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Controlled atmosphere storage of moringa (*Moringa oleifera*) pods

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ABSTRACT

A study was taken up to enhance the shelf life of moringa or drumstick (*Moringa oleifera* L.) pods by controlled atmospheric storage. A 'Local variety' (from Coimbatore) and a hybrid 'PKM 1' were selected and given fungicidal treatment of 1% for 2–3 mins. Respiration studies of moringa pods were conducted at three different temperatures (14º, 21º and 28ºC) with product to free volume ratios at 1:5, 1:10 and 1:20. Moringa at two different temperatures (14ºC and ambient) was stored in a specially designed PVC chamber with 3, 4 and 5% O_2 concentration. Loss in firmness for both 'Local' and 'PKM 1' was 12.9, 13.2 and 16.9% for 14ºC with 3, 4 and 5% O_2 concentration, respectively during 40 days of storage. The ambient stored moringa pods had higher ascorbic acid loss of 8.2% as compared to 5.5% at 14ºC. The results were comparable with local variety also. 'PKM 1' showed higher reduction of ascorbic acid of 54.1, 5.3 and 5.9%, respectively for 3, 4 and 5% O_2 concentrations at 14ºC in 40 days. Controlled atmosphere storage at refrigerated conditions revealed that the shelf life of moringa pods could be increased to approximately three to four times compared to ambient condition. The best treatment for increasing the shelf life of moringa pods upto 40 days at 14°C was 4% O_2 and 5% CO_2.

Key words: CAS, Moringa pods, PVC storage chamber, Quality, Shelf life, Temperature

Moringa *(Moringa oleifera* L.*)* is the most demanded vegetable in South India. Production of moringa during peak seasons is in excess of local demand and hence, the farmers are not able to get remunerative price for their produce. It has been estimated that about one-fourth of all moringa produce harvested is spoiled before consumption (Arun et al., 2011). In order to meet the demand for vegetables by ever-increasing population, more emphasis needs to be given to post harvest management.

Among different post harvest technologies, controlled atmosphere storage is the one of the promising technologies which helps increase the shelf life of vegetables without losing its quality. Already controlled atmosphere storage technologies are standardized for vegetables like, broccoli, cabbage, carrot, green beans, tomato, spinach and cauliflower etc. Hence a study was taken up for storing moringa under controlled atmosphere.

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MATERIALS AND METHODS

The fresh pods of 'PKM 1' hybrid of moringa were collected from a local farm at Palathurai area of Coimbatore district and pods of 'Local' variety were collected from Thondamuthur area of Coimbatore district. The pods were carefully harvested at optimum maturity and washed in potable water to remove the foreign materials adhering to it and shade dried.

Controlled atmosphere storage of moringa pods

The gas compositions for controlled atmospheric (CA) storage were selected based on the respiration rate of moringa pods. The CA storage is aimed to reduce the respiration rates, and it has been reported by Gariepy et al. (1984) that respiration rates for CA is taken as 40% of a commodity under ambient conditions. The respiration rate at 14°C was 8.75 ml/kg/h and 40% of it was 3.6 ml/kg/h. This 40% occurs at 2% O_2 concentration. Oxygen concentration below 2% initiates anaerobic fermentation. Hence a safe limit of 3, 4 and 5% oxygen concentration was selected for CAS study.

Chambers of 75 cm length and 15 cm diameter were made with PVC pipe to house moringa pods. The bottom of the chamber was enclosed by an end cap and top of the chamber was enclosed with PVC flange using rubber gasket to make it air tight. Two septums were placed on the top plate to collect the gas samples from the chamber for analysis.

One kg moringa pods were washed and dipped in 1% of fungicide solution for 2–3 min (Isaak et al., 2004) and then shade dried for about 4–5 h. Calcium hydroxide (50 g) was used as CO_2 scrubber and was kept at the bottom of the storage container. The controlled atmosphere conditions were created using external supplies of gases from pressurized gas cylinders fitted with double-stage regulators and outlet controlling devices. Gas (O_2, CO_2 and N_2) flows were restricted through needle-valves. The system was designed in such a way that three different gas combinations could be achieved at any time, with three outlets each passing through gas flow meters by which the final outlet flow of gases could be precisely controlled. After attaining the required gas composition, the containers were kept at 14°C and in ambient condition for shelf life study.

The parameters such as physiological loss in weight, firmness, ascorbic acid, titratable acidity, chlorophyll, total soluble solids and *p*H were studied during storage period. The textural properties were analyzed using texture analyzer (Camps et al., 2005). Ascorbic acid was determined by dye method (Sadasivam and Manickam, 1992) and total chlorophyll content was calculated as given by Holden (1976).

