plate of 400g was taken in a 500ml beaker, about 300ml distilled water was added to it and stirred with a glass rod until dissolved the NaOH and cooled the solution. Then the solution was transferred in a litre volumetric flask and volume was made up to the mark with distilled water.
4. **Standard (0.2N) sulphuric acid solution:** About 200ml distilled water was taken in a 1000ml volumetric flask, 5.6 ml conc. sulphuric acid was added to it and made the volume up to the mark with distilled water.

Procedure:

1. Digestion

1g previously oven-dried sample was taken in a digestion flask. 10g potassium sulphate (K_2SO_4), 0.1g copper sulphate ($CuSO_4$),1g selenium powder and 25ml conc.H_2SO_4 was added to it and heated until the solution became clear. Then the flask was cooled.

2. Distillation

After digestion about 300ml distilled water and 125ml 40% NaOH solution was added to it. Then the flask was attached quickly to the distillation set and heated the flask continuously. In the meantime, a 250ml conical flask (containing 25ml of 4% boric acid and 4-5 drops of mixed indicator) was placed at the zet of the condenser. About 150 ml distillate was collected and was titrated with 0.2 N H_2SO_4 solution.

3. Titration

The micro burette was filled with 0.01 N HCl until the blue color disappears. The blank distillation was carried out and titrated.

Calculation:

$$\% \text{ Nitrogen} = \frac{Titre\ value \times N \times 0.014 \times 100}{Weight\ of\ sample}$$

$$\% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$$

Here, 6.25 is the protein factor for plant samples.

3.3.3 Determination of fat

AOAC method (2000) was used to determine crude fat content of the samples.

Procedure

Dried mango slices of 5 g were transferred into a thimble and plugged the top of the thimble with fat-free cotton. The thimble was dropped into the fat extraction tube of a soxhlet apparatus. The bottom of the extraction tube was attached to soxhlet flask. Approximately 75 ml or more of anhydrous ether was poured into the flask. The top of the fat extraction was attached to the condenser. The sample was extracted for 6 hr at 50°C, so that the ether which volatilized was condensed and dropped continuously upon the sample without any appreciable loss.

At the end of the extraction period, the thimble was removed from the apparatus and most of the ether was distilled off by allowing it to collect in the soxhlet tube. The ether was poured off when the tube was nearly full. When the ether was reached to a small volume, it was poured into a small, dry (previously weighed) beaker through a small funnel containing plug cotton. The flask was rinsed and filtered thoroughly using ether. The ether was evaporated on a steam bath at low heat, it was then dried at 100°C for 1 hr, cooled and weighed. The difference in the weights was the ether-soluble material present in the sample.

The percent of crude fat was expressed as follows:

$$\% \text{ Crude fat} = \frac{\text{Weight of the ether soluble material}}{\text{Weight of sample}} \times 100$$

3.3.4 Determination of ash

Total ash content was determined by adopting AOAC method (2000).

Procedure

Five (5) gram of each mango samples were weighed and taken in dry, clean porcelain dishes. Hot air oven method was applied to remove the moisture. Then the samples were burnt on an electric heater. This was done to avoid the loss of sample in the muffle furnace under higher temperature. Then the samples were transferred into the muffle furnace and burnt at 550°C temperature for 4-6 hrs and ignited until light gray ash resulted (or to constant weight). The samples were then cooled in desiccators and weighed. The ash content was expressed as:

$$\% \text{ Ash} = \frac{\text{weight of residue}}{\text{weight of sample}} \times 100$$

3.3.5 Determination of total carbohydrate

The total carbohydrate of the samples was determined as the total carbohydrate by difference, which is by subtracting the measured moisture, ash, fat, and protein from 100, (Pearson, 1970).

3.4 Determination of fiber content

The crude fiber was analyzed by adopting the procedure mentioned in AOAC (2000). Five (5) gram sample was used to determine crude fiber of mango samples. The sample was boiled for 30 minutes in 200 ml of 1.25% H_2SO_4 and then filtered and washed. Then the sample was again boiled in 200 ml of 1.25% NaOH for 30 minutes and then filtered and washed. The resultant residue was dried at 110ºC for 2 hours and weighed. The dried residue was ignited at 550 ± 15ºC, cooled and reweighed. The crude fiber was calculated according to the following expression:

$$\% \text{ Fiber} = \frac{\text{Loss of weight on ignition}}{\text{Weight of sample}} \times 100$$

3.5 Determination of pH

Digital pH (HANNA, pH-211) meter was used to determine the pH value of the sample by performing two-point calibrations (with buffer 7.0 and buffer 4.0) before measuring the samples pH value.

