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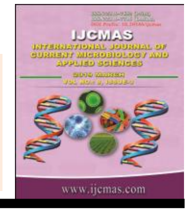

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Standardization of Drying Techniques to Develop Ready to Cook Banana Inflorescence

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A B S T R A C T

Banana inflorescence is consumed as a vegetable in many Asian countries, is also an excellent source of various minerals such as magnesium, copper and iron. However using it as a vegetable sometimes becomes very demanding as it is very difficult to remove the bracts and extract out the flowers for cooking. So it becomes very important to use some technology to develop ready to cook banana inflorescence which can be preserved for a long period. Dehydration can successfully used to safeguard a commodity as it reduces the bulk volume by lowering the moisture content and also diminishes fungal attack. But in case of dehydration of banana inflorescence the problem of enzymatic browning due to the activity of polyphenol oxidase (PPO) is very pervasive. Therefore the study was aimed to develop suitable dehydration process of banana inflorescence which would yield attractive dehydrated product with long shelf life. Banana inflorescences were subjected to various pretreatments followed by which dehydration was carried at three different temperatures of 50^0C, 55^0C and 60^0C. Thereafter the dehydrated products were packed in LDPE 50 micron pouches and stored in ambient condition. Observation for different physical and biochemical attributes were taken at 0, 30, 60 and 90 days of storage. The study revealed that banana inflorescence pretreated with initially dipping at 0.2% citric acid followed by hot water blanching for 4 minutes and final dipping at 0.1 % sodium metabisulphite with dehydration done at a temperature of 50^0C was the most promising, maintaining significant observable attributes throughout the study.

Introduction

The flowers of banana also called as the banana inflorescence (*Musa* sp.) is a pack house of nutrient reserves which makes it an important consumable product for many. In many countries of the Asian subcontinent like India, Malaysia, Philippines, Indonesia and Sri Lanka it is being consumed as a vegetable (Wickramarachchi and Ranamukhaarachchi, 2005). In the state of West Bengal of India this banana inflorescence is very popular, which is commonly called as ‘Mocha’ in the Bengali language. The banana inflorescence apart from being utilized as a cooking item can also be converted into various other forms like dehydrated products, pickles and canned fruits. For consuming banana inflorescence as a vegetable it sometime becomes very hectic to remove the bracts and extract the flowers.

So in order to overcome the difficulties of cooking the study was under taken to develop ready to cook dehydrated banana inflorescence.

Drying of food items is one of the very ancient ant common techniques used to increase the shelf life of the produce. The process of dehydration also helps in reducing the bulk volume to a considerable amount which in turn reduces the cost associated with transportation. Drying and dehydration of agricultural products apart from increasing the storage life by bringing down the chances of decay also helps in saving the capital required for transportation and shipping (Dikbasan, 2007). However aside from these merits of dehydration there are also some demerits. For dehydrated products there is always a problem of nutrient loss by leaching and also the chances of microbial contamination though is reduced but still some infestation does takes place during the storage.

Furthermore during dehydration care has to be taken about the dehydration time, as extended period may cause problem. Longer time used for dehydration is unsuitable for the product as it renders the commodity more susceptible towards microbial contaminations (Kostaropoulos and Saravacos, 1995; El-Beltagy *et al*., 2007; Akbulut and Durmus, 2009). For banana inflorescence there is another situation which comes up. In this case during the process of dehydration the problem of enzymatic browning is very prevalent which takes place due to the activity of polyphenol oxidase (PPO) and substrate concentration. Various processing steps used prior to dehydration like slicing and cutting ads to the enzymatic browning of the inflorescence (Talburt and Smith, 1987; Huxsoll and Bolin, 1989; Wickramarachchi and Ranamukhaarachchi, 2005) which in turn reduces the appearance quality of the final dried product.

Therefore the present study was undertaken with an objective to standardize suitable drying process for banana inflorescence which not only will increase its post harvest longevity but would also yield attractive ready to cook dehydrated product.

Materials and Methods

The present investigation was carried out in the Department of Post Harvest Technology of Horticultural Crops under the faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia West Bengal during the year 2015-2016. The crops were collected from farmer’s field present in the villages of ‘Satyapole’ and ‘Asudhi’ located at Nadia and North 24 Parganas districts of West Bengal respectively. Storage study and the analytical work were conducted in the laboratory of Post Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal.

The banana inflorescence taken for the study was of ‘Kanthali’ variety. The bracts were carefully removed and the flower buds were separated. The gynaecium part and the scale were discarded from each flower. The banana flowers were subjected to various pretreatments before drying (initial dipping in water containing chemical treatment + blanching in hot water + dipping in cold water containing chemical treatment) under this experiment.

T_1 – Citric acid 0.2% + 4 min blanching + potassium metabisulphite 0.1%
T_2 – Citric acid 0.2% + 4 min blanching + sodium metabisulphite 0.1%
T_3 – Citric acid 0.2% + 4 min blanching + Water
T_4 – Calcium chloride 0.2% + 4 min blanching + potassium metabisulphite 0.1%
T_5 – Calcium chloride 0.2% + 4 min blanching + sodium metabisulphite 0.1%

T_6 – Calcium chloride 0.2% + 4 min blanching + Water
T_7 – Sodium chloride 0.2% + 4 min blanching + potassium metabisulphite 0.1%
T_8 – Sodium chloride 0.2% + 4 min blanching + sodium metabisulphite 0.1%
T_9 – Sodium chloride 0.2% + 4 min blanching + Water
T_{10} – Water + 4 min blanching + potassium metabisulphite 0.1%
T_{11} – Water + 4 min blanching + sodium metabisulphite 0.1%
T_{12} – Water + 4 min blanching + Water

Drying was carried out on three different temperatures of 50^0C, 55^0C and 60^0C followed by packaging in LDPE 50 micron pouches and storage in ambient temperature. Storage studies on different physical and biochemical parameters viz. moisture content, rehydration ratio, total phenols, flavanoids, antioxidant percentage and fungal estimation were carried on 0, 30, 60 and 90 days of storage.

