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Effect of pre-treatment on the quality of minimally processed fresh-cut banana pseudo stem

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Abstract

The market for fresh-cut vegetables had been grown rapidly due to the changes in lifestyle pat ern and also health benefits associated with these foods. The pre-treatment of fresh-cut banana pseudo stem was done with two different anti-browning agents (ascorbic acid, potassium meta bi-sulphite (KMS)) at 1% for 15 min to determine the effect of a change in color (browning). The samples pre-treated with KMS had minimum decrease in color value of 'L' (70.41) and 'b' (20.94) value whereas there was a minimum increase of 'a' (1.28) value in 35 days of storage at 8±2°C which is the most desired quality for reducing the browning effect. The optimized pre-treated fresh-cut banana pseudo stem packaged in low-density polyethylene (LDPE) was stored at two different storage temperatures of 27±2°C and 8±2°C. Among which minimum quality changes were seen at 8±2°C with physiological loss in weight (2.3 %), colour values such as 'L' (70.41), 'a' (3.30) and 'b' (17.1) and fibre content (0.8 g/100g) remained same during its storage days. The minimum growth of bacteria and fungi was also found as 3.64×10^5CFU/g and 2.76×10^3 CFU/g in 35 days of storage. The sensory evaluation of minimally processed fresh-cut banana pseudo stem had maximum overall acceptability of 8.

Highlights

- Banana pseudostem improves the functionalefficiency of kidney and live.
- It also acts as a diureticagent helping to eliminate waste fluids from thebody.
- It helps in the treatment for the removal ofstones in the kidney, gall bladder, and prostate
- Changes in lifestyle pat erns has leads to increased demand for cut vegetables as the people do not have time to prepare vegetables at home as well as in hotels.
- Because of these factors consumption of minimally processed products has significantly increased.
- Shelf life of fresh-cut banana pseudostem is limited due to its enzyme activity. So in order to increase the shelf life, this study has been take up.

Keywords: Banana pseudo stem, fresh-cut vegetables, minimal processing, shelf life

Banana (*Musa spp.*) is considered to be the second largest fruit crop of tropical and subtropical regions of the world. It is a major source of carbohydrates, and it contains high levels of potassium and vitamins B and C. Af er harvesting, a large amount of pseudo stem residue is lef behind in the soil as waste. It has been estimated that a few tonnes of banana pseudo stem per hectare are produced annually (Cordeiro *et al.* 2004). The banana pseudo stem is rich in minerals and fibre content. The fiber content of banana pseudo stem helps to cure constipation and aids in detoxification of the body. It improves the functional efficiency of kidney and live. It also acts as a diuretic agent helping to eliminate waste fluids from the

body. It helps in the treatment for the removal of stones in the kidney, gall bladder, and prostate.

Changes in lifestyle pat erns have leads to increased demand for cut vegetables as the people do not have time to prepare vegetables at home as well as in hotels. Because of these factors consumption of minimally processed products has significantly increased (Allende *et al*. 2006). The shelf life of fresh-cut produce in ambient conditions is very limited which can be extended by many preservation techniques like low temperature storage, controlled atmosphere, hypobaric and modified atmosphere packaging methods. Minimally processed Banana Pseudostem tend to browning af er cut ing. Most commonly used antibrowning agents such as ascorbic acid and various forms of sulfite-containing compounds (Loizzo *et al.* 2012).

Though many vegetables are part of our dietary habit, the technology of ready to eat or ready to cook form of minimal processing is available only for few vegetables. Thus, there is a need to develop techniques to preserve banana pseudo stem. Keeping in view the above prospective, following objective was taken i. To optimize the effect of pre-treatment on the color value of fresh-cut banana pseudo stem ii. To study the storage stability, biochemical and microbiological parameters of packaged fresh-cut banana pseudo stem.

Materials and Methods

Raw material

The study was carried out on the poovan variety of banana pseudo stem procured from the university orchard of Tamilnadu Agricultural University, Coimbatore. The packaging material of LDPE was obtained from the local market, town hall, Coimbatore. The thicknesses of the packaging materials were measured using thickness meter.

