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Proximate and Mineral Analysis of Evaporative-Cooled Tomatoes

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ABSTRACT

Postharvest losses of tomatoes remain a major challenge in sub-Saharan Africa due to erratic power supply and inadequate storage systems. This study evaluated the effects of aluminium -in-pot evaporative cooling systems on the proximate composition, mineral content, and physiological weight loss of two tomato cultivars (UTC and Plum). The tomatoes were stored in five different Aluminium-in-pot evaporative (A, B, C, D and E) coolers and under ambient conditions (control). The proximate analysis was done using Association of Official Analytical Chemists (AOAC) methods, while mineral contents, lycopene, and vitamin C were determined using an atomic absorption spectrometer and titrimetric methods, respectively. Results showed that weight loss in the evaporative cooling system ranged from 2% to 9% as compared to the weight loss of the control case, which varied from 3.7% to 25%. The shelf life of tomatoes in evaporative cooler E was extended to 15 days, while for the control case, it lasted only 4 to 5 days. Additionally, evaporative cooling significantly reduced weight loss and rate of decay while improving retention of moisture, vitamin C, lycopene, and essential minerals relative to ambient. These findings demonstrate the effectiveness of evaporative cooling as a low-cost and sustainable technology for extending tomato shelf life and preserving nutritional quality, with potential application in post-harvest storage system design.

INTRODUCTION

Tomatoes contribute to a healthy, well-balanced diet, as they are rich in minerals, vitamins, essential amino acids, sugars, dietary fibres, vitamin B and C, iron and phosphorus (Haraira *et al.,* 2022; Kaboré *et al.,* 2022; Suman *et al.,* 2023). According to the National Institute of Horticultural Research (NIHORT, 2021), tomato production in Nigeria was reported to have increased from 1.8 million Metric Tonnes to 2.3 million metric tonnes over the past three years (Adeoye and Aderibigbe, 2021). It has the capability of improving the Nigerian agricultural economic development. Babaremu *et al.* (2018) asserted that 35–45% of the yearly fruits and vegetables crop from Nigeria is lost after harvest. Most of these losses were due to a lack of storage facilities, and this was a huge loss of valuable food, even when the minimum food requirement of the population was not yet met (Etefa *et al.*, 2022; Makule *et al.,* 2022; Mohan *et sal.,* 2023).

From an engineering perspective, a thorough understanding of the intrinsic properties of different tomato varieties is critical for optimizing the post-harvest supply chain. One crucial engineering metric of importance is the physiological weight loss (PWL), which is a measure of the combined effects of respiration and transpiration (water loss) (Xanthopoulos *et al.,* 2024). If not handled correctly, PWL not only leads to direct economic loss but also triggers quality deterioration, including wilting, loss of firmness, and reduced nutritional density (Mahajan *et al.,* 2014).

Abdullahi *et al.* (2016) studied the proximate, mineral and vitamin contents of fresh and canned tomatoes experimentally in order to ascertain whether some nutrients have been lost as a result of preservation. The result of the study revealed that fresh tomatoes had higher moisture and fat contents than canned tomatoes; however, it has less protein, carbohydrate, crude fibre and ash content than the canned tomatoes. The proximate analysis of tomatoes was studied by Kaboré *et al.* (2022) to determine the nutritional composition of tomatoes in combating malnutrition in children. The contents level of carbohydrate, protein and lipid were evaluated in both the peel and seed of the tomatoes. It was concluded that tomato peel had an average 15.43% carbohydrate, 11.71% protein and 5.4% lipid, while the seeds contained 58.75% carbohydrate, 15.4% protein and 22.2% lipid. They also found the minerals in the tomato sample to include zinc, iron, magnesium, sodium and potassium. Nkolisa *et al.* (2019) in their study investigated the effect of a low-cost evaporative cooling system on the quality of two types of tomato cultivars.The cultivars were stored under three separate types of conditions, namely cold room, room temperature and evaporative cooling system for twenty days. The result of their study showed that the highest level of Ascorbic acid was found in samples of tomatoes stored at Room Temperature, followed by the ones stored inside Evaporative coolers and the least by the sample stored in the cold room. Banjo et al., (2025) worked on the effect of a passive evaporative cooler on the proximate composition and physicochemical properties of tomatoes. Some of the tomatoes were stored in the passive evaporative cooler, while some of them were left in the ambient. The tomatoes' proximate composition and physicochemical properties were determined before and after storage. After every three days, the tomatoes were removed from the passive evaporative coolers and analysed. Results showed that the tomatoes stored at room temperature were able to last for 12 days before spoilage, while those in the evaporative cooler lasted for 18 days. They also found that the percentage moisture content, ash, protein, fibre and soluble contents of tomatoes stored in passive evaporative coolers dropped slightly, whereas those of the tomatoes stored at room temperature dropped sharply.