3.6 Determination of titrable acidity

The method suggested by AOAC (1980) was followed for the estimation of titrable acidity.

The following reagent was used for the determination of titrable acidity.

a. Standard NaOH solution (0.1 N).
b. Phenolphthalein Indicator.

Preparation of sample:

Ten (10) gram of mango pulp was taken in a 250ml beaker 20-25 ml distilled water was added to it and it was blending with a blender then it was filtered with a thin cloth then it was transferred in a 100 ml volumetric flask and volume up to the mark with distilled water.

Procedure:

Ten (10) milliliter of the sample was taken in a conical flask. 2-3 drops of phenolphthalein indicator were added to it and titrated with standard NaOH solution from burette. At the end point, pink color appeared.

$$\text{Titrable acidity } (\%) = \frac{\text{T} \times \text{N} \times \text{V1} \times \text{E} \times 100}{\text{V2} \times \text{W} \times 1000}$$

Where,

T=Titre value.

N=Normality of NaOH

V_1= Volume made up.

V_2= Volume of extract (used)

E= Equivalent weight of alkali.

W= Weight of sample

3.7 Determination of total soluble solids (TSS)

The total soluble solids (TSS) was determined using a laboratory scale digital refractometer (Type ATAGO, Model-9099).

3.8 Determination of β-carotene

Lycopene content was determined with a slightly modified method described by Nagata and Yamashita (1992).

Chemicals:

1. Acetone.
2. n-Hexane

Preparation of solvent: Acetone: n-Hexane (4:6).

Preparation of Sample solution

Accurately weighed 1.0 g of sliced fruit part was homogenized with 10.0 ml of acetone-hexane solution. Homogenized solution was centrifuged at 3600 rpm for 10 minutes and filtrated the solution.

Spectrophotometry

A little amount of supernatant sample was taken in a cuvette and placed in a spectrophotometer (T80 UV/VIS Spectrometer, PG Instruments LTD.). The absorbance of the prepared supernatant solution was measured at 663 nm, 505 nm and 453 nm.

Calculation:

The β-carotene content was estimated in mg/100ml by using the following equation (Barros *et al*., 2007; Igbokwe *et al*., 2013):

$$\beta\text{-carotene (mg/100 g)} = 0.216\ A_{663} - 0.304\ A_{505} + 0.452\ A_{453}$$

3.9 Determination of vitamin C

Ascorbic acid was determined following the method of Ranganna (1979)

Chemical required:

1. **Metaphosphoric acid solution**: 30 g Metaphosphoric acid dissolved in 80ml glacial acetic then this solution transferred in a 1000ml volumetric flask volume up to the mark with distilled water.

2. **Dye solution:** 260 mg 2, 6 di-chlorophenol Indophenol and 210mg $NaHCO_3$ dissolved in 1000ml distilled water.

3. **Standard vitamin C solution:** 100 mg vitamin C (L-ascorbic acid) dissolved in 1000ml metaphosphoric acid solution.

Standardization of dye solution:

Five (5) milliliter of standard vitamin C solution was taken in a 100 conical flask and titrated with dye solution from the burette.

$$\text{Dye factor} = \frac{0.5}{\text{Titrate value}}$$

Preparation of sample:

Ten (10) gram of fruit sample blended with about 50ml metaphosphoric solution then it was filtered with a white thin cloth then it was transferred in a 100ml volumetric flask and volume up to the mark with the metaphosphoric acid solution.

Titration with unknown solution:

Fruit sample of 10 ml was taken in a conical flask and titrated with dye solution from the burette.

$$\text{Vitamin C (mg/100g)} = \frac{\text{Titrate value x dye factor x volume of sample made up x 100}}{\text{Volume of sample used x weight of sample x 1000}}$$

3.10 Determination of total sugar

Chemical required:

Fehling A: Copper sulphate of 69.28 g was dissolved in distilled water. Diluted to 1000 ml filter and stored in amber colored bottle.

Fehling B: Rochelle salt (potassium sodium tartarate) of 346 g and 100 g NaOH was dissolved in distilled water. Diluted to 1000 ml filtered and stored in amber colored bottle.

