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Original Research Article

Performance Assessment of Evaporative-Cooled Storage System in Short-Term Storage of Fruit Vegetables during Transportation

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Abstract: The study presents the performance and potential of an evaporative-cooled storage system for the short-term storage of fruit vegetables during transportation. The evaporative cooler, storage unit, power supply, control panel, and real-time data monitoring system are the components of the evaporative-cooled storage system. In this study, the system performance was assessed in terms of the cooling profiles of the storage unit (temperature [T] and relative humidity [RH] profiles), and postharvest quality of the selected fruit vegetables (chilli, tomato, and long bean) for the fresh market. Three storage treatments for the selected fruit vegetables were investigated, namely evaporative-cooled storage unit (T1), ambient room (T2), and cold room (T3). The average temperature inside the storage unit was T3 < T2 < T1. T1 demonstrated RH of > 90%, in agreement with recommended RH for vegetable storage. Post-five-hour storage treatments, the fruit vegetables stored under T1 exhibited the least weight loss as compared to T2 and T3. The application of an evaporative-cooled storage system provided the potential to preserve fruit vegetables postharvest quality during transportation.

Keywords: evaporative-cooled; short-term storage; transportation, cooling profile; fruit vegetable quality

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1. Introduction

Post-harvest, vegetables, and fruits continue to transpire and respire. Due to the perishable nature of fruits and vegetables, proper storage is essential to preserve their quality. Refrigerated vegetable and fruit storage is recommended to extend their shelf life (Kitinoja & Kader, 2015). The optimal storage temperature for tropical fruits is typically 12–15°C, with relative humidity ranging from 85–95% (Oberoi & Dinesh, 2019). Degradation in taste, freshness, leaf wilting, and shrivelling are common characteristics of deterioration in these commodities in the absence of optimum conditions (Jahun *et al.*, 2016). To avoid temperature abuse and severe post-harvest losses, it is recommended that cold storage be maintained throughout the entire value chain including during transportation/shipping.

Evaporative cooling is a thermal energy improvement that is effective in preserving fruit quality. The evaporative cooling system used water as a cooling medium (Yang *et al.*, 2019). Evaporative cooling occurs when the liquid evaporates into the surrounding air and cools the object in contact. When air evaporates, it causes the relative humidity of the surrounding environment rises, which in turn causes temperature to fall. Most importantly, evaporative cooling is suitable for areas with high temperatures, low humidity, and the availability of air movement (Jahun *et al.*, 2016; Raza *et al.*, 2021).

Evaporative cooling technology has long been used to cool buildings and has since been adapted to cool and store horticultural products. In some developing countries, evaporative cooling was used to extend the shelf life of produce at a low cost. The United States Agency for International Development (USAID) even recommended an evaporative cooling chamber as a simple solution to extend the shelf life of tomatoes in Rwanda (Ahmed *et al.*, 2021). Evaporative cooling is effective in preserving vegetables and fruits, according to many scholars (Dadhich *et al.*, 2008; Liberty *et al.*, 2013a; Liberty *et al.*, 2013b). According to Liberty and co-workers (Liberty *et al.*, 2013b), the application of evaporative cooling alone can increase the shelf life of mangoes from 14 to 28 days. The evaporative cooling technique is also promising for use in freight transportation. Based on a published study from Bengaluru, India, an extended shelf life of up to 4 days for the transit of tropical fruits was successfully developed using a solar-powered evaporative cooling vehicle (Oberoi & Dinesh, 2019). Yet, the application of the evaporative-cooled system in the short-term storage of fruits and vegetables during transportation in Malaysia is still lacking and thus, provides prospects for this research. Generally, the inland transportation for fruits and vegetables in Malaysia is via canvas and cold trucks with drawbacks in product quality and high cost (Deoraj *et al.*, 2015), respectively. Thus, an evaporative-cooled truck is a renewed interest as an alternative to canvas and cold trucks.

The study was targeted to assess the performance and potential of the evaporative-cooled storage system in terms of the cooling profile of the storage unit and fruit vegetable quality for the fresh market.

2. Materials and Methods

2.1. Evaporative-cooled Storage System Development and Performance Study

The evaporative cooler, storage unit, power supply, control panel, and real-time data monitoring system of temperature **(**T) and relative humidity **(**RH) are the components of the evaporative-cooled storage system as published previously (Sairi *et al*., 2020; Sairi *et al*., 2021). The evaporative-cooled storage system alternating current **(**AC) was powered by the truck battery direct current **(**DC) via a power inverter. In this study, a stand-alone truck battery was used for the power supply. However, real applications in a truck will implement the alternator to continuously charge the battery for power supply.

