Influence of Preharvest Bagging on Maturity Indices and Postharvest Quality of Cherry Tomato (*Solanum lycopersicum var. cerasiforme*)

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**Keywords.** diseases, dry matter content, firmness, ripening, shelf life

**Abstract.** The production of cherry tomato (*Solanum lycopersicum var. cerasiforme*) is negatively affected by harsh environmental conditions such as extremely high and low temperatures, wind and hail damage, and pest and disease infestation. These factors delay maturity and cause uneven ripening, fruit abrasion, and blemishes, which consequently result in poor fruit quality and reduced shelf life. Preharvest bagging is an environmentally friendly alternative technique for enhancement of fruit quality and hence alleviates the stated problems. The study evaluated the physico-chemical quality of ‘Tinker’ and ‘Roma VF’ cherry tomato as influenced by preharvest bagging (translucent and blue plastics) during 8 days of shelf life at ambient conditions. Five clusters of fruit per plant per cultivar with a diameter of 1.5 to 2.0 cm were bagged after 16 days of fruit set and harvested at the green maturity stage, 12 days after preharvest bagging for the assessment of postharvest quality. Preharvest bagging effectively accelerated fruit maturity and ripening as indicated by enhanced fruit size, uniform color development, high pH, dry matter (DM) content, soluble solid content (SSC), and low titratable acidity (TA) during shelf life. Bagged fruit had higher loss of firmness and weight mainly due to ripening and showed very slight incidence of diseases during shelf life of 8 days. Unbagged cherry tomato had delayed maturity and ripening; small-sized fruit; uneven color development; low pH, SSC, and DM; and high TA. Although unbagged cherry tomato had lower firmness and weight loss due to delayed ripening, fruit showed moderate to severe incidence of tomato bacterial canker disease (*Clavibacter michiganensis* subsp. *michiganensis*) during shelf life. These results indicated that preharvest bagging accelerated fruit maturity and ripening, improved physico-chemical quality, and reduced disease infestation on cherry tomato during shelf life.

Cherry tomato (*S. lycopersicum var. cerasiforme*) is one of the most commonly consumed fruit worldwide and its demand has been increasing due to high nutrient content such as antioxidant compounds, including carotenoids (lycopene), proteins, minerals, and vitamins (Jiang et al. 2020; Mustapha et al. 2020). Nonetheless, uneven ripening is one of the major pre- and postharvest challenges facing the cherry tomato fruit industry (Cantwell et al. 2009). Cherry tomato fruit uneven ripening pattern could be due to the indeterminate flowering pattern of this crop, which extends up to 2 weeks, resulting in a significant variation in the fruit age, which varies the degree of maturity and thus ripening (Alenazi et al. 2020; Jiang et al. 2020).

Harvesting cherry tomato without considering certain maturity indices leads to an uneven ripening pattern that may cause economic loss because it takes substantial management practices to produce fruit of high quality per season (Zhang et al. 2020). Fruit that are harvested prematurely are highly susceptible to shriveling and mechanical damage, and develop poor flavor (Okiror et al. 2017; Zhang et al. 2020). On the other hand, fruit harvested late have a potential of being prone to several physiological disorders and pathogen invasion (Okiror et al. 2017).

Fruit growth and development plays an important role in determining the final maturity of the fruit. Tomato at different maturity stages, namely, green, breaker, turning, pink, light red, and red, have different biological characteristics and commercial values; it is therefore important to accurately identify tomato maturity stages for precision production (Alenazi et al. 2020; Jiang et al. 2020; Mustapha et al. 2020). Because during maturation the exocarp color of tomato changes from green to red, color features are commonly selected to characterize maturity (Jiang et al. 2020; Zhang et al. 2020). Tomato maturation is a complex and gradual process, which depends on multiple factors, such as cultivar and environmental conditions (Jiang et al. 2020). Also, internal physico-chemical factors, such as acid and sugar contents, of cherry tomato occur before external factors, such as fruit size or weight and peel color change. Therefore, the single surface characteristics cannot incorporate all the factors responsible for tomato maturity and thus would result in some identification errors (Casals et al. 2019; Jiang et al. 2020).

