

**DEVELOPMENT OF A SUITABLE TECHNOLOGY AND PACKAGE
FOR MARKETING OF MINIMALLY PROCESSED
MUKUNUWENNA (*Alternanthera sessilis*).**

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ABSTRACT

'Mukunuwenna' (*Alternanthera sessilis*) is one of the green leafy vegetables, which provides vitamins and minerals for many Sri Lankans. However, as the preparation of the commodity is time-consuming busy housewives now tend to exclude it from their diet. If the product is made available as a fresh cut commodity the extra time taken for the preparation can be avoided. Of the pre-treatments tested for extending the shelf life of minimally processed "Mukunuwenna" 1% citric acid and 100 ppm sodium metabisulphite showed equal performance for up to 7 days at 8°C. When the product was treated with 1% citric acid and sealed with 100-gauge polypropylene the product maintained external appearance similar to the freshly cut product for seven days and the microbial contamination was also below the limits of threshold level. Sensory evaluation of stored product at 7 days of storage showed acceptable level. Sealed polypropylene developed a passive modified atmosphere of low oxygen and high carbon dioxide, which resulted in decreased respiration hence the quality of the product maintained for up to 7 days of storage at 8°C.

KEYWORDS: Processing, *Alternanthera sessilis*, Pre-treatments, Modified atmosphere.

INTRODUCTION

'Mukunuwenna' (*Alternanthera sessilis*) is the main green leafy vegetable cultivated commercially in Sri Lanka. Of the varieties available 'Piliyandala' is the most popular variety among consumers (Anonymous, 2000). Availability of calcium (510mg/100g), iron (16.7mg/100g), carotene (5120mg/100g), vitamin B₁ (0.05mg/100g), vitamin B₂ (0.14mg/100g), niacin (1.2mg/100g) and vitamin C (17mg/100g) shows 'Mukunuwenna' is a nutritious food (DOA, 2000). In addition, the high fiber content in the commodity is beneficial to the digestive system of humans.

Due to time consumed in cleaning, sorting and slicing this vegetable, busy housewives tend to exclude it from their daily diet. Busy housewives can be encouraged to include this item in their daily diet if 'Mukunuwenna' is made available in fresh cut form (minimally processed). Minimally processed vegetables are products that contain living tissues or those that have slightly

modified their freshness, but keep their quality and character similar to those of fresh products (Alzamora *et al.*, 2000).

Minimally processed vegetables undergo rapid quality deterioration over time as a result of tissue damage resulting from processing operations such as cutting, slicing, peeling, trimming and coring. Wounding of fresh produce accelerates deterioration and ethylene production (Chranjit and Kapoor, 2000). Loss of cellular integrity at the cut surface destroys compartmentalization of enzymes and substrate. Hence browning reaction is enhanced and secondary metabolites often result as a consequence. Senescence may be accelerated and off flavors develop as respiration and ethylene production increase near the cut surfaces. In addition, exudates from the cut surface serve as medium for fungal and bacterial growth (Freier and Robbs, 2000).

Modified atmospheres help retard physiological processes such as respiration in minimally processed foods, while inhibiting pathogens and spoilage microorganisms. Further, refrigerated temperature is effective in reducing enzyme activity and slows down most microbial activity. Rinsing with water reduces bacterial load. However, washing cut vegetables would remove nutrients from the cut surface. Ascorbic acid and citric acid lower the pH and prevent browning reaction as chelating agents. Addition of lemon or limejuice lowers pH to 4.5 and helps retain natural flavour and the light green colour of fruit and vegetables (Wiley, 1994). Sulfites reduce enzymatic-browning reaction and prevent microbial spoilage. Chlorine compounds are effective in inactivating microorganisms in solutions (Pirovani *et al.*, 2001).

This paper reports the studies conducted to develop a suitable technology package to produce minimally processed 'Mukunuwenna' and to increase the shelf- life while maintaining food safety.

