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Aloe vera Extract as Bio-preservative to Selected Perishable Fruits and Vegetables

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ABSTRACT— Bio-preservation is a novel food preservation method designed for extending the shelf life and enhance safety of foods by the use of natural products or plant materials. A factorial study arranged in Randomized Complete Block Design (RCBD) was conducted to find out the effect of Aloe vera extract as bio-preservative to selected perishable fruits and vegetables. Results showed that fruits soaked in water with 25-50% aloe vera extract for 30-60 minutes had the lowest weight loss and highest weight loss was obtained for those fruits with no treatment in water. It was also observed that the levels of aloe vera extracts and length of submersion significantly affected by delaying the ripening of the fruits both in pepper and calamansi. However, no significant differences were noted in banana and tomato and on the effects of levels of aloe vera extract and length of soaking on the firmness, TSS, TA and pH of the fruit samples studied. The result of the study indicates that soaking of fruits in water with 25-50% Aloe vera extract for purposes of preservation maybe used in suppressing weight loss, delays ripening, lowers the number and percentage of rotten fruits. Delays reduction of soluble solids, titratable acidity, and impeding change of appearance of pepper, calamansi, banana and tomato fruits. The results suggest that Aloe vera extract maybe used as bio-preservative to any fruits and fruit vegetables for delaying some quality losses and eventually increasing storage/shelf life.

KEYWORDS: Aloe vera, bio-preservation, perishable fruits, vegetables.

1. INTRODUCTION

Post-harvest losses and deterioration is one of the serious issues and concern among food producers, processors, assemblers, retailers, wholesalers and consumers. It greatly affects food safety, shelf life and sustainability of supply on certain foods. It became serious problem because of rapid deterioration during handling, transport and storage in tropical regions. Fruit coloration is frequently used as a quality index among fruits. And if it goes beyond considerable period of time it will lead to decay and losses of the products. Products when harvested, loses 5 or 10 percent of its fresh weight, it begins to wilt and soon becomes unusable. The rate at which water is lost from plant depends on the difference between the water vapor pressure of the plant and the pressure of water vapor in the air. To keep water loss from fresh produce as low as possible, it must be kept in a moist atmosphere. Air flow helps to remove heat of respiration but must be controlled to prevent moisture loss [1]. In San Jorge, Samar alone, based on personal communications from the local vegetable traders and middle men, losses of various kinds of vegetable may range from 10-20% until all the products are sold to the buyers or consumers. Daily removal of undesirable fruits and vegetables while in few days of storage are their usual routine prior to the transport of the products to target buyers. Bio-preservation is a novel food preservation method designed for extension of shelf life and enhanced safety of foods by the use of natural or controlled microbiota and/or antimicrobial compounds. In postharvest technology, bio-preservation aimed at extending storage/shelf life of fruits and vegetables by utilizing plant- based products that have been used in food engineering for a long time. Recently, plant-based products have been used in fresh fruits and vegetables as bio-preservatives. Aloe vera gel is one of the promising bio-preservative as an edible coating material for fruits and vegetables driven by its antifungal activity. Aloe Vera gel-based edible

coating have been shown to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning and reduce microorganism proliferation in some agricultural products [2]. However, information regarding biopreservation effects of aloe vera maybe none in this part of Samar and even in the whole country. Hence, this study was proposed to evaluate the bio-preservative effects of aloe vera extract on the physical (number and days of ripening, weight loss, number of rotten fruits) chemical (TSS, TA, firmness, pH) properties of selected perishable fruits.

2. Materials and methods

2.1 The Fruit Samples

Number of kilos of green fresh fruits and vegetables were obtained from single a concentration/" tabo" market of same variety and source. Right after the purchase, they were cleaned, randomly distributed and subjected to different treatments.

