Original article

Effects of *Aloe vera* coating on postharvest quality of tomato

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Abstract – Introduction. Edible coatings are traditionally used to improve food appearance and preservation. They act as barriers during processing, handling and storage, and do not solely retard food deterioration, enhancing its quality, but are safe due to natural biocide activity, or to the incorporation of antimicrobial compounds. The aim of this work was to evaluate the effect of *A. vera*, applied as an edible coating, on the changes in physicochemical parameters related to tomato fruit quality during storage in ambient conditions (22 °C and 80% RH), as well as its role in controlling microbial spoilage. **Materials and methods**. The changes in physical, chemical and textural properties of commercial tomato cv. Charleston were evaluated during a storage period of 17 days in ambient conditions according to their coating (treatments), or not (control), with an aqueous extract of pure *A. vera* or diluted (2:1) in distilled water. **Results**. The pure aqueous extract of *Aloe vera* totally inhibited the growth of *Rhizoctonia solani* and *Alternaria alternata*, while it did not show antimicrobial activity against *Phytophthora parasitica*. The diluted aqueous extract of *Aloe vera* coating maintained the quality of the tomatoes during storage in ambient conditions, delaying ripening, although it did not constitute an effective barrier against weight loss. **Conclusion**. Our fundamental results may be useful to breeders and postharvest technologists, as well as distributors, importers and exporters, in handling and processing tomatoes.

Cuba / *Lycopersicon sculentum* / fruits / keeping quality / edible films / *Aloe vera* / antimicrobial properties

Effets de l'enrobage d'*Aloe vera* sur la qualité post-récolte de la tomate.

Résumé – Introduction. Des enrobages comestibles sont traditionnellement utilisés pour améliorer l'aspect et la conservation des aliments. Ils protègent les fruits au cours de leur transformation, leur manutention et leur stockage ; non seulement ils retardent la détérioration des aliments en améliorant leur qualité, mais ils sont également sans danger en raison de leur activité biocide naturelle ou de leur teneur en composés antimicrobiens. Le but de notre travail a été d'évaluer l'effet d'*A. vera*, appliqué comme revêtement comestible, sur l'évolution des paramètres physico-chimiques liés à la qualité de tomates pendant leur stockage en conditions ambiantes (22 °C et 80 % HR), ainsi que de déterminer son rôle dans le contrôle de la contamination microbienne. **Matériel et méthodes**. L'évolution des propriétés physiques, chimiques et texturales de tomates cv. Charleston du commerce a été évaluée au cours d'une période de stockage de 17 jours en conditions ambiantes en fonction de leur enrobage (traitements), ou non (témoin), avec un extrait aqueux d'*A. vera* pur ou dilué (2:1) dans de l'eau distillée. **Résultats**. L'extrait aqueux d'*A. vera* pur a inhibé totalement la croissance de *Rhizoctonia solani* et *Alternaria alternata*, mais il n'a pas montré d'activité antimicrobienne contre *Phytophtora parasitica*. Le revêtement avec l'extrait aqueux d'*A. vera* dilué a maintenu la qualité des tomates durant leur stockage en conditions ambiantes et il a retardé leur maturation, mais il n'a pas constitué une barrière efficace contre la perte de poids. **Conclusion**. Nos résultats pourraient s'avérer utile aux producteurs et techniciens de postrécolte, ainsi qu'aux distributeurs, importateurs et exportateurs, lors de la manutention et de la transformation de la tomate.

Cuba / *Lycopersicon sculentum* / fruits / aptitude à la conservation / film comestible / *Aloe vera* / propriété antimicrobienne

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1. Introduction

Tomato has become the model species for climateric fruit ripening, due to its commercial importance, easy genetic manipulation, rapid cycle and year-round non-seasonal greenhouse fruit production. Consequently, much of our understanding about the regulation of climateric fruit ripening comes from studies on tomato, although research in other species is also reported.

Tomato quality changes continuously after harvesting. Fresh tomato quality is determined by appearance, color, firmness and flavor. The main quality indices are skin color, which is related to fruit ripening and affected by the lycopene concentration [1], and the total soluble solids-total acidity ratio attained at harvest. Fruit firmness is also an important quality attribute and is directly related to enhancement of storability potential and induction of greater resistance to decay and mechanical damage.

Tomato fruits deteriorate rapidly after harvest and in some cases after transport and marketing, and thus do not reach consumers at optimum quality. The main causes of tomato deterioration are weight loss, color changes, softening, surface pitting and loss of acidity, while small variations occur in total soluble solids [2]. Finally, special care is needed with the occurrence of decay, which is mainly due to species of the genera *Alternaria*, *Rhizopus*, *Botrytis*, *Geotrichum* and *Fusarium* [3], which can cause great economic losses although the occurrence of rots and their influence on tomato quality have been reported to be dependent on the cultivar and ripening stage at harvest [4]. Several pre- and postharvest technologies have been used to control decay, but the postharvest use of chemicals as fungicides is restricted in most countries and consumers demand agricultural commodities without pesticide residues [5].

