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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 *Solunum 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 8ºC. In all the pre-treated samples stored at 8ºC, *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 8ºC found to be the best method for extending shelf-life of the fruit. The product could be kept for seven days.

***Key words*: *Solunum 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 rea ctions responsible for changes in color (inclu ding 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 min imally processed products, the increase in cut damaged surfaces and availability of cell nutrients provides conditions that increase the numb ers and types of microbes that develop (Delaq uis *et al*., 2003). Furthermore, increased handli ng 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.

Solunum surattense belongs to the genus *Solunum* 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 8ºC. Then the pieces of *S. surattense* were dipped in 100 ppm chlorinated water at 8ºC for five minutes. Thereafter, they were washed with cleaned water at 8ºC to remove residual chlorine. Washed pieces were separately subjected to following pre-treatments by dipping for five minutes at 8ºC. 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 gau ge). Dimensions of each pack were 15cm x1 5cm. Each pack contained 200g (approximately 100 pieces) of pre-treated pieces. Packages were stored in a refrigerator at 8ºC.

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-

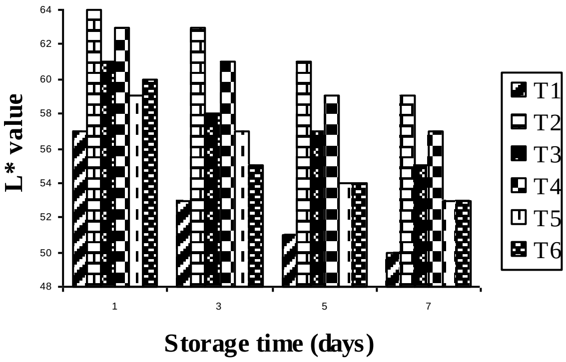

Figure 1: Mean variation of lightness (L*) with storage at 8°C for different pre-treatments

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=2% w/v calcium chloride + 1% w/v vinegar

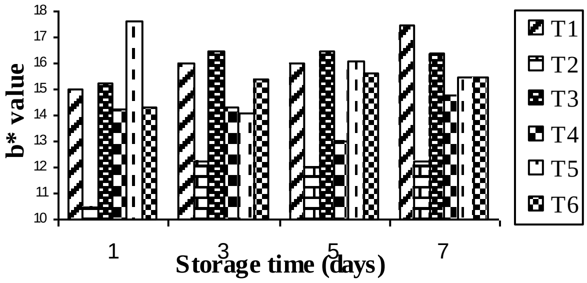

Figure 2: Mean variation of yellowness (b*) of minimally processed *S. surattense* with storage at 8°C for different pre-treatments

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 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 T_1 and T_5 during storage of 7 days at 8ºC. But in T_2, T_3, T_4 and T_6 only the slight variation was observed (Figure 1). The L* value decreased significantly with time for the untreated sample at 8ºC i.e. the degree of browning increased with storage. This was observed even 1st day after storage. The lightness of T_2 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 (T_2).

The minimum yellowness (b*) was observed in T_2 throughout the storage (Figure 2). Increase in b* values in T_3 &T_5 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 (T_2) throughout the storage showed that browning was controlled by the pre-treatnent. No significant differences were noted among other treatments.

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

Treatment	Chroma value			
	1st day	3rd day	5th day	7th 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

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=2% w/v calcium chloride + 1% w/v vinegar

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

Treatment	Chroma value			
	1st day	3rd day	5th day	7th 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

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=2% w/v calcium chloride + 1% w/v vinegar

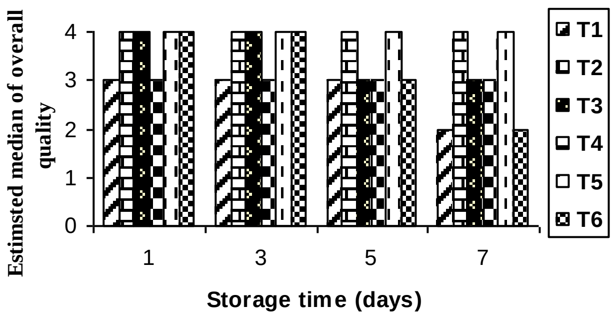

Figure 3: Mean variation of overall quality of *S.surattense* during storage at 8°C as affected by different pre-treatments

