

## APPLICATION OF EDIBLE FILM AND COATING BASED ON *ALOE VERA* GEL FOR PRESERVATION OF PHYSICOCHEMICAL PROPERTIES OF *PHYSALIS PERUVIANA* L. FRUITS

Marwa R. Ali\* and Mohamed E. Abdel-Aziz

Address(es):

Department of Food Science, Faculty of Agriculture, Cairo University, Giza, 12613, Egypt.

\*Corresponding author: [marwa3mrf@agr.cu.edu.eg](mailto:marwa3mrf@agr.cu.edu.eg)

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### ABSTRACT

The calyx removing of *Physalis peruviana* fruits for production of fresh cut fruit makes its shelf life shorter. So, *Aloe vera* gel (AV) used as edible film and coating for increasing the fruit shelf life of fresh cut *Physalis* fruit. The physical parameter of prepared AV films was investigated such as: Thickness, water vapor permeability (WVP) and water solubility. The current study evaluates the effect of AV film and coating for maintain the *Physalis peruviana* fruits without calyx at  $5\pm 1^\circ\text{C}$  and 95 % RH for 30 days. AV gel film was effective in controlling the fungal decay, which recorded the lowest value (4%) and reduced deterioration in all other physicochemical properties of *Physalis* fruit comparing with control. This study showed that the AV gel could be suitable for producing an edible film and coating with good physical characteristics such as low WVP ( $0.0037\text{g/m}^2\cdot\text{h}\cdot\text{mmHg}$ ). AV's low WVP appeared to have a great impact on maintaining post-harvest quality especially reducing the percentage of weight loss of coated fruit during storage.

**Keywords:** *Aloe Vera* gel – Coated fruit – Cold storage - *Physalis* – postharvest – Water vapor permeability

### INTRODUCTION

Consumers over the world need high-quality food with longer shelf life, without chemical preservatives. So, there are increasing efforts for developing natural antimicrobial and preservative materials. Different preservation techniques used for increasing the shelf life of fruits and vegetables after harvesting: refrigeration and MAP (Athmaselvi *et al.* 2013). The edible coating could be considered one of the promising technologies that have been used for keeping whole and minimally processed fruit's quality because of their advantages (El-Mogy *et al.* 2020). The edible coating has the ability to regulate the transfer of moisture, O<sub>2</sub>, CO<sub>2</sub>, flavor components in a food order. The edible coating has a similar effect of storage under controlled or MAP for increasing the shelf life of fresh vegetables and fruits (Castillo and Serrano 2005).

Many researches have been shown the usage of an edible coating based on AV gel for table grapes and nectarine (Martinez-Romero *et al.* 2006 and Ahmed *et al.* 2009), which would be one of the most interesting innovative methods in post-harvest treatments and commercial applications.

AV gel mainly composed of polysaccharides, the mucilage plays as a normal barrier to O<sub>2</sub> and moisture, which can increase the rate of food spoilage. Also, it could improve the safety of food. AV gel contains various antibiotic and antifungal components, like quinones and phenolic components (flavonoids) that may be responsible for delaying or inhibition of the growth of microorganisms for food-borne diseases in humans or food spoilage. The AV gel had an excellent effect as an antifungal against *Fusarium oxysporum* so, it was more effective for controlling fungal decay in cherry tomatoes (Ortega-Toro *et al.* 2017). AV gel edible coating showed a reduction in firmness loss, moisture loss, respiratory rate, development in maturity, delay browning index, and microorganism growth (Lin and Zhao 2007).

*Physalis* (*Physalis peruviana*) is a temperate climacteric fruit originated from America. *Physalis* fruit is round and small, covered with dark orange calyx and the fruit contain (150 – 300) seeds which responsible for the acid taste and considers a source of vitamins and flavonols. *Physalis* (*Physalis peruviana* L.) is known also as ground-cherry or cape gooseberry. *Physalis* fruits have an important role in nutrition as a very good base for all dietetic products. Highly valued for its unique flavor and color, several studies reported that *physalis* fruits are rich in many valuable compounds (Solange *et al.* 2016).

The calyx of *Physalis* fruit works to prolong the post-harvest life up to 67% when compared to the fruits without calyx and that may be due to the reduction in respiration rate, moisture loss and colour oxidation (Licodiedoff *et al.* 2013). According to Bolzan *et al.* (2011), the *Physalis peruviana* fruits without calyx

could be stored at  $2\pm 1^\circ\text{C}$  and  $90\pm 5\%$  relative humidity up to 58 days, nevertheless, such these conditions are so hard to obtain in the local market. The changes of the fruits depend on many factors such as the presence or absence of the fruit's calyx and storage temperature, which may lead to color change, weight loss %, softness and the relationship between total soluble solids and total titratable acidity, which responsible for taste and odor. Edible coating defined as a thin layer of edible materials which can apply and form on the surface of the products, maybe an alternate method to minimize changes in *Physalis* during storage (Licodiedoff *et al.* 2013).