Despite existing studies on evaporative cooling systems, there is limited information on the comparative effectiveness of different aluminium-in-pot evaporative cooling configurations on the nutritional quality and physiological weight loss of tomato cultivars. Therefore, this study aims to evaluate the proximate composition, mineral content, and percentage decay of Plum and UTC tomatoes stored in five different aluminium-in-pot evaporative coolers. The systems investigated include 100% clay lining, 100% charcoal lining, and clay–charcoal mixtures in ratios of 72:28, 50:50, and 28:72.

Although previous studies have investigated evaporative cooling for tomato storage, most have focused on single cooler designs or general quality parameters. Little information exists on how the composition of the lining medium, specifically clay-charcoal blends, affects both the physiological weight loss and the nutritional retention of different tomato cultivars. Moreover, the combined evaluation of proximate composition, mineral content, and decay incidence across five distinct aluminium-in-pot configurations has not been reported for the two widely grown Nigerian cultivars, UTC and Plum. This study, therefore, fills that gap by systematically comparing five lining media (100% clay, 100% charcoal, and three clay-charcoal ratios) under tropical ambient conditions. The findings provide an engineering basis for selecting lining materials to optimise shelf life and nutritional quality in low-cost evaporative coolers.

METHODOLOGY

Materials

The materials utilised in the construction of the Aluminium in pot evaporative coolers included clay and Aluminium for chamber materials, clay and charcoal for lining materials, glass fibre for lagging materials and other materials. Fresh tomato fruits were collected from Mandate tomato market, Ilorin, Kwara State, and were identified at the Department of Plant Biology, University of Ilorin. The botanical name of the tomato fruit was identified as *Lycopersicon esculentum.* Two cultivars were used in this study: Better Boy (UTC) and Kerewa (Plum). The samples were selected based on uniform size, maturity, and absence of visible defects.

Place of study

The experimental rig was set up outdoors, in a dry, ventilated space at the back of the Department of Mechanical Engineering, Faculty of Engineering and Technology, University of Ilorin, Ilorin. Ilorin is the capital city of Kwara State, Nigeria. It is located on latitude 8.4799 °N and longitude 4.5418 ºE marking a divide between the southern forest Zone and the Northern grassland of Nigeria. The climate is tropical wet and dry, characterized by a distinct wet and dry season with a mean annual temperature of about 26.80 °C, with five hours of average daily sunshine (Yahaya *et al*., 2018). The test was carried out between the month of November 2021 and January 2022.

Methods

Set up of the experimental Rig

Five cooling chambers were made with an outer earthenware clay pot and an inner Aluminium container (square shapes). The five Aluminium containers were separately inserted inside a bigger clay pot. The space between the Aluminium and clay is lined with clay, charcoal and clay-charcoal blended lining material of 5cm gap to form a wall-in-wall. The wooden box housing a suction fan is used as a lid, and a piping system was connected to ensure the supply of water to the lining media in the evaporative cooler. The shield was constructed with a 1 x 4-inch hardwood, and 5 nos aluminium roofing sheets of 67 cm x 18 cm were used to cover the rig. The reservoir support was constructed with 1 x 4-inch hardwood, and the dimensions are 56 cm x 85 cm x 100 cm, as shown in Figure 1. The lining media were constantly wetted with an equal volume of water two times daily, morning and Evening. The tomato samples were placed in each of the evaporative coolers, while the same quantity was left in the ambient as a control.

Figure 1: Pictorial of the experimental rig.

Proximate and mineral composition of stored product.

The proximate composition was determined using the Association of Analytical Chemists method (AOAC 2002), while the mineral composition was determined using an Atomic Absorption Spectrometer (AAS-3500, Thermo Scientific, UK). The proximate composition involved percentage moisture content, ash, lipid, protein, and carbohydrate contents of the stored product.

