Effect of *Aloe vera* gel combined with basil (*Ocimum basilicum* L.) essential oil as a natural coating on maintaining post-harvest quality of peach (*Prunus persica* L.) during storage

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**Abstract.** In this study, the effect of *Aloe vera* coating alone and combined with basil (*Ocimum basilicum*) essential oil at 500 and 1000 µL L⁻¹ concentrations on postharvest quality of peach (*Prunus persica* L.) was investigated. Parameters including weight loss, firmness, total soluble solids (TSS), color *L*, *a*, *b* and hue angle were measured during the storage. The results indicated that application of the *Aloe vera* alone or in combination with basil oil largely maintain the quality of the postharvest peach comparing to the untreated samples. In particular such application ameliorated the weight loss and reduction of firmness during storage. The maximum firmness was found in fruit treated with *Aloe vera* mixed basil oil at 1000 µL L⁻¹. Furthermore, coated fruit with *Aloe vera* mixed with basil oil at 1000 µL L⁻¹ illustrated the lowest TSS. However, influence of treatments on *L*, *a*, *b* and hue angle were not appreciable. These results verified the capability of composition of *Aloe vera* with basil oil on maintenance of the qualitative characteristics of peach fruit.

1. Introduction

Peach is a climacteric fruit which sustains quick ripening after harvesting due to the high respiration rate and weight loss, texture change, and internal browning. Rapid softening of the fruit and following mold growth lead to negative impact in marketing [1, 2, 3]. Several methods have been proposed in order to expand the shelf life of peach such as heat treatment [4], UV-B radiation [5], 1- methcyclopene [6], modified atmosphere packing [7], chemical treatments [8], and edible coating [9]. Recently, food industries have drawn attention to deployment of natural preservatives, as a coating [10], in food products with high quality, safety and environment sustainable development [11, 12, 13].

Natural edible coating has been considered as a preservative for delaying senescence of fruit by preventing transpiration and respiration of fruit surface [14]. This type of treatment not only maintains fruit quality as efficiently as modified atmosphere packing method [12], but also is simple and inexpensive [7, 15].

*Aloe vera* gel has been employed as a typical example of postharvest edible coating with high maintenance of postharvest qualities in several fruits such as kiwifruit slice [16], tomato [17], blueberry [18], strawberry [19], pomegranate arils [20], and orange [14]. *Aloe vera* gel is mainly composed of polysaccharides combined with soluble sugars, proteins, vitamins, and minerals, but with very low lipid
content [21]. Lipid content plays a key role in hydrophobic barrier properties of the edible coating [22]. A promising way to overcome the lipid deficiency in Aloe vera gel is to add essential oil to it which is rich in fatty acid [23]. Essential oil showed a significant effect in controlling decay and extending shelf life of fresh commodities [24, 25]. Essential oil of basil plant with 0.64 g/100 g fatty acid seems to be a good candidate, which is being used in food industry as antimicrobial and antioxidant additive agents to the food products [26, 27].

Since the combination of polysaccharide and lipid enhances the efficacy of coating in hydrophobic properties [23], in this study we presented the effect of incorporating of basil oil to Aloe vera gel as a novel coating on postharvest quality parameters of ripening in peach.

2. Materials and methods

2.1. Fruit preparation

Peach (Prunus persica L.) used in this study was obtained from JA Chikuzen Asakura located in Amagi, Fukuoka, Japan. Fifty peach fruit were selected based on uniformity of weight (almost 150 g), size, shape, color, and maturity. The homogeneous selected fruit were divided into 4 groups. Samples groups were dipped in the comparable solutions as distilled water (control), Aloe vera gel alone (AV), Aloe vera gel combined with 500 µL L\(^{-1}\) basil oil (AVBO1) and Aloe vera gel combined with 1000 µL L\(^{-1}\) basil oil (AVBO2) for 5 min. After treatment the surface dried at room temperature for 1 h and stored in an incubator (Nippon Medical & Chemical Instruments Co., Ltd.”) at 25°C and 85% of relative humidity (RH) for 7 days.

2.2. Edible coating preparation

The Aloe vera plants were obtained from a farmer in Chikugo, Fukuoka, Japan (August 2018). Aloe vera gel was extracted according to the previous work [28]. Briefly, fresh Aloe vera leaves parenchyma tissue was extracted manually and mixed in a blender (IFM-700 G, Iwatani, Japan). Leaf basil oil (100% purity), was provided from Yuwn Inc. Tokyo. Aloe vera enriched with 500 µL L\(^{-1}\) and 1000 µL L\(^{-1}\) basil essential oil were prepared by mixing basil oil in Tween-80 (0.001% (v/v)) and then added to Aloe vera gel (100 %) with which all are added up to 1 L.

