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Physico-chemical characterization of drumstick (*Moringa oleifera* L.) germplasm available in south western region of Bangladesh

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Abstract

The research work was carried out to determine the physico-chemical characteristics of 10 selected drumstick germplasm available in the south-western region of Bangladesh during August, 2012 to January, 2013. The experiment was laid out in Completely Randomized Design (CRD) with three replications. There was found a significant variation among the germplasm in relation to leaf, flower and pod. Better results were obtained from germplasm No. 01, 06, 09 and 04, in respect of total weight of leaf, length of leaf, weight of pod, skin thickness of pod, edible and non-edible portion of drumstick leaf, pod among the 10 selected germplasm. The highest leaflet number (597.333) was observed in germplasm No. 3. The highest weight of edible portion (10.347g) was observed in germplasm No.1, the highest percentage of edible portion was observed in germplasm No.9 (70.100%) and germplasm No. 4 gave the highest young pod weight (12.66 g), the highest weight of edible portion (9.290g) was observed in germplasm No. 4 in young pod, the highest percentage of edible portion was recorded in germplasm No. 5. In mature condition germplasm No.1 gave the highest weight (31.400g) of mature pod, germplasm No. 2 gave the highest pod length (48.00 cm), the highest weight of edible portion (30.72g) was observed in germplasm No. 1, the highest percentage of edible portion was observed in germplasm No. 4 (90.73 %). It was observed in the data of chemical analysis of leaf that the highest vitamin C content of leaf (101.7 mg /100 g) and titratable acid content (21.33%) was recorded from germplasm No. 4. The highest percentage of TSS (1.667 %) was observed in germplasm No. 1, anthocyanin (0.140 mg /100 g) was observed in germplasm No. 10. In respect of flower, the highest percentage of TSS recorded from germplasm No. 5 (10.00 %), the highest amount of carotenoids content (0.01163 mg /100 g) was observed in germplasm No. 2 and flavonoids content (0.0870 g /100g) recorded from germplasm No. 6. In respect of young pod the highest pH was found in germplasm No. 5 (6.486), the highest vitamin C content (80.00 mg /100 g) and carotenoids content (0.003 mg /100 g) was observed in germplasm No. 2. In mature condition the highest amount of carotenoids content of mature pod (0.4267 mg /100g), the highest vitamin C content (80.00 mg /100 g) and flavonoids content of mature pod (0.09605 g / 100g) was recorded from germplasm No. 1.

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Introduction

Moringa oleifera L., known as Moringa, is native to north India but is now found throughout the tropics. Moringa is also known as horseradish tree, drumstick tree and mother's best friend. It is fast growing and highly nutritious plant. It belongs to the plant family Moringaceae. Drumstick tree is a versatile tree useful not only for human beings but also for animals and also in various industrial applications. People have been using it as an item of their daily food for nearly 5000 years. It also distributed in Israel, Iran, Nepal, Bangladesh, China, Taiwan, Srilanka, Myanmar and Malaysia. The tree is mainly grows in semi-arid and tropical areas (Chand *et al.*, 2012).

The plant is usually very slender, with an average height of about 10 meters. The fruits (pods) are long, slender which look like "drumsticks" and hence the popular name (Vinoth and Balamurgan, 2012). The tree has softwood and produces yellowish-white fragrant flowers (Chand *et al.*, 2012). The leaves are bipinnate or more commonly tripinnate, up to 45 cm long, alternate and spirally arranged on the twigs. The leaflets are finely hairy, green. The fruits are pendulous, linear, three-sided pods with nine longitudinal ridges, usually 20 to 50 cm long. Drumstick requires an annual rainfall of between 250 and 3000 mm. It is drought resistant, though in drought conditions it may loose its leaves. It will survive in a temperature range of 25°C to 40°C but has been known to tolerate temperatures of 48°C and light frosts (Anonymous, 2013).

Drumsticks are known for their high nutrition content and almost all the parts of the plants have the nutritional value. The composition of 100g drumstick leaves includes water 78.66 g, vitamin C 51.7 mg, vitamin A 6.8 mg and 100 g drumstick pods contain water 88.20g, calorie 26, fiber 4.8 g, vitamin A 0.11 mg, vitamin C (ascorbic acid) 141.0 mg (Anonymous, 2013). Moringa tree contains many nutrients such as essential vitamins, essential minerals, aminoacids, beta-carotene, anti-oxidants, anti-inflammatory nutrients, phytochemicals and it also contains both

omega-3 and omega-6 fatty acids (Kasolo *et al.*, 2005). The flowers are edible when cooked and are said to taste like mushrooms. The Drumstick tree has also great use medicinally both as preventative and treatment (Rhamu and Omotayo, 2006).

The tree is well known for manifold usages. The leaves are useful in scurvy and respiratory ailments. They are also used as an emetic. The juice extracted from the leaves has strong antibacterial and antimalarial properties a paste of the leaves is used as an external application to promote healing of wounds (Anonymous, 2013). A soup made from the plant greatly helps to prevent infections of the skin, chest and throat. This is basically because of the fact that the plant has vital anti-bacterial properties, which are very much similar to penicillin and other antibiotics (Nambiar, 2005). Drumstick leaves and pods are helpful in increasing breast milk in the breastfeeding months. One tablespoon of leaf powder can provide 14% of the protein, 40% of the calcium, 23% of the iron and most of the vitamin A needs of a child aged one to three (Stepenson, 2006).

