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EVALUATION OF WHEAT MICROGREEN PRODUCTION IN DIFFERENT MEDIA AND HARVEST AGE

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Abstract

Planting media and harvest time are essential factors for microgreen wheat because the media has a function as a place to grow and provide water and nutrients. In contrast, harvest time affects the nutritional content. The purpose of this study was to determine the extent to which the type of media and harvest age can affect the growth, yield, and quality of microgreen wheat. This research used a Factorial Randomized Group Design. The first factor was the planting media consisting of cocopeat and nonwoven fabric, while the second factor was harvest time consisting of 7, 9, 11 and 13 days after planting (hst). The results showed that cocopeat media gave the best plant height, fresh weight of shoots and roots, and quality consisting of chlorophyll, texture, fiber, and color. The harvest age of 9 to 11 hst gave the same fresh weight and dry weight of roots, low weight loss, chlorophyll, and the highest fiber. However, harvest age 7-9 hst gave the best taste, texture, aroma, and color.

***Key words**: harvest age, microgreen, planting media, wheat.*

INTRODUCTION

Recently, many researchers have shown an increased interest in investigating microgreens. Microgreens are immature vegetables, varying in size from species to species, but are usually between 2.5-8 cm in height (Bliss, 2014). Microgreens are harvested and marketed as soon as the first leaves grow and the cotyledons are still soft (Treadwell et al., 2020). Microgreens can be obtained from vegetables, herbaceous plants, grain crops, and aromatic plants (De La Fuente et al., 2019; Kyriacou et al., 2020; Lenzi et al., 2019). Recently, microgreens have received increasing attention from producers and consumers due to their soft and crunchy characteristics, specific taste, diverse colors, and high nutritional content due to the presence of several bioactive compounds such as antioxidants, vitamins, macro and micro-minerals (Bulgari et al., 2017; Caracciolo et al., 2020; Ferron et al., 2021; Galieni et al., 2020; Sun et al., 2013; Turner et al., 2020; Zhang et al., 2020) therefore microgreens are considered as functional foods (Le et al., 2020; Sun et al., 2013).

Interestingly, mature legumes, grains, and sunflower plants are not edible, but their seeds are known to have benefits that make their microgreens edible. One grain crop that is often used for microgreens is wheat. Wheat microgreens contain vitamins A, B, C, and E, as well as minerals, phenolic acids (ferulic, gallic, sinapic, syringic, and p-coumaric acids), flavonoids, chlorophyll, amino acids, and many other active enzymes (Kaur et al., 2021). In addition, wheat microgreens contain fiber that helps maintain a healthy digestive system and improves digestion. Microgreens can be grown in any medium, whether organic, inorganic, or hydroponic solid growing media (Di Gioia et al., 2015). Media that are often used to grow microgreens include cocopeat and nonwoven fabric. The choice of the right growing medium is one of the most critical for microgreen production aspects, as the growing medium is one of the factors that determine the growth, yield and quality of microgreens (Di Gioia et al., 2017). Another factor that determines microgreen production is the age of harvest. Berba and Uchanski (2012) stated that the shelf life of microgreens may be affected by the age at harvest. Different plants are harvested at different ages according to industry standards and to achieve marketable hypocotyl length and leaf area. There is still a lack of formal studies in the literature that found the effect of harvest age on microgreen production and shelf life. Many wheat microgreen studies have been conducted. However, they focus on aspects of bioactive compounds that have the potential to provide significant health benefits. Therefore, to fill this lacuna, the objective of this study was to determine to what extent media type and harvest age can affect the growth, yield, and quality of wheat microgreens.

MATERIALS AND METHODS

The study was conducted in a laboratory with shaded conditions; light intensity in the morning was 10-100 lux, and in the afternoon, 100-400 lux. The average humidity in the morning and evening was 80-90%, and in the afternoon was 60-70%. The ambient temperature during the study was around 26-28ºC. The design used was a Factorial Randomized Group Design with two treatment factors. The first treatment was planting media, consisting of 2 levels, namely cocopeat and nonwoven fabric, while the second treatment was harvest age, composed of 4 levels, namely harvest age 7, 9, 11, and 13 hst. Wheat seeds were soaked for 12 hours, weighed as much as 64 grams, and then sown in a thin-wall box without a lid with a volume of 650 ml, which had been given cocopeat or nonwoven cloth as a growing medium. Before use, the growing box was sterilized with 75% alcohol tissue.