Storage conditions- Ambient storage

Design of experiment: Two Factorial Completely Randomized Design (Sheoran *et al*., 1998).

Replication- 2

Moisture content on dry weight basis

This parameter was calculated according to a formula (Shipley and Vu, 2002).

Moisture content (dehydrated produce)

The moisture content of dehydrated produce was determined by oven drying method. Dehydrated samples were further dried in a hot air oven at 121°C until the weight of the dried sample become stable (A.O.A.C, 2000).

Radical scavenging activity

The calculation of Radical scavenging activity (RSA) was done by the help of 2, 2-diphenyl-1-picrylhydrazyl (DPPH). The variation of the extract sample with respect to the absorbance was measured in a spectrophotometer at 517 nm. The estimation was done by determining the scavenging ability of the antioxidants against the stable DPPH radical (Brand-Williams *et al*., 1995).

Total phenols

The estimation of total phenol content present in the sample was done by the help of Folin-Ciocalteu reagent. The absorbance was calculated spectrophotometrically against a reagent blank at 760 nm (Singleton *et al*., 1999).

The final concentration of the total phenol content present in the samples were exhibited as mg gallic acid equivalents (GAE) per gram of fresh weight.

Total flavonoids

Estimation of the total flavanoid content of the samples was done according to aluminum chloride method (Zhishen *et al*., 1999) where absorbance was measured in a spectrophotometer at 510 nm against a prepared reagent blank.

Finally the total flavonoid content was manifested as mg catechin equivalents (CE) per gram of fresh mass.

Microbial load

Microbial load or the microorganisms present in the samples were calculated by using standard dilution plate count method (Allen, 1953).

Results and Discussion

Treatments under all the temperatures viz. 50^0C 55^0C and 60^0C suffered from periodic loss of moisture content (Fig. 1, 2 and 3) on basis of dry weight, with the gradual passage of dehydration time. At initial phases of dehydration the loss of moisture content (dry wt. basis) from all the treatments under the different temperatures was very expeditious, which gets stabilized (no further decrease in the value) later with further passage of dehydration time.

During the period of storage the moisture content for all the treatments dehydrated at different temperatures viz. 50^0C 55^0C and 60^0C increased (Table 1). Treatments dehydrated at 50^0C showed maximum uptake of moisture throughout the period of storage. Treatments dehydrated at 55^0C showed lesser values, with least moisture gain was recorded for the treatments dehydrated at 60^0C at the end of the storage. Among the different treatments banana inflorescence which were initially dipped at 0.2% citric acid followed by hot water blanching for 4 minutes and then dipped in 0.1 % sodium metabisulphite showed the lowest amount of moisture accumulation.`

The values for rehydration ratio decreased during the period of storage (Table 2). After 90 days of storage maximum rehydration ratio were obtained for different treatments dehydrated at 50^0C followed by treatments dehydrated at 55^0C and 60^0C respectively. Banana inflorescence where initial dipping was done at 0.2% citric acid followed by hot water blanching for 4 minutes and then dipping at 0.1 % sodium metabisulphite was found the best treatment maintaining maximum value of rehydration ratio.The different biochemical parameters viz. total phenols, flavanoids and antioxidant levels (% inhibition of DPPH) were highest at 0 days of storage and gradually decreased thereafter (Table 3, 4 and 5). At initial day of storage treatments dehydrated at temperature of 50^0C showed the highest biochemical values of 31.39 mg GAE/g of total phenol, 2.15 mg CE/g of total flavanoid, and 59.22% of antioxidant activity. This was followed by treatments dehydrated at 55^0C showing 30.66 mg GAE/g of total phenol, 2.04 mg CE/g of total flavanoid and 51.77% of antioxidant activity. Treatments dehydrated at 60^0C provided 27.59 mg GAE/g total phenols, 1.86 mg CE/g total flavanoids and 44.32% antioxidant activity. However later during the period of storage the content of total phenols, flavanoids and antioxidant levels (% inhibition of DPPH) was reduced for all the treatments dehydrated at temperature of 55^0C/B_2 and 60^0C/B_3. Treatments dehydrated at 50^0C showed the best reatinment of total phenols, flavanoids and antioxidant levels (% inhibition of DPPH) throughout the period of storage. At 90 days, dehydration temperature of 50^0C with banana inflorescence treated with initial dipping of 0.2% citric acid followed by hot water blanching for 4 minutes and final dipping in 0.1 % sodium metabisulphite showed the maximum values of total phenols, flavanoids and antioxidant levels (% inhibition of DPPH). Control, dehydrated at 60^0C recorded the lowest value for all the biochemical parameters.

With the passage of storage time the fungal infestation (unicellular and filamentous type) for different treatments dehydrated at temperatures of 50^0C, 55^0C and 60^0C increased (Table 6 and 7). Treatments dehydrated at a temperature of 50^0C were most affected by the fungal attack followed by treatments under 55^0C and 60^0C. Banana inflorescence were citric acid of 0.2% was used for initial dipping followed by 4 minutes of hot water blanching and sodium metabisulphite of 0.1 % for final dipping was found the most effective as here the fungal contamination was less.