Fruit size could also be used as an alternative measure of maturity and quality, although, cherry tomato is characterized by small fruit (<20 g for standard cherry and 20–50 g for cocktail cherry) (Casals et al. 2019). Fruit variation in size is mostly due to genetic, environmental, and interaction of both of these factors, competition for nutrients, water, light, and space within a crop (Jiang et al. 2020). Therefore, although fruit size can give a clue, it cannot serve as a reliable maturity index because of high potential of variability due to many sources of variation (Jiang et al. 2020; Shezi et al. 2020). Thus, to obtain more efficient results for estimating tomato maturity, both physical and chemical quality attributes should be evaluated simultaneously (Jiang et al. 2020).

DM content is one of the most reliable and widely used maturity index or indicators for harvest time, postharvest taste, ripeness of tomato, and correlates to SSC (Jiang et al. 2020). In fruit near maturity, the DM of tomato pulp consists of soluble sugars of ≈50%, insoluble solids (25%), organic acids (13%), minerals (8%), and others (4%) (Acharya et al. 2017). Soluble solids are inversely proportional to fruit size and range from 9% to 15% in cherry tomato (Gautier et al. 2010). However, DM and SSC vary among harvested fruit because of factors such as canopy positions, irrigation, and environmental conditions (Beckles 2012). Another
Table 1. The average microclimate inside the blue and transparent plastic bags during the two growing periods in the Spring season from Sep to Nov 2019 and 2020, respectively.

<table>
<thead>
<tr>
<th>Preharvest bagging experimental yr (PY)</th>
<th>Treatments (T)</th>
<th>Avg temp (°C)</th>
<th>Relative humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>C</td>
<td>24.54 ± 0.23 b</td>
<td>47.05 ± 0.31 e</td>
</tr>
<tr>
<td>2020</td>
<td>C</td>
<td>23.79 ± 0.19 a</td>
<td>58.22 ± 0.14 f</td>
</tr>
<tr>
<td>2019</td>
<td>TP</td>
<td>34.54 ± 0.70 e</td>
<td>29.59 ± 1.29 a</td>
</tr>
<tr>
<td>2019</td>
<td>BP</td>
<td>30.36 ± 0.35 c</td>
<td>38.12 ± 0.60 c</td>
</tr>
<tr>
<td>2020</td>
<td>TP</td>
<td>36.93 ± 0.15 f</td>
<td>34.13 ± 0.57 b</td>
</tr>
<tr>
<td>2020</td>
<td>BP</td>
<td>32.22 ± 0.40 d</td>
<td>40.03 ± 0.19 c</td>
</tr>
</tbody>
</table>

C = control; TP = transparent plastic; BP = blue plastic; LSD = least significant difference; PY*T = preharvest bagging experimental year and treatments. Values are the mean ± SE. Means within a column of the same parameter with different letters are significantly different (P < 0.001).

useful indicator of tomato maturity or taste is the SSC-to-TA ratio (Turhan and Seniz, 2009). However, the SSC:TA ratio varies within the fruit and with fruit developmental stage. The variation may also be because of TA decrease in the latter phase of ripening and with environmental conditions (Beckles 2012; Turhan and Seniz 2009).

Preharvest bagging could be an alternative for modifying the microenvironment of the fruit during its critical stages of growth and development; hence, promoting uniform ripening and further enhancing physical and chemical quality of the fruit (Santosh et al. 2017). This technique can also decrease levels of light-absorptive compounds, which are inherent in some fruit, such as chlorophyll and anthocyanin, resulting in the higher sensitivity of bagged fruit to solar irradiation (Zhu et al. 2018). This helps to achieve uniform product coloration by stimulating the biosynthesis of secondary metabolites, such as antioxidant activity, phenols, and carotenoids, when bagged fruit is re-exposed to sunlight (Feng et al. 2014). Few studies have demonstrated that preharvest bagging has the potential to improve physical and chemical quality of fruit (Islam et al. 2017; Purbay and Kumar 2015); this technique is commonly used for fruit protection against pest infestation (Feng et al. 2014; Sharma and Sanikommui 2018).

In addition, little is known about the impact of preharvest bagging on postharvest quality of fruit; hence, the current study investigated the effect of preharvest bagging on maturity indices and postharvest quality of cherry tomato.