Then, the thin-wall box that had been sprinkled with wheat seeds was placed on a rack and covered with a cloth for 2 x 24 hours. This was called the blackout phase, which aimed to make the seeds grow synchronously. After the seeds began to emerge, they were immediately introduced to light. Watering was done to maintain moisture so that plants could grow well. Watering was done using a sprayer every 3 hours at an interval from 06.00 am to 6.00 pm. Watering was done with a fogging model, this was done to keep the plants and media moist in optimal conditions in the process of germination and growth. Harvesting was carried out 4 times, namely at the age of 7, 9, 11, and 13 hst, by pulling the plants up to their roots and grouping them according to treatment. The parameters observed included the yield and quality of microgreen, namely plant height, stem diameter, fresh weight of shoots and roots, dry weight of shoots, and roots and weight loss to determine shelf life. Weight loss observations were made by weighing 5 grams of samples per box then packed with perforated plastic and weighed every day for 6 days. Storage was carried out at room temperature. Weight loss was calculated using the formula:

Weight loss (g) = plant initial wight (0 day) – plant final weight (6^{th} day)

Quality observations included total dissolved solids (refractometer method), vitamin C content (Iodometric method), total chlorophyll (using Chlorophyll Meter Konica Minolta SPAD-502 series), and fiber (SNI 01-2891-1992 method), texture test (using Fruit Penetrometer tool), and organoleptic test. The organoleptic test used a hedonic scale for respondents to assess color, taste, texture, and aroma. Respondents consisted of 10 people who had never tasted microgreen wheat before. The level of assessment includes 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, and 5 = Very like. The organoleptic test results were presented descriptively-quantitatively, and then the D*e Garmo* test was conducted (De Garmo et al., 1984) to determine the best treatment. Determination of the best treatment combination used the effectiveness value method with the following weighting procedures:

1. Categorizing parameters;
2. Giving weight to each parameter of each group 1-5 based on priority and contribution;
3. Calculating the Effectiveness Value (NE) with the formula:

$$NE = \frac{np - nj}{nb - nj}$$

where: np = treatment value; nj = worst score; nb = best value;

4. Parameterring with an average value is better; the lowest value is the worst value, and the highest value is the best value. On the other hand, for parameters with smaller values, the

better; the highest value is the worst value, and the lowest value is the best value;

5. Calculating the Result Value (NH) obtained by multiplying the effectiveness value by the weighted value;

6. Summing up the NH of all parameters in each group where the treatment that has the highest NH is the best treatment in the parameter group.

RESULTS AND DISCUSSIONS

Microgreen Growth

Observations on the fresh weight of microgreens showed that cocopeat media produced the highest fresh weight of shoots (76.32 g) and fresh weight of roots (42.72 g). The results of observations on shoot dry weight showed that cocopeat media produced the same shoot dry weight as nonwoven media. Shoot fresh weight was not affected by harvesting age. Microgreens harvested at 7 hst gave the lowest fresh weight and root dry weight of 24.61 g and 5.05 g, respectively. Harvesting age more than 7 hst produces the same fresh weight and root dry weight (Figure 2). This means that microgreen wheat will be harvested at any age and will have the same fresh weight and root dry weight. So, extending the harvest age of microgreen wheat has no impact on increasing the fresh weight of plants that have economic value.