Though very few research have been conducted on the tree, no such step has yet taken to exploit the physico-chemical potentiality specially for the south – western region. With this circumstance the present study has been undertaken to study the physico-chemical characteristics of local drumstick germplasm available in the Germplasm Center, Khulna University, Khulna. with the following objectives:

- To determine physical properties of drumstick germplasm
- To find out the chemical characteristick of the drumstick germplasm.

Materials and methods

The experiment on physico-chemical characteristics of drumstick was carried out during the period from August, 2012 to January, 2013. In the study 10 germplasm were studied which were collected randomly from Germplasm Center of Khulna

University. The collected germplasm were brought to the Molecular Horticulture Laboratory of the Agrotechnology Discipline, Khulna University, Khulna.

Experimental Design and Analysis

The experiment was laid out in Completely Randomized Design (CRD) with three replications. After collection of some drumstick they kept in ambient temperature for the study of physico-chemical characteristics. The collected data from experiment were statistically analyzed by Analysis of Variance (ANOVA) and Duncan's New Multiple Range Test (DMRT) was used to compare the means of different parameters.

Experimental Materials

Ten germplasm of drumsticks were selected as the experimental materials for the investigation. These drumsticks were collected from Germplasm Centre, Agrotechnology Discipline, Khulna University, Khulna.

Methods of Studying Parameters

By using the following methods physical and chemical parameters of the collected drumstick germplasms were studied.

Physical Parameter

Weight of drumstick leaf

The weight of individual leaf was measured by an electric balance. At first, the balance was adjusted to zero mark. The leaves were cleaned and weighed in gram (g) by keeping leaf on the chamber of the balance.

Length of leaf and diameter of midrib

Length of leaf (cm) and diameter of midrib (mm) were estimated by a slide calipers to determine their size.

Leaflet number of drumstick leaves

Leaflet number were counted to determine also the size. The values of this parameter counted in number.

Weight of edible and non-edible portion of leaf

The weight of edible portion of drumstick leaves was measured by an electric balance. At first, the balance was adjusted to zero mark. After removing the midrib from leaves the remaining edible portion (leaves) was estimated by keeping it in the chamber of balance and the reading was taken in gram (g). Weight of non-edible portion of the leaf was measured by subtracting the weight of edible portion from the total weight and also expressed in gram (g).

Percentage of edible and non-edible portion of leaf

The percentages of edible and non-edible portion of leaf were calculated by the following formulae:

$$\text{Percentage of edible portion} = \frac{\text{Weight of edible parts}}{\text{Weight of whole leaves}} \times 100$$

$$\text{Percentage of non-edible portion} = 100\% - \text{Percentage of edible portion.}$$

Physical Parameter of flower

All the part of flower is edible. So, the physical parameters in respect of flower are discarded from the experiment. All the drumstick tree did not bear flower at flowering stage. Only seven germplasm beared flower at flowering stage. So, in this experiment 7germplasm was considered as treatment.

Weight of young pod

The young pod weight (g) was measured by an electric balance. At first, the balance was adjusted to zero mark. The pods were cleaned and weighed by keeping the drumstick on the chamber of the balance.

Length and diameter of young pod

Length (cm) and diameter (mm) of the pod was estimated by a slide calipers.

Skin thickness of young pod

Skin thickness (mm) of the pod was estimated by a slide calipers.

Weight of edible and non- edible portion of young pod

The weight of edible portion of young pod was measured by an electric balance. At first, the balance was adjusted to zero mark. After removing the skin from pod the remaining edible portion (pod) was estimated by keeping it in the chamber of balance and the reading was taken in gram (g). Weight of non-edible portion (g) of the young pod was measured by subtracting the weight of edible portion from the total weight.

Percentage of edible and non-edible portion of young pod

The percentages of edible and non-edible portion of young pod were calculated by the following formulae:

Percentage of edible portion

$$= \frac{\text{Weight of edible parts}}{\text{Weight of whole pods}} \times 100$$

Percentage of non-edible portion

$$= 100\% - \text{Percentage of edible portion}$$

Weight of mature pod

The mature pod weight (g) was measured by an electric balance. At first, the balance was adjusted to zero mark. The pods were cleaned and weighed by keeping the drumstick on the chamber of the balance.

Length and diameter of mature pod

Length and diameter of the pod was estimated to determine the size by a slide calipers and scale. The value of this parameter was taken in centimetre (cm) and millimetre (mm), respectively.

Skin thickness of mature pod

Skin thickness of the mature pod (mm) was estimated to determine the size by a slide calipers.

Weight of edible and non-edible portion of mature pod

The weight of edible (g) and non-edible (g) portion of mature pod was measured by an electric balance. At first, the balance was adjusted to zero mark. After

removing the skin from pod the remaining edible portion (pod) was estimated by keeping it in the chamber of balance. Weight of non-edible (g) portion of the mature pod was measured by subtracting the weight of edible portion from the total weight.

Percentage of edible and non-edible portion

The percentages of edible and non-edible portion of mature pod were calculated by the following formulae:

Percentage of edible portion

$$= \frac{\text{Weight of edible parts}}{\text{Weight of whole pods}} \times 100$$

Percentage of non-edible portion

$$= 100\% - \text{Percentage of edible portion}$$

Chemical characteristics

The methods for the estimation of pH, TSS, Titrable acidity, vitamin C, Carotenoids, Anthocyanin and Flavonoids of drumstick pulp were followed as described by Mazumdar and Majumdar (2001) and Saini *et al.* (2006). The data were analyzed by fresh weight basis.

