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Research Article

Quality improvement of tomato (*Solanum lycopersicum* L.) 'Optima' with amino acid-enriched foliar fertilizer

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ABSTRACT

*Tomato quality is influenced by fertilization and matutity level. This study aimed to determine the best dosage of amino acid-enriched leaf fertilizer (Amiboost) and to determine the best nutritional content at several ripeness levels of 'Optima' tomatoes. Amiboost is an inorganic foliar fertilizer that is rich in amino acids that can be easily absorbed by plants. The experiment used a factorial (RCBD) with 3 repetitions. The 'Optima' tomatoes were grown at Wonosobo and fertilized with 4 levels of Amiboost fertilizer consisting of 0, 1, 2, 4 L ha^{-1} amino acid fertilizer, and 2 L ha^{-1} comparison fertilizer (standard fertilizer). The research was conducted at the Horticulture Sub-Laboratory, UGM at 27 °C with a relative humidity of 75%. The tomato quality observed was CO_2 concentrations, visual quality rating (VQR), fruit weight percentage, fruit hardness, fruit color, total soluble solids, total titrated acid, vitamin C, carotenoids, lycopene, and flavonoids. The observation was terminated when the score of VQR reached 1 as the shelf life of tomatoes. The best dose of amino acid-enriched leaf fertilizer (Amiboost) is 2 L ha^{-1} for the lightness (*L) of fruit color, ascorbic acid, and lycopene. The maturity stage of fruit significantly affected vitamin C, flavonoids, total soluble solids, carotenoids, and lycopene.*

Keywords: Aminoalkanoic; shelf life; leaf fertilizer; tomato quality

INTRODUCTION

Tomatoes (*Solanum lycopersicum* L.) can be easily damaged during postharvest. Tomato has a high amount of water content 94% of the total weight, which causes tomatoes to be perishable or easily damaged (Klunklin & Savage, 2017). Tomatoes are susceptible to mechanical injury during transportation. Tomatoes have thin cuticles that are easily injured due to mechanical damage(Saladié M et al., 2007). The cuticle is a layer on the fruit that functions to prevent water loss and protection from external stresses(Saladié M et al., 2007). Fertilization with foliar fertilizer enriched with amino acids can improve the quality and shelf life of tomatoes.

Amiboost is an inorganic foliar fertilizer that is rich in amino acids that can be easily absorbed by plants(CJ Bio, 2019). The composition of Amiboost is made from vegetable ingredients derived from plants such as the remains of sugar cane and corn (CJ Bio, 2019). According to Popko et al. (2018) production of amino acids from plants (e.g., algae, corn, and soybean) is better than from animals. The types of amino acids contained in Amiboost are L-amino which are free amino acids without binding to other amino acids so they are easily absorbed by plants (CJ Bio, 2019). Amiboost which is used in the reproductive phase can accelerate fruit formation, improve fruit color, and increase production. Based on (Ahmed & Almohammedi(2021) the use of the amino acid arginine with a concentration of 300 mg L^{-1} can increase the vitamin C and lycopene content in cherry tomatoes.

Amino acid fertilizers play a role in the quality of tomatoes. The application of amino acid fertilizers can strengthen the cell walls, minimize physical damage to the fruit, and enhance resistant to disease (Subhan et al., 2009). To improve the quality of tomatoes, both physical and nutritional values, the dosage of amino acids fertilizer needs to be determined. Therefore, it is essential to study the effect of Amiboost doses on quality and shelf life as well as to investigate the nutritional content of 'Optima' tomatoes at various stages of maturity.

MATERIALS AND METHODS

The research was conducted at the Horticulture Sub-Laboratory, Plant Production Management Laboratory, Department of Agricultural Cultivation, Faculty of Agriculture, Gadjah Mada University, from October to November 2022. Optima tomatoes were planted in Wonosobo, Central Java in June-September 2022. The altitude of the area is around 1.100-1.200 m and the location coordinates $7^0$18'43.9" S $109^0$54'26.7" E.