Among these technologies, edible coatings are traditionally used to improve food appearance and preservation [6]. They act as barriers during processing, handling and storage, and do not solely retard food deterioration and enhance its quality, but are also safe due to natural biocide activity, or to the incorporation of antimicrobial compounds [7]. Different compounds have mainly been used as edible coatings to prevent commodity weight loss, including wax, milk proteins, celluloses, lipids, starch, zein, alginate and chitosan [7, 8]. Edible coatings based on chitosan reduced weight loss and softening, and extended the shelf life of tomato [4, 9].

Currently, there is increasing interest in the use of *Aloe vera* gel in the food industry, being used as a source of functional foods in drinks, beverages and ice creams [10]. Nevertheless, the processing techniques used to obtain *A. vera* gel are very important to ensure the product quality and to maintain almost all the bioactive components [11].

Aloe vera gel is the mucilaginous gel obtained from the squeezing of the clear jelly-like substance of the parenchyma tissue of *A. vera* leaves. *Aloe vera* gel has been reported to have multiple beneficial properties for wound healing, including the abilities to penetrate and anesthetize tissue, and preclude bacterial, fungal and viral growth, and also acts as an antiinflammatory agent and enhances blood flow [12–16].

Aloe vera is well known for its polysaccharides and anthraquinone derivatives. Besides, two new dihydrocoumarin derivatives with strong antioxidant activity were isolated [17]. This activity could also be shown for some aloesin derivatives, *e.g.*, isorabaichromone, feruloylaloesin and *p*-coumaroylaloesin [18].

It was reported [19] that the use of *A. vera* gel coating preserves the functional properties of table grapes, according to their developed patent [20]. In addition, the use of an edible coating based on *A. vera* gel as a postharvest treatment to maintain sweet cherry [21] and nectarine [22] quality and safety was reported.

Aloe vera gel, used as an edible coating in fruit, would be an innovative and interesting means for commercial application and an alternative to the use of postharvest chemical treatments. The aim of our work was to evaluate the effect of *A. vera*, applied as an edible coating, on the changes in physicochemical parameters related to tomato

fruit quality during storage in ambient conditions, as well as its role in controlling microbial spoilage.

2. Materials and methods

2.1. Qualitative evaluation of antimicrobial activity of the aqueous extract of *A. vera*

2.1.1. Microorganisms tested

Pathogenic microorganisms were selected for the study on the basis of their potential to cause contamination of fruit and vegetables. The fungal strains used for the screening were *Rhizoctonia solani* spp., *Alternaria alternata* spp. and *Phytophthora parasitica* spp.

2.1.2. Determination of antimicrobial activity

Culture tubes with 5 mL of sterile peptone water (0.01%, w/v) were inoculated with strains of fungi. The suspension was stirred vigorously using a magnetic stirrer and placed in contact with the aqueous extract of *A. vera* (pharmaceutical quality, 100% purity) manufactured by Pharmaceutical Laboratories Mario Muñoz (Havana, Cuba) with the following characteristics:

– liquid from yellow to dun-reddish colors with a characteristic odor,

– pH 4.8,

– soluble solids: 0.732%,

– total polysaccharides: 0.288%,

– density: 1.004 g·mL^{-1},

– bacteria (*Bacillus* Gram +) counts: inferior to 10 UFC·mL^{-1},

– fungi counts: 23 UFC·mL^{-1}.

The dilution agar method was used for this study. Each plate, containing Potato Dextrose Agar (PDA), was seeded with 1 mL of spore suspension of fungi. The antimicrobial activity was evaluated by observing the total or partial inhibition in the growth of the microorganism after 5 days of incubation at 30 °C. The experiment was carried out in triplicate.

2.2. Plant material and experimental design

Tomato fruits (*Lycopersicon sculentum* cv. Charleston) were harvested from a commercial farm and characterized. At the laboratory, fruits were selected, based on homogeneous colour (breaker stage) according to color standards for tomato [23], and size, absence of injuries and fungal infection. Some of them were used to analyze properties at harvest and the remainder were randomly divided into three batches. One of them was treated with *A. vera* L. aqueous extract (100% purity) and the second batch was treated with a solution of *A. vera* L. aqueous extract diluted 2:1 with distilled water. The treatment was performed at 22 °C by double immersion for 2 min in film-forming solutions. The other batch was immersed in distilled water and served as the control. Following the treatment, tomatoes were air-dried, packaged in perforated corrugated cardboard boxes and stored in ambient conditions (22 °C and 80% RH). Samples of each treatment, coated and uncoated, were taken out after (3, 5, 7, 10, 12, 14 and 17) days of storage and were immediately analyzed for quality and storage potential.