Results and discussion

The experiment was carried out to determine the physico-chemical characteristics of drumstick at the Molecular Horticultural Laboratory of Agrotechnology Discipline, Khulna University, Khulna from August, 2012 to January, 2013. The data presented in Table for discussion, comprehension and understanding. The results and discussion of the study are presented under the following heads.

*Physical Characteristics of drumstick**Leaflet number*

There was no significant variation among the 10 germplasm in respect of leaf and leaflet number (Table 1). However, numerically the highest leaflet number (597.33) was counted from germplasm No. 3 followed by germplasm No.1 (559.67) and the lowest leaflet number (334.00) from germplasm No.7. Average leaflet number of 10 germplasm was

(445.70). The highest number of secondary axis (16.67) was counted from germplasm No.2 followed by germplasm No.7 (15.67) and the lowest secondary axis number (14.33) from germplasm No.1. The highest number of tertiary axis in germplasm No. 8

(176.00) and the lowest tertiary axis number (116.00) from germplasm No. 4. The average secondary axis and tertiary axis number (15.27) and (143.10) were found, respectively (Table 1).

Table 1. Physical characteristics of drumstick leaves.

Germplasm number	Leaflet number	Number of secondary axis	Number of tertiary axis	Weight of leaf (g)	Diameter of stem (mm)	Length of leaf (cm)	Weight of edible part (g)	Weight of Non-edible part (g)	Percentage of edible part	Percentage of non-edible part
1	559.67	14.33	126.67	18.73	6.07	45.00	10.35	5.71	64.79	35.17
2	474.33	16.67	148.00	15.44	4.58	42.33	9.51	4.49	67.58	32.37
3	597.33	15.33	136.33	8.97	3.97	38.67	5.06	2.47	67.24	32.70
4	455.33	15.33	116.00	9.83	3.33	33.33	4.88	2.10	69.06	30.88
5	396.33	14.67	142.67	8.45	3.03	40.33	8.91	4.84	64.90	35.03
6	431.00	14.67	144.67	11.51	3.87	36.67	6.41	4.57	66.25	33.77
7	334.00	15.67	155.33	14.25	3.28	33.33	5.63	1.70	74.15	25.67
8	492.00	15.33	176.00	13.01	4.35	42.00	7.21	4.73	63.61	36.59
9	376.00	15.67	161.33	10.39	7.12	29.33	4.28	2.32	67.23	32.70
10	341.00	15.00	124.00	7.93	5.97	40.00	6.04	2.43	70.10	29.83
Average	445.70	15.27	143.10	11.85	4.56	38.10	6.83	3.54	67.49	32.47
Level of significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. NS indicate non-significant.

Weight of individual leaf

No significant variation was found among the 10 germplasm in respect of leaf weight (Table 1). However, numerically the highest leaf weight (18.73 g) was found in germplasm No.1 and the lowest leaf weight (7.93 g) was recorded from germplasm No.10 and the average weight was 11.85g (Table 1).

Diameter of midrib

There was no significant variation was found among the 10 germplasm in respect of stem diameter (Table 1). However, numerically the highest diameter of midrib (7.12 mm) was found in germplasm No.9 and that was the lowest stem diameter (3.03 mm) in germplasm No.5 and the average diameter was 4.56 mm (Table 1).

Length of leaf

No significant variation was found among the 10 germplasm in respect of leaf length (Table 1). However, numerically the longest leaf (45.00 cm) was

found in germplasm No. 1 and the shortest leaf (29.33 cm) was found in germplasm No.9 and the average leaf length was 38.10 cm (Table 1).

Weight of edible and non-portion of leaf

No significant variation was observed among the 10 germplasm in relation to weight of edible and non-edible portion of leaf and (Table 1). However, numerically the highest weight of edible portion (10.35 g) was found in germplasm No.1 and the lowest edible portion (4.28 g) was recorded from germplasm No 8 with an average of 6.83 g (Table 1).And numerically the highest weight of non-edible portion (5.71 g) was found in germplasm No.1 and that was the lowest (1.70 g) in germplasm No 7. The average weight of non-edible portion of leaf was 3.54 g (Table 1).

Percentage of edible and non-edible portion of leaf

No significant variation was found among the 10 germplasm in respect of percentage of edible portion and non-edible portion of leaf (Table 1). However,

numerically the highest percentage of edible portion (74.15%) and the lowest percentage of non-edible portion (25.67%) counted from germplasm No.7. The lowest percentage of edible portion (63.61%) and the highest percentage of non-edible portion (36.59 %) was observed in germplasm No. 8. The average percentage of edible portion and average percentage of non-edible portion was 67.492% and 32.47 % (Table 1).

Weight of young pod

The young pod weight was significantly varied among the 7 germplasm (Table 2). The germplasm No. 4 gave the highest pod weight (12.66 g) followed by germplasm No.5 (9.219 g). It was the lowest in germplasm No. 6 (4.335 g) which was statistically similar to germplasm No. 7 (5.283 g). Average weight of pod was found 7.262 g (Table 2).

Table 2. Physical characteristics of young pod.

