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NUTRITIONAL AND ANTI-NUTRITIONAL ANALYSIS OF SOME SELECTED MICROGREENS

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ABSTRACT

Microgreens are immature greens of edible vegetables and herbs which may serve as a good nutrient source. The present study was conducted on ten locally available plants, tested as microgreens. The study included evaluation of seed germination and growth pattern for two weeks period and nutritional characterization of selected microgreens. Results showed that the seeds of selected plants had > 80% germination and attained 6-7 cm height within two weeks. Vitamin C was high in all the microgreens tested; while thiamine, riboflavin and niacin were high in microgreens of *Amaranthus viridis, Vigna radiata* and *Allium cepa*, respectively. However, vitamin content was higher in sprouts than microgreens and mature edible parts of selected plants even though some exceptions were found. Anti-nutrients analyzed in microgreens were below the toxic levels. Microgreens had low carbohydrates and anti-nutrient contents; but high vitamin contents, so these can be recommended as dietary supplement, especially for those who preferred less carbohydrate-containing food supplements.

Key words: Growth-pattern, microgreens, nutritional analysis, seed germination, vitamins

INTRODUCTION

Human beings always attempted to procure their dietary requirements from primary food crops such as cereals, pulses, vegetables and fruits. However, the foods procured from markets are over-loaded with chemical fertilizers and pesticides which adversely affect human health. Health experts believe that man needs contamination-free food and priority may be focused on nutritionally enriched food. The health-conscious society appreciates and enjoys fresh food rather than processed and packaged food. In order to bring diversity in food, home grown plants and fresh produce can be supplemented with sprouts and microgreens to get an extra-dose of taste, flavour, colour and of course health nourishing nutrients. In facts, sprouts and microgreen are new flavour trends in culinary and constitute a growing market in developed countries, where restaurant chefs use these plants or their parts to add exotic flavour and colour, and offer creative presentation to dishes to health-conscious upscale consumers (Ebert, 2017).

Sprouts are the shoots or young seedlings that emerge from a germinated seed. Sprouts of certain vegetables and grains consumed as a source of health food as they possess higher amounts of phytonutrients/phytoestrogens such as coumesterol, saponin, daidzein, equoisolariciresinol, polyphenols, saponins, flavanoids, phenolic acids and organic acid (Xiao *et al*., 2005; Tang *et al*., 2014; Mattioli *et.al*., 2016). These are grown in dark, entirely in water without soil or any growth medium. In comparison, microgreens are tender immature greens produced from the seeds of vegetables and herbs, having two fully developed cotyledon leaves with or without the emergence of rudimentary pair of first true leaves (Xiao *et al.,* 2012). They are usually harvested within two weeks after germination. Baby leaf greens are young seedlings but a bit older than microgreens. These have longer growth cycle with developed true leaves (>1 set) and are harvested 20-40 days after germination (*http*://*www.nps.ars.usda.gov*).

Microgreens are usually harvested when they attain 6-7 cm height i.e. within 1-2 weeks after germination. The size of microgreen may vary with the nature and type of plant. When greens grow beyond the above-mentioned size, they are called petite greens. The seeds of a wide variety of herbs (*e.g.* basil and cilantro), vegetables (*e.g.* radish, broccoli) and even flowers (*e.g.* sunflower) are grown as microgreens. They provide an array of intense flavours, vivid colours and tender textures and are usually consumed fresh after harvest. They contain high levels of phytonutrients, antioxidants, vitamins and minerals and are claimed to be nutritionally beneficial (Xiao *et al.,* 2012). The microgreens are nutritional, crunchy and their display looks wonderful on dishes. Microgreens contain high vitamin contents than mature plants but the type and quantity may differ. Maximum value of vitamin C, E and K have been noticed in red cabbages, garnet amaranth and green daikon radish as compared to many others plants studied (Xiao *et al.,* 2012). Cilantro microgreens showed highest concentrations of luetin, zeaxanthin, violaxanthine and beta-carotene but popcorn and golden pea tendrils have relatively low vitamin and carotenoids as compared to their mature forms (Xiao *et al.,* 2012). The macro- and micro-minerals were high in almost all microgreens (Weber, 2017). However, mineral content varied according to the growth media used for culturing them. Mineral concentration of compost grown broccoli microgreens had higher amounts of P, K, Mg, Mn, Zn, Fe, Cu and Zn as compared to control (Weber, 2017). All the vitamins and carotenoids are usually concentrated in cotyledon leaves. Light exposure during sprouting, growing and storing period have an effect on quality; for example, light exposure during storage affects the phenolic and α-tocopherols and increases ascorbic acid content. Dark storage results in higher hydroxyl radical scavenging capacity and carotenoids retentionie, light exposure accelerated deterioration of radish microgreens, while dark storage maintained the quality (Xiao *et.al.,* 2014).

