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DEVELOPMENT OF FRESH AND MINIMALLY PROCESSED BANANA INFLORESCENCE

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ABSTRACT

Banana inflorescence though a high valued vegetable, but its difficulty in extraction of flowers for cooking, restricts its consumption and popularity. Therefore, in order to get a solution from this problematic condition the experiment was conducted with an aim to develop banana inflorescence which would be fresh as well as minimally processed so they can be used instantly. In the present experiment 'Kanthali' variety for banana inflorescence was used. The bracts were separated and banana flowers were carefully removed and thereafter they were treated with various chemicals like calcium chloride, citric acid, calcium hypochlorite and even their combinations were also used. The dipping time of the banana inflorescence in the treatments was of around 10 minutes, then after keeping the treated materials under a fan in the laboratory for few minutes they were prepacked and storage was carried in refrigerated condition of 7 ± 2^0 C temperature and 80-85% relative humidity. The treatments were replicated 3 times and observations for different attributes were carried at different days of storage. From the experiment it was concluded that banana inflorescence treated with combination of calcium hypochlorite, calcium chloride and citric acid was found most superior in retaining various physical and chemical properties and was with least microbial damage throughout the storage period.

Keywords: banana inflorescence, fresh, minimal processing, packaging, refrigeration

INTRODUCTION

Banana inflorescence which is consumed as a vegetable in many Asian countries is a very high value commodity with great nutritive potential (Wickramarachchi and Ranamukhaarachchi, 2005). The banana inflorescence has also been found to contain huge amount of dietary fibers in it.The high content of dietary fibers present in it is very good for health which helps in prevention of various diseases by stabilizing the levels of blood cholesterol and insulin (Wickramarachchi and Ranamukhaarachchi, 2005). The banana inflorescence also possesses great reservoir of antioxidants which stops the oxidation process, blocks molecules from destabilizing the DNA and controls various cardiac problems. The high magnesium content present in the inflorescence helps in boosting the mood and reduces various anxiety related problems.Not only this the inflorescence or the extracts of the inflorescence is good against harmful bacteria and diseases. It has been found that the extracts obtained from the banana inflorescence has got the ability to fight against various pathogenic diseases and can also stop the growth of malarial bacteria.

However irrespective of the tremendous nutritive and health related benefits hidden in the pendulum shaped banana inflorescence, the consumption of it as a vegetable is not very popular. In India it is consumed in very selective states like West Bengal, Assam etc. The banana inflorescence for utilizing it as a vegetable the bracts are to be removed, the flowers underneath each layer of bracts has to be carefully separated and after extraction of flowers the gynoecium and the scale portions has to be removed from each and every flower. There after the flowers are chopped and cooked for preparing it into a vegetable delicacy. This entire phenomenon of converting the raw inflorescence into anedible dish is very hectic and time taking. Furthermore, today people lifestyle has changed. Everyone is busy with very less time for cooking. This over engaged schedule of common mass has led to development of ready to serve or ready to eat products. Therefore, the study was taken with an objective to develop fresh minimally processed banana inflorescence which can be cooked directly and can also be stored for a certain period of time.

MATERIALS AND METHOD

The study took place in the laboratory of Department of Post-Harvest Technology of Horticultural Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the academic year 2014-15 and 2015-16.

The banana inflorescences taken were of 'Kanthali' variety. The flowers were taken out by removing the bracts and the gynoecium and scale was carefully separated from each flower. After that the flowers were dipped in the following treatment solutions for 10 minutes. The treatments used in the study are similar as per to the works of Das *et al.*, (2019).

- T_1 – Calcium hypochlorite 100 ppm
- T_2– Calcium chloride 0.2%
- T_3 – Citric acid 0.2%
- T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%
- T_5 – Calcium hypochlorite 100 ppm + Citric acid 0.2%
- T_6 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%
- T_7 – Calcium chloride 0.2% + Citric acid 0.2%
- T_8 – Control.

After dipping the banana inflorescence in different treatment combinations, they were dried inside the laboratory under a fan and then were pre packed in Low Density Poly Ethylene packets and stored in a refrigerated condition of 7 ± 2^0 C temperature and 80-85% relative humidity. The treatments were replicated 3 times. Observations for different parameters viz. appearance quality (Peryam&Girardot, 1952, Peryam& Pilgrim, 1957), moisture content (A.O.A.C, 2000), physiological loss in weight (Ranganna, 2003), radical scavenging activity (Brand-Williams *et al*., 1995), total phenol content (Singleton *et al*., 1999), total flavanoid (Zhishen*et al*., 1999) and microbial load (Allen, 1953) were recorded at periodic storage intervals. Statistical analysis was carried by Completely Randomized Design (Gomez and Gomez, 1984; Sheoran*et al*., 1984) and Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

There was a constant increase in the physiological loss of weight (Table 1) all along the storage. The combination treatment of calcium hypochlorite, calcium chloride and citric acid was able to withhold more weight during the storage study and untreated control suffered the maximum weight loss of 11.25%.