2.2 Aloe Extract Preparation

Fresh aloe vera leaves was harvested from cultured aloe vera plants. Ordinary steps in processing the aloe to produce extract was made; flaking the leaves from the plant, washing to remove dirt's and foreign materials, then air dry, and slicing them into pieces, crushing the chopped leaves using an electric juicer or by hands, then separating the gel from the solid materials by straining with the use of cheese cloth or fine screen.

2.3 Treatments and Design

This study involved a 4x3x3 factorial experiment with three replications and arranged in Randomized Complete Block Design (RCBD). Factor A, consists of four selected perishable fruits and vegetable available in the market, Factor B includes level of the aloe vera extract, and Factor C were the length of time the fruits and vegetables are submerged in water with different levels of aloe vera extract. Below are the factors involved:

Factor A **(Fruits and Vegetables)**	**Factor B** **(Level of Aloe vera extract)**	**Factor C** **(Length of dipping time)**
Pepper	0%	0 minutes
Calamansi	25%	30 minutes
Banana	50%	60 minutes
Tomato		

The sample fruits (pepper, calamansi, banana and tomato) were treated with Aloe vera extract dilutions, prepared with potable water, (0% as control, 25% and 50%) by dipping for 0, 30, and 60 minutes. After dipping, the fruits were placed in plastic trays and studied under room temperature. A total of 28 treatment combinations (7 treatments in every sample commodity) in this experiment with three replications. Same number of fruits (5-20 fruits depending on size) was placed in perforated tray for every experimental unit. The experiment was conducted in a room temperature at the Northwest Samar State University – San Jorge Campus, San Jorge, Samar.

The treatment combination includes:

T1 = Pepper, Calamansi, Banana, Tomato; 0% aloe vera extract; 0 min. soaking.

T2 = Pepper, Calamansi, Banana, Tomato; 25% aloe vera extract; outright soaking

T3 = Pepper, Calamansi, Banana, Tomato; 25% aloe vera extract; 30 min. soaking

T4 = Pepper, Calamansi, Banana, Tomato; 25% aloe vera extract; 60 min. soaking

T5= Pepper, Calamansi, Banana, Tomato; 50% aloe vera extract; outright soaking.

T6 = Pepper, Calamansi, Banana, Tomato; 50% aloe vera extract; 30 min. soaking
T7 = Pepper, Calamansi, Banana, Tomato; 50% aloe vera extract; 60 min. soaking

2.4 Data Collected

2.4.1 Number or percentage of ripened, rotten/discarded fruits

Number of ripened, and rotten fruits was determined by counting the number of fruits ripened and rotten by weekly interval. Percentage of ripened fruits, number of rotten or discarded fruits was done every week within 4-5 weeks or until the fruits are totally ripened and rotten.

2.5 Weight loss

Weight loss was determined by considering the fresh weight at the start of the study using a balance with an accuracy of 0.01 g. Weight loss shall then be calculated from the weight of the sample measured initially before the start of the study and after 1, 2, 3, 4, and 5 weeks. Percentage of weight loss was done every week within 4-5 weeks or until the fruits are totally ripened and rotten.

2.6 Color and visual assessment

Due to absence of digital colorimeter, fruit color was determined through overall change of color from green to red or yellow depending on nature of the fruit color change of the product. Fruit that have totally changed its color are the one counted as ripened. Color assessment was done every week within 4-5 weeks or until the fruits have totally changed its color.

2.7 Firmness, total soluble solids, titratable acidity and pH.

At third week of the study, samples of the fruits were submitted for analysis at the Post Harvest Laboratory (PHL Lab), VSU, Visca, Baybay City for total soluble solids, titratable acidity, pH, and firmness determination. Whole sample fruits passed through an electric juicer (King P-110, China) and filtered through cheesecloth for the measurement of soluble solids content (SSC), pH and titratable acidity (TA). Firmness of fruits were measured by means of a penetrometer, SSC by a digital refractometer, pH by digital pH meter and TA was determined by titration.

2.8 Statistical Analysis

The experimental treatments were arranged in Randomized Complete Block Design (RCBD) with 3 replicates. Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) to determine significant differences ($p \leq 0.05$) was performed using SPSS.

