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PROXIMATE COMPOSITION AND PHYTOCHEMICAL ANALYSIS OF SIX MINOR FRUITS OF BANGLADESH

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Abstract

Nutritional composition of six minor fruits of Bangladesh namely, *Annona reticulata* L., *Manilkara zapota* (L.) P.Royen, *Aegle marmelos* (L.) Corrêa, *Diospyros malabarica* (Desr.) Kostel., *Averrhoa carambola* L. and *Garcinia pedunculata* Roxb. *ex* Buch-Ham. were studied. Dry matter, ash, crude fat, crude protein, crude fibre and crude carbohydrate contents largely varied among the studied fruits. All fruits exhibited the presence of alkaloids, flavonoids, terpenoids, tannins, phenols, and saponins. At premature stage, total phenolics and tannin contents varied from 14.59 to 1.32 and from 9.76 to 0.29 (mg GAE g^{-1} DW), respectively while at mature stage, these ranged from 9.82 to 0.87 and from 5.98 to 0.23. At premature and ripening stages, the maximum chlorophyll content was detected in *A. reticulata* and *M. zapota*, respectively. Based on the calorific value, *Garcinia pedunculata* performed better followed by *M. zapota*, and *A. carambola* the least among the studied fruits; although, *A. reticulata* possesses the largest amount of crude protein and crude fibre.

Introduction

Minor fruits grow mostly in a scattered and unattended way on roadsides, homestead lands, wastelands, village forests, etc. These are rich in phytochemicals and micronutrients such as antioxidants, polyphenols, flavonoids, minerals, and vitamins, which are essential for good health and nutrition, advancing physical and intellectual development (Ghosh 2017). These species act as life-support species in extreme environmental conditions and threatened habitats and have the tolerance to survive under harsh climatic conditions. Bangladesh has recently achieved self-sufficiency in rice production; however, hidden hunger, micronutrient deficiency, or malnutrition comes in front as a barrier/challenge to achieving the second SDGs (Harding *et al.* 2017). The minor fruits might be an option to fulfil the requirement deficits due to its localized availability and lower price.

Bangladesh, as a part of Vavilov's "Indo-Burma (Myanmar) Centre of Diversity", is rich in plant genetic resources including minor fruits, and a total of 255 underutilized, minor edible fruit-yielding species, belonging to 149 genera under 61 families, have been reported from this territory (Pasha and Uddin 2019). The minor indigenous fruits are rich in both macro- and microminerals; those 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). The collection and conservation of minor fruit genetic resources are on the priority list of the Botanical Garden, Department of Crop Botany, Bangladesh Agricultural University (BAUBG); on contrary, the fruit morphology and nutritional facts of these species were lesser studied (Hasan *et al*. 2014, 2016; Fakir *et al*. 2018). In the present study, the nutritional and phytochemical composition of six minor fruits of Bangladesh were analysed.

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Materials and Methods

Samples of six minor fruits *viz. Annona reticulata* L., *Manilkara zapota* (L.) P.Royen, *Aegle marmelos* (L.) Corrêa, *Diospyros malabarica* (Desr.) Kostel., *Averrhoa carambola* L. and *Garcinia pedunculata* Roxb. *ex* Buch-Ham., were collected, at two different stages of maturity, from the Botanical Garden, Department of Crop Botany, Bangladesh Agricultural University (24°26′ to 24°54′ N and 90°15′ to 90°30′ E) (Table 1). The growth (maturity) stage of different fruits was identified by visual colour change (Fakir *et al*. 2018). Morphological descriptors *viz.* length, diameter and weight of fruit, weight (fresh and dry), and percentage of edible portion, were measured for at least 10 samples for each harvest.

Table 1. Botanical description of minor fruits used in the present study.

Local name	English name	Botanical name	Family	Status
Nona-ata	Custard apple	*Annona reticulata* L.	Annonaceae	Native
Sofeda	Sapota	*Manilkara zapota* (L.) P.Royen	Sapotaceae	Exotic
Beal	Beal	*Aegle marmelos* (L.) Corrêa	Rutaceae	Native
Desi-gab	Malabar ebony	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae	Native
Kamranga	Star Fruit	*Averrhoa carambola* L.	Oxalidaceae	Exotic
Thoikar	Thoikar	*Garcinia pedunculata* Roxb. *ex* Buch-Ham.	Clusiaceae	Native

The fresh fruits were washed thoroughly 2-3 times with running tap water and fruit was left for air drying. The samples were dried under sunshade for several days, then samples were made ready for grinding. After complete shade drying the plant material was ground in an electric mixer, and the powder was kept in small plastic bags with proper labelling and stored in sterile bottles at 5°C for further use. The 50 g powdered plant samples were extracted successively with 250 ml methanol and the extracts were stored at 4°C for further use. Fresh plant samples were used for pigment analysis.