Table 2. Changes in L*, a*, b*, ΔE* and ripening of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life.

<table>
<thead>
<tr>
<th>SD</th>
<th>T</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔE*</th>
<th>Uneven rip</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>TP</td>
<td>54.34 ± 4.12 bc</td>
<td>-6.04 ± 1.73 c</td>
<td>13.41 ± 1.05 a</td>
<td>40.35 ± 3.54 ab</td>
<td>0.00 ± 0.00 a</td>
</tr>
<tr>
<td>4</td>
<td>TP</td>
<td>55.54 ± 1.67 bc</td>
<td>-6.94 ± 0.51 bc</td>
<td>20.48 ± 2.41 bc</td>
<td>41.84 ± 2.47 bc</td>
<td>0.00 ± 0.00 a</td>
</tr>
<tr>
<td>8</td>
<td>TP</td>
<td>43.33 ± 1.55 a</td>
<td>24.56 ± 0.32 e</td>
<td>39.98 ± 0.59 f</td>
<td>61.69 ± 0.24 c</td>
<td>0.33 ± 0.33 ab</td>
</tr>
<tr>
<td>0</td>
<td>TC</td>
<td>60.90 ± 0.40 bc</td>
<td>-9.23 ± 0.16 ab</td>
<td>16.51 ± 0.23 ab</td>
<td>35.76 ± 0.42 a</td>
<td>1.33 ± 0.33 bc</td>
</tr>
<tr>
<td>4</td>
<td>TC</td>
<td>59.29 ± 0.50 bc</td>
<td>-9.12 ± 0.35 ab</td>
<td>21.02 ± 2.00 bc</td>
<td>37.14 ± 1.30 ab</td>
<td>2.67 ± 0.33 de</td>
</tr>
<tr>
<td>8</td>
<td>TC</td>
<td>62.47 ± 1.30 c</td>
<td>-10.92 ± 0.65 a</td>
<td>22.06 ± 1.32 cd</td>
<td>39.78 ± 1.03 ab</td>
<td>3.33 ± 0.33 e</td>
</tr>
<tr>
<td>0</td>
<td>BP</td>
<td>54.31 ± 0.74 bc</td>
<td>-9.05 ± 1.35 ab</td>
<td>17.87 ± 2.60 ab</td>
<td>42.33 ± 1.11 ab</td>
<td>0.00 ± 0.00 a</td>
</tr>
<tr>
<td>4</td>
<td>BP</td>
<td>52.77 ± 4.12 b</td>
<td>-10.17 ± 0.47 a</td>
<td>20.08 ± 0.78 bc</td>
<td>44.66 ± 0.47 b</td>
<td>0.00 ± 0.00 a</td>
</tr>
<tr>
<td>8</td>
<td>BP</td>
<td>52.58 ± 0.50 bc</td>
<td>11.42 ± 1.42 d</td>
<td>28.33 ± 1.91 e</td>
<td>56.37 ± 0.63 c</td>
<td>1.50 ± 0.58 abc</td>
</tr>
<tr>
<td>0</td>
<td>BC</td>
<td>56.53 ± 6.30 bc</td>
<td>-8.41 ± 0.36 abc</td>
<td>22.50 ± 0.96 cd</td>
<td>42.45 ± 5.38 ab</td>
<td>1.67 ± 0.33 cd</td>
</tr>
<tr>
<td>4</td>
<td>BC</td>
<td>57.39 ± 1.07 bc</td>
<td>-9.60 ± 0.25 ab</td>
<td>24.75 ± 1.08 de</td>
<td>42.85 ± 0.73 ab</td>
<td>3.00 ± 0.58 e</td>
</tr>
<tr>
<td>8</td>
<td>BC</td>
<td>57.54 ± 0.98 bc</td>
<td>-9.96 ± 0.03 a</td>
<td>25.01 ± 1.04 de</td>
<td>44.02 ± 1.17 b</td>
<td>3.33 ± 0.67 e</td>
</tr>
<tr>
<td>0</td>
<td>LSD</td>
<td>7.954</td>
<td>LSD = 2.519</td>
<td>LSD = 4.592</td>
<td>LSD = 7.143</td>
<td>LSD = 1.000</td>
</tr>
<tr>
<td>4</td>
<td>SD P</td>
<td>5.532</td>
<td>SD P &lt; 0.001</td>
<td>SD P &lt; 0.001</td>
<td>SD P &lt; 0.001</td>
<td>SD P &lt; 0.001</td>
</tr>
<tr>
<td>8</td>
<td>T P</td>
<td>0.001</td>
<td>T P &lt; 0.001</td>
<td>T P &lt; 0.001</td>
<td>T P &lt; 0.001</td>
<td>T P &lt; 0.001</td>
</tr>
<tr>
<td>0</td>
<td>SD* T P</td>
<td>0.107</td>
<td>SD* T P &lt; 0.001</td>
<td>SD* T P &lt; 0.001</td>
<td>SD* T P &lt; 0.001</td>
<td>SD* T P &lt; 0.234</td>
</tr>
</tbody>
</table>