2.3. Quality attributes

2.3.1. Classification according to ripening stages

The tomatoes were classified according to their ripening stage using a visual scale [24]. The results were expressed as percentage of tomatoes in each ripening stage established by treatment.

2.3.2. pH, titrable acidity and soluble solids content

After firmness analysis, tomatoes were cut into small pieces and homogenized in a grinder, and 10 g of ground tomato were suspended in 100 mL of distilled water and then filtered. The pH and titratable acidity

Table I.
Qualitative evaluation of antimicrobial activity of the aqueous extract of *Aloe vera*.

Microorganisms	Distilled water	Aqueous extract of *Aloe vera*
Rhizoctonia solani	Without antimicrobial activity	Antimicrobial activity
Alternaria alternata	Without antimicrobial activity	Antimicrobial activity
Phytophthora parasitica	Without antimicrobial activity	Without antimicrobial activity

of the samples were assessed using a pH meter (Basic 20, Crison) [25] and titrated using 0.1 N NaOH. Titratable acidity was expressed as g citric acid·100 g^{-1} of tomato weight [26]. The soluble solids content was determined in the juice of ground tomatoes by an Atago RX-1000 digital refractometer (Atago Co. Ltd., Tokyo, Japan) at 25 °C and expressed as °Brix [27]. Measurements were made in triplicate.

2.3.3. Texture analysis

The instrument used was a cone penetrometer with a 30° cone angle (A. H. Thomas Co., USA). The mass of the cone assembly was 150 g. The penetration time used was 5 s [28]. Four replicates in an individual sample were done for each treatment. Each fruit was measured in the central zone. Firmness was measured as the maximum penetration distance reached during penetration time.

2.3.4. Weight loss and moisture content

Tomatoes were weighed at the beginning of the experiment just after coating and air-drying, and thereafter each sampling day during the storage period. Weight loss was expressed as the percentage loss of the initial total weight. For each measurement, 15 fruits corresponding to each treatment were used.

Moisture content was determined gravimetrically by drying 2.5 g of tomato samples in an oven at 105 °C until a constant weight was measured [29].

2.3.5. Physiological and fungal decay

The physiological decay of tomatoes was inspected visually at the end of the storage, evaluating the skin dehydration level (D1, D2, D3 and D4) of the products, D1 being up to 10% of dehydrated surface; D2, up to 30% of dehydrated surface; D3, more than 30% of dehydrated surface; and D4, excess ripening with visible fungal decay. Tomato fruits showing surface mycelial development were considered decayed. The tomato fruits that showed D3 or D4 dehydration levels were considered as deteriorated units. The results were expressed as percentage of damaged products.

2.4. Statistical analysis

All the experiments were performed in triplicate. Two-way ANOVA was performed using STATISTICS software [30] and Duncan's multiple range test was used for comparing differences among mean values. Mean values were reported, and the significance was defined at $p \leq 0.05$.

3. Results and discussions

3.1. Antimicrobial activity of the aqueous extract of *Aloe vera*

The evaluation of the antimicrobial activity of the aqueous extract of *A. vera* against *Rhizoctonia solani*, *Alternaria alternata* and *Phytophthora parasitica* showed that the aqueous extract of *A. vera* totally inhibited the growth of *R. solani* and *A. alternata*, while it did not have any effect against *P. parasitica* (*table I*).

The antifungal activity of *A. vera* has been reported against postharvest fruit pathogens, such as *Penicillium digitatum*, *P. expansum*, *B. cinerea* and *A. alternata* [31] and was based on the suppression of

germination and the inhibition of mycelial growth [21]. In addition, the inhibitory effects of several *Aloe* extracts have also been found on *Aspergillus niger*, *Cladosporium herbarum* and *Fusarium moniliforme*, and could be attributed mainly to the presence of *Aloe*-emodin and aloenin together with other active compounds [32], although the specific mechanism of action is still unknown. Moreover, the reduction of the growth of 17 bacteria by *A. vera* gel has been proven [15], being more effective against Gram-positive than Gram-negative microorganisms [33]. Some individual components found in *A. vera* gel, such as saponins, acemannan and anthraquinone derivatives, are known to have antibiotic activity, and could be responsible for its antibacterial activity.

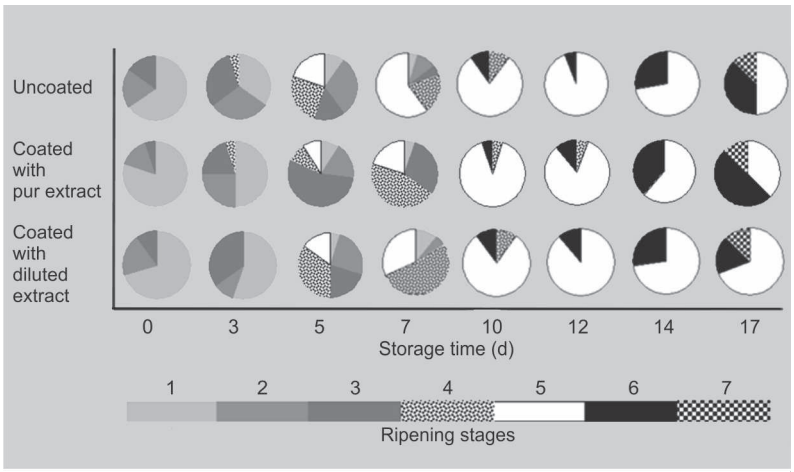

Figure 1.
Changes in ripening degree of tomatoes as a function of storage time at 22 °C for uncoated fruits (control) and fruits coated with *A. vera* L. aqueous extract, either pure, or diluted 2:1 with distilled water.

