

Effect of Pre-treatments on Extending the Shelf-life of Minimally Processed “Ela Batu” (*Solanum surattense*)

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ABSTRACT

Due to the cumbersome nature of the cleaning process and high time consumption for the preparation, most Sri Lankan housewives are reluctant to prepare *Solanum surattense* (Sinh. Elabatu) as a vegetable for their diet. If *S. surattense* is available in ‘ready to cook’ form it would become a popular vegetable among Sri Lankan housewives. Studies were carried out to identify the best conditions for minimal processing of *S. surattense*. As pre-treatments 2% (w/v) calcium chloride solution, 0.6% (w/v) turmeric solution, 1% (w/v) vinegar solution, 2% (w/v) calcium chloride + 0.6% (w/v) turmeric solution and 2% (w/v) calcium chloride +1% (w/v) vinegar solution were used. Low density polyethylene (LDPE) pouches (gauge 150) were used to pack pre-treated samples and stored them at 8°C. In all the pre-treated samples stored at 8°C, *Salmonella* and *E. coli* were absent and coliform counts were at acceptable levels. Sensory evaluation of cooked pre-treated samples showed that the sample pre-treated with 2% (w/v) calcium chloride was the best. In addition to shelf life, colour, and degree of browning of the treatments were also acceptable. Treating *S. surattense* cut fruits with 2% (w/v) calcium chloride solution before packing in LDPE pouches and storing in 8°C found to be the best method for extending shelf-life of the fruit. The product could be kept for seven days.

Key words: *Solanum surattense*, minimal processing, pre-treatments, calcium chloride, shelf life

INTRODUCTION

In order to meet today's health conscious consumers' demand for more fresh, natural, and convenient foods, concerted effort has been made to develop new methods for minimally processed and modified atmosphere packaged fruit and vegetables (Alzamora *et al.*, 2000). Minimally processed horticultural products are prepared and handled to maintain their fresh nature while providing convenience to the user. The process involves cleaning, washing, trimming, coring, slicing, shredding, and so on. While food processing techniques stabilize the products and lengthen their storage and shelf life, light processing of fruits and vegetables increases their perishability (Kaur and Kapoor, 2000). Increased sanitation, careful preparation and handling of these products are therefore required for the industry. Minimal processing generally increases the rates of metabolic processes that cause deterioration of fresh produce. The physical damage or wounding caused by preparation increases respiration and ethylene

production within minutes, and associated increases occur in rates of other biochemical reactions responsible for changes in color (including browning), flavor, texture, and nutritional quality such as vitamin loss (www.sevana.com). Higher the degree of processing, the greater the wounding response. Control of the wound response is the key to provide minimally processed product of good quality. The impact of bruising and wounding can be reduced by cooling the produce before processing. Changes in the environmental conditions surrounding a product can result in significant changes in the micro flora. The risk of pathogenic bacteria may increase with film packaging (high relative humidity and low oxygen conditions) (Janisiewicz *et al.*, 1999). With minimally processed products, the increase in cut damaged surfaces and availability of cell nutrients provides conditions that increase the numbers and types of microbes that develop (Delaquis *et al.*, 2003). Furthermore, increased handling of the products provides greater opportunity for contamination by pathogenic organisms.

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Currently consumers are demanding a high quality of convenient, fresh-cut fruits and vegetables to add to their diet that retain their natural color, texture, and flavor without added preservatives (Son *et al.*, 2000). According to the Huxsoll and Bolins (Kaur and Kapoor, 2000) minimally processed foods (MPF) are quiet similar to the aliveness of tissues, freshness, characters and qualities of the fresh commodity. Condition for processing of the raw materials such as peeling, slicing, pre-treatments, packing and storing have to be carefully worked out so that the freshness, texture and flavour of the product are preserved nearer to the raw material and have a shelf life acceptable to the consumer.