3. FINDINGS AND DISCUSSION

3.1 Average weights and weight loss of the fruits

Table 1 presents the data on initial weights, average weights and weight loss, average ripened and rotten fruits under study at 4^{th} week, except for banana which lasted only for three weeks, as affected by the time of soaking and level of aloe vera extract. The result of the study demonstrated a highly significant differences on weights loss of the sample products during the 4^{th} week of the study. Fruits without aloe vera extract treatment showed higher weight loss than those fruits submersed in water with 25-50% aloe vera extract with varied time of soaking. Fruits soaked for 30-60 minutes in water with 50% aloe extract had the lowest weight loss of 51.7 grams (T6 and T7). The highest weight loss was obtained for those fruits not treated with aloe extract in water (T1). The effects of soaking the fruits with levels of aloe vera extract (25-50%) was generally observed to the four fruits under study. All of them significantly affected as indicated in its average weights and weight losses at the end of the study period. Weekly weights increment of the fruits studied were also presented in Figure

1-4 where there was a gradual decrease of weights of the fruits as a result of respiration and transpiration. Weight loss occurs due to water loss by transpiration and loss of carbon reserves due to respiration. The higher percentage weight loss in the control group of all the products compared to those submerged in water with aloe vera extract appeared to be related to the amount of aloe vera coatings, considering that the experiment was sit at similar RH and ambient temperatures surrounding the produce. This positive effect in terms of reduction of moisture loss among fruits submerged in water with aloe extract, may be due to the hygroscopic properties of Aloe gel that combines with water that served as barrier between the fruit and the surrounding environment. Thus, preventing its external transferences [3]. The types of surfaces and underlying tissues of fruit may also have a marked effect on the rate of water loss which could be seen as reasons for the differences observed among the varieties [4]. Aloe gel based edible coating act as barrier, thereby restricting water transfer and protecting fruit skin from mechanical injuries [5]. Apart from these, Aloe vera gel has also been effective in controlling water loss from other commodities, including pine-apple [6], sweet cherry [9], Granny Smith and Red Chief apples [2]. Interestingly, Aloe vera gel mostly composed of polysaccharide [7] which is highly effective as a barrier against moisture loss without incorporation of lipid.

3.2 Average number of ripened and rotten fruits

Number of ripened fruits was determined by counting the number of fruits that have changed from green color to totally dark red or yellow color. Counting was done on the last days of 1^{th}, 2^{th}, 3^{th} and 4^{th} week of the experiment. The result showed that fruits soaked in water both 25-50 percent aloe vera extract did not differ significantly among treatments (Table 1). It can be observed that almost all fruits have been ripened at 4^{th} week of the study for pepper, calamansi and tomato and only at 3^{rd} week for banana. However, number of ripened fruits per week was observed in all of the sample products (Fig. 5-8). As indicated, The ripening can be associated to the respiration rate of the fruits. It is known that the environmental temperature affects the fruit respiration and the respiration affects the fruit temperature in return. As the temperature inside the room rises, the temperature inside the fruit increases, this leads to the increase respiration rate of the product. The Aloe vera gel or extract has a coating effect which significantly reduced the breathing rate of the product [8]. It can also be observed in the results that the length of submersion contributed to the delay of ripening of the fruits both in 25% and 50% levels of aloe vera extract in water. Rotten and discarded fruits was determined by considering the number of fruits that are about to undergo senescence stage, fruits that were showing softness, and discouraging change of fruit color. Fruits under study started to show its state of decay at end of 2^{nd} week, and succeeding measurements were taken at 3rd until 4th week. Percent of rotten fruits indicated statistical differences among treatments for pepper and calamansi. Produce which were not submerged in water with aloe vera extract obtained statistically higher rate of deterioration of 45.8 percent for pepper, 62.8 percent in calamansi, while rate of deterioration for those products treated with aloe extract had 30.0-40.5 percent for pepper and 53.9-61.1 percent for calamansi respectively. Rotting percentage were similarly observed for banana and tomato obtaining 64.3 and 62.5 percent respectively. Higher rotting percentage for banana and tomato compared to pepper and calamansi may be attributed to differences between fruit surface structure and/or fruit size. The viability of the results was on the effect of delaying the senescence period of the products, since expectedly the products should have shown maximum rotting on the third week of storage under normal condition and without application of any preservation materials. And this result agreed with the studies of [9] who reported the use of Aloe Vera gel as an edible coating to prolong the shelf life and delay senescence in sweet cherry and table grapes.

