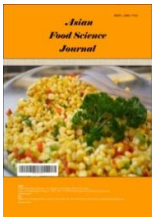

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Vitamin-C and Mineral Composition Analysis of Some Fresh Vegetables in Patuakhali, Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This comparative study was carried out to evaluate the vitamin-C and mineral content of twenty-two different sorts of nutritious and low-cost fresh vegetables.
Methodology: The study was conducted in the agricultural chemistry laboratory, Patuakhali Science and Technology University, Patuakhali during the period of January to June 2019. Vitamin C, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), phosphorus (P) contents were determined with the flame emission spectrophotometer.
Results: Vitamin-C was higher in *Momordica charantia* (87.0 mg/100 g) and lower in *Vigna unguiculata* (0.10 mg/100g). Calcium and magnesium of the green leafy vegetables were in the range of 191.0 - 12.0 mg/100g and 210.1- 9.0 mg/100g respectively. Sodium content largely varied from 58.1- 2.1 mg/100g in which *Amaranthus cruentus* content higher and *Cucumis sativus* had the lower content. The highest potassium content was recorded in *Cucurbita pepo* (384.0

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mg/100g) and the lowest potassium content was found in *Cucumis sativus* (144.20 mg / 100g). Phosphorus content was ranged between 108.0 -13.0 mg /100 g in all the green leafy vegetables. There were significant correlations between mineral contents.

Conclusion: These results revealed that selected vegetables contain an appreciable amount of vitamin C and minerals and should be included in diets as a supplement of daily allowance needed by the body.

Keywords: Fresh vegetable; vitamin-C; mineral composition; Bangladesh.

1. INTRODUCTION

Vegetables play an important role in human nutrition. They are made up of cellulose, hemicellulose and pectin substances that give them their texture and firmness. They provide an adequate amount of dietary fibers, minerals, vitamins and other nutrients which are usually in short supply in daily diets. They are very important protective foods and useful for the maintenance of health and prevention of various diseases [1]. Leafy vegetables have low energy densities thus recommended for weight management [2]. The availability of indigenous vegetables has declined drastically because of the excessive cultivation of field crops. There is also growing ignorance among young people about the existence of these readily available nutritionally rich food plants [3]. The supply of minerals is inadequate to meet the dietary requirements of rapidly growing human population in the world. Minerals cannot be synthesized by humans and animals thus they must be provided through food and water [1]. Vegetables contain numerous minerals such as Ca, Fe, Cu, P, Zn, Cl, and Na which are vital for growth and metabolism. The predominant elements found in green leafy vegetables are Ca, K, Fe and Na. These provide an alkalizing effect on acidity produced by other foods, especially those of animal origin [4]. Vitamins are important for human health and among the vitamins, vitamin-C is an essential micronutrient required for normal metabolic functions of the body. Vitamin-C plays an important role as a component of enzymes involved in the synthesis of collagen and carnitine. It is the major water-soluble antioxidant in the human body. Not only does a vitamin-C intake markedly reduce the severity of a cold, but it also effectively prevents secondary viral or bacterial complications [5]. Numerous studies have shown that an adequate intake of vitamin-C is effective in lowering the risk of developing cancers in breast, cervix, colon, rectum, lung, mouth, prostate and stomach. For maintaining good health and to prevent colds, some scientists are of the view that the human body should be kept saturated with vitamin-C [5]. Therefore, this study was carried out to evaluate the vitamin and mineral constituents of twenty two different species of vegetables commonly grown and consumed at Kalapara Upzilla of Patuakhali district in Bangladesh.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The fresh vegetable samples were collected from Kalapara upazila of Patuakhali district, located at 22.3542°N, 90.3181°E in the southern part of Bangladesh (Fig. 1). It has 31324 households and a total area of 483.08 km and a 331.9 km distance from the capital. The study area was saline water prone area 5.11 to 6.48 dS/m [6].