GP No.	Weight of pods (g)	Length of pods (cm)	Diameter of pods (mm)	Skin thickness (mm)	Weight of edible part (g)	Weight of Non-edible part (g)	Percentage of edible part	Percentage of non-edible part
1	7.35 c	32.33 bc	6.60 a	0.51	5.46 c	2.17 bc	71.56 bc	28.40 bcd
2	5.60 de	41.00 a	6.06 b	0.36	3.49 de	2.12 bc	62.32 d	37.65 ab
3	6.387 cd	35.00 b	4.17 c	0.33	3.69 d	3.48 a	51.46 e	41.37 a
4	12.66 a	31.00bcd	2.73 f	0.58	9.29 a	2.76 ab	77.21 ab	22.70 cd
5	9.22 b	29.67 cd	3.74 d	0.53	7.18 b	1.88 bcd	79.45 a	20.54 d
6	4.33 f	26.33 d	3.05 ef	0.35	3.19 e	1.19 d	72.81 ab	32.39 abc
7	5.28 ef	19.33 e	3.22 e	0.25	3.30 e	1.80 cd	64.66 cd	35.33 ab
Average	7.26	30.67	4.23	0.41	5.09	2.20	68.49	31.19
Level of significance	**	**	**	NS	**	**	**	**

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. * Indicate 5% level of significance, ** Indicate 1% level of significance and NS indicate non-significant.

Length of young pod

The length of young pod was significantly varied among the 7 germplasm (Table 2). The germplasm No. 2 gave the longest young pod (41.00 cm) followed by germplasm No. 3 (35.00 cm). It was lowest in germplasm No. 7 (19.33 cm). Average length of pod was 30.67 cm (Table 2).

Diameter of young pod

Significant variation was found among the 7 germplasm in respect of diameter of pod (Table 2). The highest pod diameter (6.60 mm) was found in germplasm No.1 followed by germplasm No. 2 (6.06 mm) and lowest pod diameter (2.73 mm) was found in germplasm No.4 preceded by germplasm No.6 (3.05 mm) and the average diameter was 4.23 mm (Table 2).

Skin thickness of young pod

There was no significant difference among the 7 germplasm in respect of skin thickness of pod (Table 2). However, numerically the thickest skin (0.58 mm) was recorded from germplasm No. 4 and the thinnest (0.25 mm) was counted from germplasm No. 7. Average skin thickness was 0.41 mm (Table 2).

Weight of edible and non-edible portion of young pod

Significant variations among the 7 germplasm in relation to weight of edible and non-edible portion of young pod was recorded (Table 2). The highest weight of edible portion (9.29 g) was found in germplasm No. 4 and the lowest of edible portion (3.190 g) was recorded from germplasm No. 6 followed by germplasm No.7 (3.30 g). The average weight of edible portion of pod was 5.09 g (Table 2). On the other hand, the highest weight of non-edible portion (3.48

g) was found in germplasm No.3 followed by germplasm No.4 (2.76 g) and the lowest weight of non-edible portion (1.19 g) was recorded from germplasm No. 6. The average weight of non-edible portion of pod was 2.20 g (Table 2).

Percentage of edible and non-edible portion of young pod

There was significant variation among the 7 germplasm in respect of percentage of edible and non-edible portion of the pod (Table 2). The highest percentage of edible portion (79.45%) was found in germplasm No. 5 followed by germplasm No. 4 (77.21%) and lowest percentage of edible portion (51.46 %) was observed in germplasm No.3. The average percentage of edible portion was 68.49 % (Table 2). On the other hand, the highest percentage

of non-edible portion was found in germplasm No. 3 (41.37%) followed by germplasm No. 2 (37.65%), germplasm No.7 (35.33%) and the lowest percentage of non-edible portion was found in germplasm No. 5 (20.54%) which preceded by germplasm No. 4 (22.70%). The average percentage of non-edible portion was 31.19 % (Table 2).

Weight of mature pod

The weight of mature pod had no significance variation among the 7 germplasm (Table 3). The germplasm No.1 gave the highest pod weight (31.40 g) followed by germplasm No. 4 (30.57 g). It was the lowest in germplasm No. 3 (22.48 g) which was statistically similar to germplasm No. 7 (23.09 g). The average weight of pod was 26.36 g (Table 3).

Table 3. Physical characteristics of mature pod.

GP No.	Weight of pods (g)	Length of pods (cm)	Dia meter of pods (mm)	Skin thickness (mm)	Seed number	Weight of edible part (g)	Weight of Non-edible part (g)	Percentage of edible part	Percentage of non-edible part
1	31.40	30.00 bc	12.83 a	0.63	13.00 ab	30.72 a	4.78 a	86.53 bc	13.62 AB
2	25.26	48.00 a	8.70 b	0.37	17.00 a	22.23 c	2.80 bc	88.89 abc	11.10 abc
3	22.48	40.00 abc	6.67 b	0.41	13.33 ab	20.17 c	2.30 c	89.73 ab	10.26 bc
4	30.57	35.00 bc	10.20 ab	0.46	14.00 ab	27.17 ab	2.80 bc	90.73 a	9.367 c
5	24.89	42.00 ab	8.91 b	0.37	16.00 a	20.74 c	3.40 abc	85.17 c	14.82 a
6	26.83	30.00 bc	8.21 b	0.38	14.67 a	24.22 bc	4.15 ab	85.30 c	14.72 a
7	23.09	28.00 c	8.07 b	0.36	10.00 b	22.65 c	3.68 abc	85.77 c	14.22 a
Average	26.36	36.14	9.08	0.42	14.00	23.99	3.42	87.45	12.59
Level of significance	NS	**	**	NS	**	*	**	*	*

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. * Indicate 5% level of significance, ** Indicate 1% level of significance and NS indicate non-significant.

