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RESEARCH

Effect of Different Concentrations of Potassium Metabisulphite and Bavistin on Postharvest Life of Litchi (*Litchi chinensis* Sonn var. Muzaffarpur)

Asmita Khanal [1,*], Ashmita Baral [2], Sandip Timilsina [1] and Susmita Khanal [3]

[1] Nepal Agricultural Research Council, Horticulture Research Station, Malepatan, Pokhara 33700, Nepal
[2] Purbanchal University, Faculty of Science & Technology, Himalayan College of Agricultural Sciences & Technology, Kathmandu 44600, Nepal
[3] Vegetable Crop Development Centre, Khumaltar, Lalitpur 44700, Nepal
[*] Author responsible for correspondence; Email(s): asmitakhanal47@gmail.com.

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Abstract

Litchi (*Litchi chinensis* Sonn var. Muzaffarpur) is cultivated in 57 districts of Nepal. However, proper post-harvest loss reduction activities are lacking, resulting in significant losses every year. In June 2023, an experiment on Litchi post-harvest was conducted at HRS, Malepatan. The Litchi fruits were uniformly mature and treated with varying concentrations of potassium metabisulfite (50, 75, 100, and 125 ppm) and Bavistin at 100 ppm. They were then stored at ambient conditions (29±4°C and RH 75±5%) for 10 days. The following parameters were recorded: physiological loss in weight (PLW), decay loss, total soluble solids (TSS), titratable acidity (TA), ascorbic acid content (Vit-C), and fruit weight to juice ratio. The fruit that was treated with 50 ppm of potassium metabisulphite recorded the lowest PLW at 20.12%. The fruit treated with 125 ppm of potassium metabisulphite had a minimum decay loss of 23.08%. The control treatment had the highest TSS at 23.65% with a minimum TA of 0.50%. The fruit treated with 100 and 125 ppm of potassium metabisulphite had the maximum ascorbic acid content at 87 mg and 85 mg, respectively, and the highest fruit weight-to-juice ratio at -2.80 and 2.73, respectively. Therefore, this study concludes that applying potassium metabisulfite at a concentration of 100-125 ppm is suitable for postharvest treatment of Litchi fruit to prolong its shelf life and maintain its quality parameters.

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Statement of Sustainability: This research examines the effect of different concentrations of potassium metabisulfite and Bavistin on the postharvest life of Litchi. The study aims to minimize post-harvest loss of Litchi, thereby supporting SDG 2 (Zero Hunger) by ensuring the long-term availability of agricultural production. Secondly, the research contributes to SDG 8 (Decent work and Economic growth) by using chemical preservatives as a post-harvest treatment. This assures quality production by minimizing product loss, which can attract farmers to adopt this technology.

1. Introduction

Litchi (*Litchi chinensis* Sonn.), a member of the Sapindaceae family, is a major fruit grown in both tropical and sub-tropical regions of Nepal (NHPC, 2017). The fruit is known for its bright red color and distinct, pleasant flavor. Litchi is popular as a table fruit, but in some countries, it is also preserved as jam, squash, dried nuts, and syrup in cans. Litchi cultivation is widespread in Nepal, with 57 districts producing a total of 42,736 metric tons from a productive area of 5,769 hectares, resulting in a productivity rate of 7.41 metric tons per hectare (MoALD, 2023). According to the NCFD report, Nepal cultivates nine different varieties of Litchi, including Seedless, Calcuttia, Bombai, Muzaffarpur, Early Large Red, Late Large Red, Rose-scented, Shahi, Meclin, and China Litchi (NCFD, 2019). Litchi is a non-climacteric fruit and is harvested only when fully ripe. Fruit is a highly perishable commodity that cannot be stored for an extended period after harvest (Budhathoki, 2004; Yadav et al., 2018). It is crucial to package the fruit as soon as it is harvested to prevent quality loss and non-marketability after a few hours in the sun. Additionally, fruit continues to undergo biochemical changes even after harvest, which can result in losses of approximately 20-30%, and sometimes even over 50% (Bhattari et al., 2013). The deterioration of Litchi fruits can be caused by several factors, including dryness, dehydration, pericarp browning, and fungal attacks.