SD = shelf life days; T = treatments; SD*T = shelf life days and treatments; L* = lightness; a* = (-) green, (+) red; b* = (-) blue, (+) yellow; ΔE* = total color difference; uneven rip = uneven ripening; TP = transparent plastic; TC = transparent plastic control; BP = blue plastic; BC = blue plastic control; LSD = least significant difference. Values are the mean ± SE. Means within a column of the same parameter with different letters are significantly different (P < 0.001).

Materials and Methods

Field experiment. The seedlings of two cherry tomato cultivars namely, Tinker and Roma VF, were collected from the commercial farm of ZZZ in Moketsi, Limpopo, South Africa (lat. 23°35′41″S, long. 30°5′51″E) and used to conduct the experiment in an open field at the University of Limpopo, South Africa (lat. 23°53′10″S, long. 29°44′15″E). The experiment was repeated twice during the spring season in Sep to Nov 2019 and 2020, respectively. An area of 45 m² was prepared using a hand hoe to remove weeds and sprayed with Roundup herbicide and then covered with black plastic to suppress weeds during the experiment. A total of 96 HORTSCIENCE VOL. 58(1) JANUARY 2023
200 tomato seedlings/cultivar were transplanted in 5 L black polyethylene growing bags filled with sandy loam soil that was steam-pasteurized at 60°C for 30 min/d before transplanting (Tseke 2013). Intrarow plant spacing was 40 cm, whereas interrow spacing was 50 cm (Buthelezi 2015). A 5-g superphosphate (16%–20% P₂O₅) fertilizer was applied manually during transplanting followed by a biweekly fertilizer application of monosodium phosphate, potassium nitrate, and calcium nitrate where 500 mg of fertilizers was mixed with 25 L of distilled water, respectively. Plants were irrigated using drip irrigation where plants received 3 L of water daily. Bollworm (Pectinophora gossypiella) and whitefly (Trialeurodes vaporariorum) pests were controlled using pyrethrin (15 mL per 16 L of distilled water) at 2-week intervals. Diseases such as early blight (Alternaria solani) were controlled using mycoguard (20 mL per 10 L of distilled water) and dithane M.45 (20 mg per 10 L of purified water) at 2-week intervals. Plants were trellised using a trellis twine (Buthelezi 2015).

Experimental design and treatments. The experiments were conducted in a randomized complete block design and the blue and transparent polyethylene plastics with the density of 20 μm, length of 30 cm, and width of 18 cm, respectively, were used as two distinct treatments. The microclimate: temperature and relative humidity (RH) were controlled using a microclimate (Table 1) in the blue and transparent plastics used to bag cherry tomato during growing periods. The fruit clusters from both cherry tomato cultivars were selected for harvesting and at the bottom to prevent excessive heat and humidity build up inside the bags (Spray 2019).

Sampling procedure. The fruit clusters from both cherry tomato cultivars without any visible defects were harvested (Dec 2019 and 2020) at the green maturity stage, 12 d after preharvest bagging. Harvested clusters were packed in four tomato boxes/cultivar/treatment/ and taken to the Postharvest Laboratory at the University of Limpopo where they were sorted and stored at room temperature (± 20°C) for a total of 8 d. A randomly sampled set of three replicates/box/treatment/cultivar were evaluated for physical and chemical quality at harvest and at 4-d intervals during shelf life.