3.2. Classification according to ripening stages

If we keep in consideration that the tomato variety studied (*L. sculentum* cv. Charleston) does not have a long life and that its commercialization cycle is between (10 and 12) days in refrigeration at 6–8 °C, it was found that the treatment of tomatoes coated with the non-diluted *A. vera* L. aqueous extract (T1) was the most effective; indeed, in this treatment, tomatoes in ripening state 4 were observed until the 12th day of storage, while in the control fruits (TC) and in the tomatoes coated with *A. vera* L. aqueous extract diluted 2:1 (T2), higher percentages of tomatoes in more advanced ripening states (5 and 6) existed (*figure 1*).

3.3. pH, titratable acidity and soluble solids content

The pH values showed a significant increase ($p \leq 0.05$) during the first two weeks of the experiment; a decrease in these values toward the end of the storage period took place, while no significant differences ($p \leq 0.05$) were observed among treatments (*figure 2*). pH values between 4 and 4.4 for tomatoes cv. FA-180 coated with chitosan were reported [34]; similar results were found in the present study, where the values oscillated between 4.2 and 4.6.

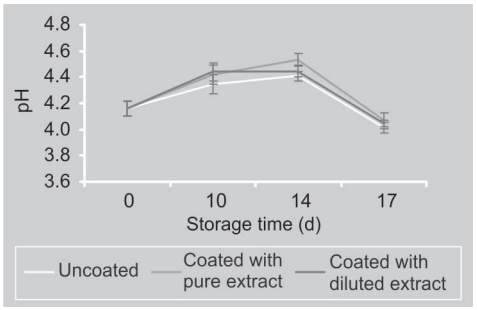

Figure 2.
Changes in pH of tomatoes as a function of storage time at 22 °C for uncoated fruits (control) and fruits coated with *A. vera* L. aqueous extract, either pure, or diluted 2:1 with distilled water. Vertical bars indicate confidence intervals (n = 3).

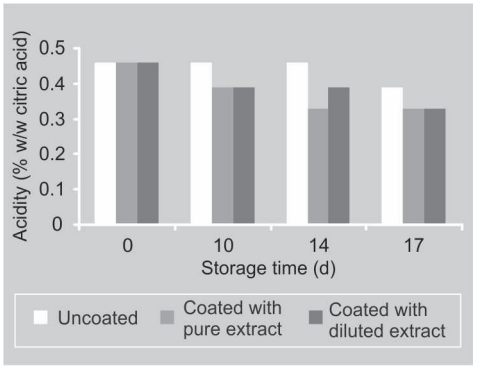

Figure 3.
Changes in acidity content of tomatoes as a function of storage time at 22 °C for uncoated fruits (control) and fruits coated with *A. vera* L. aqueous extract, either pure, or diluted 2:1 with distilled water. Vertical bars indicate confidence intervals (n = 3).

No significant differences ($p \leq 0.05$) were observed between coated samples for changes in titratable acidity values (*figure 3*), but these samples differed significantly ($p \leq 0.05$) with the values obtained for

Table II.
Changes in soluble solids content (°Brix) of tomatoes as a function of storage time at 22 °C (n = 3). Mean (standard deviation).

Time (d)	Control	Treatments with *Aloe vera* L. aqueous extract	
		Without dilution	Diluted 2:1 with distilled water
0	2.57 (0.10) a	2.57 (0.10) a	2.57 (0.10) a
10	3.17 (0.10) c	2.87 (0.05) b	3.17 (0.05) c
14	3.67 (0.05) d	2.57 (0.05) a	3.83 (0.05) d
17	3.83 (0.10) d	3.27 (0.05) c	3.63 (0.20) d

Different letters in the same column differ significantly ($p \leq 0.05$).