Litchi cultivation is a popular agri-business in Nepal. Post-harvest handling of fruits, including Litchi, commonly involves the use of chemical preservatives and treatments. However, it is essential to determine the optimal concentration of these chemicals to ensure their effectiveness in extending the shelf life of the fruit and improving its storage quality without compromising food safety and consumer health. This can be achieved by conducting further research, as suggested by Pandit (2007) and Poudel et al. (2016). Potassium metabisulfite and Bavistin are commonly used in the fruit industry for their antifungal properties. However, their efficacy can vary depending on the concentration used. Also, Kasnazany et al. (2017) found that potassium metabisulfite is effective in protecting fruits during postharvest storage. Therefore, the main objective of this study was to maintain the quality parameters of lychee fruits after harvest, reduce post-harvest losses, and extend the availability of fresh fruit in the market. The study investigated the effectiveness of Potassium metabisulphite and Bavistin in extending the shelf life of Litchi fruits under ambient room conditions.

2. Material and Methods

2.1. Experiment Site and Design of Experiment

The experiment was conducted in June 2023 at the Laboratory of Horticulture Research Station in Pokhara, Kaski, Nepal. The site is located in the sub-tropical region of Gandaki province of Nepal at 28° 21'N Latitude and 83° 97'E Longitude, with an altitude of 850 meters above sea level. A Randomized Complete Block Design (RCBD) was used, consisting of six different treatments (Table 1). The experiment involved preparing treatments with varying concentrations of Potassium metabisulphite and Bavistin. The concentrations used were Potassium metabisulphite @ 50 ppm, Potassium metabisulphite @ 75 ppm, Potassium metabisulphite @ 100 ppm, Potassium metabisulphite @ 125 ppm, Bavistin @ 100 ppm, and a control. The experiment was replicated four times.

Table 1. Treatment details of the experiment.

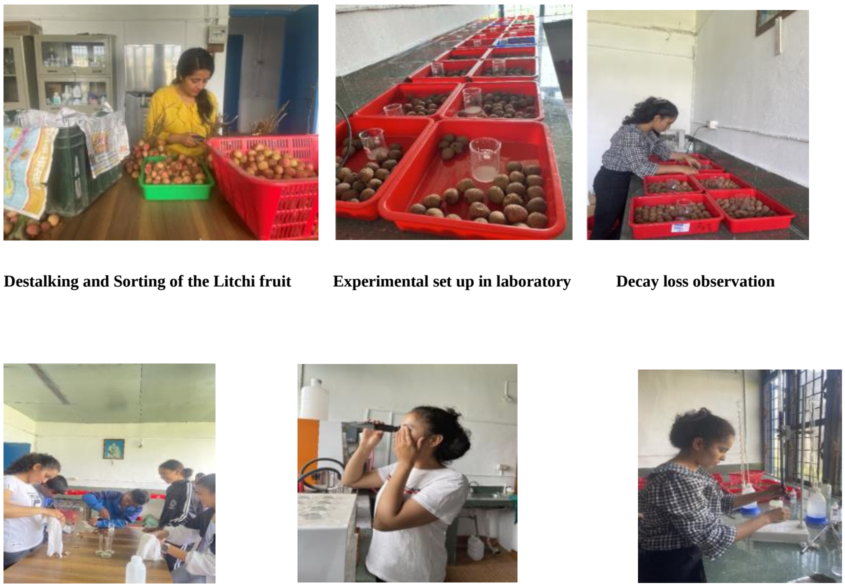
Treatment Symbol	Treatment Details
T1	Potassium Metabisulphite @ 50 ppm
T2	Potassium Metabisulphite @ 75 ppm
T3	Potassium Metabisulphite @ 100 ppm
T4	Potassium Metabisulphite @ 125 ppm
T5	Bavistin @ 100 ppm
T6	Distilled Water Only (Control)

2.2. Fruit Harvesting, Handling and Experimental Setup

The Muzaffarpur variety was chosen from the Litchi orchard in Chitwan for the experiment. This cultivar is known for its large, succulent fruit with vibrant red peel and sweet flesh. Ripe fruits were selected and harvested using a random sampling technique. The selection and harvesting process was carried out in the morning after the dew had fully evaporated. Bunches of fruits with vivid red fruits were chosen for harvesting. After the harvest was completed, the Litchi fruits were packed in plastic crates lined and layered with cushioning materials. They were then transported to the Horticulture Research Station laboratory in Malepatan, Pokhara. The fresh fruits, which were uniform in size and color, were sorted and de-stalked. Next, the selected fruits were dipped in different treatment solutions separately for five minutes and air-dried in ambient room conditions by placing them into perforated plastic trays. A total of 260 fruits were dipped in each treatment, with 65 fruits allocated per treatment per replication. The room temperature and relative humidity (RH) were maintained at 29±4°C and 75±5%, respectively, throughout the study period.

