Agriculture for Sustainable Development 3-4:112-116, 2016/Article ISSN 2347-5358 (Print)/ 2349-2228 (Online)

Agriculture for Sustainable Development

http://www.sustainableagriculture.in

EFFECT OF PACKAGING & STORAGE ON THE NUTRITIONAL QUALITIES OF DEHYDRATED BITTER GOURD (*Momordicacharantia* L.) RINGS

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Received: 13.12.2015 Revised accepted: 11.02. 2016

ABSTRACT

Bitter gourd (*Momordicacharantia* L.) rings were dried in cabinet drier at 58-60^0 C and packed in 200 g LDPE, 200 g HDPE and 260 g ALPE, with 3 different mode of packaging i.e. Vacuum pack, nitrogen pack and atmosphere pack and stored at ambient temperature (15-35^{0}C) and low temperature (7±1^{0}C) for 6 months to evaluate the best package and storage temperature for maximum retention of nutrients. Aluminum laminated polyethylene (260 gauge ALPE) pouches as packaging material with inert gas (nitrogen) and stored at low temperature was found to be good for retaining the high content of ascorbic acid, total chlorophyll, β-carotene and total carotenoids. Better rehydration ratio and sensory characteristics along with low moisture and non-enzymatic browning(NEB) were noted during six months of storage at low temperature.

Keywords:
Bitter gourd, Packages, Storage, Nitrogen pack,β-Carotene, Total chlorophyll, Rehydration ratio, Sensory quality

INTRODUCTION

Bitter gourd (*Momordicacharantia*L.) is a member of the cucurbitaceae family, native to Asia and now cultivated throughout the world. It is an important vegetable of summer as well as rainy season. Immature fruit is a good source of Vitamin C, and also contains Vitamin A, phosphorus, and iron. The tender vine tips are an excellent source of Vitamin A, and a fair source of protein, thiamin, and Vitamin C. Bitter gourd is a blood purifier, activates spleen and liver and highly beneficial in diabetes. It is a purgative, appetizer, digestive, anti-inflammatory and has healing capacity. It is consumed throughout the Asian subcontinent for culinary and medicinal purposes. Though due to bitter in taste, this vegetable is valued for its medicinal properties, particularly for the treatment of general fevers, malaria and diabetes (Kedar and Chakraborti, 1982). Bitter gourd is said to tone-up liver and spleen, useful for diabetic people, diuretic and vermicidal and improves digestion. It is also said to be a good vegetable for patient suffering from ascites, gout and pain in joints. Bitter gourd is also known for its antidiabetic properties due to its potent oxygen free radical scavenging activity of the fruit juice (SreeJayan and Rao 1991).

Drying and canning are two common methods, which are employed to preserve it. Canning increases the cost of the product due to increasing the cost of cans. However, dried product is preferred because of some advantages like it reduced mass (bulk) and lower the cost of packaging and storage requirement (Singh *et al*.,2006). Dehydrated bitter gourd rings have the potential to become an important value added product because of relatively inexpensive, easily and quickly cookable and rich in several nutrients, which are essential for human health (Singh and Sagar, 2013). Without proper pretreatment, bitter gourd develops rubbery texture and become brown and in addition to that it loses some of its bitterness principles, ascorbic acid and chlorophyll during drying (Kumar *et al.,* 1991). Dehydrated products are hygroscopic in nature and moisture exchange between food product and its surrounding atmosphere is a common problem. These changes can be controlled by providing adequate packaging material (Sagar, 2001). Hence, the present investigation was formulated to find out the suitable packaging material with the better mode of packaging and optimum storage temperature for dehydrated bitter gourd rings.

Materials and methods

Bitter gourd fruits cv. 'Pusa Hybrid-2' were obtained from Experimental Field, Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi-110012. These were washed under tap water to remove adhering dust and reduce the surface microflora. The bitter gourd fruits were cut into 1.5 cm thick slices. Slices were Water blanching followed by soaking in 0.2 % KMS solution for 15 min. The pre-treated vegetables were spread on an aluminium tray (1.05 x 0.45 m) @ 1.5 Kg/sq.m for cabinet drierwith cross flow hot air at airflow rate of 1.2-1.8 m/sec, and temperature of 58±2^{0}C (Kilburn make, Model-0248) to moisture content of 4-5% in the finished product.