The evaporative-cooled system performance was assessed in terms of the cooling profile of the storage unit (T and RH profiles). The three storage treatments for the selected fruit vegetables are:

T1 - Evaporative-cooled storage unit

T2 - Ambient room (28°C)

T3 - Cold room (10°C)

The cooling time was fixed at five hours; an assumption based on vegetable transportation duration from Cameron Highlands to Klang Valley via truck.

The T1 applied icy water as an evaporation media, and a fan speed of 5.1 m/s, based on prior studies (Sairi *et al*., 2020; Sairi *et al*., 2021). T1 was conducted in static mode. Two units of sensors were located inside the storage unit for each treatment to monitor T and RH for the duration of the experiment. One unit of the sensor was located outside the storage unit (environment). The differences in T and RH between the environment (out) and storage unit (in) were logged.

2.2. Fruit Vegetable Postharvest Quality

The selected vegetable commodities used in this study are botanically categorised as fruit. The three types of fruit vegetables (chilli, tomato, and long bean) were directly purchased from a supplier in Selangor and were assessed and graded according to their commercial maturity for the fresh market.

The fruit vegetables were placed into a basket (10 kg each) and randomised into three treatments. The quality of the fruit vegetables for the fresh market that underwent treatments T1, T2, and T3 for five hours was assessed. The weight and physical appearance were recorded pre- and post-treatments. The fruit vegetables weight losses were calculated based on a percentage (%) of fresh weight basis. Upon arrival at the distribution centre (post-treatment), the fruit vegetables were transferred to a cold room (T of 10 ± 1°C; RH of 90–95%) for subsequent postharvest storage study. The postharvest quality for each fruit vegetable was assessed on weeks 0, 1, 2, 3, and 4. HOBO® U12 data loggers (Onset Computer Corporation, USA) was used to monitor the T and RH inside the cold room during the study.

The postharvest storage quality assessment includes physical and physicochemical characteristics. The physical (visual appearance) of the fruit vegetables was scored subjectively for freshness, shrivelling, bruising, and overall acceptability ratings (Table 1). The percentage of bruising corresponded to how fruits are bruised during commercial handling, namely; fixed pressure, shock, and one or more impacts on the fruits. On the other hand, the physicochemical characteristics studied were colour, texture, total soluble solids (TSS), pH, total titratable acidity (TTA), and vitamin C.

Table 1. Percentage of freshness, shrivelling, bruising, and overall acceptability ratings of fruit vegetables (chilli, tomato, and long bean)

Rating	Freshness	Shrivelling	Bruising (% surface area)	Overall Acceptability
1	100	Fresh	0	Excellent
2	75	Slightly shrivelling	25	Good
3	50	Moderately shrivelling	50	Acceptable
4	25	Severely shrivelling	75	Poor
5	0		100	Very poor

The TSS of each fruit vegetable was determined by placing a drop of juice on a digital refractometer (Atago DBX-55, Atago Co. Ltd., Japan). Results were recorded in °Brix. pH and TTA were measured using an automatic titrator (905 Titrando, Metrohom AG, USA). TTA of the vegetable juice (3 mL) was titrated with a 0.1 N NaOH solution to the endpoint of pH 8.1 and recorded as % citric acid. Vitamin C content was measured using 10 g of blended sample extracted with 100 mL of 3% metaphosphoric acid, filtered through Whatman No. 4 filter paper. A volume of 10 mL from the filtered solution was determined by titrating with 2, 6-dichlorophenol-indophenol to a pink endpoint that persisted for 15 s. The results were recorded as mg of ascorbic acid per 100 g fresh weight (FW). The colour of the samples was measured using a chromameter (Model CR-300 Minolta, Japan). Each colour value for Hunter L (lightness), chroma, and hue angle (h°) was expressed as the mean of three measurements. The texture of samples was measured using a texture analyser (Model 1140 Instron Universal Testing Machine, USA) with a 2 mm diameter size probe and the results were expressed in Newton (N).