The proximate composition of minor fruits was determined at the Laboratory of the Department of Animal Science, Bangladesh Agricultural University following standard protocols described in Kabir *et al*. (2018).

The crude carbohydrate was calculated following Mundaragi *et al*. (2017).

Crude Carbohydrate (%) = 100 – [moisture (%) + protein (%) + fibre (%) + fat (%) + ash (%)]

Calorific value or the total energy value of fruits in kcal/100g was calculated (FAO 2003) with the help of the following equation.

Calorific value (kcal 100^{-1} g) = 4 × Protein (%) + 9 × Fat (%) + 4 × Carbohydrate (%)

The qualitative and quantitative analyses of different phytochemical constituents were conducted following different standard protocols *viz*. alkaloids (Kannamba *et al*. 2017), tannins & flavonoids (Kumar *et al*. 2007), saponins (Dhandapani and Sabna 2008), terpenoids (Edeoga *et al*. 2005), phenolics (Priyankar and Kumar 2013), total phenolic content (Singleton and Rossi 1965), and tannins content (Siddhuraju and Manian 2007).

All data were subjected to analysis of variance (ANOVA) using Statistix 10 for evaluating the variation among six minor fruit species at different maturity stages. Differences among means were determined using LSD at the 5% level of significance.

Results and Discussion

With a few exceptions, the growth of fruit size e.g., length, diameter and fresh weight, continued until ripening, although the growth rate declined after maturity (Table 2). The largest fruit was produced by *A. marmelos* (460 g fruit^{-1}) and the smallest (60.03 g fruit^{-1}) by *M. zapota*. The fresh and dry weight of the edible portion followed a similar trend. *Manilkara zapota* produces the smallest fruits with the highest percentage of an edible portion (96.34%) and *D. malabarica* produced the lowest (26.22%) (Table 2). The moisture content of the fruits was 64.6 - 92.3%. These variations are due to genetic differences among the fruits and characters of the species (Hasan *et al*. 2014, 2016).

The proximate analysis includes dry matter (% moisture), ash, crude fat (EE), crude protein (CP), crude fibre (CF) and total carbohydrate (TC). The proximate composition and calorific value of the fruits are presented in Table 3. The dry matter content varied from 89.24 to 96.15 g and ash 2.65 to 8.6 g; the amount of crude fat (EE), crude protein (CP), crude fibre (CF) and crude carbohydrate (CC) contents measured were 0.4-16.4, 1.75-7.8, 4.15-19.05 and 58.0-79.32 g 100^{-1} g of air-dried sample, respectively. The calorific value of *G. pedunculata* was the highest (433.2 and 403.81 kcal 100^{-1} g in premature and ripening stages, respectively) and the lowest in *A. carambola*, moreover, the fruit (edible) weight had little influence on the calorific value of fruits (Table 3). The moisture content might depend on the habitat and harvest time of the species. The ash content, which contains salts of metals and trace minerals, in the fruits is generally low (Islary *et al*. 2016). However, the ash content is relatively higher in minor fruits in the present research (Table 3). The per cent CP and CF of unripe fruit samples were very similar, however, a wide variation was observed in the proximate composition of ripe star fruit samples between Nigeria and Bangladesh (Edem *et al*. 2008). Although the amount of CP (%) and CF (%) were relatively smaller, the calorific value of *A. marmelos* was higher compared to Indian samples (Table 3; Singh *et al*. 2012). According to proximate composition, the minor fruits are better in all aspects compared to those of the common and major fruits of Bangladesh e.g., mango, banana, jackfruit, papaya, pineapple, etc. (Islam *et al*. 2010).