This study aims to determine the physical characteristics of AV gel film as well as the effect of AV gel as an edible coating or film on minimizing the changes in physicochemical properties of *Physalis* fruits during cold storage and its role in enhancing the postharvest quality and shelf life of *Physalis*.

### MATERIALS AND METHODS

#### MATERIALS

*Aloe Vera* leaves and *Physalis* fresh fruits (*Physalis peruviana* L.) were purchased from the Faculty of Agriculture – Cairo University experimental station. The other ingredients used to prepare an AV gel film and coating [Corn starch with 12% moisture content], as a thickening agent and glycerol (98%) were purchased from El Nasr Pharmaceutical Co., Egypt.

#### Preparation of *Aloe vera* gel

The AV gel was prepared as described by Elbandy *et al.* (2014), then the AV gel was filtered for removing the fibers. After that, the gel pasteurized at  $100^\circ\text{C}$  for 4 minutes then cooled immediately for ambient temperature. After that, the pH of the AV gel was adjusted by using citric acid solution ( $4.5\text{g l}^{-1}$ ) to pH (4) as recommended by Adetnji *et al.* (2014). Also, the moisture content of gel was determined according to AOAC, Method 934.06 (1990).

#### Preparation of *Aloe vera* gel film and coating

The *Aloe vera* gel film or coating solution was formulated as follows: 5g of starch (as a thickening agent) was dissolved in 200 ml of distilled water and heated to  $95^\circ\text{C}$  and mixed thoroughly for 30 minutes until fully homogeneous. Finally, to obtain the volume in 400 ml, the AV gel (with moisture content 98.92 %) was also incorporated, 1.25 g of glycerol was added and the solution was held

hot for 10 min with mechanical stirring. 100 ml of the film-forming solution was poured and spread evenly over a Teflon plate (23 X 22 cm) by stainless steel spreader and dried for further evaluation at room temperature for 24 hours.

### Evaluation of the film characteristics

#### Film thicknesses

The film thickness was measured using the micrometer (Model 49 - 50 - 02, Messmer Instrument, Germany). Five measurements were done for each film sample and expressed as  $\mu\text{m}$  (Abd El Magied *et al.* 2009).

#### Water solubility (%)

The film scuttle in water was defined as the dry matter content which lost in water after 24 h of immersion. Two pieces of each film (1 X 4 cm diameter) were cut and weighed. One piece was dried at 105°C / 24 h for determining the initial dry matter percentage. The other piece was immersed in 50 ml of distilled water for 24 at 25°C with sporadic stirring. After that, the pieces of film were removed and dried to constant weight at 105°C for 24 h to determine the weight of dry matter that was dispersed in water. The water solubility % was determined as the average value of 3 measurements as follows (Sadegh *et al.* 2012):

$$\text{WS (\%)} = [\text{Initial dry matter(g)} - \text{Final dry matter(g)} / \text{Initial dry matter(g)}] \times 100$$

#### Water vapor permeability (WVP)

The WVP of AV film was determined according to an ASTM E96-00 procedure (2000). WVP defined as the easing of penetration of moisture and passing through the film hydrophilic portion.

#### Preparation of *Physalis* fruits

*Physalis* fruits were harvested and stored and 95 % RH, then treated in the next day. 360 fruits with uniform size, physical damage and fungal injury free were used. The calyx of the *Physalis* fruits were removed then the fruits dipped in chlorinated water then dried using tissue paper. About 120 fruits, randomly distributed in 6 Polypropylene trays (10 x 20 cm) with 20 fruits in each tray, for each treatment. Two tray of each treatment was taken for analyses every 6 days until the 30 days of storage period completed. Three treatments conducted, the first treatment was the control (fruit without coating); the second treatment: packaging fruits in AV pouch film and the third treatment: packaging of *Physalis* fruits in AV pouch film. The third treatment: coating of *Physalis* fruits with AV coating by dipping into the AV gel solution at 25°C for 1 min.

#### Physico-chemical properties of *Physalis* fruits

##### Decay

The decay was observed and determined visually as recommended by Shehata *et al.* (2020). The decay percent of coated and uncoated *Physalis* fruit was calculated as follows: [The number of decayed fruits / the number of total fruits] X 100

##### Weight loss

The weight loss percentage was calculated by the difference between the initial weight of fruits and the weight of fruits at 0, 6, 12, 18, 24 and 30 d multiplied by 100 (Awad *et al.* 2021).

