Original Research Article
Evaluation of Postharvest Quality of Fresh Kesum Leaves (*Persicaria minor*) During Storage in Different Temperatures and Packaging

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ABSTRACT

Persicaria minor, locally known as kesum*,* is an herb synonym in Southeast Asia as a food flavor enhancer and seasoning for Eastern delicacies. Kesum leaves are quickly wilted, shrink, and lose moisture once harvested. This study aimed to determine optimum parameters: storage temperature and suitable packaging to maintain the freshness and quality of *kesum* and prolong the storage life. This study consisted of two activities: determining the best storage temperature and determining suitable packaging. Kesum leaves were harvested manually from matured plants, transported to a packinghouse, sorted, cleaned, packed, and sealed in polyethylene (PE) 0.04mm before being stored at different temperatures, which were 5°C, 8°C, 10°C and 13°C, for activity 1. For activity 2, kesum leaves were packed and sealed in different packaging: polyethylene (PE) 0.04mm and polypropylene (PP) 0.04mm and stored at 5°C. The postharvest quality of all samples and treatments (weight loss, moisture content, pH, total titratable acidity, total soluble solids, respiration rate of the leaves, total phenolic content, and leaf color values) were measured and recorded weekly throughout the storage period. The results of the study found that the storage of fresh kesum leaves at 5°C temperature can delay the senescence (lower respiration rate), maintain the color of the leaves, and show higher total phenolic content for up to 35 days of storage compared to storing in temperature of 8°C, 10°C, and 13°C. The packaging does not significantly affect some postharvest attributes. Still, PE plastic is more suitable for storing fresh kesum leaves due to the lower leaf respiration rate and maintaining the total phenolic content throughout the storage period.

Keywords: Herb, postharvest, storage, temperature, packaging

1. INTRODUCTION

Kesum (*Persicaria minor*) is an herb belonging to the family Polygonaceae that is synonymous with Malay and Asian dishes such as *asam pedas* (spicy tamarind curry), *laksa* (spicy noodle dish), *nasi kerabu* (fried herbal rice), *nasi ulam* (herbal rice), *tom yam* (spice tangy soup) and salad because of its property in enhancing flavor and aroma. In traditional medicine, kesum was used to treat dandruff, indigestion, ulcers, and fungal infections on the skin [1–2]. Kesum leaf contains various phenolic compounds that contribute to the antiulcer, antioxidant, antimicrobial, anti-inflammatory, anti-leishmanial, anti-cytotoxicity, and anti-genotoxicity [3–5]. Previous research showed that the kesum leaf is high in natural antioxidants that can combat oxidative damage by free radicals [6–7] and natural antimicrobial that can inhibit various types of

pathogenic microbes [2,8,9]. The tangy, lemony flavor in kesum leaves was contributed by oxalic acid, a reducing agent contained in kesum leaves [10]. After harvest, kesum leaves were subjected to moisture loss, shrinking, curling leaves, and leaf discoloration at ambient (25 – 27 °C) conditions. Quality preservation through postharvest practices, especially during storage and retailing, is essential so kesum leaves can be marketed and reach its users in maintained quality and freshness. This study determined optimal storage temperature and suitable packaging to preserve the quality and freshness of kesum leaves after harvest.

Information on postharvest handling techniques of leafy herbs is still lacking. Handling leafy vegetables and herbs, especially for distribution and processing, requires proper postharvest handling to reduce postharvest losses [11]. Temperature and packaging techniques play a role in postharvest handling to ensure that quality and freshness are maintained, and that produce can be stored longer to be marketed more widely. Temperature and packaging also influence quality during handling, distribution, and processing. This study determines the effect of temperature and type of packaging on the quality of kesum leaves to prolong the storage life.

2. material and methods

2.1 Samples preparation

Kesum leaves were harvested from matured plants (16 weeks after planting) and transported to a packing house for sorting, washing, drip drying, and packaging. This study determined the optimum storage temperature (activity 1) and suitable packaging (activity 2).

2.1.1 Determination of storage temperature and packaging

In the determination of storage temperature, an amount of 50g of kesum leaves was packed and sealed in polyethylene (PE) 0.04mm before being stored at different storage temperatures (5°C, 8°C, 10°C and 13°C). Meanwhile, for determination of packaging, 50g of kesum leaves were packed and sealed in polyethylene (PE) 0.04mm and polypropylene (PP) 0.04mm, then stored at optimum temperature, which was determined from activity 1. All samples were evaluated for postharvest quality weekly throughout the storage period on changes of physiology (appearance, fresh weight, moisture content, color, and respiration rate) and chemical [pH, total soluble solids content (SSC), total titratable acidity (TTA) and total phenolic content (TPC)]. All samples were prepared in triplicate for all treatments.

