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GIBBERELLIC ACID (GA_3) REGULATION OF FRUIT QUALITY IN CUCUMBERS

SUMMARY

The research aimed to evaluate the effect of GA_3 application on skin color and fruit yield quality in fruit from three varieties, namely Mars, Roberto, and Vanesa. A randomized block design (RBD) was used, consisting of treatment with emasculation and without emasculation combined with GA_3 (0, 200, 400 ppm). There were 18 treatments in the experiment, each with three replicates, resulting in 54 experimental units, each experimental unit consisted of 4 plants, and a total of 216 plants. Data were analyzed using analysis of variance (ANOVA) at a 5% significance level. The results showed a significant effect of various GA_3 concentrations on fruit skin color (a^* and b^*) and total carotenoids in the three varieties. Roberto variety with emasculation applied at 200 ppm yielded the best results in a^* value (-5.58) and total carotenoids (249.73 mg/100 g). Specifically, the combination of the Roberto variety and 200 ppm GA_3 with emasculation produced the most intense green color and the highest carotenoid content among treatments. These results demonstrate that GA_3 application at an appropriate concentration, combined with suitable varietal selection, can effectively enhance both visual quality and carotenoid accumulation in cucumber fruit.

Keywords: emasculation, fruit parameters, gibberellin, hormonal treatment, plant metabolites

INTRODUCTION

Cucumbers typically contain unique internal components, which are often considered unnecessary in the cosmetic and pharmaceutical industries due to their perceived inefficiency and potential to hinder processing. In the global market, cucumbers are one of the vegetable commodities available, and there are special criteria used as standards for the types of cucumbers to be exported. However, cultivation techniques can be applied to improve the quality of horticultural products (Hadiwijaya *et al.*, 2025; Montoya *et al.*, 2023; Win *et al.*, 2026; Zhao *et al.*, 2024). Fruit development is a complex physiological process that can be

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influenced by both natural and artificial factors in agriculture and horticulture. This process plays an important role as an agricultural trait that supports stable fruit set and improves fruit quality under adverse environmental circumstances. Fruit development can be regulated through the application of gibberellin hormone at precise stages of fruit development. This process offers several advantages, such as improving fruit growth and overall fruit quality, and enhancing plant productivity by eliminating the dependency on pollination. Therefore, hormonal regulation of fruit development is an important technique in cucumber cultivation to increase crop yield and fruit quality. Gibberellins are a class of plant hormones that regulate various aspects of growth and development. Among them, gibberellic acid (GA_3) is known to play an important role in the development and regulation of fruit set (Wang *et al*., 2020).

Application of GA_3 has been carried out on various horticultural commodities, and the process is normally applied before fertilization. Various studies have tested the GA_3 application against various parameters in several commodities. The application of 350 ppm of GA_3 had a substantial effect on the production of cucumber fruit (Hairuddin *et al.,* 2019). In addition, GA_3 application in tomatoes has also been reported to influence fruit development (Gultom and Silitonga, 2018). Other research reported that GA_3 at a concentration of 1500 ppm in custard apples, leading to an increase in fruit length, diameter, and weight, as well as an increase in fruit set (Dos Santos *et al.,* 2016). Other study concluded that GA_3 at a concentration of 1500 ppm in custard apples increased fruit length, diameter, weight, and fruit set (Rimberia *et al.,* 2006).

