A Seminar Paper on

Minor Indigenous Fruits and Vegetables for Nutritional Security of Bangladesh

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Minor Indigenous Fruits and Vegetables for Food and Nutritional Security of Bangladesh[1]

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ABSTRACT

Minor indigenous fruits and vegetables are those that are indigenous to this nation but whose cultivation is restricted or which are only grown as weeds. 25 vegetable species and a total of 225 fruit species have been identified as minor indigenous in Bangladesh. In order to source the dietary needs to guarantee food and nutritional security, this paper reviews the research works on minor indigenous fruits and vegetables. They were discovered to be abundant sources of micronutrients, vitamins, and secondary metabolites that promote health in sufficient amounts. Protein, total sugar content was highest in wood apple and hog plum. The Burmese grape contained the highest amount of fiber and carbohydrates. The content of Na, K, Ca, Mg, and P in these fruits ranged from 1-22mg/100g, 10.7-427 mg/100g, 5.8-102 mg/100g, 0.31-32.84 mg/100g, and 3.1-57mg/100g, respectively, and was, in most cases, higher than that of major fruits (mango and banana). According to reports, all of the minor indigenous fruits contain vitamin C in addition to other vitamins. They also had higher phenol contents than major fruits, with aonla having the highest total phenol content (474 mg GAE/100g). Minor indigenous vegetables had higher content of crude fiber (1.93-17.70%), TSS (3.0-7.0%), and vitamin C (30.20-244.0 mg/100g) than major ones- brinjal and bitter gourd. Their flavonoid content was also higher than brinjal. The outcome of this study suggested that minor indigenous fruits and vegetables had excellent nutritional potential and could easily satisfy the recommended dietary allowance. Hence, it is important to promote them for food and nutritional security which require further research.

Keywords: minor indigenous, nutrition, seasonality, food security

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CHAPTER 1

INTRODUCTION

Bangladesh, located between 20°34' and 26°38' north latitude and between 88°01' and 92°41' east longitude, is a predominantly rural agricultural country in South Asia with a subtropical monsoon climate. With an area of 148,460 square kilometers and a population of over 165 million, is the eighth most populous country in the world (The World Factbook, 2023). Agriculture is the largest employment sector in Bangladesh, accounting for 14.2% of GDP in 2017 from 20081000 acres of net cropped area (BBS, 2022). Fruit and vegetable planted areas are 1008190 and 1100862 acres respectively with total production of 4939092 MT and 4576225 MT (BBS, 2022). A number of fruits and vegetables are grown in Bangladesh, but only five from each category- mango, banana, jackfruit, watermelon, papaya, potato, eggplant, tomato, gourd and radish currently dominate the market. It accounts for about 73% and 62% of total annual production respectively (The Business Post, 6 Oct, 2021 and 3 June, 2022).

Although the production has increased from the previous years it is not sufficient to meet the demand created by a population growing at a rate of about 1.03% per annum (United Nations - World Population Prospects, 2022). The average Bangladeshi eats a total of 212g of fruit and vegetables daily against the minimum daily requirement of 400g of vegetables and fruit recommended by Food and Agriculture Organization (FAO) and the World Health Organization (WHO) (Rahman *et al*., 2022). This creates a large imbalance in the availability of calories, proteins, minerals and vitamins. In addition, malnutrition problem is quite prevalent in the country. It has been reported that about 40% of people suffer from vitamin-A and 91% from vitamin-C, while 30% lack of sufficient minerals viz., calcium, iron and phosphorus. Incidence of infant mortality and health problem in growing children and pregnant women are also high due to micronutrient and vitamins deficiency (Bhuyan and Uddin, 2010). These deficiencies can be greatly minimized by increasing the availability of fruits and vegetables as they are an important component of a balanced human diet and are also the main driving force in achieving global food security by providing nutrients, vitamins and minerals.

Food security is often discussed in terms of food availability, but its four fundamental parts are food availability, access, use and stability. Food security is the continuous economic, social and physical access of all populations to adequate, nutritious and hygienic food that meets their

nutritional needs to enable an active lifestyle. Development and poverty elevation can be achieved by ensuring adequate food security over the entire demographic spectrums; individual, household, national, regional and global levels (FAO, 2004). Bangladesh ranks as the most vulnerable country for potential negative impacts on agricultural production and food security challenges from accelerated sea level rise associated with climate change, floods, cyclones and coastal storms (Rabbani *et al*., 2013). Much of fruit and vegetable production depends on mainstream varieties, but underutilized native fruit and vegetable varieties can be a potentially valuable resource for health and food security.