Microgreens are valuable nutritional supplement to human diet as they require very little space, growth-time and chemical inputs and offer a lucrative solution to health-conscious consumers. However, microgreens perish fast, therefore need to be produced in sufficient quantity in a sustained manner to ensure availability. The present study was focused on to identify the germination and growth pattern of ten selected plants until microgreen stage as well as to determine their nutritional and anti-nutritional constituents and also to compare the vitamins in sprouts, microgreens and corresponding mature edible part of selected plants.

MATERIALS AND METHODS

The study was conducted in the year 2016-2018. The seeds of ten plants i.e. *Allium cepa* (onion), *Amaranthus cruentus* (red amaranth), *Amaranthus viridis* (green amaranth), *Beta vulgaris* (beet root), *Coriandrum sativum* (coriander), *Daucus carota* (carrot), *Sesbania grandiflora* (Agathikeera), *Trigonella foenum graecum* (fenugreek), *Vigna radiata* (mung bean) and *Vigna unguiculata* (red cowpea) were procured from a local market (Agrosuper Bazaar, Kissan Jyothi, Nalumukku, Fort, Thiruvananthapuram, Kerala). The seeds were sown in dirt-free sand soil taken in well aerated plates and placed in balcony where sufficient sunlight and shades were available. The seeds were scattered on wet soil and covered by a thin soil layer and watered once a day. No chemical or organic fertilizers was applied. All the seeds were grown under natural conditions. Sprouted seeds and microgreens (length ~ 7 cm) were subjected to nutritional and anti-nutritional analysis. Physical characteristics of microgreens were observed under fresh, dry powered and refrigerated conditions.

Analysis of germination percentage and growth patterns

The seeds of test plants were germinated under natural conditions. Germination and other growth parameters *viz*., number of days required for radical emergence from seeds and number of days taken to attain the characteristic height (~7 cm) were assessed in early mornings.

Analysis of physical characters

The physical parameters such as colour of seeds, plumule, microgreen stem, leaf and grinded paste of microgreens (prepared by grinding in a mortar and pestle to make a fine paste without adding any solvent) were recorded by visual examination as well as compared with Wilson's colour chart (Wilson, 1939). The attributes such as taste and odour of ground microgreens were judged by 15 volunteers. The response of majority of judges was accepted as final response.

Nutritional and anti-nutritional analysis

Phytonutrient and anti-nutrient analysis were conducted on fresh samples *i.e.* sprouts and microgreens (harvested when they reached up to 6-7 cm height), collected from each replicate from each treatment. The estimation of nutrients and anti-nutrients were done by UV-Vis spectrophotometer, except for niacin and oxalate which were estimated by titration method. The total carbohydrates were estimated as per the method of Hedge and Hofreiter (1962), proteins as per Bradford (1976) and carotene as per Yoshida *et al.* (1971). The vitamins thiamine, riboflavin, niacin and ascorbic acid were estimated as per Deepak (2011), Indian Pharmacopoeia (1996), Adepoju and Adenji (2012) and Bessey *et al.* (1938), respectively. The anti-nutrients phenol and saponin and oxalates were assayed as per the methods of Malik and Singh (1980) and AOAC (1984), respectively. All the experiments and analysis were conducted in triplicate. The data was statistically analyzed (Gomez and Gomez, 1984) and reported as means of three replicates ± standard deviation.

RESULTS AND DISCUSSION

The seeds of all test plants showed >80% germination ((Table 1). Among them, *Vigna. radiata* and *V. unguiculata* showed highest germination (95-97%) and reached microgreen stage within 4 days. High germination in above species have previously been reported (Lorenson *et al.*, 1981). *Allium cepa*, *Amaranthus cruentus* and *Trigonella foenum graecum* took almost 10 days while *Sesbania grandiflora* took even longer (~14 days) to reach this stage.