Percentage crude protein content

The percentage crude protein content was determined every three days in each of the setups. This was determined utilizing the Kjeldahl method following the (AOAC, 2002) procedures. This method involves a three-step approach to the quantification of protein, which includes digestion, distillation, and titration. 2 g of the sample was digested with 20mL concentrated sulfuric acid and Kjeldahl catalyst (5 g of K_2SO4 and 0.5 g of $CuSO_4$) in a digestion chamber until it became clear. The blank test was performed without the sample. After digestion, it was distilled in the Kjeldahl distillation chamber (Buchi-Kjeldahl K-360). The evaporated ammonia was condensed and then titrated against the known concentration (0.1 N) of Hydrochloric acid. The concentration of Nitrogen (N) was determined using the relation below (Sanusi *et al.*,2020):

$$N(\%) = \frac{(A-B)(0.01)(250)(1000)(14)}{W_d \times C} \times 100 \quad (1)$$

Where A is the volume of acid for titrating the sample, B is the volume of acid used in titrating blank, W_d is the weight of the sample digested, and C is the Aliquot of sample used (5ml)

Total crude protein is given as (Shina *et al.,* 2018; Usman *et al.,* 2023):

Total crude Protein = Nitrogen (%) x 6.25

Determination of Percentage Decay

The decay incidence percentage measures the percentage of decayed tomatoes in a sample. This is given by (Benitez *et al.,* 2021):

$$\% \, Decay = \frac{Total\ No.of\ Decayed\ Sample}{Total\ No.of\ Samples} \times 100 \quad (2)$$

Percentage Moisture Content

The moisture content (MC) was determined utilising AOAC method (AOAC, 2000). 5g of the freeze-dried sample was heated in a hot air oven at 105°C for 24 hours, cooled in a desiccator, and reweighed. The moisture content was calculated using the following (Sanusi et al., 2020):

$$MC\ (\%) \frac{Weight\ of\ Sample - Dry\ Weight}{Weight\ of\ Sample\ Taken} \quad (3)$$

Percentage Crude Ash content

The ash content was determined by the AOAC method (AOAC, 2002). The silica crucible was first heated in a muffle furnace, cooled in a desiccator, and the initial weight was taken. 5 g of the sample was heated in a muffle furnace at 550°C for 6 hours, cooled in a desiccator, and the weight of the ash was taken and the ash content was calculated (Sanusi et al., 2020):

$$Ash\ content\ \% = \frac{Weight\ of\ ash}{Weight\ of\ Sample\ taken} \times 100 \quad (4)$$

Percentage Crude fats

The crude fat content was determined following AOAC procedure (AOAC, 2002). The initial weight of the flask was taken by heating in a hot air oven overnight at 105 °C, then cooled in a desiccator. 5 g of the sample was extracted with petroleum ether using Soxhlet apparatus for about 6 hours. The extracted fat was dried in a rotary evaporator and weighed (Sanusi *et al.,* 2020).

$$Crude\ Fat\ \% = \frac{Weight\ of\ fat}{Weight\ of\ Sample\ taken} \times 100 \quad (5)$$

Percentage Crude Fibre

Crude fibre was determined according to (AOAC, 2002) method. 1 g of the dry sample was boiled with 0.25 N sulfuric acid for 30 min, followed by filtration with muslin cloth, washed with hot water and again boiled with 0.313 N NaOH. It was again filtered, washed with hot water, followed by 0.5 N sulfuric acid and 50% ethanol. The residue was dried in an oven at 130 °C for 2 hours. The dry weight of the digested sample was taken, incinerated in a muffle furnace at 600 °C for 30 min, cooled in a desiccator and weighed. The crude fibre content was calculated based on 100 g of the freeze-dried sample (Sanusi et al., 2020):

$$Crude\ Fibre\ \% = \frac{Dry\ weight\ of\ digested\ Sample - weight\ of\ ash}{Weight\ of\ Sample} \times 100 \quad (6)$$

Percentage Crude Carbohydrate

The total carbohydrate content was determined by the difference method using the expression (Sanusi et al., 2020):