A significant declining pattern was seen regarding the moisture content among all the treatments throughout the storage (Table 2). The initial day (0 DAS) of storage recorded a moisture content of 85.43% for all the treatments. Thereafter there was a gradual loss in the moisture content among the treatments throughout. However, at the end of storage at 7 days banana inflorescence treated with combination of calcium hypochlorite, calcium chloride and citric acid was found the best with maximum moisture retention

Up to 2^{nd} day of storage, all treatments maintained significant higher values with respect to appearance quality except control (Table 3).At four days of storage also the appearance score was reasonable for all the treatments but at seven days of storage the score reduced unacceptably. Though a fair amount of appearance score was seen for banana inflorescence treated with combination of calcium hypochlorite, calcium chloride and citric acid but the control flowers recorded the maximum deterioration in quality with least appearance score.

A decreasing trend was observed in the biochemical values regarding the total phenols, flavanoid and antioxidant levels of the fresh banana inflorescence (Table 4,5 and 6). The concentration regarding total phenols, flavanoid and antioxidant levels were highest on 0 days of storage, and there after gradually decreased throughout the storage period. All along the storage banana inflorescence treated with combination of calcium hypochlorite, calcium chloride and citric acid was found superior in retaining its biochemical properties (total phenols, flavanoid and antioxidant levels) as compared to other treatments. This was followed by banana inflorescence treated with combination of calcium chloride and citric acid.

The fresh cut banana inflorescence treated with various pretreatments as influenced by the microbial attack during the storage period is shown in the Table 7 and 8. At initial day (0 DAS) the bacterial load of 1.66 x 10^5cfu/g and fungal population of 1.00 x 10^2cfu/g (unicellular) and 0.66 x 10^2cfu/g (filamentous) was seen for all the treatments. With the passage in the storage period the microbial populations tend to increase. However,banana inflorescence treated with combination of calcium hypochlorite, calcium chloride and citric acid recorded significant lesser levels of microbial population with bacterial load of 3.67 x 10^5cfu/g and fungal load of 3.00 x 10^2 (unicellular) and 1.67 x 10^2 (filamentous) at 7 days of storage. Control at the end of storage documented bacterial population of 6.67 x 10^5cfu/g and 6.00 x 10^2cfu/g for unicellular fungi and 3.67 x 10^2cfu/g for filamentous fungi.

In this study the chemicals like calcium and citric acid helped in maintaining the post harvest life of banana inflorescence. Packaging with LDPE packets might also have created a modified atmospheric situation to increase the shelf life of the products. Similar results were reported by González-Aguilar *et al*., (1997) on maintaining the sensory attributes of celery sticks. The phenol content deteriorated during the experiment which may be because of the enzymatic activity of polyphenol oxidase and peroxidase (Baltacig*et al*., 2011). In the banana inflorescence treated with calcium chloride the reduction in phenol content was less, which was because

Table 1: Physiological loss in weight of fresh cut banana inflorescence at different days in storage

Treat-ments	Physiological loss in weight (%)		
	2 DAS	**4 DAS**	**7 DAS**
T_1	3.55 **g** (2.13)	6.35 **d** (2.17)	10.22 **g** (3.35)
T_2	3.13 **e** (2.03)	5.86 **bc** (2.62)	9.45 **e** (3.23)
T_3	3.33 **f** (2.08)	6.13 **cd** (2.67)	9.84 **f** (3.29)
T_4	2.81 **c** (1.95)	5.10 **a** (2.46)	8.64 **c** (3.10)
T_5	2.97 **d** (1.99)	5.63 **b** (2.57)	8.94 **d** (3.15)
T_6	2.33 **a** (1.82)	4.86 **a** (2.42)	7.84 **a** (2.97)
T_7	2.65 **b** (1.91)	5.24 **a** (2.49)	8.25 **b** (3.04)
T_8	3.83 **h** (2.19)	6.76 **e** (2.78)	11.25 **h** (3.50)
CD 5%	**0.02**	**0.076**	**0.007**
SEm±	**0.07**	**0.025**	**0.002**

Figures in parenthesis indicates square root transformed values (means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)

Table 2: Moisture content of fresh cut banana inflorescence at different days in storage