Potassium oxalate solution: Potassium oxalate solution (10%) was prepared. This reagent was used to remove the excess lead used in clarification.

Lead acetate solution: Neutral lead acetate solution (20%) was prepared.

Methylene blue Indicator: 1% of methylene blue solution was prepared in distilled water.

Estimation of reducing sugars

It was determined according to the method described by I. U. Haq. (2012) and Santini *et al*. (2014) with slight modification. Twenty gram of the mango pulp was crushed in a mortar and pestle then transferred in a 200 ml volumetric flask. The volume was adjusted to 150 ml by adding purified water. After a few minutes to allow the sugar dissolution, 10 ml of lead acetate solution and the minimum amount of potassium oxalate solution were added. The volume of the resulting solution was adjusted to 200 ml, and the solution shaken, filtered and transferred in a burette for the titration. 5ml of Fehling solution A, 5 ml of Fehling solution B and 40 ml of purified water were transferred to a flask. The solution was heated up to boiling

point and the solution was added drop by drop till the nearly complete de-coloration of the Fehling reagent. Two drops of methylene blue were added, and the boiling continued for 3 minutes. The solution from the burette was added untill the blue coloration of the indicator disappeared and the solution turned into a red color. Reducing sugar was calculated using the following equation:

$$\% \text{ Reducing sugar} = \frac{\text{Fehling factor} \times \text{Dilution} \times 100}{\text{Titre} \times \text{weight or volume of sample}}$$

Estimation of non-reducing sugars

$$\% \text{ non-reducing sugar} = \% \text{ total sugar} - \% \text{ reducing sugar}$$

Estimation of total sugars

An aliquot of 50 ml of the clarified, de-leaded filtrate was pipetted to a 100 ml volumetric flask. 5 ml conc. HCL and allowed to stand at room temperature 24 hours. It was neutralized with conc. NaOH solution followed by 0.1 N NaOH solution. The volume was made up to the mark and transferred to 50 ml burette having an offset tip and performed the titration on Fehling's solution similar to the procedure described in the determination of reducing sugar (AOAC, 2000).

$$\% \text{ Total sugar} = \frac{\text{Fehling factor} \times \text{Dilution} \times 100}{\text{Weight of sample} \times \text{Titre}}$$

3.11 Statistical analysis

All determinations were done in triplicate and mean ± standard deviation (SD) values are calculated. A commercial software program (SPSS 20.0, SPSS Inc.) was used to perform statistical analyses. Data were assessed by analysis of variance (ANOVA). Duncan's multiple range test was used to separate means. Significance was accepted at the probability of $P<0.05$ throughout the analysis.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Proximate composition of different Mango Variety

4.1.1 Moisture content

The moisture content of different mango varieties differed significantly ($P < 0.05$) as shown in **Table 4.1**. Moisture content was observed more than 70% in all varieties. However, the highest and lowest moisture content was found in Fazli (88.26%) and Amrapali (72.83%), respectively. The results are in agreement with the findings of Ueda *et al*. (2000) and Haque *et al.* (2009) who reported that most fruits are composed of 70% to 90% of water.

4.1.2 Ash content

Table 4.1 represents the ash content of different mango varieties. The results showed that ash content was not varied significantly ($P > 0.05$) among the mango varieties. The highest ash content was recorded in Amrupali variety (2.336%) followed by Gopalbogh (2.196%), Langra (2.11%), Misribogh (2.093%) and Fazli (1.97%). Regarding ash content, Gardner *et al*. (1939) reported that the total content of mineral salt as ash in fruits varied from 0.2% to 1.5%, which is lower than our observed findings. Almost similar results were also reported by Akhter *et al.* (2010).

Table 4.1. Proximate composition of different mango variety

Mango Varieties / Composition	Fazli	Amrupali	Langra	Gopalbogh	Misribogh
Moisture (%)	88.26 ± 1.34^{a}	72.83 ± 2.95^{d}	77.23 ± 1.74^{c}	82.52 ± 1.38^{b}	79.42 ± 1.96^{c}
Ash (%)	1.97 ± 0.12^{a}	2.34 ± 0.15^{a}	2.11 ± 0.07^{a}	2.20 ± 0.17^{a}	2.09 ± 0.19^{a}
Protein (%)	0.43 ± 0.08^{b}	0.53 ± 0.04^{b}	0.94 ± 0.12^{a}	0.78 ± 0.08^{a}	0.58 ± 0.07^{b}
Fat (%)	0.40 ± 0.02^{c}	1.18 ± 0.13^{a}	0.11 ± 0.04^{e}	0.54 ± 0.02^{b}	0.21 ± 0.04^{d}
Carbohydrate (%)	8.94 ± 0.13^{e}	23.12 ± 0.24^{a}	19.61 ± 0.11^{b}	13.96 ± 0.16^{d}	17.70 ± 0.14^{c}

Values are mean ± standard deviation of three replicates.
[a-e]Different superscript alphabets in each row indicate significant difference ($P < 0.05$) among the mango varieties.