% Carbohydrate = (100 – (Moisture (%) + Ash (%) + Crude protein (%) + Crude fat (%))   (7)

Lycopene content

1g of fresh tomato was weighed into a 250ml beaker and crushed with a glass rod. 25ml of HPLC grade acetone was added and shaken for 10min. 25ml of methanolic Sodium Hydroxide solution was added and a reflux condenser was attached. The mixture above was heated in a boiling water bath for 1 hour with frequent shaking. The mixture was cooled rapidly, and 50ml of distilled water was added. The hydrolysate obtained was transferred into a separatory funnel. The solution was extracted thrice with 50ml of HPLC acetone, 1g of K_2SO_4 added to remove any traces of water. The organic layer was carefully removed into a 250ml beaker and subsequently filtered into a 100ml Volumetric flask and made up to mark with HPLC acetone. Standard solutions of lycopene in the range 0-50ug/ml were prepared from a 100 ppm stock lycopene solution. The different concentrations of lycopene standard solutions were treated similarly to the sample. The absorbance or optical density of sample extracts as well as standard solutions of lycopene were taken on a Spectronic 21D Spectrophotometer at a wavelength of 340nm.

$$Lycopene\ in\ \frac{mg}{kg} = \frac{Sample\ Absorbance \times Gradient\ factor \times Dilution\ factor}{Weight\ of\ Sample\ taken} \quad (8)$$

Percentage Crude Vitamin C

10 g of the sample slurry was weighed into a volumetric flask and diluted to 100 ml with 3% metaphosphoric acid solution (0.0033M EDTA). The diluted samples were filtered using a Whatman Filter Paper No. 3. 10 ml of the filtrate was pipetted into a small flask and titrated with a standardized solution of 2.6 dichlorophenol-indophenol (DCPIP) to a faint pink endpoint. The ascorbic acid (AA) content of the fruit was determined from:

$$AA\ mg/100g\ sample = \left(\frac{V \times T}{W_a}\right) \times 100 \quad (9)$$

where,

V = ml dye used for the titration of aliquot of diluted sample.

T = AA equivalent of dye solution expressed as mg per ml of dye.

Wa = gram of sample in aliquot titrated.

Mineral Composition of Stored product

Minerals such as sodium, potassium, calcium, magnesium and phosphorus were determined using Atomic Absorption Spectrometry (AAS-3500, Thermo Scientific, UK). The sample was digested using the wet ashing method with concentrated Nitric acid. The result obtained was converted to ppm/100g of freeze-dried sample.

Physiological Weight Loss During Storage

The physiological weight loss (PWL) of the tomatoes during storage reflects the post-harvest quality deterioration. This is calculated using the relation (Xie et al., 2025):

$$PWL = \frac{W_0 - W_1}{W_0} \times 100 \quad (10)$$

Where W_0 is the initial weight and W_1 is the final weight.

Statistical Analysis

All experiments were performed in triplicate. Also, the results of all experiments were presented as the mean with $\pm$ standard deviation (SD). Significant differences among samples were analysed using SPSS analysis of variance software ANOVA followed by Tukey's HSD post-hoc test. P-value of significance was set at $p<0.05$. The version used was SPSS version 23.

RESULTS AND DISCUSSION

Percentage Decay of Stored Tomatoes

The changes in the colour of the tomatoes were observed both in the cooler and in the ambient conditions. The number of bad or rotten tomatoes was noted every day in the morning in all the setups and those in the ambient. The colour changes were based on the physical appearance of the vegetable according to Tasobya (2019). The physical texture of the tomatoes was examined and noted. The differences in the firmness were also noted after storing the tomatoes in the evaporative coolers and in ambient conditions. Two experiments were conducted. One involved Better-boy (UTC) and the second Plum (Kerewa) variety.

In the first experiment, Tomato Cultivar UTC was stored in the evaporative cooler, and it was observed that the tomatoes stored at ambient temperature started developing a rot spot at day 2 and eventually decayed at day 4 with a percentage decay of 89%. On day 7 the tomatoes stored at Setup A, B, C, D and E still retain their freshness, texture, firmness and no sign of mould formation, which is in agreement with what was reported by Zakari et al (2016). On the 9th day, there was a formation of mold and shrivelling of some tomatoes in setups A, B, C and D. On the 10th day, formation of mold was observed in the tomatoes in setup E. On day 15 the percentage decay of the tomatoes was evaluated, and Setup A has 83%, Setup B 100%, Setup C 100%, Setup D 67% and Setup E 33%. The Setup E was observed to have performed better in ensuring a firm, high-quality preserved UTC tomato up to 15 days.