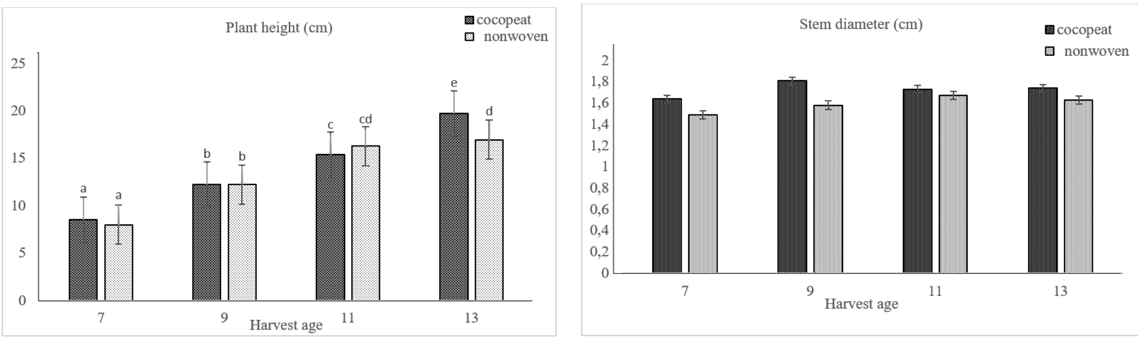

Figure 1. Microgreen growth at various harvest ages

The effect of media on the height of wheat microgreen plants was only visible at harvest age 13 hst. Microgreens grown on cocopeat media (19.73 cm) were higher than nonwoven media (16.97 cm) (Figure 1). However, this was not the case with stem diameter, which showed no difference in all media and observation ages.

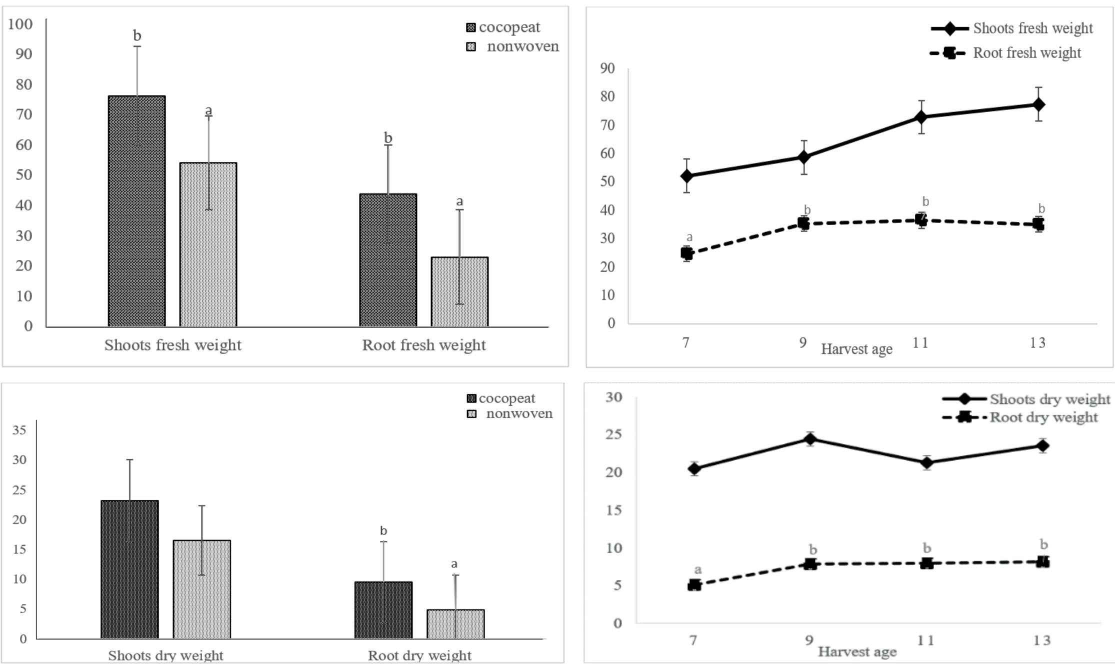

Figure 2. Fresh weight and dry weight of microgreens at different media and harvesting ages