MATERIALS AND METHODS

Experiment 1. Effect of pretreatments on quality of minimally processed 'Mukunuwenna'

Freshly harvested variety 'Piliyandala' was used for the study. Plants were sorted for unwanted plant parts and pest damaged parts and washed with running tap water. After draining excess water, plants were dipped in 100-ppm chlorine water. Plants were then drained and divided into 5 equal bundles for pretreatments. Each bundle of 'Mukunuwenna' was then separately dipped in 1-% lime juice (Wiley, 1994), 1% Ascorbic acid (Wiley, 1994), 1% citric acid and 100-ppm (Carvalho and Lima, 2000) Sodium metabisulphite (SMS) (Wiley, 1994). The remaining part was dipped in water and used as the

control. The temperature of dipped solutions was maintained at 10°C. After two minutes, plants were drained and transferred into the slicing machine (CeCoCo Food Slicer, USA). Sliced 'Mukunuwenna' particle was 2-3 mm was immediately transferred into 18.5x13.5x4cm polystyrene trays in 100g, 150g, 200g and 250g lots. Trays were then wrapped with 150-gauge polypropylene and sealed using electric sealer. Sealed packages were immediately transferred into a refrigerator operated at 8°C. The experiment was arranged as completely randomized design with 3 replicates. Browning index was recorded daily using 5 point Hedonic scale. External appearance of the product was assessed based on 'L' and 'b' values of 2E 2000 Nippon Densnoka color Difference meter.

Total aerobic plate counts (pour plate method) and *E.coli* counts were taken for raw material before and after chlorination and for all 5 treatments on the 1st, 4th and 7th day of storage respectively in accordance with Sri Lanka Standards Institution recommendations (1991). Since the total plate counts showed less microbial level than the threshold limit, sensory evaluation was carried out for all treatments. The sensory parameters tested were colour, odor, appearance, taste and overall acceptability using a 7-point hedonic scale and a trained taste panel of 12 persons. Observations were recorded on the 3rd, 5th and 7th days of storage period. The data was analyzed using Friedmans non-parametric test in a MINITAB statistical package where medians for respective treatments were estimated.

Experiment 2. Effect of type of film on quality of minimally processed 'Mukunuwenna'

'Mukunuwenna' was sorted, cleaned, pre-treated with 1-% citric acid and sliced as described in Experiment 1. Polystyrene trays (18.5×13.5×4 cm) were filled with sliced 'Mukunuwenna'. These trays were sealed with polypropylene 100, 150 and BOPP 100 gauge. Immediately after sealing the packages were transferred into a refrigerator maintained at 8°C for 7 days. Color, appearance, taste and overall quality were recorded using a 7-point hedonic scale and a 12 member trained taste panel. The data were analyzed using Friedman non- parametric test in a MINITAB statistical package.

Experiment 3. Analysis of gas composition.

Carbon dioxide concentration was analyzed using GC 9A Shimadzu Gas chromatograph. A gas sample was injected to the GC having Porapack column (110°C), oven at 90°C, flow rate 30ml/min. and thermal conductivity detector. Oxygen concentrations of samples were analyzed using the same GC and temperature conditions, but using a molecular sieve column. In package gas content was homogenized before withdrawing the gas sample.

RESULTS AND DISCUSSION

Effect of pretreatment on quality of minimally processed Mukunuwenna'.

Citric acid and SMS treated samples showed minimum browning throughout the storage (figure 1). On the other hand, both ascorbic acid treated and control samples showed significantly higher level of browning. Lime treated samples showed moderate level of browning throughout the storage period. Lightness 'L' value can also be used to record the external appearance of sliced 'Mukunuwenna'. Figure 2 shows samples treated with citric acid and SMS had higher 'L' values compared to ascorbic acid and lime treated samples. The 'L' values for control samples declined sharply during the later part of the storage.