Table.1 Moisture content (%) of dehydrated banana inflorescence subjected to different temperatures at different days in storage

0 DAS	30 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	60 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	90 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A
$A_{(1-12)}$ B_1=5.42	T_1/A_1	5.66	4.92	3.79	4.79	T_1/A_1	5.75	5.55	3.88	5.06	T_1/A_1	6.79	5.58	4.08	5.48
	T_2/A_2	5.52	4.86	3.75	4.71	T_2/A_2	5.75	5.13	3.86	4.91	T_2/A_2	6.50	5.12	4.02	5.21
	T_3/A_3	5.75	5.45	4.14	5.11	T_3/A_3	7.02	6.58	4.23	5.94	T_3/A_3	8.46	7.55	4.25	6.75
	T_4/A_4	5.69	4.97	3.85	4.83	T_4/A_4	6.17	5.94	3.48	5.20	T_4/A_4	6.98	6.21	4.13	5.77
$A_{(1-12)}$ B_2= 4.15	T_5/A_5	5.69	4.97	3.88	4.85	T_5/A_5	5.79	5.55	3.92	5.08	T_5/A_5	6.92	5.59	4.09	5.53
	T_6/A_6	5.82	5.45	4.26	5.17	T_6/A_6	7.02	6.76	5.31	6.36	T_6/A_6	8.73	7.65	4.83	7.07
	T_7/A_7	5.75	5.32	3.93	5.00	T_7/A_7	6.44	6.25	3.98	5.55	T_7/A_7	7.35	6.72	4.09	6.05
	T_8/A_8	5.70	5.16	3.87	4.91	T_8/A_8	6.42	6.17	3.97	5.52	T_8/A_8	7.35	6.67	4.14	6.05
	T_9/A_9	5.86	5.52	4.34	5.24	T_9/A_9	7.17	6.77	4.45	6.13	T_9/A_9	9.19	7.83	5.36	7.46
$A_{(1-12)}$ B_3=3.75	T_{10}/A_{10}	5.75	5.37	3.95	5.02	T_{10}/A_{10}	6.75	6.24	3.99	5.66	T_{10}/A_{10}	7.75	7.25	4.26	6.42
	T_{11}/A_{11}	5.75	5.32	3.95	5.00	T_{11}/A_{11}	6.62	6.23	3.98	5.61	T_{11}/A_{11}	7.35	6.83	4.09	6.09
	T_{12}/A_{12}	5.89	5.52	4.53	5.31	T_{12}/A_{12}	7.18	6.85	4.60	6.21	T_{12}/A_{12}	9.60	7.93	5.55	7.69
	Mean B	5.73	5.23	4.02		Mean B	6.50	6.17	4.14		Mean B	7.74	6.74	4.40	
		Factors	C.D.	SE(d)	SE(m)		Factors	C.D.	SE(d)	SE(m)		Factors	C.D.	SE(d)	SE(m)
		Factor(A)	0.020	0.010	0.007		Factor(A)	0.300	0.147	0.104		Factor(A)	0.046	0.023	0.016
		Factor(B)	0.010	0.005	0.003		Factor(B)	0.150	0.074	0.052		Factor(B)	0.023	0.011	0.008
		Factor(A X B)	0.034	0.017	0.012		Factor(A X B)	N/A	0.255	0.180		Factor(A X B)	0.080	0.039	0.028

$A_{(1-12)}$: Treatments [**A_1** (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_2** (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_3** (T_3) – Citric acid 0.2% + 4 min blanching + Water, **A_4** (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_5** (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_6** (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, **A_7** (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_8** (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_9** (T_9) – NaCl 0.2% + 4 min blanching + Water, **A_{10}** (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_{11}** (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_{12}** (T_{12}) – Water + 4 min blanching + Water]: **$B_{(1-3)}$**: Temperatures [**B_1**- 50^0C, **B_2**- 55^0C, **B_3**- 60^0C] , CD at 5%

Table.2 Rehydration ratio of dehydrated banana inflorescence subjected to different temperatures at different days in storage

0 das	30 das	$50^0c/b_1$	$55^0c/b_2$	$60^0c/b_3$	Mean a	60 das	$50^0c/b_1$	$55^0c/b_2$	$60^0c/b_3$	Mean a	90 das	$50^0c/b_1$	$55^0c/b_2$	$60^0c/b_3$	Mean a
$A_{(1-12)}$ b_1=9.12	T_1/a_1	8.88	7.92	6.87	7.89	T_1/a_1	8.37	7.55	6.15	7.35	T_1/a_1	7.75	6.83	6.06	6.88
	T_2/a_2	8.86	7.95	6.90	7.90	T_2/a_2	8.39	7.59	6.19	7.39	T_2/a_2	7.76	6.95	6.25	6.98
	T_3/a_3	8.84	6.94	5.72	7.16	T_3/a_3	8.19	6.53	5.47	6.73	T_3/a_3	7.41	6.32	5.27	6.33
	T_4/a_4	8.87	7.92	6.82	7.87	T_4/a_4	8.27	7.22	6.12	7.20	T_4/a_4	7.72	6.80	6.05	6.85
$A_{(1-12)}$ B_2= 8.97	T_5/a_5	8.87	7.92	6.84	7.87	T_5/a_5	8.27	7.54	6.12	7.31	T_5/a_5	7.76	6.81	6.04	6.87
	T_6/a_6	8.83	6.94	5.71	7.16	T_6/a_6	8.20	6.27	5.92	6.80	T_6/a_6	7.41	6.13	4.24	5.93
	T_7/a_7	8.85	7.02	6.82	7.56	T_7/a_7	8.22	6.90	6.07	7.06	T_7/a_7	7.55	6.80	5.75	6.70
	T_8/a_8	8.87	7.17	6.82	7.62	T_8/a_8	8.25	7.01	6.12	7.12	T_8/a_8	7.58	6.80	5.93	6.77
	T_9/a_9	8.83	6.94	5.71	7.16	T_9/a_9	7.99	6.27	5.15	6.47	T_9/a_9	7.33	6.12	4.56	6.00
$A_{(1-12)}$ b_3=8.44	T_{10}/a_{10}	8.84	6.96	5.72	7.17	T_{10}/a_{10}	8.20	6.90	6.00	7.03	T_{10}/a_{10}	7.44	6.45	5.27	6.38
	T_{11}/a_{11}	8.84	7.02	5.75	7.20	T_{11}/a_{11}	8.22	6.90	6.02	7.04	T_{11}/a_{11}	7.55	6.53	5.30	6.46
	T_{12}/a_{12}	8.81	6.94	5.56	7.10	T_{12}/a_{12}	7.92	6.01	5.12	6.35	T_{12}/a_{12}	7.17	5.97	4.16	5.76
	Mean b	8.85	7.30	6.27		**Mean b**	8.20	6.89	5.87		**Mean b**	7.53	6.54	5.40	
		Factors	**C.d.**	**Se(d)**	**Se(m)**		**Factors**	**C.d.**	**Se(d)**	**Se(m)**		**Factors**	**C.d.**	**Se(d)**	**Se(m)**
		Factor(a)	0.016	0.008	0.006		Factor(a)	0.038	0.019	0.013		Factor(a)	0.031	0.015	0.011
		Factor(b)	0.008	0.004	0.003		Factor(b)	0.019	0.009	0.007		Factor(b)	0.015	0.008	0.005
		Factor(a x b)	0.029	0.014	0.010		Factor(a x b)	0.066	0.033	0.023		Factor(a x b)	0.053	0.026	0.019

