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Antioxidant Properties and Sensory Evaluation of Microgreens from Commercial and Local Farms

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Abstract

Microgreens are young and tender vegetables or herbs that provide attractive color, flavor, and nutrition. The purpose of this study was to evaluate the nutritional and sensory qualities of broccoli microgreens grown by different methods (hydroponically vs. soil grown) and from different sources (commercial vs. local farm). No significant difference in total phenolic concentration and antioxidant capacity was found in all broccoli microgreens, but a significantly higher chlorophyll concentration was found in farm microgreens than the commercial one. Moreover, the soil-grown farm microgreens possessed a significantly higher vitamin C concentration than the hydroponically-grown farm sample and the commercial sample. Participants in the sensory study favored farm samples regardless of growing method, and their overall liking was significantly correlated with taste of the microgreens. In addition, six other microgreens were analyzed for their nutritional quality. These conclusions suggest a potential for consumers to still benefit nutritionally by purchasing commercial microgreens at a lower cost; however, it may be worthwhile for consumers to purchase microgreens from local farms for a better sensory experience.

Keywords

Microgreens; antioxidant; phenolic; chlorophyll; sensory; hydroponic.

1. Introduction

Microgreens are newly sprouted, immature plants without roots that are harvested after the development of the cotyledon leaves, or seed leaves, usually between 10 and 14 days from seeding [1]. They are smaller than baby greens and they are harvested later than sprouts [2]. Due to their immaturity, they tend to have concentrated flavors, tender textures, vibrant color, and densely-packed nutrients. Various microgreens, such as broccoli, kale, celery, opal basil, and red beet, are available in the market. Because of their potent flavors and appealing sensory qualities, in the past few years, microgreens have gained popularity and are often used by high-end chefs for garnishing soups and sandwiches. Their functional benefits have also drawn attention from nutrition researchers and have opened the door for use in the field of nutrition and health.

This functionality is attributed to their high content of vitamins and minerals, as well as other bioactive compounds. It has been reported that many species of microgreens are more saturated with micronutrients than the adult versions of the same plants. For instance, microgreens have shown to be high in vitamins or their precursors, including carotenoids, ascorbic acid, tocopherols and tocotrienols, phylloquinone, and folate [3-6]. Other phytochemicals found to be high in microgreens include chlorophyll [7], phenolic compounds, anthocyanins, and glucosinolates [3-5].

A few functionality studies have been carried out in rodent models to explore the health benefits of microgreens. Results from Huang et al. showed that red cabbage microgreen reduced high-fat diet induced weight gain and significantly lowered circulating LDL levels as well as expression of hepatic inflammatory cytokines in mice fed a high-fat diet [8]. Polyphenols, a class of phenolic compounds, were indicated to be a major contributor of the aforementioned effects of red cabbage microgreens, partially owing to their antioxidant and anti-inflammation properties.

Phenolic compounds, also seem to have an influence on sensory qualities of microgreens.[3] Xiao et al. reported that the total phenolic concentration was strongly correlated with the overall eating quality and several aspects of sensory qualities, including intensity of astringency, sourness, bitterness, and sweetness of microgreens [9].

Nowadays, products of microgreens are available to consumers in both chain grocery stores and local farms. The growth environments and harvesting methods, however, are quite different. Farms grow microgreens in soil or hydroponically. On the other hand, commercial microgreens are usually hydroponically grown, which increases the productivity of microgreens but may compromise their nutritional and sensory quality. In addition, microgreens purchased from local farms are usually fresher than those from grocery stores due to shorter transportation time, which may further affect the nutrition and sensory properties of the plants.

In spite of the increase of research on microgreens, no study has evaluated the nutritional and sensory qualities of these specialty vegetables grown differently or from different sources. Such information is important for consumers in purchasing or for health professionals in conducting research or giving dietary advice. Therefore, the main objective of this study was to investigate the nutritional qualities and sensory properties of microgreens grown and harvested in a commercial setting versus a local farm setting. The nutritional analysis will focus on chlorophyll content, phenolic compounds content, vitamin C content, and antioxidant capacity, which are known to contribute to the health benefits or sensory attributes of microgreens. Since broccoli microgreen is the only species available to the researchers in both local grocery stores and local farms, it was selected for the comparison in nutritional and sensory qualities. In addition, six other microgreens that were available in the local farm were also analyzed for nutritional quality. We hypothesized that microgreens grown in soil in a farm setting would possess higher nutritional qualities and produce better sensory properties as compared to those grown hydroponically and those from a commercial source.