Yellowing of leafy vegetables is an indication of the commencement of senescence. Excessive wounding due to slicing can produce ethylene, which is a senescence-inducer in vegetables. Both citric acid and SMS treated 'Mukunuwenna' showed minimum b^* value throughout the storage compared to that in ascorbic acid, lime and control samples. Maintaining a lower levels of b^* value indicated that yellowing of 'Mukunuwenna' was delayed by pre-treating with citric acid and SMS. On the other hand lime and ascorbic acid were not able to maintain the greenish colour of 'Mukunuwenna' successfully.

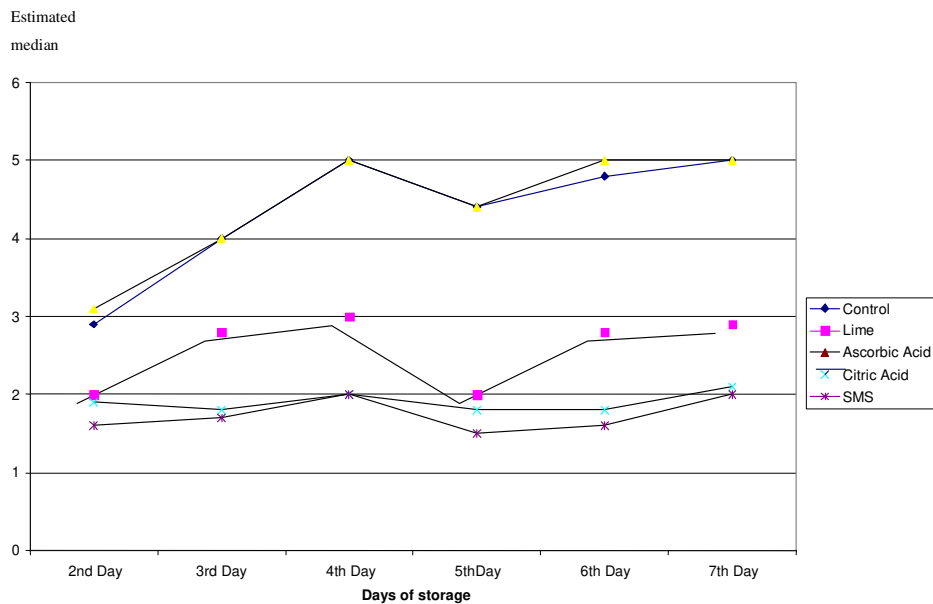


Figure 1. Estimated median of Browning Index (BI) for minimally processed Mukunuwenna' stored at 8°C.