Amino acid fertilizer (Amiboost) produced by PT Cheil Jedang contained 6.47% of N, 10.93% of P_2O_5,5.41% of K_2O, 10% of total amino acid, 0.1% of B, 0.1% of Mn. The comparison fertilizer contained 10% of N, 2% of K_2O, 2% of P_2O_5, 0.25% of Zn, Mn, Cu, and Mo, 0.125% of B, 0.0005% of Co, 5% of organic C, and 1% of Biuret. Amiboost fertilizer was applied using the spray method with a concentration of 0.4%. Treatment consisted of 5 levels, namely amino acid fertilizer (0 L ha^{-1}), Comparison fertilizer (2 L ha^{-1}), and Amiboost fertilizer (1, 2, and 4 L ha^{-1}). Fertilization was applied four times, i.e., 10, 8, 6, and 4 weeks before harvest. Each plot of land required 1.82 mL, 3.64 mL, and 7.28 mL of fertilizer diluted in 910 mL of water for the amino acid fertilizer treatment of 1 L ha^{-1}, 2 L ha^{-1}, and 4 L ha^{-1}.

The tomatoes used in this study were harvested at 90 days after planting (DAP) when the tomatoes reached the breakers (about half green and half pinkish-red) stage. The tomatoes were collected and put in perforated plastic before being transported to the laboratory. Sorting was carried out by selecting tomatoes with the same size, shape, and level of ripeness and setting aside tomatoes that are infected with pathogens. Furthermore, 20 tomatoes were placed in a plastic tray measuring 26 cm × 21 cm × 5 cm. The qualities observed in this research were physical, chemical, and physiological qualities. Microclimate conditions in the storage room, concentration of CO_2 (%) resulting from respiration carried out in 3 stages maturity, namely breakers 1 (DAH), pink (7 DAH), and red (16 DAH), weight loss, and fruit firmness (Bareiss BS 61 II Durometer), Visual Quality Rating (VQR), fruit color L*= fruit brightness; a* = green-red; b* = blue-orange used chromameter. Total soluble solids used digital refractometer, total titrated acid (%), carotenoids(Sari et al., 2021), lycopene, flavonoids, and vitamin C (Mulyani, 2018)were measured using a UV-Vis Genesys 10S spectrophotometer. The data obtained were analyzed using analysis of variance (ANOVA) at α=0,05 and Duncan's Multiple Range (DMRT).

RESULTS AND DISCUSSION

The observation of storage conditions was carried out for 21 days. The average temperature of the storage is 27°C and 75% humidity. This condition is normal for storing tomatoes. Based on Thole et al. (2021), 26 °C is the ideal temperature for storing tomatoes. For every 10 °C rise in temperature, when the temperature hits 30 °C the decreased tomato quality rate increases by 2-3 times (Kader, 2013). Based on observations, CO_2 production in each fertilization treatment was not significantly different (Figure 1). This shows that the Amiboost fertilizer treatment did not affect CO_2 concentrations in 'Optima' tomatoes. Production of CO_2 increases at the start of storage or during the breakers phase and decreases in the pink phase and then increases in the red phase. The increase of CO_2, during the breakers phase, occurs because of a process of physiological adaptation due to temperature differences then CO_2 decreases during the pink phase. In the red phase, there is an increase in CO_2 concentration because the peak respiration occurs during this phase. Tomatoes are included in the climacteric fruit which has a peak respiration point during the ripening phase and will decrease with storage time. According to Rahayu et al. (2021), the CO_2 concentration increases towards the climacteric peak and will decrease when senescence.

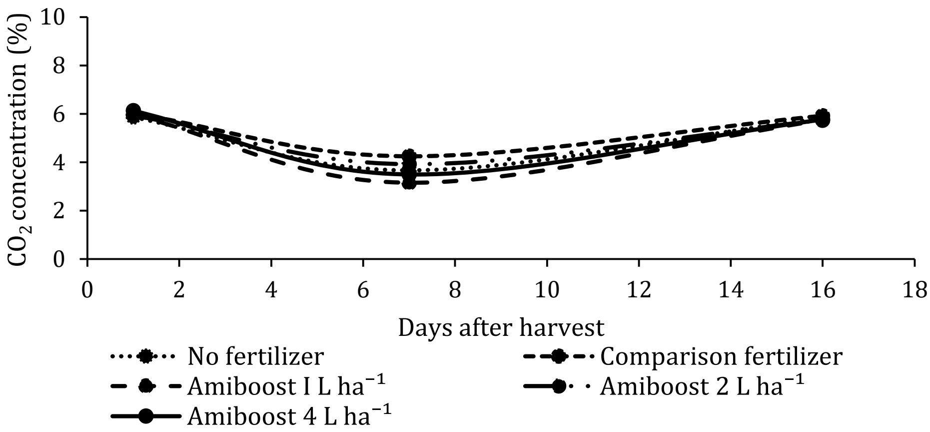

Figure 1. CO_2 concentration with various fertilization treatments. Breakers, pink, and red phases. 1 DAH (breakers), 7 DAH (pink), 16 DAH (red).