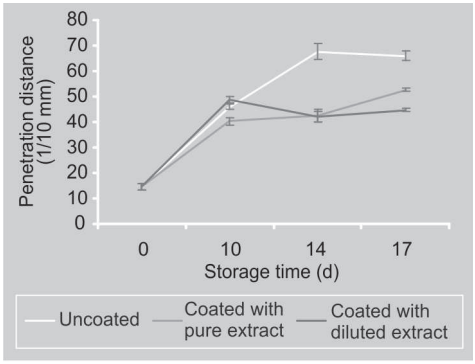

Figure 4.
Effect of *Aloe vera* coatings on the firmness of tomatoes stored at 22 °C for uncoated fruits (control) and fruits coated with *A. vera* L. aqueous extract, either pure, or diluted 2:1 with distilled water. Vertical bars indicate confidence intervals (n = 4).

uncoated samples. As can be observed, there was a correspondence between the behavior of the titratable acidity and pH values, respectively, during the storage. The uncoated tomatoes, although they were the most ripe, presented higher titratable acidity values than coated tomatoes, which coincides with reports by other authors [34].

The small differences found in pH and titratable acidity values during storage between uncoated and coated tomatoes could be related to the loss of water by samples since titratable acidity is given as a percentage of citric acid per tomato wet weight.

The soluble solids content is the index that most affects the yield during the elaboration of tomato products. Nevertheless, it is reported that this indicator increases, but not considerably, during the ripening of tomato fruits [35]. Changes in the soluble solids content of tomatoes over the storage period showed an increase ($p \leq 0.05$) during the storage, being significantly higher ($p \leq 0.05$) in uncoated tomatoes and those coated with diluted extract of *A. vera* (*table II*). This observation could be associated with the differences observed in the ripening state (*figure 1*). The increase in the soluble solids content of tomatoes is related to changes in the cellular wall, especially the pectic substances and hemicellulose [36], associated with changes in the firmness of tomato fruits. Samples coated with the pure extract of *A. vera* showed a lower increase in soluble solids content. An increase in soluble solids content in control and coated tomatoes was also reported [37]. It can be expected that soluble solids content increases during tomato ripening and decreases in mature fruit due to respiration [38].

The [soluble solids content / titratable acidity] ratio is considered as a ripening index for citric fruits; however, in tomato, this index is used as an indicator of flavor [1]. In this case, this ratio was mostly influenced by the soluble solids content values, since the titratable acidity had almost no change among treatments during storage. These results coincide with those reported by other authors [34, 39].

3.4. Firmness

When studying the changes in the firmness, evaluated as penetration distance, of control and treated fruits during the storage period of 17 days at 22 °C, all the samples presented similar initial firmness values ($p \leq 0.05$) and lost their firmness gradually during the storage period ($p \leq 0.05$) (*figure 4*).

The loss of firmness during the storage period is a normal behavior during the maturation of tomatoes, since it has been

Table III.
Loss of weight (%) of tomatoes as a function of storage time at 22 °C.
Mean (standard deviation).

Time (d)	Control	Treatments with *Aloe vera* L. aqueous extract	
		Without dilution	Diluted 2:1 with distilled water
3	0.8 (0.2)	0.8 (0.2)	0.7 (0.2)
5	1.6 (0.4)	1.7 (0.5)	1.4 (0.5)
7	2.4 (0.6)	2.5 (0.8)	2.3 (0.7)
10	3.4 (0.9)	3.6 (1.0)	3.2 (1.0)
12	4.1 (1.0)	4.3 (1.0)	3.9 (1.0)
14	4.6 (1.0)	4.9 (1.0)	4.5 (1.0)
17	5.6 (1.0)	5.8 (1.0)	5.4 (1.0)

reported that the increase in the ethylene concentration in this stage promotes the synthesis of polygalacturonase, the enzyme responsible for softening [40]. *Aloe vera* coatings exerted a beneficial effect on fruit firmness such that, by the end of the storage period, both the treatments gave rise to fruit with higher firmness values than untreated fruit ($p \leq 0.05$) (*figure 4*).

Some authors reported similar results for table grapes and cherries coated with *A. vera* gel diluted 1:3, observing a delay in the loss of firmness as well as in the evolution of the color and an increment in the ripening index ([SSC/TA] ratio) in the coated fruits, mostly due to the fact that the coatings lowered the respiration rate during postharvest storage [21, 41].

3.5. Weight loss and moisture content

All treatments showed a gradual loss of weight during storage (*table III*). As can be observed, the coating of *A. vera* aqueous extract did not delay ($p \leq 0.05$) the moisture loss, this effect being similar to those obtained with other edible coatings [34].

Although the *A. vera* coatings did not reduce the weight loss, the values of this parameter did not affect, in any of the cases, the quality of stored fruits, considering as an index of the end of the shelf life in tomato a physiological loss of weight of 10% [42, 43].

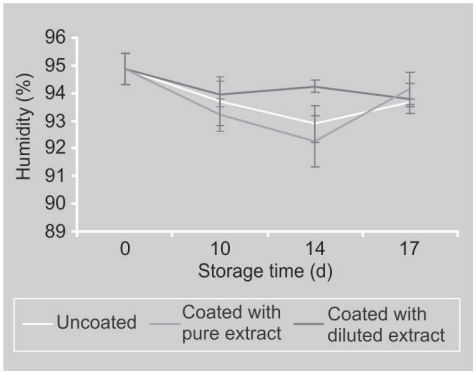

Figure 5.
Changes in humidity content of tomatoes as a function of storage time at 22 °C for uncoated fruits (control) and fruits coated with *A. vera* L. aqueous extract, either pure, or diluted 2:1 with distilled water. Vertical bars indicate confidence intervals ($n = 3$).

