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Efficacy of washing treatment for extending the post-harvest shelf-life of papaya (*Carica papaya*)

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Abstract
Papaya is most commonly grown fruits crop in tropical regions of world. About 25% - 40% of post-production losses of papaya can be observed specially in developing countries. Considerable amount of post-harvest losses of papaya is occurred due to un-hygienic conditions during post-production operations. Fruits hygiene condition is very important in order to extend its post-harvest self-life. Further, cleaning and washing practices are also very important in order to improve hygienic condition of product and directly affected to its quality. This study was conducted for scientific evaluation product call BiOWiSH™ (BW) that introduced as a fruits washer and sanitizer. BW washing treatment was tested and compare with existing non-washing practices for extending the shelf life papaya. Shelf-life improvement was evaluated by altering pattern of weight loss, visual quality, firmness, total soluble solids, pH and colour. Results revealed that BW treatment was only affected marginally for improving visual quality of papaya, it was not affected significantly for altering other parameters i.e. weight loss, firmness, total soluble solids, pH and colour in comparison to non-washed papaya. Marginal visual quality improvement indicate that BW treatment was able to control microbial contamination of papaya some extend. Overall, it can be concluded that BW washing treatment was not significantly affected to improve shelf-life of papaya.

Keywords: Papaya, shelf-life, efficacy, washing treatment, BiOWiSH™, evaluation

1. Introduction
Papaya is most commonly grown fruits crop especially in tropical regions of world. India is the highest global papaya producer and produce around 5.5 million tons annually. Brazil is the second highest papaya producer in the world. India and Brazil together make up 57% global papaya production. Other major banana producing countries are Indonesia, Nigeria, Mexico and Philippines. Papaya fruit is rich in lot of nutrition specially one important enzyme call papain (www.thedailyrecords.com).

Resent literature indicated that around 25% - 40% of post-production losses of papaya occurs specially in developing countries. These losses take place mainly during harvesting and post-harvest operations such as handling, packing, storage, transportation, and marketing (Ryall and Lipton, 1972 and www.fao.org/docrep 2012) [10, 8]. Tropical horticultural crops such as papaya, mango, banana and tomato start deterioration after harvesting due to its high respiration and evapotranspiration under relative high environmental temperature in tropical condition. Further this environment condition was also caused to increase postharvest diseases. The respiration and evapotranspiration (physiological reactions) rates of fruits and vegetables can be slowed down by providing suitable low temperature (15 ºC) hygienic storage conditions. On the other hand, post-harvest practices such as harvesting at correct maturity stage, safe handling, sorting, grading, cleaning and washing were also important for extending the post-harvest shelf-life of papaya (Anonymous 1986 and Anon 1986) [2, 1]. Among these treatments, cleaning and washing are very important to maintain hygienic condition of product. Specially cleaning and washing greatly affected to post-harvest life of fruits (Arvanitoyannis *et al*. 2005 and Karder 1993) [3, 6]. Soaking and rinsing or spray washing are generally followed washing methods of fruits and vegetables. Proper sanitation of the washing water is essential to maintain to prevent spread of diseases and inoculums build up in the wash water. The most commonly used sanitizer is chlorine (100-150ppm). BiOWiSH™ (BW) has been introduced as a fruits and vegetable washer and sanitizer. BW manufacturer pointed out that BW is a powerful composite biocatalyst that breaks down complex organic molecules, eliminating waste and odours, increases storage life by maintaining the freshness, resolves latex issue and wax on produce and reduces harmful chemicals used for washing.

However, two previous studies that evaluate efficacy of BW washing treatment for tomato and mango had shown, this treatment was not effective for extending shelf-life of that fruits. But, these studies were shown that BW treatment was somewhat effective to improve visual quality of these fruits (Champathi and Tiwari 2017 & 2018) [4, 5]. Hence, this research study was conducted for scientific evaluation of BW product suitability as fruits washer for papaya fruits. Further, study was also aimed to test treatment efficacy for increasing shelf-life of papaya in comparison to existing non-washing practice.