2.2 Sample Collection and Preparation

A total of twenty-two different species of healthy, diseases free, commonly consumed vegetables were collected from farmer's field and home gardens (Table 1). Edible parts of the plants were separated and washed thoroughly under running tap water and then were rinsed in the distilled water. Then the vegetables were cut into pieces and sundry, later then dried in an oven at 70-80^{0}C for 48 hours. The dried portions were grounded into powder using mortar and pestle. Each powdered sample was digested as reported by Anjorin et al. [7]. Briefly, 10g fresh sample was digested with 10-15 ml di-acid mixture (HNO_3: $HClO_4$ = 2:1) and heated at 180-200°C on an electric hot plate until white fumes were evolved from the conical flask. The solution was filtered with Whatman filter paper no. 42 and volume made up to 100 ml with distilled water. The aliquot was used separately to determine the mineral contents. The digests were analyzed for the mineral using Buck Scientific model 210VGP Atomic Absorption Spectrophotometer.

2.3 Determination of Vitamin-C and Minerals

The ascorbic acid content was determined according to Ranganna [8]. Calcium (Ca) and magnesium (Mg) were determined by the complexometric method of titration using Na_2-EDTA as a complexing agent [9]. Phosphorus (P) was determined using ascorbic acid as a reductant for color development and reading was recorded with the help of spectrophotometer [10]. Sodium (Na) and potassium (K) content were determined by following the method as described by Terrab et al. [10] with the help of flame emission spectrophotometer (Spectrolab analytical UK) using appropriate filters.

2.4 Statistical Analysis

Statistical analyses were carried out by using Statistical Package for Social Science (SPSS) for Windows version 20.0. Results were expressed as mean value ± standard deviation (SD). Pearson Correlations was adopted to indicate the measure of correlation and strength of the relationship between variables. For dividing the vegetable species into several groups, cluster analysis (CA) with dendrogram using Nearest neighbor method was adopted by using the overall vegetable vitamin-C and mineral content. Other calculations were done by Microsoft excel 2013.

3. RESULTS AND DISCUSSION

Fresh vegetables are important sources of nourishment and a vital ingredient in healthy and balanced diets. The roles of vegetables in the maintenance of good health are well known and highly recommended in any diet. Vitamin-C, minerals compositions of the collected vegetables like calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) and phosphorous (P) were presented in Table 2.