Analytical determination of quality parameters such as weight loss, fruit firmness, TSS, and color were measured after the treatment at different sampling days (1, 3, 5 and 7 days of storage). Three fruits were used for each treatment.

2.3. Weight loss

Weight of each fruit was measured by a digital balance (EK-610i, A & D, Japan), before storage and in each sampling day. Weight loss was calculated by the following formula:

\[
[WL \, (\%)]_N = \left( \frac{W_0 - W_N}{W_0} \right) \times 100
\]

where WL is weight loss and \(N\) refers to the sampling day, \(W_0\) is weight before storage and \(W_N\) is weight at each sampling day.

2.4. Fruit firmness

A texture analyzer (RHEONER RE-3305, YAMADEN, Japan) was employed to determine the flesh firmness of fruit and adjusted with a 5 mm-diameter cylindrical plunger under load cell of 50 Kg and speed of 1.0 mm/s. The force required to penetrate the fruit to a depth of 5 mm was expressed in N (Newton).

2.5. TSS

The TSS was measured by an automatic refractometer (Atago, Japan). Three replicates for each treatment were determined.
2.6. Color
The color of the fruit was determined by using a chroma meter (CR-200, MINOLTA, Japan). The values of \( L^* \), \( a^* \), \( b^* \) and hue angle were measured for each fruit. Assays were performed twice with three replicates (3 fruit) per treatment.

\[
\text{Hue angle} = \tan^{-1} \left( \frac{b^*}{a^*} \right)
\]

2.7. Statistical and correlation Analysis
All experiments were carried out in triplicate based on a completely randomized design as factorial arrangement. Data was analyzed using SAS 9.1 software and the means were compared by PLSD (Protected Least Significant Difference) at \( p<0.01 \). Spearman correlation coefficients between the attributes were calculated using SPSS 20.0 software.

3. Results and discussion

3.1. Results of the analysis of variance
According to the results in Table 1, application of treatments significantly affected the fruit firmness, weight loss and TSS at \( p<0.01 \). Whereas, no significant differences were observed between coated and uncoated samples on color parameters. Moreover, the results showed considerable changes of parameter measurements during storage (Time) at \( p<0.01 \) except hue angle. There was no significant interaction between treatment and time (AB) in all characteristics except the firmness trait.

| S. V     | D.F | WL     | Firmness | TSS     | \( L^* \)  | \( a^* \)  | \( b^* \)  | Hue° |
|----------|-----|--------|----------|---------|-----------|-----------|-----------|------|
| Treatments (A) | 3   | 0.68*  | 1.303**  | 2.73**  | 20.71**ns | 13.26**ns | 12.66**ns | 0.014**ns |
| Time (B)    | 3   | 5.96** | 2.600**  | 15.98** | 249.88**  | 202.24**  | 93.54**   | 0.002**ns  |
| AB         | 9   | 0.07ns | 0.262**  | 0.75**  | 7.30**ns  | 1.28**ns  | 1.34**ns  | 0.001**ns  |
| Error      | 32  | 0.16   | 0.039    | 0.57    | 31.20     | 14.28     | 8.89      | 0.006      |
| C.V%       |     | 14.7   | 4.0      | 6.2     | 10.8      | 13.0      | 12.9      | 11.3      |

\( \text{ns} \) Not significant, *, **Significant at \( p<0.01 \). (WL: weight loss)

3.2. Weight loss
All samples showed a weight loss during storage (Table 2). The weight loss in uncoated peach was more pronounced during the storage compared to the coated fruit. Weight loss mainly occurs due to water vapor by transpiration and consumption of carbon by respiration [29]. Results indicated that reduction weight loss in samples treated by AVBO1 (10.67%) and AVBO2 (10.50%) was more than in AV (14.08 %) and control (15.67%) samples. This improvement relies on the lipid content of the basil oil which acts a key role in elevating the hydrophobic properties of the edible coating by inhibiting the transpiration and respiration rate [21]. While coating based on polysaccharide do not form efficient water-vapor barriers [30]. Current result was similar to the previous finding of gelatin and frog skin oil on persimmon [31], Aloe vera and Aloe arborescense mixed with rosehip essential oil on plum [22] and Aloe vera alone and mixed with ascorbic acid on strawberry [29]. Generally, attempts of researches is to reach a weight loss around to the 5% [3], that we obtained ~10% weight loss in AVBO2.