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Table 1. Effects of levels of Aloe extract on weight loss and ripening of the fruits

		TREATMENTS						
	Fruits Studied/Variables	**T1** (0%-0 min)	**T2** 25%-0 min)	**T3** (25%-30min.)	**T4** (25%-60min)	**T5** (50%-0min)	**T6** (50%-30min)	**T7** (50%-60min)
Pepper	Ave. Initial weights (g)	146.7	146.7	143.3	143.3	136.7	130.0	143.3
	Ave. Weight at 4th week (g)	65.0^{a}	81.7^{cd}	80.0^{cd}	90.0^{b}	76.7^{cd}	78.3^{cd}	91.7^{b}
	Ave. Weight Loss @ 4th wk.	81.7 ^{a}	65.0 ^{d}	63.3 ^{cd}	53.3^{b}	60.0 ^{c}	51.7^{b}	51.7^{b}
	Percentage weight loss	55.7 ^{a}	44.3 ^{cd}	44.2 ^{d}	37.2^{b}	43.9 ^{c}	39.8^{b}	36.1^{b}
	No. of fruits at start	19	19	19	19	19	19	19
	Ave. no. of ripened fruits	15.0 ^{a}	12.3 ^{cd}	11.7 ^{bcd}	11.7^{bcd}	12.0 ^{cd}	10.3^{b}	11.3^{bc}
	Ave. no. of rotten fruits	8.7 ^{a}	7.0 ^{d}	5.7 ^{bc}	5.7 ^{bc}	7.7 ^{d}	6.0^{c}	5.7^{bc}
	Percentage rotten fruits	45.8 ^{a}	36.8 ^{cd}	30.0^{b}	30.0^{b}	40.5^{d}	31.6^{c}	30.0^{b}
Calamansi	Ave. Initial weights (g)	233.3	233.3	226.7	250.0	230.0	238.3	230.0
	Ave. Weight at 4th week (g)	118.3^{a}	143.3^{bc}	141.7^{c}	140.0^{c}	130.0^{d}	143.3^{bc}	148.3^{b}
	Ave. Weight Loss @ 4th wk.	115.0^{a}	90.0^{cd}	85.0^{bc}	110.0^{g}	100.0^{f}	95.0^{def}	81.7^{b}
	Percentage weight loss	49.3^{a}	38.6^{bc}	37.5^{bc}	44.0^{e}	43.5^{e}	39.9^{cd}	35.5^{b}
	No. of fruits at start	18	18	18	18	18	18	18
	Ave. no. of ripened fruits	12.0	12.0	12.0	12.0	13.3	12.0	12.0
	Ave. no. of rotten fruits	11.3^{a}	9.7^{b}	10.3^{c}	11.0^{a}	10.3^{c}	9.7^{b}	9.7^{b}
	Percentage rotten fruits	62.8^{a}	53.9^{b}	57.2^{c}	61.1^{d}	57.2^{c}	53.9^{b}	53.9^{b}
Banana	Ave. Initial weights (g)	1236.7	1393.3	1343.3	1316.7	1170.0	1370.0	1230.0
	Ave. Weight at 4th week (g)	663.3^{a}	923.3^{bc}	891.7^{d}	961.7^{b}	705.0^{e}	930.0^{bc}	830.0^{d}
	Ave. Weight Loss @ 4th wk	573.3^{a}	470.0^{d}	451.7^{d}	355.0^{b}	465.0^{d}	440.0^{d}	400.0c
	Percentage weight loss	46.4^{a}	33.7^{c}	33.6^{c}	27.0^{b}	39.7^{d}	32.1^{c}	32.5^{c}
	No. of fruits at start	14	14	14	14	14	14	14
	Ave. no. of ripened fruits	14.0	14.0	14.0	14.0	14.0	14.0	14.0
	Ave. no. of rotten fruits	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	Percentage rotten fruits	64.3	64.3	64.3	64.3	64.3	64.3	64.3
Tomato	Ave. Initial weights (g)	616.7	575.0	576.7	600.0	563.3	566.7	560.0
	Ave. Weight at 4th week (g)	436.7	438.3	438.3	470.0	425.0	415.0	425.0
	Ave. Weight Loss at 4th wk (g)	180.0^{a}	136.7^{b}	138.3^{bc}	130.0^{b}	138.3^{bc}	151.7^{cd}	135.0^{bc}
	Percentage weight loss	29.2^{a}	23.8^{bc}	24.0^{bc}	21.7^{b}	24.6^{bc}	26.8^{cd}	24.1^{bc}
	No. of fruits at start	16	16	16	16	16	16	16
	Ave. no. of ripened fruits	16.0	16.0	16.0	16.0	16.0	16.0	16.0
	Ave. no. of rotten fruits	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Percentage rotten fruits	62.5	62.5	62.5	62.5	62.5	62.5	62.5