There was no significant difference in the weight loss of 'Optima' tomatoes during storage. There was an increase in weight loss at 13 days after harvest. Amiboost 1 L ha^{-1} caused the highest fruit weight loss, followed by Amiboost 2 L ha^{-1}, Comparison fertilizer 2 L ha^{-1}, Amiboost 4 L ha^{-1}, and no fertilizer 0 L ha^{-1} (Figure 2). The percentage of weight loss increased during storage. This is in line with Ashadi et al. (2022) where fruit weight loss will increase with time storage. Fruit weight loss occurs due to the transpiration process in tomatoes. The transpiration process is the loss of water through the pores of the tomato skin. The hardness value of 'Optima' tomatoes decreased in all treatments during storage. According to Machado et al. (2018), a high level of physical damage causes the hardness value of the fruit to decrease or the fruit to become softer and has a high percentage of fruit weight loss. Additionally, physical damage increases the rate of respiration, ethylene production, and biochemical reactions cause changes in color, texture, and quality of the chemical content in the fruit.

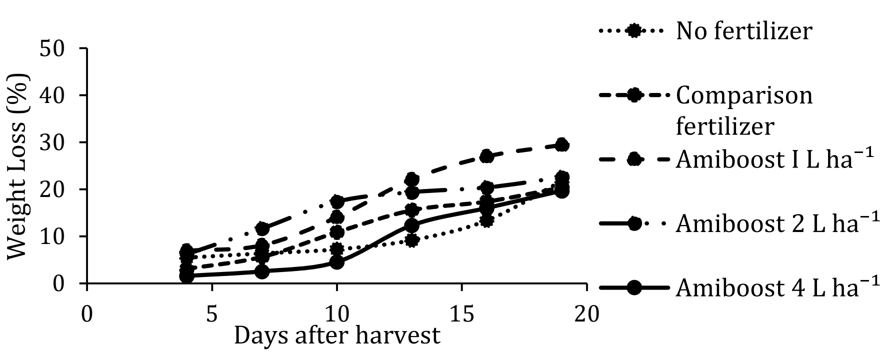

Figure 2. Weight loss percentage with various fertilization treatments.

The firmness value of 'Optima' tomatoes decreased in all treatments during storage. 'Optima' tomato fruit firmness value was not significantly different. The decrease in fruit firmness started from the second observation and continued until the end of the observation. Firmness levels typically decline slowly at the beginning of the observation up to 7 days after harvest caused by the maturity level of tomatoes that are not fully ripe. In this phase, tomatoes still have a hard fruit structure so the decrease in firmness tends to be slow. The stage of ripening decreased sharply from 10 to 19 days after harvest due to softening of the fruit structure (Figure 3). According to Adhikari et al. (2020), a sharp decrease in firmness during ripening is also caused by increased metabolic activity in fruit tissue. Fruit ripening is associated with an increase in the polygalacturonase (PG) enzyme in the fruit which causes cell wall degradation.

