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Wax Patterns, Textural Properties, and Quality Attributes of Two Eggplant (*Solanum melongena* L.) Cultivars during Storage

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Abstract. **Two eggplant cultivars (Brigitte and Dalong) were stored under ambient conditions for 8 days to examine the postharvest quality and shelf life. Results indicated that the respiration rate, firmness and springiness, and nutritional quality of both eggplant cultivars decreased with the extension of shelf life. On the contrary, opposite trends were observed in weight loss, gumminess, and chewiness of eggplant fruits. In addition, the weight loss of 'Brigitte' eggplant fruits was 3.3% and 6.9% lower compared with 'Dalong' eggplant fruits at 4 and 8 days after storage. Thicknesses of epidermal cells and the stratum corneum, the epicuticular wax content of 'Brigitte eggplant fruits increased by 42.9%, 766.7%, and 58.8% compared with 'Dalong' eggplant fruits, respectively, with a concomitant increase in the dense wax layer structure. In conclusion, the storage tolerance of 'Brigitte' eggplant fruits was higher than that of 'Dalong' eggplant fruits due to the higher epicuticular wax content and dense wax layer structure.**

Eggplant (*Solanum melongena* L.) is one of the most popular and vital cultivated vegetables worldwide and rich in dietary fiber, vitamins, and antioxidants (Ban et al. 2021; Ghahremani et al. 2021). The harvested area and global production of eggplants were 1.89 million hectares and 59.31 million tons in 2022, which increased by 6.77% and 33.54% compared with those in 2010 (Food and Agriculture Organizations Statistics 2023). In addition, China is the world's largest consumer and producer of eggplant with a harvested area and yield of 0.82 million hectares and 38.28 million tons, respectively, followed by India and Egypt. However, increasing productivity requires fruits that meet the standards required by markets for fresh consumption and industrial processing, that is, fresh fruits with good peel appearance and color and a good ratio of softness and hardness (Gomes et al. 2021).

Eggplant commercialization is a challenge for local farmers due to its reduced shelf life (Barragán López et al. 2019). Fresh eggplant fruits will soften, brown, and decay during long-term storage, which will greatly reduce their economic value (Ban et al. 2021). Water and nutrients supplied from the plants are interrupted after fruit harvest. Consequently, the main issue related to storing fruits is the gradual loss of water content, leading to additional issues such as physiological deterioration, changes in aril color, and loss of firmness, which can negatively impact consumer acceptance as the eggplant quality at the time of purchase is judged essentially by the thickness of the shell and on the appearance of the fruit. Moreover, various fruit quality attributes including tissue firmness, ascorbic acid content, and total soluble solids, as well as important postharvest characteristics such as titratable acidity, fruit weight loss, fruit decay, and browning of pulp tissue, were evaluated under postharvest conditions (Ledesma et al. 2022). Thus, the nutritional and textural properties of fruits must be preserved from harvest to consumption. Therefore, the evaluation of postharvest quality of fruits has great theoretical and practical significance.

Eggplant fruits are sensitive to chilling and should not be stored below temperature of 7 to 10 °C for long periods (Aghdam et al. 2019). Previous study indicated that eggplant fruits could be stored for 10 to 16 d at temperature of 10 to 14 °C depending on growing conditions, postharvest management, and cultivars (Ledesma et al. 2022). It is vital to select the appropriate cultivars when processing fresh eggplant fruits because different cultivars can vary in physical traits (such as texture and skin color), biochemical features (such as nutritional value and flavor), and browning potential. These differences become particularly noticeable during storage and postharvest handling. Therefore, selecting the right cultivars, along with harvesting at an appropriate maturity level and ensuring proper storage conditions are important factors that affect the shelf life of fresh eggplant fruits, as discussed by Yousuf et al. (2018). Postharvest quality of different cultivars of eggplant (Ledesma et al. 2022), Iranian pomegranate (Ghasemi Soloklui et al. 2019), and pulp dragon fruit (Lata et al. 2023) were evaluated, and the results showed that the changes in quality attributes of fruits during storage was cultivar-dependent. Although eggplant varieties differ in the color, size, and shape of the fruit, they are divided into three types based on the color of their sepals and skin: purple sepals with purple skin, green sepals with purple skin, and green sepals with white skin (Wang et al. 2017). In addition, the cultivars with dark purple skin receive more attention and are popular for the health-promoting anthocyanins contained in the fruit skin (Bombana et al. 2023). However, little information exists on the relationships between shelf life and appearance of different cultivar eggplant fruits with dark purple skin after harvest.

Epidermal wax plays an important role in preventing nutrient loss and prolonging the storage period of fruits (Wu et al. 2019). As a hydrophobic structure, the wax layer creates a dry environment where pathogens do not grow easily, significantly controlling the growth of pathogens and effectively inhibiting their invasion (Zhang et al. 2022). In addition, some antibacterial components in wax can also affect the invasion of microorganisms. The smooth surface provided by epidermal wax can reduce the probability of pollutants adhering, reducing the number of pathogens and microorganisms. Some previous studies have shown a close correlation between cuticular wax and the postharvest quality of fruit, indicating that the removal of wax from the surface of fruits led to

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the sharp increase of water loss in postharvest (Chu et al. 2018; Wang et al. 2014; Yang et al. 2023). Therefore, it is critical to figure out the relationships between the wax layer and the shelf life of different cultivar fruits during storage.