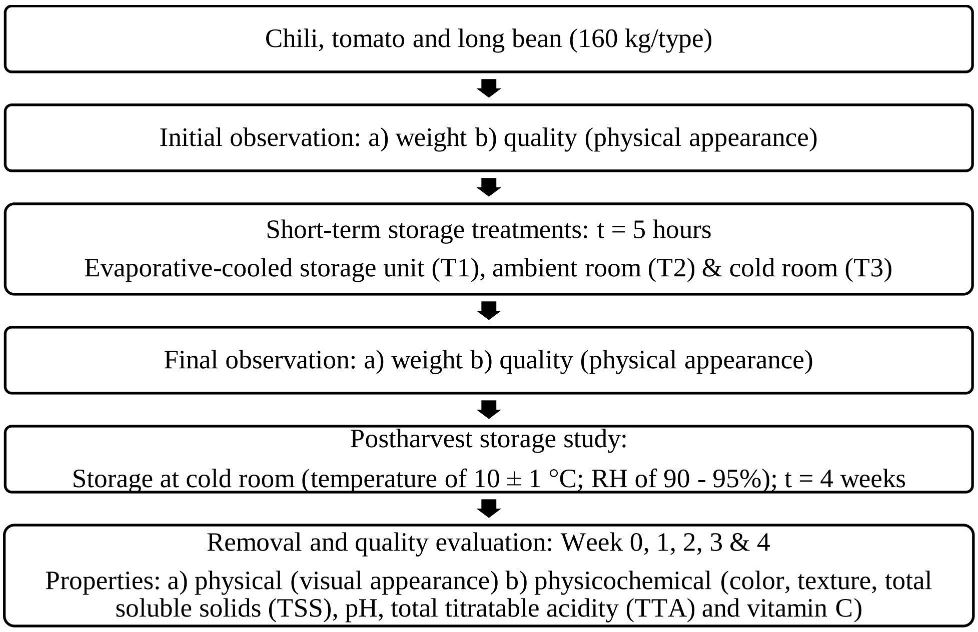

Figure 1. Fruit vegetable postharvest quality analysis process flow

2.3. Statistical Analyses

The experimental design was a completely randomized design (CRD) with three replications. The significant differences among short-term storage conditions and storage durations were examined using the Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) for mean separation. Data were analysed using Statistical Analysis System (SAS) version 9.3 (SAS Software Institute, Cary, NC, USA). Data were represented as a mean value ± standard deviation (n = 3). Unless stated otherwise, a 95% confidence interval was used for all calculations ($p \leq 0.05$).

3. Results

3.1. Evaporative-cooled Storage System Performance

The evaporative-cooled storage system performance was assessed in terms of the cooling profile (T and RH) of the storage unit, and compared with the cooling profile of ambient and cold rooms (Figure 2). The average T inside storage unit for the duration of the experiment was T3 (15.9 ± 3.3°C) < T2 (25.9 < ± 0.3°C) < T1 (29.5 ± 0.9°C). In this study, the evaporative-cooled storage system exhibited average T reduction, $\Delta T_{average}$ of 0.5 ± 2.4°C from the environment condition. In addition, an RH of > 90% was also demonstrated. The environment T and RH started to decrease and increase, respectively, approximately post-170 min due to weather changes (rain) during the experiment.

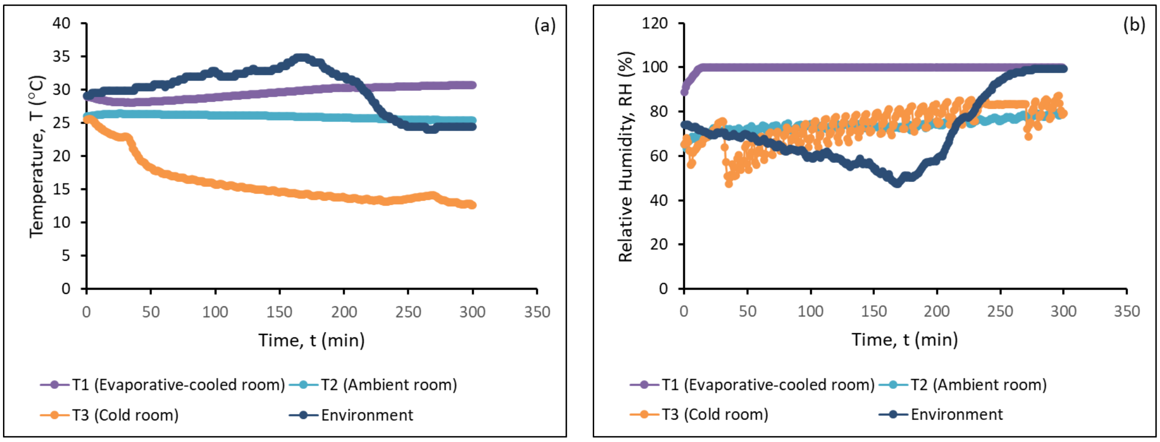

Figure 2. The plot of (a) T, and (b) RH against time between environment (out) and storage treatments. T1, T2, and T3 represent the evaporative-cooled storage unit, ambient room, and cold room, respectively