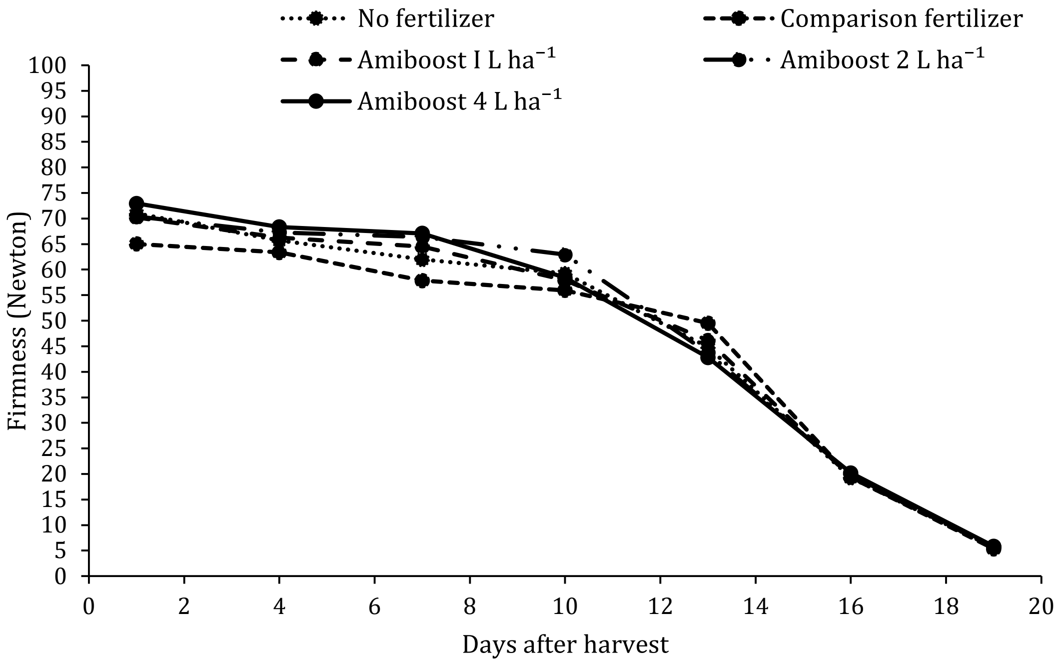

Figure 3. The firmness of tomatoes with various fertilization treatments.

Parameters of fruit hardness level include the thickness and tenacity of the fruit skin, the thickness of the fruit flesh, the internal structure fruit (pericarp), and the thickness of the fruit juice affect the level of maturity (Ambarwati et al., 2015). Fruit hardness is related to Ca^{2+} ions which play an important role in cell wall strength and fruit texture improvement (Tavallali et al., 2018). The Ca^{2+} ions affected fruit hardness due to the presence of cross-links between Ca^{2+} ions and pectin (acid residue polygalacturonic) on the cell wall and lamella so that the cell membrane becomes stable (Andaresta et al., 2022).

The research showed that there was no interaction between fertilizer treatment and level of fruit maturity and there was no significant influence of fertilization treatment on the variables observed. The highest TSS value was in the treatment without Amiboost fertilizer. Based on the level of fruit maturity, there was a significant difference in the level of fruit maturity where the more mature fruit with red color had the highest level of TSS. (Table 1). In general, the sweetness of a fruit will rise with its level of ripeness. During the respiration process, complex carbohydrates will be reduced to simple sugars like fructose and glucose. The disassembly of complex carbohydrates can also be used to maintain the rate of respiration in fruit (Abiso et al., 2015).

Table 1. Average total soluble solids with various fertilization treatments and level of maturity.

Treatments	Total soluble solid (%)
Fertilizer application	
No fertilizer (A)	3.89a
Comparison fertilizer (B)	3.69a
Amiboost I L ha^{-1} (C)	3.67a
Amiboost 2 L ha^{-1} (D)	3.77a
Amiboost 4 L ha^{-1} (E)	3.76a
Level of maturity	
Breakers (1 DAH)	3.55e
Pink (7 DAH)	3.62e
Red (16 DAH)	4.08d

Note: DAH = days after harvest. Values in the same column followed by the same letter are not significantly different based on DMRT α = 5%.

There was no significant difference in total titrated acid values (TTA) in 'Optima' tomatoes among various fertilizer treatments. but the TTA was different among fruit maturity levels The TTA value of 'Optima' tomatoes decreased with increasing fruit maturity (Table 2). According to Tigist et al. (2013), increased respiration rate and the occurrence of acid oxidation caused the total titrated acid in fruit to decrease along with the level of maturity and storage time. Increasing the rate of respiration and acid oxidation can reduce the total titrated acid in tomatoes because organic acids are used as substrates in the respiration process. Carbohydrate in fruit is the basic ingredient of organic acid content and acid components. These organic compounds are sided compounds produced from the Krebs cycle (Angelia, 2017).

Table 2. Average total titrated acid with various fertilization treatments and level of maturity.

Treatments	Total titrated acid (%)
Fertilizer application	
No fertilizer (A)	0.015a
Comparison fertilizer (B)	0.017a
Amiboost I L ha^{-1} (C)	0.013a
Amiboost 2 L ha^{-1} (D)	0.013a
Amiboost 4 L ha^{-1} (E)	0.018a
Level of maturity	
Breakers (1 DAH)	0.036d
Pink (7 DAH)	0.005e
Red (16 DAH)	0.004e

Note: DAH = days after harvest. Values in the same column followed by the same letter are not significantly different based on DMRT α = 5%.