The scientific literature currently offers limited information about the biochemical characteristics of two cultivars of eggplant fruits: purple skin eggplant fruits with purple sepals or green sepals during long-term storage. The aim of this study was to examine the shelf life of eggplant fruits between two cultivars to select cultivars suitable for minimal processing by evaluating the trend of changes in textural properties and quality attributes during storage and to identify potential correlations between the chemical composition and the shelf life of eggplant fruits.

Materials and Methods

Plant materials and treatment design. Two cultivars of eggplant (*Solanum melongena* L. cvs. Brigitte and Dalong) fruits were cultivated in the local greenhouse in Rijk Zwaan (China) Agricultural Technology Co., Ltd., Qingdao, Shandong Provence, and harvested when commercially mature mainly determined by the size and weight of eggplant fruits and accompanied by the evaluation of color and hardness evaluated by an experienced horticulturist and were transferred to the Postharvest laboratory under ambient condition (25 °C and 60% RH) in the Qingdao Agriculture University (36°19′ N, 120°23′ E), Qingdao, Shandong Provence, China. 'Brigitte' eggplants had green sepals with purple skin and 'Dalong' eggplants had purple sepals with purple skin, which were favored by consumers in Northern China. Uniform-sized healthy fruits were selected for the storage studies. Eggplant fruits were kept in corrugated fiber board boxes (six fruit per box) under ambient condition. Each cultivar comprised 3 replicates, and each box was considered as a replicate. The experiment was completely randomized. Postharvest characteristics evaluation was performed during storage at 4-day intervals.

Growth measurement

Epicuticular wax analysis. Fresh eggplant fruits were immersed twice in 500 mL of chloroform for 1 min to extract the wax. Subsequently, the extracts containing the wax and chloroform were evaporated to dryness under a stream of nitrogen at 40 °C based on the previous studies (Yang et al. 2021; Romero and Lafuente 2022). The wax content was calculated using the following formula: wax content ($\mu g/cm^2$) = $(W_1 - W_0)/A_0 \times 10^6$, where W_0 is the initial weight of the round bottom flask (g), W_1 is the final weight of the round bottom flask (g), and A_0 is the surface area of eggplant fruit (cm^2).

Weight loss and respiration rate. Fresh weight of eggplant fruits was determined by an electronic analytical balance (JY20002; Shanghai Hengping Instrument Co., Ltd., Shanghai, China). Weight loss was determined by weighing the eggplants at the beginning of the experiment (0 d), 4 d, and 8 d, where weight loss (%) = (initial weight − final weight)/initial weight × 100 (Ledesma et al. 2022).

Respiration rate was measured by placing one fruit in 1-L flask and capped with a rubber stopper for 3 h. Then 1-mL gas samples were withdrawn from the headspace by syringe to determine carbon dioxide (CO_2) using a gas chromatograph (7890A, Agilent Technology Co., Ltd., Santa Clara, CA, USA) equipped with a poropak column and thermal conductivity detector. Respiration rate was expressed as mg CO_2 $kg^{-1} \cdot h^{-1}$ on three replicates.

Scanning electron microscope and transmission electron microscope observations

The cuticular wax and the ultrastructure of eggplant fruits were observed using scanning electron microscope (SEM) and transmission electron microscope (TEM) according to the method reported by Chu et al. (2017). Plant tissue samples fixed in glutaraldehyde and dehydrated with acetone gradient and were then coated with a thin layer of gold. Plant tissue samples were observed at magnifications from 50 to 3000 × using an SEM (JSM-7500F; Tokyo Electronics Co., Ltd., Tokyo, Japan). Plant epidermal tissue (10 mm × 10 mm × 3 mm) was placed in formaldehyde-acetic acid-ethanol fixative solution at 4 °C overnight. A slicer (RM2245; Leica Biosystems, Nussloch Germany) was used to cut the embedded wax blocks into neat trapezoidal shapes. An optical microscope (DM2500, Leica Biosystems) and the ImageJ software (National Institutes of Health, Bethesda, MD, USA) were used to measure the thickness of epidermal cells and stratum corneum.

Texture analysis

The firmness, springiness, gumminess, and chewiness of peel and flesh of eggplant fruits were determined using a texture analyzer (TMS-Pro; Food Technology Corporation, Sterling, VA, USA) equipped with a 2-mm diameter probe.

Quality attributes determination

Vitamin C and soluble sugar were determined by the 2, 6-dichlorophenol indophenol titration method and anthrone sulfuric acid colorimetry method, respectively, according to (Liao et al. 2024; Zhou et al. 2023). The Updegraff method was used to measure the cellulose of eggplant fruits (Updegraff 1969).

Statistical analysis

The experimental data were presented as the means ± standard deviations of three independent replicates. Statistical analysis was performed using the SPSS (version 18.0; SPSS Inc., Chicago, IL, USA). All data were analyzed for significance by analysis of variance and Student's *t* test at the level of $P < 0.05$.

Results

Apparent evaluation. The appearance corresponded to two cultivar eggplant fruits were evaluated at the time of harvest, and there was visual deterioration during storage (Fig. 1). The appearance of two eggplant cultivars had undergone significant changes, and its commercial value had significantly decreased with the extended storage life (Fig. 1). Obvious wrinkles and depressions were observed in 'Dalong' eggplant on the eighth day, which lost its commercial value and edible value; However, the changes in appearance of 'Brigitte' eggplant during the entire storage period was relatively small, with small wrinkles appearing on the surface of the fruit peel.