2.3. Parameters Recorded

The fruits were evaluated every two days for 10 days for various qualitative parameters. Changes in the post-harvest quality of Litchi were observed and recorded (Figure 1). Four fruits were randomly removed from the tray as a destructive sample on each observation day. The pericarp and aril were removed from the fruits to observe various parameters, including physiological loss in weight (PLW), decay loss, total soluble solids (TSS), titratable acidity (TA), amount of ascorbic acid (Vitamin C), and fruit weight-to-juice ratio.



Destalking and Sorting of the Litchi fruit **Experimental set up in laboratory** **Decay loss observation**

Extraction of the juice from litchi pulp **Observation of TSS through refractometer** **Titration of litchi juice against dye**

Figure 1. laboratory setup of experiment and its observation.

- **Physiological loss in weight (PLW):** Five fruits from each treatment were separated, marked, and observed to record weight changes. The physiological loss in weight (PLW) was calculated by dividing the difference between the fruit's initial and final weight by its initial weight and expressing it as a percentage.

$$\text{PLW}\ (\%) = \frac{\text{Initial weight of fruit (g)} - \text{Final weight of fruits (g)}}{\text{Initial weight of fruit (g)}} \times 100$$

- **Decay loss percent:** During the entire storage period, the fruits underwent regular visual inspections to identify any signs of decay. Any samples exhibiting decay or disease symptoms were counted and removed. The percentage of discarded fruits (decayed and diseased) was calculated by dividing the total number of discarded fruits by the total number of fruits.

$$\text{Decay loss}\ (\%) = \frac{\text{Number of discarded fruit}}{\text{Total fruit number}} \times 100$$

- **Total soluble solid (TSS):** TSS was determined using a hand-held refractometer (Model: Atago, Japan, N-1 Brix 0-32%). Two to three drops of clear Litchi juice were placed on the prism surface and the TSS value in % was recorded from the lens.
- **Titrable acidity (TA):** TA determination was performed using the acid-base titration method, as described by Tyl and Sadler (2017) and Khanal et al. (2023). Five milliliters of fresh Litchi juice were titrated with 0.1 N NaOH (sodium hydroxide) until the appearance of a pink color indicated the endpoint, at which point the volume of NaOH consumed was recorded. TA was calculated using the following formula:

$$\text{TA}\ (\%) = \frac{0.1\ \text{N (NaOH)} \times \text{V1 (mL)} \times 0.075\frac{\text{g}}{\text{mol}})}{\text{V2 (mL)}} \times 100$$

  Where, V1 is the volume of NaOH consumed during titration of the sample (mL), V2 is the volume of the sample (mL), and 0.075g/mol is the acid milli equivalent conversion factor.
- **Ascorbic acid content (Vit-C):** The volumetric method given by Sadasivam and Manickam (1991) was used to measure the ascorbic acid content of ripe fruits. A 100 mL conical flask was used to pipette out 5 mL of working standard solution. Then, 10 mL of 4% oxalic acid was added to it and the dye was titrated against it to record V1

mL. Next, 2 mL of Litchi juice sample was pipetted out and 10 mL of 4% oxalic acid was added to make a known volume of 12 mL. The mixture was then centrifuged for 10 min. A 5 mL of the supernatant was pipetted out and mixed with 10 ml of 4% oxalic acid. The mixture was titrated against the dye to record V2 mL until the endpoint was reached, indicated by the appearance of a pink color that persisted for a few minutes.

$$\text{Amount of ascorbic acid}(\text{mg}/100\text{g}) = \frac{0.5\text{ mg} \times \text{V2 mL} \times 12\text{ mL} \times 100}{\text{V1 mL} \times 5\text{ mL} \times \text{weight of sample (g)}} \times 100$$

Where, V_1 is the amount of dye consumed during the titration of working standard solution and V_2 is the amount of dye consumed during the titration of supernatant solution (sample).

- **Fruit weight to juice ratio:** Four fruits were randomly selected and observed each day. The pericarp and aril were thoroughly removed from each fruit, and the weight of the whole fruit and aril were measured. The pericarp and aril were thoroughly removed from each fruit, and the weight of the whole fruit and aril were measured. The juice was then squeezed from the fruits and measured. The data on fruit weight and juice volume were used to calculate the ratio.

