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Retention of Nutritional Quality of Solar Dried Carrot (*Daucus carota* L.) During Storage

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Abstract

Carrot (*Daucus carota* L.) is a root crop. It belongs to the umbelliferae family. Carrot contains the highest amount of carotene among all the fruits and vegetables which the body converts to vitamin-A. Carrot was dried in a solar drier and packed in polyethylene bags, heat sealed and kept in tin container at ambient temperature for 8 (eight) months. Moisture, reducing sugar, total sugar, starch, protein, fat, vitamin-C, ß-carotene content, energy value and reconstitution time of the product were analysed during its storage period at the interval of 2 months. The initial nutrient of fresh carrot and solar dried carrot for the above parameters were analysed. During the storage period protein, starch and total sugar content decreased slightly, vitamin-C decreased remarkably, β-carotene content decreased very slowly and moisture content increased gradually. Sensory properties such as appearance, colour, flavour, texture, taste and physical parameters such as over-all shrinkage ratio, drying ratio, rehydration ratio of the product were also assessed. By assessing all the parameters it is revealed that the product is acceptable for 6 (Six) months.

Key words: Carrot, Solar drying, Storage behaviour, Physical parameters, Nutrients

Introduction

Bangladesh is an agro based country. Various types of vegetables including roots and tubers are grown in this country. Vegetables are highly seasonal and available in plenty at particular times of the year. In the peak season, the selling price decreases and this can lead to heavy losses by the grower. Root crop like carrot is grown well in the country in the winter season. Total production of carrot in 2007-2008 was 1043000 thousand M. Tons (BBS, 2008-2009). Highly nutritious root crop like carrot contains appreciable amount of B vitamins and is a rich source of β -carotene, a precursor of vitamin-A and is reported to prevent cancer (Ong and Chytil, 1983). It is assumed that one molecule of ß-carotene converts into two molecules of vitamin-A (West *et al.*, 1966). Carrot is a highly perishable commodity. It can be stored only for 2-3 days at ordinary temperature and for 10-14 days at 0^oC (Desrosier and Desrosier, 1977). So post harvest wastage during its peak period is very high. These wastages are due to microbial infestation, improper post harvest handling, lack of marketing, transportation and storage facilities etc. So attempt was made to preserve this valuable root crop to reduce post harvest losses by dehydration using solar drier and to study the shelf life, nutrient contents and physical behaviour like appearance, overall shrinkage ratio, drying ratio, rehydration ratio and reconstitution time. This preservation technology in a pre-fabricated solar drier leading to cottage industry has prospect for rural people.

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Materials and Methods

Fresh well graded, matured and large size carrots were collected from the local market. Pre history of the collected carrot was unknown. Before drying they were undergone some pre-drying unit operations viz. Weighing, Preparation of sample, Blanching, Sulphiting etc. for storage stability as well as retention of flavour, colour and nutritional qualities. The processing of carrot was done under hygienic condition.

Preparation of sample

The selection of carrot was based on right size, optimum colour, maturity and free from defects, sunburn, green cores, rots, injuries caused by insects or freezing or mechanical damage. The selected matured carrots were almost orange coloured throughout and were free from defects.

After sorting, the carrots were washed thoroughly in clean water to remove dust particles and spray residues. Then the carrots were peeled and trimmed for removal of stalks and ends. The peeling and trimming loss was found 20% of the total weight. After peeling and trimming these were sliced to thickness of 1-2 mm.

Blanching

The prepared sliced carrots were blanched in hot water (near boiling) for 6-9 minutes. The blanching process inhibits the enzymatic reactions, which were responsible for the development of brown colour and off flavour during drying and storage (Rockland and Benchat, 1987; Van Arsdel and Copley, 1964). It also reduced drying time (Jacobs, 1951).

Sulphiting

Blanched carrot slices were cooled and then dipped in the 0.075% Sodium Metabisulphite ($Na_2S_2O_5$) solution for one hour. Sulphiting helped the dehydrated products in retaining ascorbic acid and carotene (Borgstrom, 1969). It also protected the products from non-enzymatic browning and scorching as well as microbial spoilage during dehydration and storage (Van Arsdel, and Copley, 1963).

Drying procedure

The sulphited carrots were naturally dried in a cabinet type solar drier (Size 200cm X 85 cm X 81 cm, angle of inclination for collector: 30^o), fabricated from locally available raw materials such as wood, ply wood, stainless steel wire etc. The drier had a cover of 3mm thick acrylic sheet. The drier had three trays. The dimension of each tray was 60 cm x 60 cm and 2 kg of sliced carrots were thinly spreaded over each tray. The total charges in 3 trays were 6 kg. The drying time required was about 15-16 hours up to a moisture level 6-9 percent. Preservation of carrot by solar drying is possible when sun is available.