Epidermal tissue anatomy and epicuticular wax content. A variation in the waxy cuticle thickness across regions of the eggplant fruits at the at harvest was investigated (Fig. 2). Significant differences were observed in the epidermal structure of the two varieties of eggplant fruits, especially in the number of cell arrangements and compactness near the epidermis. Epidermal cell thicknesses of the two varieties were 74.9 μm ('Brigitte') and

Fig. 1. Morphological characteristics of two cultivars (Brigitte and Dalong) of eggplants at 0, 4, and 8 d after storage.

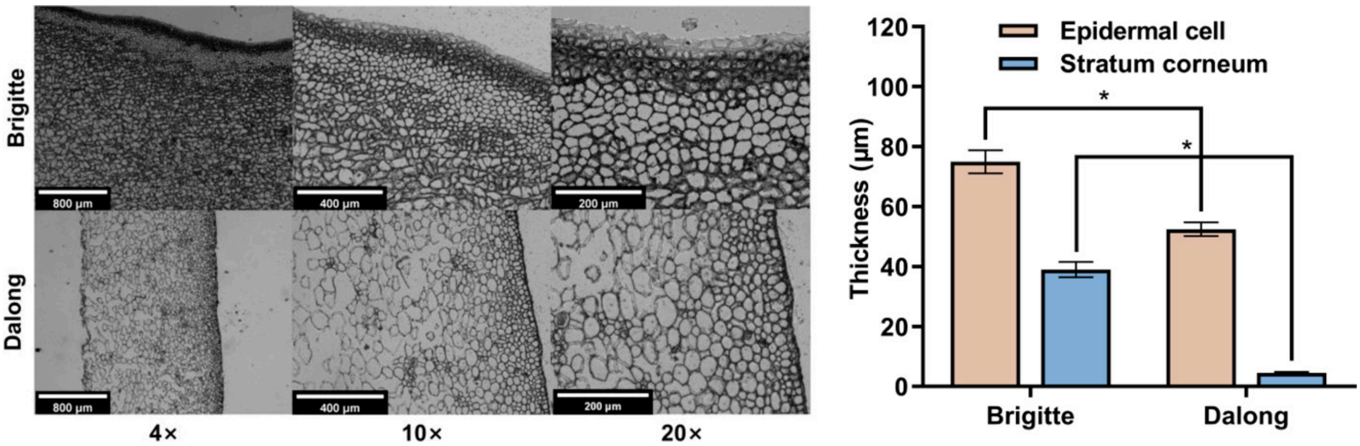

Fig. 2. Thickness of epidermal cell and stratum corneum of eggplant fruits ('Brigitte' and 'Dalong'). *Significant differences according to analysis of variance and Student's *t* test ($P < 0.05$).

52.4 μm ('Dalong'), and the thicknesses of the corneum stratum of the two varieties were 39.0 μm ('Brigitte') and 4.5 μm ('Dalong'), respectively. The thicknesses of the epidermal cell and stratum corneum were 42.9% and 766.7% higher in 'Brigitte' than 'Dalong'. A similar trend was observed in epicuticular wax content and wax crystal morphology in the two cultivars (Fig. 3). The flattening of the epidermis was observed in the eggplant fruits of both varieties ('Brigitte' and 'Dalong'). The epicuticular wax content were 58.8% higher in 'Brigitte' than 'Dalong', at 157.39 μg/cm^2 and 99.14 μg/cm^2, respectively.

Respiration rate and weight loss. A continuous decrease in respiration rate was observed in two eggplant cultivars (from 13.54 to 8.44 mg CO_2/kg in 'Brigitte' eggplant and from 29.55 to 13.58 mg CO_2/kg in 'Dalong' eggplant) during 8-day storage, the respiration rate was 118.3% higher in 'Brigitte' eggplant than 'Dalong' eggplant at 8 d after storage (Fig. 4). However, the weight loss rate of both eggplant cultivars increased continuously with the extension of storage period. The weight loss of 'Brigitte' and 'Dalong' was 6.4% and 9.7% at 4 d after storage, respectively. The weight loss of 'Brigitte' and 'Dalong' was 9.7% and 16.6% at 8 d after storage, respectively. The weight loss of 'Dalong' eggplant was 1.5-fold and 1.7-fold that of 'Brigitte' eggplant at 4 and 8 d after storage, respectively.