Treat-ments	Moisture content (%)			
	0 DAS	**2 DAS**	**4 DAS**	**7 DAS**
T_1	85.43	79.13 **b**	72.53 **b**	69.50 **b**
T_2		80.40 **d**	76.30 **d**	71.30 **d**
T_3		79.86 **c**	75.26 **c**	70.50 **c**
T_4		81.83 **f**	80.13 **f**	75.43 **f**
T_5		81.13 **e**	78.70 **e**	73.60 **e**
T_6		83.26 **h**	82.20 **h**	80.20 **h**
T_7		82.13 **g**	81.26 **g**	78.26 **g**
T_8		78.60 **a**	70.40 **a**	65.40 **a**
CD 5%	**-**	**0.154**	**0.377**	**0.37**
SEm±	**-**	**0.051**	**0.125**	**0.122**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)

Table 3: Appearance quality of fresh cut banana inflorescence at different days in storage

Treat-ments	Hedonic scaling			
	0 DAS	**2 DAS**	**4 DAS**	**7 DAS**
T_1	9.00	5.66 **ab**	4.33 **a**	2.33 **a**
T_2		6.66 **cd**	6.00 **bc**	3.66 **bc**
T_3		6.33 **bc**	5.66 **b**	3.33 **b**
T_4		7.33 **cd**	6.66 **cde**	4.66 **de**
T_5		7.00 **cd**	6.33 **bcd**	4.33 **cd**
T_6		8.33 **e**	7.33 **e**	5.66 **f**
T_7		7.66 **de**	7.00 **de**	5.33 **ef**
T_8		5.33 **a**	3.66 **a**	2.00 **a**
CD 5%	**-**	**0.874**	**0.572**	**0.544**
SEm±	**-**	**0.292**	**0.191**	**0.182**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)

Table 4: Total content of phenols of fresh cut banana inflorescence at different days in storage

Treat-ments	Total phenols (mg GAE/g)			
	0 DAS	**2 DAS**	**4 DAS**	**7 DAS**
T_1	42.05	31.40 **b**	25.32 **b**	22.19 **b**
T_2		33.92 **d**	29.73 **d**	24.81 **d**
T_3		32.96 **c**	27.15 **c**	23.21 **c**
T_4		37.17 **f**	32.19 **f**	29.52 **f**
T_5		35.87 **e**	31.30 **e**	27.65 **e**
T_6		40.27 **g**	36.74 **g**	32.37 **g**
T_7		38.41 **h**	33.34 **h**	30.39 **h**
T_8		30.44 **a**	23.40 **a**	19.90 **a**
CD 5%	**-**	**0.405**	**0.441**	**0.334**
SEm±	**-**	**0.134**	**0.146**	**0.111**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%) (T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)

Table 5: Favanoid contents of fresh cut banana inflorescence at different days in storage

Treat-ments	Flavanoid (mg CE/g)			
	0 DAS	2 DAS	4 DAS	7 DAS
T_1	2.94	2.26 **b**	1.92 **b**	1.74 **b**
T_2		2.38 **d**	2.10 **d**	1.88 **d**
T_3		2.31 **c**	2.02 **c**	1.80 **c**
T_4		2.67 **f**	2.26 **f**	2.02 **f**
T_5		2.56 **e**	2.17 **e**	1.93 **e**
T_6		2.86 **h**	2.51 **h**	2.24 **h**
T_7		2.76 **g**	2.36 **g**	2.12 **g**
T_8		2.12 **a**	1.81 **a**	1.58 **a**
CD 5%	-	**0.023**	**0.026**	**0.029**
SEm±	-	**0.008**	**0.008**	**0.010**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)

Table 6: Antioxidant activity (percent inhibition of DPPH) of fresh cut banana inflorescence at different days in storage

Treat-ments	Percent inhibition of DPPH			
	0 DAS	2 DAS	4 DAS	7 DAS
T_1	71.36	49.60 **b**	39.83 **b**	27.42 **b**
T_2		55.51 **d**	43.34 **d**	33.56 **d**
T_3		51.18 **c**	40.66 **c**	30.31 **c**
T_4		61.42 **f**	48.82 **f**	43.44 **f**
T_5		58.79 **e**	46.45 **e**	37.80 **e**
T_6		67.83 **h**	59.28 **h**	53.40 **h**
T_7		64.55 **g**	53.46 **g**	48.62 **g**
T_8		46.69 **a**	36.57 **a**	23.50 **a**
CD 5%	-	**0.315**	**0.305**	**2.164**
SEm±	-	**0.104**	**0.101**	**0.716**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_6(Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2% T_8– Control)

Table 7: Populations of bacteria on fresh cut banana inflorescence at different days in storage