Table 1: Germination percentage and growth patterns of selected plant seeds

Name of plants	Seed germination (%)	No. of days for radicle emerge from seed	Days required to attain 6-7 cm height
Allium cepa	83	3	10
Amaranthus cruentus	94	22	10
Amaranthus viridis	92	3	8
Beta vulgaris	86	3	8
Coriandrum sativum	87	3	7
Daucus carota	85	3	7
Sesbania grandiflora	80	2	14
Trigonella foenum graceum	80	2	10
Vigna radiata	95	1	4
Vigna unguiculate	95	1	4

All the experiments were conducted in triplicate

The physical parameters of microgreens of selected plants revealed that all plant species reached microgreen stage within ~ 14 days (Fig. 1). Further, the colour, taste, ordour and texture of stem

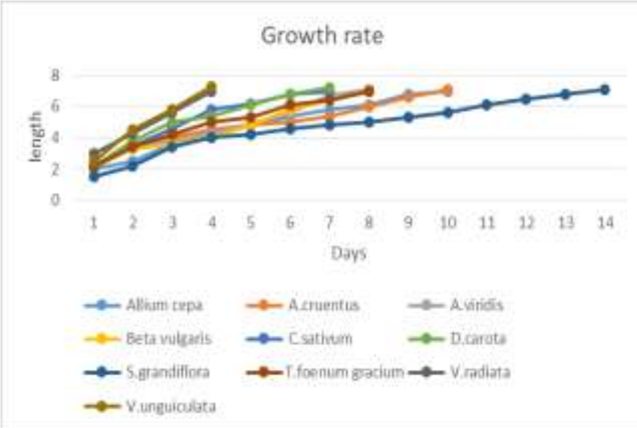


Fig. 1: Growth pattern of selected microgreens monitored over 14 days

and leaves of microgreens were acceptable when fresh (Table 2). Environment has great impact on the physical characteristics of each plant. In present study we did not consider the environmental impact as all these were grown in similar environmental conditions and attained this stage within a short time span. The physical characters of micro-greens like colour, texture, taste, odour and freshness after storage under refrigeration, placed within air-tight sealed plastic containers, showed the signs of deterioration. Reports indicate short shelf life and rapid product deterioration of microgreens on storage, although emphasizing on the pleasing palette of colour, texture and flavour when fresh (Ahamad *et al.*, 2016). Vivid colours and delicate nature were lost when dried and powdered. Hence microgreens provide optimum taste only when consumed fresh and to a maximum they can be stored for 2 days in a refrigerator.

Table 2: Physical characteristics of selected microgreens

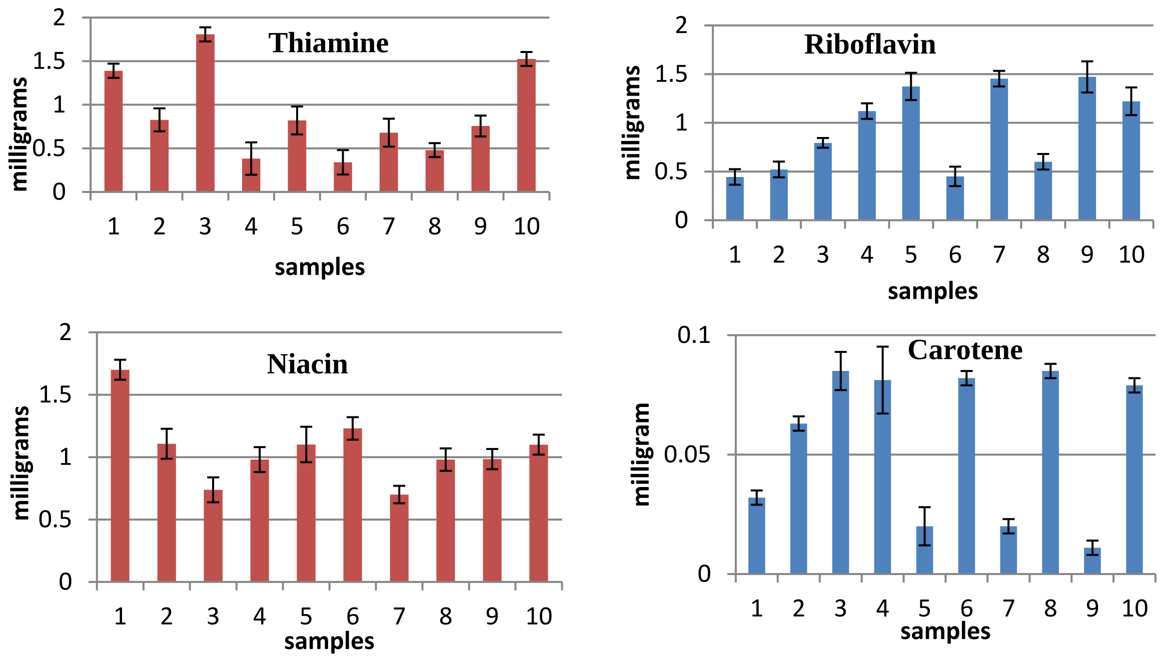
Name of plant	Seed colour	Plumule colour	Microgreen stem colour	Microgreen leaf colour	Taste	Odour	Paste colour
Allium cepa	Black	Pale greenish white	Light green	Green	Same as its bulbs	Same as its bulbs	Light green
Amaranthu scruentus	Black	Reddish white	Blood red	Dark red	Earthy	Earthy	Red
Amaranthus viridis	Black	Greenish white	Green	Green	Earthy	Earthy	Green
Beta vulgaris	Reddish yellow	Pale red	Blood red	Dark green	Earthy but Slightly sweet	Earthy	Greenish red
Coriandrum sativum	Reddish yellow	Pale green	Light green	Green	Mellow	Strong Aroma	Green
Daucus carota	Brownish yellow	Pale green	Light green	Green	Earthy	Earthy	Green
Sesbania grandiflora	Brown	Green	Brownish yellow	Green	Earthy	Earthy	Dark green
Trigonella foenum graecum	Light brown	Pale white	Green	Green	Earthy	Earthy	Dark green
Vigna radiata	Green	White	Light green	Green	Earthy	Earthy	Green
Vigna unguiculata	Reddish brown	White	Green	Green	Earthy	Earthy	Green