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Table 2. Interaction effect of time and treatment on weight loss (%) of peach during storage at 25 °C.

| Storage time | Control       | AV            | AVBO1         | AVBO2         |
|--------------|---------------|---------------|---------------|---------------|
| 1 Day        | 3.87±0.97X    | 3.71±2.05Y    | 3.26±2.42Y    | 3.13±0.69Y    |
| 3 Day        | 6.92±0.05X    | 6.24±0.62XY   | 5.10±1.19XY   | 4.62±0.79XY   |
| 5 Day        | 13.30±0.45W   | 10.32±0.36abWX| 8.48±2.17bWX  | 6.95±0.48bWX  |
| 7 Day        | 15.67±0.24W   | 14.08±0.83aw  | 10.67±0.9aw   | 10.50±0.80aw  |

* Means followed by similar letters are not significantly different according to LSD (p<0.01) test.
(a-b) Small letters have been used for comparison of treatments (row) in each time.
(x-y) Capital letters have been used for comparison of times (column) in each treatment.

3.3. Fruit firmness
Fruit firmness decreased during the storage (Table 3), but the rate of softening was more slowly in coated fruit. The firmness value in AV, AVBO1 and AVBO2 was ~30%, 32% and 46%, respectively, more than control (3.53 N) at the end of storage. These results are in agreement with study by Sogvar et al. [29] in strawberry. Lower firmness in control samples is due to the cell wall degradation by loss in cell turgidity pressure and mold growth [32]. Coating decelerates dehydration leading to the maintenance of turgor and/or pressure of cell wall [33]. Aloein and aloe-emodin in Aloe vera with antimicrobial activity play a preventive role against enzymes which have cell wall degradation activity [14]. Higher retention of firmness in AVBO2 samples in high concentration of basil oil could be due to the greater hydrophobic properties of barrier to moisture loss and outstanding antimicrobial activity in limiting the cell wall degrading enzymes [34]. This is also realized by the significant correlation (~0.913**) between firmness and weight loss (Table 4). This result is in agreement with report of Khorram et al. [30] who find correlation between orange fruit weight loss and firmness.

Table 3. Interaction effect of time and treatment on firmness (N) of peach during storage at 25 °C.

| Storage time | Control    | AV         | AVBO1      | AVBO2      |
|--------------|------------|------------|------------|------------|
| 1 Day        | 5.47±0.17W | 5.53±0.06W | 5.57±0.1W  | 5.53±0.22W |
| 3 Day        | 4.90±0.03X | 5.18±0.10WX| 5.20±0.15W | 5.25±0.21WX|
| 5 Day        | 4.10±0.07Y | 4.78±0.11abXY | 4.73±0.07bX | 5.19±0.11bW |
| 7 Day        | 3.53±0.03Z | 4.57±0.03YW | 4.71±0.05abX | 5.14±0.07W |

* Means followed by similar letters are not significantly different according to LSD (p<0.01) test.
(a-b) Small letters have been used for comparison of treatments (row) in each time.
(x-y) Capital letters have been used for comparison of times (column) in each treatment.

Table 4. Pearson’s Correlation coefficients between measured factors of peaches stored at 25 °C.

|        | WL       | Firmness | TSS | L*  | a*   | b*   | Hue* |
|--------|----------|----------|-----|-----|------|------|------|
| WL     | 1        |          |     |     |      |      |      |
| Firmness | -0.913**| -0.886**| 1   |     |      |      |      |
| TSS    | 0.928**  | -0.886**| 1   |     |      |      |      |
| L*     | -0.963** | 0.866**  | -0.951** | 1   |      |      |      |
| a*     | 0.971**  | -0.848**| 0.926**| -0.948** | 1   |      |      |
| b*     | 0.680**  | -0.466  | 0.651**| -0.729** | 0.785** | 1   |      |
| Hue*   | -0.627** | 0.702** | -0.566*| 0.513*  | -0.536* | 0.097 | 1   |

*, ** Correlation is significant at p<0.05 and p<0.01, respectively.
3.4. TSS
The TSS of control and coated samples increased with storage time (Table 5). However, the coated samples displayed the slow increase in TSS compared to the control one. It is also reported that *Aloe vera* gel coating led to a lower increase in the TSS in sour cherry [35] and raspberry [36]. The highest increase of TSS was observed in control, while the lowest increase was observed in AVBO2 treated fruit. Our finding is in a line with report of Nouruzi and Sayeri [32] by application of *Aloe vera* and seed basil oil on apricot and Sogvar et al. [29] by using *Aloe vera* and ascorbic acid on strawberry. During the fruit ripening process, the level of soluble sugars increases, and coating assists the slower ripening process by mitigation respiration rate [20, 31]. Therefore, the lower value of TSS in AVBO2 treated fruit compare other treatments could be related to the efficacy of coating with higher hydrophobic property to uptake O₂, consequently decrease respiratory and consumption of organic acids to change sugar [32]. Additionally, TSS in samples had positive correlation to weight loss (0.928**) and negative correlation with firmness (-0.886**) in Table 4 (p<0.01).