In the second experiment, the tomato cultivar, Plum (Kerewa) was stored in the evaporative coolers and ambient. It was observed that the tomatoes stored at ambient temperature started to decay on the 5th day without any sign of rot spot formation, with a percentage decay of 75%. On the 7th day, the tomatoes stored in setups A, B, C, D and E still retain their freshness, firmness and with little sign of rot spot formation in set-up D only. On the 12th day, the formation of rot spot was observed in tomatoes in setups A, B, C and D. And on the 15th day, the percentage decay of the tomatoes was evaluated and Setup A had 67%, Setup B 67%, Setup C 67%, Setup D 67% and Setup E 0%. The Setup E was observed to have performed better in ensuring firm, quality preserved Tomato Plum (Kerewa) up to 15 days without any form of decay recorded. This shows that the shelf life of Plum tomatoes is better than that of UTC, which is similar to what was reported by (Sombo et al., 2023).

It was stated by Sanusi et al. (2018) that lower temperatures retard the rate of chemical and enzymatic reactions, particularly where respiration rate, polygalacturonase and pectinmethylestarase which are responsible for cell wall dissolution. The textural quality, which varies greatly among cultivars of tomatoes, is influenced by skin toughness, flesh firmness and internal structure. In the current study, it was discovered that the Plum (*Kerewa*) variety possesses a better textural quality in the evaporative coolers after 15 days, especially in setup E, as compared to the Better-boy *(UTC*) cultivar in the same setup. The shelf life is defined as the number of days reached until at least 50% of the fruits reach senescence and are unmarketable; too soft, wrinkled or infested by fungal rots (Garuba et al., 2018). It was observed that, on the 10th day, the Better-boy variety had begun to develop mould and reached its shelf life on 15th day in setup E, while the Plum variety was still fresh, even at the 15th day. This agrees with the findings of Adegboye et al. (2020) who concluded that among the varieties of tomatoes cultivated in Oyo State, Nigeria, which were Cherry (Omo-oko), Beefsteak (Tyre), Grape (Alahusa), Plum (Kerewa), Campari (Gbeske), Better boy (UTC), the Plum (Kerewa) variety has the longest shelf life.

Physiological weight loss (PWL) of stored tomatoes after storage

Physiological weight loss is of importance in engineering applications because it can reduce marketability and shelf life of fresh tomatoes if the loss is excessive. Therefore, a better understanding of the kinetics of weight loss is paramount for the design of postharvest storage and evaporative cooling systems.

The percentage weight loss of the tomatoes stored in the five evaporative coolers was estimated for four days after storage and presented in the Figures below. Figures 2 and 3 indicate the daily weight losses during the experiment. For the control weight loss of UTC tomatoes, the result of the study showed that the percentage weight loss varied from 3.7 % to 25 %, which agrees with that of Babaremu et al., (2018). The cumulative weight loss of the tomatoes in the coolers ranged from about 2 % to 9 % as compared to 5 % to 18 % and 30 % to 60 % per day as reported by Zakari *et al*. (2016) and Ogbuagu *et al.* (2017), respectively. In all the evaporative cooler samples (A-E), weight loss of UTC tomatoes was far below that of the control samples stored at ambient temperature. The tomatoes in the control environment had lost about 25% of their weight by day 4, making them commercially unprofitable. However, the best performance was observed in UTC tomatoes stored in evaporative coolers C, D, and E, which had lost only about 5.8–6% of their weight. This supports the widely held view that evaporative cooling significantly reduces weight loss compared to ambient conditions, as reported in some studies (Patel et al., 2022; Udo, 2025).

The cumulative lowest weight lost was recorded in evaporative cooler sample E. As shown in Figure 3, the control samples of Plum tomatoes showed the greatest weight loss, thereby reaching the maximum value of 25% weight loss on day 4 when compared to tomato samples stored inside evaporative coolers A, B, C, D and E. Between day 3 and day 4, there was a sudden increase in weight loss from a value of 11% to 25%, respectively. This points to a likely collapse in epidermal integrity and with increased ageing, which leads to shrivelling. This is analogous to the behaviour of tomatoes, where excessive transpiration is not prevented when exposed to the ambient conditions, as reported by Lara *et al.* (2019).