2.2 Quality measurement

2.2.1 Physical and physiology analysis (fresh weight, moisture content, color values, respiration rate)

Fresh weights of the samples were taken in a pack using a 2-decimal balance (AND, Japan) to measure weight loss, if any. Moisture content in leaves was measured using a moisture analyzer (AND, Japan) by placing 1 g of fresh leaf on a stainless-steel tray in a moisture analyzer, and the temperature was set to 105ºC. The leaf's color values (a*- greenness, Hue - color intensity) were measured using Chromameter CR-300 (Minolta, Japan). For measurement of leaf respiration rate, CO_2 gas in the package was taken using a 10mL syringe before being injected into the gas chromatography-mass spectrometry (GCMS) Clarus 680 (Perkin Elmer, USA) for enumeration of CO_2 percentage.

2.2.2 Chemical analysis (pH, total titratable acidity, total soluble solids content)

For the enumeration of pH and total titratable acidity (TTA), a 5g ground sample was mixed into 20 mL of distilled water, and the pH reading of the solution was recorded using a pH meter (Hanna Instruments, USA). The solution was then titrated with 0.1 mol 1^{-1} NaOH to an end point of pH 8.1. The volume of NaOH titrated was recorded as total titratable acidity. A 5g ground sample was squeezed in cotton cloth to get its juice before the total soluble solids (TSS) content was read using a digital refractometer (Atago, CO., LTD, Japan).

2.2.3 Total phenolic content

The total phenolic content in leaf samples was estimated according to the Folin–Ciocalteu colorimetric method described by Mirfat *et al*. (2020)[12]. Before analysis, samples were extracted using a 70% methanol solvent (5g ground sample in 50 mL solvent; 1:10 w:v). The mixture was shaken on an orbital shaker at 200 rpm for 48 hours before being filtered using Whatmann filter paper No. 4. The extracts were then dried at 60°C using a rotary evaporator. The dried extracts were weighed and diluted with 70% methanol, and the mixtures were mixed using a sonicator (JAC ultrasonic, 1505) to achieve a final concentration of 100 mg/mL. 50 µL extract was mixed with 100 µL Folin Ciocalteu's phenol reagent. After 3 min, 100 µL 10% sodium carbonate (Na_2CO_3) was added to the reaction mixture and allowed to stand in the dark for 60 min. The analysis was carried out in triplicates with a minimum exposure of light. The resulting blue-colored complex was measured at 725 nm absorbance against a blank using a spectrophotometer. Using the calibration curve, the gallic acid was used as a reference standard, and the total phenol content was expressed in gallic acid equivalents (GAE) in milligram per g samples.

2.3 Statistical analysis

Data from three replicates of each treatment were used for statistical analysis. The data analysis was done using Analysis of Variance (ANOVA) IBM SPSS software version 26. A mean comparison between samples and treatments was obtained using Duncan's multiple range test at $p = 0.05$.

3. results and discussion

Figures 1 and 2, respectively, show the fresh weight of kesum leaves stored at different storage temperatures (5°C, 8°C, 10°C, and 13°C) and types of packaging (LDPE 0.04mm, LDPP 0.04mm) throughout the 42 days of storage. It was found that storage temperature and type of packaging did not affect the leaves fresh weight during storage. There was no significant difference in leaves' fresh weight between temperature treatments and packaging types throughout the storage period.

Figure 1. Fresh weight of kesum leaves at different storage temperatures throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

Figure 2. Fresh weight of kesum leaves in different packaging (PP 0.04mm, PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

The same trend was obtained in the moisture content of kesum leaves throughout the storage period, where there was no significant difference in moisture content of kesum leaves between storage temperature (Figure 3) and type of packaging (Figure 4). The moisture content maintained around 80±5 % throughout the storage period in all treatments. On day-7 storage, moisture content was significantly reduced in all storage temperatures. However, the leaves regained their moisture content on day 14 and were maintained until the last day of storage. This may be due to leaves having undergone rapid moisture loss during harvesting and processing before packaging and storage. Moisture content or water loss is often related to a reduction in the fresh weight of the produce [13]. Moisture content is also associated with fresh appearance, and loss of moisture content can relate to stress that reduces postharvest quality [14].

Figure 3. The moisture content of kesum leaves at different storage temperatures throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

Except for 5ºC temperature, data measurements for temperatures 8ºC, 10ºC, and 13ºC were taken until 28 days of storage due to the samples' senescence.