Solanum surattense belongs to the genus *Solanum* of the plant family *Solanaceae*. It is commonly taken as a vegetable in Sri Lanka. Studies on minimal processing of *S. surattense* have not been reported. Therefore, objective of the study was to produce a consumer acceptable minimally processed *S. surattense* by minimizing the deterioration process using appropriate pre-treatments and suitable package.

MATERIALS AND METHODS

Processing and packing of *S. surattense*

Fresh mature fruits of *S. surattense* purchased from the markets in Panadura, Kadawatha and Kandy were used in the experiment. Fruits were washed with distilled water and cut into four pieces using a sharp stainless steel knife. The center part of the fruits which containing seeds was removed. Remaining edible parts were washed with distilled water at 8°C. Then the pieces of *S. surattense* were dipped in 100 ppm chlorinated water at 8°C for five minutes. Thereafter, they were washed with cleaned water at 8°C to remove residual chlorine. Washed pieces were separately subjected to following pre-treatments by dipping for five minutes at 8°C. The pre-treatments were carried out in duplicates for each treatment. Selected treatments were T_1 = Distilled water (Control), T_2 = 2% w/v Calcium chloride solution, T_3 = 0.6% w/v Turmeric solution, T_4 = 1% w/v Vinegar solution, T_5 = 2% w/v Calcium chloride solution + 1% w/v Vinegar solution and T_6 = 2% w/v Calcium chloride solution + 0.6% w/v Turmeric solution. In treatments T_5 and T_6 fruit pieces were dipped in each solution for five minutes

separately.

The pre-treated samples were drained and air-dried. The samples were packed in low density poly ethylene (LDPE) pouches (150 gauge). Dimensions of each pack were 15cm x15cm. Each pack contained 200g (approximately 100 pieces) of pre-treated pieces. Packages were stored in a refrigerator at 8°C.

Determination of the quality of minimally processed *S. surattense*

Tristimulus reflectance colourimetry was used to assess extent of browning. Lightness (L^*), green colour (a^*) and yellowness (b^*) values of three pieces of sample randomly selected were measured using ze2000 Nippon Denshoku colour difference meter. Chroma (C^*) value was calculated from a^* and b^* [$C^* = (a^{*2} + b^{*2})^{1/2}$] (Hewage *et al* 1996). Browning index was recorded using an index 0-4 where 0=none, 4=dark (Anguilar *et al*, 2000). Firmness was recorded using a scale 0-4 where 0= rotten, 4= hard (Naik *et al*, 2001). Overall quality was evaluated using a scale 0-4 where 0= poor and 4= excellent by observing colour and texture. Concentrations of oxygen and Carbon dioxide were measured using 280 COMBO Gas analyzer. Three replicates were used to record the above observations on 1st day, 3rd day 5th day and 7th day of storage. Microbial analysis for total aerobic plate count for *Coliforms*, *E.coli* and *Salmonella* were carried out in triplicates for each treatment on the 1st day, 4th day and 7th day of storage (SLS, 1991). Determinations were carried out in duplicates. After microbial evaluation of the product, sensory evaluation was done for all six treatments, as the samples did not contain *Salmonella* and *E. coli*. Sensory evaluation was done by trained judges for the pre-treated samples on the 7th day of storage using 9 point hedonic scale where 9=like extremely and 1= dislike extremely. Considered sensory properties were colour, appearance, texture, taste, flavor, mouth feel and overall acceptability.

Data were analyzed using Kruskal Wallis test in MINITAB statistical package for non-parametric data and by using ANOVA in SAS statistical package for parametric data. The experimental design used was a completely randomized design (CRD) and the level of significance was observed by using Duncan's Multi-

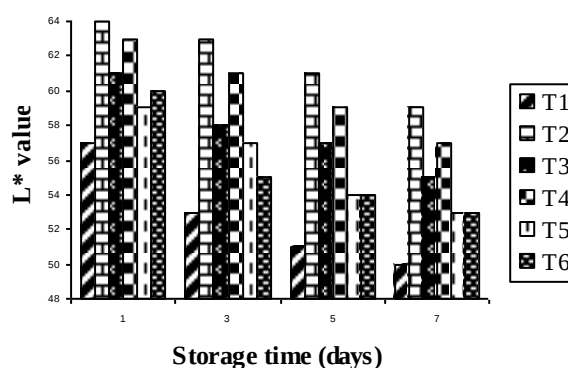


Figure 1: Mean variation of lightness (L*) with storage at 8°C for different pre-treatments

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

ple Range Test (DMRT).