$A_{(1-12)}$: Treatments [**A_1** (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_2** (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_3** (T_3) – Citric acid 0.2% + 4 min blanching + Water, **A_4** (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_5** (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_6** (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, **A_7** (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_8** (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_9** (T_9) – NaCl 0.2% + 4 min blanching + Water, **A_{10}** (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_{11}** (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_{12}** (T_{12}) – Water + 4 min blanching + Water]: **$B_{(1-3)}$**: Temperatures [**B_1**- 50^0C, **B_2**- 55^0C, **B_3**- 60^0C] , CD at 5%

Table.3 Total content of phenols (mg GAE/g) of dehydrated banana inflorescence subjected to different temperatures at different days in storage

0 DAS	30 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	60 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	90 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A
$A_{(1-12)}$ B_1=31.39	T_1/A_1	28.14	27.09	25.12	26.78	T_1/A_1	25.60	23.88	22.93	24.14	T_1/A_1	20.05	19.07	16.58	18.57
	T_2/A_2	28.39	27.14	25.54	27.02	T_2/A_2	26.79	25.59	23.39	25.25	T_2/A_2	20.20	19.17	17.18	18.85
	T_3/A_3	25.89	22.82	19.48	22.73	T_3/A_3	21.14	21.77	16.68	19.86	T_3/A_3	14.47	13.16	10.71	12.78
	T_4/A_4	27.93	26.91	25.02	26.62	T_4/A_4	25.04	23.39	22.03	23.49	T_4/A_4	17.41	17.13	15.28	16.60
$A_{(1-12)}$ B_2= 30.66	T_5/A_5	28.05	27.79	25.09	26.97	T_5/A_5	25.13	25.08	22.65	24.29	T_5/A_5	17.66	17.14	15.45	16.75
	T_6/A_6	25.51	22.39	18.90	22.26	T_6/A_6	21.94	21.03	16.18	19.72	T_6/A_6	14.38	11.88	10.49	12.25
	T_7/A_7	26.28	26.11	21.17	24.52	T_7/A_7	24.49	22.93	20.82	22.74	T_7/A_7	15.17	14.23	14.34	14.58
	T_8/A_8	26.62	26.54	22.23	25.13	T_8/A_8	24.71	23.17	20.95	22.94	T_8/A_8	15.37	14.53	15.10	15.00
	T_9/A_9	25.30	22.12	18.40	21.94	T_9/A_9	20.18	19.16	16.02	18.45	T_9/A_9	14.20	11.13	10.04	11.79
$A_{(1-12)}$ B_3=27.59	T_{10}/A_{10}	26.05	23.91	20.56	23.50	T_{10}/A_{10}	23.50	22.19	20.07	21.92	T_{10}/A_{10}	14.55	13.65	11.59	13.26
	T_{11}/A_{11}	26.16	24.64	20.95	23.91	T_{11}/A_{11}	23.80	22.48	20.58	22.29	T_{11}/A_{11}	15.05	13.95	11.89	13.63
	T_{12}/A_{12}	23.36	21.83	17.60	20.93	T_{12}/A_{12}	19.12	18.05	15.47	17.54	T_{12}/A_{12}	13.04	10.98	8.68	10.90
	Mean B	26.47	24.94	21.67		Mean B	23.45	22.39	19.81		Mean B	15.96	14.67	13.11	
		Factors	**C.D.**	**SE(d)**	**SE(m)**		**Factors**	**C.D.**	**SE(d)**	**SE(m)**		**Factors**	**C.D.**	**SE(d)**	**SE(m)**
		Factor(A)	0.097	0.048	0.034		Factor(A)	0.560	0.275	0.195		Factor(A)	0.073	0.036	0.025
		Factor(B)	0.049	0.024	0.017		Factor(B)	0.280	0.138	0.097		Factor(B)	0.037	0.018	0.013
		Factor(A X B)	0.168	0.083	0.058		Factor(A X B)	0.971	0.477	0.337		Factor(A X B)	0.127	0.062	0.044

$A_{(1-12)}$: Treatments [**A_1** (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_2** (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_3** (T_3) – Citric acid 0.2% + 4 min blanching + Water, **A_4** (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_5** (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_6** (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, **A_7** (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_8** (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_9** (T_9) – NaCl 0.2% + 4 min blanching + Water, **A_{10}** (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_{11}** (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_{12}** (T_{12}) – Water + 4 min blanching + Water]: **$B_{(1-3)}$**: Temperatures [**B_1**- 50^0C, **B_2**- 55^0C, **B_3**- 60^0C] , CD at 5%