3.2. Fruit Vegetable Postharvest Quality

The weight and quality of selected fruit vegetables (chilli, tomato, and long bean) for the fresh market that underwent the three treatments for 5 h were assessed pre- and post-short-term storage. Post-five-h storage treatments, vegetables stored under T1 exhibited the least weight loss (% fresh weight basis) as compared to T2 and T3 (T1 < T3 < T2) (Table 2). All the treatments demonstrated weight loss of < 3%.

Table 2. Effect of short-term storage treatments toward fruit vegetable weight reduction/loss

Treatment (T)	Weight loss, wt (%) (± std. dev.)
T1	0.26 ± 0.25
T2	0.89 ± 0.57
T3	0.85 ± 0.47

Table 3 presents the effects of different storage treatments and storage durations on the quality (physical appearance) of the three types of fruit vegetables.

Table 3. The effects of different storage treatments and storage durations on the quality (physical appearance) of fruit vegetables (chilli, tomato, and long bean)

Main factors	Freshness	Shrivelling	Bruising	Overall acceptance
Treatment (T)				
T1	1.54	1.42	1.31	1.42
T2	1.62	1.46	1.38	1.49
T3	1.54	1.54	1.35	1.47
F-Test significant	ns	ns	ns	ns
Storage Week (W)				
0	1.17	1.17	1.22	1.29
1	1.33	1.33	1.00	1.31
2	1.33	1.33	1.28	1.10
3	2.00	1.42	1.00	2.00
4	2.00	2.00	2.00	2.00
F-Test significant	ns	ns	ns	ns
Interaction T*W	ns	ns	ns	ns

Means separation within columns and main effect by Duncan's Multiple Range Test at $p \leq 0.05$
ns, *, ** non-significant or significant or highly significant at $p \leq 0.05$, respectively

Table 4 presents the effects of different storage treatments on the physicochemical properties of the three types of fruit vegetables.

Table 4. The effects of storage treatments on the physicochemical properties of fruit vegetables (a) chilli (b) tomato, and (c) long bean

(a)

Main Factors	TSS (°Brix)	pH	TTA (% citric acid)	Vitamin C (mg/100 g FW)	Colour			Texture (N)
					L*	C*	Hue	
Treatment								
T1	6.67b	4.78b	0.28	3.12b	38.37	49.20	32.28	8.76
T2	6.78a	4.82a	0.27	3.54a	38.42	49.45	32.52	8.72
T3	6.60b	4.80a	0.27	3.69a	38.12	48.70	31.90	8.80
F-Test significant	*	*	ns	*	ns	ns	ns	ns

(b)

Main Factors	TSS (°Brix)	pH	TTA (% citric acid)	Vitamin C (mg/100 g FW)	Colour			Texture (N)
					L*	C*	Hue	
Treatment								
T1	3.99	4.10b	0.37	21.05a	41.26	32.65	47.88	4.99
T2	4.16	4.14a	0.36	19.69a	41.56	32.76	49.16	4.93
T3	4.12	4.16a	0.35	17.82b	40.69	33.35	48.92	4.98
F-Test significant	ns	*	ns	*	ns	ns	ns	ns

(c)

Main Factors	TSS (°Brix)	pH	TTA (% citric acid)	Vitamin C (mg/100 g FW)	Colour			Texture (N)
					L*	C*	Hue	
Treatment								
T1	4.50b	4.83	0.23	4.63b	48.62	29.88	120.34	20.75
T2	4.82a	4.82	0.23	5.49a	50.08	29.57	120.72	20.70
T3	4.57ab	4.81	0.22	4.52b	49.35	29.52	120.30	21.45
F-Test significant	*	ns	ns	*	ns	ns	ns	ns

Means separation within columns and main effect by Duncan's Multiple Range Test at $p \leq 0.05$
ns, *, ** non-significant or significant or highly significant at $p \leq 0.05$, respectively

Table 5 presents the effects of storage durations on the physicochemical properties of the three types of fruit vegetables.