Falah *et al.* (2019) conducted an investigation about zucchini fruit with GA_3 application and different application times. The results showed that a concentration of 1500 ppm with pre-anthesis application time showed the most optimal results in increasing the ratio of female flowers, fruit set, and the least number of zucchini seeds. This research was carried out with GA_3 spraying treatments of 0 ppm (with pollination), 500 ppm (without pollination), 1000 ppm (without pollination), and 1500 ppm (without pollination), which were applied during pre-anthesis and anthesis. These findings indicate that GA_3 plays a significant role in regulating fruit development and productivity across horticultural crops. Therefore, the supply of GA_3 may have also contributed to the rise of photosynthetic pigments. There are several studies that indicate an increase in pigment content in the form of chlorophyll in sweet pepper after GA_3 is applied (Mbandlwa *et al.,* 2020). In addition, the application of GA_3 was found to increase chlorophyll content in potato leaves (Wheeler and Humphries, 1963). Application of GA_3 at a concentration of 200 ppm provides the most optimal effect on vegetative growth, acceleration and increase in flowering, flower production, and the quality and vigor of petunia seeds (Sravya *et al.,* 2024). Overall, 200 ppm is the optimal dose to increase the productivity and resilience of Cape gooseberry in arid environments (El-Tohamy *et al.,* 2023). However, the majority of earlier research has mostly concentrated on how GA_3 affects growth, yield, and overall physiological reactions, paying little attention to how it affects fruit quality characteristics, especially pigment composition and secondary metabolites in cucumbers. Additionally, there are yet few comparison studies assessing how various cucumber types react to GA_3 administration under particular growing regimes. By assessing the impact of various GA_3 concentrations on skin color traits and carotenoid content in several cucumber types, this study is focused on closing this gap and offer fresh perspectives on the function of GA_3 in enhancing both visual and nutritional quality.

MATERIAL AND METHODS

Research location and time

This research was carried out from July to September 2020, at the screen house, Faculty of Agriculture, Universitas Padjadjaran, Indonesia, at an altitude of 752 ml above sea level. The average daily temperature during cucumber cultivation was 23.86 ˚C. The highest daily temperature was in August, at 25.15 ˚C, and the lowest in September, at 22.52 ˚C. The optimum temperature for cucumber growth is 20 ˚C to 30 ˚C (Aparna *et al.,* 2023; Yin *et al.,* 2024). The average daily humidity during the cucumber planting period was 83.58%. The highest daily humidity was in September, at 85.13%, and the lowest daily humidity was in August, at 80.62%. Fruit quality analysis was carried out at the Laboratory of Horticulture, Faculty of Agriculture, Universitas Padjadjaran, Indonesia.

Procedures and design of the experiment

Seeding

The cucumber (*Cucumis sativus* L.) seeds used in this study were purchased from a certified seed distributor in Indonesia. Vanesa (East West Seed, Indonesia), Mars (Tjap Bukit Mas, Indonesia), and Roberto (Bisi international, Indonesia) varieties were soaked in water for 15 minutes. Then, the soaked seeds were transferred to a wet towel until the roots emerged. Subsequently, the seeds were transferred to the nursery seeding medium, consisting of soil and manure at a ratio of 1:1. Cucumber seeds were also sprayed with the fungicide Propamocarb Hydrochloride at 0.5 ppm with a spraying interval of 1 week.

Preparation of planting media

The planting media used were soil, husk charcoal, and chicken manure (1:1:1). NPK fertilizer was added at a rate of 19.8 ml/plant and placed in a polybag (40 x 40 cm with a capacity of 10 kg). Subsequently, polybags filled with planting media were placed and arranged according to the experimental plot. The distance between rows was 70 cm, and the planting distance was 40 cm. The planting medium was left for 14 days before transplanting.

Planting

The seedlings were transplanted into individual polybags filled with planting media once they had grown two leaves. One seed was planted per polybag. The polybags in which the seeds were planted received furadan insecticide at a dose of 0.65 g/plant embedded near the seeds. Subsequently, the seeds containing the polybag were doused with water. Compound NPK fertilizer at a dose of 9.8 g/plant was given when the seedlings were 14 days after planting (DAP).

Application of GA_3

Plants treated with emasculation on all male flowers were cut to prevent pollination, and this process was performed to minimize the possibility of the occurrence of fertilization. The GA_3 was sprayed on all parts of the female flower 3 times using a hand sprayer. Spraying of the flower was carried out when the female flowers were still in bud, at the beginning of flowering, and 24 hours after the first application, and this process was conducted from 07.00–09.00 in the morning. After spraying, the flowers were wrapped in plastic and labeled.