However, the samples stored inside the evaporative coolers showed a significant decrease in weight loss as compared to the control samples. Better performance in reduction in cumulative weight loss was shown by the Plum tomatoes in evaporative coolers C, D and E, with average weight loss of E being the best. By day 4, evaporative cooler E had a cumulative weight loss of 5.6 %, C (5.62 %), and D (5.79 %), showing the effectiveness of lower temperatures in the evaporative coolers. Lower performance was obtained from cooler B with 6.99 % on day 4 and A with 8.34 % on day 4. This shows the lower effectiveness of cooler A in addressing the preservation of the Plum tomatoes when compared to other coolers. The daily percentage weight loss in each of the evaporative coolers for Plum and UTC tomatoes is shown in Figures 2 and 3, respectively.

Proximate and phytochemical Composition

The proximate composition of the two cultivars was determined and compared as presented in Tables 1 and 2. Tables 3 and 4 compare the phytochemical composition of the tomatoes. In all the proximate composition, the Better Boy was found to have a higher level of ash content, moisture, crude fibre, crude protein, fats, lycopene and vitamin C contents in comparison to Plum tomatoes except in carbohydrate content.

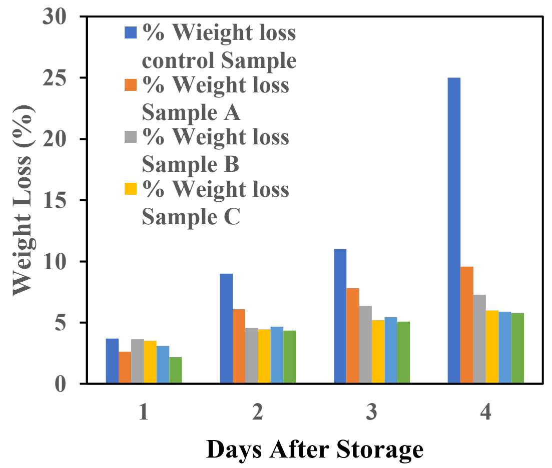

Figure 2: The daily percentage weight losses of tomatoes (UTC) in different coolers.

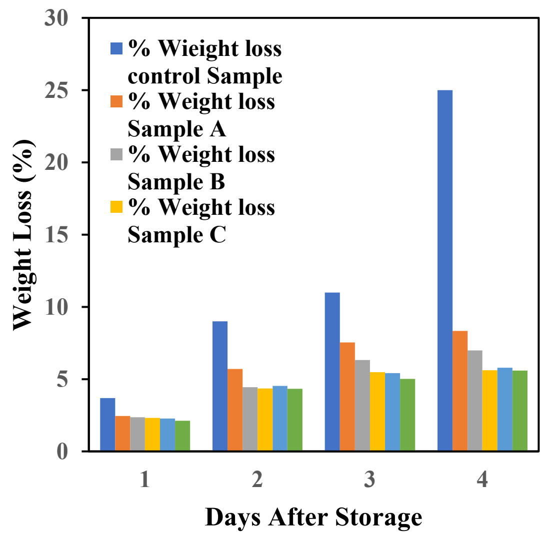

Figure 3: The daily percentage weight loss of Plum tomatoes in different coolers.

From the presented figures, the moisture content of Better-Boy at 78.5 % was higher when compared to Plum (74.6 %). However, the high-water content is a trait typical of tomatoes, which is responsible for its low calorie density and also its hydrating properties (Quinet et al., 2019). The lesser moisture content of Plum points towards a slightly higher concentration of nutrients per unit weight.

For the carbohydrate content, the Plum (18.91%) showed that it contains almost 1.5 times as much as that of Better Boy (13.65 %) tomatoes. According to the US Department of Agriculture, the carbohydrate content in tomatoes should be between 3-5 g in 100 g, which translates into between 3-5% of carbohydrates (USDA, 2021). This difference may be as a result of specific or sweeter cultivar of both Better Boy or Plum. The Better Boy lower carbohydrate maybe a good option for a lower-calorie diet, while the higher carbohydrate may be suitable for better sweetness.