"Indigenous" means native to that country or region. Fruits and vegetables originated from Bangladesh or other parts of South Asia are classified as indigenous. Indigenous or traditional fruits and vegetables have very substantive biodiversity. They are adapted to local agroecological conditions, require few inputs of production to grow, are usually hardy and can withstand more harsh and difficult environments. As long as they are grown in our growing system, they do not have any significant pest or disease problems and require little or no pesticide use. They are considered as crucial food sources for fighting hunger and malnutrition and supporting agriculture and rural development. Especially in developing countries where most of them are native species and are mainly cultivated and accepted as food (FAO, 2012). They are generally considered to have a superior nutritional composition compared to most commonly consumed staple foods (Hunter *et al*., 2019). Indigenous fruits and vegetables with limited cultivation and grown as volunteers in specific habitats or as weeds are classified as underutilized or minor indigenous fruits (IFs) and vegetables (IVs). In Bangladesh, a good number of nutritious local fruits and vegetables are grown without or with low maintenance in areas near farms, woodland areas, roadsides and railroad tracks. Currently, there is a lot of scientific information that we do not know about indigenous fruits and vegetables. For example, not all are well documented including their nutritional compositions, seasonal availability, production status etc. Which calls for further research involving the great variety of minor indigenous fruit and vegetables that are available in our country to address their potential in providing food and nutritional security.

The present study was conducted with the following objectives:

-To explore the nutritional aspects of some minor indigenous fruits and vegetables.

-To evaluate their potentiality in food and nutritional security of Bangladesh.

CHAPTER 2

MATERIALS AND METHODS

This seminar paper is completely a review paper. So, no specific methods of studies are involved to prepare this paper. This paper mainly depends on the secondary data. Different published reports of different journals mainly supported in providing data for this paper. During the preparation of this paper, I also went through various relevant reports, magazines etc. For collecting recent information internet browsing was also being practiced. Good suggestions, valuable information and kind consideration from my honorable major professor and course instructors were taken to enrich this paper. After collecting necessary information, it was compiled and arranged chronologically for better understanding and clarification.

CHAPTER 3

REVIEW OF FINDINGS

3.1 Global food and nutritional security

Escalating population is estimated to reach nine billion heads by 2050 and feeding this rising number of people raises a serious concern in terms of food security & nutritional quality (Buttriss & Riley, 2013). While the proportion of undernourished people in the Asia-Pacific region has decreased by half between 2000 and 2015 in line with the Millennium Development Goals, there are still about 490 million undernourished people worldwide (62% of the total), of whom 281 million live in South Asia (Li & Siddique, 2020). Stunting appears to be the most common outcome of malnutrition and 90% of stunted children reside in 36 countries of the world (Akhtar, 2016). Asia is the house of around 70.0% of the world's malnourished children. As a result of malnutrition, Bangladesh had 24.67% stunted, 9.75% wasted, roughly 20.57% underweight, and 6.80% overweight children under the age of five in 2019 (Hossain *et al*., 2020). Bangladesh is also one of the five countries with severe micronutrient deficiencies. The difference between the growth of the human population and the supply of food is growing significantly every day. Additionally, a lot of people typically eat a diet high in cereal, which eventually led to nutrient deficiencies. Consequently, it has been very difficult to give future generations access to nutritious sources that are both safe and healthy. Therefore, the researchers emphasized the need to look for some alternative food sources that must be healthy and accessible and do not include conventional foods in order to meet the demand for food and nutrition. Minor indigenous fruits and vegetables have become a notable food alternative in this regard (Shaheen *et al*., 2017). They are affordable for the low-income segment of the economy because they are locally accessible. To fully utilize minor indigenous fruits and vegetables' contribution to food and nutritional security, they must be incorporated into the mainstream diet.

3.2 Minor indigenous fruits (IFs) in Bangladesh

Bangladesh possesses an immense potential to produce wide range of tropical and sub-tropical fruits. A total of 255 minor edible fruit yielding species belonging to 149 genera under 61 families have been documented (Pasha & Uddin, 2019). Table 1 contains the botanical information of 20 of the fruit species under minor indigenous category.

Table 1. List of minor indigenous fruits

Sl. no.	English name	Local name	Scientific name	Family
1.	Aonla	Aamlaki	*Phyllunththus emblica* L.	Phyllanthaceae
2.	Hog plum	Amra	*Spondias mombin* L.	Anacardiaceae
3.	Cucumber tree	Bilimbi	*Averrohoa bilimbi* L.	Oxalidaceae
4.	Elephant apple	Chalta	*Dillenia indica* L.	Dilleniaceae
5.	Monkey Jack	Dewa	*Artocarpus lakoocha*	Moraceae
6.	Citron	Jara lebu	*Citrus medica*	Rutaceae
7.	Melanesian papeda	Satkara	*Citrus macroptera*	Rutaceae
8.	Ber	Sour kul	*Ziziphus mauritania*	Rhammaceace
9.	Toikar	Toikar	*Garcinia pedunculata*	Clusiaceae
10.	River ebony	Deshi gab	*Diospyros discolor*	Ebenaceae
11.	Governor's plum	Boichi	*Flacourtia indica*	Flacourtiaceae
12.	Indian plum	Lukluki	*Flacourtia jangomas*	Flacourtiaceae
13.	Red pear	Gutgutia	*Protium serratum*	Burseraceae
14.	Cowa	Kawphal	*Garcinia cowa*	Clusiaceae
15.	Burmese grape	Lotkon	*Baccaurea ramiflora*	Phyllanthaceae
16.	Karanda	Karamcha	*Carissa carandas*	Apocynaceae
17.	Wood apple	Bael	*Aegle mermelous*	Rutaceae
18.	Star Gooseberry	Orboroi	*Phyllanthus acidus*	Euphorbiaceae
19.	Longan	Kath lichu	*Dimocarpus longan*	Sapindaceae
20.	Water chestnut	Paniphol	*Trapa bispinosa*	Trapaceae