Harvest and post-harvest

The harvest is typically conducted between 29 to 32 DAP, with the first harvest feasible approximately 8 to 10 days after the full opening of the first female flower. Subsequently, the next harvest can be performed every 2 days, which can be carried out by cutting the fruit stalk using a knife or scissors. The fruit ready for harvesting can be seen from the uniform color, the spines will start to disappear, and the top of the fruit become rounded (Kusumiyati and Putri, 2023). The harvested fruit is then taken to the laboratory for further testing.

Data analysis

The experimental design used was a randomized block design (RBD), which included treatments involving emasculation with the application of GA_3 (0, 200, 400 ppm) as well as treatments without emasculation with the application of GA_3 (0, 200, 400 ppm). All treatments were carried out on three cucumber varieties, such as Mars, Vanesa, and Roberto. Emasculation in cucumber fruit was carried out by removing the male part of the flower before pollination occurs. In contrast, no-emasculation is a condition where the flower is left intact without removal of the male parts, allowing natural pollination to occur. This research also compared the GA_3 application effect in the conditions of emasculation and without emasculation on cucumber fruit quality, specifically on the parameters of fruit skin color, water content, total carotenoid content, and vitamin C. The experiment performed consisted of 18 treatments, each with 3 repetitions, and 54 experimental units were obtained. Each experimental unit consisted of 4 plants, and there were 216 plants in total. The Analysis of variance in the F test with a level of 5% (SPSS version 25) was used. If the F test indicated significant differences, the Tukey test would be used to further analyze the observational data.

Research Observations

Fruit Color Analysis

The measurements of color on the fruit skin were carried out after harvest. The color measurements were tested using a reflectance spectrophotometer (Konica Minolta type CM 600d). The quantitative color value is shown by the L^*, a^*, and b^* values, the L^* scale expresses the brightest value of 100 and the darkest value of 0. A positive a value shows the presence of red, and a negative a value shows the presence of green. Similarly, a positive b value indicates the presence of yellow, and a negative b value shows the presence of blue. Observations were made on 2 different sides, each consisting of 3 points, including tip, middle, and base of each sample.

Water Content Analysis

The water content was tested using the gravimetric method, and the sample weighed 3 grams and dried in an oven at 105˚C (Kusumiyati *et al.,* 2024). The sample was dried until a constant weight was obtained. Water content is calculated using the following formula:

$$\mathrm{WC} = \frac{\mathrm{W1}-(\mathrm{W1}-\mathrm{W2})}{\mathrm{W1}-\mathrm{W2}}\ x\ 100\%$$

Where:
WC = water content (%)
W1 = wet sample weight (g)
W2 = dry sample weight (g)

Total carotenoid analysis

Analysis of total carotenoids was carried out using a spectrophotometer at wavelength 440 nm (Shimadzu UV mini-1240, Tokyo, Japan) (Hadiwijaya and Putri, 2025; Kusumiyati *et al.,* 2025). Cucumber samples were sliced thinly and placed in a baking dish. Then, the sample was put into an oven at a temperature of 50˚C (Memmert Schutzart DIN 40050-IP 20, Schwabach, Germany). The dried samples were then finely ground using a grinder and put into ZIP plastic, the dried sample was weighed 5 mg and put into a 10 ml vial. Furthermore, 10 mL of acetone was added using a micropipette pipette (Thermo Fisher Scientific, Waltham, MA, USA). The samples were extracted using an ultrasonic tool (cleaner BK-2000, China) for 15 minutes at 33˚C. After extraction, the sample was transferred into a 10 ml volumetric flask, and acetone was added to the limit mark. Subsequently, the sample extract solution was put into a 10 ml tube and centrifuged (Corona 80-2 Centrifuge) for 10 minutes.

Vitamin C Analysis

The content of vitamin C in cucumbers was analyzed using high-performance liquid chromatography (HPLC) (Shimadzu, LC 20AT Prominence, Tokyo, Japan) (Chebrolu *et al.,* 2012). The sample was finely blended, and 2.5 mL of the wet sample was put into a centrifuge tube. In addition, 2.5 mL of trichloroacetic acid (TCA) solution was added and vortexed for 5 minutes. The solution that had been vortexed was then put into a centrifuge for 10 minutes. The solution was analyzed further using HPLC.

