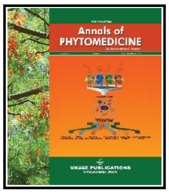
Annals of Phytomedicine 11(2): 591-596, 2022

DOI: http://dx.doi.org/10.54085/ap.2022.11.2.72

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885



Original Article : Open Access

Impact of various substrates on the physicochemical properties of radish microgreens

Shahzadi Khatoon and Mukta Singh◆
Department of Home Science, Banaras Hindu University, Varanasi-221005, Uttar Pradesh, India

Article Info

Article history
Received 13 July 2022
Revised 28 August 2022
Accepted 29 August 2022
Published Online 30 December-2022

Keywords
Substrates
Organic compost
Nutrients
Morphology
Consumer acceptability

Abstract

Microgreens are the immature, leafy green parts of a variety of vegetables, herbs, cereals and flowers that have the potential to improve human health and diversify the world's food supply in a sustainable way. The current study's goal is to examine the impact of various growing substrates on morphological properties and nutritional content of radish microgreens and also to evaluate its sensory attributes. In order to do the same, four growing media were utilized for cultivation of radish microgreens:(i) only soil (Ts), (ii) soil with vermicompost (Tsv), (iii) only cocopeat (Tc) and (iv) cocopeat with vermicompost (Tcv). The results obtained from the study reveals a statistically significant difference among the height of plant, grown in different substrates, *viz*., 9.20 ± 0.34 cm in Ts, 11.16 ± 0.20 cm in Tsv, 9.30 ± 0.20 cm in Tc and 11.40 ± 0.36 cm in Tcv. However, no significance difference was observed in the number of leaves of radish microgreens in different media, on 10th day of monitoring. Furthermore, an increase in energy content (61.20 kcal), carbohydrate (6.19 ± 0.12 g/100g), fat (0.59 ± 0.09 g/100 g), ash (2.41 ± 0.17 g/100 g) and fiber (3.43 ± 0.32 g/100 g) are found in Tcv medium. Whereas, protein content was found highest in Tsv medium (6.59 ± 0.18 g/100g). Likewise, in context of minerals content analysis, Ca was found highest in Tsv medium (63.73 mg/100g), Fe in Tcv medium (0.63 mg/100 g), Mg and Zn in Tcv medium. Overall, it is concluded that Tcv is the best growing medium, followed by Tsv for radish microgreens.

1. Introduction

Microgreens are an exotic variety of edible greens that may be found in upscale shops and restaurants. During the recent years, they have become a hot new culinary craze.They are fragile, immature greens grown from vegetable and herb seeds that have two completely formed cotyledon leaves and may or may not have the development of the first two real leaves. They are significantly younger than baby greens and older than sprouts. In California, microgreens gained popularity in the middle of the 1990s and the term "microgreens" was first used in 1998, according to records. Microgreens typically grow to a height of 1-3 inches, are picked 7-14 days after germination. Despite being small, microgreens may offer a wide variety of potent aromas, vibrant colours and soft textures. In order to enhance the colour, texture, or flavour of salads, soups and sandwiches, microgreens can be used as a new element. They can also be used to a variety of major courses as an edible garnish (Lee *et al*., 2004; Murphy and Pill, 2010)**.** Microgreens can be grown in different organic substrate also with the supplementation of organic composting. Organic treatments significantly affect the morphological properties of crop (Jabborova *et al.*, 2021)**.** Plants offers a huge source of metabolites with a diverse spectrum of chemical structures that may hold promise as potential therapeutics (Balyan and Ali, 2022). Fruits and vegetables include a significant number of mineral content, phenolic compounds, antioxidants and flavonoids. It has been discovered that eating them is connected with a lower risk of developing certain diseases (Malik *et al*., 2020).

In most cases, a balanced diet is enough to provide the right balance of minerals to support the immune system. Although, in the modern era, where adulteration practices are rising, it is challenging to bring a pure balanced diet to people's plate.The availability of minerals is crucial for the innate immune system to operate at its best as well as for adaptive immune defence mechanisms, which include defences against infections and a long-term equilibrium between pro- and anti-inflammatory regulations. Any one of these mineral deficiencies may lead to a short-term reduction in immune function or, in the long run, a disruption in the regulation of systemic inflammation (Weyh *et al*., 2022).