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=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 (T_2) throughout the storage showed that browning was controlled by the pre-treatnent. 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)x10²
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

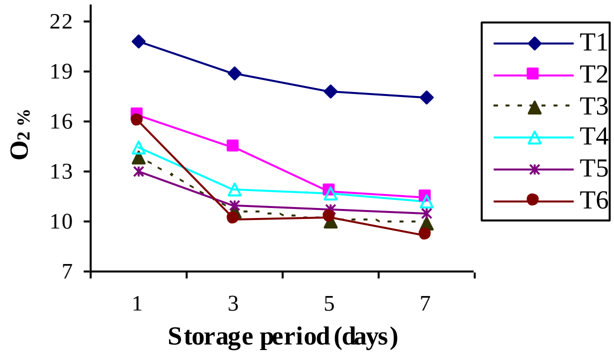

Figure 4: Mean oxygen concentrations of *S.surattense* packages during storage 8°C, as affected by different pretreatments

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=2% w/v calcium chloride + 1% w/v vinegar

Overall quality rating of the samples stored at 8°C indicated that the samples except T_6 had a higher quality rate than control (Figure 3). The best treatments were T_2 and T_5.

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 O_2 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. surettense during* storage at 8°C as affected by different pre-treatments

Treatment	Storage period (Days)	Coliform counts (org/ml x 10³)
Fresh (before chlorination)	0	3.2
T_1	1	1.8
	4	1.6
	7	8.75 x10²
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

Treat-ment	Sensory characteristics					
	Appear-ance	Colour	Texture	Mouth feel	Taste & Flavour	Overall accept-ability
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
T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=2% w/v calcium chloride + 1% w/v vinegar

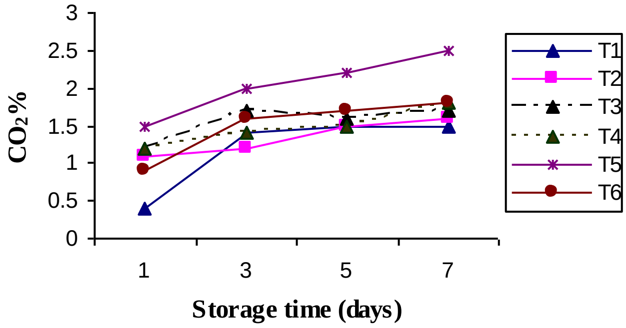

Figure 5: Mean CO_2 concentrations of *S. surattense* packages during storage at 8°C, as affected by different pre-treatments for different pre-treatments

T_1=Distilled water, T_2=2% w/v calcium chloride, T_3= 0.6% w/v turmeric, T_4= 1% w/v vinegar, T_5=2% w/v calcium chloride + 0.6% w/v turmeric and T_6=2% w/v calcium chloride + 1% w/v vinegar

tion of Carbon dioxide concentration in fresh *S. surattense* during storage at 8ºC. CO_2 concentration increased significantly with time for untreated sample (T_1) up to 5^{th} day. For treated samples there was a slight increase in CO_2 concentration. The CO_2 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 O_2 and elevated CO_2 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 O_2 and increased concentration of CO_2 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 $x10^2$ (cfu/g) to 0.92 $x10^2$ (cfu/g) on the 7^{th} day of storage. Similar results were obtained by Sarananda *et al* for Mukunuwenna. The lowest plate count was observed in sample T_3 and T_5. 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 7^{th} day of storage in T_5 was the lowest. *Salmonella* and *E.coli* was not present even on the 7^{th} day of storage in any sample.

Texture was rated as liked very much for all treated samples except T_4 and control (Table 5). The colour was liked very much only for T_2 and T_4. Although overall median for sensory evaluation was almost similar for all treated samples, the evaluators indicated the appearance and taste of T_2 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. Pretreatment 2% w/v calcium chloride and sealed in LDPE (150 gauge) stored at 8ºC showed the best performance for up to seven days. Quality of *S. surattense* can be maintained with the technology and the product in safe for consumer due to the acceptable range of total aerobic plate counts, *coliforms* and absence of S*almonella* 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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