Texture analysis. Firmness of peel and flesh in two cultivar eggplants decreased significantly with the extension of storage; however, gumminess and chewiness of peel and flesh in the two eggplant cultivars increased significantly (Fig. 5). In addition, the changes of firmness, springiness, gumminess, and chewiness of 'Dalong' was greater than that of 'Brigitte'. Peel firmness of 'Dalong' decreased by 48.8% and 68.0% at 4 and 8 d after storage, respectively. In contrast, peel gumminess of 'Dalong' increased by 497.3% and 579.1% at 4 and 8 d after storage, respectively. For 'Brigitte', peel firmness of fruits decreased by 18.9% and 38.4% at 4 and 8 d after storage, respectively. The peel firmness of 'Brigitte' eggplant was 65.9% and 101.7% higher than 'Dalong' eggplant at 4 and 8 d after storage, respectively. In contrast, peel gumminess of fruits increased by 76.2% and 122.8% at 4 and 8 d after storage, respectively. The peel gumminess of 'Brigitte' eggplant was 187.1% and 158.1% lower in than 'Dalong' eggplant at 4 and 8 d after storage, respectively. Decreasing trends were also observed in two eggplant cultivars in flesh firmness and springiness, which were decreased by 17.8% and 9.1% in 'Brigitte' at 4 d after storage and decreased by 18.9% and 11.0% in 'Dalong' at 4 d after storage, respectively. The flesh firmness and springiness 'Brigitte' were 41.8% and 18.7% higher in than 'Dalong' at 8 d after storage, respectively. Increased trends were observed in two eggplant cultivars in flesh gumminess and chewiness, which increased by 100.7% and 373.8% in 'Brigitte' at 4 d after storage, and increased by 189.0% and 2041.7% in 'Dalong' at 4 d after storage. The flesh gumminess and chewiness of 'Brigitte' eggplant were 25.9% and 34.6% lower than 'Dalong' eggplant at 8 d after storage, respectively.

Nutritional quality determination. The type of cultivar and the duration of storage influenced the nutritional quality of eggplant fruits significantly ($P < 0.05$) (Fig. 6). Vitamin C, soluble sugar, and cellulose content of two cultivar eggplants decreased with the extension of storage time. In addition, significant differences were observed in these parameters between two cultivars. Vitamin C content of 'Brigitte' decrease significantly by 18.9% and 27.7% after 4 d storage and 8 d storage, respectively. Soluble sugar content of 'Brigitte' decreased significantly by 11.2% and 17.4% after 4 d storage and 8 d storage,

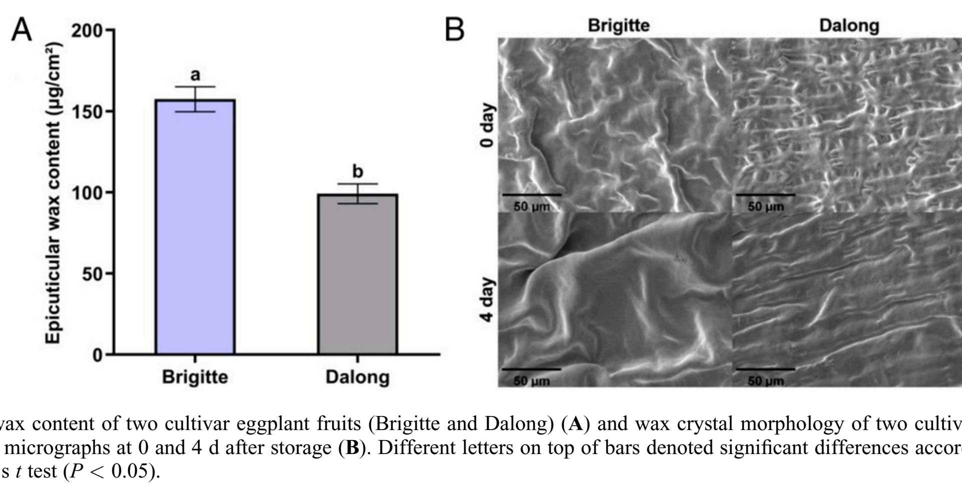

Fig. 3. Epicuticular wax content of two cultivar eggplant fruits (Brigitte and Dalong) (**A**) and wax crystal morphology of two cultivar eggplant fruits under scanning electron micrographs at 0 and 4 d after storage (**B**). Different letters on top of bars denoted significant differences according to analysis of variance and Student's *t* test ($P < 0.05$).

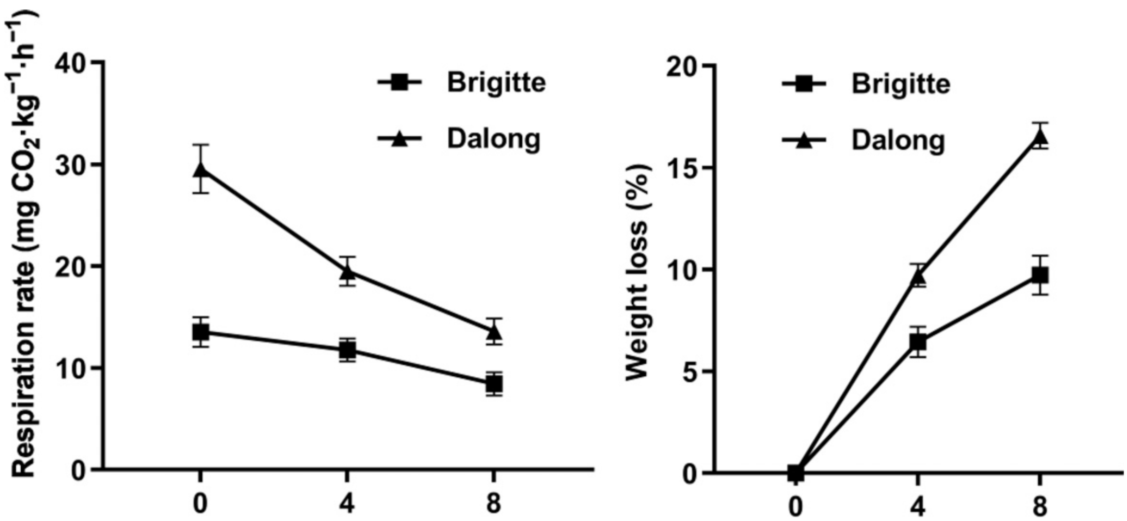

Fig. 4. Respiration rate and weight loss of two cultivar eggplants (Brigitte and Dalong) at 0, 4, and 8 d after storage.

respectively. Cellulose content of 'Dalong' decrease significantly by 22.4% after 4 d storage, which decreased significantly by 59.5% after 8 d storage, the cellulose content of 'Brigitte' was 121.0% significantly higher than 'Dalong' at 8 d after storage.