Table 3. shows that the ascorbic acid levels were not significantly affected by the various fertilization treatments but were affected by the levels of fruit maturity. Ascorbic acid or vitamin C levels increased at 7 days after harvest and decreased at 16 days after harvest. This occurs as a result of the highest vitamin C value occurring at 7 days after harvest also known as the pink phase. In the pink phase, the process of synthesizing vitamin C in the cells is more efficient so that the cells begin to produce vitamin C. This is in accordance with Sari et al. (2021)that the vitamin C is affected by the level of maturity of the fruit. At low-level breakers, vitamin C biosynthesis is low and the fruit ripeness increases. The level of vitamin C decreases due to the increase in sugar content in the fruit and is related to the release of the hormone ethylene which can stop the biosynthesis of vitamin C.

Table 3. Average ascorbic acid content with various fertilization treatments and level of maturity.

Treatments	Ascorbic acid (mg $100g^{-1}$)
Fertilizer application	
No fertilizer (A)	45.57a
Comparison fertilizer (B)	38.45a
Amiboost I L ha^{-1} (C)	35.17a
Amiboost 2 L ha^{-1} (D)	45.00a
Amiboost 4 L ha^{-1} (E)	42.54a
Level of maturity	
Breakers (1 DAH)	36.24e
Pink (7 DAH)	67.74d
Red (16 DAH)	20.07e

Note: DAH = days after harvest. Values in the same column followed by the same letter are not significantly different based on DMRT α = 5%.

The color of the 'Optima' tomatoes from the breakers to the red phase is seen in Table 4. Based on the results of the chromameter test, the treatment without fertilizer had a dark red color, while in the Comparison fertilizer treatment, Amiboost 1 L ha^{-1}, Amiboost 2 L ha^{-1} had a brighter red color and Amiboost 4 L ha^{-1} had a bright red color with a yellow tinge.

Table 4. Color variable effect of fertilizer treatments on 'Optima' tomatoes.

Treatments	L*		a*		b*	
	Breakers (1 DAH)	Red (16 DAH)	Breakers (1 DAH)	Red (16 DAH)	Breakers (1 DAH)	Red (16 DAH)
No fertilizer	33.63b	32.88b	6.44a	17.13a	15.62b	11.78b
Comparison fertilizer (B)	40.46a	37.48a	5.50ab	15.97ab	19.28a	16.26a
Amiboost 1 L ha^{-1}	41.29a	36.59a	2.61c	13.34c	16.58b	14.29ab
Amiboost 2 L ha^{-1}	41.63a	36.44a	3.11c	15.15bc	16.92a	15.64a
Amiboost 4 L ha^{-1}	40.46a	36.58a	3.84bc	13.83c	16.43b	15.43a
CV (%)	4.85	3.77	14.32	6.28	5.00	10.54

Note: Values in the same column followed by the same letter are not significantly different based on the DMRT test α = 5%. DAH = days after harvest. L* = fruit lightness; a* = green – red fruit color' b* = fruit color blue – orange.

Fruit color is an important parameter in determining the quality of horticultural commodities. According to Purwati (2007), tomatoes are preferred by consumers because they have a bright red color, moderate hardness, slightly oval fruit shape, rather large fruit size, sweet fruit taste, not sour, contain lots of fruit juice, and the fruit is chewy or crunchy.

Table 5. shows that there was no significant effect in each fertilization treatment on carotenoid values. The level red phase is the highest carotenoid value in 'Optima' tomatoes. (Table 5.2). Carotenoids are one of the pigments contained in tomatoes that play a role in yellow or orange color. During the fruit ripening process, color changes occur due to the degradation of chlorophyll pigments and the occurrence of carotenoid synthesis which causes the accumulation of carotenoid pigments. The high value of carotenoid content in fruit is characterized by a change in color from green to orange or red-orange in tomatoes. This is in line with Novita et al. (2015) where the fruit ripening process is one of the factors in the change in fruit color.

Table 5. Average carotenoid content with various fertilization treatments and level of maturity (mg $100g^{-1}$).

Treatments	Carotenoid content
Fertilizer application	
No fertilizer (A)	9.27a
Comparison fertilizer (B)	9.62a
Amiboost I L ha^{-1} (C)	10.36a
Amiboost 2 L ha^{-1} (D)	9.65a
Amiboost 4 L ha^{-1} (E)	10.05a
Level of maturity	
Breakers (1 DAH)	6.63e
Pink (7 DAH)	7.63e
Red (16 DAH)	15.25d

Note: DAH = days after harvest. Values in the same column followed by the same letter are not significantly different based on DMRT α = 5%.