The effect of harvest age on the fresh weight of wheat roots (or other microgreen roots) is significant because this is the phase of growth where the roots of a plant have significant development, even if the plant itself is still in a young phase. Root fresh weight is one of the parameters that can be used to measure the growth and nutritional potential of microgreen plants. The growing medium should have a physical structure that creates the right air and water balance for healthy root development. This balance must be maintained throughout the crop production cycle, which can last from a few weeks to more than a year. The structure of a growing medium is determined by the size, shape, texture, and physical arrangement of its constituent particles (Bilderback et al., 2005).
This is because the growing medium plays a vital role in determining the growth, yield, and quality of microgreens and the sustainability of their production (Di Gioia et al., 2017; Nurzyński, 2005). Komosa et al. (2010) reported that although applied to the same nutrients, various substrates such as sand, rockwool, wood fiber, and peat had marked differences in nutrient content. Cocopeat is an organic growing medium made from coconut fibers that are dried and crushed into fine powder. This growing medium has several advantages over rockwool and nonwoven fabric. As reported by Krishnapillai et al. (2020) and Krishnapillai et al. (2020), cocopeat has outstanding physical and chemical characteristics such as high water holding capacity, good drainage, and aeration properties, as well as high cation exchange capacity, pH ranging from 5.5 to 7. So, in this study, cocopeat media showed the best plant height, fresh weight of shoots, and roots.

Storability

Microgreen resistance to storability was observed from the weight shrinkage after harvest. Weight loss observations were made three times, namely at harvest (day 0), after the first 3 days of storage (day 3 weight - day 0 weight), after the second 3 days of storage (day 6 weight - day 3 weight), after 6 days of storage (day 6 weight - day 0 weight). ANOVA analysis revealed that there was no interaction between media type and harvest age on the weight loss of wheat microgreens. The treatment of planting media did not affect the storability of microgreens either at the first 3 days (0-3), the second 3 days (3-6), or even 6 days after harvest (0-6). However, harvesting age affected the storability of microgreens at 6 days after harvest (0-6). Figure 3 shows that the weight loss on the first 3 days (1.63 g) was not significantly different from the second 3 days (1.60 g). With the longer harvesting age (11 to 13 hst), the shrinkage weight decreased, although the microgreen harvested at 11 or 13 hst had the same weight shrinkage rate of 1.07 and 1.08 g. This means that the younger the microgreen is harvested, the higher the weight loss. This means that the younger the microgreen is harvested (7 and 9 hst), the higher the shrinkage so that it cannot be stored.

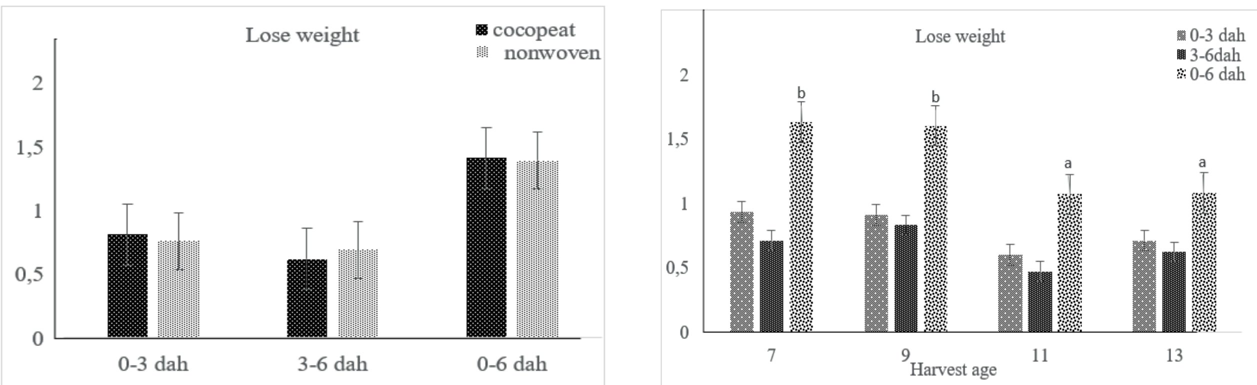

Figure 3. Shrinkage of microgreen fresh weight during storage

Harvesting age is one of the crucial factors that affect crop productivity. Some scholars (Anggraeni et al., 2020; Ianah et al., 2022; Maulidiyah et al., 2022) argued the length of harvesting age could increase the fresh weight and dry weight of microgreen red-redish plants. This research is also in accordance with the research of Wahyono et al. (2019) that the longer the harvest period, the dry weight content will increase, with a dry weight content of 27.55% to