Table.4 Flavanoid content (mg CE/g) of dehydrated banana inflorescence subjected to different temperatures at different days in storage

0 DAS	30 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	60 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	90 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A
$A_{(1-12)}$ B_1=2.15	T_1/A_1	1.85	1.71	1.48	1.68	T_1/A_1	1.42	1.36	0.87	1.22	T_1/A_1	1.29	1.09	0.78	1.05
	T_2/A_2	1.88	1.74	1.54	1.72	T_2/A_2	1.45	1.42	0.97	1.28	T_2/A_2	1.29	1.16	0.97	1.14
	T_3/A_3	1.69	1.49	1.19	1.45	T_3/A_3	1.18	1.12	0.65	0.98	T_3/A_3	1.13	0.73	0.38	0.74
	T_4/A_4	1.80	1.64	1.44	1.63	T_4/A_4	1.40	1.30	0.83	1.18	T_4/A_4	1.24	0.93	0.50	0.89
$A_{(1-12)}$ B_2= 2.04	T_5/A_5	1.82	1.69	1.48	1.66	T_5/A_5	1.40	1.32	0.83	1.18	T_5/A_5	1.27	1.05	0.52	0.94
	T_6/A_6	1.69	1.45	1.15	1.43	T_6/A_6	1.18	1.04	0.65	0.95	T_6/A_6	0.96	0.73	0.34	0.67
	T_7/A_7	1.74	1.55	1.33	1.54	T_7/A_7	1.32	1.23	0.73	1.09	T_7/A_7	1.22	0.83	0.45	0.83
	T_8/A_8	1.76	1.61	1.39	1.59	T_8/A_8	1.34	1.26	0.76	1.12	T_8/A_8	1.24	0.88	0.49	0.87
	T_9/A_9	1.64	1.34	1.07	1.35	T_9/A_9	1.13	0.92	0.62	0.89	T_9/A_9	0.93	0.70	0.34	0.66
$A_{(1-12)}$ B_3=1.86	T_{10}/A_{10}	1.73	1.52	1.21	1.48	T_{10}/A_{10}	1.22	1.17	0.69	1.02	T_{10}/A_{10}	1.20	0.76	0.41	0.79
	T_{11}/A_{11}	1.73	1.53	1.27	1.51	T_{11}/A_{11}	1.27	1.23	0.71	1.07	T_{11}/A_{11}	1.20	0.79	0.45	0.81
	T_{12}/A_{12}	1.52	1.27	0.87	1.22	T_{12}/A_{12}	0.96	0.87	0.62	0.82	T_{12}/A_{12}	0.88	0.69	0.28	0.61
	Mean B	1.73	1.54	1.28		Mean B	1.27	1.18	0.74		Mean B	1.15	0.86	0.49	
		Factors	**C.D.**	**SE(d)**	**SE(m)**		**Factors**	**C.D.**	**SE(d)**	**SE(m)**		**Factors**	**C.D.**	**SE(d)**	**SE(m)**
		Factor(A)	0.014	0.007	0.005		Factor(A)	0.013	0.007	0.005		Factor(A)	0.011	0.005	0.004
		Factor(B)	0.007	0.003	0.002		Factor(B)	0.007	0.003	0.002		Factor(B)	0.005	0.003	0.002
		Factor(A X B)	0.024	0.012	0.008		Factor(A X B)	0.023	0.011	0.008		Factor(A X B)	0.019	0.009	0.007

$A_{(1-12)}$: Treatments [**A_1** (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_2** (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_3** (T_3) – Citric acid 0.2% + 4 min blanching + Water, **A_4** (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_5** (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_6** (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, **A_7** (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_8** (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_9** (T_9) – NaCl 0.2% + 4 min blanching + Water, **A_{10}** (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_{11}** (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_{12}** (T_{12}) – Water + 4 min blanching + Water]: **$B_{(1-3)}$**: Temperatures [**B_1**- 50^0C, **B_2**- 55^0C, **B_3**- 60^0C] , CD at 5%

Table.5 Antioxidant activity (percent inhibition of DPPH) of dehydrated banana inflorescence subjected to different temperatures at different days in storage