There was no interaction between the fertilization treatments and maturity level in the lycopene concentration and there was no significant difference among fertilization treatments on the lycopene content of 'Optima' tomatoes. This means that the application of Amiboost fertilizer does not affect lycopene (Table 6). The highest lycopene value at the maturity level of red. The increase in lycopene levels 16 days after harvest was due to an increase in the rate of respiration due to the oxidation reaction that occurred which increased the bioactive compounds (López-Palestina et al., 2018).

Table 6. Average lycopene content with various fertilization treatments and level of maturity.

Treatments	Lycopene content (mg $100g^{-1}$)
Fertilizer application	
No fertilizer (A)	86.31a
Comparison fertilizer (B)	113.10a
Amiboost I L ha^{-1} (C)	97.07a
Amiboost 2 L ha^{-1} (D)	113.78a
Amiboost 4 L ha^{-1} (E)	90.20a
Level of maturity	
Pink (7 DAH)	84.25e
Red (16 DAH)	115.94d

Note: DAH = days after harvest. Values in the same column followed by the same letter are not significantly different based on DMRT α = 5%.

The flavonoid contents were not different among fertilization treatments but they were different among fruit maturity levels (Table 7.). The highest levels of flavonoids were found in the pink phase. This is similar to García-Valverde et al. (2013)that the level of maturity can affect the levels of flavonoids in tomatoes. The flavonoid level of the pink phase is caused by an increase in enzyme activity and as a response to oxidative stress in the fruit.

The VQR values show no significant difference in each treatment. In general, the VQR value of tomatoes will decrease over time due to the loss of water during the transpiration. Continuous loss of water in the fruit causes shrinkage which reduces the visual quality of the fruit (Figure 4).

Changes in the value of the visual quality of tomatoes are characterized by the occurrence of shrinkage due to the loss of water content in the fruit due to the transpiration process. At 19 days after harvest 'Optima' tomatoes showed VQR 1 in all treatments (Nunes & Emond, 2007). There was no significant difference in each treatment for both VQR 3 and VQR 1 (Table 8).

Table 7. Average flavonoid content with various fertilization treatments and level of maturity.

Treatments	Flavonoid content (mgEQE/g)
Fertilizer application	
No fertilizer (A)	10.32a
Comparison fertilizer (B)	10.14a
Amiboost I L ha^{-1} (C)	6.87a
Amiboost 2 L ha^{-1} (D)	9.70a
Amiboost 4 L ha^{-1} (E)	10.30a
Level of maturity	
Breakers (1 DAH)	5.30e
Pink (7 DAH)	14.39d
Red (16 DAH)	8.72e

Note: DAH = days after harvest. Values in the same column followed by the same letter are not significantly different based on DMRT α = 5%.

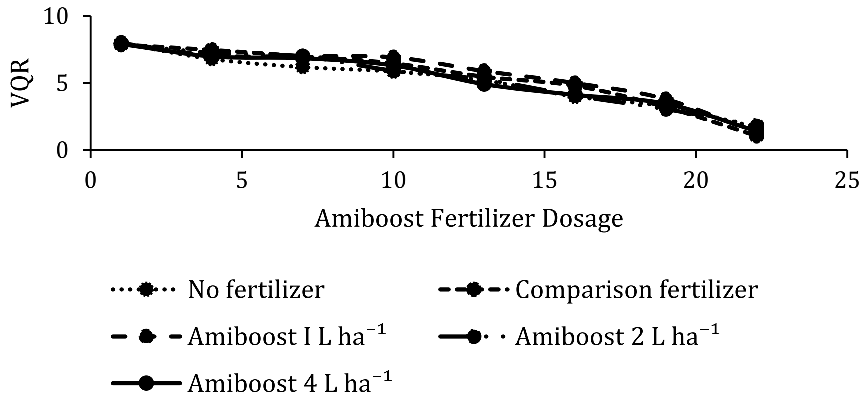

Figure 4. VQR values with various fertilization treatments.

Table 8. 'Optima' tomato shelf life with various fertilization treatments.