29.74%. The increase in dry weight content is due to the increased conversion of nutrients obtained from water and food reserves in seeds. The older the age of the plant, there is usually an increase in fiber content, which can affect the increase in dry weight content. This is due to the older age of the plant, which has a high cell wall component. In connection with the development of maturity (plant age), there will also be an increase in fiber concentration (Savitri et al., 2013).

Microgreen Quality

Media type and harvest age affected chlorophyll, texture, and fiber content, while Total Dissolved Solids and vitamin C content were not affected by the treatments. Microgreens grown in cocopeat media produced the highest chlorophyll, texture, and fiber content of 45.59 µg/mL; 1.61g f/cm^2; 11.80% and 37.76 µg/mL; 1.53g f/cm^2; 11.63% for nonwoven media, respectively (Figure 4). Microgreens harvested at 9 and 11 hst had a higher chlorophyll content of 54.05 µg/mL and 46.93 µg/mL, respectively, which was significantly different from microgreens harvested at 7 and 13 hst, which were 41.85 µg/mL and 23.86 µg/mL, respectively. The earlier the microgreen is harvested (7 hst) or the longer the harvest age (13 hst), the lower the chlorophyll content. The results of texture and fiber analysis show that the longer the harvest age will produce a harder and more fibrous texture, respectively 1.31, 1.56, 1.66, and 1.75 g f/cm^2 for texture and 10.45, 11.33, 12.54, and 12.55% for fiber content (Figure 4).

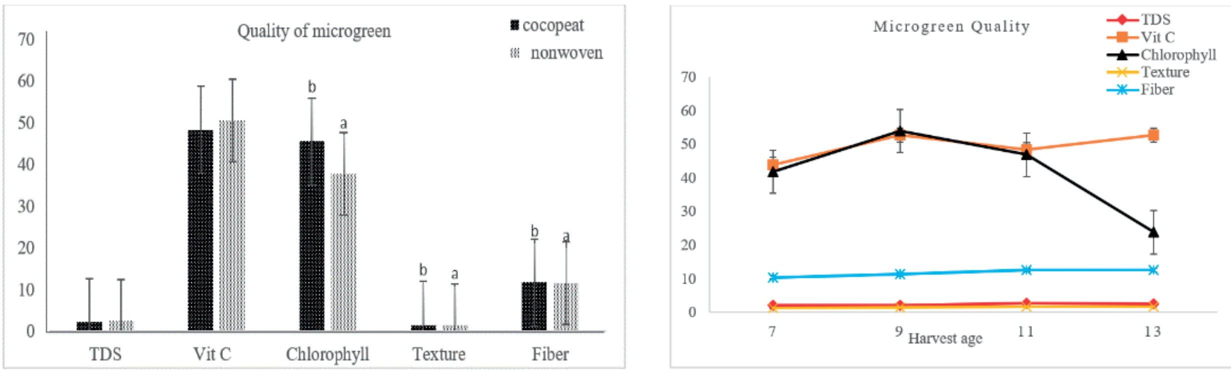

Figure 4. Microgreen quality at various media and harvesting ages

a product is accepted or rejected by consumers, and these aspects are even more relevant in products such as microgreens, which are also highly valued for their color (Barret et al., 2010). Cocopeat has the capacity to hold water and provide nutrients in a readily available form that can be used to produce a wide variety of high-quality crops (Awang et al., 2009; Di Gioia & Santamaria, 2015). Good chemical and physical properties of cocopeat are determinants of its ability to support the development of quality crops (Awang et al., 2009; Ilahi & Ahmad, 2017; Nazari et al., 2011; Paramanandham et al., 2013; Udayana et al., 2017; Xiong et al., 2017). Therefore, wheat microgreens grown on cocopeat media appear to have higher chlorophyll content. The higher lignification process causes an increase in crude fiber production. Cocopeat is a rich source of lignocellulose consisting of lignin, cellulose, and hemicellulose (Norhasnan et al., 2021). Therefore, cocopeat media produces higher fiber content than nonwoven. The presence of these higher fibers makes the texture of microgreens grown in cocopeat media harder than those grown in nonwoven media.