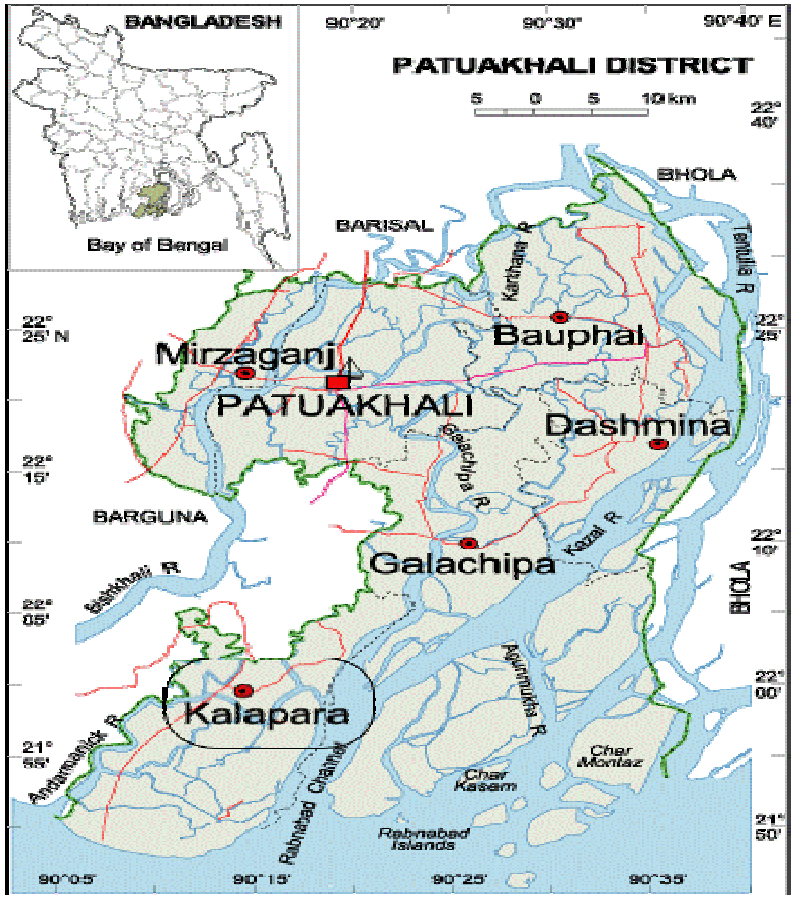

Fig. 1. Map showing the study area

Table 1. List of vegetable sample used in this study

SL. No.	English Name	Scientific Name	Parts used for consumption
1	Bitter gourd	*Momordica charantia*	Fruits
2	Tomato	*Solanum lycopersicum*	Fruits
3	Brinjal	*Solanum melongena*	Fruits
4	Lady's finger	*Abelmoschus esculentus*	Fruits
5	Potato	*Solanum tuberosum*	Fruits
6	Bottle gourd	*Lagenaria siceraria*	Fruits
7	Pumpkin	*Cucurbita pepo*	Fruits
8	Ash gourd	*Benincasa hispida*	Fruits
9	Cowpea	*Vigna unguiculata*	Fruits and seeds
10	Cucumber	*Cucumis sativus*	Fruits
11	Drum stick	*Moringa oleifera*	Fruits
12	Pointed gourd	*Trichosanthes dioica*	Whole part
13	Ridge gourd	*Luffa acutangula*	Fruits
14	Snake gourd	*Trichosanthes cucumerina*	Fruits
15	Teasel gourd	*Momordica dioica*	Fruits and seeds
16	Radish	*Raphanus sativus*	Whole part
17	Plantain	*Musa paradisiaca*	Fruits
18	Pea	*Pisum sativum*	Seeds
19	Bean	*Phaseolus vulgaris*	Fruits
20	Papaya	*Carica papaya*	Fruits
21	Chilli	*Capsicum frutescens*	Fruits
22	Red Amaranth	*Amaranthus cruentus*	Whole part

3.1 Content of Vitamin-C

In this study, the concentration of vitamin-C was between 87 ±0.85 to 0.10 mg/100g. The highest vitamin-C content of 87 ±0.85 mg/100g was found in *Momordica charantia* followed by Rahman et al. [11] (88 mg/100g). Almost similar content of 79.50±.36 mg/100g in *Capsicum annuum* which was agreed with Olatunji and Afolayan, [12] 80.6 mg/100g. Although, Emmanuel-Ikpeme et al. [13] found vitamin-C content was 47.55±0.44%. According to Table 2, *Vigna unguiculata* contains the least amount of vitamin-C content of 0.10±.00 mg/100g. A little bit higher vitamin-C content was found by Chikwendu et al. [14] (0.59 ± 0.01 mg/100g) in husks of cowpea where Soris and Mohan [15] observed a much higher (34.44 ± 1.28 mg/100g) value than the present study.

3.2 Content of Calcium (Ca)

Calcium among the various vegetables was found to be concentrated in *Amaranthus cruentus* (191±0.8 mg/100g) than all other vegetable samples, followed by *Abelmoschus esculentus* (85±.53 mg/100g), *Phaseolus vulgaris* (69.30±.26 mg/100g). *Cucumis sativus* was having the least calcium content of 12±.36 mg/100g compared to *Solanum tuberosum* and *Solanum lycopersicum* with 14±.10 and 14±.42 mg/100g respectively (Table 2). Various values have been previously reported for *Amaranthus cruentus*, Valcárcel-Yamani and Lannes [16] found ranged at 180.1 - 217.0 mg/100g in amaranth seeds, Topwal [17] found Calcium ranged at 160 - 212 mg/100g, Soriano-García et al. [18] as 159 mg/100g. In case of *Abelmoschus esculentus,* Habtamu et al. [19] found mean calcium content was 81.77 mg/100g which was similar to the present study and higher than those reported for okra seed by Ndangui et al. [20] as 78.65 mg/100g, but lower than those reported as 112.50 - 345.83 mg/100g [21]. In this study, the lowest calcium content found in *Cucumis sativus* (12±.36 mg/100g) which was less than Abbey et al. [22] as 20.45 to 25.47 mg/100g.

