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Management of Invasive Alien Species (IAS) of West Bengal via bioprospecting for a potential source of food supplement

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Abstract
The purpose of the present work was to evaluate the proximate composition, minerals content (Na, K, Ca, Fe, Cu, Mn, Mg and Zn), simultaneous quantification of water soluble vitamins (like ascorbic acid, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine and folic acid) by HPLC of five different Invasive Alien Species (IAS) *viz. Alternanthera paronychioides, Cleome rutidosperma, Mikania micrantha, Pilea microphylla* and *Scoparia dulcis.* The result showed the highest calorific value of *C. rutidosperma* (124.220 ± 0.581 kcal/100g) which was also found to contain highest amount of protein (15.802 ± 0.115%). An appreciable quantity of carbohydrate was estimated in the leaves of *S. dulcis* (13.906 ± 0.131%) and *A. paronychioides* (13.610 ± 0.215%). *A. paronychioides* had the highest potassium content (3.916 ± 0.003 mg/g) and calcium content (5.902 ± 0.005 mg/g). The sodium content ranged between 0.071 – 0.125 mg/g. The leaves of *M. micrantha* (152.253 ± 0.033 mg/100g) contained a very good amount of vitamin C. The water soluble B vitamin content in these plants under investigation ranged between 0.014 to 2.457 mg/100gm.The results indicate that these IAS can be utilized as feed supplement.

Keywords: invasive alien species, proximate composition, mineral content, water soluble vitamins

1. Introduction
Convention for Biological Diversity (1992) visualize "biological invasion of alien species as the second worst threat after habitat destruction". Alien species are exotic organisms that occur outside their natural habitat and dispersal potential [1]. Naturalization is the first phase of biological invasions. After successful local establishment, some naturalized species disperse and produce viable offspring in areas distant from the sites of introduction. Such naturalized species are called invasive [2]. About 40% of the Indian flora is alien and 25% of which are IAS predominantly of neotropic origin [1, 3-4]. The invasive alien species are ready colonizers in disturbed areas and cause considerable ecological damage to India's natural areas, speed the disappearance of threatened and endemic species, reduce the carrying capacity of pastures, increase the maintenance costs of croplands. At the same time these IAS also contribute as food supplement in poverty stricken areas like leaves of *Asphodelus tenuifolius, Cassia tora* [5], tender shoots of *Alternanthera philoxeroides* and rhizomes of *Eichhornia crassipes* are used as vegetables [6]. Amongst the different IAS identified in West Bengal [3, 7-9] the following five plants (*Alternanthera paronychioides, Cleome rutidosperma, Mikania micrantha, Pilea microphylla* and *Scoparia dulcis*) possesses ethnomedicinal value and are further studied for their nutritional value as animal feed and vitamin supplement.
Whole plant decoction of *A. paronychioides* (Amaranthaceae) is used in diarrhoea [6]. Leaves of *C. rutidosperma* (Cleomaceae) [10] are used as vegetables. Leaf juice of *C. rutidosperma, M. micrantha* (Asteraceae) and *P. microphylla* (Urticaceae) are reported to be applied for wound healing [11-13]. Decoction of leaves of *M. micrantha* is taken to treat diabetes [14]. Leaves of *S. dulcis* (Scrophulariaceae) are used in the treatment of cough, bronchial trouble [6], diabetes [11]. The present programme of study is designed with the objectives to analyze the nutritional potential of these selected IAS, thus controlling their spread by bioprospecting.

2. Materials and Methods
2.1 Plant Materials
The fresh plants (aerial parts) of *A. paronychioides, C. rutidosperma, M. micrantha, P. microphylla*and *S. dulcis* were collected from various locations of Kolkata, India and the identification were authenticated from Botanical Survey of India, Howrah. The voucher specimens were preserved in our office. The plant materials were taken in our laboratory at refrigerated temperature using cold packs. The refrigerated plant samples were stored at 15^0C and one part processed for vitamin estimation. The other parts were shed-dried, pulverized and stored in an airtight container to evaluate proximate composition, minerals content and antioxidant properties.

2.2 Chemicals
The standards chemicals like ascorbic acid (C), thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine

(B6), folic acid (B9), were purchased from Sigma Chemical Co. (St. Louis, MO, USA), HPLC-grade solvents (such as acetonitrile, methanol, water and trifluoroacetic acid), anthrone, sodium hydroxide, sodium carbonate, sodium dihydrogen phosphate, Di-sodium hydrogen phosphate, petroleum ether (60-80°C) were purchased from Merck (Germany). All the chemicals used including the solvents, were of analytical grade.