2. Methodology

This study was conducted at Institute of Post-Harvest Technology, Sri Lanka. Tropical papaya variety call "Rathna" was selected and this variety has somewhat thick skin (outer cover). The papaya harvested at correct stage of maturity were used for this experiment. Washing solution was prepared by 5g of BW powder in one liter of water (as an instruction of manufacture). Experimental papaya sample (2200g) was dipped 10min in this solution washed and remove excess solution by assonant paper tissue. As control, same amount of papaya sample was taken without any washing treatment as an existing method. Those papaya samples were placed at laboratory in ambient room temperature (26 ±3 ºC) with proper ventilation. Change of weight loss percentage, visual quality rating (VQR), firmness, total soluble solids (TSS), pH and colour were analysed as follows to determine treatment effect for shelf-life extension. All experiments were replicate 3 times.

2.1. Analysis of weight loss percentage

The physiological weight loss of papaya was determined by dividing weight difference to initial weight from initial weight of papaya sample at regular 2 days' intervals. Sample weight is measured every 2 days' interval for 6 days. Equation 1 adopted for calculating weight loss percentage.

$$Weight\ Loss\ \% = \frac{Weight\ difference\ to\ inital\ weight}{Initial\ weight\ of\ the\ sample} \times 100 \quad (1)$$

2.2. Visual Quality Rating (Visual quality changers) (VQR)

Visual Quality Rating (VQR) is a widely used method to identify visual appearance of fruits and vegetables. Accordingly, visual quality of papaya samples was determined by visual observations of papaya on regular two-day interval up to six days by trained panellists. Rating was performed by table 1

Table 1: Rating Scale for Overall Visual Quality of Produce (VQR)

Score	Degree of severity	Description
9	Excellent	Essentially no symptoms of deterioration
7	Good	Minor symptoms of deterioration, not objectionable
5	Fair	Deterioration evident, but not serious, limit of salability
3	Poor	Serious deterioration, limit of usability
1	Extremely poor	Not usable

2.3. Firmness Change

The papaya fruit's firmness was measured every 2days intervals for six days. Digital fruit firmness tester (TR Model 53205) with a 4 mm cylindrical shape (flat end) probe was used for measuring of firmness.

2.4. Total Soluble Solids (TSS) change

The total soluble solids (TSS) in fruit juice was measured using a hand held refractometer (ATAGO, model: HR-5) and reading was reported as percentage of brix. Procedure explain by Mitcham *et al.*, (2010) was adopted to analysis TSS that 10g piece was taken from samples and blended for one minute with 50 ml of distilled water. This sample placed in refractometer and TSS was measured for 6 experiment days.

2.5. pH change

pH of experimental papaya samples was measured in two-day interval for 6 days using a digital pH meter.

2.6. Colour Change

Peel colour of papaya samples were measured by 2-day interval for 6 days using mini-scan XE plus Hunter Lab Colorimeter. L*, a*, b* values were determined. *L** stood for lightness (back=0, white=100), *a** represented for greenness and redness (+*a**, redness; -*a**; greenness), *b** indicated blueness and yellowness (-*b**, blueness; +*b**, yellowness)

2.7. Statistical Analysis

Experimental data was analysed by SAS® computer statistical package. Each treatment was replicated three times. Analysis of Variance (ANOVA) on Complete Randomized Design (CRD) by General Liner Model (GLM) procedure was performed. Treatment mean were separated by Duncan Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Change of Weight Loss

Generally, weight loss of papaya fruit occurs mainly due to continuous respiration and evapotranspiration. Figure 3.1 shows the change of weight loss of BW treated papaya and control samples. Results clearly indicated that BW treatment was not caused significantly for reducing weight loss in comparison to control. Further, it has been indicated that BW treatment was unable to control respiration or evapotranspiration from papaya fruits. Previous studies that evaluate efficacy of BW washing treatment for tomato and mango had shown similar results (Champathi and Tiwari 2017 & 2018) [4, 5].