3.3 Content of Magnesium (Mg)

Magnesium is important for many processes in the body. Soft tissue magnesium functions as a co-factor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis and maintenance of the electrical potential of nervous tissues and cell membranes [23]. As shown in Table 2, *Amaranthus cruentus* contained the largest amount of magnesium (210.1±.29 mg/100g) among the studied

Table 2. Vitamin C and minerals composition of fresh vegetables (mg/100g)

English Name		Ca	Mg	Na	K	P	Vit-C
Bitter gourd	Mean ± SD	25 ± .46	33 ± .44	37 ±0.72	174 ± .46	22± .36	87 ±0.85
	Range	24.60-25.50	32.70-33.50	36.40-37.80	173.60-174.50	21.70-22.40	86.20-87.90
Tomato	Mean ± SD	14±.42	9±.45	8±.56	158±.36	26±0.26	20.1±.20
	Range	14.50-15.50	8.50-9.40	7.50-8.60	157.60-158.30	25.80-26.30	19.90-20.30
Brinjal	Mean ± SD	19±.26	23±.26	7±.79	172±.66	48±.26	11.50±.26
	Range	18.80-19.30	22.70-23.20	6.40-7.90	171.40-172.70	47.80-48.30	11.20-11.70
Lady's finger	Mean ± SD	85±.53	27±.26	39±.56	181±.26	29±.56	22.5±.30
	Range	84.60-85.60	26.70-27.20	38.50-39.60	180.70-181.20	28.50-29.60	22.20-22.80
Potato	Mean ± SD	14±.10	19±.66	18±.36	285±.66	43±.26	10.40±.43
	Range	13.90-14.10	18.40-19.70	17.70-18.40	284.40-285.70	42.80-43.30	10.10-10.90
Bottle gourd	Mean ± SD	26.83±.75	12±.26	38±.36	150±.52	53±.26	10.60±.44
	Range	26.40-27.70	11.80-12.30	37.70-38.40	149.60-150.60	52.70-53.20	10.30-11.10
Pumpkin	Mean ± SD	32±.56	38±.26	11±.10	384±.56	91±.66	7.3±.26
	Range	31.50-32.60	37.70-38.20	10.90-11.10	437.50-438.60	90.40-91.70	7.10-7.60
Ash gourd	Mean ± SD	28.10±.53	16.10±.44	38.1±.53	148±.15	13±.36	30.10±.72
	Range	27.70-28.70	15.80-16.60	37.70-38.70	147.40-148.90	12.70-13.40	29.50-30.90
Cowpea	Mean ± SD	52.2±.36	42.10±.53	19.10±.43	302±.55	48.77±1.0	0.10±.00
	Range	51.90-52.60	41.70-42.70	18.80-19.60	301.50-302.60	47.70-49.70	0.1-0.1
Cucumber	Mean ± SD	12±.36	10.80±.53	2.1±.26	144.20±.53	16.20±.60	6.9±.26
	Range	11.70-12.40	10.40-11.40	1.90-2.40	143.70-144.70	15.80-16.90	6.70-7.20
Drum stick	Mean ± SD	23.1±.53	27.40±.36	41±.36	256±.53	108±.36	67.80±.53
	Range	22.70-23.70	27.10-27.80	40.70-41.40	255.60-256.60	107.70-108.40	67.40-68.40
Pointed gourd	Mean ± SD	15±.55	14.40±.36	27.10±.53	152.85±.26	17.80±.10	18.50±.36
	Range	14.50-15.60	14.10-14.80	26.70-27.70	152.10-153.60	17.70-17.90	18.20-18.90
Ridge gourd	Mean ± SD	19.40±.36	13.80±.10	37.5±.26	148.95±.36	31.20±.36	4.36±.37
	Range	19.10-19.80	13.70-13.90	37.30-37.80	148.10-149.80	30.80-31.50	4.10-4.80
Snake gourd	Mean ± SD	29.10±.53	16.20±.36	38.10±.43	152.10±.53	27±.66	17.80±.70
	Range	28.70-29.70	15.80-16.50	37.80-38.60	151.70-152.70	26.40-27.70	17.30-18.60
Teasel gourd	Mean ± SD	25.40±.36	18.10±.53	51.10±.53	184.10±.53	25.10±.53	70.30±.26
	Range	25.10-25.80	17.70-18.70	50.70-51.70	183.70-184.70	24.70-25.70	70.10-70.60
Radish	Mean ± SD	23.60±.53	13.90±.20	38.60±.53	150.15±.36	21.50±.30	16.70±.20
	Range	23.20-24.20	13.70-14.10	38.20-39.20	149.80-150.50	21.20-21.80	16.50-16.90
Plantain	Mean ± SD	21.30±.26	27.60±.53	3.7±.20	239.20±.36	20.30±.26	7.2±.36