Minerals perform a wide range of tasks, including acting as the building blocks for our bones, affecting the way that muscles and nerves function and controlling the water balance in the body (Kim and Choi, 2013).

Microgreens have more than two and three fold of these minerals, phytochemicals and bioactive compounds, which play a key role for immune system. It is a crucial tool to combat of malnutrition due to its increased vitamin or pesticide residue-free attention (Thakur *et al.*, 2022). But in India, growing and awareness is very low regarding this super food. It is gaining in popularity in some metro cities, but mostly in restaurants and limited to supermarkets. Although, it has been asserted that microgreens are nutritionally advantageous, there is, as far as we are aware, very little scientific information on micro-greens specifically in India.

Corresponding author: Dr. Mukta Singh
Professor, Department of Home Science, Banaras Hindu University, Varanasi-221005, Uttar Pradesh, India
E-mail: drmuktasingh@gmail.com
Tel.: +91-7376623033

2. Materials and Methods

2.1 Growing media, seed sowing and harvesting

As a growing media, four distinct substrates-simply soil (T_s), soil with vermicompost (T_{sv}) in 1:1(v/v), cocopeat (T_c) and cocopeat with vermicompost (T_{cv}) in 1:1(v/v) were separately used in perforated plastic trays measuring 52 × 45 × 4 cm then filled to a 2.5 cm depth. The radish seeds were evenly distributed on the surface of the substrate and then a thin layer of that particular media was applied. In the winter, the seedlings were watered once in a day while being kept at room temperature and exposed to natural light. Growth rate were monitored regularly and harvested 10th day after germination. Sharp sterilised scissors were used to cut the seedlings at the surface of the growing media. The height, leaves per plant and fresh weight of the microgreens were calculated.

2.2 Analysis of growth rate and nutritional component

Plant height was taken through scale in every 5th day after germination in triplicates, fresh weight was calculated digital weighing balance and number of leaves by eyes.

The association of official analytical chemists (AOAC) approved techniques of analysis were used to determine the proximate content on dry basis, except moisture content of the radish microgreens (AOAC, 2000a; Bhathal *et al.*, 2017; Bunkar *et al.*, 2020). Energy was determined using the physiological calorific value (kcal/100 g) of the sample. Protein was determined using the Kjeldahl method, fat was assessed using the Soxhlet method and moisture was determined using the hot air oven method (AOAC, 2000b), in which 5 g sample was taken in a silica crucible and heated to 130 ± 2°C. The sample's moisture content was determined based on the weight difference between before and after drying and reported as a percentage. Carbohydrate estimated by difference methods subtracting the sum of values per 100 g for crude fiber, crude fat, crude protein and total ash from hundred. A standard method of analysis was used to determine the amount of ash (AOAC, 2000b) in which 5 g of sample weighed and charred in pre-heated and pre weighted porcelain dish, thereafter cooled in desiccator and ignite in muffle furnace at 550 ± 2°C. Mineral contents were determined by Atomic absorption spectrophotometer: AAS-7000 (AOAC, 2000c).

2.3 Sensory evaluation

Sensory evaluation was performed through Hedonic rating scale by (Peryam, 1952), which is 9 point likert scale from like extremely to dislike extremely**.** Five semi-trained panel members were selected for sensory evaluation. Recipe were prepared in raw (salad) and cooked (soup) both form.

3. Results

3.1 Growth analysis of radish microgreens grown in different medium

Table 1 demonstrates the height of plants cultivated in various substrates. The observation shows statistically significant difference in the height, *viz.*, 6.60 ± 1.5 cm, 8.86 ± 0.15 cm, 7.20 ± 0.10 cm and 8.06 ± 0.05 cm for soil (T_s), soil with vermicompost (T_{sv}), cocopeat (T_c) and cocopeat with vermicompost (T_{cv}), respectively. Table 1 also contains the observation made during monitoring of microgreens, *i.e.*, after five days. A significant variation in the number of leaves in various medium can be noticed.

