Study of Various Antibrowning Agents in Fresh-cut Apple cv Manalagi

N A Utama*, R Hardianti, K Julynasari, C K Setiawan
Department of Agrotechnology, Universitas Muhammadiyah Yogyakarta, Indonesia

*E-mail: nafi@umy.ac.id

Abstract. Cutting treatment on fresh-cut apple could lead to browning incident in fruit. Several chemicals could be used as an antibrowning agent. In this study, we compared several antibrowning agents in fresh-cut Apple cv Manalagi. This study was carried out in a single factor experimental design and arranged in completely randomized design (CRD) consisting of four treatments: 100 mmol L-Arginine, 150 ppm Citric Acid, 150 ppm Ascorbic Acid, 50 ppm Natrium metabisulfite, and control with no treatment. The result showed that Sodium metabisulfite and L-Arginine treatment significantly could inhibit browning in fresh-cut Apple cv Manalagi on day 10. L-arginine also showed a high overall score in panelist preferences in sensory test. Further study could explore on L-arginine potential as antibrowning agent for other fresh-cut fruit and vegetables.

1. Introduction

Apple has been known as one of the temperate fruit. Although it is known as a fruit cultivated by subtropical countries, there are three apple cultivar, which is growing in Indonesia, namely ‘Manalagi’, ‘Anna’, and ‘Rome Beauty’. Among them, apple ‘Manalagi’ is known as the main cultivar and widely cultivated in Malang, Indonesia [7]. Consumers nowadays tend to change their habits and lifestyle. They want to consume fresh fruit, but they do not have enough time to preserve it, such as fruit peeling. Fresh-cut fruit is one of the solutions to overcome this future trend. Fresh-cut fruit production and consumption raise significantly in current years. As reported in [4], this trend will increase by 19% In 2014. Healthy benefit, fresh and convenience is the top reasons. However, fresh-cut treatment brings several problems, such as browning and short shelf life due to cutting treatment [16]. Browning was happened because of the exposure of oxygens in the cutting surface that induce polyphenol degradation by polyphenol oxidase. The final product in the polyphenol degradation is quinone that will show brown color in the open surface [1]. Several techniques have been reported effectively to inhibit browning process. Among them, chemical antibrowning procedure is the most favorite with its convenience and inexpensive.

Many antibrowning agents have been used in apple, for example, ascorbic acid, sodium sulfite, citric acid, and arginine. Ascorbic acid has been known as natural antibrowning agent where it could be found easily in the plant tissue. Ascorbic acid is also recognized as inexpensive, safe, and customer-friendly [20]. Ascorbic acid treatments minimize browning of the surface and improve apple slices longevity, but for just a limited period, ascorbic acid could soften the tissue and encourage microbial production and fruit quality. After ascorbic acid is wholly oxidized into dehydroascorbic acid, quinones can be produced again and browned after the reaction leads to backward quinones being converted to phenolic compounds [10]. Sodium bisulfite is well known as an effective antibrowning and antimicrobial agent in apple [5] and was used on some processed fruits and
vegetables. However, the [9] banned sodium metabisulfite on fruits and vegetables due to its residues may lead to severe allergic reactions. As organic acid, citric acid could easily find in the fruit. Some researchers have been reviewed and mentioned that citric acid has antrowning properties in processed fruit [17]. Citric acid also could be used as combination treatment, such as combination of sodium metabisulfite and citric acid could increase the sweet potato shelf-life [22]. Arginine has been explored as antbrowning agents in apple by a previous study [27]. It was explained that L-arginine could produce nitric oxide that positively affects the browning process in apple [19].

Apple has been revealed some benefit for human health. High phenolic compound content in the apple could help as health-promoting, antimicrobial, anticarcinogenic, antiviral, and cholesterol-lowering [21]. However, in terms of Apple ‘Manalagi’, its benefit and product development are less explored in Indonesia. Previously, [25] reported that Carboxymethyl Cellulose coating with piper betel prolongs apple ‘Manalagi’ shelf life. In this study, several antibrowning agents were compared to find out the most effective browning inhibition in fresh-cut apple ‘Manalagi’.