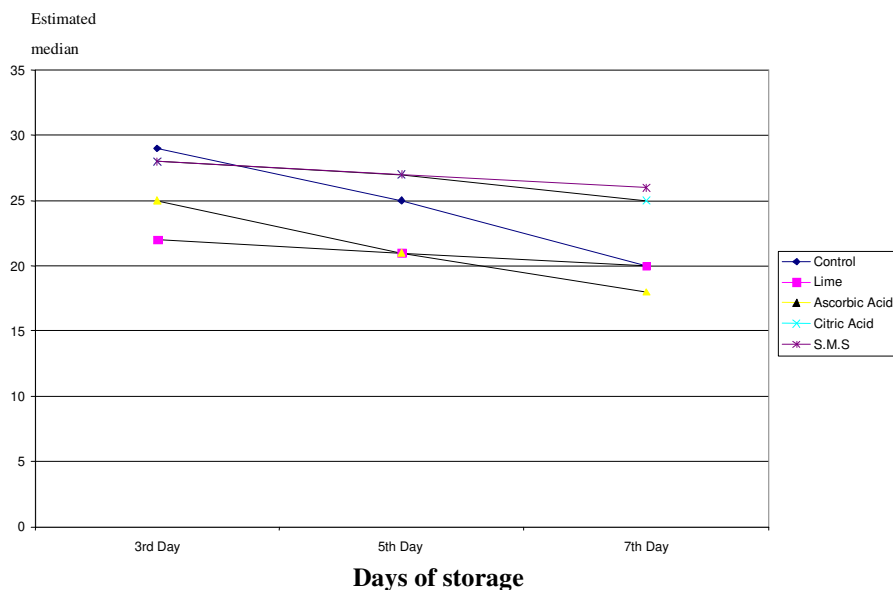


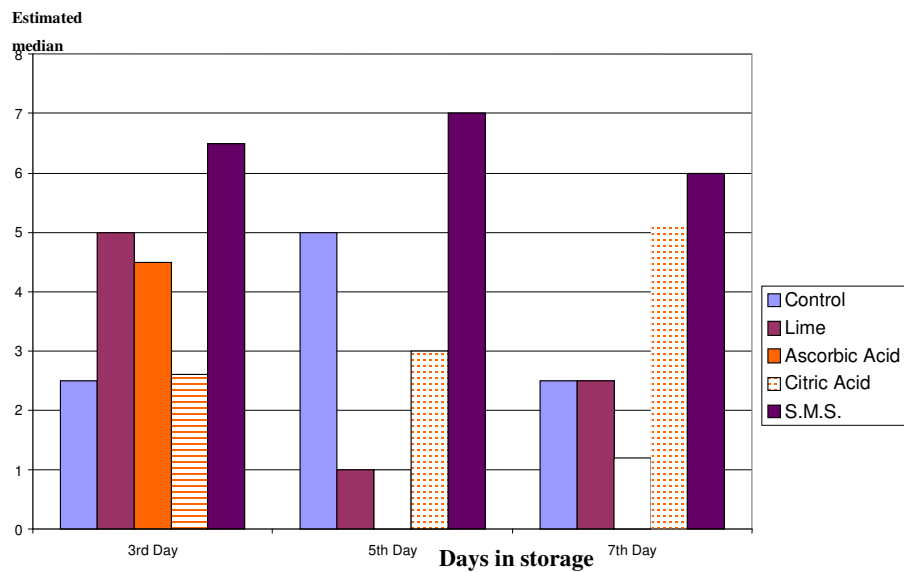
Figure 2. Changes of Lightness (L*) during storage at 8°C.

Total aerobic plate counts of raw material before chlorination treatment was 0.12×10^2 (table 1). After chlorine (100-ppm) treatment it was reduced down to 0.09×10^2 . Samples drawn from all five treatments including controls on the 1st, 4th and 7th day after storage were given acceptable total plate count readings at 8°C. The counts were further reduced after cooking (Mellum). Low microbial counts in the final product may be due to cumulative effect of the disinfectant, low temperature, modified atmosphere, 100 ppm citric acid, 100 ppm SMS, 1% lime, 100 ppm ascorbic acid and heat treatment. This result confirms the results reported by Amanathidou *et al.* (2000) that 0.1% to 0.5% citric acid significantly reduced the microbial load in minimally processed carrots showed at 8°C for 8 days. Microbial analysis of all five treatments with control was given acceptable results therefore sensory evaluation was conducted.

Sensory evaluation on colour, off odour, taste and overall acceptability of 'Mukunuwenna' at 3, 5, and 7 days of storage are given in figure. 3A, 3B, 3C and 3D.

Table 1. Aerobic plate counts for different treatments during storage period.

Treatment (mg/kg)	1 st Day (cfu/g)	4 th Day (cfu/g)	7 th Day (cfu/g)
1.Before chlorine treatment	0.12×10 ²		
2.After chlorine treatment 100ppm	9.5		
3.Control 0ppm	9.3	1.4	1.9
4.Lime treatment 100ppm	8.0	8.7	8.9
5.Ascorbic acid treated 100ppm	8.5	9.0	9.0
6.Citric acid treated 100ppm	7.66	7.9	8.0
7.SMS treated 100ppm	5.7	5.9	6.3
8. 'Mallum' citric acid treated 100ppm			5.3
9. 'Mallum' SMS treated 100ppm			4.2