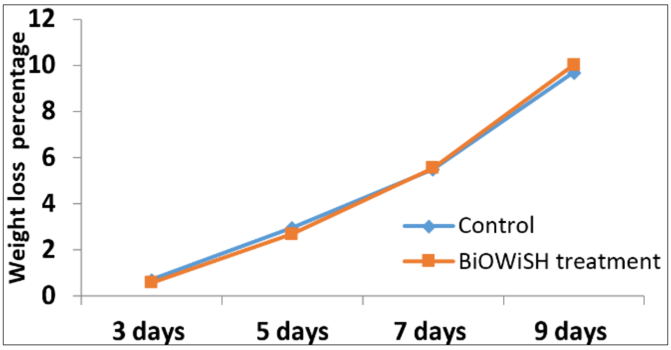

Fig 3.1: Change of weight loss percentage of papaya with time

3.2. Change of visual quality rating

The visual quality of fresh papaya is one of the most important factor for determination it outer quality and market value. VQR was determined by trained panel. Initial observation of papaya was not shown any symptoms of deteriorations in both treatment and control samples. It was also remained unchanged for next two days in BW treated sample but control papaya fruits were deteriorated continuously but, BW treated papaya was also deteriorated in same way as control in 4th day of storage. Treated papaya was not observed any further deterioration. But, although BW treated papaya remain same 4th day appearance even in 6th day of experiment, control sample was deteriorated continuously (figure 3.2). It was indicated that BW treatment was slightly effective and preserves fruits visual and microbial quality. But it was insignificant.

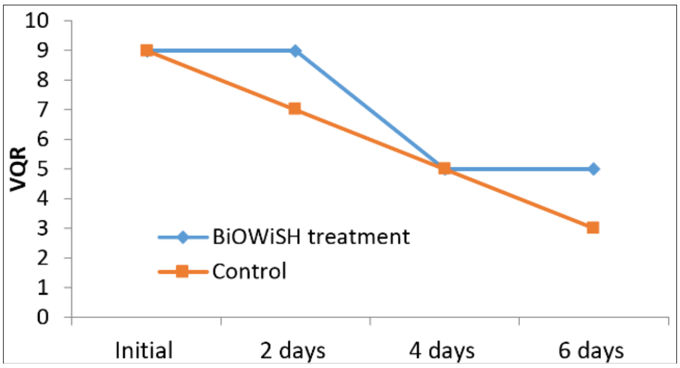

Fig 3.2: Change of VQR of papaya in experimental sample

3.3. Changing of Firmness

Figure 3.3 shows the firmness change of experimental banana samples. Results reveiled that BW tretmant was not caused to alteration firmness of papaya fruits. Wills *et al.* (1980) [11] pointed out that firmness of fruits and vegetables was reduced with ripening process. The BW treated and control samples was observed similar reduction of firmness with time. It was indicated that BW treatment was not significantly effective to slow down the ripening process of papaya.

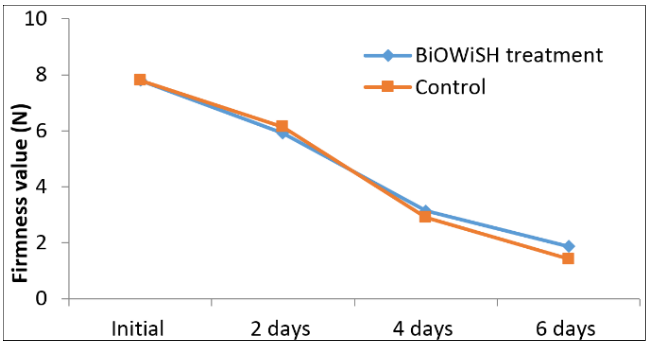

Fig 3.3: Change of firmness of experimental samples with time

3.4 Change of total soluble solids

Figure 3.4 shows change of Total Soluble Solids (TSS) of BW treated and control samples. Picha, (1988) [9], Ryall and Lipton (1972) [10] had observed TSS was increased with ripening, if the ripening process was slow, TSS change was also slow. However, TSS change of BW treated samples were not observed significant difference with control samples. TSS was changed similar way in both treatments. It indicated that BW treatment was not caused slowed down the ripening process of papaya.