Length and diameter of mature pod

The length and diameter of mature pod were varied significantly among the 7 germplasm (Table 3). The germplasm No. 2 gave the longest pod (48.00 cm) followed by germplasm No. 5 (42.00 cm). It was the lowest in germplasm No. 7 (28.00 cm). The average length of pod was 36.14 cm (Table 3). On the other hand, the highest pod diameter (12.83 mm) was found in germplasm No. 1 followed by germplasm No. 4 (10.20 mm) and the lowest pod diameter (6.67 mm) was found in germplasm No.3 which was preceded by germplasm No. 5 (8.91 mm), germplasm No. 6 (8.21

mm), germplasm No. 7 (8.07 mm) and the average diameter was 9.08 mm (Table 3).

Skin thickness of mature pod

There was no significant difference among the 7 germplasm in respect of skin thickness (Table 3). However, numerically the thickest skin (0.63 mm) was recorded from germplasm No. 1 and the thinnest skin (0.36 mm) was found in germplasm No. 7. The average skin thickness was 0.42 mm (Table 3).

Seed number per mature pod

Significant variation was found among the 7 germplasm in respect of seed number per pod (Table 3). The highest seed number (17.00) of pod was counted from germplasm No. 2 which is followed by germplasm No. 5 (16.00) and lowest seed number of pod (10.00) was observed in germplasm No. 7 which was preceded by germplasm No. 1 (13.00) and the average seed number of pod was 14.00 (Table 3).

Weight of edible and non-edible portion of mature pod

There was a significant variation among the 7 germplasm in relation to weight of edible and non-edible portion (Table 3). The highest weight of edible portion (30.72 g) was found in germplasm No. 1 followed by germplasm No. 4 (27.17 g) and the lowest weight of edible portion (20.17 g) was recorded from germplasm No. 3 preceded by germplasm No. 5 (20.74 g). The average weight of edible portion of pod was 23.99 g (Table 3). On the other hand, the highest weight of non-edible portion (4.78 g) was found in germplasm No. 1 which is followed by germplasm No. 6 (4.15 g) and the lowest weight of non-edible portion (2.30 g) was found in germplasm No. 3. The average weight of non-edible portion of pod was 3.42 g (Table 3).

Percentage of edible and non-edible portion of mature pod

Significant variations were observed among the 7 germplasm in respect of percentage of edible and non-edible portion of the mature pod (Table 3). The highest percentage of edible portion (90.73 %) was found in germplasm No. 4 followed by germplasm No. 3 (89.73 %) and the lowest percentage of edible portion (85.17 %) was found in germplasm No. 5 preceded by germplasm No. 6 (85.30 %). The average percentage of edible portion was found 87.45 % (Table 3). On the other hand, the highest percentage of non-edible portion (14.82%) was observed in germplasm No. 5 followed by germplasm No. 6 (14.72 %) and the lowest percentage of non-edible portion (9.37%) was found in germplasm No. 4 preceded by

germplasm No. 3 (10.26 %) and average percentage of non-edible portion was 12.59 % (Table 3).

*Chemical characteristics of drumstick**Vitamin C (ascorbic acid) content of drumstick leaf*

There was a significant variation among the 10 germplasm in respect of vitamin C content of drumstick leaf (Table 4). The highest vitamin C content of leaf (101.7 mg /100 g) was found in germplasm No. 4. The lowest amount of ascorbic acid content (16.33 mg /100 g) was observed in germplasm No. 6 which was statistically similar to germplasm No. 2 (23.33 mg /100 g) preceded by germplasm No. 9 (28.33 mg /100 g) (Table 4). Average vitamin C content of leaf was 43.27 mg /100 g (Table 4).

Titrateable acidity of drumstick leaf

The titrateable acidity showed significant variation among the 10 germplasm (Table 4). The highest percentage of titrateable acid content (21.33%) was recorded from germplasm No. 4 followed by germplasm No. 3 (18.67%) and germplasm No. 2 (15.52%). The lowest percentage of titrateable acid content (6.40 %) was recorded from germplasm No. 6 (Table 4). The average titrateable acidity of drumstick leaf was 12.73% (Table 4).

Total soluble solids of drumstick leaf

Total soluble solids had no significant variation among the 10 germplasm (Table 4). However, numerically the highest percentage of TSS (1.67 %) was observed in germplasm No. 1. The lowest percentage of total soluble solids of drumstick leaf (1.00 %) was observed in germplasm No. 10 which was statistically similar to germplasm No. 4 (1.00%) (Table 4). Average total soluble solids were found 1.43 % (Table 4). Increase in total soluble solid may be attributed to increase in soluble sugar, soluble pectin, soluble organic acids etc.

pH of drumstick leaf

There was no significant variation among the 10 germplasm in respect of pH of drumstick leaf (Table

4). The highest pH of drumstick leaf (5.53) was found in germplasm No. 1 and the lowest pH content of drumstick leaf (4.23) was observed in germplasm

No.8 which was statistically similar to germplasm No. 2 (4.7). Average pH content of drumstick leaf was found 5.10 (Table 4).

Table 4. Chemical characteristics of drumstick leaves.