The dehydrated bitter gourd rings (100 g/pouch 4x6 cm size) were each packed with Ambient pack (AP), Nitrogen pack (NP) and Vacuum pack (VP)with low density polyethylene (LDPE) 200 gauge pouches, high density polyethylene (HDPE) 200 gauge pouches and Aluminum laminated polyethylene (ALPE) 260 gauge pouches. The packed dehydrated rings were stored at ambient temperature (AT, 25-35^{0}C) and low temperature (LT, 7±1^{0}C) up to 6 months and the product was drawn at two months interval for analysis. The moisture content was determined by drying the sample in a hot air oven at 60±5^{0}C to a constant weight. Ascorbic acid (mg/100g), Total chlorophyll (mg/100g), β-carotene (mg/100g),

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Total carotenoids (mg/100g), NEB (O.D. at 420 nm), Rehydration ratio were determined according to Ranganna (2002).

Sensory analysis: Overall acceptability was evaluated by a panel of 7 semi trained members. The samples were presented after rehydration in tap water. Attributes were scored on 5-point Hedonic scale of excellent 1, good 2, fair 3, poor 4 and very poor 5 (Okoli et al 1988).

Statistical analysis: The data obtained in 3 replications were subjected to statistical analysis by Completely Randomized Design (CRD) as suggested by Gomez and Gomez (1984). The critical difference (C.D) value at 5% level of probabilitywas used for comparison among treatment means.

Results and discussion

The product remained good in respect of colour, flavour, texture and overall acceptability up to 60% RH and below in dehydrated bitter gourd rings (Fig. 1). At higher RH, product absorbed moisture and as a result it turned dark. The critical and danger point in terms of moisture content of 10.52 %, 8.81% were observed respectively. At 80% RH and above, the products were affected by mould growth. Sagar and Maini (1997) observed that the moulds were able to grow at aw level of 0.80 and above in onion powder.

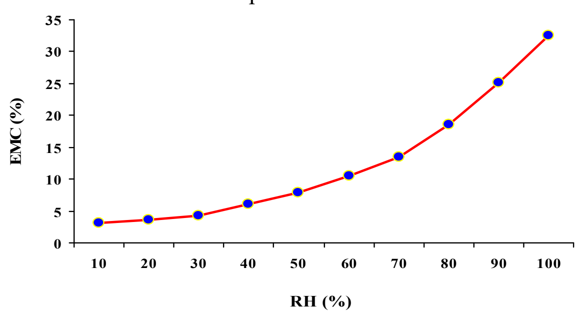

Fig-1: Pattern of equilibrium relative humidity in dehydrated bitter gourd rings

Moisture content increased during storage of dehydrated bitter gourd rings irrespective of packaging material and storage period (Table 1). The moisture content was low in the dehydrated bitter gourd rings packed in 260 g ALPE pouches (5.71%). It was higher in the dehydrated bitter gourd rings packed with atmosphere pack (5.88%) compared to vacuum pack (5.81%) and nitrogen pack (5.76%). The low content of moisture in nitrogen packed samples may be due to elimination of air from the packages by an inert gas of nitrogen. Similar results were observed by Sagar*et al.* (1999) in dehydrated ripe mango slices. The moisture content was lower in the samples stored at low temperature(5.79%). Similar observations were reported by Kumar *et al.* (2008) in osmo-vac dehydrated ripe mango slices.

The ascorbic acid content was significantly higher in the dehydrated bitter gourd rings packed in 260 g ALPE pouches (46.49mg/100g) as compared to 200 g HDPE (Table 2).

Table 1: Changes in moisture content (%) of dehydrated bitter gourd rings during storage (Initial value: 4.94)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	5.02	5.32	5.94
HDPE 200 g	5.02	5.30	5.80
ALPE 260 g	4.99	5.26	5.71
Mode of pack (M)			
AP	5.03	5.32	5.88
VP	5.02	5.29	5.81
NP	4.99	5.27	5.76
Storage Temp. (T)			
AT	5.02	5.31	5.84
LT	5.00	5.28	5.79
Factor	SE(±)		CD
Packaging (P)	0.04		NS
Mode of pack (M)	0.04		NS
Temperature (T)	0.03		NS
Storage period (S)	0.06		0.17

*g=gauge, NEB=Non-enzymatic browning, NS=Not significant ($p \leq 0.05$), AT=25-35^{0}C, LT=7±1^{0}C, LDPE=Low density polyethylene, HDPE=Highdensity polyethylene, ALPE=Aluminum Laminated polyethylene, n=3