2.3 HPLC equipment

HPLC analyses were performed using Dionex Ultimate 3000 liquid chromatograph including a diode array detector (DAD) with 5 cm flow cell and with Chromeleon system manager as data processor. Separation was achieved by a reversed-phase Acclaim C18 column (5 micron particle size, 250 × 4.6 mm). 20 μL of sample was introduced into the HPLC column.

2.4 Proximate Composition

2.4.1 Estimation of ash

Five gm of each sample was weighed in a silica crucible and heated in muffle furnace for about 5-6 h at 500 °C. It was cooled in a desiccator and weighed. It was heated again in the furnace for half an hour, cooled and weighed. This was repeated consequently till the weight became constant (ash became white or grayish white). Weight of ash gave the ash content [15].

2.4.2 Estimation of moisture

Two gm of each sample was taken in a flat-bottom dish and kept overnight in an air oven at 100–110°C and weighed. The loss in weight was regarded as a measure of moisture content [15].

2.4.3 Estimation of crude fat

Two gm moisture free of each sample was extracted with petroleum ether (60-80°C) in a Soxhlet apparatus for about 6-8 h. After boiling with petrol, the residual petrol was filtered using Whatman no. 40 filter paper and the filtrate was evaporated in a pre-weighed beaker. Increase in weight of beaker gave crude fat [15].

2.4.4 Estimation of crude fibre

Two mg of moisture and fat-free material of each sample was treated with 200 mL of 1.25 % H_2SO_4. After filtration and washing, the residue was treated with 1.25 % NaOH. It was then filtered, washed with hot water and then 1 % HNO_3 and again with hot water. The washed residue was dried in an oven at 130 °C to constant weight and cooled in a dessicator. The residue was scraped into a pre-weighed porcelain crucible, weighed, ashed at 550 °C for two hours, cooled in a desiccator and reweighed. Crude fibre content was expressed as percentage loss in weight on ignition [15].

2.4.5 Estimation of crude protein

The crude protein was determined using micro Kjeldahl method. Two gm of each sample compound was decomposed by digestion with concentrated sulphuric acid in the presence of a catalyst, ammonium sulphate is produced. An excess of sodium hydroxide solution was added to the diluted reaction mixture, the liberated ammonia was distilled in steam and absorbed in a measured excess of standard sulphuric acid. Titration of the residual mineral acid with standard sodium hydroxide gives the equivalent of ammonia obtained from the weight of the sample taken. From this the percentage of nitrogen in the compound can was calculated. On the basis of early determinations, the average nitrogen (N) content of proteins was found to be about 16 percent, which led to use of the calculation N × 6.25 (1/0.16 = 6.25) to convert nitrogen content into protein content [15].

2.4.6 Estimation of carbohydrate

The total carbohydrate content was estimated by the method of Hedge and Hofreiter (1962) [16]. 100mg of the sample was hydrolysed by keeping it in a boiling water bath for 3h.with 5.0 ml of 2.5N hydrochloric acid. Following hydrolysis it was cooled to room temperature and then neutralized with solid sodium carbonate until the effervescence ceased. After filtration, the volume of resulting mixture was made upto100 ml. To 0.2 ml of this mixture, 0.8 ml distilled water and 2.0 ml of 0.2 % anthrone (200 mg anthrone dissolved in 100 ml of ice cold 95% Sulphuric acid) was added, heated for 8 mins in a boiling water bath, cooled rapidly and absorbance was measured at 630 nm. Glucose was taken as standard. The carbohydrate content in microgram per ml (µg/ml) of dry material was calculated using the following equation based on the calibration curve: $y = 0.0081x + 0.2475$, $R^2 = 0.9955$, where y was the absorbance and x was the carbohydrate content (µg/ml). % carbohydrate is given as amount of carbohydrate (µg/ml) dived by volume of sample taken for analysis.

2.4.7 Estimation of energy content

The three components of foods which provide energy are protein, carbohydrate and fat. One gram carbohydrate and protein yield 4 kcal energy whereas one gram fat yields 9 kcal energy. Therefore the energy content of each plant samples were determined by multiplying the values obtained for protein, fat and available carbohydrate by 4.00, 9.00 and 4.00, respectively and adding up the values [15].