GP No.	Vitamin C (mg/100g)	T-acidity (%)	TSS (%)	pH	Carotenoids (mg/100g)	Anthocyanin (mg/100g)	Flavonoids (g/100g)
1	42.33 bcd	7.533 cd	1.67	5.53	0.08	0.04 c	1.73 b
2	23.33 de	15.52 abc	1.33	4.70	0.09	0.03 c	1.59 b
3	32.33bcde	18.67 ab	1.33	5.33	0.09	0.04 c	1.55 b
4	101.7 a	21.33 a	1.00	5.53	0.04	0.08 abc	2.13 ab
5	47.33 bcd	13.87 abcd	1.33	5.37	0.08	0.06 bc	2.54 ab
6	16.33 e	6.400 d	2.33	5.50	0.01	0.06 bc	3.51 a
7	39.67bcde	11.35 bcd	1.33	5.43	0.04	0.09 abc	2.47 ab
8	48.33 bc	11.6 bcd	1.67	4.23	0.02	0.12 ab	3.55 a
9	28.33 cde	11.31 bcd	1.33	4.83	0.06	0.05 bc	2.95 ab
10	53.00 b	9.71 cd	1.00	4.57	0.02	0.14 a	2.41 ab
Average	43.27	12.73	1.43	5.10	0.05	0.07	2.44
Level of significance	**	**	NS	NS	NS	*	**

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. * Indicate 5% level of significance, ** Indicate 1% level of significance and NS indicate non-significant.

Carotenoids content of drumstick leaf

There was no significant difference among the 10 germplasm in respect to carotenoids content (Table 4). However, numerically the highest amount of carotenoids content of drumstick leaf (0.09 mg /100 g) was found in germplasm No. 3 and the lowest amount of carotenoids content (0.01 mg /100 g) was observed in germplasm No. 6. Average carotenoids content was 0.05mg /100 g of drumstick leaf (Table 4).

Anthocyanin content of drumstick leaf

The difference of anthocyanin content of drumstick leaf was significant among the 10 germplasm (Table 4). The highest amount of anthocyanin of drumstick leaf (0.14 mg /100 g) was observed in germplasm No. 10 followed by germplasm No.8 (0.12 mg/100 g). The least amount of anthocyanin of drumstick leaf (0.03 mg /100 g) was recorded from germplasm No. 2 preceded by germplasm No. 1 (0.04 mg /100 g) and germplasm No. 3 (0.04 mg /100 g) (Table 4). The average anthocyanin content of drumstick leaf was 0.07 mg /100 g (Table 4).

Flavonoids content of drumstick leaf

There was a significant variation among the 10 germplasm in respect to flavonoids content of drumstick leaf (Table 4). The highest flavonoids content of drumstick leaf (3.55 g /100 g) was found in germplasm No. 8 followed by germplasm No. 6 (3.51 g/100 g). The lowest flavonoids content of drumstick leaf (1.55 g /100 g) was observed in germplasm No. 3 preceded by germplasm No. 2 (1.59 g /100 g) and germplasm No.1 (1.73 g /100 g). Average flavonoids content was 2.44 g /100 g of drumstick leaf (Table 4).

Vitamin C (ascorbic acid) content of drumstick flower

There was a significant variation among the 7 germplasm in respect to vitamin C content of flower (Table 5). The highest vitamin C content of flower (2.97 mg /100g) was found in germplasm No. 6 followed by germplasm No. 2 (2.67 mg/100 g). The lowest amount of ascorbic acid content (0.50 mg /100 g) was observed in germplasm No. 4 which was statistically similar to germplasm No. 1 (0.57 mg /100 g) (Table 5). Average vitamin C content of flower was 1.83 mg /100 g (Table 5).

Table 5. Chemical characteristics of drumstick flowers.

GP No.	Vitamin C (mg/100g)	T-acidity (%)	TSS (%)	p ^H	Carotenoids (mg/100g)	Anthocyanin (mg/100g)	Flavonoids (g/100g)
1	0.57b	0.09	5.33 d	5.33	0.009 ab	0.10 f	0.08 b
2	2.67 a	0.07	9.33 ab	6.39	0.011 a	0.35 b	0.06 de
3	2.53 a	0.07	7.67 bc	5.27	0.009 ab	0.39 a	0.05 f
4	0.50 b	0.07	7.33 bcd	5.15	0.001 b	0.11 e	0.06 e
5	1.20 ab	0.13	10.00 a	5.63	0.002 b	0.12 d	0.07 bc
6	2.97 a	0.09	5.67 cd	4.72	0.006ab	0.35 b	0.09 a
7	2.40 ab	0.09	9.33ab	5.29	0.002 b	0.25 c	0.07 cd
Average	1.83	0.09	7.81	5.40	0.006	0.24	0.07
Level of significance	*	NS	**	NS	**	**	**

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. * Indicate 5% level of significance, ** Indicate 1% level of significance and NS indicate non-significant.

Titrateable acidity of drumstick flower

The titrateable acidity had no significant variation among the 7 germplasm (Table 5). The highest percentage of titrateable acid content (0.13 %) was found in germplasm No. 5. The lowest percentage of titrateable acid content (0.07 %) was recorded from germplasm No. 3 (Table 5). Average titrateable acidity of drumstick flower was 0.09 % (Table 5).

Total soluble solids of drumstick flower

The difference of total soluble solids had no significant variation among the 7 germplasm (Table 5). However, numerically the highest percentage of TSS was observed in germplasm No. 5 (10.00 %). The lowest percentage of total soluble solids of drumstick flower (5.33 %) was recorded from germplasm No. 1 was statistically similar to germplasm No. 5 (5.67 %) (Table 5). The average total soluble solids was 7.81 % (Table 5).

pH of drumstick flower

There was a no significant variation among the 7 germplasm in respect to pH of drumstick flower (Table 5). However, numerically the highest pH of drumstick flower (6.39) was found in germplasm No. 2 and that was the lowest pH (4.72) in germplasm No. 6 (Table 5). Average pH content of drumstick flower was 5.39 (Table 5).