Preparation of fresh-cut banana pseudo stem

Fresh good quality and uniformly matured banana pseudo stems (*var.* poovan) were cut in to small cubes of approximately 5mm and immediately pretreated for 15 minutes with two different anti-browning agents (1% ascorbic acid and 1% potassium meta-bisulphite (KMS) to avoid browning (Plate 2). The treated cubes were shade dried for 15 minutes to remove surface moisture and approximately 100g of samples were packaged in LDPE packaging material. The test samples were stored under 8±2°C, 27±2°C and analyzed for colour value. Based on the colour value, the pre-treatments were optimized.

Respiration Rate

The pre-treated banana pseudo stem of known quantity was kept in a container for the measurement of respiration rate. The containers were closed, and the lid was made air tight by wrapping with plastic tape and stored at 27±2°C and 8±2°C. The gas samples were drawn at an interval of one hour through septum using needle and gas concentration of oxygen and carbon dioxide was found out using gas analyzer (Plate 1) (Make: PBI Dansensor Model: Checkmate II).

Physico-Chemical and Microbiological characteristics of fresh-cut banana pseudo stem:

Physiological loss in weight (PLW)

Fresh-cut vegetables was weighed with the help of an electronic balance (Make: Avery; Model: OC-51) at regular intervals. The initial and final weights of the leaves was recorded and the percentage loss in weight was calculated. (Parmpal *et al.* 2015).

Physiological loss in weight (%) =

$$\frac{\text{ht - Final Weight}}{\text{al Weight}} \times 100$$

Colour

Hunter lab colour flex meter (Make: Hunter Lab, Model: 45º/0º) was used for the measurement of colour. It works on the principle of collecting the light and measures energy from the sample reflected across the entire visible spectrum. The meter uses filters and the mathematical models called Hunter model which rely on "standard observer curves" that define the amount of red, green, and blue

(primary lights) required to match a series of colours across the visible spectrum. All the three standard CIE colour parameters 'L', 'a', 'b' was observed for daylight colour.

Crude fibre

Crude fibre was determined from the 2g of sample extracted using ether (to remove fat). Boil the 2g of dried sample with 200ml of sulphuric acid for 30min with bumping chips. Then filter it through muslin and wash it with boiling water until acidic nature are removed. Boil with 200ml of sodium hydroxide solution for 30min and filter through muslin cloth again. The filtered solution is been washed with 25ml of boiling 1.25% H_2SO_4, three 50ml portions of water and 25ml alcohol. Remove the residue (W1) and dry it for 2h at 130 ±2°C. Dried residue are cooled in a desiccator (W_2). Ignite for 30min at 600 ±15°C. Cool in a desiccator and reweigh (W_3). (Pradhan *et al.* 2015)

Loss in weight $(W_2 - W_1) – (W_3 - W_1)$

% crude fiber in sample =

$$\frac{\text{Loss in weight } (W_2\text{-}W_1)\text{-}(W_3\text{-}W_1)}{\text{Weight of the sample}} \times 100 \quad \text{___ (2)}$$

Microbial Analysis

The qualities of fresh-cut vegetables are based on the number and kind of microorganisms present, which was assessed by standard plate count method (Lee *et al.* 2014). Commonly used media for the enumeration of bacteria and fungi are nutrient agar medium and Martin's Rose Bengal Agar medium.

Organoleptic Evaluation

Organoleptic evaluation of the vegetables was evaluated by a panel of 12 untrained judges for for appearance, color, flavor, texture, taste and overall acceptability. The quality was evaluated using 9-point Hedonic scale (IS 6272: 1991).

Statistical analysis

Factorial Completely Randomized Design (FCRD) was followed for all the statistical analysis. Analysis of variance (ANOVA) was performed to determine the significant effect of the independent variables on the response variables. The treatments and their interactions were compared at $p \leq 0.01$ and $p \leq 0.05$ level using least square deference (LSD) test which was performed by the statistical analysis sof ware AGRES.