Phytochemical constituents of minor fruits were identified, measured, and presented in Table 4 and Figs 1-3. The existence of various bioactive compounds like alkaloids, flavonoids, terpenoids, tannins, phenols, and saponins was identified in all the minor fruits (Table 4). These secondary metabolites are the main sources of pharma- and nutraceuticals, food additives, fragrances, and biopesticides (Thoppil and Bishayee 2011; Kurek 2019; Janabi *et al*. 2020). Interestingly, the presence of terpenoids was observed only in the ripening staged fruit of *A. reticulata* and *G. pedunculata*. The total phenolic contents (mg GAE g^{-1} DW) in the methanol extract of the fruit varied from 14.59 to 1.32 in the premature stage and 9.82 to 0.87 in the mature stage (Fig. 1). The tannin contents (mg GAE g^{-1} DW) in the methanol extract of the fruit varied from 9.76 to 0.29 in the premature stage and 5.98 to 0.23 in the mature stage (Fig. 2). An overall trend of decrease in total phenolics and tannin content of fruits was observed from premature to mature stages except in *A. carambola* (Figs 1 and 2).

Chlorophyll a and b, and the total Chlorophyll contents were higher in the premature stage compared to the ripening stage. Chlorophyll a content in minor fruits varied widely and ranged from 0.43 to 0.27 mg g^{-1} FW at premature stage and 0.33 to 0.19 mg g^{-1} FW at ripening stage (Fig. 3); however, the trends were different. In the case of premature stage, the highest amount of Chlorophyll a was detected in *A. reticulata* >*M. zapota* > *A. marmelos* > *A. carambola* > *D. malabarica* > *G. pedunculata*; at the ripening stage, the trend was *M. zapota* > *D. malabarica* > *A. carambola* > *G. pedunculata* > *A. reticulata* > *A. marmelos*. Chlorophyll b content in minor fruits varied widely and ranged from 0.73 to 0.42 mg g^{-1} FW at the premature stage and 0.41 to 0.27 mg g^{-1} FW at ripening stage. The total Chlorophyll content in minor fruits also widely varied ranging

Table 2. Morphological parameters of minor fruits at premature and ripening stages.

Botanical names of fruits	Stages	Fruit			Edible portion		
		Length (cm)	Diameter (cm)	Fresh weight (g)	Fresh weight (g)	Dry weight (g)	Moisture (%)
Annona reticulata	Premature	6.60±0.49 d	19.05±0.32 e	112.33±0.47 f	98.29±0.22 f	25.42±0.55 e	74.1±0.58 fg
	Ripening	8.59 ±0.39 c	22.40±0.67 d	231.00±0.76 d	191.19±0.61 c	46.54±0.57 c	75.6±0.16 e
Manilkara zapota	Premature	4.19±0.59 e	11.86±0.17 h	26.58±0.55 k	24.8±0.51 j	5.40±0.44 i	78.2±0.61 d
	Ripening	5.72±0.19 d	15.42±0.85 f	60.03±0.26 h	57.83±0.67 h	14.67±0.69 f	74.6±0.49 ef
Aegle marmelos	Premature	8.43±0.65 c	25.70±0.69 c	278.90±0.75 c	168.08±0.61 d	55.72±0.49 b	66.8±0.56 h
	Ripening	10.16±0.19 b	31.42±0.61 a	460.02±2.89 a	289.21±1.03 b	77.43±0.58 a	73.2±0.13 g
Diospyros malabarica	Premature	3.56±0.13 e	12.07±0.57 h	30.42±0.76 jk	6.82±1.10 l	2.36 ± 0.11 j	65.4±1.03 i
	Ripening	4.62±0.45 e	14.91±0.19 fg	55.56±5.00 i	14.57±0.63 k	5.15±0.2 i	64.6±0.93 i
Averrhoa carambola	Premature	5.89±0.05 d	12.37±0.39 h	33.32±0.51 j	29.06±0.64 i	2.03±0.19 j	93.0±0.33 a
	Ripening	9.14±0.52 bc	26.04±0.58 c	127.47±0.54 e	105.72±0.85 e	8.18±0.19 h	92.3±0.56 a
Garcinia pedunculata	Premature	4.37±0.00 e	14.27±0.30 g	64.81±0.57 g	59.24±0.59 g	9.23±0.38 g	84.4±0.65 c
	Ripening	12.25±0.68 a	28.88±0.53 b	432.85±1 b	399.20±0.58 a	45.51±0.85 d	88.6±0.43 b
LSD (%)		1.086	1.111	3.936	1.139	0.983	1.179

Values are means±SEM (n = 10). In a column, dissimilar letters denote significant variation ($p < 0.05$).

Table 3. Proximate analysis of six minor fruits at premature and ripening stages.