2.4. Data Analysis

The data collected during the study period was entered into Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington, USA). The analysis of variance was performed using the Statistical Tool for Agricultural Research (STAR) version 2.0.1 (IRRI, Philippines), and significance was determined using Fisher's Least Significant Difference at P<0.05 (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Physiological Loss in Weight of Litchi

The PLW of Litchi fruit did not show significant differences among the treatments. However, all treatments showed an increase in PLW with prolonged storage days (Table 2). The Litchi fruit treated with potassium metabisulphite at 50 ppm exhibited the lowest PLW throughout the storage period, with a value of 20.12% on the 10th day after treatment. Fruits treated with 100 ppm of potassium metabisulphite had similar PLW to those treated with 50 ppm, with minimal weight loss (20.64%). The control treatment had the highest physiological loss (25.16%) among all treatments. Physiological loss increased with longer storage periods for all treatments, which is a common phenomenon in postharvest fruit handling. The observed weight loss is attributed to the transpiration and evaporation processes inherent in fruits. Potassium metabisulfite treatment can extend the shelf life of Litchi fruit by minimizing physiological loss. This treatment creates a thin film of moisture around the fruit, which helps to retain its moisture content and reduces the transpiration process, resulting in minimal weight loss (Kasnazany et al., 2017). The reduced weight loss may be attributed to the slowing down of respiration and enzymatic activities that cause the breakdown of cellular structure (Pandey and Lal, 2014). This study's findings are consistent with those of Yadav et al. (2018) and Reginer et al. (2004) in Litchi fruit.

Table 2. Effects of different concentrations of potassium metabisulphite and Bavistin on physiological loss in weight (PLW %) of Litchi fruit at different days of storage.

Treatment	2nd Day of Storage	4th Day of Storage	6th Day of Storage	8th Day of Storage	10th Day of Storage
T1	3.30	7.21	10.80	15.34	20.12
T2	4.10	8.20	12.60	18.41	23.35
T3	4.12	8.28	12.71	16.49	20.64
T4	4.08	7.64	10.88	17.56	21.69
T5	5.52	9.11	12.62	16.15	21.01
T6	6.40	8.14	11.90	20.84	25.16
Mean	4.59	8.10	11.92	17.47	22
CV (%)	51.73	22.97	15.45	20.98	17.42
P-value	0.48	0.78	0.49	0.37	0.45
$LSD_{0.05}$	ns	ns	ns	ns	ns

CV- Coefficient of Variation, LSD- Least Significant Differences, ns- Non-Significant at 5 % level of significance.

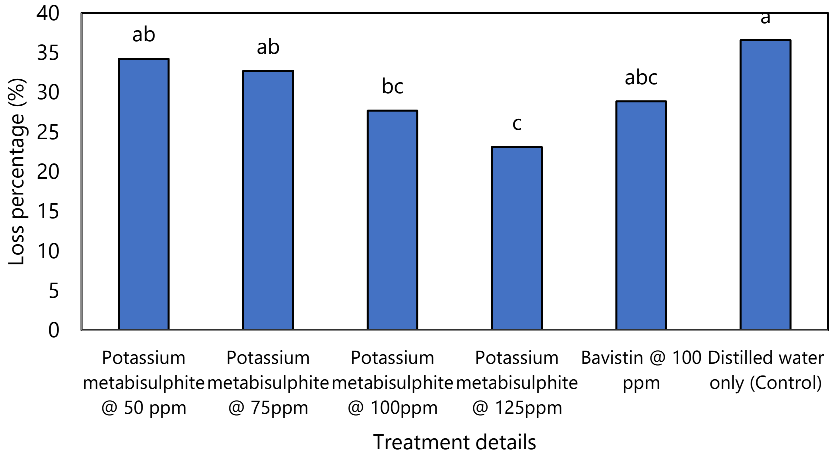


Figure 2. Effects of different concentrations of potassium metabisulphite on decay loss (%) of Litchi fruit at end of the storage (10th day of storage; Means within the bar-graph followed by same letter do not differ significantly at 5 % level by LSD).