RESULTS AND DISCUSSION

Color Analysis

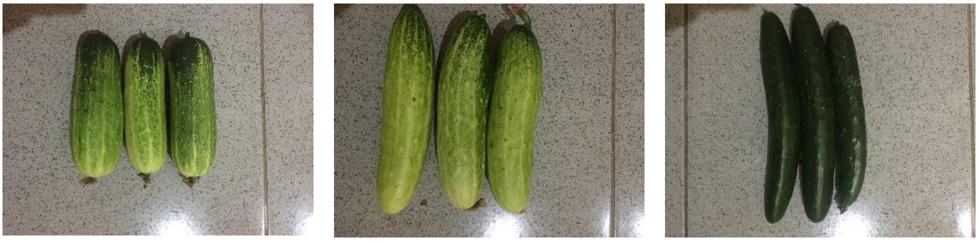
The results of the analysis of variance for L^*, a^*, and b^* are presented in Table 1. The results showed no effect of GA_3 concentration and various cucumber varieties on the lightness value (L^*) of cucumber fruit. The measurements of the lightness value are important because they determine the color brightness, the higher the L^* value, the higher the color's brightness level. Conversely, if the L^* value is low, it indicates a relatively dark/intense fruit color (León *et al.,* 2006). This shows that GA_3 concentration does not affect the lightness value of various cucumber varieties. The a^* value describes the colors green – red, if the a^* value is negative, it shows green; if the a^* value is positive, it shows red. The color of the cucumber is indicated by a negative a^* value. Based on Table 1 above, it shows that there is an effect between cucumber varieties on the a^* value. The average value of cucumber fruit with emasculation resulted in the best treatment at Roberto 200 ppm. The best a^* value for cucumber fruit without emasculation shows the best Roberto 0 ppm variety results. The best results for a* values were obtained on the Roberto 0 ppm variety.

Table 1. Effect of GA_3 in various cucumber varieties on L^*, a^* and b^* values

Treatment	L^*	a^*	b^*
0 ppm, Mars (emasculation)	55.30 a	-8.45ab	26.88b
0 ppm, Roberto (emasculation)	40.11 a	-5.10de	8.55a
0 ppm, Vanesa (emasculation)	47.40 a	-9.85a	34.77b
200 ppm, Mars (emasculation)	55.00 a	-8.05abc	30.66b
200 ppm, Roberto (emasculation)	38.63 a	-5.58cde	9.72a
200 ppm, Vanesa (emasculation)	45.53 a	-8.45ab	32.81b
400 ppm, Mars (emasculation)	59.28 a	-8.33abc	30.67b
400 ppm, Roberto (emasculation)	40.05 a	-5.06de	8.14a
400 ppm, Vanesa (emasculation)	45.27 a	-10.27a	34.27b
0 ppm, Mars (without emasculation)	56.99 a	-7.79abcd	24.15b
0 ppm, Roberto (without emasculation)	40.72 a	-4.87e	8.17a
0 ppm, Vanesa (without emasculation)	46.36 a	-8.87a	33.5b
200 ppm, Mars (without emasculation)	53.82 a	-8.72a	30.49b
200 ppm, Roberto (without emasculation)	40.82 a	-5.54cde	9.4a
200 ppm, Vanesa (without emasculation)	46.83 a	-9.08a	35.10b
400 ppm, Mars (without emasculation)	56.24 a	-7.83abcd	31.91b
400 ppm, Roberto (without emasculation)	40.31 a	-5.70bcde	9.71a
400 ppm, Vanesa (without emasculation)	48.04 a	-8.22abc	34.27b

Note: The same numbers followed by the same lowercase letters are not significantly different according to Tukey's test