2. Material and Method

2.1. Material and treatment applications

Apple ‘Manalagi’ were harvested 110 days after anthesis in Malang, Indonesia, and brought to the Postharvest laboratory, Universitas Muhammadiyah Yogyakarta, within 10h. Fruit was selected based on no defect and uniform characteristic. Selected fruit was stored in the chiller (14 ℃) until used. Fruit then cut in into six pieces each. Fresh-cut apple was dipped separately in different treatment, namely 50 ppm Sodium metabisulfite (MERCK) in 5 min, 100 mmol L-arginine in 10 min, 150 ppm Ascorbic Acid in 10 min, and 150 ppm Citric acid in 10 min. No dipping treatment was used as a control. Sodium metabisulfite used in this experiment is far lower than usually used in the previous application. Once it was treated, six pieces fresh-cut apple were placed in polystyrene trays. The trays were wrapped with PVC film and stored at ±10 ℃ until further observation. The analysis of total phenol compound, color (hue angle, L-value, chroma) as well as the sensory properties were carried out after 10 days of storage.

2.2. Fruit quality assessment

Three replications in each treatment were observed for weight loss (WL), Fruit firmness (FF), titratable acidity (TA), total soluble solids (TSS), and reducing sugar (RS). WL was estimated using weight on ten days reduced by weight on initial day and its expressed as percentage weight loss. In the FF parameter analysis, the Fruit Hardness Tester FHT200 (Extech Instruments, USA) was used. The samples were evaluated in three different points on its equatorial position using a 6 mm diameter probe. The result was expressed in N/mm2. The analysis of TSS was conducted with a hand refractometer (Atago, Japan). The instrument determined the TSS content of the sample’s juice after the homogenization of the flesh. The result of TSS analysis was shown in Brix unit. The measurement of RS was performed based on the Nelson-Somogyi Technique [25] and expressed in percentage. Absorbance observation was conducted with 540 nm abs using Spectrophotometer UV mini-1240 (Shimadzu, Japan).

2.3. Fruit flesh color

Nine replications units (3 rep x 3 positions) were observed for each treatment. The observation was done using chromameter CR-400 (Konika Minolta, Inc, Japan). This chromameter was calibrated using a white plate. The data used CIELAB color attribute and reported for its lightness (L value), chrome (C), and hue angle (h°) for each treatment [12].

2.4. Total phenolic content

Total phenol was determined based on the Folin–Ciocalteu method [23]. For each apple slice, one gram tissue was cut in the flesh adjacent to the core area to flesh adjacent to the skin at a point halfway
from the calyx to the core, and the sample was immediately homogenized at 4°C with 10 ml distilled water. A 0.5 ml sample was added five ml aquadest and FC reagent and sodium carbonate solution and the absorbance at 765 nm was determined. Gallic acid was the calibration standard and the data were expressed as mg/L gallic acid equivalents.

2.5. Sensory analysis

The analysis of sensory parameters in this study was performed based on a previous study by Utama, 2018 [25]. Fifteen semi-trained panellists analyzed the sensory using the 5-point hedonic scales (1=very dislike; 2=dislike; 3=neither like nor dislike; 4=like; 5= like very much). The sensory parameters evaluated were odor, taste, texture, and color. In addition, the overall likeness of each samples was also included in the questionnaire. The panellists consist of selected staff and students from the department. A preliminary sensory evaluation was conducted for the panellists to be familiar with the sample. The samples used in this analysis were the samples observed after ten days of storage.

2.6. Statistical analysis

The statistical analysis in this study was performed using the one-way analysis of variances (ANOVA). Afterward, a posthoc analysis was conducted using the Fisher LSD test. The data were analyzed using R studio program. Differences were significant when the p-value was less than 0.05.

3. Result and Discussion

Weight loss incident often happens in fresh-cut fruit. The results showed insignificant difference of weight loss (p > 0.05) between all treatments after 10 days of storage at 10 °C. The data indicated that all treatment could not inhibit moisture losses in the tissue. The composition of each treatment did not contain inhibition compound which could help to maintain water content. For example, edible coating from CMC could help to maintain weight loss fresh-cut apple by reducing water vapor permeability [26]. Fruit firmness is one of the main indicators related to fresh-cut fruit shelf life and the main indicator for fruit freshness [15, 18]. The bar chart in Figure 1B showed significantly (p<0.05) differences among all treatment. Sodium metabisulfite treatment showed a higher firmness score, while the control was the lowest firmness score. L-arginine and ascorbic acid treatment were lower than sodium metabisulfite but higher than the control treatment. Moreover, TSS and RS are reflected in quality changes in fresh-cut fruit and vegetables [3]. TS is generally associated with sweetness, and RS TSS and RS data is showed in Figure 1 C and D. Sodium metabisulfite and ascorbic acid treatment showed highest TSS content, but it becomes first and second-lowest among treatments in RS content. In the other hand, L-arginine showed lowest in TSS content but highest in RS content. The firmness and TSS maintained by sodium sulfite might be related to its ability to inhibit ACC oxidase activity during ethylene synthesis, resulting in less fruit quality declining during storage [11]. On the contrary, the result shown in the arginine treatment was the opposite of previous reports, suggesting that arginine treatment reduces postharvest broccoli respiration rate [24].