Stage/Fruis	DM (%)	Ash (%)	CP (%)	CF (%)	EE (%)	CC (%)	CV (kcal 100^{-1} g)
Premature stage							
Annona reticulata	92.46±0.66 e	4.50±0.29 e	7.87±0.31 a	13.20±0.33 b	2.10±0.31 e	64.79±0.39 d	362.34±0.58 g
Manilkara zapota	94.41±0.50 b-d	2.90±0.38 g	2.62±0.11 f	11.85±0.51 c	0.70±0.22 f	76.34±0.26 c	369.54±0.58 e
Aegle marmelos	94.56±0.52 bc	5.90±0.17 c	5.25±0.20 c	4.95±0.69 e	0.70±0.06 f	77.76±0.07 b	358.14±1.00 h
Diospyros malabarica	93.46±0.21 de	5.70±0.52 cd	4.37±0.24 d	4.15±0.26 e	0.55±0.06 f	78.69±0.58 ab	353.79±0.95 j
Averrhoa carambola	89.85±0.58 gh	8.60±0.33 a	7.87±0.29 a	9.90±0.61 d	4.00±0.58 c	59.48±0.48 f	345±0.58 k
Garcinia pedunculata	90.45±0.48 fg	2.65±0.56 g	3.50±0.17 e	9.90±0.50 d	16.40±0.18 a	58.00±0.58 g	433.2±0.38 a
Ripening stage							
Annona reticulata	95.21±0.33 ab	6.30±0.22 bc	7.87±0.31 a	19.05±0.39 a	3.10±0.28 d	58.89±0.34 fg	371.14±0.63 d
Manilkara zapota	96.15±0.19 a	2.90±0.45 g	2.62±0.11 f	12.10±0.20 c	0.67±0.08 f	77.86±0.29 b	376.35±0.49 c
Aegle marmelos	94.28±0.15 b-d	3.60±0.61 f	7.00±0.56 b	4.60±0.48 e	0.40±0.05 f	78.68±0.44 ab	364.72±0.74 f
Diospyros malabarica	93.99±0.38 cd	5.65±0.58 cd	4.37±0.24 d	4.20±0.23 e	0.45±0.2 f	79.32±0.54 a	355.61±0.58 i
Averrhoa carambola	91.10±0.62 f	6.85±0.51 b	7.87±0.29 a	9.10±0.08 d	3.80±0.65 cd	63.48±1.09 e	356±0.58 i
Garcinia pedunculata	89.24±0.99 h	5.10±0.20 de	1.75±0.63 g	9.40±0.18 d	13.45±0.85 b	59.54±0.58 f	403.81±0.53 b
LSD (%)	1.059	0.675	0.653	0.345	0.757	1.026	1.322

DM = Dry matter, CP = Crude protein, CF = Crude fibre, EE = Ether extract (crude fat), CC = Crude carbohydrate, CV = Calorific value. Values are means±SEM (n = 3). In a column, dissimilar letters denote significant variation ($p < 0.05$).

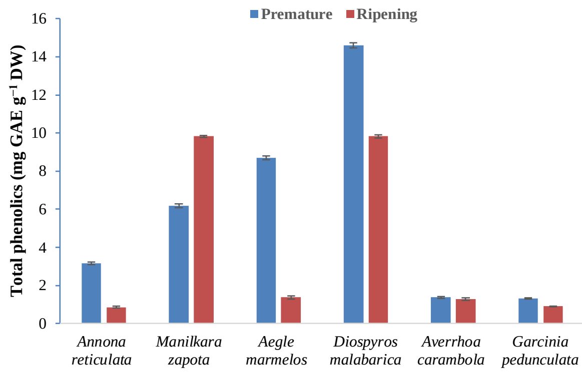

Fig. 1. Total soluble phenolics content in six minor fruits at pre-mature and ripening stages. Each data point is the average of three replicates (± SEM).

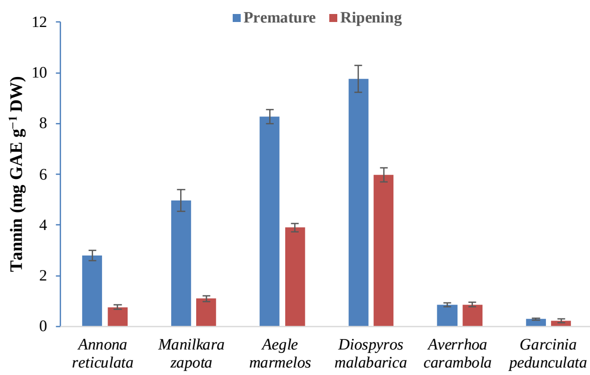

Fig. 2. The total soluble tannin content in six minor fruits at pre-mature and ripening stages. Each data point is the average of three replicates (± SEM).