##### Texture analysis

Fruits firmness was determined using a texture analyzer as described by Licodiedoff *et al.* (2016). Tissue firmness was measured by a texture analyzer (Force Gauge, Model M4-200, USA) with a 50 kg charge cell. A 2 mm-diameter cylinder pointer was used to analyze perforation. Speeds during the test were respectively, 3.3 mm.s<sup>-1</sup>, with a 5 mm penetration depth for the 30s. Results were given in N. The results were expressed as the mean of 3 determinations for each treatment.

##### Total soluble solids content

TSS (Brix°) was determined using a hand refractometer (PAL-3, ATAGO, Japan) according to AOAC method 22.024 (2005).

##### Browning Index

The fruit's color was measured using a colorimeter with a Minolta standard (KONICA MINOLTA, Japan) according to the method described by Ganjloo *et al.*, (2009). The color coordinates  $a^*$ ,  $b^*$  and  $L$  were used to calculate the

browning index (BI) for the mean of 3 determinations for each treatment according to the method described by Palou *et al.*, (1999).

$$\text{BI} = [100 (X - 0.31) / 0.172]$$

$$X = [(a^* + 1.75 L) / (5.645 L + a^* - 3.02 b^*)]$$

##### pH value

Fruit's pH measured using the digital pH meter (Hanna Instruments, HI 9219) according to Ali *et al.* (2021).

##### Titration acidity % (TA%)

Ten grams of fruit was homogenized and made up to 100 ml with distilled water. Then 10 ml of the aliquot was taken and titrated with 0.1 N NaOH in presence of Phenolphthalein as an indicator in triplicates, from the titer, the Titration acidity % was calculated (El – Mogy *et al.* 2019).

##### Maturity index (MI)

The maturity index was calculated according to Catarina *et al.* (2015) according to the following equation: MI = TSS/ %TA

##### Sensory evaluation

The consumer panels were used in this study consisted of untrained ten panelists from the staff of Food Science Department, Faculty of Agriculture, Cairo University, Giza, Egypt (6 females and 4 males, aged ranged from 25 to 45 y) was used for evaluating sensory quality of *Physalis* fruit after one day of coating and every 6 days of cold storage. The panelists do not know the experimental approach and the fruits were blind to artificial light at 25°C. The sensory criteria as color, texture, taste and overall acceptability were carried out based on a nine-point hedonic scale (1=dislike extremely, 3-4 = mild dislike, 5 = reasonable, 6 8 = moderate dislike, 9, like extremely) (Ali and EL Said, 2020).

##### Statistical analysis

The results were presented as mean  $\pm$  SD. The statistical analysis was performed using One-Way Analysis of Variance (ANOVA). Statistical significance was determined at ( $P < 0.05$ ). Statistical analyses were performed using Co-stat Statistics Software, version 6.4 (Co Hort Software, California, USA).

## RESULTS AND DISCUSSION

### Evaluation of the physical characteristics of the film

#### Film Thickness

Results show that AV film was flexible and transparent. The prepared AV film thickness was 65  $\mu\text{m}$ . The obtained results are in accordance with Ortega-Toro *et al.* (2017) who reported that starch-based film containing the highest ratio of AV gel (1:1) and plasticized with 0.15 g glycerol/g starch were more homogenous and had a higher gloss and transparency. Also, Pinzon *et al.* (2018) was shown that the thickness of starch-chitosan-*Aloe vera* gel film was increased 59.3 to 174.5  $\mu\text{m}$  with increasing of AV gel concentration 0 to 500 g/l. Abugoch *et al.* (2011) reported that the film thickness depends on the film chemical composition and the film-forming polymer nature. Also, Silva-Weiss *et al.* (2013) reported that the addition of polyphenolic compounds to starch-chitosan films have a crosslinking effect that leads to increase in thickness. A similar result was observed in this study of the AV film solution which contains 5g starch/ 200ml (as a thickening agent).

#### Water solubility

The obtained results were shown that the water solubility (WS) of AV gel was relatively low (20.65 %) in comparison with other types of polysaccharides polymer films. These can be observed by Sadegh *et al.* (2012) who noticed that an increment in the portion of AV gel was followed by a decreasing in the water solubility of *Aloe vera* gel incorporated into Chitosan films. A similar effect was also shown when Pinzon *et al.* (2018) added AV gel into the chitosan film at 50% concentration. The edible films with low water vapor permeability usually tend to have low water solubility. Even though it is important to know that the most components of the AV gel are polysaccharides, organic acids and amino acids, which have high water solubility, so they could easily soluble from the edible films. So, the lower water solubility of AV gel film or how the addition of AV to different types of edible polymers decreasing water solubility still unknown and need more study.