Table 2: Changes in ascorbic acid (mg/100g, db) of dehydrated bitter gourd rings during storage (Initial value: 57.34)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	50.24	45.02	38.79
HDPE 200 g	50.66	46.18	39.99
ALPE 260 g	50.98	46.71	40.49
Mode of pack (M)			
AP	50.19	45.09	39.03
VP	50.63	45.98	39.87
NP	51.06	46.83	40.38
Storage Temp. (T)			
AT	50.40	45.43	39.44
LT	50.85	46.50	40.08
Factor	SE(±)		CD
Packaging (P)	0.13		0.37
Mode of pack (M)	0.13		0.37
Temperature (T)	0.11		0.30
Storage period (S)	0.19		0.52

Legends as in Table 1, n=3

This mightbe due to the less oxidation ofascorbic (39.99mg/100g) and 200 g LDPE (38.79mg/100g) pouches acid in the samples packed in 260 g ALPE pouches by trapped oxygen in packaging pouches which results in the formation of less dehydro ascorbic acid. Similar results were also reported by Sethi (1991) in mango slices. The ascorbic acid content was low in the dehydrated bitter gourd rings packed with atmosphere pack (39.03mg/100g) compared to vacuum pack (39.87mg/100g)and nitrogen pack (40.38mg/100g). The low content of ascorbic acid in nitrogen packed samples may be due to low moisture pick up by the packages due to low permeability of ALPE pouches to oxygen. The loss of ascorbic acid was higher in the samples stored at ambient temperature (39.44mg/100g)compared to low temperature (40.08mg/100g). This may be due to higher rate of oxidation of ascorbic acid at ambient temperature comparative to low temperature. Similar findings have been reported by Geetha*et al.* (2005) in hurdle processed pineapple and guava slices during storage.

The destruction in total chlorophyll content was low in the dehydrated bitter gourd rings packed in 260 g ALPE (9.90

g/100g)as compared to dehydrated bitter gourd rings packed in 200g HDPE (9.67mg/100g)and 200 g LDPE pouches (9.63mg/100g). The total chlorophyll content in dehydrated bitter gourd rings decreased with increase in duration of storage(Table 3). Similar results were observed by Negi and Roy (2001a) that a continuous decline in chlorophyll content of dehydrated green leaves during long term storage. The loss of total chlorophyll content in the dehydrated bitter gourd rings was lower in the samples when packed with nitrogen pack (9.95mg/100g)compared to others. The loss of total chlorophyll content was higher in the samples stored at ambient temperature (9.62mg/100g)compared to low temperature (9.84mg/100g). This might have been due to better prevention of chlorophyhllase activity at low temperature and checked the conversion of chlorophyll to pheophytin. Similar results have been reported by Singh and Sagar (2008) in dehydrated leafy vegetables.

Higher total carotenoids content found significantly in the samples when they were packed in 260 g ALPE pouches (1.66mg/100g)as compared to samples packed in 200g HDPE (1.64mg/100g) and 200 g LDPE pouches (1.63mg/100g). The total carotenoids content decreased gradually with increase in the duration of storage of the dehydrated bitter gourd rings(Table 4). The degradation could be due to photosensitive nature and oxidation of carotenoids during storage. Similar results have been reported by Singh and Sagar (2008) in dehydrated green leafy vegetables. The total carotenoids content was low in the dehydrated bitter gourd rings when packed with atmosphere pack (1.59mg/100g) compared to vacuum pack (1.65mg/100g) and nitrogen pack (1.68mg/100g). Similar results were observed by Sagar*et al.* (1999) in dehydrated ripe mango slices. The total carotenoids content was higher in the samples stored at low temperature (1.66mg/100g) compared to ambient temperature (1.62 mg/100g). This might be due to lesser losses in total carotenoids by the oxidation of carotenoids in these samples stored at low temperature as compared to ambient temperature. The less pick up of the moisture (stability of water activity) and low level of oxygen in the pouches might have caused reduction in oxidations of carotenoids during storage at low temperature (Arya*et al.,* 1979)

Theβ-carotene content in the dehydrated bitter gourd rings was higher in the samples packed in 260 g ALPE pouches (0.400mg/100g). The β-carotene content in dehydrated bitter gourd rings decreased gradually with increase in storage period(Table 5). The loss in β-carotene content was significantly ($p \leq 0.05$) lower amongthe different packaging material stored at low temperature as compared to ambient temperature. The β-carotene content was lower in the dehydrated bitter gourd rings packed with atmosphere pack (0.347mg/100g)compared to vacuum pack (0.375mg/100g)and nitrogen pack(0.401mg/100g). Similar results were observed by Kumar *et al.* (2008) in osmo-vac dehydrated ripe mango slices. The high moisture content might be due to less degradation of β-carotene at low temperature as compared to ambient temperature. Similar observations were reported by Singh and Sagar (2008) vegetables and Negi and Roy (2001b) in dehydrated green leaves.