2.5 Estimation of minerals

Plant material was taken in a pre-cleaned and constantly weighed silica crucible and heated in a muffle furnace at 400°C till there was no evolution of smoke. The crucible was cooled at room temperature in a desiccator and carbon-free ash was moistened with concentrated sulphuric acid and heated on a heating mantle till fumes of sulphuric acid ceased to evolve. The crucible with sulphated ash was then heated in a muffle furnace at 600°C till the weight of the content was constant (~2–3 h). One gram of sulphated ash obtained above was dissolved in 100 mL of 5 % HCl to obtain the solution ready for determination of mineral elements through atomic absorption spectroscopy (AAS) (AA 800, Perkin-Elmer Germany). Standard solution of each element was prepared and calibration curves were drawn for each element using AAS [17].

2.6 Estimation of water soluble vitamins

2.6.1 Preparation of mixture standard vitamin solutions

The stock standard solutions of vitamin C, B1, B3, B5 and B6

and were prepared by dissolving 25 mg of the each standard in 1 ml 0.1M hydrochloric acid in 25 ml standard volumetric flask and volume made up to mark with double distilled water. For preparation of standard stock solutions of vitamin B9 and B2, 25 mg of the each standard were dissolved in one ml 0.1 M sodium hydroxide in 25 ml standard volumetric flask and volume made up to mark with double distilled water. The standard solution was stored in amber-glass bottles in the refrigerator at 4^0C. The working standards were prepared from the standard stock solutions by mixing 100 µl mixed vitamins standard (vitamin B9, B5 and B2), 800 µl phosphate buffer (1M, pH 5.5) and 100 µl mixed vitamins standard (vitamin C, B1, B6 and B3) which represent 100 µg/ml mixed working standards. The working standard solutions of concentrations 20, 40, 60 and 80µg/ml were prepared accordingly.

2.6.2 Preparation of sample solution

Plant materials were cleaned, rinsed thoroughly with tap water and then with distilled water. The washed plant materials were dried with clean cloth, were cut into very small pieces, frozen in liquid nitrogen, freeze-dried and kept at -20 ^{0} C until analysis. One gm each of freeze-dried sample was soaked in 10 ml water. Then 1 ml 0.1M and 10 ml phosphate buffer (1M, pH 5.5) were added to it and kept in dark for 24 hours. The solution was first filtered through a Whatman No. 1 filter paper and the resulting filtrate was taken in a 25 ml volumetric flask and solution was topped up to the mark with HPLC grade water. The sample solution was filtered through 0.45 μm membrane filter before injection into LC system. The stock solutions of sample were kept in a refrigerator for further use [18].

2.6.3 Chromatographic analysis of water soluble vitamins

The chromatographic analysis was carried out following the method as described by Seal *et al.* (2017) [18] with minor modifications. The mobile phase contains acetonitrile (Solvent A) and aqueous trifluoro acetic acid (TFA, 0.01% v/v) (Solvent B), the column was thermostatically controlled at 22^0 C and the injection volume was kept at 20 µl. A gradient elution was performed by varying the proportion of solvent A to solvent B. The gradient elusion was 1 % A and 99 % B with flow rate 0.5 ml/min in 5 min, from 1 % to 25% A with flow rate 0.5 ml/min for 16 min, 45 % A, with flow rate 0.5 ml/min for 8 min. from 45 to 1 % A with flow rate 0.5 ml/min in 5 min. The mobile phase composition back to initial condition (solvent A: solvent B =1: 99) in 34 min and allowed to run for another 1 min, before the injection of another sample. Total analysis time per sample was 35 min. The various concentrations of (20, 40. 60, 80 and 100 µg/ml) vitamin working standards were injected into the HPLC column separately and the retention times were noted and used to identify the vitamins in the sample. HPLC Chromatograms of all vitamins were detected using a photo diode array UV/detector at four different wavelengths (210, 245, 275 and 290 nm) according to absorption maxima of analysed compounds. Each compound in the plant extracts were identified by its retention time and by spiking with standards under the same conditions. The quantification of the sample was done by the measurement of the integrated peak area and the content was calculated using the calibration curve by plotting peak area against concentration of the respective standard sample. The data were reported as means ± standard error of means of three independent analyses.