**Figure 3A. Estimated median of sensory evaluation data for colour of minimally processed mukunuwenna**

Based on estimated medians of color, off odor, taste and overall acceptability both SMS and citric acid treated samples were significantly better compared to those treated with ascorbic acid, lime and control samples. Sapers (1993) reported that sulfites are effective for the inhibition of most of the deterioration enzymes in the plant tissue, which may act upon processing and storage. Further, oxidation deterioration of processed vegetables is minimized by sulfites because they are antioxidants. Sulfites are effective reducing agents and prevent browning. The similar observations reported that

in the SMS treated 'mukunuwenna' is therefore comparable with reported data.

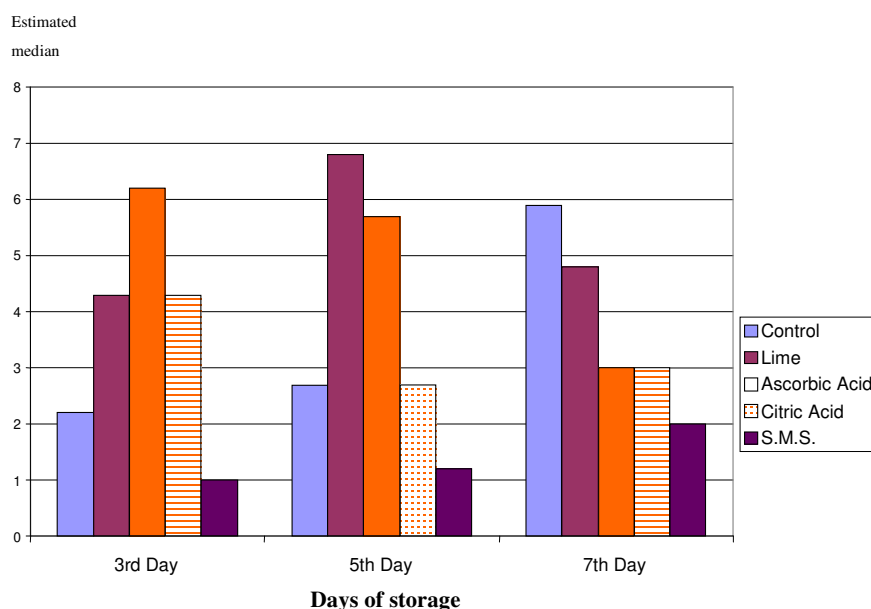


Figure 3B. Estimated median of sensory evaluation data for off odor of minimally processed Mukunuwenna

Labell (1983) reported that citric acid has been used to control enzymatic browning as an alternative for sulfites. Zagory and Kader (1988) have reported that 0.1 to 0.5% citric acid successfully maintained the original appearance of carrot when stored at 8°C. However, ascorbic acid was not effective in maintaining the sensory properties of 'mukunuwenna' compared to these in citric acid. This may be due to comparative efficiency of preservatives used in minimal processing. Langdon (1987) reported that citric acid is more effective than ascorbic acid in inhibiting phenolase as the former reduces the pH of the media and chelates the copper prosthetic group of the enzyme. Wiley (1994) reported that citric acid also has a protective effect on ascorbic acid by slowing the rate of its oxidation. If citric acid is used together with ascorbic acid, better results would have been expected.

No off odor development of 'Mukunuwenna' stored in sealed polyethylene bags showed anaerobic respiration has not been taken place. Low oxygen and elevated carbon dioxide would result in reduced level of respiration of 'Mukunuwenna' hence senescence would have been delayed.