Post drying unit operations and storage

The products were inspected to remove discoloured and defective pieces. After inspection they were packed at the rate of 200 g in each polyethylene bag (0.06 mm thickness), heat sealed and kept in tin container which was used as low cost master container. Polyethylene bags were taken as packaging materials due to low permeability for water vapour (Whitely, 1952). Tin containers were taken as master container to keep the products free from rodent and insect infestation and also free from atmospheric humidity. The unit packs in tin container were stored at ambient temperature ($20\text{-}32^oC$) condition for a period of 8 (eight) months.

Evaluation of physical parameters and nutrients of carrot

Fresh well graded and matured carrot was analyesd for moisture, reducing sugar, total sugar, starch, vitamin-C, β-carotene content and protein content. The dried carrot was also evaluated for the same parameters and the sensory properties were also assessed after every two months interval. Physical parameters such as overall shrinkage ratio, drying ratio and rehydration ratio were evaluated by using equations 1, 2 and 3 (Van Arsdel and Copely, 1964). Reconstitution time was determined by observing the time required for reconstitution in boiling water. Reconstitution means conversion of dehydrated product into fresh form by soaking water. The reconstitution of product was assessed by observing its maximum capacity of soaking water and the soaking time. Moisture content was determined by moisture meter (AND, Mx-50, 0.01%/ Max 51g, A&D Company Ltd., Japan). Among the nutrients, starch and protein contents were determined by A.O.A.C. methods (A.O.A.C., 1960) and reducing sugar, total sugar, vitamin-C and fat were estimated according to Rangana (1986). β-carotene content was estimated according to Holden method (Holden *et al.* 1981), except that only alumina was used in stead of alumina and anhydrous sodium sulphate for the separation of β-carotene from other pigments. The amount of β-carotene in column effluent was estimated by taking absorbance against a water blank at 420 nm compared with a standard $K_2Cr_2O_7$ solution (Kaup *et al.*, 1968). Energy value was calculated (Gaman and Sherrington, 1981). Change in sensory properties of the dehydrated carrots were carried out by a panel consisting of five members, who were experienced for the sensory evaluation. Retention values were calculated on the basis of dry matter content.

Over-all shrinkage ratio

$$= \frac{\text{Weight of the unprepared raw carrot (g)}}{\text{Net weight of the acceptable dried carrot (g)}} \quad (1)$$

$$\text{Drying ratio} = \frac{\text{Weight of the prepared raw carrot (g)}}{\text{Net weight of the acceptable dried carrot (g)}} \quad (2)$$

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated carrot (g)}}{\text{Net weight of dried carrot (g)}} \quad (3)$$

Results and Discussion

Table I shows the moisture, reducing sugar, total sugar, starch, protein, fat, vitamin-C, β-carotene content and energy value of fresh as well as solar dried carrot. From Table I it is observed that there is a remarkable difference in the nutrients between the fresh and the solar dried carrots. This difference is due to the concentration of the nutrients after solar drying.

The overall shrinkage ratio and drying ratio of the solar dried carrot are 11:1 and 8.8:1 respectively (Table I). From the ratio it is evident that yield of solar dried carrot was 9.09% from the harvested fresh carrot and 11.36% from the pre-

Table I: Some Parameters of Fresh Carrot and Solar dried Carrot

Parameters	Fresh carrot	Solar dried carrot
Moisture (%)	88.12	7.05
Reducing sugar (%)	3.04	21.32
Total sugars (%)	4.15	28.95
Starch (%)	3.47	25.12
Protein (%)	1.09	7.92
Fat (%)	0.05	0.39
Vitamin-C (mg/ 100g)	15.33	69.68
ß-carotene (µg/ 100g)	7401.17	38792.24
Energy value (Kcal/100g)	35.29	251.47
Overall shrinkage ratio	11 : 1	
Drying ratio	8.8 : 1	

pared fresh carrot. The processing losses i.e. sorting, peeling, trimming and screening losses were 25%.

It appears from Fig. 1 that the retention of protein, starch, total sugar, reducing sugar, fat, vitamin-C, β-carotene, and energy value were 97.22%, 91.32%, 90.04%, 89.34%, 94.56% 58.00%, 72.15%, and 92% respectively.