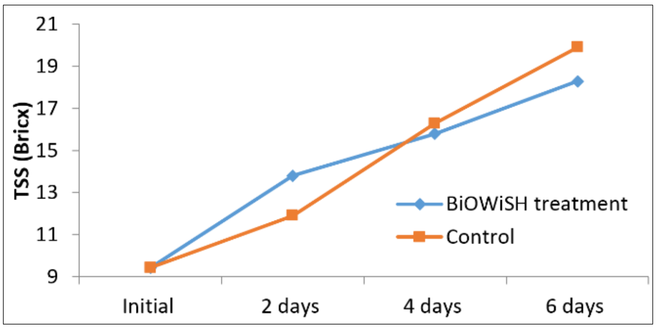

Fig 3.4: Change of TSS of experimental samples with time

3.5. Change of pH (acidity)

Figure 3.5 shows change of acidity (pH) experimental samples. Fruits pH changes with maturity. Generally, when fruits are immature, they reported low pH and high acidity. Acidity of the fruits (pH) is decreasing (pH increasing) during ripening of fruits. Accordingly, acidity of papaya should be decreased while increasing ripening process. If BW treatment will able to delay ripening, pH of BW samples should be altered slowly than control. However, in this experiment, pH level of both BW treated and control samples were increased in same way with time. Therefore, it revealed that BW treatment was not shown significant effect for controlling ripening in order to extend shelf-life of papaya fruits.

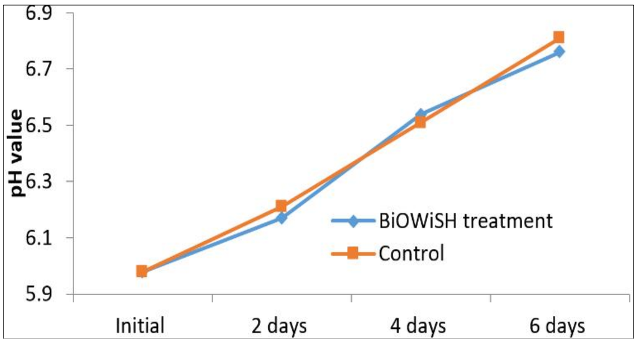

Fig 3.5: Change of pH of experimental samples with time

3.6. Change of colour (*L**, *a** and *b** values)

Colour change of experimental papaya samples were measured by hunter coloury meter in terms of *L**, *a**and *b** values.

3.6.1. Change of *L* colour value

Figure 3.6.1 show *L** colour value change of the experimental samples, *L** value represent lightness or darkness mean back=0, white=100. Results clearly indicate that BW treatment was not showing any significant effect for changing brightness of the papaya because, both samples *L** value is changing in similar pattern. Further, results were clearly indicated that brightness was increased with storage time,

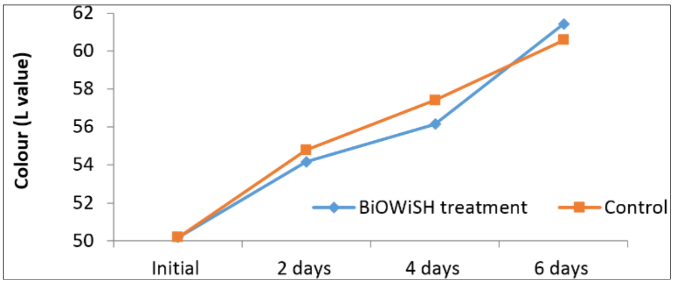

Fig 3.6.1: Change of *L** colour value

3.6.2. Change of *a** colour value
Figure 3.6.2 show change of *a** colour value in the experimental samples with time. *a** colour value indicated greenness and redness (+*a**, redness; -*a**; greenness) of fruits. Initially both control and treated sample were in green colour hence, *a** has – value. Generally green colour changed to yellow/red colour with ripening process. Results clearly indicated that green colour of both BW treated and control sample samples reduced and yellow/redness were increased with experimental time in same way. Therefore, it can be concluded that BW treatment has not shown any effect to reduce the speed of ripening of papaya.