Table 1: Morphological properties of radish microgreens 5th day of monitoring

Morphological status	T_s(5th DAS)	T_{sv}(5th DAS)	T_c(5th DAS)	T_{cv}(5th DAS)	*p*-value
Height/plant (cm)	6.6 ± 1.5	8.86 ± 0.15	7.20 ± 0.10	8.06 ± 0.05	<0.01(2-tailed)
No of leaves/plant	0.00 ± 0.00	2.00 ± 0.00	1.00 ± 0.00	2.00 ± 0.00	<0.01(2-tailed)

***DAS: Day after sowing

Table 2 shows statistically significant difference among the height of plant grown in different substrates on 10th day of monitoring, *viz.*, 9.20 ± 0.34 cm, 11.16 ± 0.20 cm, 9.30 ± 0.20 cm, 11.40 ± 0.36 cm, for soil (T_s), soil with vermicompost (T_{sv}), cocopeat (T_c), cocopeat with vermicompost (T_{cv}), respectively. However, no significance difference was observed in number of leaves of microgreens of different media on the 10th day of monitoring.

Table 2: Morphological properties of radish microgreens on 10th day of monitoring

Morphological status	T_s(10th DAS)	T_{sv}(10th DAS)	T_c(10th DAS)	T_{cv}(10th DAS)	*p*-value
Height/plant (cm)	9.20 ± 0.34	11.16 ± 0.20	9.30 ± 0.20	11.40 ± 0.36	<0.01(2-tailed)
No of leaves/plant	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00	>0.01(2-tailed)

3.2 Fresh yield after 10th day of harvesting

Table 3 indicates a significant difference in fresh weight of radish microgreens grown in different substrates. It is noticed that cocopeat with vermicompost provided the highest yield, *viz.*, 382 ± 18.00 g/tray.

Table 3: Weight of fresh shoot of microgreens per tray grown in different medium

Crop	T_s	T_{sv}	T_c	T_{cv}
Radish microgreens (g/tray)	334.00 ± 9.00	348.00 ± 13.00	330 ± 11.00	382 ± 18.00
p-value	The 0.001 level of significance for correlation (2-tailed) on crop fresh weight			

3.3 Proximate content of radish microgreens

Proximate composition of radish microgreens grown in different medium is also carried out (Table 4). Table 4 shows that statistically no significance difference was found in moisture content. Highest energy content was observed in T_{cv} medium which was 61.20 per cent. Furthermore, an increase in energy content (61.20 kcal), carbohydrate (6.19 ± 0.12 g/100g), fat (0.59 ± 0.09 g/100 g), ash (2.41 ± 0.17 g/100 g) and fiber (3.43 ± 0.32 g/100 g) are found in T_{cv} medium. Whereas, protein content was found highest in T_{sv} medium (6.59 ± 0.18 g/100 g). Almost similar protein and fiber content were observed of rat tailed radish microgreens 6.83 g/100 g and 3.70 g/100 g, respectively (Kowitcharoen *et al*., 2021). Another investigation was done on several microgreens grown in various soilless media and discovered nearly same moisture and fat contents of 93.19 ± 1.2% and 0.50 ± 0.01 g/100 g (Muchjajib *et al*., 2013).

Table 4: Proximate composition of radish microgreens (per 100 g) after 10th day of harvesting

Proximate content	T_s	T_{sv}	T_c	T_{cv}	*p*-value
Moisture (per cent)	92.20 ± 0.32	91.82 ± 1.15	90.84 ± 0.94	91.57 ± 1.30	0.612
Energy (kcal)	54.69 ± 0.59	60.89 ± 0.33	52.81 ± 0.65	61.20 ± 0.97	0.674
Carbohydrate (g)	5.43 ± 0.36	5.90 ± 0.12	5.32 ± 0.35	6.19 ± 0.12	<0.05
Protein (g)	5.75 ± 0.10	6.59 ± 0.18	5.69 ± 0.18	5.63 ± 0.56	0.827
Fat (g)	0.30 ± 0.03	0.55 ± 0.12	0.37 ± 0.04	0.59 ± 0.09	0.633
Ash (g)	2.23 ± 0.29	2.22 ± 0.29	2.16 ± 0.16	2.41 ± 0.17	0.931
Fiber (g)	3.10 ± 0.10	3.19 ± 0.24	3.00 ± 0.10	3.43 ± 0.32	<0.05