The NEB was higher in the samples packed in 200 g LDPE followed by 200 g HDPE pouches and it was low in the dehydrated bitter gourd rings packed in 260 g ALPE pouches(Table 6). This might be due to the high moisture content and inadequate sulphur dioxide level in the dried samples packed in 200 g LDPE and 200 g HDPE pouches. Similar results have been reported by Sagar*et al.* (1999) in dehydrated ripe mango slices. The NEB in the dehydrated bitter gourd rings registered an increase during of six months of storage. This could be attributed to higher degradation of ascorbic acid and formation of brown colour with increase in storage period of dried products. Similar results were observed by Sagar and Maini (1997) in dehydrated onion slices during storage. The NEB was higher in the dehydrated bitter gourd rings packed with atmosphere pack compared to vacuum pack and nitrogen pack. This might be due to variation in moisture content and elimination of air during the vacuum and nitrogen packing from the packages. Similar results were observed by Sagar*et al.* (1999) in dehydrated ripe mango slices. The NEB was higher in the samples stored at ambient temperature compared to low temperature.

Higher rehydration ratio observed in the samples when they were packed in 260 g ALPE pouches (5.11) as compared to 200g HDPE (4.99)and 200 g LDPE pouches (4.90). The rehydration ratio of dehydrated bitter gourd rings decreased gradually with increase in storage period(Table 7). The rehydration ratio was better in the dehydrated bitter gourd rings packed with nitrogen compared (5.04)to vacuum pack (5.00)and atmosphere pack (4.96). This may be due to nitrogen gas inside the pack which might have prevented the free movement of the rings and helped to retain good texture of the product (Sagar*et al.,* 1999). The rehydration ratio was better in the samples stored at low temperature (5.03)compared to ambient temperature (4.97). Similar resultshave been reported by Singh and Sagar(2008) in dehydrated leafy vegetables.

The poor sensory score were due to poor texture, loss of flavour and poor in colour with prolonged storage (Table 8). Betteroverall sensory score was obtained in the samples when they were packed in 260 g ALPE pouches (1.84) as comparedto other. This could be attributed to various factors such as less moisture, NEB and high β-carotene content which might haveaffected the texture and colour of the stored product. Similar results were observed by Krishnaveni*et al.* (1999) in jack fruit bar. The overall sensoryscore of dehydrated bitter gourd rings decreased with increase in storage period. This could be due to poor texture, loss of flavour and poor colour of the dehydrated bitter gourd rings with prolonged storage. Similar results have been reported by Kumar *et al.*(2008) in osmo-vac dehydrated ripe mango slices. The overall sensory score was better in the dehydrated bitter gourd rings packed with nitrogen (2.05) compared to vacuum pack (2.12) and atmosphere pack (2.22).This might be due to nitrogen gas inside the pack which might have prevents the free movement of the rings and helped to

Table 3: Changes in total chlorophyll (mg/100g, db) of dehydrated bitter gourd rings during storage(Initial value: 11.78)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	10.32	10.00	9.63
HDPE 200 g	10.64	10.05	9.67
ALPE 260 g	11.07	10.39	9.90
Mode of pack (M)			
AP	10.35	9.89	9.51
VP	10.64	10.12	9.74
NP	11.04	10.44	9.95
Storage Temp. (T)			
AT	10.53	9.99	9.62
LT	10.82	10.31	9.84

Factor	SE(±)	CD
Packaging (P)	0.12	0.32
Mode of pack (M)	0.12	0.32
Temperature (T)	0.09	NS
Storage period (S)	0.16	0.45

Legends as in Table 1, n=3

Table 4: Changes in total carotenoids (mg/100g, db) of dehydrated bitter gourd rings during storage (Initial value: 2.11)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	1.92	1.73	1.63
HDPE 200 g	1.95	1.77	1.64
ALPE 260 g	1.98	1.80	1.66
Mode of pack (M)			
AP	1.91	1.72	1.59
VP	1.95	1.77	1.65
NP	1.98	1.80	1.68
Storage Temp. (T)			
AT	1.94	1.74	1.62
LT	1.96	1.79	1.66