Figure 4. The moisture content of kesum leaves in different packaging (PP 0.04mm, PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

The pH value of kesum leaves increased significantly throughout the 42-day storage period in all temperatures (Figure 5) and packaging treatments (Figure 6). The pH value of the leaves was found to increase from 5.32 on day 0 to 7.01 on day 42. There was a slightly significant difference in pH values between storage temperatures, where the trend showed an increase in pH value as the storage temperature increased. However, there was no significant difference in pH between packaging PP and PE up to 21 days of storage. However, after 28 days, there was a slight significant difference where leaves in PP packaging showed higher pH than in PE. pH changes result from physiological and cell activity due to conditions such as increased temperature, storage time, and packaging, which change complex sugars to acidic or alkaline compounds. The trend of increasing pH values during storage was also seen in the *asam gelugur* (*Garcinia atroviridis*) [11] and green citrus [15] stored in different packaging.

Figure 5. pH values of kesum leaves at different temperatures throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

Except for 5ºC temperature, data measurements for temperatures 8ºC, 10ºC, and 13ºC were taken until 28 days of storage due to the samples' senescence.

Figure 6. pH values of kesum leaves in different packaging (PP 0.04mm, PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

In contrast to pH, the TTA of kesum leaves in different storage temperatures and packaging showed a decreasing trend up to 42 days of storage (2.93 on day 0 to 1.70 on day 42), as shown in Figure 7 and Figure 8. There was no significant difference between storage temperatures of 5°C, 8°C and 10°C throughout the storage period, but at 13°C temperature, the TTA of kesum leaves decreased significantly on days 21 and 28. There was also no significant difference between packaging PP and PE until day 28, but on days 35 and 42, TTA in PP was significantly lower than in PE. TTA value, a quantitative measure of the organic acid, decreases with the senescence process [16].

Figure 7. Total titratable acidity of kesum leaves at different storage temperatures throughout the 42-day storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

Except for 5ºC temperature, data measurements for temperatures 8ºC, 10ºC, and 13ºC were taken until 28 days of storage due to the samples' senescence.

Figure 8. Total titratable acidity of kesum leaves in different packaging (PP 0.04mm, PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at P=0.05 according to Duncan's Multiple Range Test

As storage time increased, the total soluble solids (TSS) of kesum leaves increased. Storage temperature affected TSS in kesum leaves, as shown in Figure 9, whereas TSS of kesum leaves stored at 8°C, 10°C, and 13°C increased significantly after 21 days of storage (4.60, 5.30, and 5.60, respectively). However, TSS at 5°C remained lower until 28 days (3.40, 3.80) before increasing to 4.70 and 4.60 for the rest of the storage time. The packaging type did not affect the TSS value of kesum leaves during storage (Figure 10). There was no significant difference between TSS in packaging PP and PE throughout the storage period, except on day 21, where TSS was slightly higher in plastic PP than PE. The increment of TSS may be because of the degradation of complex components of carbohydrates and organic acids converted to reducing sugar when fruit prolongs the storage life [17]. Cells and tissues carry out these biological processes to carry on respiration and other metabolic functions [18]. A lower TSS value indicated delayed quality changes.

Figure 9. Total soluble solids of kesum leaves at different storage temperatures throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

Except for 5ºC temperature, data measurements for temperatures 8ºC, 10ºC, and 13ºC were taken until 28 days of storage due to the samples' senescence.

Figure 10. Total soluble solids of kesum leaves in different packaging (PP 0.04mm,

PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according To Duncan's Multiple Range Test

Figures 11 and 12 show the respiration rate of kesum leaves in storage at different temperatures and in different packaging throughout the 42 days of storage. There was no significant difference in the respiration rate of kesum leaves in all storage temperatures up to 14 days of storage. At this period, the respiration rate in all storage temperatures is around 0.48 - 0.99%. After 22 days, it was found that the leaf respiration rate in the 13°C temperature had increased significantly (1.2%), but there was no significant difference in the respiration rate in the 5°C (0.43%), 8°C (0.86%) and 10°C (0.94%) temperatures. However, after 28 days, there was a significant increase in leaf respiration rate in temperatures of 8°C (0.74%), 10°C (1.07%), and 13°C (1.72%). The respiration rate of kesum leaves at a storage temperature of 5°C remained low throughout the 42 days of storage (0.81 - 0.53%). Meanwhile, kesum leaves in polyethylene (PE) plastic exhibited significantly lower respiration rates than in polypropylene (PP) plastic throughout the storage period at 5°C. This may be due to the different plastic materials used in PE and PP. Respiration rate is correlated with the senescence of plant tissue and can be used as an indicator for the rate of metabolism and perishability of plant tissue [19]. The respiration rate rises as the tissue undergoes senescence and deteriorates [20]. Temperature is an important factor affecting the quality of harvested herbs. All metabolism activities in plant tissues increased as the temperature increased, thus accelerating the senescence process.