Consumer Favorability

The results of the organoleptic test show that the average ranking of panelists' or consumers' preference for the taste, texture, aroma, and color of microgreen wheat plants ranges from 4 to 5, meaning that consumers like microgreen wheat. The higher the average ranking of panelists' liking, the greater the level of panelists' liking for the taste, texture, aroma, and color of microgreen wheat plants. Cocopeat planting media gives an influence on the level of color liking only while the harvest age gives an influence on the level of liking for taste, aroma, texture and color with treatments that are much preferred at the age of harvesting 7 hst (Table 1).

Table 1. The average level of consumer favorability due to the application of planting media with different harvesting ages

Treatment	Consumer Favorability			
	Taste	Texture	Aroma	Color
Planting media				
cocopeat	4.55	4.36	4.58	4.50 b
nonwoven cloth	4.51	4.25	4.51	4.41 a
Tukey 5%	NS	NS	NS	0.08
Harvest Age (dap)				
7	4.75 c	4.93 d	4.68 b	4.95 c
9	4.60 bc	4.60 c	4.63 b	4.60 b
11	4.55 b	4.18 b	4.58 b	4.18 a
13	4.23 a	3.53 a	4.30 a	4.10 a
Tukey 5%	0.19	0.18	0.17	0.12

Remark: NS (Not Significant)

Through the taste indicator, the treatment of harvest age has a significant effect on the level of consumer preference. The consumers much preferred the 7th harvest age, with an average value of 4.75, and the lowest treatment was the 13th harvest age treatment with an average value of 4.23. In contrast, the treatment of planting media did not have a significant effect on the level of taste preference. This showed that the taste of microgreen wheat was still customary even though the taste of microgreen wheat was like raw peanuts and few respondents showed a dislike for taste. For the color indicator, the level of preference of all respondents really liked the color because it has a bright and fresh green color

The favorability level in the aroma indicator found that half participants liked the aroma of microgreen wheat. This result is indicated due to the very distinctive aroma of microgreen wheat. Indicator of microgreen wheat texture: most of the panelists preferred to choose the texture that is owned when microgreen wheat is harvested at the age of harvest 7 hst (value 4.93), while the least preferred by panelists is the age of harvest 13 hst (value 3.53). It is presumed that microgreen wheat harvested at the age of 13 hst has a hard texture.

De Garmo Test

Determination of the best treatment on plant yield variables includes plant height, stem diameter, bud fresh weight, bud dry weight, and weight loss (Figure 5). The highest variable weight is shoot fresh weight with a weight of 0.33, followed by shoot dry weight of 0.27, plant height of 0.20, stem diameter of 0.13, and weight shrinkage of 0.07. The best treatment combination in microgreen wheat plants is obtained from a combination of cocopeat media with the 13th harvest age with the following characteristics: average plant quality of bud fresh weight (230.32 grams); bud dry weight (53.11 grams); plant height (19.73 cm); stem diameter (1.74 mm); and weight loss (1.21 grams).

Determination of the best treatment on plant quality variables includes total soluble solids, vitamin C, chlorophyll, texture, and fiber content. The highest variable weight was total soluble solids of 0.33, followed by vitamin C at 0.27, chlorophyll at 0.20, texture at 0.13, and fiber content at 0.07. The best treatment in microgreen wheat plants is obtained from a combination of cocopeat media with a harvest age of 11 hst with the following characteristics: average crop quality on total soluble solids (3.02^{o} brix); vitamin C (44 $mL.g^{-1}$); chlorophyll (26.36 $\mu g.mL1^{-1}$); texture (1.66 g $f.cm^{-2}$) and fiber content (12.51%).