The moisture content showed a significant reduction ($p \leq 0.05$) for all treatments during the storage (*figure 5*), while significant differences ($p \leq 0.05$) between coated and uncoated samples were not observed.

In contrast with our results for weight loss during storage, it was reported that the *A. vera* gel coating was effective as a physical barrier and thus reduced the weight loss and lowered the respiration rate during the postharvest storage of table grapes and cherries, respectively [21, 41]. The mechanism for these positive effects is based on their hygroscopic properties, which enables formation of a barrier to water diffusion between the fruit and the environment, thus avoiding its external transference [44]. Composite coatings of polysaccharide-lipid are known to increase water barrier efficacy with increased lipid content and in turn more reduction of weight loss could be achieved [45]. However, *A. vera* gel, the

Table IV.
Loss of fruit (%) due to physiological and fungal decay at the end of the storage at 22 °C during 17 days.

Treatments		Dehydrated surface			Total
		Until 10%	Until 30%	> 30%	
Control		18.75	25	43.75	87.50
Treatments with *Aloe vera* L. aqueous extract	Without dilution	31.25	25	18.75	75
	Diluted 2:1 with distilled water	43.75	25	6.25	75

composition of which is mainly polysaccharides [46], was highly effective as a moisture barrier without the lipid incorporation.

3.6. Loss of fruit due to physiological and fungal decay

Aspect is a critical quality attribute in the consumer acceptability of fresh fruit and vegetables. When considering the losses of fruit due to physiological and fungal decay at the end of the storage, we observed that uncoated and coated tomatoes did not show signs of fungal decay after the storage at 22 °C for 17 days (*table IV*); nevertheless, the control units (TC) showed the biggest percentages of wrinkled tomatoes by dehydration, although there were no significant differences ($p \leq 0.05$) in the weight loss among treatments (*table IV*); additionally, the uncoated tomatoes presented the lowest firmness values (*figure 4*).

4. Conclusion

The pure aqueous extract of *Aloe vera* totally inhibited the growth of *Rhizoctonia solani* and *Alternaria alternata*, while it did not show antimicrobial activity against *Phytophthora parasitica*. The aqueous extract of *Aloe vera* coating, with respect to the diluted extract, maintained the stability of the tomatoes cv. Charleston during storage in ambient conditions, delaying the ripening, although it did not constitute an effective barrier against weight loss.

References

[1] Artés F., Artés-Hernández F., Tratamientos postrecolección del tomate fresco. Tendencias e Innovaciones, in: Namesny A. (Ed.), Tomates. Producción y comercio, Ed. Hortic. S.L. Reus, Spain, 2004.

[2] Kader A.A., Modified atmospheres during transport and storage, in: Kader A.A. (Ed.), Postharvest technology of horticultural crops, Univ. Calif., U.S.A., 2000.

[3] Escriche A.J., Marín J.G., Alteraciones de origen patológico en la postrecolección. III. Tomate, Phytoma 65 (1995) 26–33.

[4] Díaz R., Casariego A., Rodríguez J., Martínez A., García, M., Coberturas de quitosana como método de envasado activo en vegetales enteros y cortados, Cienc. Tecnol. Alim. 20 (2010) 31–36.

[5] Wilcock A., Pun M., Khanona J., Aung M., Consumer attitudes, knowledge and behaviour: a review of food safety issues, Trends Food Sci. Technol. 15 (2004) 56–66.

[6] Aguiar R.P., Miranda M.R.A., Lima A.M.P., Mosca J.L., Moreira R.A., Eneas J., Effect of a galactomannan coating on mango postharvest physicochemical quality parameters and physiology, Fruits 66 (2011) 269–278.

[7] García M., Películas y cubiertas de quitosana en la conservación de vegetales, Cienc. Tecnol. Alim. 18 (2008) 71–76.

[8] Cha D.S., Chinnan M., Biopolymer-based antimicrobial packaging: a review, Crit. Rev. Food Sci. Nutr. 44 (2004) 223–237.

[9] Rodríguez M., Ramos V., Del Blanco L., Agulló E., Preservación de tomates con aplicación de capas de quitosano, Inf. Tecnol. 11 (2000) 25–31.

[10] Moore E.D., MacAnalley B.H., A drink containing mucilaginous polysaccharides and

its preparation, U.S. Patent 5 (1995) 443, 830.

[11] He Q., Changhong L., Kojo E., Tian, Z., Quality and safety assurance in the processing of *Aloe vera* gel juice, Food Control 16 (2005) 95–104.