4.1.3 Protein content

The protein in different mango varieties shown in **Table 4.1**. Significant (P<0.05) differences in protein among mango varieties were found in this study. The highest value of protein was found in Langra variety (0.93%), whereas the lowest value was found in Fazli variety (0.43%). Gopalan *et al*. (1993) have been reported that maximum protein content in the different varieties of tropical fruits varies from 0.4 to 0.8 %. Ara *et al.* (2014) reported that protein content varied between 0.07 to 0.26 % depending on the mango varieties.

4.1.4 Fat content

The total fat ranged from 0.11 to 1.18 % (**Table 4.1**), which was found to be varied significantly (P < 0.05). Amrupali showed the highest total fat content (1.18 %) and Langra (0.11 %) was found with the low amount of the fat content. It was reported that usually fat content of different fruits is not greater than 1% (Norman, 1976), which supports our findings.

4.1.5 Total carbohydrate content

Generally, carbohydrate of fruit is less concentrated than cereals because of their high water content. Fruits rich in carbohydrate provides a high amount of energy. In this study, the total carbohydrate content was ranged from 8.94 to 23.12 % (**Table 4.1**), which was found to be varied significantly (P < 0.05) among the mango varieties. Since, carbohydrate was calculated by subtracting the percent moisture, ash, protein and fat from 100%, so its content is totally dependent on the content of others components.

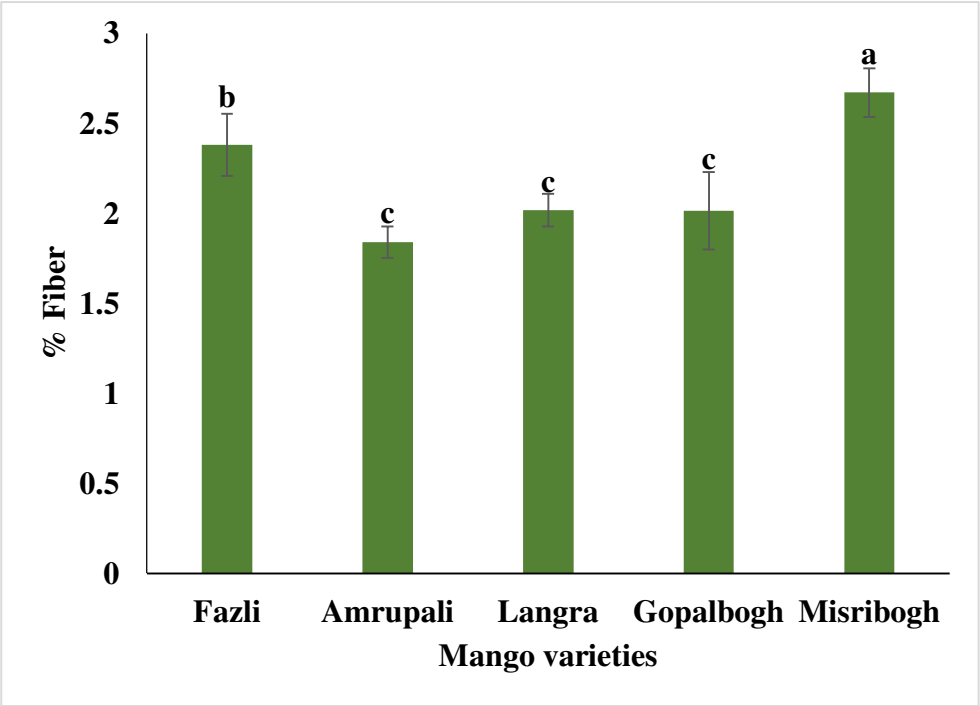

Figure 4.1. Total fiber content of different mango varieties.