*Dry basis analysis except moisture

3.4 Mineral composition of radish microgreens

Mineral content of radish microgreens grown in four different medium shown in Table 5 represent that radish microgreens grown in T_{sv} medium have found significantly higher amount of Ca (63.73 mg/100 g), followed by 62.26 mg/100 g, 62.12 mg/100 g, 62.09 mg/100 g, for T_s, T_c, T_{cv}, respectively. Almost similar value was found in Daikon radish (66 mg/100 g) by Xiao *et al*. (2015). Moreover, Fe content is found significantly high in T_{cv} medium (0.63 mg/100 g) than control media (0.59 mg/100 g). The value observed in T_{cv} medium is approximately two times higher than the mature radish which is 0.36 mg/100 g (Longvah *et al*., 2017). Highest content of magnesium and zinc are also found high in T_{cv} based media, *viz*., 60.94 mg/100 g and 0.43 mg/100 g, respectively, than control T_s.

Table 5: Mineral composition of radish microgreens (per 100 g) after 10th day of harvesting

Mineral contents	T_s	T_{sv}	T_c	T_{cv}	*p*-value
Ca (mg)	62.26 ± 0.42	62.73 ± 0.57	62.12 ± 0.02	63.09 ± 0.20	<0.05
Fe (mg)	0.59 ± 0.01	0.61 ± 0.01	0.59 ± 0.01	0.63 ± 0.01	<0.01
Mg (mg)	59.22 ± 0.16	60.12 ± 0.10	58.59 ± 0.50	60.94 ± 0.24	.089
Zn (mg)	0.37 ± 0.02	0.40 ± 0.00	0.35 ± 0.00	0.43 ± 0.01	<0.01

* Correlation is significant at the 0.05 level (1-tailed)
** Correlation is significant at the 0.01 level (1-tailed)

3.5 Organoleptic test of radish microgreens

Sensory acceptance was analysed for different parameters, *i.e*., colour and appearance, texture, taste and flavour, overall acceptability of microgreens salad and soup to assess consumers demand raw or cooked. Result shown in Table 6 indicates that 60 per cent respondents like moderately colour and appearance of microgreens in a raw from as a salad. Almost 80 per cent members like moderately taste and flavour of radish microgreens. 60 per cent members like slightly taste and flavour of raw radish microgreens salad. Overall acceptability of radish salad was rated 6.8 ± 0.44, which means members liked the salad recipe slightly. This may be due to peppery flavour of radish microgreens.

Table 6: Sensory evaluation of radish microgreens salad after 10th day of harvesting

Attributes	Colour and appearance		Texture		Taste and flavour		Overall acceptability	
	F (%)	Mean ± SD	F (%)	Mean ± SD	F (%)	Mean ± SD	F (%)	Mean ± SD
Like moderately	3(60)	6.60 ± 0.54	4(80)	6.80 ± 0.44	-	5.6 ± 0.54	4(80)	6.8 ± 0.44
Like very much	-		-		-		-	
Like extremely	-		-		-		-	
Nether like nor dislike	-		-		2(40)		-	
Like slightly	2(40)		1(20)		3(60)		1(20)	
Total	5(100)		5(100)		5(100)		5(100)	

F(frequency), SD (standard deviation)

In contrast, Table 7 shows that 80% members like moderately colour and appearance of radish microgreens soup and, 80% respondents like very much taste and flavour of soup. Overall acceptability of soup was rated 7.8 ± 0.44, which is significantly higher than rating of radish microgreens salad. Rating greater than 7 indicates that members likes microgreens soup moderately.