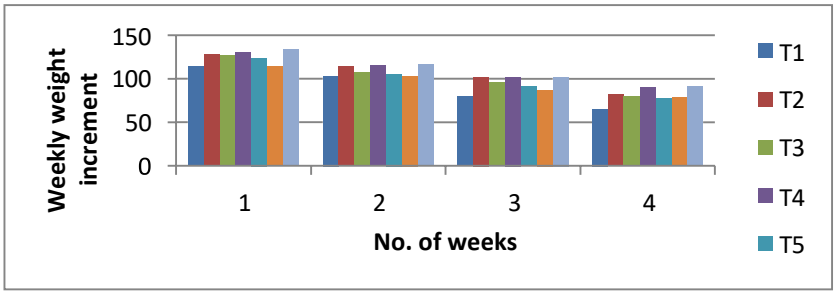

Figure 1 Weekly weight increment for pepper

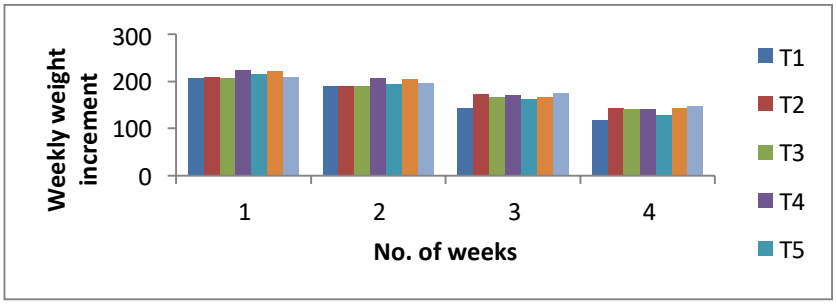

Figure 2. Weekly weight increment for Calamansi

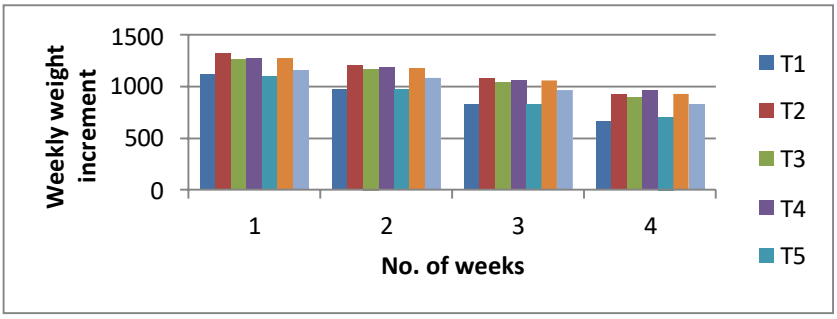

Figure 3. Weekly weight increment for Banana

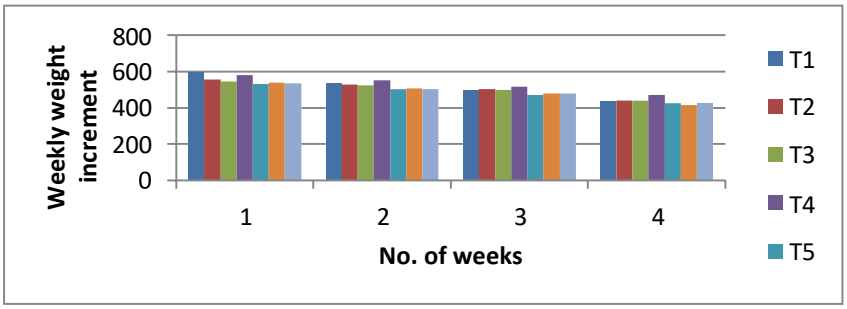

Figure 4. Weekly weight increment for Tomato

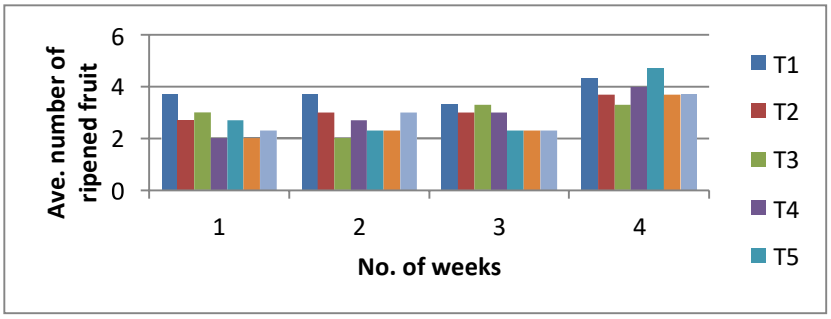

Figure 5. Weekly ripened fruit for pepper as affected by aloe preservation

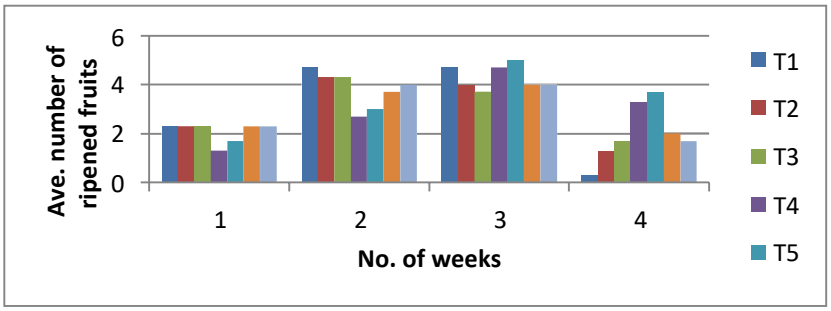

Figure 6. Weekly ripened fruit of Calamansi as affected by aloe preservation

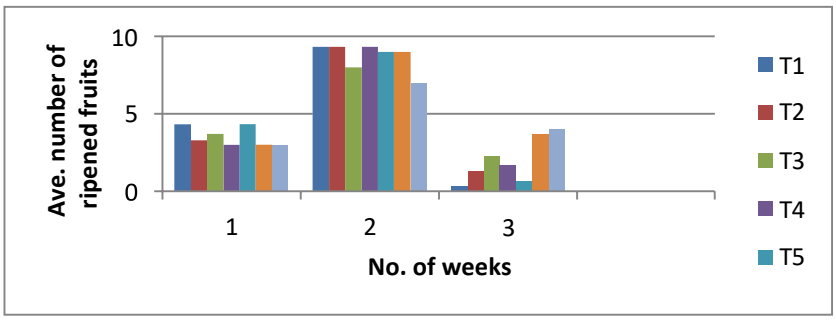

Figure 7. Weekly ripened fruit of Banana as affected by aloe preservation

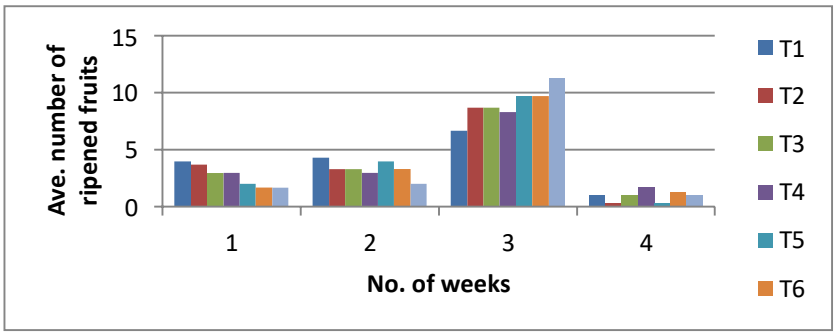

Figure 8. Weekly ripened fruit of tomato as affected by aloe preservation

3.3 Effects of Aloe extract on firmness, TSS, TA, and pH of pepper, calamansi, banana and tomato fruits

Firmness. This is a critical quality attribute in the consumer acceptability of fresh fruit and vegetables. A fruit may change in firmness during maturation, especially during ripening when it may become rapidly softer. Excessive loss of moisture may also affect the texture or firmness of crops. The rate and extension of firmness loss during storage are the main factors determining fruit quality and postharvest shelf