Results and Discussion

Optimization of pre-treatment for fresh-cut banana pseudo stem

Consumers take product appearance into main consideration colour has been considered as a primary factor in food preference and acceptability, and it also influence taste of the food thresholds. Enzymatic browning is the most important reactions that affect the colour during processing of fresh-cut banana pseudo stem. The most important enzyme associated with discoloration of fresh-cut produce is polyphenol oxidase (Garcia and Barret , 2002). Hence, the pre-treatment are optimized based on the color value. Krokida *et al.* (2007) used colour value for optimizing the pretreatment for apple, banana and carrot. To prevent browning in effective manner the anti-browning agents KMS, AA are selected for the study. The fresh-cut banana pseudo stem was pre-treated, packaged in LDPE (100μ) and stored under 27±2°C and 8±2°C

Effect of pre-treatments on colour value of fresh-cut banana pseudo stem

The banana pseudo stem cubes were pre-treated with two different chemicals viz., potassium meta bi-sulphite and ascorbic acid with 1% concentration for 15 min. The effect of colour value on pre-treated fresh-cut banana pseudo stem packaged in LDPE and stored under 27±2°C and 8±2°C are presented in the Table.1.

Change in 'L' value of fresh-cut banana pseudo stem

The initial 'L' value of the fresh-cut banana pseudo stem was 70.34 and it increased to 72.54 for ascorbic acid and for KMS (1% for 15 min) it was 73.56. From the table, it was observed that 'L' value decreased

with increase of storage period, and this may be due to enzymatic browning (PPO activity) in fresh-cut banana pseudo stem.

The minimum decrease in 'L' value was found in P2RT2 (70.41) in 35 days of storage, and the maximum decrease was in control P1AT1 (46.19) af er five days of storage at ambient condition. The samples treated with KMS were in good condition for 20 days under ambient storage without browning and the 'L' value was 70.03 in LDPE pouch. The browning effect was more in the samples treated with ascorbic acid, and it was in good condition only up to ten days with less 'L' value (57.58 - LDPE).

It is evident from the table that under 8±2°C (low temperature), the KMS treated samples were in good

Plate 1. Gas Analyser

Plate 2. Fresh-cut Banana Pseudostem- after Treatment

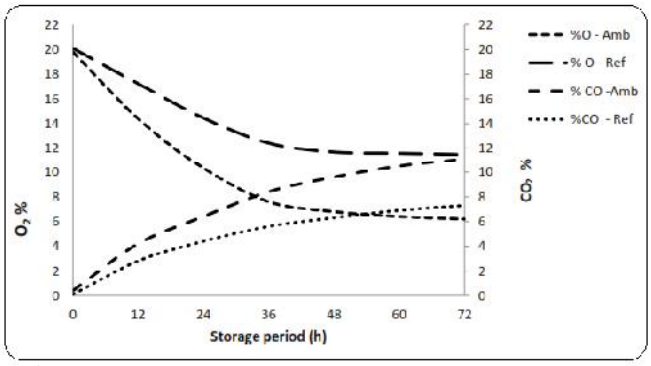
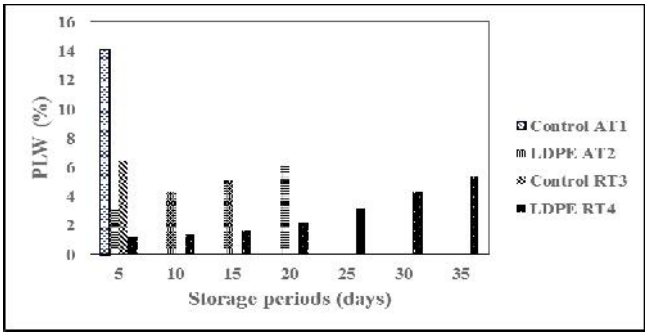