### Water vapor permeability (WVP)

The film composition hydrophilic–hydrophobic ratio plays an important role in water vapor permeability (WVP). The water vapor permeability of AV gel film at 30 °C and 0/100 % relative humidity was recorded as 0.0037 g.m<sup>-2</sup>.h.mmHg, which is considered relatively low in comparison with other polysaccharides polymer films. So, the AV gel addition could be used for reducing WVP with other types of polysaccharide polymer film as shown in the study of **Sadegh et al. (2012)** who found that AV gel incorporation had the potential role in enhancing the chitosan film barrier property to water vapor. **Ortega-Toro et al. (2017)** showed that the addition of AV gel into starch based Film (1:1 w/w) reduced water vapor permeability. Also, **Pinzon et al. (2018)** reported that, the addition of AV gel significantly decreases the water vapor permeability values of the banana starch–chitosan films 2.85 g Pa<sup>-1</sup> s<sup>-1</sup> m<sup>-1</sup> in films without AV gel to 1.99 g Pa<sup>-1</sup> s<sup>-1</sup> m<sup>-1</sup>. Also, he explained that, with the interaction between the AV gel components and starch–chitosan molecules, reducing the availability of the hydrophilic groups in all of starch and chitosan to interact with water and reducing the film's WVP.

### Physico-chemical properties of *Physalis* fruits

#### Decay

The maximum shelf life of fruits was defined as the time pass away between the application of coatings or films and the visual decay. Results in Table (1) showed that the decay increased significantly during storage. Percentage of decayed fruits was 12% for the control fruit after 18 days of storage period, however, shelf-life of the AV coated fruit and fruits packed in AV pouch film extended up to 18 days without decay. These results are in accordance with **Licodiedoff et al. (2016)** who reported that the edible coating of gelatin and calcium chloride markedly reduced the number of decayed fruits and prolonged the storage time up to 17 days without decay. This result is similar to the result of **Tripathi et al. (2004)**, who reported that AV gel was successful in reducing microorganism proliferation in table grape, the effect is higher for yeast and molds than for mesophilic aerobics. Moreover, **Brishti et al. (2014)** reported that decay percentage reached 27% of papaya fruits coated with AV gel compared with the control which reached to 100% at the end of storage. Also, **Ortega-Toro et al. (2017)** showed that, the starch-based film containing AV gel (1:1 w/w) was more effective for controlling fungal decay in cherry tomatoes because he found that, the AV gel has a good effect as antifungal especially for *Fusarium oxysporum*. The AV film was more effective for reducing the number of infected *physalis* fruits than the coated fruits. That was explained by **Cock, (2008)** who identified 26 bioactive phytochemical compounds in AV gel such as anthraquinones, dihydroxyanthraquinones, saponins, acemannan.

**Table 1** Effect of *Aloe vera* gel film and coating on physical properties of *Physalis* fruit during storage at 5±1°C for 30 days.

Physical properties	Treatment	Storage time at 5 °C (days)					
		1 day	6 days	12 days	18 days	24 days	30 days
Fungal decay %	Control	0.00 ± 0.00	0.00 ± 0.00	2.00 <sup>a</sup> ± 0.71	12.00 <sup>a</sup> ± 0.71	22.00 <sup>a</sup> ± 1.41	43.00 <sup>a</sup> ± 2.12
	Film	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.00 <sup>c</sup> ± 0.71	4.00 <sup>c</sup> ± 0.70
	Coating	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	3.00 <sup>b</sup> ± 0.71	6.00 <sup>b</sup> ± 1.41	10.00 <sup>b</sup> ± 0.71
Weight loss %	Control	0.00 ± 0.00	3.89 <sup>a</sup> ± 0.00	7.25 <sup>a</sup> ± 0.00	12.21 <sup>a</sup> ± 0.00	20.69 <sup>a</sup> ± 0.01	24.74 <sup>a</sup> ± 0.01
	Film	0.00 ± 0.00	3.12 <sup>b</sup> ± 0.05	6.11 <sup>b</sup> ± 0.04	10.3 <sup>b</sup> ± 0.11	15.69 <sup>b</sup> ± 0.03	18.05 <sup>b</sup> ± 0.06
	Coating	0.00 ± 0.00	3.03 <sup>b</sup> ± 0.04	5.31 <sup>c</sup> ± 0.13	9.08 <sup>c</sup> ± 0.00	14.09 <sup>c</sup> ± 0.01	16.25 <sup>c</sup> ± 0.02
Firmness (N)	Control	1.49 <sup>a</sup> ± 0.09	1.11 <sup>b</sup> ± 0.00	1.00 <sup>b</sup> ± 0.16	0.78 <sup>b</sup> ± 0.16	0.66 <sup>c</sup> ± 0.00	0.56 <sup>b</sup> ± 0.16
	Film	1.47 <sup>a</sup> ± 0.13	1.45 <sup>a</sup> ± 0.16	1.33 <sup>ab</sup> ± 0.00	1.22 <sup>a</sup> ± 0.16	0.88 <sup>b</sup> ± 0.00	0.88 <sup>ab</sup> ± 0.00
	Coating	1.66 <sup>a</sup> ± 0.16	1.56 <sup>a</sup> ± 0.00	1.45 <sup>a</sup> ± 0.16	1.33 <sup>a</sup> ± 0.00	1.11 <sup>a</sup> ± 0.00	1.00 <sup>a</sup> ± 0.16
TSS%	Control	8.85 <sup>a</sup> ± 0.01	11.00 <sup>a</sup> ± 0.00	11.25 <sup>a</sup> ± 0.64	12.15 <sup>a</sup> ± 0.91	12.9 <sup>a</sup> ± 0.26	13.50 <sup>a</sup> ± 1.27
	Film	8.75 <sup>a</sup> ± 0.01	9.65 <sup>ab</sup> ± 0.45	11.00 <sup>a</sup> ± 0.13	11.25 <sup>ab</sup> ± 0.25	11.30 <sup>b</sup> ± 0.13	12.20 <sup>b</sup> ± 0.01
	Coating	8.65 <sup>a</sup> ± 0.00	8.90 <sup>b</sup> ± 0.00	10.15 <sup>b</sup> ± 0.36	10.90 <sup>b</sup> ± 0.46	10.95 <sup>b</sup> ± 0.09	12.10 <sup>b</sup> ± 0.41