3. Results and Discussion

3.1 Proximate Composition

The proximate analyses of the nutritive contents of five plants are depicted in Table 1. All the plant had a moderate moisture content ranging from 46 – 53%. The lowest moisture content was in *P. microphylla* (46.27 ± 1.300 %). Lesser moisture content indicates that storage of these species would be easier and less liable to deterioration. Ash content was relatively high with values ranging from 10.642 ± 0.102 % for *S. dulcis* to 26.286 ± 0.113 % for *P. microphylla.* Ash content of aerial parts of *M. micrantha* is 5.23 % [19] which is much lower to that obtained in this study 13.456 ± 0.115 %. This variation may be due to ecological factors or age of the plant samples under study. These values indicate that these plant species may be considered as good sources of minerals and could be considered as fodder supplement. The energy content of *C. rutidosperma* (124.220 ± 0.581 kcal/100g) is the maximum followed by that of *S. dulcis* (110.067 ± 0.734 kcal/100g). *M. micrantha* had the lowest nutritive value (70.800 ± 0.217 kcal/100g). The outcome of investigation revealed that these plants had greater nutritive potential than the common leafy vegetables like cabbage (27 kcal/100g), spinach (26 kcal/100g) and lettuce (21 kcal/100g) [20]. The carbohydrate content is maximum in *S. dulcis* (13.906 % ± 0.131), while *A. paronychioides* and *C. rutidosperma* both are significant in carbohydrate content. The lowest carbohydrate content was observed in *P. microphylla* (4.634 % ± 0.020) and these values are lower than those reported from other wild leafy vegetables like *Brassica nigra* (76.14 %), *Eurya acuminate* (76.14 %) [21]. The recommended carbohydrate values for children and adults are 130 g. It implies that 3.5 to 10.69 % of the daily requirement could be reached when 100 g of dried studied leaves are consumed.

Table 1: Proximate composition of the selected IAS

Plants	Proximate composition						
	Moisture %	**Ash %**	**Crude fat %**	**Crude fibre %**	**Crude protein %**	**Carbohydrate %**	**Energy content kcal/100g**
P. microphylla	46.27 ± 1.30	26.28 ± 0.11	3.59 ± 0.577	10.48 ± 0.18	7.38 ± 0.054	4.63 ± 0.02	81.59 ± 0.831
S. dulcis	51.53 ± 0.87	10.64 ± 0.10	2.513 ± 1.15	8.79 ± 0.15	8.10 ± 0.065	13.90 ± 0.13	110.06 ± 0.73
M. micrantha	51.96 ± 1.77	13.45 ± 0.11	1.46 ± 0.12	5.08 ± 0.04	7.78 ± 0.113	6.72 ± 0.39	70.80 ± 0.217
A. paronychioides	50.65 ± 1.31	13.07 ± 0.47	1.39 ± 0.17	12.15 ± 0.01	6.23 ± 0.132	13.61 ± 0.22	92.28 ± 0.418
C. rutidosperma	53.84 ± 1.72	12.9 7± 0.11	1.59 ± 0.11	4.55 ± 0.12	15.80 ± 0.11	11.71 ± 0.15	124.22 ± 0.581

Each value in the table was obtained by calculating the average of three experiments and data are presented as Mean ± SEM

The total fat content ranged between 1.392–3.593 % in these plants which is in congruence to the findings of many works which showed that leafy vegetables are poor sources of lipids [22]. However, it's important to note that diet providing 1 – 2 % of its caloric energy as fat is said to be sufficient to human beings, as excess fat consumption yields to cardiovascular disorders such as atherosclerosis, cancer and aging [23]. Therefore, the consumption of these plants as vegetables in large amount may be recommended to individuals suffering from obesity. The crude fibre content in *A. paronychioides* (12.155 % ± 0.013) would be advantageous for their active role in the regulation of intestinal transit, increasing dietary bulk due to their ability to absorb water [24]. The protein content ranges from 6.230 ± 0.132 % (*A. paronychioides*) to 15.802 ± 0.115% (*C. rutidosperma*). Nwaogu and Udebuani (2010) [25] showed seeds of *C. rutidosperma* to be richer source of protein and carbohydrate than the leaves evaluated in this study. Plant foods which provide more than 12 % of their calorific value from proteins have been shown to be good source of proteins [26]. This suggests that all the plants investigated are good sources of proteins and could play a significant role in providing cheap and available proteins for rural communities. Nutritional evaluation of the above IAS suggests that these can be considered to be utilized as alternate food source.