0 DAS	30 DAS	50^{0}C/B_1	55^{0}C/B_2	60^{0}C/B_3	Mean A	60 DAS	50^{0}C/B_1	55^{0}C/B_2	60^{0}C/B_3	Mean A	90 DAS	50^{0}C/B_1	55^{0}C/B_2	60^{0}C/B_3	Mean A
$A_{(1-12)}$ B_1=59.22	T_1/A_1	51.18	46.92	31.90	43.33	T_1/A_1	34.63	33.03	26.12	31.26	T_1/A_1	30.16	28.85	18.06	25.69
	T_2/A_2	51.18	47.78	32.71	43.89	T_2/A_2	37.45	33.26	26.70	32.47	T_2/A_2	31.52	29.77	18.70	26.66
	T_3/A_3	41.90	37.47	24.16	34.51	T_3/A_3	27.17	22.90	15.02	21.70	T_3/A_3	21.72	16.69	9.71	16.04
	T_4/A_4	47.29	45.18	27.52	39.99	T_4/A_4	32.84	28.81	25.31	28.98	T_4/A_4	26.72	24.52	13.63	21.62
$A_{(1-12)}$ B_2= 51.77	T_5/A_5	50.71	45.78	27.97	41.48	T_5/A_5	33.88	31.49	19.93	28.43	T_5/A_5	30.06	28.65	13.91	24.21
	T_6/A_6	41.49	35.36	23.34	33.40	T_6/A_6	26.49	22.06	14.25	20.93	T_6/A_6	21.72	16.69	8.61	15.67
	T_7/A_7	45.07	40.92	27.13	37.70	T_7/A_7	29.08	27.57	17.68	24.78	T_7/A_7	23.91	22.33	13.02	19.75
	T_8/A_8	45.21	42.61	27.13	38.31	T_8/A_8	29.50	28.21	19.29	25.66	T_8/A_8	26.16	24.52	13.63	21.44
	T_9/A_9	41.49	33.27	21.82	32.19	T_9/A_9	26.04	19.73	14.25	20.01	T_9/A_9	20.65	16.05	7.62	14.77
$A_{(1-12)}$ B_3=44.32	T_{10}/A_{10}	43.24	38.68	22.96	34.96	T_{10}/A_{10}	27.81	24.11	15.02	22.31	T_{10}/A_{10}	23.34	17.57	9.80	16.90
	T_{11}/A_{11}	44.80	40.49	25.68	36.99	T_{11}/A_{11}	27.92	24.64	15.53	22.69	T_{11}/A_{11}	23.78	18.81	12.88	18.49
	T_{12}/A_{12}	37.46	30.52	21.08	29.68	T_{12}/A_{12}	22.51	19.15	13.08	18.25	T_{12}/A_{12}	18.92	15.56	7.05	13.84
	Mean B	45.08	40.41	26.11		Mean B	29.61	26.25	18.51		Mean B	24.89	21.67	12.22	
		Factors	C.D.	SE(d)	SE(m)		Factors	C.D.	SE(d)	SE(m)		Factors	C.D.	SE(d)	SE(m)
		Factor(A)	0.467	0.230	0.162		Factor(A)	0.174	0.086	0.061		Factor(A)	0.176	0.087	0.061
		Factor(B)	0.234	0.115	0.081		Factor(B)	0.087	0.043	0.030		Factor(B)	0.088	0.043	0.031
		Factor(A X B)	0.810	0.398	0.281		Factor(A X B)	0.302	0.148	0.105		Factor(A X B)	0.306	0.150	0.106

$A_{(1-12)}$: Treatments [**A_1** (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_2** (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_3** (T_3) – Citric acid 0.2% + 4 min blanching + Water, **A_4** (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_5** (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_6** (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, **A_7** (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_8** (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_9** (T_9) – NaCl 0.2% + 4 min blanching + Water, **A_{10}** (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, **A_{11}** (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, **A_{12}** (T_{12}) – Water + 4 min blanching + Water]: **$B_{(1-3)}$**: Temperatures [**B_1**- 50^{0}C, **B_2**- 55^{0}C, **B_3**- 60^{0}C] , CD at 5%

Table.6 Populations of unicellular fungi (x 10^2 cfu/g) on dehydrated banana inflorescence subjected to different temperatures at different days in storage

0 DAS	30 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	60 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	90 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A
$A_{(1-12)}$ B_1=1.00	T_1/A_1	1.00	1.00	0.50	0.83	T_1/A_1	1.50	1.50	1.00	1.33	T_1/A_1	2.00	2.00	2.00	2.00
	T_2/A_2	1.00	1.00	0.50	0.83	T_2/A_2	1.50	1.50	1.00	1.33	T_2/A_2	2.00	2.00	1.50	1.83
	T_3/A_3	2.00	1.50	1.50	1.67	T_3/A_3	2.50	2.50	2.00	2.33	T_3/A_3	4.00	3.00	2.50	3.17
	T_4/A_4	1.50	1.00	0.50	1.00	T_4/A_4	2.00	1.50	1.50	1.67	T_4/A_4	2.50	2.50	2.00	2.33
$A_{(1-12)}$ B_2= 1.00	T_5/A_5	1.50	1.00	0.50	1.00	T_5/A_5	1.50	1.50	1.00	1.33	T_5/A_5	2.00	2.00	2.00	2.00
	T_6/A_6	2.00	1.50	1.50	1.67	T_6/A_6	2.50	2.50	2.00	2.33	T_6/A_6	4.50	3.50	3.00	3.67
	T_7/A_7	1.50	1.50	1.00	1.33	T_7/A_7	2.50	2.00	1.50	2.00	T_7/A_7	3.00	2.50	2.50	2.67
	T_8/A_8	1.50	1.00	1.00	1.17	T_8/A_8	2.00	1.50	1.50	1.67	T_8/A_8	2.50	2.50	2.50	2.50
	T_9/A_9	2.00	1.50	1.50	1.67	T_9/A_9	2.50	2.50	2.00	2.33	T_9/A_9	4.00	3.50	3.00	3.50
$A_{(1-12)}$ B_3=0.5	T_{10}/A_{10}	1.50	1.50	1.50	1.50	T_{10}/A_{10}	2.50	2.00	2.00	2.17	T_{10}/A_{10}	3.50	3.00	2.50	3.00
	T_{11}/A_{11}	1.50	1.50	1.00	1.33	T_{11}/A_{11}	2.50	2.00	1.50	2.00	T_{11}/A_{11}	3.50	3.00	2.00	2.83
	T_{12}/A_{12}	2.00	2.00	1.50	1.83	T_{12}/A_{12}	3.00	2.50	2.50	2.67	T_{12}/A_{12}	5.00	4.00	3.50	4.17
	Mean B	1.58	1.33	1.04		Mean B	2.21	1.96	1.63		Mean B	3.21	2.79	2.42	
		Factors	C.D.	SE(d)	SE(m)		Factors	C.D.	SE(d)	SE(m)		Factors	C.D.	SE(d)	SE(m)
		Factor(A)	0.635	0.312	0.220		Factor(A)	0.664	0.326	0.231		Factor(A)	0.554	0.272	0.192
		Factor(B)	0.317	0.156	0.110		Factor(B)	0.332	0.163	0.115		Factor(B)	0.277	0.136	0.096
		Factor(A X B)	N/A	0.540	0.382		Factor(A X B)	N/A	0.565	0.400		Factor(A X B)	N/A	0.471	0.333