[12] Davis R.H., DiDonato J.J., Hartman, G.M., Haas R.C., Anti-inflammatory and wound healing activity of a growth substance in *Aloe vera*, J. Am. Podiat. Med. Assoc. 84 (1994) 77–81.

[13] Grindlay D., Reynolds T., The *Aloe vera* phenomenon: A review of the properties and modern used of the leaf parenchyma gel, J. Ethnopharmacol. 16 (1986) 117–151.

[14] Heggers J.P., Kucukcelebi A., Listengarten D., Stabenau J., Ko F., Broemeling L.D., Beneficial effect of *Aloe* on wound healing in an excisional wound model, J. Altern. Complement. Med. 2 (1996) 271–277.

[15] Reynolds T., Dweck, A.C., *Aloe vera* leaf gel: a review update, J. Ethnopharmacol. 68 (1999) 3–37.

[16] Yao H., Chen Y., Li S., Huang L., Chen W., Lin X., Promotion proliferation effect of a polysaccharide from *Aloe barbadensis* Miller on human fibroblasts *in vitro*, Int. J. Biol. Macromol. 45 (2009) 152–156.

[17] Zhang X.F., Wang H.M., Song Y.L., Nie L.H., Wang L.F., Liu B., Shen P.P., Liu Y., Isolation, structure elucidation, antioxidative and immunomodulatory properties of two novel dihydrocoumarins from *Aloe vera*, Bioorg. Med. Chem. Lett. 16 (2006) 949–953.

[18] Yagi A., Hamada K., Mihashi K., Harada N., Nishioka I., Structure determination of polysaccharides in *Aloe saponaria* (Hill) haw (Liliaceae), J. Pharmacol. Sci. 73 (2002) 62–65.

[19] Serrano M., Valverde J.M., Guillén F., Castillo S., Martinez-Romero D., Valero D., Use of *Aloe vera* gel coating preserves the functional properties of table grapes, J. Agr. Food Chem. 54 (2006) 3882–3886.

[20] Martínez-Romero D., Serrano M., Valero D., Castillo S., Aplicación de *Aloe vera* como recubrimiento sobre frutas y hortalizas, Spain Patent 200302937, 2003.

[21] Martínez-Romero D., Alburquerque N., Valverde J.M., Guillén F., Castillo, S., Valero D., Serrano M., Postharvest sweet cherry quality and safety maintenance by *Aloe vera* treatment: a new edible coating, Postharvest Biol. Tecnol. 39 (2006) 93–100.

[22] Ahmed M.J., Singh Z., Khan A.S., Postharvest *Aloe vera* gel-coating modulates fruit ripening and quality of 'Arctic Snow' nectarine kept in ambient and cold storage, Int. J. Food Sci. Technol. 44 (2009) 1024–1033.

[23] Anon. Dep. Agric., United states standards for grades of fresh tomatoes, U.S. Dep. Agric. (USDA), Wash., D.C., U.S.A., 1991.

[24] Wills R., McGlasson B., Graham D., Joyce, D., Introducción a la fisiología y manipulación poscosecha de frutas, hortalizas y plantas ornamentales, 2nd ed., Acribia, Zaragoza, Spain, 1998, 240 p.

[25] Anon., Productos de frutas y vegetales. Determinación del pH, NC-ISO 1842, Of. Nac. Normal., La Habana, Cuba, 2001.

[26] Anon., Productos de frutas y vegetales. Determinación de la acidez valorable, NC-ISO 750, Of. Nac. Normal., La Habana, Cuba, 2001.

[27] Anon., Productos de frutas y vegetales. Determinación del contenido de sólidos solubles. Método refractométrico, NC-ISO 2173, Of. Nac. Normal., La Habana, Cuba, 2001.

[28] Hayakawa M., Deman J., Interpretation of cone penetrometer consistency measurements of fats, J. Texture Stud. 13 (1982) 201–210.

[29] Anon., Official methods of analysis, 17th ed., in: Horwitz W. (Ed.), Assoc. Off. Anal. Chem. (AOAC), Wash., DC., U.S.A., 2003.

[30] Anon., STATSOFT. Statistics for Windows: release 5.1, Tulsa, U.S.A., 1998.

[31] Jasso de Rodríguez D., Hernández-Castillo D., Rodríguez-García R., Angulo-Sánchez J.L., Antifungal activity *in vitro* of *Aloe vera* pulp and liquid fraction against plant pathogenic fungi, Ind. Crop. Prod. 21 (2005) 81–87.

[32] Ali M.I.A., Shalaby N.M.M., Elgamai M.H.A., Mousa A.S.M., Antifungal effects of different plant extracts and their major components of selected *Aloe* species, Phytother. Res. 13 (1999) 401–407.

[33] Ferro V.A., Bradbury F., Cameron P., Shakir E., Rahman S.R., Stinson W.H., *In vitro* susceptibilities of *Shigella flexneri* and *Streptococcus pyogenes* to inner gel of *Aloe barbadensis* Miller, Antimicrob. Agents Chemother. 47 (2003) 1137–1139.