4.1.6 Total fiber content

Results obtained for total fiber content of different mango variety are presented in **Figure 4.1**. The total fiber of mango variety ranged from 1.84 to 2.67 %, which were found to vary significantly ($p \leq 0.05$) among the mango varieties. Nonetheless, the highest fiber content was reported in Misribogh, while the lowest in Amrupali variety.

4.2 Biochemical properties of different mango variety

4.2.1 Total soluble solids

Total soluble solids content also differed significantly ($P < 0.05$) and found to range between 12.87 to 20.55 ^{o}Brix being maximum in Amrupali and it was minimum in Misribogh. These findings are similar to the reports of previous literature (Akhter *et al.*, 2010; Sarder *et al.,* 1998). Total soluble solids (TSS) are directly correlated with the acidity of the fruit. Generally, the acidity of fruit decreases and the TSS increases during maturity and ripening stage of fruit (Padda *et al.*, 2011; Sajib *et al.*, 2014).

4.2.2 pH and titrable acidity

pH is an important quality parameter for fruits and vegetables since the growth of microorganisms highly influenced by its value. This study revealed that significant ($P < 0.05$) difference exist in pH of different mango varieties (**Table 4.2**), which was ranged between 4.45 to 4.67. The acidity of this study varied from 0.073 to 0.421 % (**Table 4.2**), which was found to be significantly different from each other. The highest acidity value was found in mango of Fazli variety, while the lowest value was found in Misribogh variety **(Table 4.2)**. It was reported, higher pH (4.2 to 5.7) and lower acidity (0.05 to 0.22%) in mango grown in Mediterranean subtropical climate (Pleguezuelo *et al*., 2012). It was also observed that pH and titrable acidity in Langra was 3.35 and 0.68% and in Chausa was 3.75 and 0.63%, respectively (Akhter *et al*., 2010). Hamdard *et al.* (2004) also reported that acidity varies from 0.25 to 0.60%. The variation in pH value and titrable acidity of mangoes and mango products due to the ripening of the mango and the storage has reported by (Prusky *et al.,* 1993).

Table 4.2. Total soluble solid (TSS), pH, titrable acidity, reducing sugar, non-reducing sugar and total sugar of different mango varieties.

Mango Varieties / Composition	Fazli	Amrupali	Langra	Gopalbogh	Misribogh
Total soluble solids (^{o}Brix)	18.11 ± 0.49^{b}	20.55 ± 1.68^{a}	15.54 ± 0.16^{c}	14.68 ± 0.20^{c}	12.87 ± 4.40^{d}
pH	4.67 ± 0.09^{a}	4.50 ± 0.12^{c}	4.45 ± 0.00^{d}	4.56 ± 0.01^{bc}	4.60 ± 0.07^{b}
Acidity (%)	0.42 ± 0.02^{a}	0.20 ± 0.03^{b}	0.14 ± 0.01^{c}	0.10 ± 0.01^{d}	0.07 ± 0.00^{e}
Reducing Sugar (%)	10.39 ± 0.54^{b}	15.02 ± 0.31^{a}	8.40 ± 0.50^{c}	15.43 ± 0.81^{a}	14.92 ± 0.14^{a}
Non-Reducing sugar (%)	10.11 ± 0.60^{ab}	12.54 ± 0.71^{ab}	10.48 ± 0.76^{a}	9.24 ± 0.60^{b}	10.20 ± 0.19^{ab}
Total sugar (%)	20.49 ± 0.48^{a}	27.55 ± 0.95^{ab}	18.88 ± 0.31^{d}	23.67 ± 0.48^{b}	25.12 ± 0.06^{a}

Values are mean ± standard deviation of three replicates.
$^{a-e}$Different superscript alphabets in each row indicate significant difference ($P < 0.05$) among the mango varieties.

4.2.3 Sugar content

4.2.3.1 Reducing sugar

Table 4.2 shows the results varied in the reducing sugar content among the mango variety. The reducing sugar ranged from 8.40 to 15.43% is the highest content in Gopalbogh (15.43%) followed by Amrupali (15.02%), Misribogh (14.92%), Fazli (10.39%) and Langra (8.40%) variety. These values are similar to the content of reducing sugar for various mango varieties reported by Ara *et al*. (2014).

4.2.3.2 Non-reducing sugar

Non-reducing sugar content of different mango variety was found to be significantly ($P < 0.05$) different, which are presented in **Table 4.2**. However, the highest non-reducing sugar was recorded in Amrupali (12.54%) followed by Langra variety (10.48%), Misribogh (10.20%), Fazli (10.11%), and Gopalbogh (9.24%) variety.