Table 3: Carbohydrates and protein contents (g 100 g^{-1}) in microgreens of selected plants

Name of plants	Carbohydrate	Protein
Allium cepa	0.334 ± 0.0008	0.707 ± 0.0081
Amaranthus cruentus	0.303 ± 0.0008	0.818 ± 0.0816
Amaranthus viridis	0.337 ± 0.0081	0.999 ± 0.0816
Beta vulgaris	0.401 ± 0.0008	0.912 ± 0.0008
Coriandrum sativum	0.377 ± 0.0081	0.600 ± 0.0816
Daucus carota	0.577 ± 0.0081	0.602 ± 0.0081
Sesbania grandiflora	0.420 ± 0.0081	0.701 ± 0.0816
Trigonella foenum graecum	0.360 ± 0.0081	0.810 ± 0.0081
Vigna radiata	0.600 ± 0.0081	0.921 ± 0.0816
Vigna unguiculate	1.251 ± 0.0081	0.965 ± 0.0816

All the values are mean of three replicates

The microgreens possessed high protein contents in the range of 0.600 to 0.999 g 100 g^{-1} (Table 3) with higher values in *A. viridis V. unguiculata*, *V. radiata* and *B. vulgaris* and minimum in *C. sativum*.



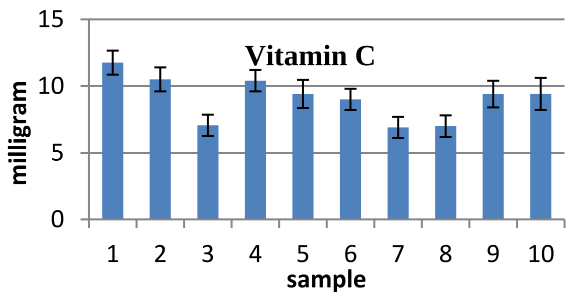


Fig. 2: The vitamin contents in selected microgreens *1) Allium cepa, 2) Amaranthus cruentus, 3) Amaranthus viridis, 4) Beta vulgaris, 5) Coriandrum sativum, 6) Daucus carota, 7) Sesbania grandiflora, 8) Trigonella foenum graceum, 9) Vigna radiata* and *10) Vigna unguiculate*

The carbohydrates were less in microgreens. The vitamin analysis showed that the selected microgreens were rich in all the five vitamins studied (Fig. 2). The *Amaranthus viridis*, *Vigna radiata*, *Allium cepa*, *Trigonella foenum graceum* and *A. cepa* were rich in thiamine, riboflavin, niacin, carotene and vitamin C, respectively.