Means ± SD (n=3) in the same column followed by the same small letter are not significantly different (p < 0.05).

### Weight Loss

The results of weight loss% of all samples "Control (Non-coated fruits), coated and packed with the film" are shown in the table (1). Weight loss % of the fruits was increased with increasing the storage time for all treatments. The results showed a significant increase in weight loss for all treatments through storage time. However, the weight loss of the control sample was significantly higher than the other treatments. On the contrary, the *Physalis* fruits coated with the AV coating was superior to the other treated samples that had the lowest weight loss (16.25%) after 30 days of storage at 5°C. A similar effect was reported by **Mohebbi et al. (2014)** who showed that bell pepper coated with AV and gum tragacanth, which recorded the lowest values of weight loss (15.44 and 16.15%), respectively, meanwhile the weight loss of control reached to 26.80 % at the end of storage period (30 days) at 4°C. **Morillon et al. (2002)** explained that, the main cause of weight loss of fruit as a result of migration of water from the fruit to the environment during storage. The essential mechanism participating to weight loss is the water evaporation which activated by a flair of water vapor pressure at different sites in bell pepper. The mechanism is based on the coating hygroscopic properties, which has the ability for forming a barrier to water diffusion between the fruit and environment to avoid its external transference. From the previous result we found that the AV film had a lower WVP so, that may be the cause of reducing the weight loss % of coated or packed *physalis* fruits.

### Firmness

Results in the table (1) show that the firmness retention of AV coating and pouch film samples were statistically different compared to the control especially after 6 days of storage. The firmness of the control sample gradually decreased during the storage period, where it decreased by 62.4% after 30 days of storage at 5± 1 °C. At the end of the experiment (30 days), there is no significant difference (P<0.05) between the firmness retention of the AV coating and the AV pouch film

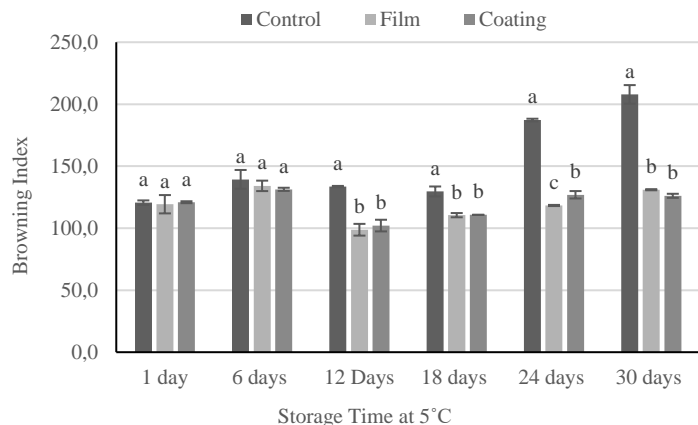
of *physalis* fruits (Table 1). A similar effect was observed by **Bolzan et al. (2011)** who reported that the firmness of fruits with or without calyx decreased during storage. Also, **Mohebbi et al. (2014)** reported that using of AV and gum tragacanth as a coating delayed the changes in texture and no excessive softness was noticed in bell peppers after 30 days of storage at 4 °C. The coating may also inhibit the activities of pectin-degrading enzymes closely related to decrease in texture by reducing the metabolic processes rate during senescence, which also participated in the maintenance of fruit hardness (**Gwanpua et al. 2014**).