RESULTS AND DISCUSSION

Effect on physiological loss in weight of moringa pods

The effect of concentration of oxygen and storage temperature on physiological loss in weight (PLW) of moringa pods of 'PKM 1' and 'Local' varieties presented in Table 1 revealed that as the storage period increased, the physiological loss in weight also increased. Similar trend of results (1.2 to 1.75 %) was also reported by Bulent et al. (2007) for cucumber.

The PLW was the maximum under ambient condition, followed by 14°C for both 'PKM 1' and 'Local' variety. Moringa pods stored in higher O_2 concentration lost more weight than treatments with lower O_2 concentration, which may be due to higher respiration rates of the pods. Hertog et al. (2003) also reported the same trend of response in avocado.

Among the CA stored samples at ambient condition, 'PKM 1' exhibited the maximum physiological loss in weight (8.4%) in 5% oxygen concentration. A reduction of 80% was recorded in PLW for both 'PKM 1' and 'Local' variety stored at 14°C with 5% concentration of oxygen.The PLW may be due to the water loss as a result of respiration (Wills et al., 1982) and also due to transpiration water loss (Moleyar and Narasimhan, 1994) during the storage period.

The samples stored at refrigerated condition had a maximum shelf life of 40 days and the PLW ranged from 1.47 to 1.73%.

The statistical analysis revealed that there was a significant effect (P<0.01) of PLW on all treated 'PKM 1' and 'Local' variety of moringa pods for the concentration of oxygen. The interaction effect between the parameters were also found to be significant at (P<0.05).

Effect on firmness of moringa pods

The change in firmness of the moringa pods under different CA conditions are presented in Fig. 1 and Fig. 2. Fresh pods of 'PKM 1' had a higher firmness in the range of 5.87–5.97 N as compared to 'Local' variety of 5.21–5.27. Control samples spoiled on the day 3 itself and had a reduction of 0.86 N and 0.31 N, respectively, for 'PKM 1' and 'Local' variety.

The loss in firmness increased with the increase in oxygen concentration. For 'PKM 1' the loss in firmness was 12.9, 13.2 and 16.9% for 14°C CA with 3, 4 and 5% of oxygen, respectively, for 40 days of storage. Similar trend was observed for the 'Local' variety also.

The gradual decline observed in the firmness values are mainly related to turgidity loss and dehydration depending on the storage conditions and storage period and the observations are similar to the results of Ozcelik et al. (1999). Low oxygen and high carbon dioxide conditions also influence many oxidative reactions associated with firmness breakdown (Gwanpua et al., 2012).

Effect on ascorbic acid of moringa pods

The change in ascorbic acid content during CA storage are presented in the Fig. 3 and Fig. 4. The fall in ascorbic acid content was observed in increasing oxygen concentration of the CA storage. In 'PKM 1' variety, the highest reduction in ascorbic acid was noticed for CA with 5% oxygen concentration at ambient and refrigerated conditions. The ambient stored pods had higher loss of 8.2% compared to 5.5% for samples stored at 14°C. The results were comparable for 'Local' variety also.

The ascorbic acid decreased as O_2 level decreased which was also reported by Lee and Kader (2000). In 'PKM 1' the reduction of ascorbic acid during a storage period of 40 days at CA with 14°C was 5.1, 5.3 and 5.9% respectively for 3, 4 and 5% oxygen concentrations. Similar trends were observed in both the varieties at 14°C and ambient conditions. These results are in agreement with previous studies of Sanchez et al. (2006) on leaves of *Phaseolus vulgaris* L. that low O_2 levels help to delay ascorbic acid losses.

The statistical analysis showed a significant effect of all the treatments on 'PKM 1' and 'Local' moringa pods on ascorbic acid for all the oxygen concentrations. The storage temperature had a significant effect on the ascorbic acid content of stored pods. The pods stored under 14°C displayed an improved retention of ascorbic acid than the control samples and samples stored at ambient CA.

The pods of 'Local' variety of moringa, stored at ambient temperature, displayed more losses (5 to 10%) after 15 to 20 days of storage. The loss was lesser at 14°C with 5 to 6%.

Effect on pH *of moringa pods*

With the increase in storage period *p*H increases for both varieties of moringa pods in all CA treatments (Table 1). Similar results were also reported by Gomez and Artes (2004) for green celery quality, where the *p*H increased from 5.85 to 6.44.

The change in the *p*H for control samples was lesser but it got spoiled within three days of storage. The 'Local' variety which had a lower *p*H (5.28) than the 'PKM 1' (5.87) showed higher increase of 12.5% for CA storage with 5% oxygen at ambient conditions. On the other hand, the lowest change in *p*H of 2% was observed in the 'PKM 1' pods stored in CA of 3% oxygen concentration at 14°C. The change in *p*H of the stored moringa pods also showed an increasing trend with the increase in oxygen concentration of CA storage for both varieties. All the treatments under CA had significant effect on *p*H for both 'PKM 1' and Local varieties for all the oxygen concentration.