Treat-ments	Bacterial population (x 10^5cfu/g)			
	0 DAS	2 DAS	4 DAS	7 DAS
T_1	1.66	3.00 **c**	4.67 **bc**	5.67 **d**
T_2		2.67 **bc**	4.33 **b**	5.33 **cd**
T_3		2.67 **bc**	4.33 **b**	5.67 **d**
T_4		2.00 **ab**	3.00 **a**	4.00 **ab**
T_5		2.67 **bc**	3.33 **a**	4.67 **bc**
T_6		1.67 **a**	2.67 **a**	3.67 **a**
T_7		1.67 **a**	3.00 **a**	4.00 **ab**
T_8		3.33 **c**	5.33 **c**	6.67 **e**
C.D. (0.05)	**-**	**0.873**	**0.797**	**0.873**
SE m ±	**-**	**0.289**	**0.264**	**0.289**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)

of the inhibitory action demonstrated by the chloride ions against polyphenol oxidase. The finding is similar to the prior reports of Rinaldi *et al*., (2010). Moline *et al*., (1999) in their study also reported that calcium chloride was able to reduce the enzymatic browning in minimally processed chinese cabbage.

According to Lund, (1992) the inner tissues or layers of vegetables are very much free from microorganisms as compared to the outer layers. Taking out the banana flowers from the bracts exposed them to the outside environment rendering them more susceptible to bacterial and fungal attack. Nguyen and Carlin (1994) in their work recorded a bacterial population of 10^3-10^6 cfu/g and fungal population of of 10^3-10^4cfu/g for fresh cut vegetables. Low temperature storage proved beneficial for banana inflorescence. Waldemar *et al.,*(2008) and Gong and Mattheis, (2003) in their studies showed the significance of low temperature storage for maintaining the fresh like attributes of stored broccoli. Yuan *et al*., (2010) concluded that low temperature storage could reduce the membrane lipid degradation which ultimately would bring down the flavanoid oxidation in fresh broccoli.

Table 8: Populations of unicellular and filamentous fungi on fresh cut banana inflorescence at different days in storage

Treat-ments	Fungal population (x 10^2cfu/g)							
	0 DAS		2 DAS		4 DAS		7 DAS	
	Uni	Fil	Uni	Fil	Uni	Fil	Uni	Fil
T_1	1.00	0.66	2.67 **cd**	1.33**ab**	4.33 **cd**	2.67 **b**	5.33 **de**	3.00 **bc**
T_2			2.33 **bcd**	1.00 **ab**	3.67 **bc**	2.33 **b**	4.00 **bc**	2.67 **abc**
T_3			2.67 **cd**	1.33 **ab**	4.00 **cd**	2.67 **b**	4.67 **cd**	2.67 **abc**
T_4			1.67 **ab**	0.67 **a**	3.00 **ab**	1.67 **ab**	3.33 **ab**	2.00 **ab**
T_5			2.00 **abc**	1.00 **ab**	3.00 **ab**	2.33 **b**	3.67 **ab**	2.67 **abc**
T_6			1.33 **a**	0.67 **a**	2.33 **a**	1.00 **a**	3.00 **a**	1.67 **a**
T_7			1.67 **ab**	0.67 **a**	2.67 **a**	1.67 **ab**	3.33 **ab**	2.00 **ab**
T_8			3.00 **d**	1.67 **b**	4.67 **d**	2.67 **b**	6.00 **e**	3.67 **c**
C.D.	-	-	**0.943**	**0.873**	**0.873**	**N/A**	**0.873**	**0.943**
SE m ±	-	-	**0.312**	**0.289**	**0.289**	**0.312**	**0.289**	**0.312**

(means in the column followed by the same alphabet do not differ significantly by DMRT at 5%)(T_1 – Calcium hypochlorite 100 ppm, T_2– Calcium chloride 0.2%, T_3 – Citric acid 0.2%, T_4 – Calcium hypochlorite 100 ppm + Calcium chloride 0.2%, T_5– Calcium hypochlorite 100 ppm + Citric acid 0.2%, T_6– Calcium hypochlorite 100 ppm + Calcium chloride 0.2% + Citric acid 0.2%, T_7– Calcium chloride 0.2% + Citric acid 0.2%, T_8– Control)
[Uni: Unicellular funigi; Fil: Filamentous fungi]

CONCLUSION

In the study minimal processing was carried by subjecting the extracted banana flowers to different chemicals like calcium hypochlorite, calcium chloride, citric acid and their combinations. It was found that all along the storage period of seven days banana inflorescence treated with combination of calcium hypochlorite, calcium chloride and citric acid was found superior in retaining various physical, chemical and microbial properties. This was followed by banana inflorescence treated with combination of calcium chloride and citric acid. Untreated banana flowers on the other hand suffered maximum nutrient loss and highest microbial contaminations.

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