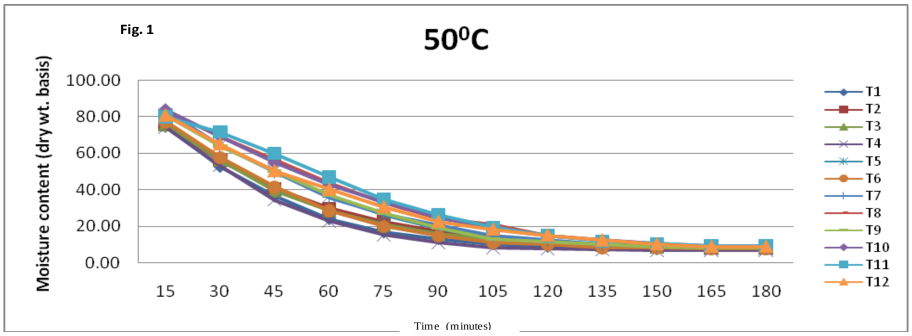
$\mathbf{A_{(1-12)}}$: Treatments [$\mathbf{A_1}$ (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_2}$ (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_3}$ (T_3) – Citric acid 0.2% + 4 min blanching + Water, $\mathbf{A_4}$ (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_5}$ (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_6}$ (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, $\mathbf{A_7}$ (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_8}$ (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_9}$ (T_9) – NaCl 0.2% + 4 min blanching + Water, $\mathbf{A_{10}}$ (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_{11}}$ (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_{12}}$ (T_{12}) – Water + 4 min blanching + Water]: $\mathbf{B_{(1-3)}}$: Temperatures [$\mathbf{B_1}$- 50^0C, $\mathbf{B_2}$- 55^0C, $\mathbf{B_3}$- 60^0C] , CD at 5%

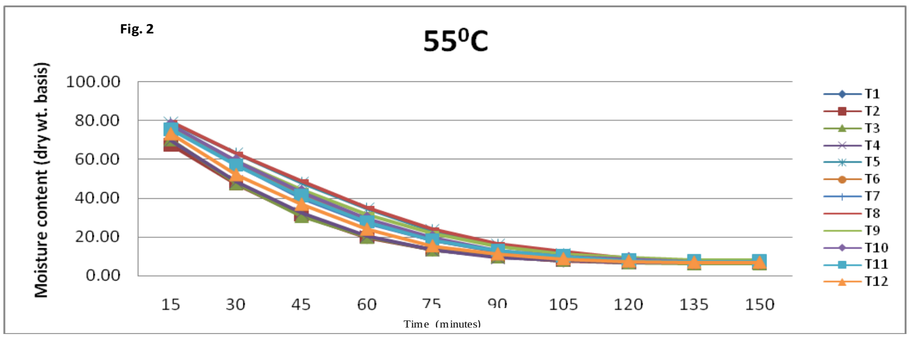
Table.7 Populations of filamentous fungi (x 10^2 cfu/g) on dehydrated banana inflorescence subjected to different temperatures at different days in storage

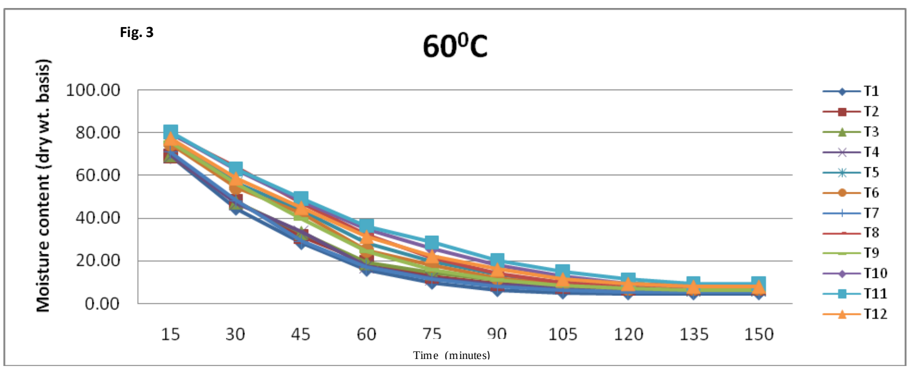
0 DAS	30 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	60 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A	90 DAS	$50^0C/B_1$	$55^0C/B_2$	$60^0C/B_3$	Mean A
$A_{(1-12)}$ B_1=0.50	T_1/A_1	0.50	0.50	0.50	0.50	T_1/A_1	1.50	1.00	1.00	1.17	T_1/A_1	1.50	1.00	1.00	1.17
	T_2/A_2	0.50	0.50	0.50	0.50	T_2/A_2	1.00	0.50	1.00	0.83	T_2/A_2	1.00	0.50	1.00	0.83
	T_3/A_3	1.00	1.00	1.00	1.00	T_3/A_3	1.50	1.50	1.00	1.33	T_3/A_3	2.50	2.00	1.50	2.00
	T_4/A_4	0.50	0.50	0.50	0.50	T_4/A_4	1.50	1.50	1.00	1.33	T_4/A_4	1.50	1.50	1.00	1.33
$A_{(1-12)}$ B_2= 0.50	T_5/A_5	0.50	0.50	0.50	0.50	T_5/A_5	1.50	1.00	1.00	1.17	T_5/A_5	1.50	1.00	1.00	1.17
	T_6/A_6	1.00	1.00	1.00	1.00	T_6/A_6	1.50	1.50	1.00	1.33	T_6/A_6	2.50	2.50	1.50	2.17
	T_7/A_7	1.00	0.50	0.50	0.67	T_7/A_7	1.50	1.50	1.00	1.33	T_7/A_7	1.50	1.50	1.00	1.33
	T_8/A_8	1.00	0.50	0.50	0.67	T_8/A_8	1.50	1.50	1.00	1.33	T_8/A_8	1.50	1.50	1.00	1.33
	T_9/A_9	1.00	1.00	1.00	1.00	T_9/A_9	1.50	1.50	1.50	1.50	T_9/A_9	2.50	2.50	1.50	2.17
$A_{(1-12)}$ B_3=0.50	T_{10}/A_{10}	1.00	1.00	0.50	0.83	T_{10}/A_{10}	2.00	1.50	1.00	1.50	T_{10}/A_{10}	2.00	1.50	1.50	1.67
	T_{11}/A_{11}	1.00	0.50	0.50	0.67	T_{11}/A_{11}	1.50	1.50	1.00	1.33	T_{11}/A_{11}	2.00	1.50	1.50	1.67
	T_{12}/A_{12}	1.50	1.50	1.00	1.33	T_{12}/A_{12}	1.50	1.50	1.50	1.50	T_{12}/A_{12}	2.50	2.50	2.00	2.33
	Mean B	0.88	0.75	0.67		**Mean B**	1.50	1.33	1.08		**Mean B**	1.88	1.63	1.29	
		Factors	**C.D.**	**SE(d)**	**SE(m)**		**Factors**	**C.D.**	**SE(d)**	**SE(m)**		**Factors**	**C.D.**	**SE(d)**	**SE(m)**
		Factor(A)	N/A	0.312	0.220		Factor(A)	N/A	0.319	0.226		Factor(A)	0.664	0.326	0.231
		Factor(B)	N/A	0.156	0.110		Factor(B)	0.325	0.160	0.113		Factor(B)	0.332	0.163	0.115
		Factor(A X B)	N/A	0.540	0.382		Factor(A X B)	N/A	0.553	0.391		Factor(A X B)	N/A	0.565	0.400