Color. A Minolta Chroma Meter (CR-400, Konica Minolta Sensing Inc., Tokyo, Japan) was used to evaluate the color of cherry tomato at harvest and during shelf life of 8 d (Farina et al. 2020). The International Commission on Illumination color parameters L* (luminosity), a* (redness), and b* (yellowness), were directly recorded on the surface
Fig. 3. Soluble solid content of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by different letters in each bar indicate a statistically significant difference (P < 0.001). LSD = least significant difference; SD = shelf life days; T = treatments; SD*T = shelf life days and treatments; TP = transparent plastic; TC = transparent plastic control; BP = blue plastic; BC = blue plastic control.

Fig. 4. Maturity index of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by different letters in each bar indicate a statistically significant difference (P < 0.001). LSD = least significant difference; SD = shelf life days; T = treatments; SD*T = shelf life days and treatments; TP = transparent plastic; TC = transparent plastic control; BP = blue plastic; BC = blue plastic control.

The maturity index was calculated as the ratio of SSC to TA according to Peralta-Ruiz et al. (2020) using Eq. [3].

\[
\text{MI} = \frac{\text{SSC} \times \text{Acidity}}{100},
\]

where SSC is soluble solid content.

DM content. The DM content of sliced tomato pericarp was determined after drying at 60°C using a convection oven until constant weight (Antonilinos et al. 2020). Thereafter, it was weighed, and the DM content was expressed as a percentage of a fraction of dry mass to fresh weight of the pericarp tissue Eq. [4].

\[
\text{DM} = \frac{C - A}{B - A} \times 100,
\]

where DM is dry matter, A is mass of petri dish, B is total mass of fresh sample and petri dish, and C is total mass of dry sample and petri dish.
Dry matter content of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by different letters in each bar indicate a statistically significant difference ($P < 0.001$). LSD = least significant difference; SD = shelf life days; T = treatments; $SD^*T =$ shelf life days and treatments; TP = transparent plastic; TC = transparent plastic control; BP = blue plastic; BC = blue plastic control.

Firmness. The firmness of the pericarp was determined at harvest and at 4-d intervals during shelf life using a digital penetrometer (53205; Turoni, Forli, Italy) with a plunger with a diameter of 8 mm inserted into the fruit pericarp manually. The firmness was tested at the equatorial region of the fruit on opposite sides (Farina et al. 2020). The penetration force readings were in kilogram-force (kg f) and converted to Newton (N) units.

Weight loss. Weight loss was evaluated according to Anjum et al. (2020), with slight modifications. Individual fruit were weighed on a digital balance (PCB 6000-0; Kern, Fareham, United Kingdom) at harvest and the same fruit were weighed repeatedly at 4-d intervals during shelf life. Weight loss (%) was calculated using Eq. [5] as follows:

$$WL\ % = \frac{W_i - W_f}{W_f} \times 100, \quad [5]$$

where $W_i$ and $W_f$ are initial and weight, respectively.

Size. Individual fruit were measured at harvest and the same set of fruit was measured again at the end of shelf life using a digital electronic carbon fiber vernier caliper gauge micrometer (150 mm LCD; Hamamatsu, Kawasaki, Japan) and results were expressed in mm (Shu et al. 2020).

Disease damage. Disease damage (DD) was evaluated visually according to the methodology used by Peralta-Ruiz et al. (2020), following the hedonic damage scale of a) no damage (0% damage), b) mild damage (10% to 15% damage), c) moderate damage (25% to 50% damage), and d) severe damage (>50% damage). The results of fungal presence, mechanical damage, and physical deterioration of the pericarp were calculated using Eq. [6].

$$DD = \frac{1n + 2n + 3n + 4n}{N} \times 100, \quad [6]$$

where DD is disease damage, n is number of fruit classified in each level of the damage scale, and N is number of total fruit analyzed in each treatment per day. DD on fruit was evaluated on days 0, 4, and 8.