English Name		Ca	Mg	Na	K	P	Vit-C
	Range	21.10-21.60	27.20-28.20	3.50-3.90	238.80-239.50	20.10-20.60	6.80-7.50
Pea	Mean ± SD	42±.55	45.40±.43	3.5±.30	242±.66	105.60±.53	7.10±.44
	Range	41.50-42.60	45.10-45.90	3.20-3.80	241.40-242.70	105.20-106.20	6.80-7.60
Bean	Mean ± SD	69.30±.26	49.50±.30	8.6±.53	168±.36	48±.55	8.7±.20
	Range	69.10-69.60	49.20-49.80	8.20-9.20	167.60-168.30	47.50-48.60	8.50-8.90
Papaya	Mean ± SD	14.5±.26	54±.66	6.10±.53	148.20±.44	14±.55	17.50±.26
	Range	14.30-14.80	53.40-54.70	5.70-6.70	147.80-148.60	13.50-14.60	17.30-17.80
Chilli	Mean ± SD	20.7±.20	42±.36	11±.66	281±.26	29.10±.20	79.50±.36
	Range	20.50-20.90	41.70-42.40	10.40-11.70	280.80-281.30	28.90-29.30	79.20-79.90
Red Amaranth	Mean ± SD	191±0.8	210.1±.29	58.1±.53	260±.53	31.1±.20	41.50±.26
	Range	190-193.60	209.70-210.89	57.70-58.70	260.20-261.20	30.90-31.10	41.30-41.80

Table 3. Pearson correlation coefficient matrix for vitamin C and minerals in the vegetables sample

	Pearson Correlations					
	Ca	Mg	Na	K	P	Vit C
Ca	1					
Mg	.897**	1				
Na	.425*	.776**	1			
K	.219	.422*	-.168	1		
P	.038	.048	-.133	.574**	1	
Vit C	.553**	.153	.435*	.056	-.057	1

. Correlation is significant at the 0.05 level (2-tailed);. Correlation is significant at the 0.01 level (2-tailed).*

vegetables, followed by *Carica papaya* (54±.66 mg/100g), *Phaseolus vulgaris* (49.50±.30 mg/100g), *Pisum sativum* (45.40±.43 mg/100g). In *Amaranthus Cruentus,* authors found magnesium as 248 mg/100g [18, 24], Valcárcel-Yamani and Lannes [16] found ranged at 279.2 - 319.0 mg/100g which was higher than the present study. Okon et al. [25] found 22.33± 0.88 mg/100g in raw *Carica papaya*, Ali et al. [26] as ranged between 10 to 33 mg/100g which was contrasting with present research. In this study, *Solanum lycopersicum* contains the lowest amount of magnesium 9±.45 mg/100g. This value was similar to the findings of Anjum et al. [27] as ranged between 9.73 to 31.5 mg/100g, Suaréz et al. [28] as ranged between 7 to 13 mg/100g. But lower than previous data stated by some authors Nour et al. [29] as 13.77 to 32.58 mg/100g and Costa et al. [30] as 12 to 20 mg/100g.