Table 7: Sensory evaluation of Radish microgreens soup after 10th day of harvesting

Attributes	Colour and appearance		Texture		Taste and flavour		Overall acceptability	
	F (%)	Mean ± SD	F (%)	Mean ± SD	F (%)	Mean ± SD	F (%)	Mean ± S.D.
Like moderately	4(80)	7.20 ± 0.44	2(40)	7.60 ± 0.54	-	8.20 ± 0.44	1(20)	7.8 ± 0.44
Like very much	1(20)		3(60)		4(80)		4(80)	
Like extremely	-		-		1(20)		-	
Nether like nor dislike	-		-		-		-	
Like slightly	-		-		-		-	
Total	5(100)		5(100)		5(100)		5(100)	

** Correlation is significant at the 0.01 level (1-tailed)

4. Discussion

Media or growing substrates affects growth and production of plant directly or indirectly. As shown above the results, maximum plant height was found in T_{sv} medium on 5th day of monitoring. A similar out come was reported by Polash (2019), noting that only soil-based media showed decline while organic compost-based media showed maximum plant height. Another study examined the greatest number of leaves, height and length of roots in organic composed-based media such as vermicompost-based medium as compared to other media, like growing just in soil (Khan and Ishaq, 2011). After 10th day of reporting maximum height of plant was found in T_{cv} medium, followed by T_{sv}. According to Supriya (2020) media and nutrients have a substantial impact on production indices like yield per plant and yield per hectare. In other studies also growth and production of ginger rhizomes is found more effective in a media having 75:25 ratio of cocopeat to sand and fertigation of 40% RDF (Chongtham *et al*., 2013; Sanwal *et al*., 2012).

Furthermore, maximum fresh shoot was obtained in T_{cv} based medium.The possible reason could be organic composed based medium possessed optimal water holding capacity and aeration that favours the increase germination process. Growing media should have an ideal water holding capacity and aeration for imbibition hydration of protoplasm and restoration of enzymatic activity that leads to germination (Abad *et al*., 2001; Bewley, 1997).

Overall maximum nutrient contents were observed in T_{cv} medium, this may be due to soilless cocopeat media found to good physicochemical properties for plant substrates among other organic media. Another study reported that when vermicompost applied to other substrates, it has strong structural qualities and is hydrophilic. Vermicomposting seems to have the most promise as a high-value biofertiliser that not only boosts plant growth and productivity by supplying nutrients, but is also reasonably priced (Arancon *et al*.,2004; Kalaivani and Jawaharlal, 2019; Vijaya *et al*., 2008).

In respect to mineral contents, iron content was found in microgreens more than mature radish. It is well known that most prevalent nutritional deprivation condition in the world is Fe deficiency, which causes anaemia. It is estimated to affect about 25% of the world's population, while it is much more prevalent in certain groups including females (pregnant and non-pregnant) and children (between 30 and 47%) (McLean *et al.*, 2009). Iron plays a significant role in various immunity based functions. Fe deficiency impairs T-lymphocyte activity, adaptive antibody responses, and B-cell proliferation (Jiang *et al.*, 2019). Magnesium content and zinc content was found more than mature radish leaves, *viz.*, 57.96 mg/100 g and 0.49 mg/100 g respectively. A similar data is also reported in recent literature (Longvah *et al*. 2017). Another study was also reported almost similar magnesium and iron content (Xiao *et al*., 2015). Magnesium has a variety of roles in the control of immunological processes, especially in relation to the operation of various immune cell subpopulations (Laires and Monteiro, 2008). Mg has a significant impact on lymphocyte growth, differentiation and proliferation (Feske *et al.*, 2012). Lack of magnesium appears to favour an overactive innate immune response while simultaneously weakening the adaptive immune response. This may be one of the factors contributing to chronic, low-grade inflammation is linked to Mg insufficiency (Guerrero-Romero *et al.*, 2011). The overall regulation of the immune system is also linked to Zn status. According to studies, a Zn deficit causes adaptive immunological activation, as well as a rise in oxidative stress and systemic inflammatory reactions (Gammoh and Rink, 2017; Wong *et al.*, 2015, 2019). Numerous inflammatory cytokines can be affected by Zn in terms of their signalling as well as their synthesis (Milanino *et al.*, 1993). Sensory members slightly like the raw radish microgreens than cooked one. This may be due to peppery taste of raw radish leaves. Another possible reason could be food Neophobia, since microgreens consumption is not very common in India. Consumers usually admired the microgreens appearance and their acceptance was mostly influenced by their flavour and texture. In particular, microgreens are more palatable to consumers when they have lower levels of astringency, sourness and bitterness (Caracciolo *et al*., 2020).