Statistical analysis. The collected data were subjected to analysis of variance using GenStat statistical software (GenStat, 18.1 edition; VSN International, Hemel Hempstead, UK) 18.1. Means were compared using Fischer’s least significant differences at the 5% level of significance.

Results and Discussion

Microclimate in the bagging materials. Preharvest bagging materials significantly affected the average temperature ($P < 0.001$) and RH ($P < 0.001$) inside the plastic bags during the experiments (Table 1). In both the experiments of 2019 and 2020, the transparent plastic used to bag ‘Tinker’ and ‘Roma VF’ cherry tomato had the higher temperature (34.54 °C and 36.93 °C) and low relative RH (29.59% and 34.13%) compared with the blue plastic bag, which had the temperature of 30.36 °C and 32.22 °C and RH of 38.12%
Fig. 7. Weight loss of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by different letters in each bar indicate a statistically significant difference ($P < 0.001$). LSD = least significant difference; SD = shelf life days; T = treatments; SD*T = shelf life days and treatments; TP = transparent plastic; TC = transparent plastic control; BP = blue plastic; BC = blue plastic control.

Fig. 8. Fruit size of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by different letters in each bar indicate a statistically significant difference ($P < 0.001$). LSD = least significant difference; SD = shelf life days; T = treatments; SD*T = shelf life days and treatments; TP = transparent plastic; TC = transparent plastic control; BP = blue plastic; BC = blue plastic control.
trained panelists, tomato ripening pattern. According to the tern at harvest and at day 4, whereas at the end blue plastics showed no uneven ripening pat-

cherry tomato bagged with the transparent or

ging signi

Jiang et al. 2020). Table 2 also shows that bag-
large or dense canopy (Cantwell et al. 2009; 

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fruit.

hanced fruit color compared with unbagged

with tissue-non-woven fabric effectively en-

the transparent bags let in more light than those

that are translucent blue or blue (Table 1).

Transparent bags effectively promote the light


color, such as carotenoid, particularly lycopene,

stimulates pigments responsible for exocarp

fruit. This could be because preharvest bagging

who reported that bagging tomato fruit

16

nomic losses (Peralta-Ruiz et al. 2020). Some

export market resulting in postharvest and eco-

lenge in the tomato industry, where such fruit

reported that bagging tomato fruit

low 16

nificantly (P < 0.001) increased in bagged cherry tomato compared with un-

Fig. 9. Disease damage of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by differ-

Shelf life time (days)

Disease damage

Shelf life time (days)

Disease damage

0 4 8

0 4 8

TP

TC

BP

BC

TP

TC

BP

BC

Fig. 9. Disease damage of ‘Tinker’ and ‘Roma VF’ cherry tomatoes during 8 d of shelf life. Means followed by differ-

ent letters in each bar indicate a statistically significant difference (P < 0.001). LSD = least sig-

ificant difference; SD = shelf life days; T = treatments; SD*T = shelf life days and treatments; TP = transparent plastic;

TC = transparent plastic control; BP = blue plastic control; BC = blue plastic control.

0.001) higher a*, b*, and ΔE*, indicating a faster ripening process and also lower L* value, indicating increase and darkening of the red color in cherry tomato compared with the blue plastic. This could be because the transparent bags let in more light than those that are translucent blue or blue (Table 1). Transparent bags effectively promote the light sensitivity of fruit and stimulate pigments responsible for exocarp color, such as carotenoids or lycopene synthesis, compared with the blue plastic (Purkey and Kumar 2015; Santosh et al. 2017). Our results are similar to de Oliveira Borges et al. (2020), who reported that bagging tomato fruit ‘Carina Star’ with tissue-non-woven fabric effectively en-

the transparent plastic had signi

s h e l fl i f e c o m p a r e dw i t hu n b a g g e df r u i t .A l s o ,

increase could be attributed to fruit ripening.