Carotenoids content of drumstick flower

There was significant difference among the 7 germplasm in respect to carotenoids content (Table 5).

The highest amount of carotenoids (0.012 mg /100 g) was found in germplasm No. 2 followed by germplasm No. 3 (0.009 mg /100 g) and germplasm No. 3 (0.009 mg /100 g) and the lowest amount of carotenoids (0.001 mg /100 g) was recorded from germplasm No. 4 preceded by germplasm No. 5 (0.002 mg /100 g) and germplasm No. 7 (0.002 mg /100 g). Average carotenoids content was 0.006 mg /100 g (Table 5).

Anthocyanin content of drumstick flower

The difference of anthocyanin content of drumstick flower was significant among the 7 germplasm (Table 5). The highest amount of anthocyanin content of drumstick flower (0.39 mg /100 g) was observed in germplasm No. 3 followed by germplasm No. 2 (0.35 mg /100 g). The least amount of anthocyanin content of flower (0.10 mg /100 g) was recorded from germplasm No. 1. Average anthocyanin content of drumstick flower was 0.24 mg /100 g (Table 5).

Flavonoids content of drumstick flower

There was a significant variation among the 7 germplasm in respect of flavonoid content of drumstick flower (Table 5). The highest flavonoid content of drumstick flower (0.09g /100g) was found in germplasm No. 6 followed by germplasm No.1 (0.08 g/100g) and germplasm No.5 (0.07 g /100g). The lowest flavonoids content of drumstick flower (0.05 g /100g) was observed in germplasm No. 3

preceded by germplasm No. 4 (0.06 g/100g). Average flavonoids content was 0.07 g /100 g (Table 5).

Vitamin C (ascorbic acid) content of young pod

There was a significant variation among the 7 germplasm in respect of vitamin C content of young pod of drumstick (Table 6). The highest vitamin C

content of young pod (80.00 mg /100 g) was recorded from germplasm No. 2 followed by germplasm No. 6 (73.00 mg /100 g) and germplasm No. 1 (53.33 mg /100 g). The lowest amount of ascorbic acid content (36.33 mg /100 g) was observed in germplasm No. 4 (Table 6). Average vitamin C content of pod was 54.24 mg /100 g.

Table 6. Chemical characteristics of young pod.

GP No.	Vitamin C (mg/100g)	T-acidity (%)	TSS (%)	pH	Carotenoids (mg/100g)	Anthocyanin (mg/100g)	Flavonoids (g/100g)
1	53.33 b	2.49f	5.33 c	6.38a	0.001	0.01 g	0.03 d
2	80.00 a	11.52b	9.33 a	5.55 b	0.003	0.05 d	0.06 a
3	45.00 bc	13.15a	7.00 b	4.79 c	0.001	0.06 a	0.04 c
4	36.33 c	4.65e	5.33 c	5.50b	0.001	0.05 c	0.02 f
5	46.67 bc	6.39d	5.67 bc	6.49 a	0.002	0.06b	0.02 g
6	73.00 a	7.04c	5.33 c	5.41 b	0.003	0.04 e	0.03 e
7	45.33 bc	0.12g	5.33 c	5.56b	0.001	0.02 f	0.04 b
Average	54.24	6.48	6.19	5.67	0.001	0.04	0.04
Level of significance	**	**	**	**	**	**	**

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. * Indicate 5% level of significance, ** Indicate 1% level of significance and NS indicate non-significant.

Titrateable acidity of young pod

The titrateable acidity showed significant variation among the 7 germplasm (Table 6). The highest percentage of titrateable acid content of young pod (13.15 %) was observed in germplasm No. 3 followed by germplasm No. 2 (11.52 %). The lowest percentage of titrateable acid content (0.121%) was recorded from germplasm No. 7 preceded by germplasm No.1 (2.49 %). Average titrateable acidity of pod was 6.48 % (Table 6).

Total soluble solids of young pod

The difference of total soluble solids was significant variation among the 7 germplasm (Table 6). The highest percentage of TSS was observed in germplasm No. 2 (9.33 %) followed by germplasm No. 3 (7.00 %). The lowest percentage of total soluble solids of pod (5.33 %) was found in germplasm No. 1 which was statistically similar to germplasm No. 4 (5.33 %), germplasm No. 6 (5.33 %) and germplasm No. 7 (5.33 %). Average total soluble solids were 6.19 % (Table 6).

pH of young pod

There was a significant variation among the 7 germplasm in respect of pH of young pod (Table 6). The highest pH of pod was found in germplasm No. 5 (6.49) followed by germplasm No. 2 (5.55) and germplasm No. 4 (5.50). The lowest pH content of pod (4.7) was recorded from germplasm No. 3. Average pH content of pod was 5.67 (Table 6).

Carotenoids content of young pod

There was no significant difference among the 7 germplasm in respect of carotenoids content (Table 6). However, numerically the highest amount of carotenoids (0.003 mg /100 g) was found in germplasm No. 2 and the lowest amount of carotenoids (0.001 mg /100 g) was observed in germplasm No. 3. Average carotenoids content was 0.001 mg /100 g of drumstick pod (Table 6).

Anthocyanin content of young pod

The difference of anthocyanin content of young pod was significant among the 7 germplasm (Table 6). The

highest amount of anthocyanin content of young pod (0.06 mg /100 g) was observed in germplasm No. 3 followed by germplasm No. 5 (0.06 mg /100 g) and germplasm No. 4 (0.05 mg /100 g). The lowest amount of anthocyanin of pod (0.008 mg /100 g) was observed in germplasm No. 1. Average anthocyanin content of pod was 0.04 mg /100 g (Table 6).