5. Conclusion

It can be stated that the cocopeat with vermicomposed based medium outperformed the other media to the greatest extent. It may be attributed to the cocopeat excellent ability to retain water, low bulk density as well as the presence of vermicompost which promotes healthy germination, easy root penetration, enough nutrient supplementation and provide good conditioning to the medium. Therefore, it can be concluded that for a variety of horticultural uses, cocopeat can be the perfect medium of growth due to its many advantageous characteristics. This study also portrays the best medium, *viz*., cocopeat with vermicompost based substrate followed by T_{sv} based medium in context of radish microgreens.

Conflicts of interest

The authors declare no conflicts of interest relevant to this article.

References

Abad, M.; Noguera, P. andBures, S. (2001). National inventory of organic wastes for use as growing media for ornamental potted plant production: Case study in Spain. Bioresource Technology, **77**(2): 197-200. https://doi.org/10.1016/S0960-8524

AOAC (2000a). American Society of Analytical Chemistry: Preparation Method. 999:10.

AOAC (2000b). Approved methods of the American association of cereal chemists. American Association of Cereal Chemists. Approved Methods Committee.

AOAC (2000c). Official methods of analysis 17th Edn. Association of Official Agricultural Chemists. Washington DC, USA.

Arancon, N. Q.; Edwards, C. A.; Bierman, P.; Welch, C. and Metzger, J. D. (2004). Influences of vermicomposts on field strawberries: Effects on growth and yields. Bioresource Technology, **93**(2):145-153. https://doi.org/10.1016/j.biortech.2003.10.014

Balyan, P. and Ali, A. (2022). Comparative analysis of the biological activities of different extracts of *Nigella sativa* L. seeds. Ann. Phytomed., **11**(1):577-587.

Bewley, J. D. (1997). Seed germination and dormancy. The Plant Cell, **9**(7):1055-1066.

Bhathal, S. K.; Kaur, N. and Gill, J. (2017). Effect of processing on the nutritional composition of quinoa (*Chenopodium quinoa* Wild). Agricultural Research Journal, **54**(1):90-93. https://doi.org/10.5958/2395-146x.2017.00015.1.

Bunkar, D. S.; Anand, A.; Kumar, K.; Meena, M.; Goyal, S. K. and Paswan, V. K. (2020). Development of production technology for preparation of beetroot powder using different drying methods. Ann. Phytomed., **9**(2):293-301. https://doi.org/10.21276/ap.2020.9.2.29.

Caracciolo, F.; El-Nakhel, C.; Raimondo, M.; Kyriacou, M. C.; Cembalo, L.; de Pascale, S. and Rouphael, Y. (2020). Sensory attributes and consumer acceptability of 12 microgreens species. Agronomy, **10**(7):1043. https://doi.org/10.3390/agronomy10071043.

Chongtham, T.; Chatterjee, R.; Hnamte, V.; Chattopadhyay, P. K. and Khan, S.A. (2013). Ginger (*Zingiber officinale* Rosc.) germplasm evaluation for yield and quality in southern West Bengal. Journal of Spices and Aromatic Crops, **22**(1):88-90.

Feske, S.; Skolnik, E. Y. and Prakriya, M. (2012). Ion channels and transporters in lymphocyte function and immunity. Nature Reviews Immunology, **12**(7):532-547. https://doi.org/10.1038/nri3233.