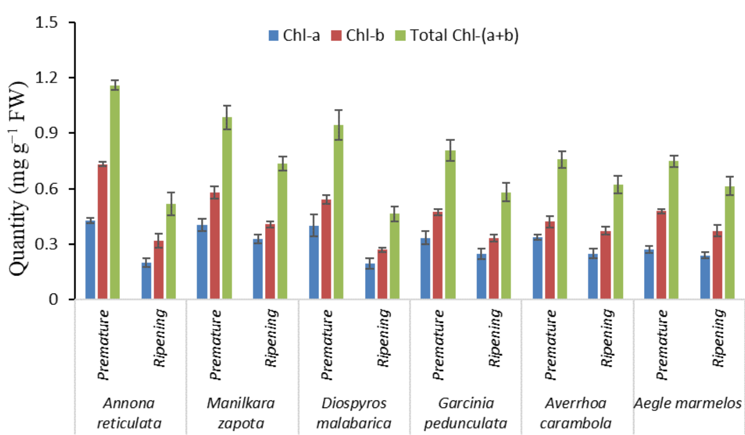

Fig. 3. Chlorophyll a, Chlorophyll b and total Chlorophyll content in six minor fruits at premature and riprening stages. Each data point is the average of three replicates (± SEM)

Table 4. Qualitative analysis of phytochemical constituents in six minor fruits at premature and ripening stages.

Fruits	Stage	Alkaloids	Flavonoids	Terpinoids	Tanins	Phenols	Saponins
Annona reticulata	Premature	+	+	-	+	+	+
	Ripening	+	+	+	+	+	+
Manilkara zapota	Premature	+	+	+	+	+	+
	Ripening	+	+	+	+	+	+
Aegle marmelos	Premature	+	+	+	+	+	+
	Ripening	+	+	+	+	+	+
Diospyros malabarica	Premature	+	+	+	+	+	+
	Ripening	+	+	+	+	+	+
Averrhoa carambola	Premature	+	+	+	+	+	+
	Ripening	+	+	+	+	+	+
Garcinia pedunculata	Premature	+	+	-	+	+	+
	Ripening	+	+	+	+	+	+

from 1.15 to 0.75 mg g^{-1} FW at premature stage and 0.74 to 0.46 mg g^{-1} FW at ripening stage (Fig. 3). At the premature stage, the total Chlorophyll content trend was *A. reticulata* > *M. zapota* > *A. marmelos* > *D. malabarica* > *A. carambola* > *G. pedunculata.* On the other hand at the ripening, the highest amount of Chlorophyll (a+b) was detected in *M. zapota* > *A. carambola* > *G. pedunculata* > *D. malabarica* > *A. reticulata* > *A. marmelos.*

Based on the calorific value, *G. pedunculata* was the best performer followed by *M. zapota* and *A. carambola* was the least among the studied minor fruits; although, *Annona reticulata* possesses the biggest amount of crude protein and crude fibre. These fruits could be used in different product development for the enlargement of a healthy food assortment. The nutritional and phytochemical profiles of these fruits, even better compared to those of the major fruits, should be highlighted to encourage and popularize their consumption rather than that of both major and exotic fruits.

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References

Dhandapani R and Sabna B 2008. Phytochemical constituents of some Indian medicinal plants. Ancient Sci. Life **27**: 1-8.

Edem CA, Dosunmu MI, Ebong AC and Jones M 2008. Determination of the proximate composition, ascorbic acid and heavy metal contents of star fruit (*Averrhoa carambola*). Global J. Pure Appl. Sci. **14**: 193-195.

Edeoga HO, Okwu DE and Mbaebie BO 2005. Phytochemical constituents of some Nigerian medicinal plants. African J. Biotechnol. **4**: 685-688.

Fakir MSA, Rahman MM, Hasan MM, Moonmoon S and Rahman MM 2018. Flower morphology and fruit maturity of four minor fruits (*Diospyros peregrina*, *D. discolor*, *Muntingia calabura* and *Careya arborea*) of tropics and subtropics. Int. J. Minor Fruits Med. Aroma. Plants **4**(2): 18-27.

FAO (Food and Agriculture Organization of the United Nations) 2003. Food energy – methods of analysis and conversion factors. FAO Food and Nutrition paper 77, Rome.

Ghosh SN (ed.) 2017. Minor fruits: nutraceutical importance and cultivation (3 Parts). Jaya Pub. House, Delhi.