3.2. Decay Loss of Litchi

The study shows that decay loss in Litchi fruit varies depending on the postharvest treatment. Potassium metabisulphite is effective in reducing physiological weight loss and decay loss, as demonstrated in Figure 2. The decay loss percentage ranges from a minimum of 23.08% in Litchi fruits treated with 125 ppm of potassium metabisulphite to a maximum of 36.54% in the control treatment. The results indicate that the treatment with 125 ppm of potassium metabisulphite is highly effective in preventing fruit decay, with a low decay loss of only 23.08%. Fruits treated with 100 ppm of potassium metabisulphite also showed a significant reduction in decay loss, with a value of 27.69%. This can be attributed to the antimicrobial properties of potassium metabisulphite, which help to maintain firmness and minimize respiration rate (Jiang et al., 2006). Potassium metabisulfite is an inhibitor of the polyphenol oxidase enzyme and is commonly used as a preservative in fruits and fruit products (Kasnazany, 2018). Its use in higher concentrations helps minimize decay loss and decrease fungal infection in different fruits due to its sulfite content (Kumar et al., 2009; Alwan and Hassan, 2020). These findings are also supported by Yadav et al. (2018).

Table 3. Effects of different concentrations of potassium metabisulphite on total soluble solid (TSS %) and titrable acidity (TA %) of Litchi fruit at end of the storage.

Treatment	TSS (%)	TA (%)
T1	19.10[b]	0.52
T2	18.07[b]	0.60
T3	19.80[b]	0.56
T4	19.05[b]	0.60
T5	19.95[b]	0.59
T6	23.65[a]	0.50
Mean	19.94	0.56
CV(%)	5.20	17.35
P- value	0.00	0.57
$LSD_{0.05}$	2.38	ns

CV- Coefficient of Variation, LSD- Least Significant Differences, ns- Non Significant at 5 % level of significance. Means within the column followed by same letter do not differ significantly at 5% level by LSD

3.3. Total Soluble Solid and Titratable Acidity of Litchi

The table in question (Table 3) shows significant differences in TSS levels among the treatments applied. The TSS content ranges from 18.07% to 23.65%, with a mean value of 19.94%. The control treatment recorded the highest TSS (23.65%) at the end of storage, followed by fruit treated with Bavistin @ 100 ppm (19.95%). Notably, the lowest TSS (18.07%) was recorded from fruit treated with 50 ppm potassium metabisulphite. The increase in TSS in the control treatment may be attributed to the concentration of juice resulting from continued metabolic activity and water loss from the fruit through transpiration or evaporation, with the breakdown of complex carbohydrates into simple sugars (Hussain, 2019). These findings are consistent with those of Aktar et al. (2020) and Aklimuzzaman et al. (2011) in Litchi fruit. The TA in Litchi fruit did not differ significantly among the treatments applied (Table 3). The titrable acidity (TA) content of the fruits ranged from 0.50% to 0.60%, with a mean value of 0.56%. The control treatment had the lowest TA content (0.50%) at the end of storage, followed by fruits treated with 50 ppm potassium metabisulfite (0.52%). However, fruits treated with 75 and 125 ppm potassium metabisulfite had higher TA content (0.60%). The metabolic activities of fruits increase after harvest. In untreated fruits, the acid content of the fruit changes into sugar, lowering its TA (Alwan and Hassan, 2020). Durrant et al. (2010) reported an increase in TA content of apples and pears treated with sodium metabisulfite. Fruit treatments help to lower the metabolic process while maintaining quality parameters. These observations align with the previous study by Reginer et al. (2004).

3.4. Amount of Ascorbic Acid Content (Vit-C) of Litchi

The study found that the amount of ascorbic acid in Litchi did not significantly differ based on the treatment. However, it was observed that the ascorbic acid content increased during the storage period, regardless of the treatment used. Table 4 below summarizes the outcomes. On the 10th day of storage, the fruits treated with 100 ppm potassium metabisulphite had the highest ascorbic acid content (87 mg/100g), followed by fruits treated with 125 ppm potassium metabisulphite (85 mg/100g). The Litchi fruit recorded a minimum ascorbic acid content of 58 mg/100g when treated with Bavistin at 100 ppm. Postharvest treatment with potassium metabisulphite was effective in preserving the ascorbic acid content of the fruits during storage. The increase in ascorbic acid can be attributed to the degradation of other naturally occurring acids in the fruits (Alwan and Hassan, 2020). The increase in ascorbic acid content is attributed to the synthesis of L-ascorbic acid from its precursor glucose-6 phosphate and slow rate of respiration (Poudel et al., 2018). These findings are consistent with those of Pandey and Lal (2014) and Sahu et al. (2023) in Litchi.

Table 4. Effects of different concentrations of potassium metabisulphite on ascorbic acid (Vit-C) content of Litchi fruit.