2. Material and Methods

2.1. Microgreen samples and preparation

Commercial broccoli *(Brassica oleracea)* microgreen sample, which was hydroponically grown, was purchased ($0.035/gram) from the Fresh Market in Tuscaloosa, Alabama. This sample was designated as CH in this article. Farm grown broccoli microgreen samples were purchased from the Alabama Microgreens (Microgreen Enterprises, Inc., Huntsville, Alabama). To elucidate the effects of growth environment (soil vs. hydroponic system) on the qualities of microgreens, microgreen samples both grown in soil (FS, $0.123/gram) and hydroponically (FH, $0.106/gram) were obtained from the Alabama Microgreens. Six other microgreens, including amaranth, kale, kohlrabi, pea, spicy broccoli, and wasabi, were also purchased from the Alabama Microgreens. The commercial microgreens were packaged in plastic clamshell containers with unknown harvest date, while the farm samples were harvested on the same day of delivery and packaged in paper clamshell containers. Samples were used for laboratory analysis on the day of purchase and stored at 4 °C for the sensory study during following three days. The optical images of the three broccoli microgreen samples (CH, FH, and FS) are shown in **Figure 1**.

2.2. Chemicals

Acetone, methanol, hexanes, sodium hydroxide, gallic acid, Trolox, Fast Blue BB reagent [4-benzoylamino-2,5-dimethoxybenzenediazonium chloride hemi- (zinc chloride)], and DPPH (2,2-diphenyl-1-picrylhydrazyl) were purchased from MilliporeSigma (Burlington, MA, USA).

2.3. Total chlorophyll concentration (TCC)

The TCC of microgreen samples was determined using a direct spectrophotometric method after extraction. About 1 gram of each finely-chopped microgreen sample was added into 10 mL of 80% (v/v) aqueous acetone solution and homogenized for 1 min at a rate of 15000 rpm using a VWR 200 homogenizer (VWR International, Radnor, PA, USA). The resulting mixture was filtered through a Grade 413 filter paper (VWR International, Radnor, PA, USA) into a volumetric flask and the residue was rinsed with 80% (v/v) acetone until colorless. The filtrate was diluted to 25 mL with 80% (v/v) acetone. Absorbance was read at 646, 663, and 710 nm using an UV5Bio ultraviolet-visible spectrophotometer (Mettler Toledo, Columbus, OH, USA). The 80% (v/v) acetone was used as the blank. TCC was calculated using the following equation [10]:

$$TCC(mg/g) = [(A_{646} - A_{710}) \times 0.01732 + (A_{663} - A_{710}) \times 0.00718] \times dilution\ volume/fresh\ weight\ \ (FW)$$

2.4. Total phenolic concentration (TPC)

The TPC was determined using a direct, phenolic-binding Fast Blue BB (FBBB) assay as previously reported [11]. About 200 mg of finely-chopped microgreen sample was added into 10 mL of 80% (v/v) aqueous methanol solution and homogenized for 30 s. Aliquots of 1 mL was added with 0.4 mL of hexanes and homogenized again for another 30 s. Mixtures were then centrifuged at 3000 g for 10 min at 25 °C. The supernatant (hexanes phase) was discarded and the hexanes wash procedure was repeated for another two times. The washed methanolic extract was a syringe filter (pore size 0.45 µm). Then, 1 mL of the filtered methanolic extract was added with 0.1 mL of FBBB reagent and 0.1 mL of 5% (w/v) sodium hydroxide. The mixture was mixed using a vortex mixer and incubated in light at room temperature (20 °C) for 90 min. After the incubation period, the mixture was centrifuged at 6500 g for 1 min. Absorbance of the supernatant was measured at 420 nm. The 80% (v/v) aqueous methanol solution was used as the blank. Gallic acid solutions (concentrations of 10, 50, 100, 200, 250, and 500 mg/L) were used to establish the calibration curve. The results were expressed as milligram of gallic acid equivalents (GAE) per gram of fresh weight (mg GAE/g FW).