Table 5. Interaction effect of time and treatment on TSS (Brix) of peach during storage at 25 °C.

| Storage time | Treatments       | Control   | AV         | AVBO1     | AVBO2     |
|--------------|------------------|-----------|------------|-----------|-----------|
| 1 Day        |                  | 11.00±0.58^W | 10.67±0.33^X | 11.33±0.17^X | 10.67±0.33^W |
| 3 Day        |                  | 11.67±0.33^XY | 11.33±0.33^X | 11.67±0.33^X | 11.33±0.58^W |
| 5 Day        |                  | 12.83±0.33^X  | 12.33±0.33^WX | 12.33±0.33^WX | 11.67±0.67^W |
| 7 Day        |                  | 14.67±0.67^W  | 14.00±0.33^W  | 13.67±0.33^abW | 12.00±0.58^W |

*††* Means followed by similar letters are not significantly different according to LSD (p<0.01) test.

(a-b) Small letters have been used for comparison of treatments (row) in each time.

(x-y) Capital letters have been used for comparison of times (column) in each treatment.

3.5. Colour
The reduction in $L^*$ value represents the color darkening [37]. The results of $L^*$ value in this study indicated the darkening tendency during storage while no significant difference was observed among all samples. Likewise, in hue angle no notable difference was detected between coated and uncoated fruit during storage (data not showed). The color of peaches in terms of $a^*$ and $b^*$ values demonstrated increasing tendency during storage, although no significant differences observed between the coated and uncoated samples for 7 days storage (data not showed). Our results of color were similar with study of Kingwascharapong et al. [31] who found no significant difference between uncoated and coated persimmons by gelatin and frog skin oil.

4. Conclusion
In this study the effect of the combination of *Aloe vera* gel and basil oil as a new coating, on postharvest quality of peach fruit was investigated. This combination leads to the formation of higher barrier efficacy. According to the current results, *Aloe vera* mixed with 1000 µL L⁻¹ concentration of basil oil demonstrated the highest firmness, lowest weight loss and TSS. Finally, it is recommended to use *Aloe vera* gel supplemented with basil oil at of 1000 µL L⁻¹ concentration as a potential candidate for senescence inhibition of stored peaches. More studies are still needed, such as the possible effect of this treatment on reducing respiration rate and ethylene production and its effect on postharvest quality of peach under cold storage period. Moreover, future investigations should be focused on other fruits.
References

[1] Huan C, Jiang L, An X, Yu M, Xu Y and Ma R 2016 Postharvest Biol. Technol. 111 175
[2] Yang C, Chen T, Shen B, Sun S, Song H, Chen D and Xi W 2019 Int. J. Food Sci. Nutr. 7 3635
[3] Ranjan S, Chandrasekaran R, Paliyath G, Lim L and Subramanian J 2020 Food Package Shelf Life 23 100447
[4] Spadonina A, Cappellin L, Neria F, Algarra A, Romanob A, Guidicelli M, Gasperib F, Biasioliib F and Maria M 2015 Plant Pathol. J. 64 11
[5] Scattino C, Negrini N, Morgutti S, Cocucci M, Crisostio C H, Tonutti, P, Castagna A and Ranieria A 2016 J. Sci. Food Agric. 96 939
[6] Yu L, Shao X, Wei Y, Xu F and Wang H 2017 Postharvest Biol. Technol. 124 25
[7] Zhou H, Ye Z and Su M 2018 Hort. Sci. 53 511
[8] Kaur M and Kaur A 2019 J. Pharmacogn. Phytochem. 8 460
[9] Li X, Du X, Liu Y, Tong L, Wang Q and Li J 2019 Sci. Hortic. 257 685
[10] Choi J and Lee J 2016 J. of power Source 307 63
[11] Tavassoli-Karafini E, Shekarchizadeh H and Masoudpour M 2016 Carbohydr. Polym. 137 360
[12] Ncama K, Samukelo L, Mditshwa A, Koushesh Saba M. and Emamifar A 2015 J. HPFR Int. J. Biol. Macromol. 23 29
[13] Hassanpour H 2015 Food Sci. Technol. 598 109041.
[14] Nasiri M, Barzegar M, Sahari M and Niakousari M 2018 Int. J. Biol. Macromol. 106 218
[15] Qu T, Li B, Huang X, Li X, Ding Y, Chen J. and Tang X 2020 Food Bioprocess Tech. 13 404
[16] Ravanfar R, Niakousari M, and Mafloozanzad N 2014 J. Food Sci. Technol. 51 2872
[17] Karamoker P, Obatake W, Tanaka F and Tanaka F 2018 Environ. Control Biol. 56 177