Correlation analysis. The shelf life of eggplant fruits was positively correlated with stratum corneum thickness, epidermal cell thickness, and wax content (Fig. 7). Similarly, positive relationships were also observed among the thickness of epidermal cell, stratum corneum, and the epicuticular wax content with correlation coefficients higher at 0.97. In terms of biochemical properties, shelf life of eggplant fruits was positively correlated with weight loss, gumminess, and chewiness, and negatively correlated with respiration rate, firmness, springiness, vitamin C, soluble sugar, and cellulose content. Similar trends were observed in weight loss and other biochemical properties. The firmness and springiness of eggplant fruits were positively correlated with vitamin C content, soluble sugar content, and cellulose content, which were negative correlated with chewiness and gumminess (Fig. 8).

Discussion

The freshness and economic weight of fruit production are directly influenced by their moisture content, which also impacts their physicochemical properties of fruits (Wardak et al. 2024). When moisture and dry matter content decrease, fruits experience weight loss due to higher transpiration and respiration rates at room temperature, according to a study reported by Garavito et al. (2021), which aligns with our findings. In our study, two cultivar eggplant fruits showed increased weight loss and decreased respiration rate with the extension of shelf life. In addition, 'Brigitte' eggplant fruits had lower weight loss and respiration rate compared with 'Dalong' eggplant fruits (Fig. 3B). Previous studies had reported a gradual upsurge in weight loss as room temperature increased in mango (Njie et al. 2023), nectarine (Wang et al. 2022), and red pulp dragon fruit (Wu et al. 2023), which because the higher the respiratory intensity, the faster the plant consumes its reserves (sugars), thus leading to senescence (Florent Haba et al. 2023). In our study, the respiration rate of the fruits was influenced by spoilage and senescence, explaining the decrease in respiration rate as storage time increased. Similarly, a gradual decrease in respiration rate of dragon fruit during storage was reported by previous studies (Zahid et al. 2013). Additionally, water loss and H_2O_2 content of eggplant fruits increased with extended shelf life, whereas a contrasting trend was observed in terms of firmness and total phenolic content, as demonstrated by Ban et al. (2021).

During the storage process of fruits and vegetables after harvest, mechanical wounds or wax cracks on the surface of the fruit may act as sites of bacterial invasion, causing

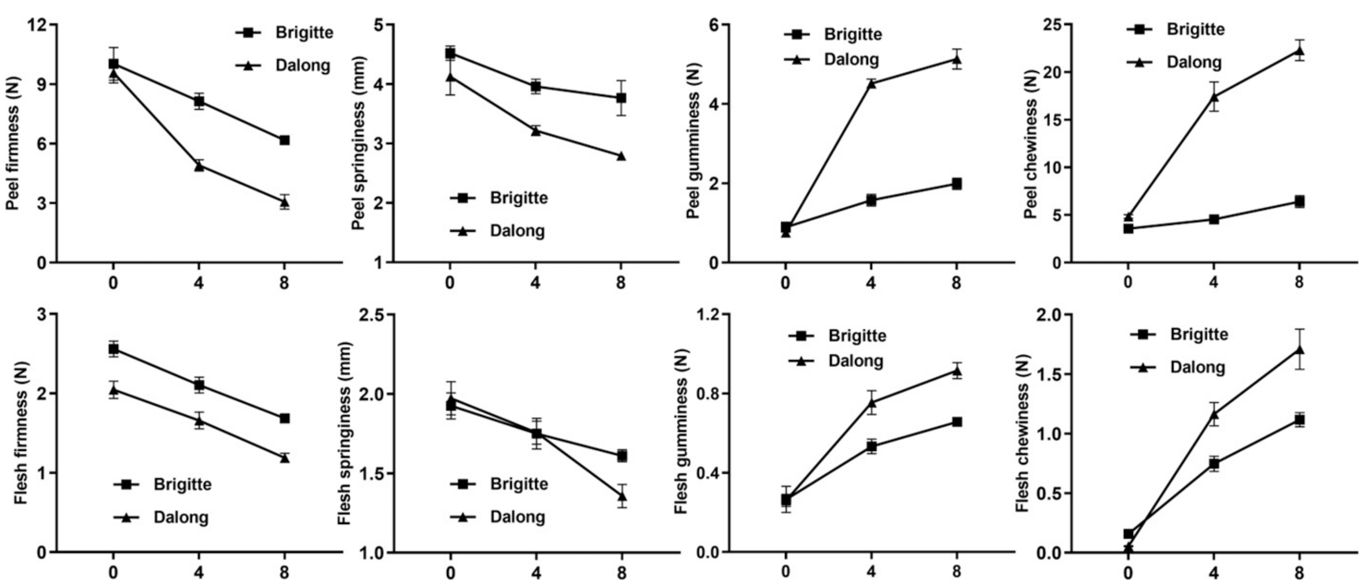

Fig. 5. Firmness, springiness, gumminess, and chewiness of two cultivar eggplant fruits (Brigitte and Dalong) at 0, 4, and 8 d after storage.