Fig. 1. The effect of different environment on gas concentration inside the closed container with fresh-cut banana pseudo stem

$\%O_2$- Amb – percentage of oxygen at 27±2°C, $\%O_2$- Ref – percentage of oxygen at 8±2°C, $\%CO_2$- Amb – percentage of carbon dioxide at 27±2°C, $\%CO_2$- Ref – percentage of carbon dioxide at 8±2°C



LDPE – low density poly ethylene, A- ambient temperature (27±2°C), R- refrigerated temperature (8±2°C)

Fig. 2. The effect of a storage period on the physiological loss in weight of fresh-cut banana pseudo stem

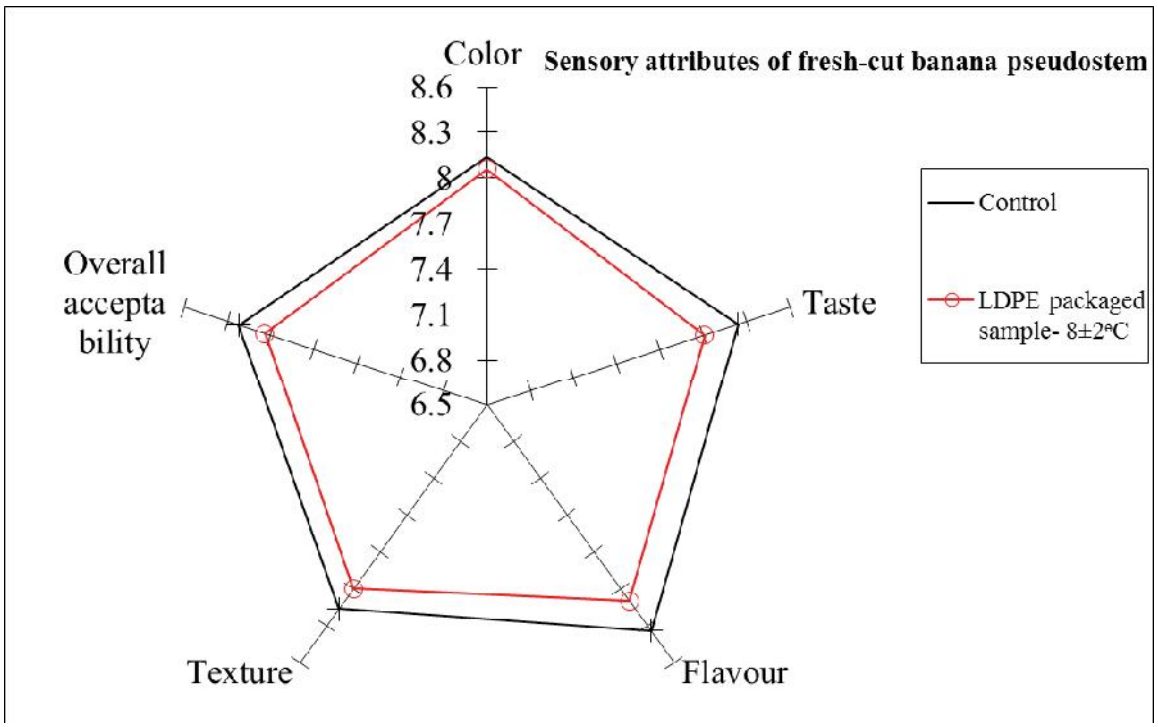


Fig. 3. Sensory evaluation of the fresh-cut banana pseudo stem

condition up to 35 days ('L' value – 70.41) with less browning effect compared to ascorbic acid treated samples only for 20 days ('L' value- 56.62). Similar result were reported by Sandhu and Parhawak (2002) for potato cubes treated with KMS.

The 'L' value decreased with increase of the storage period which indicates the change of the samples towards darkness (73.56 to 70.41). The effect of pre-treatment, storage period and packaging material at both 30±2°C and 8±2°C on colour value 'L' of fresh-cut banana pseudo stem were statistically analysed and the results indicated that the treatments significantly influence the 'L' value at ($p \leq 0.01$). The pre-treatment, storage period and packaging materials individually had a significant effect on the 'L' value ($p \leq 0.01$), and their interactions were also found to be significant ($p \leq 0.01$).