Treatments	Shelf life (days)	
	VQR 3	VQR 1
No fertilizer (A)	19.00	21.33
Comparison fertilizer (B)	17.67	20.67
Amiboost I L ha^{-1} (C)	18.00	21.67
Amiboost 2 L ha^{-1} (D)	18.67	22.00
Amiboost 4 L ha^{-1} (E)	18.00	22.00
CV (%)	8.02	3.83

Note: Not significant in the ANOVA at 5% level.

The shelf life was not different, the application of Amiboost fertilizer at doses of 2 and 4 L ha^{-1} could reach 22 days of storage while at a dose of 1 L ha^{-1}, it was no different from the treatment without fertilizer, namely as long as 21 days. Comparison fertilizer treatments have a shelf life of 20 days of storage. In Ambarwati et al. (2015) tomatoes will reach a visual score of 4 quality rating when the tomatoes have experienced moderate damage. For comparison, the shelf life of tomatoes at room temperature storage, 'Diomond' has a shelf life is 23.43 days, and 'Fortuna' has a shelf life of up to 30.43 days.

CONCLUSIONS

Application of amino acid-enriched leaf fertilizer (Amiboost) at 2 L ha^{-1} resulted in the best result on the lightness quality (*L) of fruit color, ascorbic acid, and lycopene contents. The application of inorganic foliar fertilizer-enriched amino acids did not suppress CO_2 production or slow down the rate of respiration so it was not able to increase shelf life but could maintain the quality of vitamin C and flavonoids. 'Optima' tomatoes in the pink phase level of maturity showed the highest levels of ascorbic acids and flavonoids, while the red phase had the highest levels of total soluble solids, carotenoids, and lycopene.

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REFERENCES

Abiso, E., Satheesh, N., & Taye, A. H. (2015). Effect of storage methods and ripening stages on postharvest quality of tomato (*Lycopersicom esculentum* Mill) CV. Chali. *Food Science and Technology*, *16*(1), 127–137.

Adhikari, P., Dhakal, A., Pahadi, K., Adhikari, S., Ghimire, P., Subedi, S., & Ghimire, D. (2020). Effect of different plastic packaging on postharvest quality of tomato (*Lycopersicon esculentum* Mill.). *Tropical Agroecosystems*, *1*(1), 15–18. https://doi.org/10.26480/taec.01.2020.15.18

Ahmed R.Z., & Almohammedi O.H.M. (2021). Response of cherry tomato to foliar spray of amino acid, bio-catalyst and dotted type in qualities and evaluation of drip irrigation system. *IOP Conf. Series: Earth and Environmental Science*, *910*(1), 1-8. https://doi.org/ 10.1088/1755-1315/910/1/012100

Ambarwati, E., Murti, R. H., Rahman, Y. A., & Hastari, R. P. (2015). Shelf life and fruit quality of the expected mutant strain cultivated at two different altitudes. (In Indonesian). *Agrivet*, *19*, 36–45.

Andaresta, A., Miftakhurrohmat, A., Nurmalasari, I. R., & Arifin, S. (2022). Effect of N fertilizer on the amount of chlorophyll and the quality of tomatoes (*Lycopersicon esculentum*). *IOP Conference Series: Earth and Environmental Science*, *1104*(1), 1-8. https://doi.org/10.1088/1755-1315/1104/1/012005

Angelia, I. O. (2017). The content of pH, total titrated acid, total soluble solid, and vitamin C in some horticultural commodities. (In Indonesian.). *Journal of Agritech Science*, *1*(2), 68–74.

Ashadi, R., Syam, N., & Alimuddin, S. (2022). Effect of temperature and type of packaging on the shelf life and quality of tomatoes (*Solanum lycopersicum* L.). (In Indonesian.). *Jurnal AGrotekMAS*, *2*(3): 19-28. https://jurnal.fp.umi.ac.id/index.php/agrotekmas

CJ Bio. (2019). *Amiboost & Ferami. CJ Bio*. Https://Www.Cjbio.Net/En/Products/AmiboostFerami.Do.

García-Valverde, V., Navarro-González, I., García-Alonso, J., & Periago, M. J. (2013). Antioxidant bioactive compounds in selected industrial processing and fresh consumption tomato cultivars. *Food and Bioprocess Technology*, *6*(2), 391–402. https://doi.org/10.1007/s11947-011-0687-3

Kader, A. A. (2013). Postharvest technology of horticultural Ccrops-An overview from farm to fork. In *J. Appl. Sci. Technol, 1*(1): 1-8.