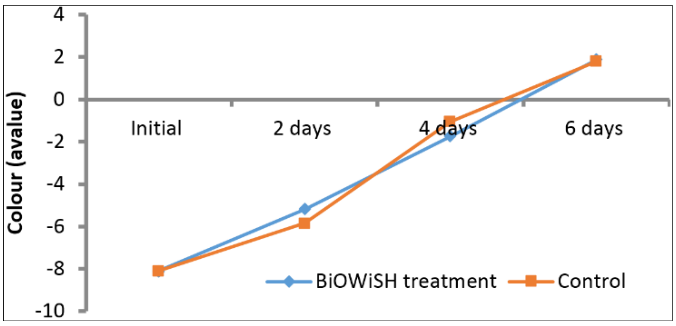

Fig 3.6.2: Change of *a** colour value

3.6.2. Change of *b** colour value
Figure 3.6.3 show change of *b** colour value in the experimental samples with time. The *b** colour value indicated blueness and yellowness (-*b**, blueness; +*b**, yellowness). Generally, when fruit starts ripening, its colour change green to yellow. Results clearly shows that *b** colour value of both treatment was increased in similar pattern. Therefore, it was indicated that BW treatment has not shown effect changing its yellow colour and slow down the ripening process.

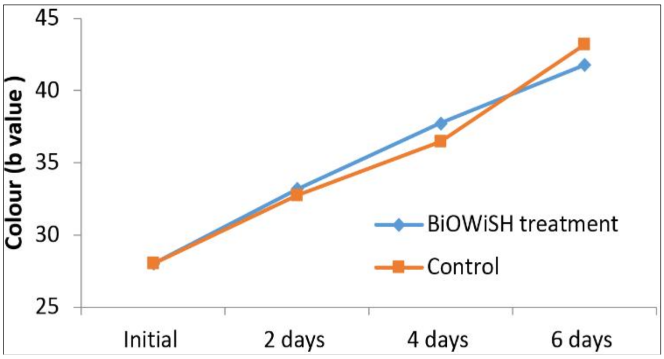

Fig 3.6.3: Change of *b** colour value

Table 2 is shown the results of the mean comparison of BW treatment with control sample by Duncan Multiple Range Test (DMRT). BW Treatment effect was compared with control by its 6th day reposes i.e. weight loss percentage, VQR, firmness, total soluble solids (TSS), pH and colour. It was clear from the results that BW treatment was not shown significant affect for altering weight loss percentage, VQR, firmness, total soluble solids (TSS), pH and colour values of papaya in comparison to control. These results revealed that BW treatment was not effective for improving shelf-life of papaya.

Table 2: DMRT mean comparison between BW treatment and control

Treatment	Weight Loss%	VQR	Firmness	TSS	pH	Colour change		
						L	*a*	*b*
BW	9.64[a]	4.15[a]	2.21[a]	18.64[a]	6.8[a]	61.62[a]	2.01[a]	42.81 [a]
Control	9.59[a]	3.11[a]	2.16[a]	19.12[a]	6.7[a]	59.91[a]	2.02[a]	43.52 [a]

[a] Columns having same letter are not significantly difference at $\alpha = 0.05$ by DMRT

4. Conclusion
Based on the overall discussion made over, it can be concluded that BW treatment was not significantly effective for altering the parameters such as weight loss percentage, VQR, firmness, total soluble solids (TSS), pH and colour that can be used for detecting shelf-life extension. However, BW treatment was affected marginally for improving visual quality of papaya fruits. Visual quality improvement of papaya fruits indicated that BW washing treatment has ability to control microbial spreading in the fruits. Finally it can be concluded that BW washing treatment was not effective for improving shelf-life of papaya fruit.

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