2.5 Vitamin C concentration (VCC)

The VCC of microgreen samples was determined using the Megazyme L-ascorbic acid assay kit (Megazyme Inc., Chicago, IL, USA) following extraction by metaphosphoric acid. Approximately 1 g of finely-chopped microgreen sample was added into ice-cold 3% (w/v) metaphosphoric acid with 10 mM EDTA, and homogenized at a rate of 15000 rpm for 30 s. The homogenized tissue was centrifuged at 7000 g for 20 min at 4 °C, and the supernatant was filtered through a 0.22 µm syringe filter. The filtrate was used for VCC determination following the procedure described in the manufacturer's instructions and the absorbance values were measured using a CLARIOstar Plus microplate reader (BMG Labtech Inc., Gary, NC, USA).

2.6. Total antioxidant capacity (TAC)

The TAC of microgreen samples was evaluated using the 1,1-Diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging assay according to [11]. A volume of 0.5 mL of the same filtered methanolic extract used for TPC assay was added to 0.5 mL of DPPH solution (0.1 mM in methanol), mixed using a vortex mixer, and incubated in the dark for 40 min. A mixture of 0.5 mL of 80% (v/v) methanol and 0.5 mL of DPPH solution was used as the positive control. Absorbance was read at 517 nm with 80% (v/v) methanol as the blank. Trolox solutions (concentrations of 10, 50, 100, 200, 250, and 500 mg/L) were used to react with DPPH to establish a standard curve. The results were expressed as milligram of Trolox equivalents (TE) per gram of fresh weight (mg TE/g FW).

2.7 Sensory study

The sensory study was conducted on campus at the University of Alabama to evaluate the sensory qualities of microgreen samples. Data collection was carried out in the student center during weekday lunch time (11am-2pm). Participants were recruited by being asked whether they were interested in evaluating microgreens and completing a survey. After being explained with the purpose of the study and showed the consent form, participants were provided the three samples of broccoli microgreens (CH, FS, and FH) in a random order, each in a small cup, for testing. Information about the source and growth conditions of the samples was blind to participants. Participants were asked to observe, smell, and taste each sample and evaluate their liking of smell, appearance, taste, and overall liking in a 7 Likert scale from very poor (1) to excellent (7). Participants were asked to drink water between samples. Upon completion of the survey, participants (n=150) received a $3 Amazon gift card as an incentive. The study procedure and survey questionnaire were reviewed and approved by the Institutional Review Board at the University of Alabama.

2.8 Statistical analysis

Data were reported as mean ± SD. One-way ANOVA followed by Tukey's test for multiple comparisons was used for all the measures to determine the differences between groups ($p < 0.05$) using GraphPad Prism (GraphPad Software, San Diego, CA, USA). A Pearson correlation test in GraphPad Prism was applied to analyze the correlation between different sensory attributes: (****) was used to indicate significance levels of 0.0001.

3. Results and Discussion

3.1. Nutritional analysis of broccoli microgreens

3.1.1 Total chlorophyll concentration (TCC)

As shown in **Figure 2A**, broccoli microgreen samples from the local farm had significantly higher TCC (0.33 and 0.30 mg/g FW, respectively) than that from the commercial source (0.029 mg/g FW). The TCC of hydroponically grown samples from the local farm was higher than that of the soil grown samples, but the difference did not reach statistical significance. Chlorophyll is a green pigment found in most plants and is essential for photosynthesis [12]. A higher concentration of chlorophyll might indicate the production of more energy nutrients in the plants. Chlorophyll cannot be synthesized by animal tissues and must be obtained from plant foods. Recently, chlorophyll and chlorophyll-rich diets have been reported to play roles as cancer-preventive agent attributed to the ability of chlorophyll to form complexes with specific carcinogens, as well as its antioxidant and antimutagenic properties [13, 14]. Some other preventive or therapeutic properties of chlorophyll were also reported in literature, such as stimulating immune system, detoxification of the liver, and normalizing blood pressure [15-17]. Although more research is needed to elucidate the mechanisms under these functions of chlorophyll, it could be a valuable dietary compound for human nutrition and health.

It was reported that mature broccoli contains about 0.02 mg/g of TCC [18], while our results showed that TCC in farm grown broccoli microgreens was about 15 times higher. The TCC in those farm grown broccoli microgreens was also higher than that of many other species of mature vegetables, such as celery, lettuce, and artichoke [18]. The incorporation of these microgreens in the diet can be a promising way to provide the health-beneficial chlorophyll and warrants more investigation. As compared to the high level of chlorophyll in farm grown broccoli microgreens, commercial samples had a much lower TCC. Several factors might contribute to this difference.