RESULTS AND DISCUSSION

The variation of lightness was measured using L* values (lightness ranges from black=0 to white=100) and b* values (positive b* indicates yellow and negative b* blue) gives the variation of lightness. Values a* are responsible for the variation of green color and this study has not concerned on that separately (positive a* indicates red/purple and negative a* bluish /green). The chroma value (C*) calculated from the a* and b* values say the extent of browning. The lightness (L*) of *S. surattense* was significantly reduced in T₁ and T₅ during storage of 7 days at 8°C. But in T₂, T₃, T₄ and T₆ only the slight variation was observed (Figure 1). The L* value decreased significantly with time for the untreated sample at 8°C i.e. the degree of browning increased with

Table 1: Mean variation of chroma (C*) values with time of storage at 8°C for different pre-treatments

Treatment	Chroma value			
	1 st day	3 rd day	5 th day	7 th day
T ₁	16.90	16.26	16.28	17.37
T ₂	10.60	12.29	12.16	12.40
T ₃	15.24	16.57	16.59	16.52
T ₄	14.20	14.39	14.92	13.09
T ₅	17.70	14.24	16.32	15.45
T ₆	14.26	15.44	15.74	15.71

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

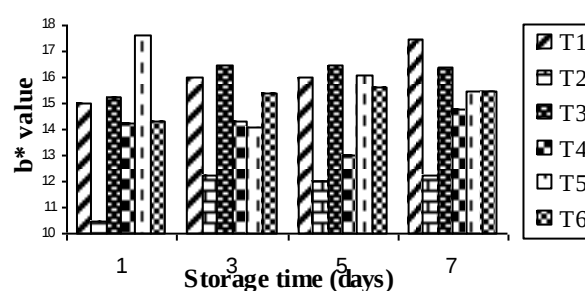


Figure 2: Mean variation of yellowness (b*) of minimally processed *S. surattense* with storage at 8°C for different pre-treatments

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

storage. This was observed even 1st day after storage. The lightness of T₂ dropped significantly only on the 7th day. A significant decrease in L* value on the 3rd day was observed in the remaining treatments. According to the results it is clear that degree of browning i.e. chilling injury was lowest in sample treated with 2% w/v Calcium chloride (T₂).

The minimum yellowness (b*) was observed in T₂ throughout the storage (Figure 2). Increase in b* values in T₃ & T₅ was due to turmeric. Increase in b* values in other pretreated samples and in the control may be due to onset of senescence.

Increased C* value indicates higher degree of browning of the treated samples (Table 1). Significant reduction of C* values in 2% (w/v) Calcium chloride treated samples (T₂) throughout the storage showed that browning was controlled by the pre-treatment. No significant differences were noted among other treatments.

Table 2: Mean variation of firmness as observed visual with storage at 8°C

Treatment	Chroma value			
	1 st day	3 rd day	5 th day	7 th day
T ₁	4	4	4	4
T ₂	4	4	4	4
T ₃	4	4	4	4
T ₄	4	4	4	4
T ₅	4	4	4	4
T ₆	4	4	4	4