(Source: Molla *et al*., 2021, Shajib *et al*., 2013, Hossain *et al*., 2021)

3.2.1 Dietary importance of minor indigenous fruits

Fruits yield colorful, flavored, diverse, low caloric, tasty and nutritionally rich nourishment. They are considered rich sources of some essential dietary micronutrients and dietary fiber, and more recently they have been recognized as important sources of a wide array of phytochemicals that individually or in combination may benefit health (Yahia, 2017). Minor indigenous fruits have been documented to possess superior nutritional qualities. They help to prevent deficiency symptoms from many nutritional deficiency diseases particularly in marginal and communities around urban suburbs of developing countries (Hossain *et al*., 2021).

3.2.1.1 Biochemical composition

Table 2. Comparison of selected major and minor indigenous fruits in respect to biochemical composition

	Parameters	Edible portion (%)	Protein (%)	Total sugar (%)	Carbohydrate (%)	Fiber (%)
Major Fruit	Mango	61.28	1.11	4.71	12.83	2.72
	Banana	68.00	5.42	12.23	16.59	0.68
Minor fruit	Aonla	84.62	2.87	7.32	7.11	3.70
	Hog plum	47.59	1.06	5.64	13.90	1.87
	Cucumber tree	98.00	3.70	4.07	4.13	0.62
	Karanda	89.56	0.40	2.63	12.38	2.79
	Elephant apple	79.03	3.26	4.13	4.71	3.54
	Toikar	84.41	2.39	4.02	4.85	5.50
	Ber	88.37	3.18	4.35	4.15	4.76
	Burmese grape	44.50	5.58	4.42	51.90	21.40
	Wood apple	71.50	8.16	5.01	39.25	2.90
	Star Gooseberry	92.50	0.25	4.50	4.80	0.60

(Source: Molla *et al*., 2021, Ara *et al*., 2015, Agatonovic-Kustrin *et al*., 2018)

Edible portion

Edible portion is the part of the food which is eaten by the people. It is expressed in percentage, which is equivalent to portion of food eaten by people x 100/as purchased weight of the food. Edible portion of minor IFs ranged from 44.50% to 98% with the highest percentage in cucumber tree fruit and lowest in burmese grape. Most of the minor IFs had edible portion in a range of 70% to 90%. Whereas mango and banana had a moderate percentage of edible portion with 61.28% and 68.00% respectively.

Protein

The protein content of minor IFs ranges from 0.25% to 8.16%. Wood apple has the highest amount of protein (8.16%) and relatively higher amount was observed in burmese grape (5.58%) both being higher than mango and banana in protein content.

Total sugar content

Total sugar content of the minor fruit ranged from 2.63 to 7.32% with the maximum content recorded for aonla (7.32%) which is higher than that of mango (4.71%). The minimum was recorded for karanda (2.63%). Most of the minor Ifs had a total sugar content within the range of 4-5% which is almost similar to that of mango.

Carbohydrate

Among the minor Ifs, amount of carbohydrate was highest in burmese grape (51.90%) and relatively higher percentage was in wood apple (39.25%), hog plum (13.90%), and karanda (12.38%). The lowest was in cucumber tree (4.13%). The minor IF Burmese grape and wood apple contains much higher carbohydrate than mango (12.83%) and jackfruit (16.59%).

Fiber

Fiber consists largely of cellulose (60-80%) and lignin (4-6%) plus some mineral matter. These Fibers are beneficial in treating or preventing constipation, hemorrhoids, diverticulosis, coronary heart diseases, and some type of cancer (Madhu *et al.*, 2017). The fiber content of the selected minor IF ranged between 0.60 to 21.40%. The minimum amount of fiber was calculated as 0.60% for star gooseberry and maximum was calculated for burmese grape (21.40%). Relatively higher amount was found in toikar (5.50%), ber (4.76%) and aonla (3.70%). When compared to mango (2.72%) and banana (0.68%), most of the minor IFs had more or similar amount of fiber percentage.

3.2.1.2 Mineral elements

Minerals are the inorganic components present in foodstuff as ash when food is burned. Different mineral elements such as sodium, potassium, iron, calcium and many other trace elements are essential for the human body. It is reported that sodium and potassium are the main cations which are located in every cell of the body to regulate the acid-base balance, nerve and muscle contraction and to maintain the plasma volume (Akpanyung, 2005) and phosphorus is the

principal element in the structure of the nucleus and cytoplasm of all tissue cells (Berdanier *et al.*, 2007). Minor IFs are rich sources of all essential minerals that have been documented in Table 3.