### Total soluble solids content

The total soluble solids content (Birix<sup>o</sup>) of different *physalis* fruits, either coated or pouched and the control sample was presented in Table (1). It could be shown from the results that there were a significant differences between all the tested samples during storage times for the three treatments. As the storage time increased as directly proportional for the entire sample under investigation as shown in Table (1). Usage of AV gel blend coating or film enhance the protection of *physalis* fruits which could lower the change of TSS% which recorded 12.10% and 12.20 % at the end of storage respectively. On the other hand, the control sample recorded the highest percentage of TSS during all storage periods. The TSS% was 12.15, 12.9 and 13.50% after 18, 24 and 30 days respectively. The obtained results are in accordance with **Sharmin et al. (2015)**, who found that, the lowest TSS% 7.610% was found in papaya coated with AV gel (1.5%), compared with the control which recorded the highest value of TSS% 11.47% after 12 days of storage. **Valero1 and Serrano (2013)** reported that TSS in grape cultivars increase during storage as a consequence of the advancement of the postharvest ripening process. Such respiration phenomena and variance in TSS content occur together in different strength in accordance with the maturation stage. This may be due to the effect of AV gel coating on the lowering the activity of α-galactosidase, polygalacturonase and pectin methylesterase (**Nunan et al. 1998**).

**Browning index (BI)**

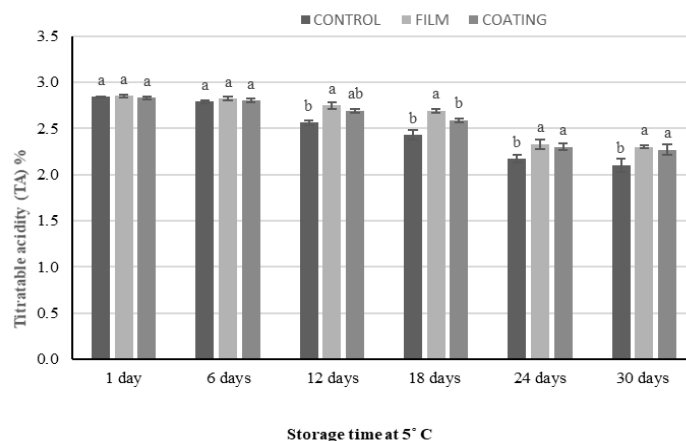
Figure (1) showed the result of the BI of *Physalis* fruits with AV edible film and coating stored at 5±1°C for 30 days. No significant difference was observed in all treatments for BI of *Physalis* fruit after 30 days of storage. All treatments up to 12 days of storage were in significantly ( $P < 0.05$ ). The AV gel (film or coating) could delay the increase in BI during storage which reached to 126.11 and 131.03, respectively compared with the control which reached to 207.72 at the end of storage. These results are in accordance with **Supapvanich et al. (2016)** who reported that, the ability of fresh AV gel for maintaining  $L^*$  and delaying the increase in browning index of apple slices after storage for 6 days at 4°C. According to previous articles, AV gel edible coating was shown a reduction in firmness loss, moisture loss, respiratory rate, development in maturity, delay browning index, and microorganism growth in fruits such as table grapes (**Martinez-Romero et al. 2006**) and nectarines (**Ahmed et al. 2009**) also, they suggested that the AV gel coating or film created a modified atmosphere around the fruits which reduced the production rate of ethylene, which, delay ripening, degradation of chlorophyll, accumulation of anthocyanin and synthesis of carotenoid and that lower fruits color surface changes.



**Figure 1** Effect of *Aloe vera* gel film and coating on browning index (BI) of *Physalis* fruit during storage at 5±1°C for 30 days. Means followed by different letters are significantly different ( $P < 0.05\%$ ).