Table 5. The effects of storage durations on the physicochemical properties of fruit vegetables (a) chilli (b) tomato, and (c) long bean

(a)

Main Factors	TSS (°Brix)	pH	TTA (% citric acid)	Vitamin C (mg/100g FW)	Colour			Texture (N)
					L*	C*	Hue	
Storage Week								
0	7.30a	4.87a	0.24c	4.21a	38.94ab	46.61b	41.23a	10.01a
1	7.00b	4.89a	0.26c	3.69b	39.68a	49.25a	30.88b	9.18b
2	6.52c	4.82b	0.28ab	3.16c	38.03bc	48.59ab	29.22b	8.13cd
3	6.39d	4.72c	0.30a	3.21c	37.63c	50.78a	30.10b	8.69bc
4	6.21e	4.74c	0.27b	2.98c	37.25c	50.36a	29.74b	7.80d
F-Test significant	**	**	**	**	*	*	*	**

(b)

Main Factors	TSS (°Brix)	pH	TTA (% citric acid)	Vitamin C (mg/100g FW)	Colour			Texture (N)
					L*	C*	Hue	
Storage Week								
0	4.61a	4.06d	0.41a	21.47a	43.65a	29.40c	53.99a	5.78a
1	4.47a	4.19a	0.34b	19.90ab	42.20a	33.17b	48.12b	5.49a
2	3.89b	4.1bc	0.35b	19.62ab	42.09a	33.45b	47.86b	4.85b
3	3.84b	4.17ab	0.34b	18.77b	39.17b	32.56b	48.12b	4.79b
4	3.60b	4.11c	0.36b	17.87b	38.70b	36.22a	45.15b	3.93c
F-Test significant	**	**	*	*	**	**	*	**

(c)

Main Factors	TSS (°Brix)	pH	TTA (% citric acid)	Vitamin C (mg/100g FW)	Colour			Texture (N)
					L*	C*	Hue	
Storage Week								
0	4.83a	4.73b	0.24a	5.11a	48.29b	29.28	120.71a	21.92
1	4.42b	4.90a	0.21b	4.65b	50.40a	30.03	119.57b	20.11
F-Test significant	*	*	*	*	*	ns	*	ns

Means separation within columns and main effect by Duncan's Multiple Range Test at $p \leq 0.05$
ns, *, ** non-significant or significant or highly significant at $p \leq 0.05$, respectively

4. Discussion

4.1. Evaporative-cooled Storage System Performance

The evaporative cooling system operates by passing the hot and dry outside air through the water-filled cooling pad; causing water to evaporate from the hot air, which subsequently lowers the T and increases the RH (Raza *et al.*, 2021). These are essential factors beneficial for commodities' freshness, shelf-life enhancement, and marketable quality; which in turn lessen storage losses (Sairi *et al.*, 2020; Sairi *et al.*, 2021).

Previous studies reported a reduction of T of 10–12°C in the evaporative-cooled storage system as compared to the environment storage, and an increment of RH to > 90% (Chinenye *et al.*, 2013; Dadhich *et al.*, 2008; lal Basediya *et al.*, 2013; Mordi & Olorunda, 2003). The study on the application of an evaporative-cooled system in tomato storage by Mordi and Olorunda (2003) stated a T reduction of 8.2°C from the ambient temperature of 33.0°C, and an RH increment to 97.0%. In addition, Chinenye and co-workers (2013) demonstrated a T reduction of 13.8°C from the ambient temperature of 37.0°C, and an RH increment to 85.6–96.8% in the developed evaporative cooler; where it was experimented with highly respiring cut pumpkin and amaranthus leaf. The conditions were able to prolong the product shelf life for 8 days (Chinenye *et al.*, 2013). In India, the transportation of fruits (mango, banana, and guava) in evaporative-cooled vans/wagons implementing phase change material (cooling pad) assisted in improving product shelf life. In addition, the evaporative-cooled van/wagon integrated with a radio frequency identification (RFID) system and sensors (for ethylene, T, and RH monitoring), aided in product traceability (Oberoi & Dinesh, 2019).