Klunklin, W., & Savage, G. (2017). Effect on quality characteristics of tomatoes grown under well-watered and drought stress conditions. *Foods*, *6*(8), 1-10. https://doi.org/10.3390/foods6080056

López-Palestina, C., Aguirre-Mancilla, C., Raya-Pérez, J., Ramírez-Pimentel, J., Gutiérrez-Tlahque, J., & Hernández-Fuentes, A. (2018). The effect of an edible coating with tomato oily extract on the physicochemical and antioxidant properties of garambullo (Myrtillocactus geometrizans) fruits. *Agronomy*, *8*(248), 1-14. https://doi.org/10.3390/agronomy8110248

Machado, T. de A., Fernandes, H. C., Megguer, C. A., Santos, N. T., & Santos, F. L. (2018). Quantitative and qualitative loss of tomato fruits during mechanized harvest. *Revista Brasileira de Engenharia Agrícola e Ambiental*, *22*(11), 799–803. https://doi.org/10.1590/1807-1929/agriambi.v22n11p799-803

Mulyani, E. (2018). Comparison of the results of determining vitamin C levels in kiwi fruit (*Actinidia deliciousa*) using the iodimetry and UV-Vis spectrophotometry methods. (In Indonesian.). *Pharmauho*, *3*(2), 14–17.

Novita, M., Satriana, S., & Hasmarita, E. (2015). The content of lycopene and carotenoids in tomato (*Lycopersicum pyriforme*) at various levels of maturity effect of coating with chitosan and storage. (In Indonesian). *Jurnal Teknologi Dan Industri Pertanian Indonesia*, *7*(1), 35–39. https://doi.org/10.17969/jtipi.v7i1.2832

Nunes, C. N., & Emond, J.-P. (2007). Relationship between weight loss and visual quality of fruits and vegetables. In *Proc. Fla. State Hort. Soc*, 120, 235-245. http://www.envirotainer.

Popko, M., Michalak, I., Wilk, R., Gramza, M., Chojnacka, K., & Górecki, H. (2018). Effect of the new plant growth biostimulants based on amino acids on yield and grain wuality of winter wheat. *Molecules*, *23*(470): 1-13. https://doi.org/10.3390/molecules23020470

Purwati, E. (2007). Quality Improvement of Kaliurang tomato varieties. *Jurnal Agrivor*, *3*, 270–275.

Rahayu, D., Bintoro, N., & Saputro, A. D. (2021). Modeling the respiration rate of climacteric fruit during storage at various temperatures. (In Indonesian). *Agrointek*, *15*(1), 80–91.

Saladié M, Matas A.J., Isaacson T, Jenks M.A., Goodwin S.M., Niklas K.J., Xiaolin R, Labavitch J.M., Shackel K.A., Fernie A.R., Lytovchenko A., O'Neill M.A., Watkins C.B., & Rose J.K. (2007). A reevaluation of the key factors that influence tomato fruit softening and integrity. *Plant Physiology*, *144*, 1012–1028.

Sari, L. D. A., Kurniawati, E., Ningrum, R. S., & Ramadani, A. H. (2021). Vitamin C levels of tomato (*Lycopersicum esculentum* Mill.) each maturity phase based on the day after planting. (In Indonesian). *Jurnal Farmasi dan Ilmu Kefarmasian Indonesia*, *8*(1), 74-82. https://doi.org/10.20473/jfiki.v8i12021.74-82

Subhan, N. Nurtika, & N. Gunadi. (2009). The response of tomato plants to the use of NPK 15-15-15 compound fertilizer on latosol soil in the dry season. (In Indonesian.). *J. Hort*, *19*(1): 40-48.

Tavallali, V., Esmaili, S., & Karimi, S. (2018). Nitrogen and potassium requirements of tomato plants for the optimization of fruit quality and antioxidative capacity during storage. *Journal of Food Measurement and Characterization*, *12*(2), 755–762. https://doi.org/10.1007/s11694-017-9689-9

Thole, V., Vain, P., & Martin, C. (2021). Effect of elevated temperature on tomato post-harvest properties. *Plants*, *10*(11); 1-18. https://doi.org/10.3390/plants10112359

Tigist, M., Workneh, T. S., & Woldetsadik, K. (2013). Effects of variety on the quality of tomato stored under ambient conditions. *Journal of Food Science and Technology*, *50*(3), 477–486. https://doi.org/10.1007/s13197-011-0378-0