$\mathbf{A_{(1-12)}}$: Treatments [$\mathbf{A_1}$ (T_1) – Citric acid 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_2}$ (T_2) – Citric acid 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_3}$ (T_3) – Citric acid 0.2% + 4 min blanching + Water, $\mathbf{A_4}$ (T_4) – $CaCl_2$ 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_5}$ (T_5) – $CaCl_2$ 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_6}$ (T_6) – $CaCl_2$ 0.2% + 4 min blanching + Water, $\mathbf{A_7}$ (T_7) – NaCl 0.2% + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_8}$ (T_8) – NaCl 0.2% + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_9}$ (T_9) – NaCl 0.2% + 4 min blanching + Water, $\mathbf{A_{10}}$ (T_{10}) – Water + 4 min blanching + $K_2S_2O_5$ 0.1%, $\mathbf{A_{11}}$ (T_{11}) – Water + 4 min blanching + $Na_2S_2O_5$ 0.1%, $\mathbf{A_{12}}$ (T_{12}) – Water + 4 min blanching + Water]: $\mathbf{B_{(1-3)}}$: Temperatures [$\mathbf{B_1}$- 50^0C, $\mathbf{B_2}$- 55^0C, $\mathbf{B_3}$- 60^0C] , CD at 5%

Fig.1,2,3 Moisture content on the basis of dry weight during dehydration of banana inflorescence at different temperatures







The experiment showed that different physical and biochemical parameters were highest at the initial day of storage for treatments dehydrated at 50^0C followed by treatments dehydrated at 55^0C and treatments dehydrated at 60^0C. However later during the period of storage the retainment of different attributes decreased for all the treatments dehydrated at different temperatures.

Prior to dehydration, the banana inflorescence were subjected to various pretreatments in the laboratory conditions. Also the inflorescences of banana were provided with hot water blanching which helped in maintaining the condition of the produce. Blanching was mainly adopted as it helps in loosening and softening of internal tissues which helps in enhancing the rate of drying and facilitates uniform shrinking during dehydration (Kunzek *et al*., 1999; Munyaka *et al*., 2010; Waldron *et al*., 2003).

The chemicals used in the study for treating the banana inflorescence were also found to be very useful.

Different chemicals which were used for providing pretreatments to banana inflorescence here were citric acid, calcium chloride, sodium chloride, sodium metabisulphite which were also used in the works of Veli *et al*., 2007; Kostaropoulos and Saravacos, 1995; Kingsly *et al*., 2007; Doymaz, 2004a,b; El- Beltagy *et al*., 2007; Pan *et al*., 2008; Marquez-Rios *et al*., 2009).. These chemicals helped in increasing the post harvest longevity of the dehydrated banana inflorescence. According to Kingsly *et al*., (2007) pretreatment prior to dehydration helps in inactivation of various enzymes which are responsible for loss of colour they also de-stress the tissues which minimizes the dehydration time and ultimately provides dehydrated product of superior quality. From the study it was also found that the microbial activity in the post harvest life of the produce got lowered. These pretreatment helped in bringing down the microbial infestations and dehydration furthermore reduces the chances of fungal decay Agbo (2014).

In conclusion, among the three different temperatures used for dehydration, 50^0C was found best in retaining the physical and biochemical properties of the dehydrated product as compared to the other two temperatures used for dehydration in the study. Though the fungal attack was comparatively little more for treatments dehydrated at 50^0C then the treatments dehydrated at 55^0C and 60^0C, but with respect to overall maintenance of physical and biochemical attributes, treatments dehydrated at 50^0C were found good for storage. Under the dehydration temperature of 50^0C, banana inflorescence initially dipped at 0.2% citric acid followed by hot water blanching for 4 minutes and then dipped in 0.1 % sodium metabisulphite was most successful in maintaining a significant contents of phenols, flavanoids and antioxidant levels with lesser fungal infestation. Control where banana inflorescence were only dipped in water recorded the lowest value for all the physical and biochemical attributes and showed maximum fungal growth all throughout the storage period.

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