3.2 Minerals Content

Mean values for mineral content of the selected leafy vegetables are presented in Table 2. Sodium (Na) concentration ranged from 0.073 ± 0.001 mg/g (*A. paronychioides*) to 0.125 ± 0.001 mg/g (*S. dulcis*). The sodium levels of some cultivated vegetables and fruits vary between 30-1249 mg/kg [20]. The potassium (K) ranged between 1.611 ± 0.006 – 3.916 ± 0.003 mg/g. Na and K take part in ionic balance of the human body and maintain tissue excitability. Na plays an important role in the transport of metabolites and K is important for its diuretic nature. The ratio of K/Na in any food is an important factor in prevention of hypertension and arteriosclerosis, with K depresses and Na enhances blood pressure [27]. The ratio of K/Na in *A. paronychioides* (54.520), *M. micrantha* (25.287) *C. rutidosperma* (22.386) are comparable to some common fruits (*Castanea sativa* 56.67, Amla 45, ripe papaya 11.5, tomato 11.31) [28]. The calcium (Ca) content was highest in the leaves of *A. paronychioides* (5.902 ± 0.005 mg/g). Ca levels varied within 4.160 ± 0.003 – 5.902 ± 0.005 mg/g whereas that in of some cultivated vegetables (lettuce, cabbage and spinach) varies between 0.39 –0.73 mg/g [20]. It is also very much required for the normal functioning of the cardiac muscles, blood coagulation and the regulation of cell permeability [28]. The iron content of these plants ranged between 0.166 ± 0.002 – 0.762 ± 0.002 mg/g. Iron is essential in oxygen binding to hemoglobin and also acts as catalyst for many enzymes like cytochrome oxydase [29]. Thus, the selected leaves of this study could be recommended in diets for reducing anemia. The magnesium content ranged between 0.039 ± 0.004 mg/g in *C. rutidopserma* to 0.056 ± 0.004 mg/g in *P. microphylla.* Magnesium helps to prevent cardiomyopathy, muscle degeneration, growth retardation, immunologic dysfunction, impaired spermatogenesis, congenital malformations and bleeding disorders [30]. The recommended dietary allowance (RDA) for minerals: calcium (1000 mg/day); magnesium (400 mg/day) and iron (8 mg/day) (FAO/ WHO) (2001) [31], the results suggests that these plants contribute substantially in improving the diet in terms of mineral requirement.

Copper (Cu) acts as an important part of copper protein. Cytochrome C oxidase, lysyl oxidase and tyrosine oxidase are the major Cu containing metalloenzymes. The recommended intake of copper is 1.35 mg/day [32]. The maximum amount of Cu was observed in *M. micrantha* (8.144 ± 0.057), and the least amount was found in *A. paronychioides* (1.781 ± 0.051). Manganese (Mn) acts as the cofactor for the enzymes like arginase, and glycosyl transferase. There are other enzymes like phosphoenol pyruvate carboxy kinase and glutamine synthetase, which are activated by Mn ions. Mn is also essential for haemoglobin formation [17]. The manganese concentration ranged between 0.015–0.070mg/g. Zinc has a role in stabilizing macromolecular structure and synthesis. The role of the metal ion in the DNA and RNA synthesis is well documented and both DNA and RNA polymerases are zinc-dependent enzymes [32]. All the IAS under study had a moderate Zn concentration ranging between 0.023–0.044 mg/g.

Table 2: Minerals content of the selected IAS

Plants	Minerals present mg /g							
	Sodium	**Potassium**	**Calcium**	**Iron**	**Magnesium**	**Copper**	**Zinc**	**Manganese**
P.microphylla	0.103 ± 0.002	1.611 ± 0.007	5.336 ± 0.003	0.762 ± 0.002	0.056 ± 0.002	4.715 ± 0.115	0.031 ± 0.005	0.037 ± 0.005
S.dulcis	0.125 ± 0.001	1.612 ± 0.006	4.378 ± 0.006	0.326 ± 0.002	0.052 ± 0.002	2.523 ± 0.005	0.035 ± 0.001	0.015 ± 0.002
M.micrantha	0.078 ± 0.002	1.931 ± 0.013	4.160 ± 0.003	0.571 ± 0.004	0.053 ± 0.002	8.144 ± 0.057	0.044 ± 0.002	0.070 ± 0.005
A.paronychioides	0.073 ± 0.001	3.916 ± 0.003	5.903 ± 0.005	0.166 ± 0.002	0.039 ± 0.002	1.781 ± 0.051	0.023 ± 0.006	0.017 ± 0.003
C.rutidosperma	0.086 ± 0.002	1.960 ± 0.002	5.125 ± 0.003	0.571 ± 0.004	0.039 ± 0.004	2.814 ± 0.009	0.043 ± 0.002	0.032 ± 0.005