Table 3. Macro and micromineral composition of selected major and minor indigenous fruits

Parameters (mg/100g)		Na	K	Ca	Mg	P	Fe	Zn	Cu
Major fruits	Mango	34.03	10.23	19.45	14.00	1.54	4.29	0.87	1.05
	Banana	4.00	326.00	5.00	22.00	28.00	0.40	0.16	0.10
Minor indigenous fruits	Aonla	4.20	282.00	27.60	28.20	11.80	3.30	1.80	0.28
	Hog plum	5.55	32.84	11.03	32.84	15.09	0.33	-	0.11
	Cucumber tree	1.80	10.70	5.80	0.31	3.10	3.21	0.04	0.41
	Toikar	18.00	37.00	87.00	21.00	49.00	23.82	2.23	39.55
	Ber	22.00	87.00	102.0	12.00	57.00	15.57	1.07	15.57
	Burmese grape	9.49	198.00	52.20	17.10	11.30	1.48	0.90	0.25
	Wood apple	-	427.00	70.30	22.70	16.70	2.23	0.43	2.02
	Star Gooseberry	1.00	104.00	10.80	5.70	3.60	1.17	0.67	0.10
	Karanda	-	207.00	26.20	14.40	7.50	0.95	0.67	0.25
	Elephant apple	19.00	108.00	54.00	11.00	28.00	8.39	1.78	15.77

(Source: Shajib *et al*., 2013, Molla *et al*., 2021)

The amount of sodium, potassium, calcium, magnesium and phosphorus in these fruits varied from 1-22mg/100g, 10.7-427 mg/100g, 5.8-102 mg/100g, 0.31-32.84 mg/100g, 3.1-57mg/100g respectively. Ber had the highest amount of sodium and calcium while wood apple and hog plum had the highest amount of potassium and magnesium respectively. Mango contained more sodium (34.03 mg/100g) but less potassium (10.23 mg/100g) and phosphorus (1.54 mg/100g) than any of the minor fruits. Many of the minor fruits had more calcium and magnesium than mango that had 19.45 mg/100g Ca and 14 mg/100g Mg. The micromineral content of minor IFs varied from 0.33-23.8 mg/100g for iron, 0.43-2.23mg/100g for zinc and 0.1-39.55 mg/100g for copper with the highest content being available in toikar. Mango contained higher amount of Fe (4.29mg/100g), Zn (0.87mg/100g) and Cu (1.05mg/100g) than some the minor IFs, but many of them were higher in those micromineral content than mango and most them were higher in content than banana (0.40, 0.16, 0.10 mg/100g Fe, Zn and Cu respectively).

3.2.1.3 Vitamin contents

The vitamin comprise a diverse group of organic compounds required by humans or animals in small amount to ensure normal growth and maintenance of health. Vitamins are essential micronutrients because humans can't synthesize such compounds in amounts adequate for daily needs. Plants have the ability to synthesize most of the vitamins and serve as primary sources of these dietary essentials. An insufficiency of a vitamin in human diet or its poor absorption from the digestive tract, frequently induces a disease with characteristic symptoms. Fruits as taken raw retain all of its nutrients and body can absorb them easily.

Table 4. Vitamin constitutions of some minor indigenous fruits of Bangladesh

	Vit A	Thiamine	Riboflavin	Niacin	Vit C
Aonla	✓	✓	✓	✓	✓
Hog plum	✓	✓	✓		✓
Cucumber tree	✓	✓	✓		✓
Elephant apple					✓
Monkey Jack	✓	✓	✓		✓
Melanesian papeda					✓
Ber	✓	✓	✓	✓	✓
Toikar					✓
Indian plum	✓	✓	✓		✓
Cowa	✓		✓		✓
Burmese grape		✓	✓		✓
Karanda	✓	✓	✓		✓
Wood apple	✓	✓	✓	✓	✓
Star Gooseberry		✓	✓		✓
Longan	✓				✓

(Source: Rahman *et al*., 2014)

Minor IFs are rich source of vitamins. All the minor IFs of Table 4 contained vitamin C. Vitamin A was present in almost all the fruits except elephant apple, Melanesian papeda, toikar, Burmese grape and star gooseberry. Thiamine and riboflavin were also present in almost all of the minor IFs. Niacin availability in minor IFs was rare, it was only present in aonla, ber and wood apple.

3.2.1.4 Phenolic content

Phenolic compounds are the largest group of phytochemicals found in plants. Polyphenolic compounds are the major contributors to the antioxidant properties of fruits and vegetables. To

date, only a very limited information on phenolic compounds is available for the scientific community, especially phenolic compounds in the minor fruits yet the available data informs that minor indigenous fruits are great source of total phenol contents shown in Figure 1.