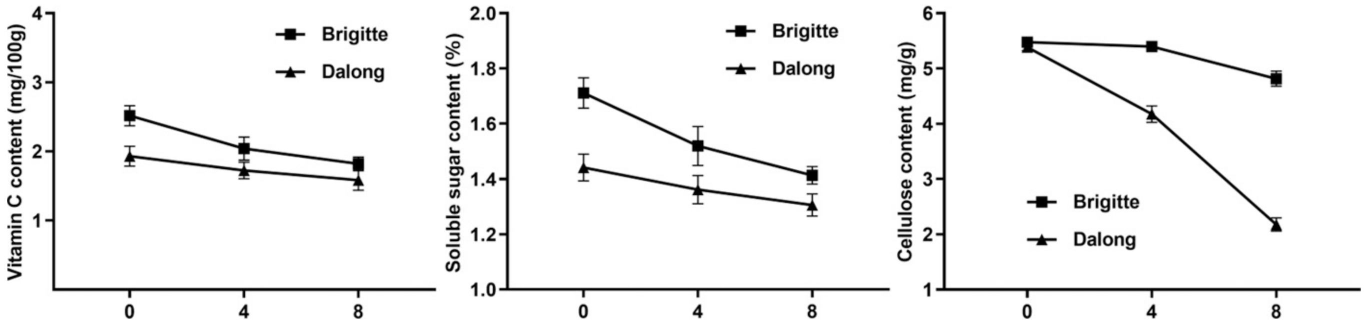

Fig. 6. Vitamin C, soluble sugar, and cellulose content of two cultivar eggplant fruits (Brigitte and Dalong) at 0, 4, and 8 after storage. Different letters on top of bars denoted significant differences according to analysis of variance and Student's t test ($P < 0.05$).

decay and substantial financial losses (Kuruppu et al. 2023). The epicuticular wax layer on the fruit's surface, composed of keratin esters, creates a polar channel framework. Wax, acting as a filler, increases the path length and tortuosity for water diffusion, consequently reducing water loss within the tissue not occurring through stomata (Fernández-Muñoz et al. 2022). The composition, content, and thickness of epicuticular wax affect the loss of water of fruits, and the epicuticular wax is the first protective barrier against abiotic and biotic stresses (Chu et al. 2018). In our study, the epicuticular wax content of 'Brigitte' eggplant fruits were significantly higher compared with 'Dalong' eggplant fruits, which is consistent with the results of the length of the shelf life (Fig. 1). Previous studies indicated that the increase in wax can improve the water use efficiency of plants and enhance their stress resistance (Hasanuzzaman et al. 2017). The primary factor contributing to weight loss during storage is the loss of water from the fruit into the surrounding environment. This process was significantly influenced by the presence of the fruit's natural wax bloom, which provided a protective layer on the surface of fruits (Plesoianu et al. 2020). This result also explained why the weight loss rate of 'Dalong' eggplant was significantly higher than that of 'Brigitte' fruits. The higher wax content of 'Brigitte' fruit suppresses its own water loss and ensures fruit quality (Fig. 4).

In addition, 'Brigitte' fruits had a close and distinct arrangement of cells within the field of view of the two types of objective lenses (Fig. 2). It can be seen that the cells of 'Brigitte' eggplant fruits farthest from the epidermis were still tightly combined, which may be one of the reasons why they had a lower weight loss rate than another eggplant cultivar. Although the cells near the epidermis of eggplant are densely distributed, the gap between the cells farthest from the epidermis begins to widen, and some cell tissue boundaries become blurred. In contrast, the distal cells of the 'Dalong' eggplant epidermis are irregularly arranged, and most of the cells had unique shapes, suggesting that the cells may have been inactivated. The results showed that 'Brigitte' eggplant fruits with the densest arrangement of epidermal cells, the thickest stratum corneum and epidermal cell thickness happened to have the lowest weight loss rate and respiration rate. A previous study indicated that rapidly elongating eggplants had a greater number of epidermal and parenchyma cells per unit area than slowly developing fruit (Valerga et al. 2020). It can be inferred that epicuticular wax content, the thickness of epidermal cell and stratum corneum, and transpiration rate interactions ultimately contribute to the shelf-life length of eggplant fruits. In addition, the 'Briggitte' eggplant fruits had longer shelf life compared with the 'Dalong' eggplant fruits, which could be due to the falling off of the wax from the peel surface during fruit storage; the density of flesh cells and the thickness of the fruit peel also play crucial roles. Therefore, it indicated that the shelf life of eggplant fruits was closely related to their characteristics, and the wax content and structure of *S. epidermis* fruit were key factors.