Treatment	2nd Day of Storage	10th Day of Storage
T1	64.60	62
T2	78.47	79
T3	79.60	87
T4	72.70	85
T5	55.37	58
T6	62.30	76
Mean	68.84	74.50
CV (%)	18.92	25.51
P-value	0.10	0.21
$LSD_{0.05}$	ns	ns

CV- Coefficient of Variation, LSD- Least Significant Differences, ns- Non Significant at 5 % level of significance.

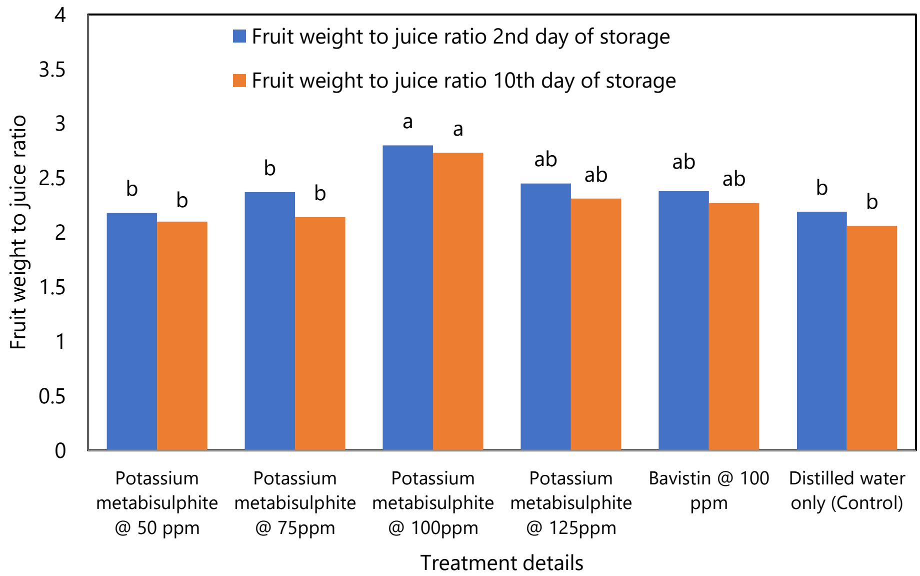


Figure 3. Effects of different concentrations of potassium metabisulphite on fruit weight to juice ratio of Litchi fruit on different days of storage (Means within the bargraph followed by same letter do not differ significantly at 5 % level by LSD).

3.5. Fruit Weight to Juice Ratio of Litchi

During the storage period, which spanned from day 2 to day 10, significant differences in fruit weight to juice ratio were observed (Figure 3). The highest ratios (2.80 and 2.73) were recorded from fruits treated with potassium metabisulphite at 100 ppm on both the 2nd and 10th day of storage, followed by fruits treated with potassium metabisulphite at 125 ppm. At the end of storage, the lowest ratio was observed in the control treatment (2.06), followed by fruit treated with potassium metabisulphite at 50 ppm (2.10). This parameter evaluates the quality of Litchi fruits by analyzing the impact of moisture loss, mainly in the form of water vapor, which is primarily caused by transpiration and evaporation. These losses can cause a rapid decline in fruit quality due to associated metabolic changes and a subsequent reduction in juice volume (Jiang et al., 2006). The highest fruit weight-to-juice ratio was observed in fruits treated with potassium metabisulfite, which may be due to a minimum PLW. According to Kasnazany et al. (2017), as weight loss increases, the juice content in the fruit decreases. This finding is consistent with the previous study by Shivakumar et al. (2005) on Litchi fruit.

4. Conclusion

An experiment was conducted to enhance the shelf life of Litchi fruit through various post-harvest treatments. After ten days of observation, fruits treated with potassium metabisulfite at concentrations of 100 ppm and 125 ppm exhibited better results in terms of minimizing PLW and decay loss while retaining the fruit's vitamin C content and fruit weight to juice ratio compared to other treatments. Although the fruit juice in the control treatment had the lowest TA and maximal TSS content, there was a significantly higher rate of fruit shriveling and decay loss. Therefore, this study concludes that the application of potassium metabisulfite at 100-125 ppm is appropriate for postharvest treatment of Litchi fruit to prolong its shelf life and preserve its quality parameters.

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Conflicts of Interest: The authors declare no conflict of interest.

Institutional/Ethical Approval: Ethical approval did not apply to this study as the work does not contain human or animal participants or experiments.

Data/Supplementary Information Availability: Not applicable.

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