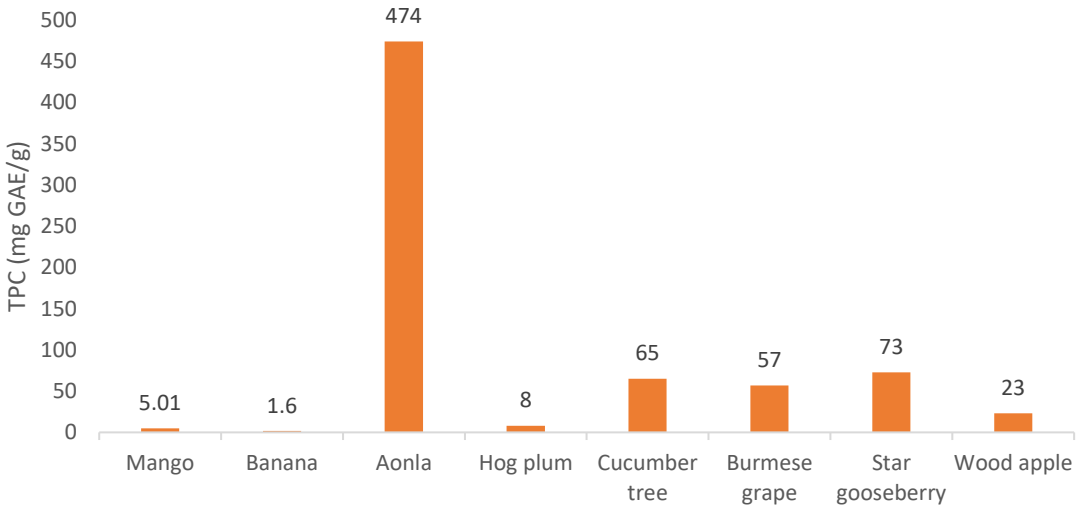


Figure 1. Total phenolic content (TPC) comparison of selected major and minor IFs

(Source: Agatonovic-Kustrin *et al*., 2018, Sulaiman *et a*l., 2011, Rahman *et al*., 2016, Oladunjove *et a*l., 2021, Hasanuzzaman *et al*., 2013, Sultana *et al*., 2022, Chakraborty *et al*., 2012, Hazra *et al*., 2020)

Figure 1 shows that aonla had the highest amount of TPC, 474 mg GAE/g. Comparatively lower TPC was observed in star gooseberry (73 mg GAE/g), cucumber tree (65 mg GAE/g) and Burmese grape (57 mg GAE/g). The lowest amount of TPC was available in hog plum (8 mg GAE/g) followed by wood apple (23 mg GAE/g). TPC of Mango and banana was 5.01 and 1.6 mg GAE/g respectively which was lower than any of the minor IFs. It depicts that minor IFs had higher antioxidant capacity than major fruits.

3.3 Minor indigenous vegetables (IVs)

A wide range of vegetables are being grown in Bangladesh. About 98 species of vegetables have been documented. Among them 45 vegetables are reported as indigenous and 20 are classified as major and 25 as minor indigenous vegetables (Saifullah *et al*., 2011). Table 5 contains the botanical information of 20 of the vegetable species under minor indigenous category.

Table 5. List of minor indigenous vegetables

Sl.	English name	Local name	Scientific name	Family	Edible part
1.	Winged bean	Kamranga sheem	*Psophocarpus tetragonolobus*	Leguminaceae	Pod, seed, tuberous root
2.	Sword bean	Makhan sheem	*Canavalia ensiformis*	Leguminaceae	Pod, seed
3.	Lima bean	Rukuri	*Phaseolus limensis*	Leguminaceae	Pod, seed
4.	Yam bean	Sakalu	*Pachyrrhizus tuberosa*	Leguminaceae	Pod, seed
5.	Water spinach	Kalmi shak	*Ipomoea aquatica*	Convolvulaceae	Leaf, stem
6.	Ivy gourd	Talakuchi	*Coccinia grandis*	Cucurbitaceae	Fruit
7.	Tripatri leaves	Tripatrishak	*Desmodium triflorum*	Leguminaceae	Leaf
8.	Spiny amaranth	Katanotey	*Amaranthus spinosus*	Amaranthaceae	Leaf, stem
9.	Leaf amaranth	Shaknotey	*Amaranthus viridis*	Amaranthaceae	Leaf, stem
10.	Haicha	Chanchi	*Alternanthera sessilis*	Amaranthaceae	Leaf, stem
11.	Goose foot	Bathua	*Chenopodium album*	Chenopodiaceae	Leaf, stem
12.	Marsh herb	Helencha	*Enhydra fluctuans*	Compositeae	Leaf, stem
13.	Indian penny wort	Thankuni	*Centella asiatica*	Umbelliferae	Leaf
14.	Sorrel	Tak palang	*Rumex vesicarius*	Polygonaceae	Leaf
15.	Aligator weed	Malancha	*Jussiaea repens*	Onagraceae	Leaf
16.	Wood sorrel	Amrulshak	*Oxalis corniculata*	Oxalidaceae	Leaf
17.	Garden purslane	Nunia	*Portulaca oleracea*	Portulacaceae	Leaf
18.	Laffa	Laffa	*Malva verticillata*	Malvaceae	Leaf
19.	Fern	Dhekishak	*Dryopteris filix-mas*	Polypodiaceae	Leaf
20.	Water cress	Shachi	*Nasturtium officinale*	Cruciferae	Leaf