4.2.3.3 Total sugar

The total sugar content of different mango varieties is presented in **Table 4.2**. It was observed that total sugar content was found to be varied significantly ($P < 0.05$) among the varieties and ranged from 20.49 to 27.55 % (**Table 4.2**). The highest sugar was observed in Amrupali variety while the lowest was found in Fazli variety.

4.3 Bioactive compounds in different mango variety

4.3.1 Vitamin C

Vitamin C or ascorbic acid is an important antioxidant in food and it is the major vitamin present in citrus fruits. Ascorbic acid plays a major role as an antioxidant in the detoxification of hydrogen peroxide, superoxide radicals (O^{2-}) and hydroxyl radicals ($OH^{\bullet}$) that are generated from the different reactive oxygen species in the plant tissue (Moldau 1998). This study found that vitamin C of different mango variety was varied significantly ($P < 0.05$) from 28.63 mg/100g to 40.92 mg/100g (**Figure 4.2**). **Figure 4.2** shows that the highest vitamin C value was found in Langra (40.92 mg/100g) variety followed by Fazli (38.19 mg/100g), Amrupali (33.53 mg/100g), Gopalbogh (31.75 mg/100g) and Misribogh (28.63 mg/100g) variety. According to the previous reports (Robles-Sánchez *et al*. 2009; Valente *et al*. 2011), the ascorbic acid content varied between the mango cultivars, and also depend on various factors such as temperature, storage conditions, exposure to light, air etc.

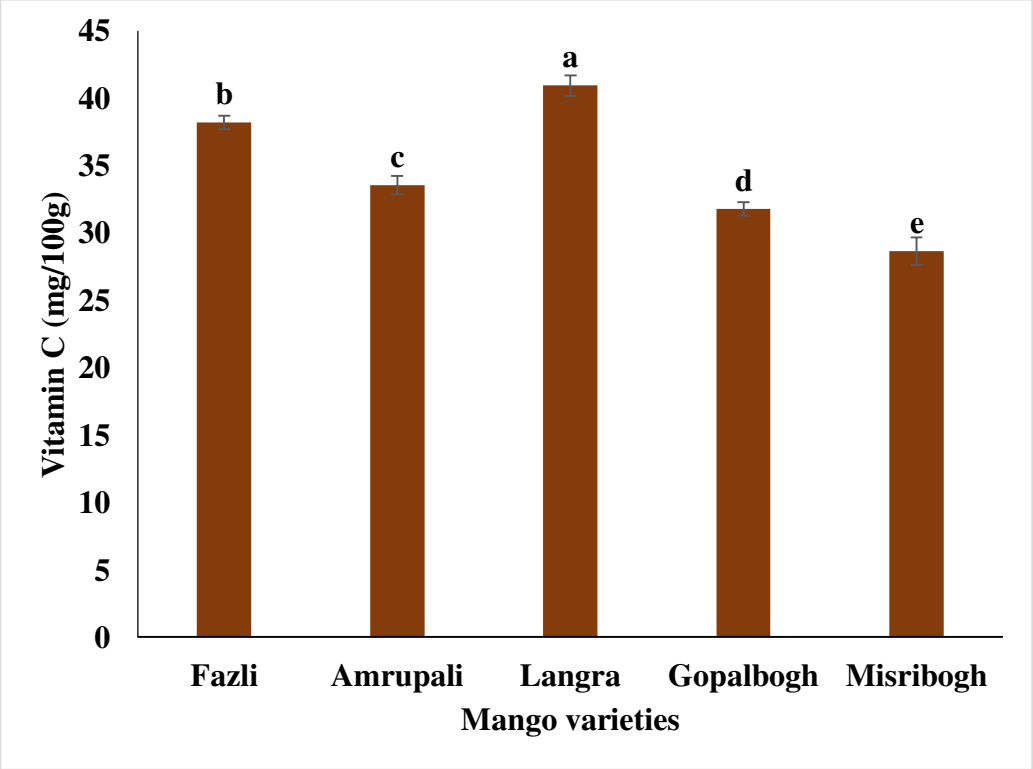

Figure 4.2. Vitamin C content in different mango varieties

4.3.2 β-carotene

β-carotene is ubiquitously present in green leafy and yellow-orange fruits and vegetables. β-carotene content of different variety was found in the range of 0.01593 mg/100g to 0.02028 mg/100g (**Figure 4.3**).