The commercial samples might have been harvested before the development of the cotyledon leaves, where chlorophyll accumulates. The plant does not require light for the first few days of growth. The chlorophyll might also be degraded due to long supply chain and storage time of the commercial samples, deteriorating the freshness of the vegetable. The TCC could affect sensory quality of the microgreens, especially their appearance and the impression of freshness.

3.1.2. Total phenolic concentration (TPC)

Results in **Figure 2B** show that there was no significant difference in the TPC between commercial and local farm samples. Furthermore, whether it was soil grown or hydroponically grown did not affect the TPC of the samples from the local farm. Phenolic compounds are a large class of plant secondary metabolites that comprise an aromatic ring with one or more hydroxyl substituents [19]. These compounds are important for the quality of plants and are strongly associated with the flavor properties of vegetables, such as taste and color. For instance, phenolic compounds, e.g., tannins and phenolic acids, contribute to the astringency taste, i.e., the drying, puckering, and shrinking sensation in the oral cavity [20]. Some phenolic compounds (most phenolic acids) are colorless, while some others (e.g., anthocyanins and tannins) show various colors [21]. Phenolic compounds show numerous bioactive properties, most well-known of which are their antioxidant and anti-inflammatory activities [22]. Furthermore, a number of phenolic compounds demonstrate inhibitory effect on the activity of enzymes to digest starch in gastrointestinal tract, e.g., α-amylase and α-glucosidase [23], indicating a potential of these compounds in improving glucose homeostasis and metabolic conditions. The average TPC in broccoli microgreen samples in this study was in the range from 10.71 to 11.88 mg GAE/g FW. It is about 10 times higher than the TPC in a lot of species of mature vegetables, including broccoli, brussels sprout, and kailan, which are known to be excellent sources of phenolic compounds [24].

Therefore, these microgreens can be regarded as great sources of this class of phytochemicals. Future research is needed to analyze the profiles of specific phenolic compounds in microgreens as well as their *in vivo* bioavailability, and to explore their beneficial effects in human health.

Our results indicated that different growing and harvesting conditions did not affect the TPC of the microgreens. The TPC of plants depends on the balance between its synthesis and oxidation. Phenolic compounds are produced through the phenylpropanoid metabolic pathway, which starts with the reaction of L-phenylalanine converted to trans-cinnamic acid, and other phenolics are produced via subsequent reactions [11]. As antioxidants, phenolic compounds can be oxidized to quinone under oxidative stress. It was previously reported that light exposure or different packaging methods did not affect the TPC of radish microgreens [11]. Future research on the effects of growth environment, harvesting condition, and/or post-harvest interventions on the synthetic or oxidation pathway of phenolic compounds in plants will provide insights into the key factors that determine the TPC of microgreens.

3.1.3. Vitamin C concentration (VCC)

Results on VCC **(Figure 2C)** indicated that broccoli microgreen samples grown in soil from the local farm possessed significantly higher VCC than hydroponically grown ones from the farm and the commercial ones also grown hydroponically. Vitamin C is a cofactor required by many enzymatic reactions and a critical antioxidant. Previous studies showed that higher circulating vitamin C concentrations are associated with lower risks of hypertension, coronary heart disease, and stroke [25-28]. Mature raw broccoli, known as an excellent source of vitamin C, contains an average of 0.89 mg/g of total ascorbic acid according to the USDA National Nutrient Database for Standard Reference [29]. Mature spinach, one of the most commonly consumed leaf vegetable in the United States, has about 0.28 mg/g of total ascorbic acid [11].

The VCC of our microgreen broccoli samples is in the range of 0.33-0.56 mg/g. Worth to note is that the VCC measured in this study is the content of free ascorbic acid so the total ascorbic acid content would be higher. Therefore, microgreen broccoli, especially the soil-grown ones from the local farm, can be regarded as good sources of vitamin C.

Comparing VCC in vegetables grown in soil and hydroponically has created mixed results. For instance, [30] found significantly higher ascorbic acid content in soil grown raspberries yet lower in soil grown strawberries, compared with their hydroponically grown counterparts. [31] reported significantly higher total ascorbic acid content in three of the four hydroponically grown lettuce varieties than their soil grown versions, while the fourth one showed higher but non-significantly total ascorbic acid content. Although not fully understood, vitamin C is synthesized in plants as a response to oxidative stresses and through the L-galactose pathway using mannose or galactose [32]. Therefore, the growth conditions, including nutrition in soil and hydroponic growing media, and environmental stresses may all impact vitamin C biosynthesis in microgreens and result in the VCC difference in this study.