Change in 'a' value of fresh-cut banana pseudo stem

The effect of 'a' value of fresh-cut banana pseudo stem packaged in LDPE films at both 27±2°C and 8±2°C are presented in Table.1. The 'a' value of un-treated fresh-cut banana pseudo stem was recorded as 1.23. The 'a' value increased due to pre-treatment and it was 1.17 immediately after the treatment in KMS whereas it was 1.42 in ascorbic acid treated samples. The 'a' value showed a gradual increase with storage period and indicated the browning effect.

The minimum increase of 'a' value was found in P2RT2 (1.28) in 35 days of storage at 8±2°C, and maximum increase was observed in P1AT1 (1.76) on 5th day of storage at 27±2°C. The 'a' value for ascorbic acid (1% for 15min) treated samples were 1.58 for

Table 1. Effect of pre-treatment on the color value of fresh-cut banana pseudo stem

Pre-treatment	Storage Periods	27±2°C						8±2°C					
	(Days)	Control (AT1)			LDPE (AT2)			Control (RT1)			LDPE (RT2)		
		L	a	b	L	a	b	L	a	b	L	a	b
Ascorbic Acid - P1 (1% for 15 min)	0	72.57	1.56	22.33	72.57	1.56	22.33	72.57	1.56	22.33	72.57	1.56	22.33
	5	46.19	3.78	16.78	69.12	1.94	22.12	56.19	2.06	20.89	72.45	1.67	21.44
	10	*	*	*	57.68	2.42	21.92	52.94	2.17	18.46	70.34	2.12	21.32
	15	*	*	*	*	*	*	*	*	*	68.23	2.53	20.26
	20	*	*	*	*	*	*	*	*	*	56.62	2.82	19.5
Potassium Meta Bisulphite - P2 (1% for 15 min)	0	73.56	1.17	22.56	73.56	1.17	22.89	73.56	1.17	22.33	73.56	1.17	22.33
	5	49.19	1.47	21.78	73.44	1.23	22.76	57.19	1.23	21.76	73.08	1.26	22.31
	10	*	*	*	71.46	1.46	22.04	53.45	2.11	21.27	72.65	1.32	21.99
	15	*	*	*	70.27	1.8	21.78	*	*	*	71.76	1.43	21.84
	20	*	*	*	70.03	2.32	21.1	*	*	*	71.48	1.64	21.63
	25	*	*	*	*	*	*	*	*	*	70.78	1.73	21.26
	30	*	*	*	*	*	*	*	*	*	70.44	1.82	21.08
	35	*	*	*	*	*	*	*	*	*	70.41	1.94	20.94

*- samples got spoiled

Table 2. Effect of a storage period on microbial growth for fresh cut banana pseudo stem

Storage Periods	Bacteria (10^5 CFU/g)				Fungi (10^3 CFU/g)			
	27±2°C		8±2°C		27±2°C		8±2°C	
	Control (T1)	LDPE (T2)	Control (T3)	LDPE (T4)	Control (T1)	LDPE (T2)	Control (T3)	LDPE (T4)
0	6.12	6.12	6.12	6.12	4.23	4.23	4.23	4.23
1	0	0	0	0	0	0	0	0
5	6.24	2.21	5.13	0	5.1	0	5.1	0
10	*	2.46	5.78	0.4	*	0.8	*	0
15	*	3.32	*	1.36	*	1.4	*	0.92
20	*	3.67	*	1.47	*	2	*	1.78
25	*	*	*	2.18	*	*	*	2.14
30	*	*	*	2.58	*	*	*	2.54
35	*	*	*	3.64	*	*	*	2.76

*samples got spoiled

LDPE on 10th day of storage whereas for KMS (1% for 15min) treated samples it was 1.54 for LDPE after 20 days of storage at 27±2°C.