In this study, the RH in the evaporative-cooled storage system agrees with the suggested RH for fruit vegetable storage (90–95%) (lal Basediya *et al.*, 2013). Higher RH is advantageous to prevent moisture loss and keeping vegetables hydrated during storage. On the contrary, the T reduction did not agree with the recommended value by previous studies (Chinenye *et al.*, 2013; Mordi & Olorunda, 2003), and this might be due to the weather changes during the experiment. In this case the T reduction was only calculated before the weather changes, and so the $\Delta T_{average}$ value could only be improved to 2.9 ± 1.0°C. Another possible reason was the static mode experiment, in contrast with the research group's previous study on the evaporative-cooled storage system for storage of leafy vegetables conducted in dynamic mode (a journey from Cameron Highlands to Serdang for five hours); the $\Delta T_{average}$ was 10.1 ± 3.8°C (Sairi *et al.*, 2021). In static mode, the outside air was allowed to flow inside naturally via the air inlet, whereas in dynamic mode, the outside air was forced to flow inside the storage unit by truck movement. The forced air flowing through the inlet and outlet maintains the humidity inside the storage unit, enhances the air exchange rate between the storage unit and the environment, and may help to reduce the T inside the evaporative-cooled storage unit greater.

The T profiles in the evaporative-cooled storage system for short-term storage of fruit vegetables (this study) and leafy vegetables (the research group's previous study (Sairi *et al.*, 2020) both conducted in static mode and exhibited a similar trend, although the T increased slightly at the end of both experiments.

Environment humidity influences the efficiency of the evaporative cooling system in which drier air will demonstrate greater cooling since more moisture is added to the air as compared to wetter air (Liberty *et al.*, 2013a). In Malaysia, our climate is relatively high in humidity hence less moisture can be added to the air, and thus T reduction is lower. In contrast, countries that experience hot and dry climatic conditions will exhibit greater temperature reduction as more moisture can be added to the air (Jahun *et al.*, 2016; Raza *et al.*, 2021). The application of the evaporative cooling system is more appropriate in low-humidity countries/areas. The environment humidity in the research group’s previous study was in the range of 36.0 to 67.2% (Sairi *et al.*, 2021) whereas the current study environment humidity was in the range of 47.5 to 99.5%. Wetter air in the current study exhibited lower T reduction as compared to drier air in the previous study (Sairi *et al.*, 2021).

Post-harvest, fresh vegetables (leaf and fruit) continually lose water to the environment, hence weight loss occurs. Kader reported obvious wilting or shrivelling may be seen when 3–5% of the vegetable fresh weight is lost (Kader, 2002). In this study, since all the treatments demonstrated weight loss < 3%, no obvious wilting or shrivelling was observed post-five-hour storage study. The least weight loss demonstrated by fruit vegetables stored under T1 treatment might be due to the highest RH demonstrated in the treatment. The measured weight loss of the fruit vegetables during storage is mainly caused by water loss due to water vapour migration from the saturated internal atmosphere (intercellular spaces) to the less saturated external atmosphere (environment). Water loss rate (then wilting and shrivelling symptoms) can be reduced by storing fresh vegetables at low T and high RH. The weight loss of tomatoes in ambient and evaporative cooling storage post-ten days storage was 52% and 28%, respectively (Burbade *et al.*, 2017). In another study, post-seven days storage, the weight loss in ambient and evaporative cooling storage was 47.2% and 8.7% (red tomatoes); 9.3% and 4.3% (sweet oranges) (Adekanye & Babaremu, 2019).

4.2. Fruit Vegetable Postharvest Quality

Perishable fresh produce such as fruits and vegetables start to deteriorate rapidly just after harvest due to a warm humid environment. However, by eliminating the field heat and adding cooling as soon as possible after harvesting, fruits and vegetables' shelf life can be extended (Rajapaksha *et al.*, 2021). This study revealed all the storage treatments (T1, T2, and T3) preserved the freshness and quality acceptance during the storage of fruit vegetables at 10°C. Table 3 exhibited there was no significant difference between all the storage treatments and storage durations. Previous studies mentioned that chilli (Cho *et al*., 2016) and tomato (Mohammud *et al.*, 2016) were able to maintain their quality for two to four weeks during storage at 8–10°C, whereas long beans maintained the quality for less than one week at 13°C (Soontornwat *et al.*, 2013).