(Source: Saifullah *et al*., 2011, Hossain and Hasan, 2018)

3.3.1 Dietary importance of minor indigenous vegetables

Vegetables are the most inexpensive and effective vitamin sources. They enhance appetite; have great taste, high vitamins and dietary fiber contents, which results in enhanced digestion (Sachdeva *et al*., 2013). Indigenous vegetables are rich sources of essential nutrients, particularly

vitamins and minerals, and other non-nutritive phytochemicals for maintaining human health and strengthening resistance to disease and infection (Bokelmann *et al*., 2022)

3.3.1.1 Biochemical composition

Table 6. Comparison of selected major and minor IVs in respect to biochemical composition

Parameters		Edible portion (%)	Crude Fiber (%)	TSS (%)	Vit C (mg/100g)	Flavonoid (mg/100g)
Major IVs	Brinjal	81.00	1.92	3.23	6.57	19
	Bitter gourd	-	3.30	3.20	50.00	438
Minor IVs	Fern	46.40	17.70	3.00	47.60	47
	Marsh herb	51.29	11.95	5.00	30.20	57
	Leaf amaranth	51.32	1.93	6.33	65.60	78
	Indian penny wort	93.50	5.4	3.33	77.50	52
	Goose foot	60.87	4.0	4.33	72.20	68
	Wood sorrel	69.64	ND	7.00	244.00	87
	Aligator weed	49.47	25.5	5.00	70.33	69
	Water spinach	49.79	9.26	4.00	91.80	72

(Source: Dash *et al*., 2015, Satter *et al*., 2016, Quamruzzaman *et al*., 2020, Sorifa, 2018)

Edible portion

Edible portion of IVs are expressed in percentage as equivalent to portion of food eaten by people x 100/as purchased weight of the food. Edible portion of minor IVs ranged from 46.40% to 93.50% with the highest percentage in Indian penny wort and lowest in fern. Whereas brinjal had 81% of edible portion which was higher than most of the minor IVs.

Crude fiber

The crude fiber content of the wild vegetables presented in Table 6 was found between 1.93% and 17.70%, which was lowest in leaf amaranth and highest in fern. Most of the minor IVs had higher crude fiber content than that of brinjal (1.92%) and bitter gourd (3.30%).

Total soluble solids (TSS)

TSS states the amounts of soluble solids in liquid. The highest TSS (7.0%) was observed from wood sorrel following leaf amaranth (6.33%), marsh herb (5%) and alligator weed (5%). The

lowest TSS was observed in fern (3.0%) followed by Indian penny wort (3.33%). Brinjal and bitter gourd had TSS at 3.23% and 3.20% respectively that depicts that TSS percentage of minor IVs are greater or at least similar to that of major IVs.

Vitamin C

Vitamin C (Ascorbic acid) is the most important vitamin in fruits and vegetables. Except human and other primates, most of the phylogenetically higher animals can synthesize vitamin C (L-ascorbate). More than 90% of the vitamin C in human diets is supplied by fruits and vegetables. Vitamin C is defined as the generic term for all compounds exhibiting the biological activity of L-ascorbic acid (Kumar *et al*., 2013). Vitamin C content of the minor IVs was variable. The highest vitamin C content (244.00 mg/100g) was found in wood sorrel and the lowest (30.20 mg/100g) was recorded from marsh herb. Among the major and minor IVs brinjal had the lowest (6.57 mg/100g) vitamin C. The vitamin C content of another major IV-bitter gourd was 50 mg/100g which was considerably high but many of the Minor IVs had higher vitamin C.

Flavonoid

Flavonoids are considered as one of the major group of natural phenolics that have been reported to have highest antioxidant activity (Zihad *et al*., 2019). In Table 6, the flavonoid content of minor IVs ranged between 47-87 mg/100g. Wood sorrel possessed the highest and fern had the lowest flavonoid content. Major IV bitter gourd had fairly high flavonoid (438 mg/100g) but the flavonoid content of brinjal was lower (19 mg/100g) than any of the minor IVs.

3.3.1.2 Mineral elements

Generally macro- and microminerals are present in foodstuffs and play important metabolic roles in body functions (Molla *et al*., 2021), and contribute to our daily diet. The minerals compositions of some minor IVs like sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe) and zinc (Zn) are listed in Table 7.