Total phenol content and color composition after storage in 10 days is presented in Figure 2. Sodium metabisulfite shown highest total phenol content compared to other treatments (p<0.05). In the other hand, citric acid shown lowest total phenol content (p<0.05). Findings confirmed that sodium sulfite could inactivate polyphenol oxidase, which is related to phenol oxidation [13, 14]. This relation could induce phenol accumulation in the tissue. On the other hand, citric acid also mentioned that it could not inhibit phenol oxidation alone. Citric acid normally cooperates with other chemical compounds to get better inhibition [17, 8].

The phenolic compound is an essential secondary metabolite in plants and plays a role in plant quality characteristics, especially appearance and flavor. Furthermore, these compounds were oxidized by polyphenol oxidase and peroxidase, resulting in quinone, which showed a brown color in the plant tissue [6]. The color observation in fresh-cut apple ‘Manalagi’ after 10 days of storage showed that L-
arginine has the highest hue angle (p<0.05) and shared high L value with other treatments except control. Nitric oxide resulting from L-arginine oxidation could help maintain color in the fresh-cut apple ‘Manalagi’ [27]. Sodium metabisulfite also acts as a slow releaser of sulfur oxide (SO₂) that previously mentioned could inhibit phenol oxidation in litchi [13] and banana [2].

![Figure 1](image1.jpg)

**Figure 1.** Effect of different antibrowning agents on (A) weight loss, (B) Firmness, (C) Total Soluble Solid (TSS), and (D) Reducing Sugar fresh-cut apple fruit ‘Manalagi’ after 10 days of storage at 10 ± 1 °C; 75 ± 10% RH. The different letters indicate a significant difference between the means after the Fisher’s LSD post hoc analysis (p > 0.05). SB = sodium metabisulfite; AR= L-arginine; AsA= ascorbic acid; CiA= citric acid; con= control, no treatment.

![Figure 2](image2.jpg)

**Figure 2.** Effect of different antibrowning agents on (A) Total phenol content, (B) hue angle, (C) L-value (TSS), and (D) chroma fresh-cut apple fruit ‘Manalagi’ after 10 days of storage at 10 ± 1 °C; 75 ± 10% RH. The different letters indicate a significant difference between the means after the Fisher’s LSD post hoc analysis (p > 0.05). SB = sodium metabisulfite; AR= L-arginine; AsA= ascorbic acid; CiA= citric acid; con= control, no treatment.
In the study, the sensory parameters evaluated were odor, taste, texture, and color. The overall acceptability was also carried out after 10 days at 10 °C (Figure 3). The result showed that sodium metabisulfite treatment had the highest score in color but quite low in taste and odor. On the other hand, L-arginine showed high taste, color, and texture, resulting in highest overall acceptability among all treatments. Low odor score in sodium metabisulfite might be correlated with SO$_2$ release [8] and accumulate in the packaging that affecting panelist preferences.

![Figure 3. The sensory analysis results of fresh-cut apple fruit ‘Manalagi’ with different antibrowning agents after 10 days of storage at 10 ± 1 °C; 75 ± 10% RH. SB = sodium metabisulfite; AR= L-arginine; AsA= ascorbic acid; CiA= citric acid; con= control, no treatment.]

4. Conclusion
In conclusion, sodium metabisulfite showed better result in this overall comparison study. However, because of the negative effect on sodium metabisulfite consumption resulting from severe allergic symptoms, it is important to find an alternative chemical application. L-arginine seems to promise alternative since it could inhibit browning color in fresh-cut apple ‘Manalagi’. Moreover, its tasteless and odorless characteristic could increase its potential to be applied in the real application.

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