The b^* value describes the color of the fruit skin, which is blue-yellow. If the b^* value is negative, it shows blue, if the b^* value is positive, it shows yellow. In Table 1, the b^* value shows the effect of GA_3 application on various cucumber varieties on the b^* value. The best average b^* value for cucumbers was found in the 0 ppm Mars variety with emasculation. Furthermore, this treatment was not significantly different from other emasculation treatments (Vanesa 0 ppm, Mars 200 ppm, Vanesa 200 ppm, Mars 400 ppm, Vanesa 400 ppm). The 0 ppm Mars variety with emasculation was also not significantly different from the various varieties without emasculation (Mars 0 ppm, Vanesa 0 ppm, Mars 200 ppm, Vanesa 200 ppm, Mars 400 ppm, and Vanesa 400 ppm). The b^* value of fruit skin color indicates how blue or yellow the color is.



(a) (b) (c)

Figure 1. Characteristics of cucumber skin (a) Mars variety; (b) Vanesa variety; (c) Roberto variety

Water Content Analysis

Table 2 shows that the Mars, Roberto, and Vanesa varieties have water content that is not significantly different. The water content of cucumber varieties Mars, Roberto, and Vanesa at various concentrations of GA_3 ranged from 88.23% to 91.78% which is not significantly different. In general, this variance showed that treatments with various concentrations and methods (emasculation or not) did not produce significant differences in water content in cucumbers. The analysis of variance did not show any significant differences in GA_3 concentrations in the water content of various cucumber varieties (Table 2).

Table 2. Effect of GA_3 on fruit water content of cucumbers

Treatment	Water Content (%)
0 ppm, Mars (emasculation)	90.35a
0 ppm, Roberto (emasculation)	89.09a
0 ppm, Vanesa (emasculation)	88.72a
200 ppm, Mars (emasculation)	91.56a
200 ppm, Roberto (emasculation)	88.80a
200 ppm, Vanesa (emasculation)	90.80a
400 ppm, Mars (emasculation)	88.23a
400 ppm, Roberto (emasculation)	89.90a
400 ppm, Vanesa (emasculation)	89.59a
0 ppm, Mars (without emasculation)	90.25a
0 ppm, Roberto (without emasculation)	91.36a
0 ppm, Vanesa (without emasculation)	90.23a
200 ppm, Mars (without emasculation)	90.80a
200 ppm, Roberto (without emasculation)	89.57a
200 ppm, Vanesa (without emasculation)	90.58a
400 ppm, Mars (without emasculation)	90.80a
400 ppm, Roberto (without emasculation)	90.88a
400 ppm, Vanesa (without emasculation)	91.78a

Note: The same numbers followed by the same lowercase letters are not significantly different according to Tukey's test

Analysis of total carotenoids

Table 3 shows that the cucumber varieties, including Mars, Roberto, and Vanesa have varying total carotenoid contents. In this research, the total carotenoid content obtained ranged from 8.36-322.16 mg/100 g. The combination of treatments showed that the Roberto variety at various GA_3 concentrations consistently had higher carotenoid content. The Roberto variety showed significantly higher carotenoid contents in almost all treatments, while Mars and Vanesa showed relatively consistent lower carotenoid contents. In this research, based on the Tukey test, there were significant differences in the analysis of the effect of GA_3 concentration and cucumber varieties, presented in Table 3.

Table 3. Effect of GA_3 on total carotenoids of cucumbers

Treatment	Total Carotenoids (mg/100 g)
0 ppm, Mars (emasculation)	29.92a
0 ppm, Roberto (emasculation)	322.16b
0 ppm, Vanesa (emasculation)	19.37a
200 ppm, Mars (emasculation)	36.80a
200 ppm, Roberto (emasculation)	249.73b
200 ppm, Vanesa (emasculation)	8.36a
400 ppm, Mars (emasculation)	32.56a
400 ppm, Roberto (emasculation)	261.60b
400 ppm, Vanesa (emasculation)	49.46a
0 ppm, Mars (without emasculation)	40.50a
0 ppm, Roberto (without emasculation)	265.40b
0 ppm, Vanesa (without emasculation)	29.46a
200 ppm, Mars (without emasculation)	24.65a
200 ppm, Roberto (without emasculation)	112.81b
200 ppm, Vanesa (without emasculation)	62.74a
400 ppm, Mars (without emasculation)	48.08a
400 ppm, Roberto (without emasculation)	10.25a
400 ppm, Vanesa (without emasculation)	37.87a