Harding KL, Aguayo VM and Webb P 2017. Hidden hunger in South Asia: a review of recent trends and persistent challenges. Public Health Nutr. **21**(4): 1-11. doi:10.1017/S1368980017003202

Hasan MM, Fakir MSA, Rahman MM and Naznin S 2014. Fruit growth and proximate composition of deshi (*Diospyros peregrina*) and bilati gab (*D. discolor*). J. Bangladesh Agril. Uni. **12**(2): 261-266.

Hasan MM, Fakir MSA, Rahman MM, Moonmoon S and Naznin S 2016. Fruit growth and proximate composition of *Dilllenia indica* Linn. Int. J. Minor Fruits Med. Aroma. Plants **2(**1**)**: 19-24.

Hossain MM, Rahim MA and Haque MR 2021. Biochemical properties of some important underutilized minor fruits. J. Agric. Food Res. **5**: 100148. doi: 10.1016/j.jafr.2021.100148

Islam SN, Khan MNI and Akhtaruzzaman M 2010. A food composition database for Bangladesh with special reference to selected ethnic foods. Final Report PR #11/08, FAO-National Food Policy Capacity Strengthening Programme, Dhaka.

Islary A, Sarmah J and Basumatary S 2016. Proximate composition, mineral content, phytochemical analysis and *in vitro* antioxidant activities of a wild edible fruit (*Grewia sapida* Roxb. *ex* DC.) found in Assam of North-East India. J. Invest. Biochem. **5**: 21-31. doi: 10.5455/jib.20160422015354

Janabi AHW, Kamboh AA, Saeed M, Xiaoyu L, BiBi J, Majeed F, Naveed M, Mughal MJ, Korejo NA, Kamboh R, Alagawany M and Lv H 2020. Flavonoid-rich foods (FRF): A promising nutraceutical approach against lifespan-shortening diseases. Iranian J. Basic Med. Sci. **23**: 140-153. doi: 10.22038/IJBMS.2019.35125.8353

Kabir AKMA, Moniruzzaman M, Gulshan Z, Rahman ABMM and Sarwar AKM Golam 2018. Biomass yield, chemical content and *in vitro* gas production of different *dhaincha* (*Sesbania* spp.) accessions from Bangladesh. Indian J. Anim. Nutr. **35**: 397-402. doi: 10.5958/2231-6744.2018.00060.9

Kannamba B, Winnie D, Surekha M and Lavanya B 2017. Effect of extraction methods and solvent on phytochemical composition of medicinal plant extracts. Der Pharma Chemica **9**(9):152-156.

Kumar B, Vijaykumar M, Govindarajan R and Pushpangadan P 2007. Ethnopharmacological approaches to wound healing-exploring medicinal plants of India. J. Ethnopharmacol. **114**: 103-113.

Kurek J 2019. Introductory chapter: alkaloids - their importance in nature and for human life. In Alkaloids - their importance in nature and for human life. Kurek J. (ed). IntechOpen. doi: 10.5772/intechopen.85400

Mundaragi A, Devarajan T, Bhat S and Jeyabalan S 2017. Proximate analysis and mineral composition of potential minor fruits of Western Ghats of India. Scientific Papers. Series A. Agronomy **LX**: 340-346.

Pasha MK and Uddin SB 2019. Minor edible fruits of Bangladesh. Bangladesh J. Plant Taxon. **26**: 299-313. https://doi.org/10.3329/bjpt.v26i2.44596

Priyankar D and Kumar CT 2013. Quantification and correlation of the bioactive phytochemicals of *Croton bonplandianum* leaves of Sub-Himalayan region of West Bengal. Asian J. Pharm. Clin. Res. **6**: 142-147.

Siddhuraju P and Manian S 2007. The antioxidant activity and free radical scavenging capacity of dietary phenolic extracts from horse gram (*Macrotyloma uniflorum*) seeds. Food Chem. **105**: 950-958. https://doi.org/10.1016/j.foodchem.2007.04.040

Singh PU, Kochhar A and Boora R 2012. Proximate composition, available carbohydrates, dietary fibres and anti-nutritional factors in Bael (*Aegle marmelos* L.) leaf, pulp and seed. Int. J. Sci. Res. Pub. **2**: 1-4.

Singleton VL and Rossi JA 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J. Enol. Viticult. **16**: 144-158.

Thoppil RJ and Bishayee A 2011. Terpenoids as potential chemopreventive and therapeutic agents in liver cancer. World J. Hepatol. **3**:228-249. doi: 10.4254/wjh.v3.i9.228

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