[34] García M., Empleo de coberturas de quitosana en la conservación de productos hortofrutícolas, Univ. Havana, Thesis, Havana, Cuba, 2009, 80 p.

[35] Gross K.C., Wang C.Y., Saltveit M., The commercial storage of fruits, vegetables, and florist and nursery stocks, in: Agricultural handbook No. 66, USDA, U.S.A., 2003.

[36] Giovannoni J.J., Genetic regulation of fruit development and ripening, Plant Cell 16 (2004) 170–180.

[37] Park H.J., Chinnan M.S., Shewfelt R.L., Edible coating effects on storage life and quality of tomatoes, J. Food Sci. 59 (1994) 568–570.

[38] Beckles D.M., Hong N., Stamova L., Luengwilai K., Biochemical factors contributing to tomato fruit sugar content: a review, Fruits 67 (2012) 49–64.

[39] Santa-Cruz S., Aplicación del ozono en el tratamiento poscosecha de tomate (*Lycopersicon esculentum* Mill.), Univ. Havana, Thesis, Havana, Cuba, 2007, 62 p.

[40] Ramírez H., Encina-Rodríguez L.I., Benavides-Mendoza A., Robledo-Torres V., Hernández-Dávila J., Alonso-Corona S., Influencia de la temperatura sobre procesos fisiológicos en postcosecha de tomate (*Lycopersicon esculentum* Mill.), Nueva Época 1 (2004) 31–37.

[41] Valverde J.M., Valero D., Martinez-Romero D., Guillén F., Castillo S., Serrano M., Novel edible coating based on *Aloe vera* gel to maintain table grape quality and safety, J. Agr. Food Chem. 53 (2005) 7807–7813.

[42] Pal R.K., Roy S.K., Srivastava S.S., Storage performance of Kinnow mandarins in evaporative cool chamber and ambient conditions, J. Food Sci. Technol. 34 (1997) 200–203.

[43] Getinet H., Seyoum T., The effect of cultivar, maturity stage and storage environment on quality of tomatoes, J. Food Eng. 87 (2008) 467–478.

[44] Morillon V., Debeaufort F., Blond G., Capelle M., Voilley A., Factors affecting the moisture permeability of lipid-based edible films: a review, Crit. Rev. Food Sci. Nutr. 42 (2002) 67–89.

[45] Pérez-Gago M.B., Rojas C., Del Río M.A., Effect of lipid type and amount of edible hydroxypropyl methylcellulose-lipid composite coatings used to protect postharvest quality of Mandarins cv. Fortune, J. Food Sci. 67 (2002) 2903–2910.

[46] Ni Y., Turner D., Yates K.M., Tizard I., Isolation and characterization of structural components of *Aloe vera* L. leaf pulp, Int. Immunopharmacol. 4 (2004) 1745–1755.

Efectos del recubrimiento con *Aloe vera* en la calidad poscosecha de tomate.

Resumen – Introducción. Los recubrimientos comestibles son usados tradicionalmente para mejorar la apariencia y conservación de los alimentos. Actúan como barreras durante el procesamiento, manipulación y almacenamiento y no solo retardan su deterioro incrementando su calidad, sino también su seguridad a través de su actividad biocida natural o por la incorporación de compuestos antimicrobianos. El objetivo de este trabajo fue evaluar el efecto del *A. vera*, aplicado como recubrimiento comestible sobre los cambios en los parámetros físico-químicos relacionados con la calidad de tomates durante su almacenamiento en condiciones ambientales (22 °C y 80 % HR), así como su papel en el control del deterioro microbiológico. **Material y métodos**. Se evaluaron los cambios en las propiedades físicas, químicas y texturales de tomates comerciales var. Charleston durante 17 días de almacenamiento en condiciones ambientales de acuerdo a sus recubrimientos (tratamientos) o no (control), con extracto acuoso de *A. vera* puro o diluido (2:1) en agua destilada. **Resultados**. El extracto acuoso puro de *A. vera* inhibió, totalmente, el crecimiento de *Rhizoctonia solani* and *Alternaria alternata*, mientras que no mostró actividad antimicrobiana contra *Phytophtora parasitica*. El recubrimiento de extracto acuoso diluido de *A. vera* mantuvo al calidad de los tomates durante su almacenamiento en condiciones ambientales, retardando su maduración, aunque no constituyó una barrera efectiva contra las pérdidas de peso. **Conclusión**. Nuestros resultados fundamentales pueden ser útiles para productores y tecnólogos poscosecha, así como distribuidores, importadores y exportadores, relacionados con el manejo y procesamiento de tomates.

Cuba / *Lycopersicon sculentum* / frutas / aptitud para la conservación / film comestible / *Aloe vera* / propiedades antimicrobianas