Flavonoids content of young pod

There was a significant variation among the 7 germplasm in respect of flavonoids content of young pod (Table 6). The highest flavonoids content of pod (0.06 g /100g) was found in germplasm No. 2 followed by germplasm No.7 (0.04 g /100g). The lowest flavonoids content of pod (0.02 g /100g) was in germplasm No. 5 preceded by germplasm No. 4 (0.02 g /100g). Average flavonoids content was 0.03 g /100 g (Table 6).

Vitamin C (ascorbic acid) content of mature pod

There was a significant variation among the 7 germplasm in respect of vitamin C content of mature pod (Table 7). The highest vitamin C content of pod (80.00 mg /100 g) was found in germplasm No. 1 which was statistically similar to germplasm No. 2 (75.00 mg /100 g) and germplasm No. 5 (72.00 mg /100 g). The lowest amount of ascorbic acid content (41.67 mg /100 g) was observed in germplasm No. 7 which was statistically similar to germplasm No. 6 (42.00 mg /100 g) and germplasm No. 4 (43.00 mg /100 g). Average vitamin C content of pod was 57.95 mg /100 g (Table 7).

Titrateable acidity of mature pod

The titrateable acidity showed significant variation among the 7 germplasm (Table 7). The highest percentage of titrateable acid (13.75 %) was found in germplasm No. 7 followed by germplasm No. 2 (12.49%) and germplasm No. 4 (7.69 %). The lowest percentage of titrateable acid (4.65 %) was recorded from germplasm No. 3 preceded by germplasm No. 1 (5.11%) and germplasm No. 6 (5.80 %). Average titrateable acidity of pod was 8.19 % (Table 7).

Total soluble solids of mature pod

The difference of total soluble solids had no significant variation among the 7 germplasm (Table 7). However, numerically the highest percentage of TSS (8.33 %) was observed in germplasm No. 2. The lowest percentage of total soluble solids of pod (5.33 %) was observed in germplasm No. 7. Average total soluble solids were 6.29 %. Increase in total soluble solid may be attributed to increase in soluble sugar, soluble pectin, soluble organic acids etc. (Table 7).

pH of mature pod

There was no a significant variation among the 7 germplasm in respect of pH of mature pod (Table 7). However, numerically the highest pH of pod was found in germplasm No. 2 (6.49) and the lowest pH content of pod (5.05) was recorded from germplasm No. 6. Average pH content of pod was 5.67 (Table 7).

Carotenoids content of mature pod

There was significant difference among the 7 germplasm in case of carotenoids content (Table 7). The highest amount of carotenoids (0.43 mg /100 g) was found in germplasm No. 2 which was statistically similar to germplasm No. 6 (0.23 mg /100 g) and the lowest amount of carotenoids (0.01 mg /100 g) observed in germplasm No.3 which was statistically similar to germplasm No.1 (0.02 mg/100g). Average carotenoids content was 0.16 mg /100 g of drumstick pod (Table 7).

Anthocyanin content of mature pod

The difference of anthocyanin content of mature pod was significant among the 7 germplasm (Table 7). The highest amount of anthocyanin of mature pod (0.25 mg /100 g) was observed in germplasm No. 5 which was statistically similar to germplasm No. 6 (0.22 mg /100 g), germplasm No. 3 (0.21 mg /100 g), germplasm No. 2 (0.21mg /100 g), germplasm No. 4 (0.19 mg /100 g). The lowest amount of anthocyanin of pod (0.032 mg /100 g) was observed in germplasm No. 1 (Table 7). Average anthocyanin content of pod was 0.19 mg /100 g (Table 7).

Flavonoids content of mature pod

There was a significant variation among the 7 germplasm in respect of flavonoids content of mature pod (Table 7). The highest flavonoids content of mature pod (0.09 g /100g) was observed in

germplasm No. 1 followed by germplasm No.2 (0.05 g / 100g) and germplasm No.3 (0.05 g / 100g). The lowest flavonoids content of mature pod (0.03 g /100g) was recorded from germplasm No. 5. Average flavonoids content was 0.05 g /100 g of pod (Table 7).

Table 7. Chemical characteristics of mature pod.

GP No.	Vitamin C (mg/100g)	T-acidity (%)	TSS (%)	pH	Carotenoids (mg/100gm)	Anthocyanin (mg/100gm)	Flavonoids (g/100g)
1	80.00 a	5.11 c	6.00	5.50	0.01 bc	0.03 b	0.09 a
2	75.00 a	12.49 ab	8.33	6.49	0.43 a	0.21 a	0.05 b
3	52.00 ab	4.65 c	6.33	5.41	0.01c	0.21 a	0.05 c
4	43.00 b	7.69 bc	7.00	5.56	0.03 bc	0.19 a	0.03 e
5	72.00 a	7.86 bc	5.33	5.85	0.17 bc	0.25 a	0.02 g
6	42.00 b	5.80 c	5.67	5.05	0.26 ab	0.22 a	0.03f
7	41.67 b	13.75 a	5.33	5.85	0.21 abc	0.19a	0.04 d
Average	57.95	8.19	6.29	5.67	0.16	0.18	0.09
Level of significance	**	**	NS	NS	*	**	**

Note: In column figures having similar letters don't differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. * Indicate 5% level of significance, ** Indicate 1% level of significance and NS indicate non-significant.

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