3.1.4. Total antioxidant capacity (TAC)

Similar to the results of TPC, no significant difference was observed in the TAC of microgreen samples from different sources and grown conditions (**Figure 2D**). It has been well established that the consumption of vegetables is inversely associated with morbidity and mortality from chronic diseases [33-35] and antioxidants play a significant role in the beneficial effects [36]. Many different classes of antioxidants are present in vegetables and it is hard to elucidate which ones are more associated with the benefits. Also, the synergistic effect and interaction of different antioxidants in one food leads to the fact that the level of a single antioxidant is not a good indicator of the total antioxidant capacity of the food item. Therefore, measuring the total antioxidant capacity, which is the cumulative capacity of food components to scavenge free radicals, has become an effective way to evaluate the potential benefits of various vegetables in preventing or managing chronic diseases [37]. The average TAC of the microgreen samples evaluated in this study ranged from 1.06 to 1.18 mg TE/g FW, which are comparable to previous results on microgreens [11] and mature vegetables and fruits [37]. Since the TAC assay was conducted using the methanolic extract used for TPC analysis, it was not surprising that there was no significant difference in both values among samples, as phenolic compounds could be the main contributor to the TAC in this experiment.

3.2. Nutritional analysis of additional farm grown microgreens

Several other microgreens, including amaranth, kale, kohlrabi, spicy broccoli, pea, and wasabi, grown hydroponically, were also available in the local farm, and thus were analyzed for their TCC, TPC, VCC, and TAC (Table A.1 in Appendix A). Of these species, kohlrabi stood out as having the highest levels of TCC, TPC, and TAC. High levels of TPC and TAC were also noted in kale. Correlations among TCC, TPC, VCC, and TAC of microgreens were analyzed and a strong correlation was only found between TPC and TAC ($r = 0.88^{****}$). This correlation was expected, since the two analyses used the same solvent extract, and phenolic compounds are one of the major contributors to antioxidant activity in vegetables.

3.3. Sensory analysis of broccoli microgreens

A total of 150 participants' data was collected and analyzed in the sensory study. The descriptive information of participants is shown in **Table 1.** The participants were asked about their prior experience in purchasing and consuming microgreens. Eighty-two percent had not purchased and 69% had not consumed microgreens before participating in this study.

Table 1. Descriptive information of participants (N=150).

Variable	Frequency	Percentage
Gender		
Male	57	39%
Female	93	61%
Age		
19-24	113	75%
25-34	23	15%
35-44	10	7%
45-54	2	1%
55-64	2	1%
Education		
High school	7	5%
Attending college	102	68%
College graduate	16	11%
Post-graduate	25	17%
Ethnicity		
Caucasian	86	57%
African-American	25	17%
Hispanic	7	5%
Asian	25	17%
Others	7	4%
Marital Status		
Never Married	120	80%
Married	26	17%
Separated	1	<1%
Others	3	2%
Household spending on grocery per week		
<$50	43	29%
$50-$100	68	45%
$101-$150	23	15%
$151-$200	5	3%
$201-$250	5	3%
>$250	5	3%
Missing value	1	<1%

According to the results of the sensory study (**Table 2**), scores for the smell, appearance, taste, and overall liking of microgreens were all significantly ($p < 0.05$) higher for those from the local farm as compared to those from commercial. A higher average of scores was noted for soil-grown farm samples as compared to water-grown farm samples but did not reach statistical significance. The average scores for all the sensory attributes of farm microgreens were in the range of 4.54 – 5.38 out of 7 (Fair to Very good), while those for the commercial microgreens were in the range of 3.09 – 3.68 (Not good to Fair).

Table 2. Sensory properties of broccoli microgreens from a commercial grocery store grown hydroponically (CH), from the local farm grown hydroponically (FH), and from the local farm grown in soil (FS).