Each value in the table was obtained by calculating the average of three experiments and data are presented as Mean ± SEM

3.3 Quantification of water soluble vitamins

The vitamin content in the selected IAS is depicted in Table 3. Vitamin C is well known for its antioxidant properties and it helps inhibiting infection, and toxicity. It is also required for the prevention of scurvy and maintenance of healthy skin. Highest amount of ascorbic acid was found in *M. micrantha* (152.253 ± 0.033 mg/100gm) which is high when compared to that found in common edible vegetable like tomato (23 mg/100g), spinach (51 mg/100g) and onion (190mg/100g) [33]. The recommended daily requirement for Vitamin C according to FAO/ WHO (2001) [31] is between 45.83 mg/day to 68.50 mg/day for both male and female adults between the ages of 19 to 65 years. Furthermore, the availability of reasonable amounts of vitamin C in the vegetables in this study provides

a new source of antioxidants required for the maintenance of health.

Thiamine (B1) is essential for energy production, carbohydrate metabolism and nerve cell function (2001). Maximum amount of B1 (0.110 ± 0.003 mg/100g) was found in *S. dulcis*. Thiamine has been shown to occur in some common vegetables like beans (0.132mg/100gm), cauliflower (0.073 mg/100gm), spinach (0.076mg/100gm) [34] and these amounts are very much similar to the thiamine content detected in the invasive species under investigation.

Table 3: Quantification of water soluble vitamins in the selected IAS

Vitamin content in mg/100gm							
Plants	**C**	**B1**	**B2**	**B3**	**B5**	**B6**	**B9**
P.microphylla	36.667 ± 0.266	0.019 ± 0.001	0.962 ± 0.003	0.452 ± 0.003	ND	2.457 ± 0.020	0.084 ± 0.002
S. dulcis	42.649 ± 0.033	0.110 ± 0.003	1.066 ± 0.006	ND	0.830 ± 0.003	0.430 ± 0.006	0.320 ± 0.003
M.micrantha	152.253 ± 0.033	0.032 ± 0.001	0.130 ± 0.006	ND	0.318 ± 0.003	0.991 ± 0.006	0.136 ± 0.006
A.paronychioides	15.275 ± 0.033	0.014 ± 0.002	1.866 ± 0.006	1.924 ± 0.003	ND	0.195 ± 0.003	0.049 ± 0.002
C.rutidosperma	48.262 ± 0.066	0.024 ± 0.002	0.924 ± 0.006	ND	0.468 ±0.006	0.421 ± 0.003	0.063 ± 0.001

Each value in the table was obtained by calculating the average of three experiments and data are presented as Mean ± SEM

ND: Not detected

The maximum amount of riboflavin (B2) was found in *A. paronychioides* (1.866 ± 0.006 mg/100g) and the least amount in *M. micrantha* (0.130 ± 0.006). Leaves of *S. dulcis* also contained high amount of B2. The data obtained from this study is comparable to some common vegetables like spinach (0.24 mg/100g), green beans (0.12 ± 2 mg/100g, potato (0.023 ±1 mg/100g) [34]. The B2 content in these invasive species is much higher than found in wild edible fruits like *D. indica* (0.525±0.004) and *Elaeagnus latifolia* (0.05±0.003) [35].

Vitamin B3 and B6 is also found in adequate amount in these invasive species under study. Maximum amount of B3 was found in *A. paronychioides* (1.924 ± 0.003 mg/g), followed by that in *M. micrantha* (0.991 ± 0.006 mg/g). Vitamin B3 plays an important role in DNA repair and fat metabolism [31]. Vitamin B6 content showed a wide range of variation. It was found in maximum in *P. microphylla* (2.457 ± 0.020 mg/g) and minimum in *A. paronychioides* (0.195 ± 0.003 mg/g). Folic acid (B9) plays an important role in DNA synthesis and repair [31]. It was found in maximum amount in *S. dulcis* (0.320 ± 0.003 mg/g). Consuming these invasive species as vegetables would partly satisfy the vitamin requirement of human and therefore can be considered as alternative food source.

4. Conclusion

These selected invasive plants were also rich in protein, available carbohydrate, total dietary fibre and minerals, and could be used as an alternate nutritional source of animal feed due to their good nutritional qualities and might provide adequate protection against diseases with their antioxidant activity. It is believed that adopting this concept for harvesting invasive species is an indirect way of controlling them.

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