The KMS treated samples had extended shelf life of 35 days with 'a' value of 1.28 (LDPE) whereas for ascorbic acid treated samples, the shelf life was only 20 days with more 'a' value of 1.50 (LDPE) at 8±2°C. Gonzalez *et al.* (1993) reported that a decrease in 'L' value and an increase in 'a' value are indicatives of browning. The packaging did not have any effect on the colour value of fresh-cut banana pseudo stem. The pre-treatment, storage period and packaging materials individually had a significant effect on the 'a' value ($p \leq 0.01$). Their interactions were found to be significantly ($p \leq 0.01$) influence the colour value of 'a'.

Changes in 'b' value of fresh-cut banana pseudo stem

The 'b' value of fresh-cut banana pseudo stem packaged in LDPE pouches are furnished in the Table.1. The initial 'b' value of fresh-cut banana pseudo stem was recorded as 22.14. The 'b' value gradually decreased with increase of the storage period. From the table it was observed that minimum change in 'b' value was found in P2RT2 (20.94) in 35 days of storage at 8±2°C and maximum was in P1AT1 (21.78) after 5 days of storage at 27±2°C.

The 'b' value for KMS treated samples were 21.1 (LDPE) whereas for ascorbic acid treated samples it was 21.92 (LDPE) after ten days of storage at 27±2°C. The KMS treated samples were stored up to 35 days without browning and 'b' value was 20.94 (LDPE) whereas the ascorbic acid treated samples were in good condition only up to 20 days and 'b' value was 18.5 (LDPE) at 8±2°C. The packaging materials did not have any effect on 'b' value. Apintanapong *et al.* (2007) reported that for pre-treated banana slices had the lowest change of L* and b* that represented less browning and blueness. The pre-treatment, storage period and packaging materials individually had a significant effect on the 'b' ($p \leq 0.01$) and their interactions were also found to be significant.

From the results of colour value, it was observed that the samples pre-treated with KMS had minimum decrease in 'L' and 'b' value whereas there was a minimum increase of 'a' value which is most desired for reducing the browning effect in both ambient and refrigerated condition. Hence, it is concluded that the KMS treatment of fresh-cut banana pseudo stem for 15 min with a concentration of 1% was the best. Hence, all further studies were carried out with this pre-treatment.

Influence of oxygen (O_2) and carbon dioxide (CO_2) concentration on fresh-cut banana pseudo stem:

The oxygen and carbon dioxide concentration of fresh-cut banana pseudo stem stored in the closed container are presented in the Figure 1. It was observed that concentration of O_2 decreased whereas that of CO_2 increased under both 27±2°C and 8±2°C. At 27±2°C, the O_2 concentration had come down to 6.2% whereas in refrigerated condition, it was 11.5% from the initial value of 19.8 per cent. In the case of CO_2, it reached 11.1% at 27±2°C; however, it was only 7.3% at 72h in 8±2°C.

The reduction in O_2 concentration and increase in CO_2 was more under 27±2°C compared to 8±2°C. The higher temperature would have influenced more respiration that would have facilitated more depletion of O_2 and more production of CO_2.

Physicochemical characteristics for MAP of fresh-cut banana pseudo stem.

The physicochemical analysis of fresh-cut banana pseudo stem was carried out for physiological loss in weight, crude fibre and microbial growth during the storage period.

Physiological loss in weight for MAP fresh-cut banana pseudo stem

The effects of a storage period on physiological loss in weight for MAP fresh-cut banana pseudo stem are presented in the Figure.2. It is observed from the figure that the physiological loss in weight increased with increase of the storage period at 27±2°C. Same trend of result was obtained by storing Barasami

lemon (Jawandha *et al.* 2014). During storage, the loss in weight was more (14.1%) in control (T1) sample in 5 days. The PLW was more at 27±2°C this may be due to less humidity in the atmospheric air compared to that of 8±2°C.