Sensory attributes	Broccoli Microgreen Samples		
	CH	FH	FS
Smell	3.29 ± 1.35 [b]	4.45 ± 1.26 [a]	4.63 ± 1.28 [a]
Appearance	3.09 ± 1.27 [b]	5.24 ± 0.97 [a]	5.53 ± 1.05 [a]
Taste	3.68 ± 1.50 [b]	4.61 ± 1.32 [a]	4.75 ± 1.29 [a]
Overall Liking	3.60 ± 1.41 [b]	4.85 ± 1.15 [a]	5.00 ± 1.15 [a]

Values are means ± SD, n = 150. Different letters indicate statistically significant differences , a > b, $p < 0.05$.

Several factors may contribute to the better sensory quality of the microgreen samples from the farm. Firstly, the greatly higher level of chlorophyll as aforementioned gave the farm samples a more vibrant color as compared to the commercial ones, and therefore contribute to the higher evaluation on the appearance. Appearance of a food product, especially fruits and vegetables, is the initial quality that attracts consumers, and affects their first-time purchase intention [38]. Secondly, samples from the local farm were delivered the same day of harvest and were used for the sensory test on the following 3 days. However, the exact harvest time of the commercial samples was unknown and it might take several days for transportation and storage until they reached the consumers. The freshness of vegetables may significantly affect the evaluation on all the sensory attributes, including smell, taste, and appearance. Thirdly, it was reported that total sugar content is a factor that can greatly affect the sweetness, bitterness, and sourness, and thus the taste of vegetables [39]. The higher level of chlorophyll in the farm samples as observed may result in a higher production of sugar owing to greater capability of photosynthesis, which may contribute to the higher scores on the taste of those samples as compared to the commercial ones. Future analysis can be conducted to measure the sugar contents of microgreen samples from different sources.

To explore the impact of smell, taste, and appearance on the overall liking for microgreens, the correlations among sensory attributes were analyzed. It was found that the overall liking was most strongly correlated with the taste of microgreens (r = 0.83****). Scores of overall liking were also strongly correlated with the appearance and the smell of microgreens (r = 0.67**** and r = 0.65****, respectively). The results indicated that taste, smell, and appearance all contributed to consumers' perception of microgreens but taste may be the best predictor. This is consistent with previous findings that flavor-related characteristics best predicted consumer preferences for overall eating quality, although visual quality characteristics also contributed [9].

4. Conclusion

Nutritional and sensory qualities are significant factors in determining consumers' purchase intention toward a food product. To the authors' knowledge, this is the first study of its kind to evaluate and compare the nutritional qualities, emphasizing the antioxidant properties, and the sensory qualities of microgreens from commercial and local farms, grown hydroponically and in soil. The results indicated a significantly higher chlorophyll concentration, a similar total phenolic concentration, and a similar antioxidant capacity in the farm samples as compared to the commercial samples. The soil-grown farm samples possessed a significantly higher vitamin C content than hydroponically-grown samples and commercial samples. The farm grown broccoli microgreens possessed much higher chlorophyll content and total phenolic content as compared to many species of mature vegetables.

It was hypothesized that hydroponic growing and long transit time in the commercial setting may cause the microgreens to be less nutritious, which is true for the measure of vitamin C content, while plants from the two sources have the same total phenolic content and total antioxidant capacity. It implies that hydroponic growing may produce comparable nutritional quality in microgreens as soil growing, probably because external nutrition is not essential during the first few days of growth for producing microgreens. Because hydroponic growing can increase the productivity of microgreens and reduce the cost of the plants, there is a potential for consumers to obtain similar nutrition and antioxidant benefits at a cheaper price. Microgreens may have the potential to serve as functional foods, regardless of the growing method or environment. Yet, as limitations existed in this study, more research studies are needed to look at other species of microgreens as well as to measure the levels of more nutrients and dietary bioactive compounds. In addition, there is a lack of exact information on the harvesting and transportation time of commercial microgreens.

Despite the non-significance in some findings regarding nutritional qualities, the microgreens from the local farm did show a significantly better sensory quality. It is therefore still worthwhile for consumers or restaurants to purchase microgreens from local farms for a better sensory experience. Future in-depth sensory studies are warranted to explore the factors or mechanisms that contribute to the better sensory qualities of microgreens from local farms as compared to those from commercial source.

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Conflicts of Interests

The authors declare no conflicts of interests.

Appendix A. Supplementary data

Table A.1. Total chlorophyll content, total phenolic content, vitamin C content, and antioxidant capacity in microgreens from a local farm.

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