Table 7. Mineral composition comparison of selected major and minor IVs

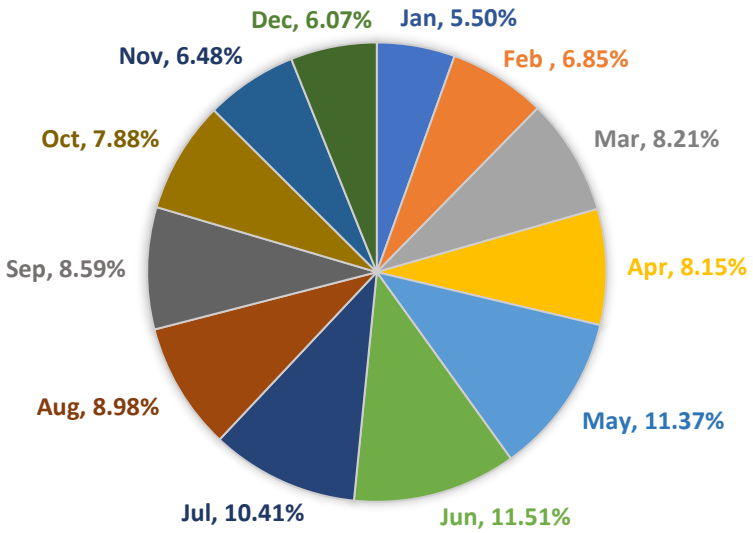
Minerals (mg/100g)		Na	K	Ca	Mg	Fe	Zn
Major IVs	Brinjal	4.14	131	30.27	19.30	1.44	0.22
	Bitter gourd	3.0	26.0	22.0	16.0	0.9	0.1
Minor IVs	Fern	94.40	1065	279	148	13.41	2.29
	Mersh herb	135	1253	902	57.38	23.34	4.38
	Water spinach	1092	2055	772	193	22.26	5.16
	Indian penny wort	21.20	377	176	104	4.10	10.9
	Spiny amaranth	-	679	419	265	14.4	0.32
	Goose foot	13.30	601	226	155	6.29	1.36

(Source: Satter *et al*., 2016, Punchay *et al*., 2020, Quamruzzaman *et al*., 2020, Sorifa *et al*., 2018.)

Among the minor IVs water spinach had the highest amount of Na (1092 mg/100g) and K (2055 mg/100g). The highest amount of Ca (902 mg/100g) and Fe (23.34 mg/100g) were recorded in mersh herb. Spiny amaranth had the highest amount of Mg (265mg/100g). While Indian penny wort had the maximum Zn (10.9 mg/100g) content, it was lowest in K (377 mg/100g), Ca (176 mg/100g) and Fe (4.10 mg/100g) content. In Table 7, the lowest amount Na, Mg, and Zn were possessed by goose foot (13.30 mg/100g), mersh herb (57.38 mg/100g) and spiny amaranth (0.32 mg/100g) respectively. Table 7 also shows that mineral contents of the two mentioned major IVs (brinjal and bitter gourd) were much lower than the minor IVs.

3.4 Seasonal availability of minor indigenous fruits and vegetables

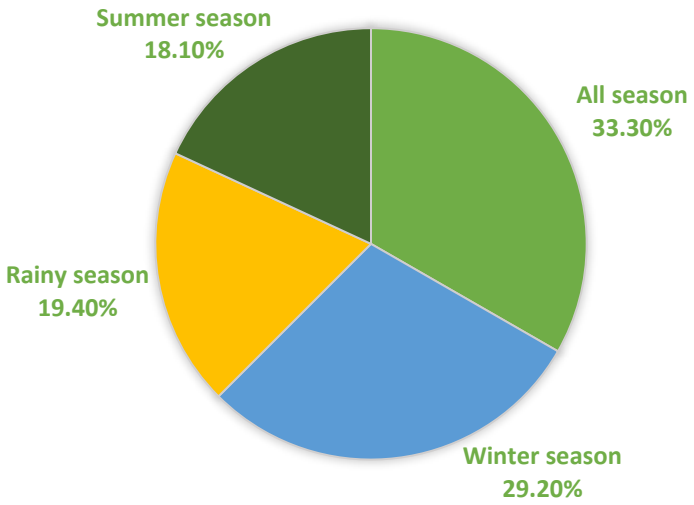
The flowering and fruiting time of the minor edible fruit yielding plant species varies significantly. Although the majority of minor fruit yielding plants are found fruiting in the months between March and September, the fruits are more or less available throughout the year. The month with the highest fruit yield is June (11.51%) followed by May (11.37%) and July (10.41%). The poorest fruit yielding month is January (5.50%) followed by December (6.07%) and November (6.48%) (Pasha & Uddin, 2019).



(Source: Pasha & Uddin, 2019)

Figure 2. Availability percentage of the edible minor fruits per month in a year in Bangladesh

Many of the indigenous vegetables grow wild, have short lifespan and can be cultivated 3-4 times a year. Considering the percentage of seasonal availability of these, 33.3% IVs found year-round, 29.2% collected winter season and 19.4% found in rainy season and 18.1% found in summer season. (Abdullah *et al*., 2020).