The comparative study of vitamins in sprouts, microgreens and mature edible part of plants showed that all the vitamins analyzed were high in sprouts and were reduced in microgreens and with further decrease in mature edible part, with certain exceptions (Fig. 3). Microgreens of *Daucus carota* had comparatively high amount of niacin while mature edible part of *Sesbania grandiflora* showed higher amount of vitamin C. Carotene content was high in mature edible part of all selected plants. The nutritional analysis revealed that all the microgreens had low carbohydrates content in the range of 0.303 (in *A. cruentus*) to 1.25 g (in *V. unguiculata*) 100 g^{-1}. The carbohydrate content in *A. cepa, A. cruentus, A. viridis, C. sativum, T. foenum graecum* was comparatively lower than others; whereas *V. radiata* and *V. unguiculata* had high carbohydrate content. Lowering the carbohydrate intake can help in reducing the total calorie intake for weight loss. The recommended microgreens as source of a particular vitamin as revealed from the present study is given Table 4. As per the Institute of Medicine, US National Academy of Science the children and adults should consume 45 to 65% calories intake as carbohydrates and at least 130 g carbohydrate per day. Since lowering the carbohydrate intake and increasing protein intake can help reduce total calorie intake for weight loss, about 50% of calories should come from carbs for successful weight loss (Coleman, 2017). Hence these micro-greens can be recommended as dietary supplement for people who prefer less carbohydrate containing food supplements.

The anti-nutrients are natural or synthetic compounds that interfere in nutrient absorption. The

Table 4: The US [National Institutes of Health (NIH)], Recommended Daily Allowance (RDA) values for the five vitamins studied

Vitamins	Men (mg 100 g^{-1})	Women (mg 100 g^{-1})	Recommended microgreens as source of vitamins from present study
Thiamine	1.2	1.1	*Allium cepa* (1.39 mg), *Amaranthus viridis* (1.807) and *Vigna unguiculate* (1.525 mg) per 100 g^{-1})
Riboflavin	1.3	1.1	*Beta vulgaris, Coriandrum sativum, Sesbania grandiflora, V. radiata and V. unguiculate* showed comparable values
Niacin	16	14	*A. cepa, A. cruentus, C. sativum, D. carota & V. unguiculata* (>1 mg)
Carotene	0.9	0.7	*A. cruenthus, A. viridis, D. carota* and *V. radiata*
Vitamin C	90	75	All selected microgreens (1000 g)