**Titrateable acidity**

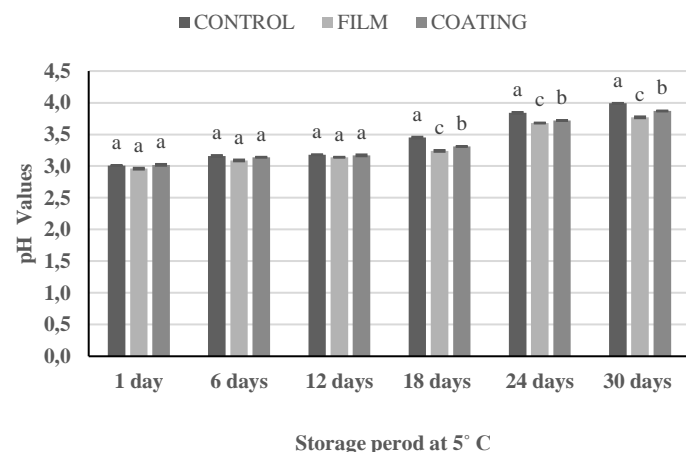
The total titrateable acidity (TA) was calculated as citric acid, which is the dominant acid in *physalis* fruits. Results in Fig. (2) show the changes of titrateable acidity (TA%) of different tested *physalis* fruits, either coated or packed with the AV as well as the control sample through different storage times (up to 30 days) at 5°C. A significant difference could be shown among all the tested samples. Data in Fig (2) show that the titrateable acidity for all the samples recorded the highest percentage of the initial storage (after one-day storage). However, as the storage time (days) increased, the titrateable acidity (%) decreased. The lower level of titrateable acidity could be noticed in the control sample at the end of storage time, which recorded 2.10 %. Meanwhile, the coated or packed samples with AV had almost the same percentage of titrateable acidity after 30 days of storage 2.27 and 2.30 %, respectively. Also, **Sharmin et al. (2015)**, reported that papaya fruits coated AV gel (0.5%) recorded the minimum change of titrable acidity (0.39 %). This retention of TA content by coated papaya was due to the protective effect of AV coating as a barrier to  $O_2$  from the surrounding atmosphere and reduction of respiration (**Srinu et al. 2012**). **Andrea et al. (2017)** who found that the decrease in titrateable acidity of Gooseberry fruits coated with calcium chloride demonstrates maturity development. They also noticed that the TA was decreased as storage time increased for all the tested samples. So, the application of AV film and coating support the postharvest life of *Physalis* fruits and prolong the shelf life due to a higher fruits content of acid. Therefore, **Valerol and Serrano (2013)** reported that mature fruits do not taste acidic because of the large amounts of accumulated sugars and the decrease of total acidity that usually occur during ripening.



**Figure 2** Effect of *Aloe vera* gel film and coating on titrateable acidity % of *Physalis* fruit during storage at 5±1°C for 30 days. Means followed by different letters are significantly different ( $P < 0.05\%$ ).

**pH value**

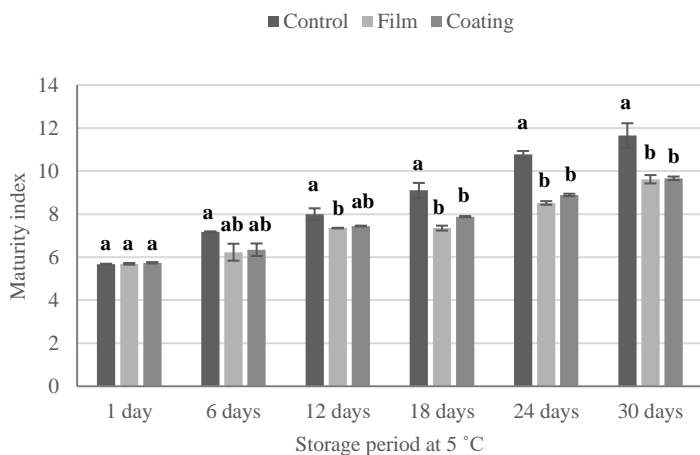
Figure (3) show the pH values for *Physalis* fruits stored at 5±1°C for 30 days for different treatments. The pH values of different tested *Physalis* fruits, either coated or packed with AV as well as the control sample through different storage times (up to 30 days) at 5 ± 1 °C. A significant difference could be shown among all the tested samples. Data in Fig (3) show that the pH values for all the samples recorded the lowest percentage of the initial storage (after one-day storage). However, as the storage time (days) increased, the pH values increased. The highest values of pH could be noticed in the control sample at the end of storage time, which recorded 3.99. Meanwhile, the packed fruits with AV had the lowest pH value (2.77) after 30 days of storage followed by the coated fruits which recorded (3.87). The obtained results in accordance with **Athmaselvi et al. (2013)** showed that the pH value of uncoated tomato after 20 days of storage was 4.15, whereas for tomato fruits coated with AV gel was 4.07. It may be suggested that the increase in pH values may be linked with the maturation process. The respiration process of fruits corresponds to the oxidation reactions of organic acids and carbohydrates which are converted to water and  $CO_2$ , and producing chemical energy during storage **Athmaselvi et al. (2013)**.



**Figure 3** Effect of *Aloe vera* gel film and coating on pH of *Physalis* fruit during storage at 5±1°C for 30 days. Means followed by different letters are significantly different ( $P < 0.05\%$ ).

**Maturity index**

Maturity index showed significant change during cold storage between control and other treatments meanwhile, no differences were observed between film and coating of AV gel (Fig 4). The obtained results were shown a higher maturity index of near 12 for control sample at the end of the storage period (30 days) comparing with other treatment of AV which recorded lower value near to 10. These results are in according with **Catarina et al. (2015)** Who observed lower maturity index (near to 9) in gooseberry fruits coated with Alginate and stored at 2°C for 21 days. The results showed the ability of AV gel coat or film for significantly decreasing the metabolism activity of fruit during the storage at 5°C without significant changes of the fruit organoleptic quality.