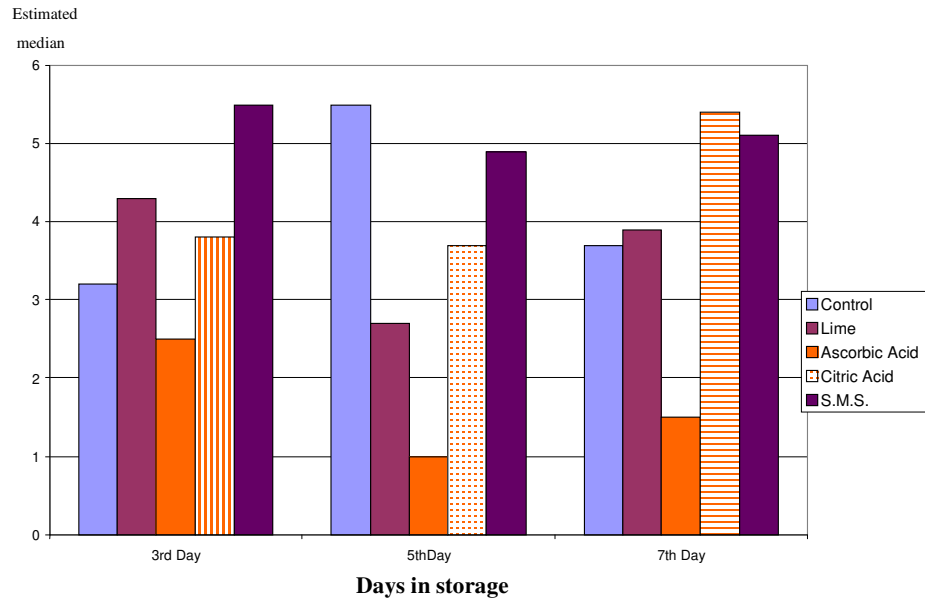


Figure 3C. Estimated median of sensory evaluation data for taste of minimally processed 'Mukunuwenna'.

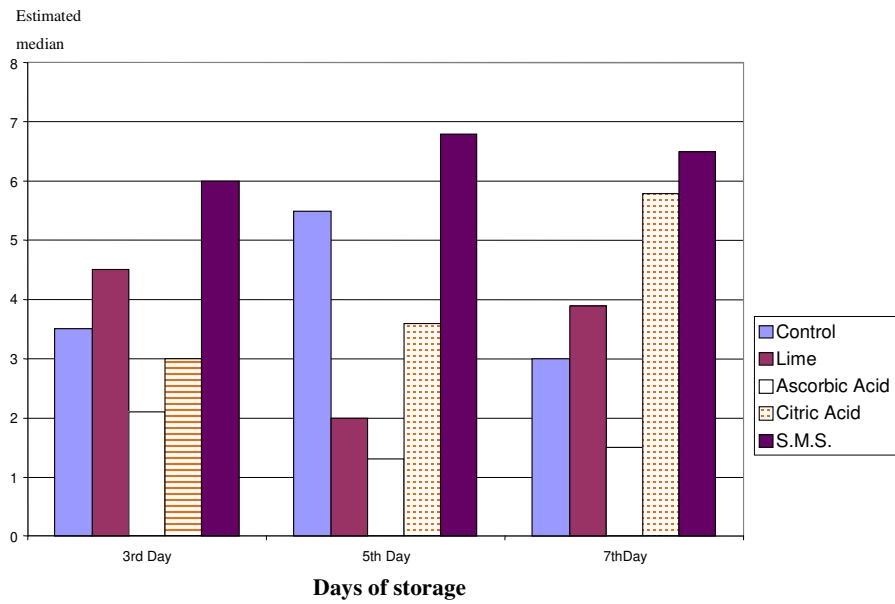


Figure 3D. estimated median of sensory evaluation data for overall quality of minimally processed 'Mukunuwenna'.

Effect of type of polypropylene film on quality

Citric acid (1%) treated 'Mukunuwenna' was packed in pp (100), pp (150) and BOPP (150) and sensory evaluation data was presented in figure 4.