Table II shows the effect of storage on the nutrients of the solar dried carrot. Initially total sugar, starch and protein were found 28.95%, 25.12% and 7.92% respectively. Whereas the total sugar, starch and protein were 27.39%, 23.14% and 7.31% respectively at the end of 8 months storage. Vitamin-C content was found to decrease remarkably during the storage period and β-carotene content decreased very slowly during the storage period. The initial vitamin-C and β-carotene contents were 69.68 mg/100g & 38792.24µg/ 100g respectively and at the end of 8 months storage were11.08 mg/100g & 25168.59µg/ 100g respectively. The retention of total sugars, protein, starch, vitamin-C and β-carotene contents were 95.34%, 93.31%, 92.95%, 19.19% and 73.07% respectively at the end of 6 months and were

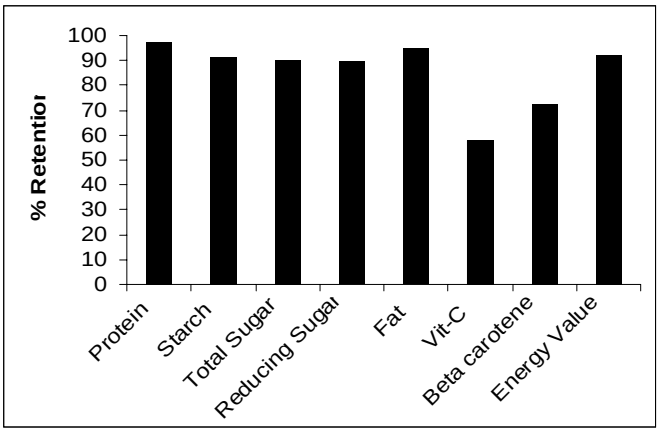

Fig 1: Retention of Nutrients Just after Solar drying

94.61%, 92.30%, 92.12%, 15.90% and 64.88% respectively at the end of 8 months storage period.

Table III shows the effect of storage on physical parameters of the dehydrated carrot. Moisture content was found increase gradually. It was within the permissible limit up to 6 months storage, which was 14%. Initially it was 7.05%. Hendel *et al*. showed that the rate of non-enzymatic browning of dehydrated product was most rapid at a moisture of 15-20% (Hendel *et al.* 1955). For this reason the product at 8 month storage is not acceptable (Table IV). There is a significant difference in retention of ascorbic acid in storage period which were shown in Table II. Rehydration ratio was little affected and reconstitution time remained same up to 4 months of storage. After this period it was slightly increased.

Table II: Effect of Storage on Nutrients Retention

Storage periods (months)	Total Sugar %	Retention %	Protein %	Retention %	Starch %	Retention %	Vit C mg/100g	Retention %	ß -carotene µg/100g	Retention %
0	28.95	-	7.92	-	25.12	-	69.68	-	38792.24	-
2	28.26	97.62	7.58	95.71	24.16	96.18	30.95	44.42	35823.52	92.34
4	27.88	96.30	7.47	94.32	23.64	94.11	19.68	28.24	32012.73	82.52
6	27.60	95.34	7.39	93.31	23.35	92.95	13.37	19.19	28347.28	73.07
8	27.39	94.61	7.31	92.30	23.14	92.12	11.08	15.90	25168.59	64.88

Table III. Effect of Storage on Physical Parameters

Storage Period	Moisture % (months)	Reconstitution time (min)	Rehydration ratio
0	7.05	25	6.8: 1
2	11.12	25	6.3:1
4	13.65	25	6.0:1
6	14.94	30	5.2:1
8	16.22	30	4.5:1

Table IV: Effect of the Sensory Qualities of Solar dried Carrot during Storage Period

Storage period (months)	Appearance	Colour	Flavour	Texture	Taste	Comments
0	Very good	Brilliant yellowish red	Acceptable	Acceptable	Acceptable	Acceptable
2	Very good	Brilliant yellowish red	Acceptable	Acceptable	Acceptable	Acceptable
4	Good	Brilliant yellowish red	Acceptable	Acceptable	Acceptable	Acceptable
6	Good	yellowish red	Acceptable	Acceptable	Acceptable	Acceptable
8	Moderate	Pale yellowish red	Not acceptable	Not acceptable	Not acceptable	Not acceptable

Table IV shows the effect on the sensory qualities of the solar dried carrot during the storage period. The solar dried carrots were in brilliant yellowish red colour up to 4 months storage period. At the end of 4 months storage colour become yellowish red and at the end of the 8 months storage it become pale yellowish red.

Conclusion

The flavour, texture and taste after reconstitution were found normal upto 6 months of storage. All these investigations indicate that the solar dried carrot was acceptable up to 6 months of storage for edible purposes. Solar drying technology is particularly important for rural people and carrot growers for preservation at grass root level. This will help them to consume the product during off seasons and food shortage. Farmers can also be benefited by selling the preserved carrot. The solar dried carrot has the potentiality for commercialization in cottage industry level. Children suffering from night blindness can be benefited by taking this preserved vegetable. Solar dried carrot can be used for instant cooking, making instant mash and can also be used in various culinary purposes.

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