Note: The same numbers followed by the same lowercase letters are not significantly different according to Tukey's test

Vitamin C Content

Table 4 shows that cucumbers contain vitamin C, ranging from 2.84 to 4.10 mg/100 g. These results indicate that variations in GA_3 concentration did not cause significant changes in vitamin C content in cucumber fruit among the varieties tested. The variance analysis results showed no effect of GA_3 concentration in various cucumber varieties on vitamin C content. The Tukey test results for analyzing the effect of GA_3 concentration in various cucumber varieties are presented in Table 4.

Table 4. Effect of GA_3 on vitamin C of cucumbers

Treatment	Vitamin C (mg/100 g)
0 ppm, Mars (emasculation)	4.10a
0 ppm, Roberto (emasculation)	3.90a
0 ppm, Vanesa (emasculation)	2.84a
200 ppm, Mars (emasculation)	3.87a
200 ppm, Roberto (emasculation)	3.69a
200 ppm, Vanesa (emasculation)	3.09a
400 ppm, Mars (emasculation)	3.24a
400 ppm, Roberto (emasculation)	3.56a
400 ppm, Vanesa (emasculation)	3.51a
0 ppm, Mars (without emasculation)	2.87a
0 ppm, Roberto (without emasculation)	3.46a
0 ppm, Vanesa (without emasculation)	3.53a
200 ppm, Mars (without emasculation)	3.20a
200 ppm, Roberto (without emasculation)	2.84a
200 ppm, Vanesa (without emasculation)	3.80a
400 ppm, Mars (without emasculation)	3.61a
400 ppm, Roberto (without emasculation)	4.07a
400 ppm, Vanesa (without emasculation)	3.71a

Note: The same numbers followed by the same lowercase letters are not significantly different according to Tukey's test

DISCUSSION

Cucumber skin color is generally green, however, some varieties exhibit non-green coloration. Determining the fruit's skin color value is very important in the agricultural industry and the fruit trade, as it often indicates ripeness and fruit quality. The fruit's skin color can signify that the fruit has reached its optimal level of ripeness, which will affect the taste, texture, and nutritional content. Additionally, consumers often select fruit based on its visual appearance, attractive fruit colors can enhance market appeal and increase the selling value of the fruit (Chung and Fong, 2018; Kennison *et al.*, 2026). On the production side, monitoring fruit skin color also helps farmers determine the right harvest time, reducing losses due to harvesting early or late. Therefore, the value of fruit skin color is an important tool to ensure the quality and consistency of fruit products in the market. Differences in varieties can cause discrepancies in skin color in cucumbers. Based on the Tukey test, GA_3 concentration and cucumber varieties significantly affect the a^* and b^* values. The Roberto variety is significantly different and shows higher value than Mars and Vanesa. This is because the Roberto variety of cucumbers tends to have a deeper green color than the other two varieties (Figure 1). However, GA_3 concentration and cucumber variety did not significantly affect the L^* value (Table 1). A higher b^* value indicates a yellow color, while a lower (or negative) b^* value indicates a blue color (Markovic *et al.*, 2013; Milovanovic *et al.*, 2020; Nagvanshi and Goswami, 2021). In this research, GA_3 application can affect the color value of fruit skin.

This is related to color pigment, in line with research conducted by Wen *et al.* (2018) which stated that GA_3 can increase the pigment content in *Camellia oleifera* by 100% compared to the control.