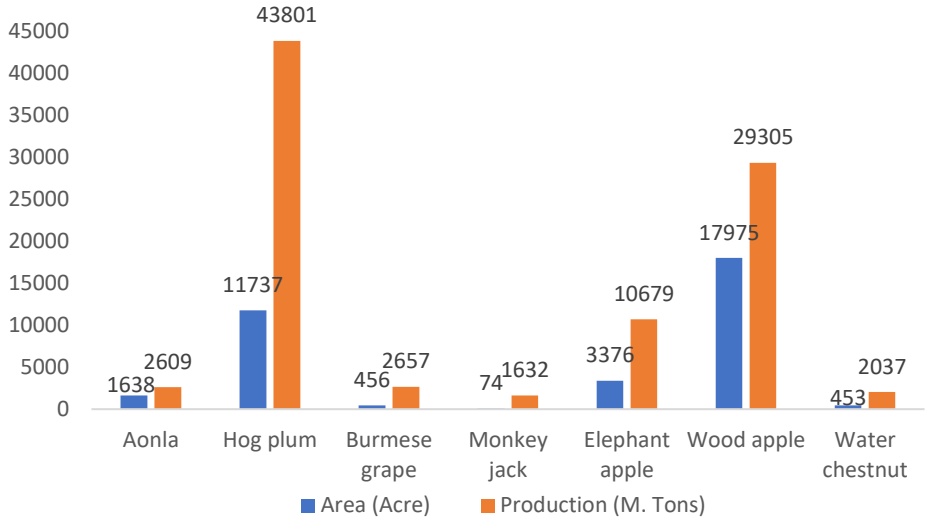


(Source: Abdullah *et al*., 2020)

Figure 3. Availability percentage of the minor IVs in Bangladesh

3.5 Production status of minor indigenous fruits and vegetables in Bangladesh

Minor fruit occupies 3.01% of the area and 8.38% of production compared to the total fruit production of Bangladesh (BBS, 2011). Current scenario of covered area and production some of the minor fruits are shown in Figure 4.



(Source: BBS, 2022)

Figure 4. Area and production status of some minor indigenous fruits

Wood apple covered the highest area among the minor indigenous fruits with 17975 acres. The second largest area was covered by hog plum with 11737 acres although the production of it was higher (43801 M. Tons) than wood apple (29305 M. Tons). Elephant apple placed third in area coverage with 3376 acres and also in production of 10679 M. Tons fruits in the year 2021-2022.

Many of the minor indigenous vegetables grow wild with minimum production inputs, with little or no human interference. They play an important role in daily nutritional requirement of rural people due to barriers of availability and price of exotic vegetables (Pearson *et al.*, 2014). Many of them are traditionally being used with staple food to enhance the taste and color of the diets in both urban and rural areas of Bangladesh. The economic potential of underutilized vegetables are poorly addressed so their role is confined to local and traditional uses mostly. Hence the area coverage and production status of different minor indigenous vegetables are not yet known.

3.6 Constraints for the utilization of minor indigenous fruits and vegetables in Bangladesh

Awareness among the people about the nutritional and medicinal value of minor indigenous fruits and vegetable crops and their lack of acceptability might be major constraints for their utilization. Lack of desirable seeds and planting material, innovative and novel technologies such as biotechnology, plasticulture restrain their productivity. Lack of knowledge about post-harvest management practices, limited and inadequate marketing support & infrastructure facilities for transportation, storage and processing are also drawbacks of proper utilization of resourceful minor indigenous fruits and vegetables. (Jena *et al*., 2018)

3.7 Strategies to succeed over the constraints

Raising awareness among common people about the rich nutritional potential of minor indigenous fruits and vegetables should be encouraged. Domestication of potential wild species through homestead cultivation should be emphasized. Increased focus to document indigenous knowledge is required such as through ethnobotanical studies. Strategies need to be worked out particularly at national and regional levels to develop and make available promising selections/varieties, overcoming constraints of production of good seed material, planting material, in-vitro/tissue cultured material etc. Development of improved production and processing practices is necessary for proper utilization of the minor indigenous fruits and vegetables. (Jena *et al*., 2018)

CHAPTER 4

CONCLUSION

Minor indigenous fruits and vegetables are embedded with rich nutrient potentials. Wood apple had the highest protein content of the studied minor indigenous fruits while burmese grape had the highest carbohydrate content, and aonla had the highest total phenol content. Wood apple had higher levels of macrominerals and toikar had higher microminerals. Additionally, vitamin C, A, thiamine, and riboflavin were also present in minor indigenous fruits under study. Alligator weed, one of the minor indigenous vegetables, had the highest crude fiber content and wood sorrel had the highest levels of vitamin C and flavonoids. Water spinach had higher mineral content.

Minor indigenous fruits and vegetables are available throughout the year, albeit in smaller quantities and with fewer varieties, but they are rich sources of phytochemicals and nutrients. Despite their acknowledged significance, these crops are underutilized because there is a lack of understanding regarding their nutritional value, a shortage of planting materials, and a lack of knowledge regarding the methods used in their production. Since increased consumption of nutrient-dense underutilized fruits and vegetables is helpful to combat malnutrition in the population in developing countries like Bangladesh, they need to be revitalized and brought back into the mainstream diet so that they can play their role in food and nutritional security. This study will assist the general public in understanding the nutritional potential of minor indigenous fruits and vegetables and create scope for conducting further research in enhancing utilization of them.

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