3.4 Content of Sodium (Na)

Sodium is an important mineral and electrolyte necessary for many functions in the body. It has an important role in maintaining water balance within cells and is involved in the proper functioning of both nerve impulses and muscles within the body. Sodium among the various vegetable was found to be concentrated in *Amaranthus cruentus* (58.1±.53 mg/100g) than all other vegetables samples, followed by *Momordica dioica* (51.10±.53 mg/100g), *Moringa oleifera* (41±.36 mg/100g). *Cucumis sativus* was having the least sodium content of 2.1±.26 mg/100g, compared to *Musa paradisiaca* with 3.7±.20 mg/100g (Table 2). Different authors reported the level of sodium in *Amaranthus cruentus* was 4 mg/100g which was much lower than the present study [18, 24]. Salvi and Katewa [31] reported sodium as 58 mg/100g in *Momordica dioica* which was similar to this study but in contrast, Kumar et al. [32] found lower content of sodium as 2.8±0.2 mg/100g. The author found the least content of sodium in *Cucumis sativus* which was similar to the study of Abbey et al. [22] as 2.43 mg/100g, but higher than Olayinka and Etejere [33] as 0.112 mg/100g. The present found a higher level of Na comparatively than the other studies. It is maybe due to the water salinity of the study area.

3.5 Content of Potassium (K)

Potassium is the most abundant cation in intracellular fluid, where it plays a key role in maintaining cell function, particularly in excitable cells such as muscles and nerves [34]. In the present study, Potassium content among the various vegetables was found to be higher in *Cucurbita pepo* (384±.56 mg/100g) flesh than all other vegetable samples, followed by *Vigna unguiculata* (302±.55 mg/100g), *Capsicum frutescens* (281±.26 mg/100g). *Cucumis sativus* was having the least potassium content of 144.20±.53 mg/100g, compared to *Carica papaya* with 148.20±.44 mg/100g (Table 2). Various researchers found a variety range of potassium content, Faiku et al. [35] found 172.31 mg/100g in flesh, Elinge et al. [36] 237.24±0.09 mg/100g in the seed of *Cucurbita pepo* which was lower than this study. In contrast, Syed et al. [37] found much higher (809.0 mg/100g) than the present study. Emmanuel-Ikpeme et al. [13] found 331.32±0.02 mg/100g and Raimi et al. [38] found lower content of potassium (98.80±0.15 mg/100g) in *Capsicum frutescens.* Abbey et al. [22] found 145.55 ± 0.3 mg/100g and Labban et al. [39] found 147.03±0.25 mg/100g in *Cucumis sativus* which was similar to this study.

3.6 Content of Phosphorus (P)

Phosphorus is an essential mineral required for cell structure, signaling, energy transfer, and other important functions. The main function of phosphorus is in the formation of bones and teeth. Phosphorus content among the various vegetables was found to be higher in *Moringa oleifera* (108±.36 mg/100g) than all other vegetable samples, followed by *Pisum sativum* (105.60±.53 mg/100g), *Cucurbita pepo* (91±.66 mg/100g). *Benincasa hispida* was having the least phosphorus content of 13±.36 mg/100g, compared to *Carica papaya* with 14±.55 mg/100g (Table 2). Gopalakrishnan et al. [40] and Witt [41] observed the level of phosphorus in *Moringa oleifera* was ranged between 90 to 112 mg/100g which supports the present study. In contrast, Sahay et al. [42] and Abbas et al. [43] found 70 mg/100g and 70.8 mg/100g respectively. The different authors found a different value of phosphorus in *Cucurbita pepo.* Adebayo et al. [44] found 118.30 ± 0.10 mg/100g which was higher than this study. Elinge et al. [36] and Hashash et al. [45] observed lower content of phosphorus as 47.68±0.04 mg/100g and 27.47 mg/100g respectively. Saxena et al. [46] found 19 mg/100g phosphorus in *Benincasa hispida* approximate to this study. The differences in the mineral content of the vegetable plant might be due to soil compositions and the rate of uptake of minerals by an individual plant [7, 47].