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

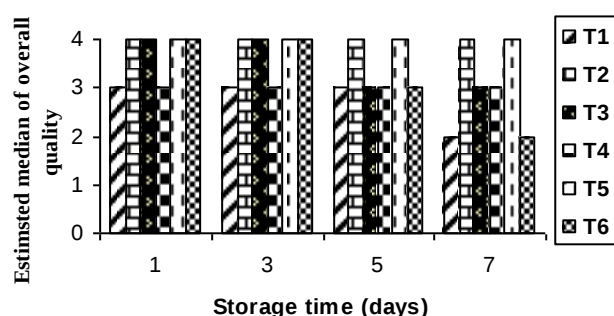


Figure 3: Mean variation of overall quality of *S. surattense* during storage at 8°C as affected by different pre-treatments

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

Increased C* value indicates higher degree of browning of the treated samples (Table 1). Significant reduction of C* values in 2% (w/v) Calcium chloride treated samples (T₂) throughout the storage showed that browning was controlled by the pre-treatment. No significance differences were noted among other treatments.

Firmness of *S. surattense* was remained unchanged regardless of pre-treatments for the storage period of 7 days at 8°C (Table 2).

Table 3: Mean aerobic plate counts of *S. surattense* with storage time at 8°C as affected by different pre-treatments

Treatment	Storage period (days)	Aerobic plate count (cfu/g)×10 ²
Fresh (before chlorination)	0	1.33
T ₁	1	0.79
	4	0.92
	7	0.92
T ₂	1	0.71
	4	0.74
	7	0.76
T ₃	1	0.67
	4	0.66
	7	0.68
T ₄	1	0.82
	4	0.82
	7	0.84
T ₅	1	0.68
	4	0.68
	7	0.74
T ₆	1	0.72
	4	0.76
	7	0.80

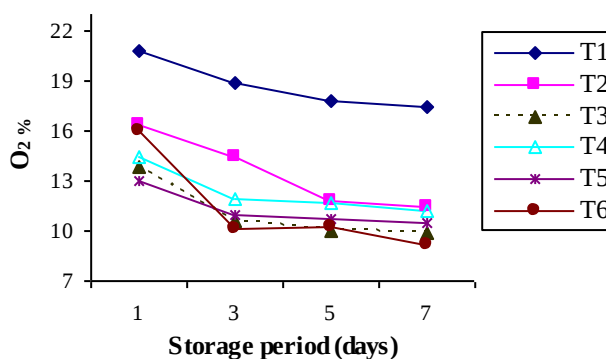


Figure 4: Mean oxygen concentrations of *S. surattense* packages during storage 8°C, as affected by different pretreatments

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

Overall quality rating of the samples stored at 8°C indicated that the samples except T₆ had a higher quality rate than control (Figure 3). The best treatments were T₂ and T₅.

Figure 4 shows the change in Oxygen concentration of *S. surattense* treated with different pre-treatments and stored at 8°C. It was observed that the concentration of O₂ decreased with time up to 5th day of storage and remained constant thereafter. Figure 5 shows the varia-

Table 4: Mean coliform counts of *S. surattense* during storage at 8°C as affected by different pre-treatments

Treatment	Storage period (Days)	Coliform counts (org/ml × 10 ³)
Fresh (before chlorination)	0	3.2
T ₁	1	1.8
	4	1.6
	7	8.75 × 10 ²
T ₂	1	1.4
	4	1.6
	7	1.7
T ₃	1	1.6
	4	1.7
	7	1.7
T ₄	1	1.8
	4	1.0
	7	2.0
T ₅	1	1.2
	4	1.2
	7	1.3
T ₆	1	1.6
	4	1.8
	7	1.9

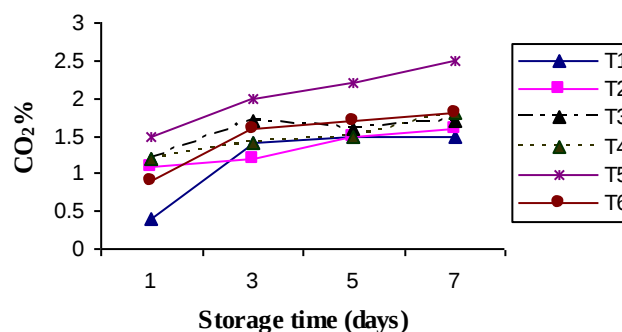
Table 5: Estimated median for the variation of sensory characteristics on 7 days of storage