Moisture loss of fruits was also associated with textural changes, which can influence the fruit and pulp firmness (Paniagua et al. 2013). Our study indicated that weight loss was significant negative correlation with firmness and springiness of eggplants fruits ('Briggitte' and 'Dalong') (Fig. 8). Springiness reflected the overall binding force and organizational structure between the internal molecules of the fruit flesh and exhibited the subjective perception of fruit quality (Faber et al. 2017). Decreased trends were observed in firmness and springiness of two cultivar eggplant fruits during the entire storage period. In addition, 'Dalong' eggplant fruits exhibited lower firmness and springiness compared with 'Brigitte' eggplant fruits. We speculate that it may be related to its high water loss rate and the high degradation rate of cellulose related to degrading enzymes because this may lead to a serious decrease in the tightness of eggplant fruit flesh cells. Our research results also found

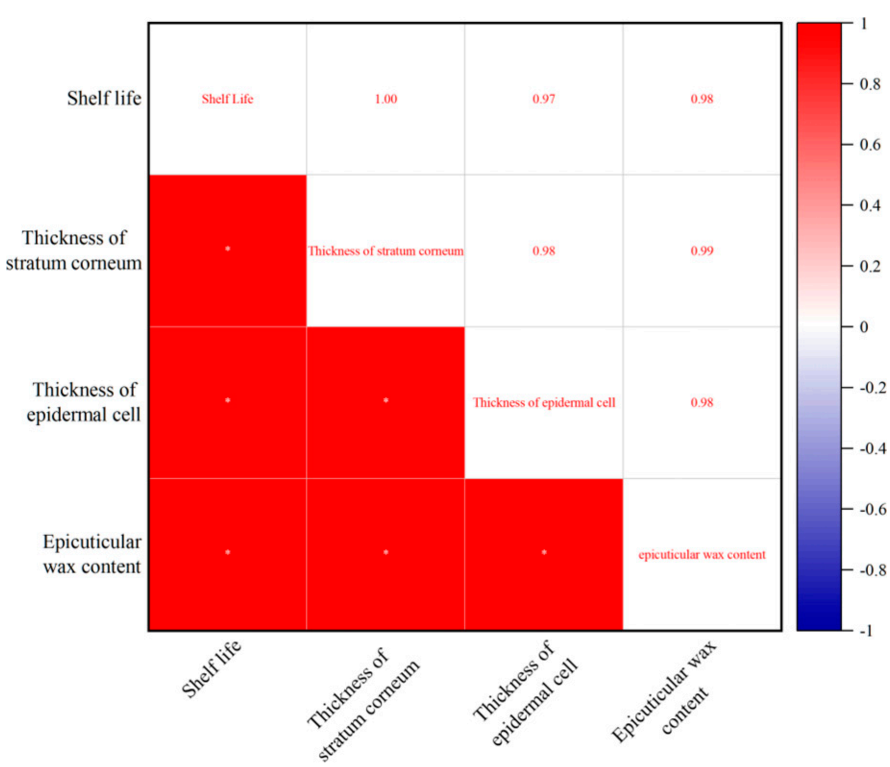

Fig. 7. Correlation coefficient evaluation between shelf life, thickness of stratum corneum and epidermal cell, and epicuticular wax content of eggplant fruits. *Significant correlation at the $P < 0.05$ level.

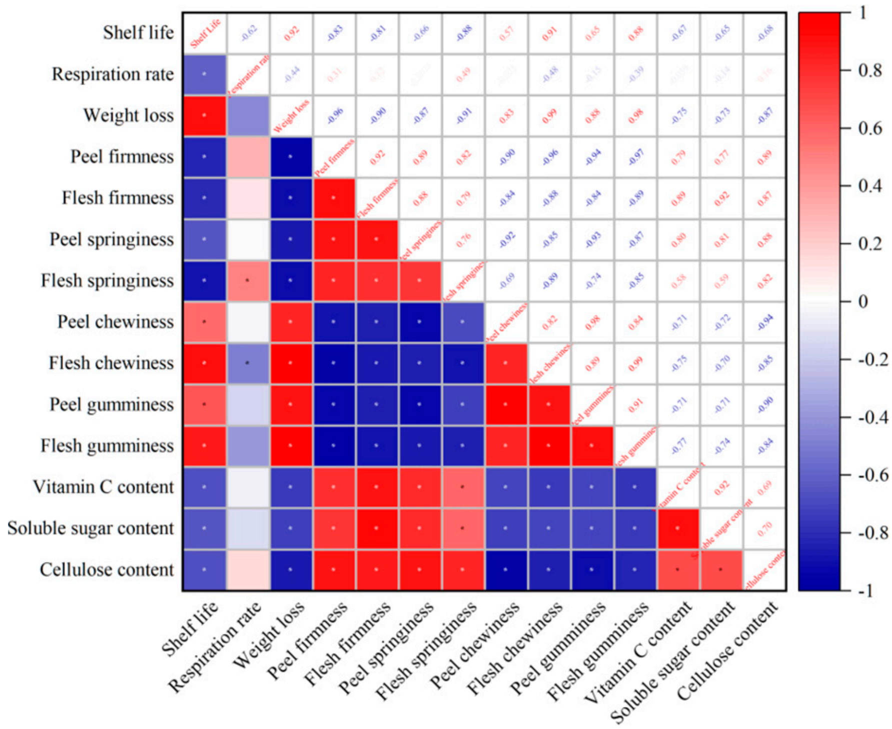

Fig. 8. Correlation coefficient evaluation between morphological, biochemical, and physiological parameters of eggplant fruits. *Significant correlation at the $P < 0.05$ level.

obvious differences in the thickness of epidermal cell and stratum corneum between the two varieties of eggplants (Fig. 2). When subjected to various cellulose degrading enzymes, such as pectinmethyl galacturonase, pectinmethyltransferase, and polygalacturonase, the fruit's cell wall undergoes gradual degradation. This process reduces the regularity of the cell structure and causes the fruit flesh to shrink, leading to a decrease in the fruit's springiness (Jiang et al. 2019). Our results show that the shelf life of eggplant fruits was positively correlated with stratum corneum thickness, epidermal cell thickness, and wax content (Fig. 7). These results are in agreement with those reported by Chu et al. (2018), who observed that the removal of natural wax from the blueberry fruit accelerated the postharvest water loss and decay and reduced the sensory and nutritional qualities of the fruit.