An indicator of dietary fibre is the crude fibre content. Better Boy tomato with 2.55% crude fibre was higher than Plum (1.43%). Dietary fibre is known to be important for digestive health, glycaemic control, and cholesterol management in humans (Barber et al., 2020). The ash content is an indicator of the total minerals in the tomatoes. The percentage present in the two cultivars is similar with the two samples having 2.39 % against 2.34 %. This suggests similar overall mineral density. Crude protein and fat contents were also similar and relatively low in both fruits, which is characteristic of most fruits, where proteins and lipids are minor components (Marić and Ninčević, 2021).

Lycopene and Vitamin C

The red colour of tomatoes is an indicator of the lycopene content. Better Boy had a higher level of 6.88 mg/100g which was more than Plum (5.686 mg/100g). This finding aligns with the established knowledge that tomatoes are a primary dietary source of lycopene. Tomatoes' lycopene content varies greatly depending on the cultivar, ripeness, and growing environment. In raw tomatoes, values usually range from 0.9 to 4.2 mg/100 g, while some varieties can have higher levels (Martí et al., 2016).

Ascorbic acid (vitamin C) in Plum tomatoes (4.68 mg/100g) is slightly higher than in Better Boy (4.5 mg/100g). Interestingly. Vitamin C is known to be a powerful antioxidant and important ingredient for collagen formation and immune system performance (Alberts et al., 2025; Carr and Maggini, 2017).

Table 1: The proximate composition of stored product (Plum)

Proximate Composition	**Plum (Kerewa)**	SD ±
Ash %	2.34	0.028
Moisture %	74.6	0.436
Crude fibre %	1.43	0.062
Crude protein	1.32	0.067
Fat %	1.36	0.064
Carbohydrate %	18.95	0.236

Table 2: The proximate composition of stored tomatoes (UTC)

Proximate Composition	**Better-Boy (UTC)**	**SD**
Ash %	2.39	0.049
Moisture %	78.5	0.458
Crude fibre %	2.55	0.095
Crude protein	1.32	0.045
Fat %	1.59	0.070
Carbohydrate %	13.65	0.217

Table 3: The Phytochemical composition of stored Plum Tomatoes

Phytochemical Composition	**Plum (Kerewa)**	SD
Lycopene (mg/100g)	5.69	0.095
Vitamin C (mg/100g)	4.68	0.080

Table 4: The Phytochemical composition of stored Better Boy Tomatoes

Phytochemical Composition	Better-Boy (UTC)	SD ±
Lycopene (mg/100g)	6.88	0.128
Vitamin C (mg/100g)	4.50	0.091

The noticeable higher level of vitamin C in the Plum enhances its nutritional value, particularly if it is eaten fresh, as vitamin C is heat-labile and can easily be degraded during its processing (Quintero-Quiroz et al., 2026; Shaikh and Shaik, 2026).

Mineral composition of stored product

The mineral composition of the two cultivars was determined. Figures 4 and 5 shows the mineral composition of Better-boy (UTC) and Plum (kerewa) tomatoes. Potassium is the dominant element in the two cultivars as reported in other work (Rasheed *et al.,* 2022). From an engineering standpoint, potassium content influences tomato tissues' osmotic pressure and water retention properties, which may have an impact on moisture migration and physiological weight loss during storage (Song et al., 2025). The higher level of potassium in UTC over Plum help to contribute to its water retention capacity. Research has shown that calcium tend to improve the structural integrity of the tissues of fruits which leads to higher resistance to spoilage during storage handling and better shelf life (Guo et al., 2023; Sun et al., 2025). Calcium is present in both UTC in almost equal amount. Other elements present in the two cultivars are magnesium, sodium, phosphorous. Magnesium concentration is below what is in literature. However, its presence in the tomatoes affect the rate of respiration and metabolic activity which in turn affect the rate at which the tomatoes deteriorate (Quddus et al., 2022).