Maturity index. The rate of change of SSC to GA gives the maturity index (MI), which serves as a good indicator of the ripening and palatability of fruit (Beckles 2012). The MI significantly (P < 0.001) increased in bagged cherry tomato during shelf life compared with unbagged fruit (Fig. 4). ‘Tinker’ and ‘Roma VF’ cherry tomato bagged with the transparent plastic had significantly (P < 0.001) higher increase of MI (5.13%–8.86% and 4.63%–11.26%) followed by fruit bagged with the blue plastic (4.99%–9.90% and 5.24%–13.76%) during shelf life compared with unbagged fruit (4.03%–8.96% and 7.67%–11.44% and 3.86%–7.99% and 5.47%–10.52%), respectively. This in-

crease could be attributed to fruit ripening. The MI (SSC/TA), as the most important fruit quality parameter, determines consumer ac-

ceptability and fruit flavor (Mustapha et al. 2020). An increase in MI has an influence on the taste through increasing sweetness and decreasing sourness (Iglesias and Echeverría 2009). During shelf life, organic acids decrease
faster than sugars (Peralta-Ruiz et al. 2020), thus, Figs. 2 and 3 show that bagged fruit had higher decrease of TA and increase of SSC, respectively, as a result of accelerated maturity or ripening compared with unbagged fruit. Our results demonstrated that preharvest bagging, particularly the transparent plastic, significantly accelerated fruit ripening. These findings are similar to Mustapha et al. (2020), who reported an increase of MI in cherry tomato as fruit ripened.

**DM content.** The DM content of bagged cherry tomato significantly \((P < 0.001)\) increased with increasing shelf life days compared with fruit (Fig. 5). ‘Tinker’ and ‘Roma VF’ cherry tomato bagged with the transparent plastic had significantly \((P < 0.001)\) high DM content (6.50%–9.53% and 6.07%–7.97%) compared with unbagged fruit (4.90%–7.07% and 5.00%–6.90% and 5.10%–7.33% and 6.00%–7.00%), respectively. The increase of DM could be attributed to fruit ripening probably due to water loss through transpiration (Stoyanova et al. 2018). A similar trend of high SSC was observed in bagged cherry tomato compared with control (Fig. 3) as a result of ripening (Casals et al. 2019). Previous studies have demonstrated that higher DM and SSC values are found in fully ripe tomato (Antolinos et al. 2020; Casals et al. 2019). Our results demonstrated that fruit preharvest bagging effectively accelerated maturity or ripening in cherry tomato.

**Firmness.** Fruit firmness significantly \((P < 0.001)\) decreased during shelf life of 8 d (Fig. 6). ‘Tinker’ and ‘Roma VF’ cherry tomato bagged with the transparent plastic showed a higher \((P < 0.001)\) decrease of firmness (57.98–31.69 N and 70.89–56.35 N), as well as fruit bagged with the blue plastic (72.03–59.62 N and 80.20–66.67 N) during shelf life as a result of ripening compared with control (76.93–61.90 N and 74.81–67.33 N and 74.81–70.40 and 88.17–77.99 N), respectively. Teixeira et al. (2011) reported that firmness of apples (Malus domestica) decreased after bagging fruit using transparent microporous plastic or nontextured fabric bags compared with unbagged fruit, which agrees with our findings. Fruit softening depends on deterioration in the cell structure, intracellular substances, and cell wall components (Seymour et al. 2012). It is also a biochemical process due to the hydrolysis of pectin and starch by enzymes present in the cell wall (Peralta-Ruiz et al. 2020). As fruit ripening progresses, depolymerization or softening of chain length of pectic materials occurs along with an increase in polygalacturonase and pectin esterase activities (Yaman and Bayouderk 2002).

**Weight loss.** Figure 7 shows that the weight loss of bagged and unbagged cherry tomato progressively \((P < 0.001)\) increased with increasing shelf life days. ‘Tinker’ and ‘Roma VF’ cherry tomato bagged with the transparent and blue plastics had significantly \((P < 0.001)\) higher weight loss of 46.74% and 35.56% and 36.23% and 31.34% at the end of shelf life compared with unbagged fruit (27.43% and 23.94% and 26.49% and 23.34%), respectively. This could be due to fruit ripening as cherry tomato changes from green to lighter green, and then to yellow or red as chlorophyll is broken down; and during color change the pulp becomes softer and sweeter as the ratio of sugars to starch increases (Adenji and Barimalaa 2008). This is further supported by Table 1 and Fig. 3, which show that bagging accelerated color change and enhanced SSC in cherry tomato compared with control. In addition, the gradual increase in weight loss during shelf life could primarily result from transpiration and the loss of carbon atoms from fruit in each cycle of respiration (Das et al. 2013; Khorram et al. 2017).