life. Fruits softening considerably occur as a result of degradation of the middle lamella of cell wall. Changes in cell wall structure and in their composition is mainly due to joint action of enzymes hydrolases, particularly polygalacturonase, pectinestarage, β-Galactosidase, pectate lyase and cellulose [10]. The present study firmness of the fruits, showed no significant differences among treatments and cultivars (Table 2). However, numerical data suggests that aloe vera extract had slightly maintained the firmness of the products on the basis of the lower firmness values of the treated produce as compared to the untreated or control groups throughout the four cultivars. The lower values on firmness of the aloe vera treated fruits correlates with the lower water losses of the products. Aloe vera extract incapacitated the excessive water loss from the products since its molecules has stricken on the surface without affecting its internal structures to cause rapid change of firmness of the products. This result conforms with the findings of [11] on his study on mango, stating that aloe vera gel could suppress the firmness loss of the product. The firmness of a fruit is linked to the state of maturity and ripeness and may be influenced by variety, the region of production and growing conditions as well as storage procedures.

TSS. During the development of the flesh of a fruit in many species, nutrients are deposited as starch, which during the ripening process is transformed into sugars. The progression of the ripening process leads to increasing sugar levels. The result of this study (Table 2) showed no significant differences among treatments in the four cultivars. However, a declining TSS content of the sample fruits were observed with the increased levels of aloe vera extract from 25-50% in water solution and extended time of soaking from 30-60 minutes of soaking. It can be noted that aloe vera extract soaked fruits led to a lower TSS than those fruits soaked in water without aloe extract, which indicated that control (0% aloe extract) fruits manifested a more evident

ripening and maturation development than those submerged fruits in water containing 25-50% aloe vera extract. The decrease in TSS in all fruits studied (pepper, calamansi, banana, tomato) was repressed by higher concentrations of Aloe vera extract treatments. This may be again due to modified atmospheric conditions created by Aloe vera gel or extract, which may decrease respiration and eventually catabolism of soluble solids including sugars and organic acids. This results on TSS content of fruits corroborates with the study of [8] on his study on nectarines coated with Aloe vera gel.