Gammoh, N. Z. and Rink, L. (2017). Zinc in infection and inflammation. Nutrients, **9**(6). https://doi.org/10.3390/nu9060624

Guerrero-Romero, F.; Bermudez-Pena, C. and Rodríguez-Moran, M. (2011). Severe hypomagnesaemia and low-grade inflammation in metabolic syndrome. Magnesium Research, **24**(2):45-53. https://doi.org/10.1684/mrh.2011.0281

Jabborova, D.; Kadirova, D.; Narimanov, A. and Wirth, S. (2021). Beneficial effects of biochar application on lettuce (*Lactuca sativa* L.) growth, root morphological traits and physiological properties. Ann. Phytomed., **10**(2):93-100. https://doi.org/10.21276/ap.2021.10. 2.13

Jiang, Y.; Li, C.; Wu, Q.; An, P.; Huang, L.; Wang, J.; Chen, C.; Chen, X.; Zhang, F.; Ma, L.; Liu, S.; He, H.; Xie, S.; Sun, Y.; Liu, H.; Zhan, Y.; Tao, Y.; Liu, Z.; Sun, X.; Hu, Y.; Wang, Q.; Ye, D.; Zhang, J.; Zou, S.; Wang, Y.; Wei, G.; Liu, Y.; Shi, Y.; Eugene Chin, Y.; Hao, Y.; Wang, F. and Zhang, X. (2019). Iron-dependent histone 3 lysine 9 demethylation controls B cell proliferation and humoral immune responses. Nature Communications, **10**(1):1-15. https://doi.org/10.1038/s41467-019-11002-5.

Kalaivani, K., and Jawaharlal, M. (2019). Study on physical characterization of coco peat with different proportions of organic amendments for soilless cultivation. Journal of Pharmacognosy and Phytochemistry, **8**(3):2283-2286.

Khan, A., and Ishaq, F. (2011). Chemical nutrient analysis of different composts (Vermicompost and Pitcompost) and their effect on the growth of a vegetative crop *Pisumsativum*. Asian Journal of Plant Science and Research, **1**(1):116-130.

Kim, M. H., and Choi, M. K. (2013). Seven dietary minerals (Ca, P, Mg, Fe, Zn, Cu, and Mn) and their relationship with blood pressure and blood lipids in healthy adults with self-selected diet. Biological Trace Element Research, **153**(1-3):69-75. https://doi.org/10.1007/s12011-013-9656-1.

Kowitcharoen, L.; Phornvillay, S.; Lekkham, P.; Pongprasert, N. and Srilaong, V. (2021). Bioactive composition and nutritional profile of microgreens cultivated in Thailand. Applied Sciences (Switzerland), **11**(17):7981. https://doi.org/10.3390/app11177981.

Laires, M. J. and Monteiro, C. (2008). Exercise, magnesium and immune function. Magnesium Research, **21**(2):92-96. https://doi.org/10.1684/mrh.2008.0136.

Lee, J. S.; Pill, W. G.; Cobb, B. B. and Olszewski, M. (2004). Seed treatments to advance greenhouse establishment of beet and chard microgreens. Journal of Horticultural Science and Biotechnology, **79**(4):565-570. https://doi.org/10.1080/14620316.2004.11511806.

Longvah, T.; Ananthan, R.; Bhaskarachary, K. and Venkaiah, K. (2017). Indian Food Compostion Tables. National Institute of Nutrition. Indian Council of Medical Research, Hyderabad, India.

Malik, T.; Madan, V. K. and Prakash, R. (2020). Herbs that heal: Floristic boon to the natural healthcare system. Ann. Phytomed., **9**(2):1-9. https://doi.org/10.21276/ap.2020.9.2.2.