**Figure 4** Effect of *Aloe vera* gel film and coating on maturity index of *Physalis* fruit during storage at 5±1°C for 30 days.

Means followed by different letters are significantly different (P<0.05%).

**Sensory evaluation of *Physalis* fruits**

The results of the sensory evaluation of the three treatments for *Physalis* fruits illustrated in Table (2) showed significant differences (P <0.05). The coated fruits, as well as the fruits packed into the AV gel film, were superior compare to the control sample for color, taste, texture and overall acceptability up to 12 days of storage period that affected by the surrounded environmental conditions. Control *Physalis* fruits showed a great decrease in all the tested parameters throughout the storage times meanwhile, the coated or packed fruits looked shiny, attractive and did not produce an unacceptable odor or off-flavor. These results in accordance with **Martinez-Romero et al. (2006)** who reported that the cherry tomato coated with AV gel and stored for 16 days at 1°C had a good appearance and acceptable flavor than the control which, showed several symptoms of dehydration and color oxidation.

**Table 2** Sensory evaluation for *Physalis* fruits coated and packed in *Aloe Vera* gel edible film as well as control stored at 5±1°C for 30 days.

Parameter	Treatment	Storage time at 5 °C					
		1 day	6 days	12 days	18 days	24 days	30 days
Color	Control	9.0 <sup>a</sup> ± 0.0	8.0 <sup>b</sup> ± 0.0	8.0 <sup>a</sup> ± 0.0	8.0 <sup>a</sup> ± 0.0	6.5 <sup>a</sup> ± 0.7	5.8 <sup>b</sup> ± 0.4
	Film	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.7	7.6 <sup>a</sup> ± 0.4	7.3 <sup>a</sup> ± 0.0
	Coating	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.5	7.7 <sup>a</sup> ± 0.3	7.0 <sup>a</sup> ± 0.3
Taste	Control	9.0 <sup>a</sup> ± 0.0	8.0 <sup>a</sup> ± 0.0	8.0 <sup>a</sup> ± 0.0	7.0 <sup>b</sup> ± 0.0	6.6 <sup>b</sup> ± 0.7	4.7 <sup>b</sup> ± 0.4
	Film	9.0 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.7	8.5 <sup>a</sup> ± 0.7	8.5 <sup>a</sup> ± 0.0	7.8 <sup>a</sup> ± 0.4	7.0 <sup>a</sup> ± 0.4
	Coating	9.0 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.7	8.5 <sup>a</sup> ± 0.7	8.0 <sup>ab</sup> ± 0.7	7.3 <sup>ab</sup> ± 0.4	7.3 <sup>a</sup> ± 0.0
Texture	Control	9.0 <sup>a</sup> ± 0.0	8.0 <sup>a</sup> ± 0.0	7.5 <sup>a</sup> ± 0.7	6.3 <sup>b</sup> ± 0.4	5.3 <sup>b</sup> ± 0.3	5.0 <sup>b</sup> ± 0.0
	Film	9.0 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.0	8.8 <sup>a</sup> ± 0.7	7.8 <sup>a</sup> ± 0.4	7.4 <sup>a</sup> ± 0.1	7.3 <sup>a</sup> ± 0.0
	Coating	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.7	8.5 <sup>a</sup> ± 0.4	7.8 <sup>a</sup> ± 0.4	7.6 <sup>a</sup> ± 0.2	7.5 <sup>a</sup> ± 0.4
Overall acceptability	Control	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	8.0 <sup>b</sup> ± 0.0	7.0 <sup>b</sup> ± 0.0	6.3 <sup>b</sup> ± 0.4	4.5 <sup>b</sup> ± 0.0
	Film	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	8.3 <sup>ab</sup> ± 0.7	7.8 <sup>a</sup> ± 0.4	7.5 <sup>a</sup> ± 0.4
	Coating	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	9.0 <sup>a</sup> ± 0.0	8.5 <sup>a</sup> ± 0.4	8.3 <sup>a</sup> ± 0.4	7.8 <sup>a</sup> ± 0.0

Means ± SD (n=3) in the same column followed by the same small letter are not significantly different (p < 0.05).

**CONCLUSIONS**

The results of this study showed that the AV gel solution is suitable for producing an edible film and coating with good physical characteristics. Also, the current study showed the ability of *Aloe Vera* gel edible film and coating for prolonging the shelf life and maintain of the quality parameter of *Physalis* fruits. Edible film and coating showed a decreasing in fungal decay % comparing to control fruits. Moreover, *Aloe Vera* gel film and coating conserve the regarding of the physicochemical parameters for 30 days of storage at 5°C which, significantly reduced weight loss, firmness and retarded the changes on the color of *physalis* fruits.

**CONFLICT OF INTEREST:** Authors have no conflict of interest to declare.

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