For a given variety of moringa, it can be clearly seen that the storage temperature had a significant effect on the increase in *p*H. The interactions effect of temperature and oxygen concentration on the pH was also found to be significant. Variations in *p*H might influence the enzymatic activity of the respiratory pathways (Escalona et al., 2006).

Effect on chlorophyll content of moringa pods

The oxygen concentration used in CA was more influential on chlorophyll reduction than the

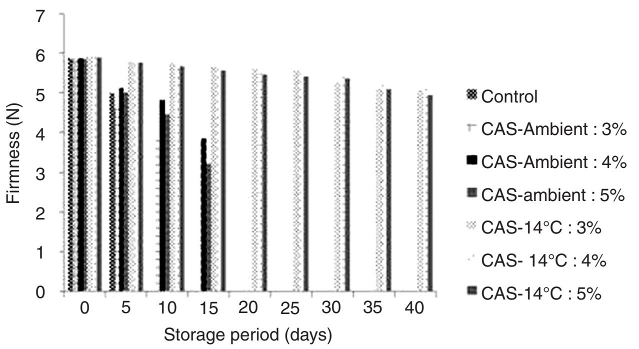

Fig. 1. Effect of controlled atmosphere storage on firmness of moringa pods ('PKM 1')

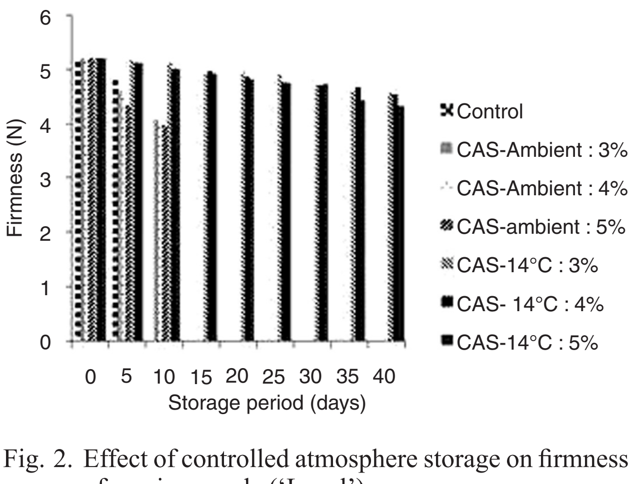

Fig. 2. Effect of controlled atmosphere storage on firmness of moringa pods ('Local')

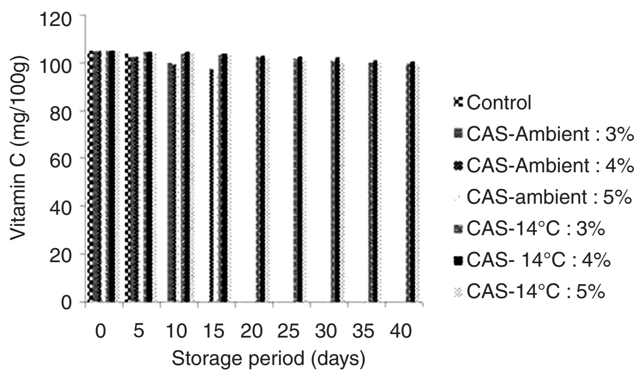

Fig. 3. Effect of controlled atmosphere storage on ascorbic acid of moringa pods ('PKM 1')

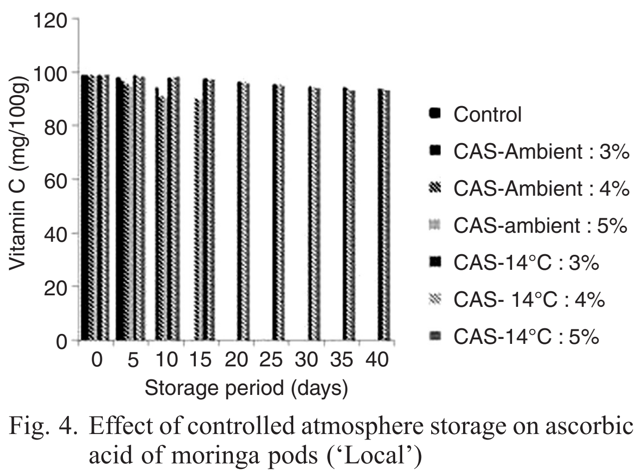

Fig. 4. Effect of controlled atmosphere storage on ascorbic acid of moringa pods ('Local')

Table 1. Effect of different concentrations of oxygen on physiological loss in weight, *p*H and chlorophyll content in moringa pods