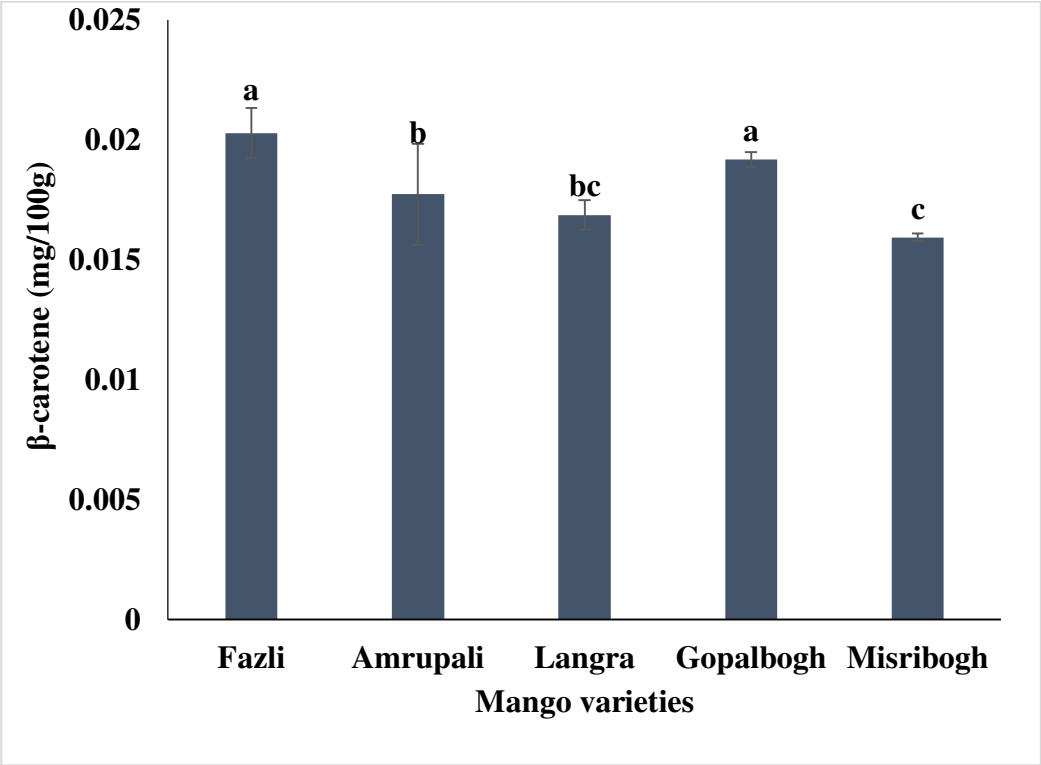

Figure 4.3. Contents of β-carotene in different mango varieties.

The maximum value of β-carotene was found in Fazli variety while the minimum value was found in Misribogh, although there was no significant difference among the mango variety. The β-carotene content of fruits may be influenced by the growing conditions, maturity index, post-harvest handling conditions, as well as variety or cultivar (Mangels *et al.,* 1993).

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The present study was undertaken to characterize five most common mango varieties (e.g. Fazli, Amrupali, Langra, Gopalbogh and Misribogh) for their physicochemical and nutritional properties. Present study indicates that all varieties of mango are rich sources of nutrition in terms of ash, protein, carbohydrate, vitamin C, fiber, β-carotene, vitamin A, total sugar etc. The nutritional properties of the selected mango varieties were found to be standard with different literature reports.

Results of this study revealed that, high amount of moisture was found in Fazli variety, Amrapali contains high ash, fat and carbohydrate hence provides more energy. Langra contains highest amount of protein, non-reducing sugar and vitamin C and Gopalbogh contains high reducing sugar. Misribogh contains high amount of fiber and total sugar, whereas Amrupali contains high total soluble solids. pH and acidity was high in Fazli variety.

Therefore, these varieties may be suitable for dietary recommendation and may be suitable for different product development. Finally, nutritional status of popular five mango varieties of Bangladesh were systematically addressed and recommended their nutritional parameters, which will help the consumers, dietitian and industry policy makers. So far we know, this type of work has partially been done in our country. Further analysis like antioxidant and individual minerals profile could be explored for complete nutritional information of these mango varieties.

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