The T during transportation affects the physicochemical quality of vegetables since it is one of the factors that have the greatest impact on how rapidly freshly harvested produce deteriorate (Rajapaksha *et al.*, 2021). Storing the harvested produce at the lowest safe temperature can extend the shelf life by lowering the respiration rate, decreasing ethylene sensitivity, and reducing water loss. In this study, ambient room storage (T2) exhibited significantly higher TSS, pH, and vitamin C as compared to the other treatments (Table 4). The evaporative-cooled storage unit and cold room treatments did not show a significant difference.

The physicochemical quality of the fruit vegetables for all the treatments gradually decreased during the storage period (Table 5). The reduction of TSS, TTA, and vitamin C in fruit vegetables during storage was probably due to respiration and metabolism activities. In this regard, a suppressed respiration rate slows down the synthesis and the use of metabolites, resulting in lower soluble solids due to the slower hydrolysis of carbohydrates to sugars (Das *et al.*, 2013). During storage, the respiration process promotes higher sugar accumulation in tomatoes which is susceptible to mechanical injuries and increased water loss that caused shorter shelf life (Hussein *et al.*, 2020). In the present study, TSS gradually reduced during storage duration. The TTA and pH of vegetables differed significantly over the storage period. During storage, the decline of TTA is due to the metabolic activities of the living tissue and can be associated with ripening and increased respiration rate (Hatami *et al.*, 2012). Vitamin C in Table 5 showed a highly significant reduction due to storage duration. Similarly, Grace and co-workers reported the vitamin C content in tomatoes decreased with increasing time of storage at both refrigeration and room temperatures (Grace *et al.*, 2014). Long beans can be stored successfully for about 1 week at 10°C and slowly showed the reducing physicochemical content due to a chilling injury occurring at week 2 (Table 5). The most common symptoms of chilling injury on long beans include brown or black surface discolouration, surface pitting, and sunken areas; high levels of decay began during storage and greatly deteriorated due to water loss (Zong *et al.*, 1992). During the storage period, there were highly significant colour and firmness changes in tomato and chilli. According to Silva and co-workers (2017), mango colour changes significantly decreased in lightness (L*) during storage and presented yellowish colour as a result of ripening (Silva *et al.*, 2017). Besides, loss in fruit texture was greatly related to water loss and accelerates senescence during storage (Lufu *et al.*, 2020).

The evaporative-cooled storage system showed a comparable result between the cold room and ambient room conditions in maintaining the postharvest quality of the fruit vegetables. However, the effect was more significant on leafy vegetable quality as previously published by the research team. The applications of the evaporative-cooled truck during vegetable transportation provided positive effects on leafy vegetable quality for up to two weeks of storage at 5°C (Sairi *et al.*, 2021). Since the developed system is only meant for short-term storage during transportation, it provides an alternative to the non-refrigerated truck.

5. Conclusions

The evaporative-cooled storage system for short-term storage of fruit vegetables during transportation showed good cooling profile performance, and acceptable fruit vegetables (chilli, tomato, and long bean) postharvest quality for the fresh market. The evaporative-cooled truck demonstrated an RH of > 90% and agreed with the recommended RH for vegetable storage. Fruit vegetables stored under T1 exhibited the least weight loss as compared to the other treatments. The application of an evaporative-cooled storage system soon after harvesting showed the potential to preserve fruit vegetable quality during short-term storage. However, the effect was more significant on leafy vegetable quality as previously published by the research team.

Author Contributions: Masniza Sairi: conceptualization, methodology, data collection, data curation, writing, review, and editing of the manuscript, supervision, and project administration. Nur Syafini Ghazali and Joanna Cho Lee Ying: methodology, data collection, data curation, writing the manuscript, and supervision. Mohd Shukry Hassan Basri: conceptualization, methodology, and data collection. Sharifah Hafiza Mohd Ramli: data collection and writing of the manuscript. Mohd Fazly Mail: methodology and data collection. Arina Mohd Noh and Yahya Sahari: data collection. Mohd Shahrir Azizan: data collection and project administration. Mohd Zaffrie Mat Amin: data curation. Rahayu Anang and Azman Hamzah: supervision. Azhar Mat Noor, Mohamad Abhar Akmal Hamid, Nur Izzati Muhsin, Mohd Hafiz Mohd Amin Tawakkal, Amir Redzuan Shamsulkamal, Shafie Alwi, Mohd Zaimi Zainol Abidin, Muhammad Aliq Jamaluddin, Mohd Daniel Hazeq Abdul Rashid, and Mohd Azmirredzuan Sani: data collection.

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