McLean, E.; Cogswell, M.; Egli, I.; Wojdyla, D. and De Benoist, B. (2009). Worldwide prevalence of anaemia, WHO vitamin and mineral nutrition information system, 1993 2005. Public Health Nutrition, **12**(4): 444-454. https://doi.org/10.1017/S1368980008002401

Milanino, R.; Frigo, A.; Bambara, L.M.; Marrella, M.; Moretti, U.; Pasqualicchio, M.; Biasi, D.; Gasperini, R.; Mainenti, L. and Velo, G.P. (1993). Copper and zinc status in rheumatoid arthritis: studies of plasma, erythrocytes, and urine, and their relationship to disease activity markers and pharmacological treatment. Clin. Exp. Rheumatol., **11**(3):271-281.

Muchjajib, U.; Muchjajib, S.; Suknikom, S. and Butsai, J. (2013). Production of microgreens from local plant species in Thailand. Acta Horticulturae, **1091**:67-72. https://doi.org/10.17660/actahortic.2015.1091.7

Murphy, C. J. and Pill, W. G. (2010). Cultural practices to speed the growth of microgreen arugula (*Roquette; Erucavesicaria* subsp. sativa). Journal of Horticultural Science and Biotechnology, **85**(3):171-176. https://doi.org/10.1080/14620316.2010.11512650.

Peryam, D. (1952). Girardot NF advanced taste-test method. Food Engineering, **24**:58-61.

Polash, M. A. S.; Sakil, A.; Sazia, S. and Hossain, A. (2019). Selection of suitable growing media and nutritional assessment of microgreens. Agricultural Research Journal, **56**(4):752. https://doi.org/10.5958/2395-146x.2019.00116.9.

Sanwal, S. K.; Singh, S. K.; Yadav, R. K.; Singh, P. and Mishra, A. K. (2012). Yield and quality assessment of ginger (*Zingiber officinale* Rosc.) genotypes. Indian J. Plant Genet. Resour, **25**(3):281-286.

Supriya, G.; Bhoomika, H.; Ganapathi, M.; Nataraj, S.and Ravi, C. (2020). Effect of different media and nutrients on growth and yield of ginger (*Zingiber officinale* Rosc.) in soilless culture under protected structure. Journal of Pharmacognosy and Phytochemistry, **9**(6):2004-2007.

Thakur, N.; Verma, A.; Kaur, K.; Thakur, C. and Aakriti. (2022). A review on microgreens as an emerging food for health benefits. Ann. Phytomed., **11**(1):68-77. http://dx.doi.org/10.54085/ap.2022.11.1.7.

Vijaya, D.; Padmadevi, S.N.; Vasandha, S.; Meerabhai, R.S. and Chellapandi, P. (2008). Effect of vermicomposted coirpith on the growth of *Andrographis paniculata*. Journal of Organic Systems, **3**(2):51-56.

Weyh, C.; Krüger, K.; Peeling, P. and Castell, L. (2022). The role of minerals in the optimal functioning of the immune system. nutrients, **14**(3):1-15.

Wong, C. P.; Rinaldi, N. A. and Ho, E. (2015). Zinc deficiency enhanced inflammatory response by increasing immune cell activation and inducing IL6 promoter demethylation. Molecular Nutrition and Food Research, **59**(5):991-999. https://doi.org/10.1002/mnfr.201400761.

Wong, C. P.; Dashner-Titus, E. J.; Alvarez, S. C.; Chase, T. T.; Hudson, L. G. and Ho, E. (2019). Zinc deficiency and arsenic exposure can act both independently or cooperatively to affect zinc status. Oxidative Stress, and Inflammatory Response. Biological Trace Element Research, **191**(2):370-381. https://doi.org/10.1007/s12011-019-1631-z.

Xiao, Z.; Lester, G. E.; Park, E.; Saftner, R. A.; Luo, Y. and Wang, Q. (2015). Evaluation and correlation of sensory attributes and chemical compositions of emerging fresh produce: Microgreens. Postharvest Biology and Technology, **110**:140-148.https://doi.org/10.1016/j.postharvbio.2015.07.021.

Citation **Shahzadi Khatoon and Mukta Singh (2022). Impact of various substrates on the physicochemical properties of radish microgreens. Ann. Phytomed., 11(2):591-596. http://dx.doi.org/10.54085/ap.2022.11.2.72.**