**Fruit size.** Bagging significantly \((P < 0.001)\) promoted fruit development and larger size of cherry tomato (Fig. 8). ‘Tinker’ and ‘Roma VF’ cherry tomato bagged with the transparent and blue plastic had significantly \((P < 0.001)\) larger fruit size (22.05 and 24.18 mm and 24.70 and 23.03 mm) at harvest compared with unbagged fruit (18.45 and 23.03 mm and 20.07 and 19.41 mm), respectively. These results are similar to Yang et al. (2009), who reported that bagging longan (Dimocarpus longan) using perforated translucent plastic, white adhesive-bonded fabric, and black adhesive-bonded fabric bags promoted fruit development, resulting in larger fruit size compared with unbagged fruit. Another study by Chonhenceb et al. (2011) demonstrated that bagging mango using wavelength-selective bags increased fruit size compared with unbagged fruit. However, Fig. 8 shows that fruit size decreased with increasing shelf life days in both bagged and unbagged cherry tomato. This could be attributed to loss of firmness (Fig. 6) and weight (Fig. 7). Moreover, ‘Tinker’ and ‘Roma VF’ cherry tomato bagged with the transparent and the blue plastics showed lower decrease of fruit size (20.93 mm and 23.16 mm and 22.85 mm and 21.85 mm) at the end of shelf life compared with unbagged fruit, which had higher decrease of fruit size (15.60 mm and 18.47 mm and 18.79 mm and 18.46 mm), respectively. This could be attributed to shrinkage as a result of weight loss or loss of firmness, which is associated with moisture evaporation and respiration through the exocarp (Tesfay and Magwaza 2017).

**Disease damage.** Disease damage was shown in Fig. 9. bagging cherry tomato resulted in no or very low \((P < 0.001)\) incidence of diseases compared with unbagged fruit. ‘Tinker’ cherry tomato bagged with the transparent plastic had no DD during shelf life of 8 d, whereas fruit bagged with the blue plastic showed slight damage of tomato bacterial canker disease (Clavibacter michiganensis subsp. michiganensis) at the end of shelf life. ‘Roma’ fruit bagged with the transparent and blue plastics had no incidence of diseases at harvest and at day 4, whereas at the end of shelf life fruit showed mild damage of tomato bacterial canker disease. Unbagged fruit had mild to severe damage of tomato bacterial canker disease during shelf life. The results of this study showed that bagging cherry tomato with the transparent plastic effectively protected fruit from disease infestation, whereas bagging fruit with the blue plastic reduced DD during shelf life. Our results are in agreement with Sharma and Pal (2012), who reported that bagging mango and apples using black and transparent polybags or brown paper bags and spunbonded light-yellow bags effectively reduced apple fly speck (Schildothryum pomi) and sooty blotch (Phyllochroa pomi-genus) diseases.

**Conclusion.** The current study demonstrated that the bagging plastic bags enhanced microclimate compared with control. Moreover, the transparent plastic bag performed better compared with the blue plastic treatment and corresponding controls. Bagging ‘Tinker’ and ‘Roma VF’ cherry tomato using the transparent plastic bag effectively enhanced fruit quality and protected fruit against disease infestation during shelf life compared with unbagged fruit. Also, fruit bagged with the blue plastic bag had significantly improved postharvest quality and reduced DD during shelf life compared with unbagged fruit. Therefore, it can be recommended to bag cherry tomato with especially the transparent plastic for enhancement of fruit quality and shelf life. In addition, although this study showed that bagging cherry tomato using the transparent and blue plastics effectively improved fruit maturity or ripening and enhanced postharvest quality and shelf life of cherry tomato, future studies should investigate packaging materials as well as edible coatings for effectively enhancing fruit ripening pattern during shelf life and cold storage. Moreover, the bagging materials used in this study are not biodegradable and expensive to recycle; future studies should look to the potential of biodegradable bagging plastics to improve fruit quality and shelf life of tomato.

**References Cited.**


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