Determination of the best treatment on organoleptic variables includes taste, color, aroma, and texture. The highest parameter weight is taste, with a weight of 0.40, followed by texture 0.30, color 0.20, and aroma 0.10. The best treatment in microgreen wheat plants is obtained from a combination of cocopeat media with a harvest age of 7 hst with the following characteristics: the average level of panelist preference for taste 4.75 (like); color 5 (very like); aroma 4.7 (like) and texture 5 (very like).

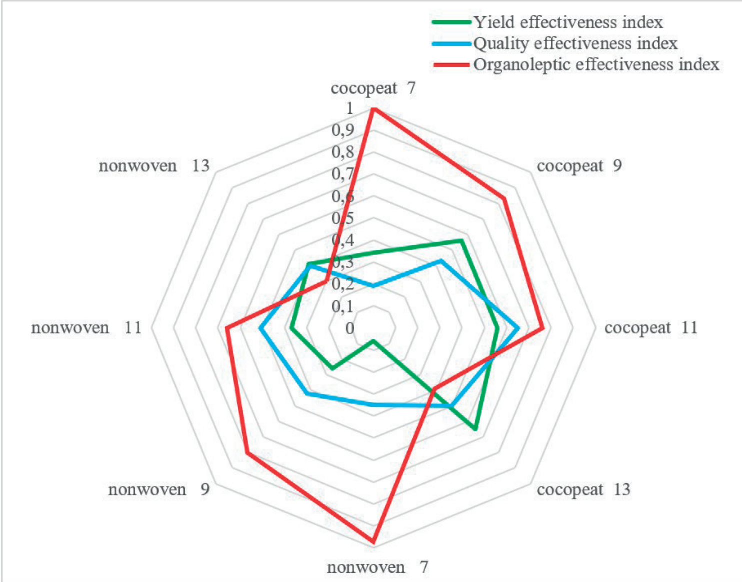

Figure 5. De Germo test results on yield, quality, and organoleptic tests

Correlation Test of Quality and Organoleptic Variables

The correlation test between texture, fiber content, and consumer preference level shows that the laboratory texture test with fiber content shows a positive value of 0.9, meaning that the texture test affects the fiber content in microgreen wheat. Still, the correlation between the laboratory texture test and consumer preference level shows a negative correlation, meaning that the higher the texture test value makes the consumer preference level less preferred. This is because microgreen with a high texture test value produces an unpleasant taste, texture, aroma, and unattractive color.

The correlation test between consumer preference levels showed a positive correlation in all parameters of preference levels, including taste, texture, aroma, and color (Table 2). This states that consumers like microgreen wheat. The results of the De Garmo test in this study show the most preferred treatment was the combination of cocopeat media treatment with the 7th hst harvest age. For plant quality variables, including total soluble solids, vitamin C, chlorophyll, texture, and fiber content, the treatment that has the best productivity is the combination of cocopeat media with the 11th harvest age.

Table 2. Correlation test of quality and organoleptic variables of microgreen wheat plants

Parameters	Laboratory		Organoleptic			
	Texture	Fiber Test	Taste	Texture	Aroma	Color
Texture Test	1					
Fiber Test	0.9456	1				
Taste	-0.8230	-0.7826	1			
Texture	-0.8403	-0.8558	0.9722	1		
Aroma	-0.6909	-0.6856	0.9723	0.9487	1	
Color	-0.8843	-0.9535	0.8373	0.9220	0.7778	1

CONCLUSIONS

The selection of growing media and harvesting age of microgreens can affect product quality. The results of this study showed that the selection of growing media significantly affected the growth, yield, quality, and storability of microgreens. Cocopeat can be applied as a cheap and renewable alternative media for microgreen production. Harvest age determines the level of acceptance by consumers, meaning that the younger the microgreen is harvested the more preferred by consumers because the taste is better, the texture is softer, the aroma is fresher, and the color is more attractive.

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