Titrable acidity. It is the sugar/acid ratio which contributes towards giving many fruits their characteristic flavor and so is an indicator of commercial and organoleptic ripeness. At the beginning of the ripening process the sugar/acid ratio is low, because of low sugar content and high fruit acid content, this makes the fruit taste sour. During the ripening process the fruit acids are degraded, the sugar content increases and the sugar/acid ratio achieves a higher value. Overripe fruits have very low levels of fruit acid and therefore lack characteristic flavor. In this study, the result revealed that at the third week of ripening period of all the products their TA values declined and significantly different among treatment levels of aloe vera extract. The results signify that aloe extract acted and prevented the products from rapid degradation of fruits resulting to lower TA values as compared to the control group. This effect was generally observed to all the products submitted for titratable acidity analysis. This result conforms with the study of [8].

pH. The pH of a solution or product is a measure of the molar concentration of hydrogen ions in the product and as such is a measure of the acidity or basicity of the solution. The pH value of the sample products studied were slightly increased for all the products submerged in water with 25-50% of aloe extract irrespective of the time of soaking. The increasing pH values of peppers 5.60-5.73 as compared to 5.57 for the untreated groups indicates an increasing basicity of the product which means that conversion of the sugar content of the product to acid was controlled as a result of delayed ripening. This effect may be due to the coating effect of the aloe vera extract on the surface of the products. Same observation was noted to the calamansi (2.93-3.93 vs. 2.70), banana (4.60-4.70 vs 4.57) and tomato (5.33-6.23 vs 5.17) on the pH values of the products.

Table 2. Effects of levels of Aloe extract and time of soaking on Firmness, TSS, TA, and pH of the sample fruits.

Fruits studied/ Variables		**TREATMENTS**						
		T1 (0%-0 min)	**T2 25%-0 min)**	**T3 (25%-30min.)**	**T4 (25%-60min)**	**T5 (50%-0min)**	**T6 (50%-30min)**	**T7 (50%-60min)**
Pepper	Firmness	12.77	12.67	12.23	12.27	12.53	12.37	12.20
	Total Soluble solids (TSS)	8.0	7.87	7.47	7.40	7.73	7.53	7.27
	Titrable Acidity (TA)	1.97	1.85	1.76	1.67	1.39	1.56	1.38
	pH	5.57	5.60	5.63	5.73	5.67	5.70	5.70
Calamansi	Firmness	8.37	8.30	7.87	8.23	8.13	7.30	7.77
	Total Soluble solids (TSS)	8.03	8.0	7.93	7.93	7.67	7.40	7.87
	Titrable Acidity (TA)	16.43	14.47	13.65	12.36	13.44	13.66	10.41
	pH	2.70	2.93	3.93	3.73	3.70	3.53	3.73
Banana	Firmness	6.90	6.83	5.80	6.20	6.53	6.60	6.40
	Total Soluble solids (TSS)	26.17	24.57	24.57	25.60	25.23	25.47	23.67
	Titrable Acidity (TA)	2.99	2.29	3.35	2.21	1.89	2.33	2.26
	pH	4.57	4.60	4.63	4.60	4.67	4.70	4.63
	Firmness	5.60	5.87	5.73	5.87	5.37	5.37	5.73

Tomato	Total Soluble solids (TSS)	3.90	3.90	3.97	3.70	3.70	3.70	3.70
	Titrable Acidity (TA)	0.77	0.74	0.75	0.58	0.58	0.57	0.58
	pH	5.17	5.33	5.90	6.20	5.63	6.23	5.70

4. Conclusion

Based on the result of the study, it may be concluded that soaking of fruits in water with 25-50% Aloe vera extract can suppress weight loss, delayed ripening, lower the number and percentage of rotten fruits. It also delayed the reduction of soluble solids, titratable acidity, and impeding change of appearance of pepper, calamansi, banana and tomato fruits. For having no adverse effects on sample fruits studied or to the environment, Aloe vera extract could be used/applied as bio-preservative to any fruits and fruit vegetables for delaying some quality losses and eventually increasing storage/shelf life.

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