Storage period (days)	Physiological loss in weight (%)													
	Control	PKM-1						Control	Local					
		Ambient temperature			14°C				Ambient temperature			14°C		
		Oxygen conc. (%)			Oxygen conc. (%)				Oxygen conc .(%)			Oxygen conc. (%)		
		3	4	5	3	4	5		3	4	5	3	4	5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1.2 0*	2.50	2.20	3.20	0.20	0.21	0.28	1.16*	2.70	2.50	3.00	0.23	0.25	0.30
10	-	5.50	6.00	6.20	0.50	0.52	0.59	-	5.80	4.80	5.80	0.48	0.57	0.59
15	-	-	8.10	8.40	0.90	0.99	1.00	-	-	7.40	8.00	0.87	0.95	0.98
20	-	-	-	-	1.00	1.10	1.23	-	-	-	-	1.10	1.19	1.29
25	-	-	-	-	1.30	1.40	1.49	-	-	-	-	1.24	1.35	1.40
30	-	-	-	-	1.40	1.48	1.54	-	-	-	-	1.37	1.43	1.51
35	-	-	-	-	1.45	1.52	1.69	-	-	-	-	1.42	1.51	1.62
40	-	-	-	-	1.47	1.65	1.73	-	-	-	-	1.49	1.59	1.68
							pH							
0	5.87	5.87	5.87	5.87	5.87	5.87	5.87	5.28	5.28	5.28	5.28	5.28	5.28	5.28
5	5.89 *	5.99	5.91	5.97	5.85	5.89	5.96	5.36*	5.45	5.51	5.60	5.31	5.31	5.31
10	-	6.12	6.01	6.06	5.86	5.91	5.98	-	5.52	5.67	5.73	5.33	5.32	5.33
15	-	-	6.13	6.15	5.88	5.92	6.01	-	-	5.89	5.94	5.34	5.34	5.35
20	-	-	-	-	5.91	5.94	6.05	-	-	-	-	5.36	5.36	5.38
25	-	-	-	-	5.93	5.95	6.09	-	-	-	-	5.39	5.38	5.41
30	-	-	-	-	5.95	5.98	6.13	-	-	-	-	5.42	5.40	5.46
35	-	-	-	-	5.97	6.00	6.15	-	-	-	-	5.45	5.43	5.49
40	-	-	-	-	5.98	6.12	6.16	-	-	-	-	5.46	5.47	5.63
							Chlorophyll content							
0	8.76	8.76	8.76	8.76	8.76	8.76	8.76	7.3	7.30	7.30	7.30	7.30	7.30	7.30
5	8.63*	8.65	8.63	8.61	8.74	8.71	8.66	7.21*	7.20	7.17	7.16	7.25	7.23	7.21
10	-	8.57	8.43	8.20	8.71	8.68	8.56	-	7.13	6.97	6.75	7.22	7.20	7.04
15	-	-	8.32	7.96	8.69	8.66	8.45	-	-	6.86	6.51	7.18	7.11	6.91
20	-	-	-	-	8.64	8.60	8.31	-	-	-	-	7.12	7.07	6.81
25	-	-	-	-	8.59	8.52	8.26	-	-	-	-	6.98	6.94	6.72
30	-	-	-	-	8.57	8.45	8.15	-	-	-	-	6.95	6.90	6.61
35	-	-	-	-	8.53	8.40	8.06	-	-	-	-	6.9	6.84	6.51
40	-	-	-	-	8.45	8.33	8.00	-	-	-	-	6.77	6.71	6.50

* Senescence

temperature of storage (Table 1). For a particular oxygen concentration used in CA, the change in chlorophyll was more or less the same irrespective of the temperature of storage.

Comparing the chlorophyll content on day 15 for all samples, refrigerated samples of moringa showed a smaller change in chlorophyll content compared to the ambient CA samples. At lower storage temperatures, chlorophyll is stabilized probably by the formation of metal-chlorophyll compounds (Martins and Silva, 2002). However, greater loss of chlorophyll for the entire storage period was seen in both the varieties stored at CA refrigerated conditions. This was because refrigeration extended the storage life to 40 days, but at ambient conditions the pods could be stored only up to 10–15 days.

As the concentration of oxygen in CA for a particular temperature increased, the loss of chlorophyll also increased simultaneously. Similar results of decrease in chlorophyll were reported by Gomez and Artes (2004) for controlled atmosphere storage of green celery. This trend was observed in both varieties of moringa. The results were also statistically analyzed and found to be significant.

CONCLUSION

Controlled atmosphere storage study at refrigerated conditions revealed that the shelf life of moringa pods could be increased to approximately three to four times compared to the CAS ambient condition. The best treatment for increasing the shelf life of moringa pods under cold storage was upto 40 days with 4% oxygen and 5% carbon dioxide.

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