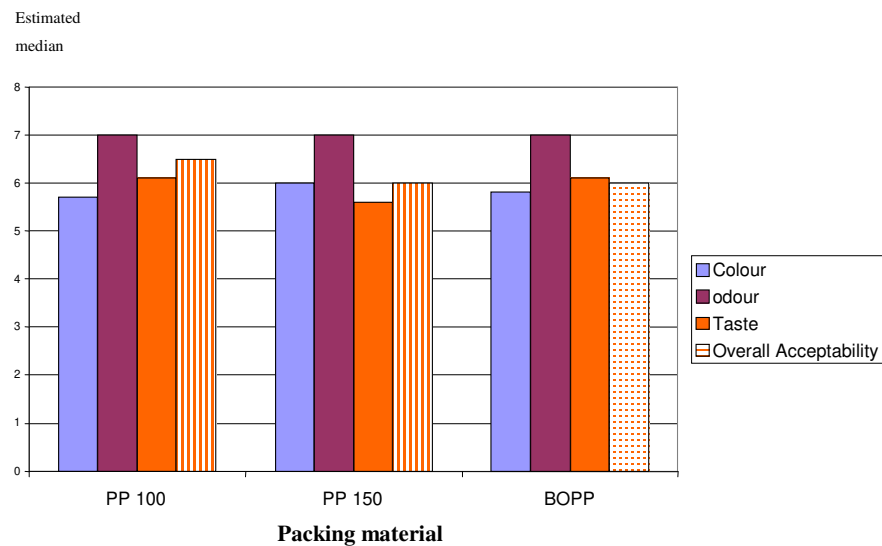


Figure 4. Estimated median of sensory evaluation data for different packing material for minimally processed 'Mukunuwenna'

Color and odor of 'Mukunuwenna' packed in all 3 tested packaging were remained same indicating that performances of packaging materials were the same as far as those two sensory parameters are concerned. However, 'Mukunuwenna' packed in PP (150) showed lesser taste compared to that in other 2 packaging. Although BOPP was equally performed with PP 100 the overall acceptability was significantly lowered compared to those in PP 100.

Zagory and Kader (1988) reported that off odor development caused by anaerobic respiration is a common problem in packaging of many fruit and vegetables. Therefore, selection of a suitable packaging material is critical to establish an atmosphere within package, which does not cause anaerobic respiration. Packages are barriers for movement of oxygen, carbon dioxide and water vapour and facilitate to maintain high relative humidity. The highest overall acceptability of 'Mukunuwenna' stored in PP 100 showed it was the best film to extend the shelf life of minimally processed 'Mukunuwenna' while maintaining the quality.

Oxygen and carbon dioxide compositions of citric acid 100 ppm treated mukunuwenna were given in table 2. Although oxygen concentration was dropped down to 1.9% at 7 days of storage, no sign of anaerobic respiration was observed. This may be due to low temperature used to store the product. Carbon dioxide concentration has increased up to 29.5% at 7 days of storage. Storage of 'Mukunuwenna' beyond 7 days cannot be expected due to excessive level of carbon dioxide accumulated may cause carbon dioxide injury.

Table 2. Change of oxygen and carbon dioxide content of minimally processed 'Mukunuwenna' during storage treated with Citric acid 100ppm and packed in PP 100 at 8 °C.

<i>Days of storage</i>	<i>Oxygen (%)</i>	<i>Carbon dioxide (%)</i>
2	15.8	6.3
4	7.5	17.8
7	1.9	29.5

CONCLUSION

Results from study indicate that 'Mukunuwenna' variety 'Piliyandala' can be used for sale as minimally processed food refrigerated at 8 °C. Chlorinated mukunuwenna must be treated with either SMS 100ppm or citric acid 1% to reduce the microbial counts before slicing them. Sliced mukunuwenna must immediately be packed in 2:1 surface area to weight ratio using PP 100 gauge. Packed produce must be kept at 8 °C until use for cooking. Acceptable range of total plate counts no anaerobic respiration and absent of *E. coli* counts in the package helps to preserve the quality of the product up to 7 days of storage period. Since SMS can be allergic for some consumers use of citric acid is the best pretreatment for processed 'Mukunuwenna'.

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