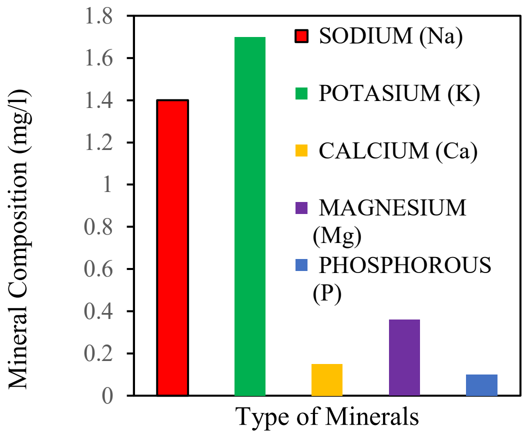

Figure 4: The Mineral composition of Stored UTC tomatoes.

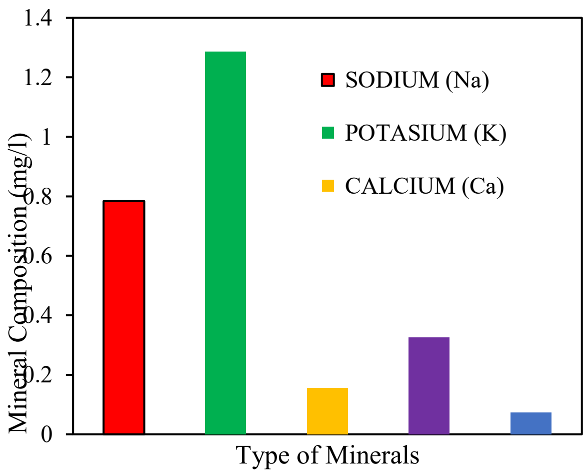

Figure 5: The Mineral composition of Plum tomatoes

The superior performance of cooler E (100% charcoal lining) can be attributed to the high specific surface area and capillary action of charcoal, which enhances water evaporation and maintains a lower and more stable internal temperature compared to clay or mixed linings. This is consistent with the findings of Defraeye et al. (2024), who reported that charcoal-based evaporative blankets effectively reduce temperature and delay senescence in fresh produce. The extended shelf life of the Plum cultivar relative to UTC may be linked to differences in cuticle thickness and initial firmness, as noted by Lara et al. (2019). In evaporative coolers, the reduced transpiration rate which is evidenced by lower physiological weight loss and slower metabolic activity evidenced by slower degradation of lycopene and vitamin C synergistically preserve both marketable quality and nutritional value.

RESULT OF STATISTICAL ANALYSIS

A statistical analysis was conducted on UTC tomatoes to know if there was significant difference in the percentage weight loss of the tomatoes stored in the evaporative coolers A, B, C, D, and E and the control case using ANOVA. Result showed that the control group shows significantly higher weight loss (mean=25%) compared to all evaporative coolers samples ($p < 0.001$ for all comparison). Among the evaporative coolers' samples, tomato sample in cooler A (9.57 %) shows significantly higher weight loss than samples B, C, D, and E ($p < 0.001$ for all cases). Sample B (7.27%) shows significantly higher weight loss than Samples C, D, and E ($p < 0.001$ for all). Sample C (5.99%) shows significantly higher weight loss than Sample E ($p = 0.002$), but is not significantly different from Sample D ($p = 0.126$). Sample D (5.89%) and Sample E (5.78%) are not significantly different from each other ($p = 0.098$).

CONCLUSIONS

The proximate composition, mineral composition, daily percentage weight losses of Plum and Better-boy tomatoes preserved inside five types of evaporative coolers have been investigated. The shelf life of the tomatoes under ambient conditions was 4 days for UTC and 5 days for Plum while it was extended to 15 days for UTC and more than 15 days under evaporative conditions. The lining media Sample E used in evaporative cooler (100% of charcoal) showed great potential in extending shelf life of stored products. The Better-boy tomatoes had a shelf life of 15 days in cooler E and lower value in the other coolers. The cumulative weight loss of the tomatoes in the coolers ranged from about 2% to 9% while in the ambient, it ranged between 3.7 % to 25 %. There was a distinct difference in the proximate and mineral of the two cultivars of tomatoes used in this study. The evaporative cooler treatments significantly reduce the percentage weight loss compared to control case among the evaporative cooler samples; sample A is the least effective (higher weight loss among the tomatoes in cooler sample). Tomato samples in D and E are the most effective with lower weight loss and no significant difference between them.

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