There was a minimum of 5.4% weight loss observed in 35 days of storage with LDPE pouches (T4) in 8±2°C. Under this condition, the respiration rate was less due to low temperature and high humidity resulting in minimum loss in weight. Loss in weight is mainly due to retardation in respiration and transpiration

The samples stored in LDPE pouch under 27±2°C was having a minimum weight loss of 6.2% in 20 days whereas under 8±2°C weight loss of only 5.4% was recorded in 35 days. Similar results of more loss of weight under for fresh-cut zucchini (*Cucurbita* pepo) was reported by Lucera *et al.* (2010). The results indicated that the treatments are not significantly influence the PLW. However, the factors, storage period, packaging materials individually had a significant effect on the PLW ($p \leq 0.01$), and their interactions were also found to be significant.

Change in fibre content for fresh-cut banana pseudo stem

Fibre is an indigestible cell wall component of plant materials which plays an important role in human health. The initial fibre content of fresh-cut banana pseudo stem was 0.8 g/100g. The fibre content at 27±2°C did not change during the storage period, and it remained as such up to 20 days. This may be due to the reason that the fibre is relatively inert and not sensitive to degradation during storage. At 8±2°C also it was observed that there was no change in fibre content up to 35 days.

Microbial growth for fresh-cut banana pseudo stem

The effect of a storage period on the microbial growth of fresh-cut banana pseudo stem are presented in the Table 2. The initial bacterial and fungal population of the fresh-cut banana pseudo stem was 6.12×10^5 CFU/g and 4.3×10^3 CFU/g respectively. After the pre-treatment, the fresh-cut banana pseudo stem had no bacteria and fungi; however, there was microbial growth at later stages. This may be due to that, the microbes become inert due to pre-treatment and when the effect of KMS reduced, they started to grow.

As the storage period increased, the microbial growth also increased due to oxidative reactions. The KMS act as antimicrobial agents which are freely soluble in water forming sulphurous acid, bisulphate and sulphite ions. Sulphurous acid blocks enzymes of the micro -organism by reducing essential disulphide (S-S) linkage. The bacterial and fungal growth was less in T2 (3.67×10^5 CFU/g, 2×10^3 CFU/g) in 20 days of storage at 27±2°C. Srinivasa *et al.* (2002) reported that microbial growth increased inside the package due to more condensation of water from the vegetables. Steen *et al.* (2002) reported that for fresh cut produce the atmospheric air packaging inhibits the growth of microorganism, prevent undesired anaerobic respiration and maintain the quality.

In 8±2°C, the pre-treated fresh-cut banana pseudo stem had a shelf life of 35 days with less microbial growth of 3.64×10^5 CFU/g for bacteria, and it was 2.26×10^3 CFU/g for fungi. Willocx, (1995) reported that refrigerated condition is the most suitable or fresh-cut vegetables. The results indicated that the treatments did not significantly influence the microbial growth. The storage period, packaging materials individually had a significant effect on the microbial growth ($p \leq 0.01$), and their interactions were also found to be significant.

Sensory evaluation for fresh-cut banana pseudo stem

The microbial quality is the main parameter in determining the product shelf life. From the results obtained for the microbial analysis, it was observed that the sample of T4 were within the safe. Hence, the above samples were taken for conducting the sensory evaluation. Curry was prepared from selected samples and were evaluated based on the nine -point hedonic scale.

From the Figure. 3 it is observed that, the control sample scored overall acceptability of 8.2. The LDPE packaged sample T4 at 8±2°C scored maximum

overall acceptability of 8. The minimally processed fresh-cut banana pseudo stem had 35days of shelf life with good color and texture. The effect of sensory evaluation on the minimally processed fresh-cut banana pseudo stem was analyzed statistically and the treatments are found to be significant ($p \leq 0.01$).

Conclusion

The fresh-cut banana pseudo stem treated with 1% KMS had minimum loss in quality and increased the shelf life up to 35 days at 8±2°C. This would be a bet er technology for minimally processed fresh-cut banana pseudo stem.

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