Gumminess is the negative force generated on the surface of a sample after compression deformation (Funami and Nakuma 2022). It can be explained as sticky taste, which means that the higher the hardness and elasticity of the fruit, the lower its adhesive strength. Therefore, it can be seen that there is a negative correlation between firmness and gumminess (Fig. 8). The stickiness of the fruits (peel and flesh) of the two eggplants gradually increased throughout the storage period, and the increase in purple calyx eggplants was higher than that of the other two types. The reason may be that the purple calyx eggplant may suffer from rapid cell wall degradation, which in turn accelerated fruit dehydration, increased respiratory rate, promoted nutrient loss, and triggered deformation and atrophy of flesh cells, thus leading to a decrease in fruit hardness and elasticity, ultimately resulting in a shorter shelf life.

Chewing ability can be explained as the energy required to chew solid food, mainly used in describing the taste of solid and semi solid foods (Kong et al. 2022). The chewiness and stickiness of eggplant fruits during the entire shelf life are similar, with values continuously increasing with length of the storage period (Fig. 5). Purple sepal eggplant ('Dalong') grows the fastest and ultimately surpasses green sepal eggplant ('Brigitte'). The reasons may be multifaceted, ultimately leading to a rapid decline in the overall quality of purple sepal eggplant.

The determination of vitamin C, soluble sugar, and cellulose content can serve as vital physiological indicators of antiaging and stress resistance and are of great significance when identifying the fruit quality and breeding good varieties. Vitamin C is widely found in fresh fruits, vegetables, and many other organisms, which act as an antioxidant substance protecting plants from harmful side effects, such as drought, ozone, and ultraviolet radiation (Gürbüz Çolak et al. 2020). Soluble sugar serves as important nutrition for fruit development including cell wall formation, cellulose synthesis, and starch biosynthesis and provides sweetness to fruits. It is widely accepted that the combined function of sugar metabolism and transportation is one of the critical factors for determining the formation and maintenance of citrus fruit quality (Bush 2020). Cellulose, as the main structural component of plant cell walls, is usually bound to hemicellulose, pectin, and lignin, and the binding method and degree can significantly impact the texture of plant-based foods (Liu et al. 2024). Our results indicated that the vitamin C, soluble sugar, and cellulose content of two cultivar eggplant fruits continuously decreased with the extension of shelf life. However, it is worth noting that significant differences in vitamin C and soluble sugar contents of two cultivar eggplant fruits were observed at the beginning of the storage, and the gap gradually decreases with the extension of shelf life. The differences in vitamin C and soluble sugar contents of eggplant fruits at harvest reflected the characteristics of different varieties, as previous studies indicated that biochemical properties of fruit are associated with cultivar and the horticultural practices (Ghasemi Soloklui et al. 2019). However, an opposite trend was found in cellulose content of two eggplant cultivars; significant differences were observed in cellulose content with the extension of shelf life. In addition, the vitamin C, soluble sugar, and cellulose content of 'Dalong' eggplant fruits were lower compared with 'Brigitte' eggplant fruits. The cellulose content of 'Dalong' eggplant rapidly decreases, and it remained in a state of rapid decline until the end of storage. In contrast, the cellulose degradation rate of 'Brigitte' eggplant was the lowest and consistently higher compared with another eggplants, indicating that the 'Brigitte' eggplant fruit was generally in a state of uniform degradation, which had the highest weight loss rate and respiratory rate, accompanied by the lowest fruit hardness. It can be speculated that the cell wall structure of 'Dalong' eggplant fruit was relatively fragile due to the easier degradation of cellulose. After in vitro fruit is stored on shelves, it significantly enhances its own respiration, leading to increased loss of water and nutrients, and ultimately forming its own extremely resistant storage characteristics.

Conclusion

Eggplant fruits with green sepals ('Dalong') stored at ambient temperature showed a significant reduction in nutritional composition and during long-term storage compared with eggplant fruits with purple sepals ('Brigitte'). The storage tolerance of 'Brigitte' was higher than that of 'Dalong', and 'Brigitte' fruits had a longer shelf life than 'Dalong' fruits. Therefore, it is advisable to prevent the occurrence of unsold or wasted products by selling them before reaching the end of their suitable shelf life because this can lead to a reduction in their commercial value. In addition, the shelf-life length is positively related to thickness of stratum corneum and epidermal cell and to the epicuticular wax content of eggplant fruits. In general, the variations in shelf life, along with the levels of changes in other quality attributes during storage, can provide opportunities for breeding superior eggplant cultivars in the future, which can be strengthened by realizing good correlations among shelf life, epidermal structure, and specific value of the biochemical contents.

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