Factor	SE(±)	CD
Packaging (P)	0.01	0.03
Mode of pack (M)	0.01	0.03
Temperature (T)	0.01	0.02
Storage period (S)	0.02	0.04

Legends as in Table 1, n=3

Table 5: Changes in β-carotene (mg/100g, db) of dehydrated bitter gourd rings during storage (Initial value: 0.863)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	0.585	0.458	0.356
HDPE 200 g	0.614	0.470	0.368
ALPE 260 g	0.616	0.515	0.400
Mode of pack (M)			
AP	0.569	0.451	0.347
VP	0.602	0.475	0.375
NP	0.644	0.517	0.401
Storage Temp. (T)			
AT	0.585	0.462	0.363
LT	0.625	0.500	0.386

Factor	SE(±)	CD
Packaging (P)	0.008	0.024
Mode of pack (M)	0.008	0.024
Temperature (T)	0.007	0.019
Storage period (S)	0.012	0.033

Legends as in Table 1, n=3

Table 6: Changes NEB (OD at 420nm) during storage of dehydrated bitter gourd rings (Initial value: 0.511)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	0.628	0.745	0.783
HDPE 200 g	0.595	0.665	0.705
ALPE 260 g	0.567	0.615	0.657
Mode of pack (M)			
AP	0.615	0.700	0.742
VP	0.598	0.673	0.713
NP	0.577	0.652	0.690
Storage Temp. (T)			
AT	0.604	0.687	0.724
LT	0.589	0.663	0.706

Factor	SE(±)	CD
Packaging (P)	0.008	NS
Mode of pack (M)	0.008	NS
Temperature (T)	0.006	0.018
Storage period (S)	0.011	0.031

Legends as in Table 1, n=3

Table 7: Changes in rehydration ratio during storage of dehydrated bitter gourd rings (Initial value: 5.51

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	5.10	4.95	4.90
HDPE 200 g	5.14	5.07	4.99
ALPE 260 g	5.29	5.17	5.11
Mode of pack (M)			
AP	5.11	5.02	4.96
VP	5.18	5.06	5.00
NP	5.23	5.12	5.04
Storage Temp. (T)			
AT	5.13	5.03	4.97
LT	5.21	5.10	5.03

Factor	SE(±)	CD
Packaging (P)	0.05	0.15
Mode of pack (M)	0.05	NS
Temperature (T)	0.04	NS
Storage period (S)	0.08	0.21

Legends as in Table 1, n=3

Table 8: Changes in sensory score during storage of dehydrated bitter gourd rings (Initial value: 1.12)

Package	Storage period (month) (S)		
	2	4	6
Material (P)			
LDPE 200 g	2.26	2.30	2.41
HDPE 200 g	1.98	2.08	2.14
ALPE 260 g	1.71	1.77	1.84
Mode of pack (M)			
AP	2.07	2.15	2.22
VP	1.97	2.03	2.12
NP	1.90	1.96	2.05
Storage Temp. (T)			
AT	2.02	2.09	2.17
LT	1.93	2.01	2.09

Factor	SE(±)	CD
Packaging (P)	0.03	0.08
Mode of pack (M)	0.03	0.08
Temperature (T)	0.02	0.06
Storage period (S)	0.04	0.11

Legends as in Table 1, n=3

retain good colour of the product and texture of the rings. Similar results have been reported by Sagar*et al.* (1999) in dehydrated ripe mango slices.The overall sensory score was better in the samples stored at low temperature (2.09) as compared to ambient temperature (2.17). This could be due to non availability of oxygen (under nitrogen and vacuum packing)and prevailing low temperatureconditionsthatmight have prevented both enzymatic and non-enzymatic oxidation process which could have slowed down the browningand caused better sensory score. Similar findings have been reported by Mehta and Tomar (1980) in dehydrated guava slices during storage.

Conclusion

The dehydrated bitter gourd rings can be stored for longer durationin ALPE (260 gauge) pouches with Nitrogen pack followedby storage at 7±1^{0}C with betterretention of β-carotene, ascorbic acid,total chlorophyll content, Rehydration ratio, sensory scoreand less moisture and NEB in the dried product compared to LDPE 200 gaugeand HDPE 200 gauge as well as in Vacuum pack and Ambient pack. Dehydrated bitter gourd rings have potentialfor use throughout the year for the preparationof several types of dishes.

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