Treatment	Sensory characteristics					
	Appearance	Colour	Texture	Mouth feel	Taste & Flavour	Overall acceptability
Fresh	6	6	8	6	6	7
T ₁	6	6	6	6	7	6
T ₂	8	8	8	8	8	8
T ₃	8	7	8	7	7	7
T ₄	8	8	6	8	8	8
T ₅	7	7	8	8	7	6
T ₆	7	7	8	8	7	8

9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely
 T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

tion of Carbon dioxide concentration in fresh *S. surattense* during storage at 8°C. CO₂ concentration increased significantly with time for untreated sample (T₁) up to 5th day. For treated samples there was a slight increase in CO₂ concentration. The CO₂ concentration of treated samples was higher than the control at the end of the storage period. Similar results have been reported by Anguilar *et al.* (2000) for fresh cut mangoes. It is reported that low O₂ and elevated CO₂ causes increased production of ethanol and acetaldehyde, which results in softening, development of off flavour, browning and odour in fresh cut fruits. But modified atmosphere created in package of *S. surattense* did not indicate such deterioration. Reduction of O₂ and increased concentration of CO₂ help to reduce the rate of respiration, there by increasing the shelf life.

Principally good sanitation and temperature management controls microbial growth on minimally processed products. Sanitation of all equipment and use of chlorinated water are standard approaches. Low temperature during and after processing generally retards microbial growth. Chlorination treatment has significant effect on reducing aerobic plate count (cfu/g). In control, plate count was increased from 0.79 x10² (cfu/g) to 0.92 x10² (cfu/g) on the 7th day of storage. Similar results were obtained by Sarananda *et al* for Mukunuwenna. The lowest plate count was observed in sample T₃ and T₅.

**Figure 5: Mean CO₂ concentrations of *S. surattense* packages during storage at 8°C, as affected by different pre-treatments for different pre-treatments**

T₁=Distilled water, T₂=2% w/v calcium chloride, T₃= 0.6% w/v turmeric, T₄= 1% w/v vinegar, T₅=2% w/v calcium chloride + 0.6% w/v turmeric and T₆=2% w/v calcium chloride + 1% w/v vinegar

This may be due to the antimicrobial effect of turmeric. In addition all the treatments in this study were shown the disinfective effect.

Control and treated samples contained coliform and the count on the 7th day of storage in T₅ was the lowest. *Salmonella* and *E.coli* was not present even on the 7th day of storage in any sample.

Texture was rated as liked very much for all treated samples except T₄ and control (Table 5). The colour was liked very much only for T₂ and T₄. Although overall median for sensory evaluation was almost similar for all treated samples, the evaluators indicated the appearance and taste of T₂ were better than those of other treatments. Calcium has also been considered in extending the shelf life of minimally processed fruits and vegetables by controlling respiration rate, texture loss, ethylene production, and microbial decay (Ponting *et al.*, 1972). Production of minimally processed fruits and vegetables that retain high sensory quality as well as nutritional value plays an important role in the food manufacturing and retail industries (Laurila, *et al.*, 2004).

CONCLUSION

Freshly harvested *S. surattense* cut in to four pieces, washed with water to remove seeds and washed with chlorine (100 ppm) water can successfully be used for minimal processing. Pre-treatment 2% w/v calcium chloride and sealed in LDPE (150 gauge) stored at 8°C showed the best performance for up to seven days. Quality

of *S. surattense* can be maintained with the technology and the product is safe for consumer due to the acceptable range of total aerobic plate counts, *coliforms* and absence of *Salmonella* and *E. coli* in the package. The product maintained the highest sensory properties indicating that the technology can commercially be applied.

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