The water content of cucumber fruit is an important parameter to test because it directly affects the fruit's quality, freshness, and durability. Moreover, fruit contain high water content, which also contribute to its crispness and freshness. Moisture content can also indicates the optimal ripeness level, which affects taste and nutritional value. Furthermore, monitoring water content is important in storage and distribution, because fruit with a balanced water content is more resistant to damage and rot. By analyzing water content, farmers and distributors can ensure that cucumber fruit remains fresh and high-quality until it reaches consumers. Cucumber fruit contains abundant water, which is quite high ranging from 72 - 90% (Eboibi *et al.*, 2018; Okeoghene Eboibi, 2018). GA_3 did not cause a significant difference in the water content of cucumbers, due to several factors. It usually play a role in promoting stem growth, flowering, and fruit enlargement. However, its effect on fruit water content is not significant because water content is more affected by other factors such as genetics, environmental conditions, and irrigation management (Khadivi-Khub, 2014; Lufu *et al.*, 2020; Shewangizaw *et al.*, 2024). The concentration of GA_3 used and the application method were insufficient to produce significant changes in water content.

The total carotenoids in cucumbers are an important parameter showing the content of natural pigment compounds with health benefits (Putri and Hadiwijaya, 2026). This compound is included in the antioxidant compounds, which can help fight free radicals in the body. The total carotenoids are antioxidants protecting the body from damaging free radicals, which can cause damage to cells. Carotenoids also play an important role in determining fruit skin color, influencing consumer attractiveness. The carotenoid content can vary depending on the variety, growing conditions, and the degree of fruit ripeness. By controlling carotenoid biosynthesis pathways, GA_3 improves fruit quality and carotenoid accumulation (Davière and Achard, 2013; Sun, 2011). Analyzing total carotenoids is important for producers and research to improve fruit's nutritional and aesthetic value. This is also beneficial for developing new varieties with higher nutritional content. An in-depth understanding of carotenoids can also help in marketing and promoting cucumbers as a healthy dietary option. The total carotenoids can be found in yellow to orange fruits and vegetables. The Roberto variety has 4–10 times the beta-carotene content between the Mars and Vanesa varieties. This proves that GA_3 has a significant effect on pigment values. It follows research conducted by Wen *et al.* (2018) which stated that increasing the concentration of GA_3 positively affected cape gooseberry's pigment content. Other studies have also reported that GA_3 raised the amounts of carotenoid, chlorophyll a, and chlorophyll b in C. *betacea* as compared to the control (Astiari *et al.*, 2026; Xu *et al.*, 2022)

Vitamin C in cucumbers is an important component that contributes to the fruits' nutritional value. Vitamin C, or ascorbic acid, is known for its powerful antioxidant properties, which help fight free radicals in the body and improve the immune system. Its content varies depending on the variety, growing conditions, and level of fruit ripeness, and the measurements of vitamin C content help producers and consumers evaluate the fruit's nutritional value. In another research, Kalsum *et al.* (2021), reported that spraying GA_3 had no real effect on the vitamin C content of pomelo oranges. This is also in line with research from Mayadewi and Astawa, (2022), who stated that the effect of various natural GA_3 sprays was not significantly different on the vitamin C content of tomatoes. Previous studies have also indicated that there was no discernible difference in the vitamin C level between the G_2 (100 ppm) and G_3 (200 ppm) treatments of Kale (*Brassica Oleracea* Var. Acephala) (Sholihah and Dewi, 2023).

CONCLUSIONS

The Roberto variety with emasculation and GA_3 applied with a concentration of 200 ppm showed the best results on fruit skin color and total carotenoids. This variety showed optimal a^* and b^* values and higher carotenoid content than other treatments. These findings indicated that the combination of emasculation and application of GA_3 at a concentration of 200 ppm significantly improved the quality and nutrition of cucumber fruit, especially in the Roberto variety. These findings provide a valuable reference for farmers and producers in optimizing cultivation techniques for the production of high-quality seedless cucumbers.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Kusumiyati Kusumiyati: Conceptualization, formal analysis, investigation, methodology, software, writing – original draft; Ines Ramariyanti: formal analysis, investigation, writing – review & editing. Syariful Mubarok: investigation, writing – review & editing.

DATA AVAILABILITY STATEMENT

The data that support the results are available from the corresponding author upon reasonable request.

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