Figure 11. Respiration rate of kesum leaves in different storage temperatures throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

Figure 12. Respiration rate of kesum leaves in different packaging (PP 0.04mm, PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

Storage temperature and type of packaging were also found to affect the total phenolic content (TPC) in kesum leaves during the storage period, as shown in Figures 13 and 14. There was an increase in TPC after 7 and 14 days of storage in all four storage temperatures. On day 14, there was no significant difference in TPC in temperatures of 5°C, 8°C and 10°C (148.58, 148.11, and 135.73 mg GAE/g), compared to temperatures of 13°C which showed a significant decrease in TPC (71.98 mg GAE/g). However, after 28 days, the TFC of kesum leaves was found to show significant differences between storage temperatures. An increase in storage temperature causes a decrease in TPC. Storage at 5°C maintained the highest TPC (137.33 mg GAE/g) and decreased in temperature of 8°C (119.73 mg GAE/g), 10°C (76.27 mg GAE/g) and lowest at 13°C (47.27 mg GAE/g). Storage in different packaging at 5°C showed that the TPC of kesum leaves increased from day 0 until day 14. There was no significant difference in TPC between kesum leaves in PE and PP plastic until day 14 of storage. However, on days 28 and 35, the TPC of kesum leaves in PE plastic was significantly higher (137.77 and 90.46 mg GAE/g, respectively) compared to PP plastic, where it decreased

significantly at day 28 and 35 (101.05 and 60.04 mg GAE/g). Kesum leaves are rich in various phenolic compounds. Vimala et al. [1] found 2800.6 mg/100g GAE of total phenolic content in kesum leaf aqueous extract, while Nor Syamimi et al. [7] reported 645.6 mg/100g GAE in methanol extract. Sasongko et al. [21] found 28 volatile compounds in extracts of fresh and dried kesum, where the significant compounds were eupatoriochromene, dodecanal, alpha-caryophyllene, beta-caryophyllene, and decanal.

Figure 13. Total phenolic content of kesum leaves at different storage temperatures throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

Except for 5ºC temperature, data measurements for temperatures 8ºC, 10ºC, and 13ºC were taken until 28 days of storage due to the samples' senescence.

Figure 14. Total phenolic content of kesum leaves in different packaging (PE 0.04mm, PP 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

The leaf's color of kesum during storage in different storage temperatures and packaging are shown in Figures 15 and 16. The a* value measures the green color, while the hue value indicates color intensity. The color value a* and hue at 5°C temperature remained stable throughout the storage period, indicating the green leaves color was retained. However, at temperatures of 8°C, 10°C, and 13°C, it was found that there was a change in color from green to brown after 21 days of storage, which showed an increase and decrease in a* and hue values, respectively. The packaging does not significantly affect the leaf's color value as there was no significant difference in a* and hue color value between PE and PP throughout the storage period. The decreased hue value during storage indicated the discoloration from green to yellow or browning [12].

Figure 15. The color value of kesum leaves in different storage temperatures throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

Except for 5ºC temperature, data measurements for temperatures 8ºC, 10ºC, and 13ºC were taken until 28 days of storage due to the samples' senescence

Figure 16. Color value of kesum leaves in different packaging (PP 0.04mm, PE 0.04mm) throughout the storage period

Different letters between treatments indicate significant differences at p=0.05 according to Duncan's Multiple Range Test

4. Conclusion

Temperature was found to affect some postharvest attributes during storage, especially total soluble solids content, pH, rate of respiration, total phenolic content, and color of

kesum leaves. Fresh kesum leaves stored at 5°C can maintain lower TSS content and respiration rate, higher total phenolic content, and color up to 35 days of the storage period, compared to temperatures 8°C, 10°C and 13°C where the quality declined earlier after 21 - 28 days of storage. However, the packaging did not significantly affect postharvest quality attributes such as color, TSS, and TTA. LDPE 0.04mm plastic was more suitable for packaging kesum because it kept the respiration rate lower and had higher total phenolic content than LDPP 0.04mm plastic. The findings of this study can be used as a guide for good postharvest practice for the postharvest handling of leafy herbs, especially kesum.

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