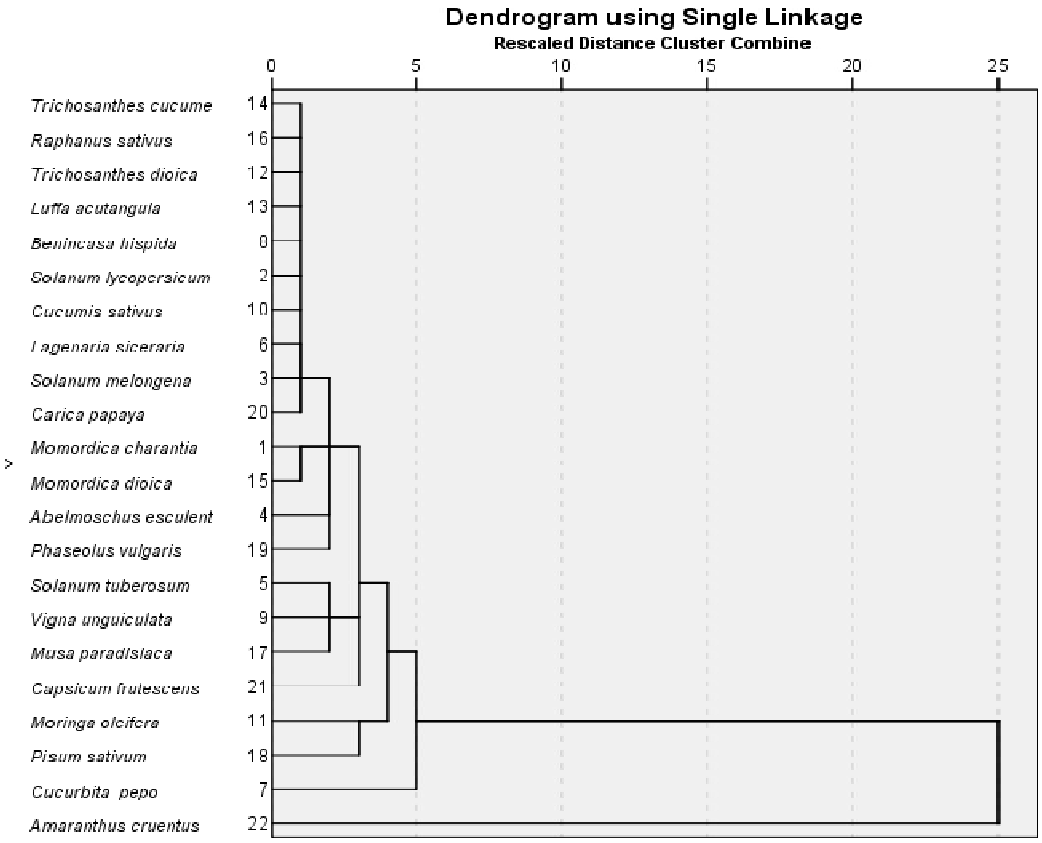

Fig. 2. Cluster analysis of vegetables samples collected from Patuakhali district, Bangladesh

3.7 Source Analysis of Minerals and Vitamin-C

Pearson's correlation coefficient was performed to see if some mineral and vitamin-C interrelated with each other and the results are presented in Table 3. The calcium showed significant positive correlation with magnesium (r=.897**), sodium (r=.425*) and vitamin-C (r=.553**). Similarly, magnesium showed a significant positive correlation with sodium (r=.776**) and potassium(r=.422*). Besides that significant positive correlation was found among sodium-vitamin-C (r=.435*) and potassium-phosphate (r=.574**). Other relationships among the constituents of vegetable samples were not significant. Considering the relationship between the combinations showed a positive significant relationship which indicates the parameters were interrelated with each other and maybe originated from the same sources of the study area [48]. Furthermore, using the overall nutrient content in vegetable samples, cluster analysis (CA) with dendrogram using Nearest neighbor method was adopted to divide the vegetable samples into several groups as shown in Fig. 2. Different clusters were formed between different selected vegetables, where the vegetables in each group were of similar growing nature. Moreover, based on nutrient concentrations in some vegetable groups showed strong significant correlations by forming primary groups/clusters with each other (Fig. 2).

4. CONCLUSION

This study indicates that there are significant differences in the vitamin-C and mineral composition of different species of fresh vegetables. The results obtained from the proximate analysis of all species of vegetable showed that they are good sources of vitamin-C, minerals such as Ca, Mg, Na, K and P. Based on the results of the analysis, it appears that the

vegetable species studied are highly nutritious and compared favorably with other nutritious food materials. Therefore, it can be concluded that these vegetable species are good sources of nutrients. Further study should be conducted on the assessment of different minerals and vitamins in vegetables for food and nutritional security in the study area.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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