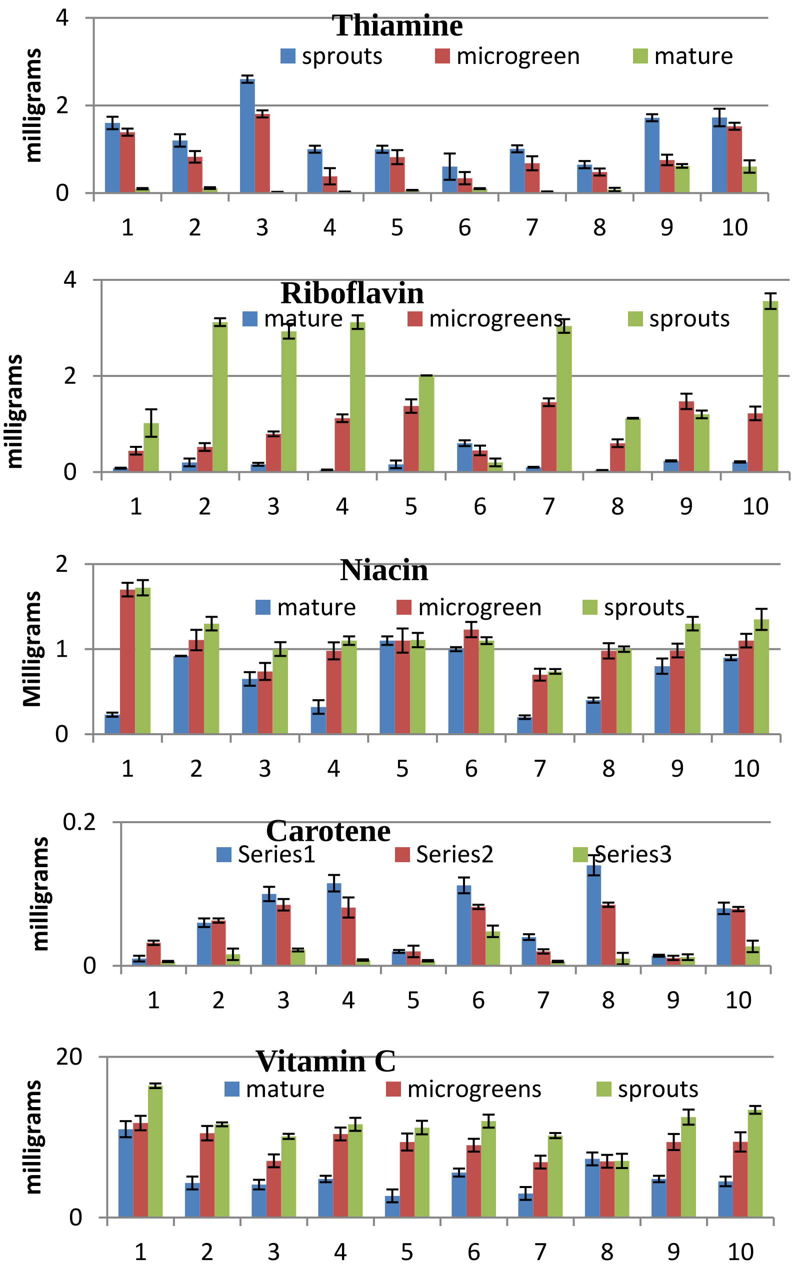


Fig. 3: Vitamin contents in microgreens, sprouts and mature parts of selected plants

anti-nutritional factors (ANFs) *viz.*, phenol, saponin and oxalate contents in microgreens were examined. The phenol and saponin values were below the toxic level but comparatively higher values were observed for oxalates (1.00 ± 0.024 to 1.150 ± 0.287 mg) in all the microgreens studied (Table 5). Lower values were noticed for saponins (0.78 ± 0.033 to 1.49 ± 0.008 mg) and phenols (0.096 ± 0.002 in *A. cepa* to 0.235 ± 0.004 mg in *V. unguiculata*) in that order. The three anti-nutrients were well below the toxic levels. According to Augustin *et al.* (2000) the recommended total intake of phenolic compounds is 1 g d^{-1}. Our results are in conformity with Guajardo *et al.* (2012) who reported that additional germination days decreased the amount of most abundant saponins in sprouts. A high total oxalate content (greater than 50 mg 100 g^{-1}) was found in whole grain wheat species *Triticum durum* (76.6 mg 100 g^{-1}), *Triticum sativum* (71.2 mg 100 g^{-1}) and *Triticum aestivum* (53.3 mg 100 g^{-1}) [Siener *et al.*, 2006]. In comparison to these cereals, microgreens thus selected for study contain low oxalates.

Table 5: Anti-nutritional analysis of selected microgreens (values mean of three replicates).

Name of plants	Phenol (mg)	Saponin (mg)	Oxalate (mg)
Allium cepa	0.096 ± 0.0016	0.940 ± 0.0326	1.100 ± 0.033
Amaranthus cruentus	0.194 ± 0.0032	1.730 ± 0.0244	1.150 ± 0.003
Amaranthus viridis	0.099 ± 0.0008	1.490 ± 0.0081	1.150 ± 0.033
Beta vulgaris	0.100 ± 0.1423	0.900 ± 0.0816	1.150 ± 0.008
Coriandrum sativum	0.137 ± 0.0024	1.140 ± 0.0326	1.100 ± 0.032
Daucus carota	0.101 ± 0.0008	0.900 ± 0.2867	1.000 ± 0.024
Sesbania grandiflora	0.104 ± 0.0032	1.100 ± 0.0163	1.150 ± 0.008
Trigonella foenum graecum	0.124 ± 0.0326	1.020 ± 0.0081	1.100 ± 0.082
Vigna radiata	0.200 ± 0.0816	0.780 ± 0.0326	1.100 ± 0.032
Vigna unguiculate	0.235 ± 0.0040	1.110 ± 0.0081	1.150 ± 0287

Conclusions: Among the ten microgreens studied, the microgreens of *Vigna radiata* and *V. unguiculata* performed better in terms of carbohydrate, protein and vitamin content apart from their high germination potential and speed of growth. All the selected microgreens possessed high amounts of vitamins and lesser quantity of ANFs. Though the corresponding sprouts were found to be a good source of vitamins, the microgreens were equally good and are likely to attract the palette with their crunchy texture, bright colour and tangy taste. Further, growing microgreens requires less space, money, time and care. Hence, these can be recommended as a valuable alternative for substituting our diet, setting aside the chemically polluted vegetables.

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