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STABILITY OF DRUM-DRIED CARROT POWDER UNDER SEVERAL CONDITIONS OF PREPARATION AND STORAGE

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Abstract. Conditions for the preparation of carrot powder by drum-drying are described. Effect of addition of sodium metabisulphite alone and in conjunction with rice flour on the quality of carrot powder was studied. Storage studies on the dried samples were conducted in three different packaging materials viz. polyethylene, polyethylene plus paper carton plus Cellophane; and hermetically sealed tin cans. Moisture and β-carotene content, browning and organoleptic qualities were determined at intervals up to 6 months. Addition of rice flour and sodium metabisulphite at 2.5 and 0.05% of fresh carrots respectively, proved beneficial in the drying operation as well as in reducing β-carotene losses during drying and subsequent storage. Addition of metabisulphite alone did not reduce β-carotene losses. Losses of β-carotene, though minimum in the sample treated with metabisulphite and rice flour and packed in tin cans, were still considerable (72%) after 6 months' storage period. Polyethylene and polyethylene+carton+Cellophane were found unsuitable packing materials during humid conditions in the rainy season. After six months of storage all samples developed a typical off-flavour although the sample containing metabisulphite and rice flour packed in cans was still acceptable organoleptically.

Carrot powder is one of the several dehydrated convenience food products which have been introduced in the consumer's market. Carrot, which is among the major vegetable crops of Pakistan, is a rich source of β-carotene—a precursor of vitamin A, and is used in many popular Pakistani dishes. Preparation of carrot powder of an acceptable quality would not only utilize some of the excess vagetable produced in the country but would also make available throughout the year.

Storage studies of carrot powder have shown it to be stable for over one year under an atmosphere of nitrogen, particularly at low temperature.[1] However, on storage in the presence of oxygen, the processes of destruction of colour due to oxidation of β-carotene, and the development of hay-like off-flavour occur quite rapidly.[2] In view of the high cost of the packing material for storage under nitrogen, investigations were undertaken to prepare a product that maintains quality during storage under ambient conditions in relatively cheaper packing material for longer periods. The results of the effect of different processing conditions and packing materials on the storage stability of drum-dried carrot powder are presented in this paper.

Materials and Methods

Fresh red carrots were brought from a vegetable market. They were cleaned in a rod washer, trimmed at both ends, peeled in an abrasive peeler and cut into slices about ¼in thick. The sliced carrots were cooked in live-steam for 10 min and then treated as follows:

Sample A:2.5% rice flour was added to fresh carrots; followed by 0.05% sodium metabisulphite. Metabisulphite was sprayed on the cooked carrot slices in the form of a 1%-solution.

Sample B:Sodium metabisulphite only, was added as described for sample A.

Sample C:No treatment was given to the sample.

The samples were then mixed and minced in a Hobart food chopper to get uniform slurries.

Drum-Drying and Packing. All samples were drum-dried on a locally fabricated drum-drier using a speed of 10 rev/min, steam pressure 15 lb/in^2 and distance between the drums, 0.01 in. The dried samples with moisture content around 7%, were then dried to a moisture content of about 5% in an oven at 104–105°F.

Dried samples were packed into three types of packages, i.e. polyethylene, polyethylene plus cardboard carton and tin cans. Cartons were also wrapped with Cellophane paper. Packed samples were stored at room temperature (70–114°F).

Measurement of Browning. Browning was measured by the method of Gooding *et al.*[3] 1 g sample was taken in a 50-ml test-tube and brown pigments were extracted with 25 ml 50% ethanol with occasional stirring. After 24 hr the material was filtered and browning was measured in the filtrate as optical density (O.D.) at 420 nm in silica cells of 1-cm light path using ethanol 50% (v/v) as blank.

Estimation of β-Carotene. β-Carotene was measured essentially by the method described by Kremerer and Fraps.[4] Dry carrot flakes (0.5 g) were ground with sand and 40 ml of a mixture of acetone and petroleum ether, 1:1 v/v (b.p. 60–80). The material was filtered and the filtrate washed with distilled water (3×15 ml) to remove acetone. The ether layer was mixed with anhydrous sodium sulphate to remove traces of moisture before diluting it to 25 ml with dry petroleum ether. The diluted extract (10 ml) was chromatographed on an alumina column and the β-carotene estimated spectrophotometerically in the eluate.

Organoleptic Evaluation. A sweet dish was pre-

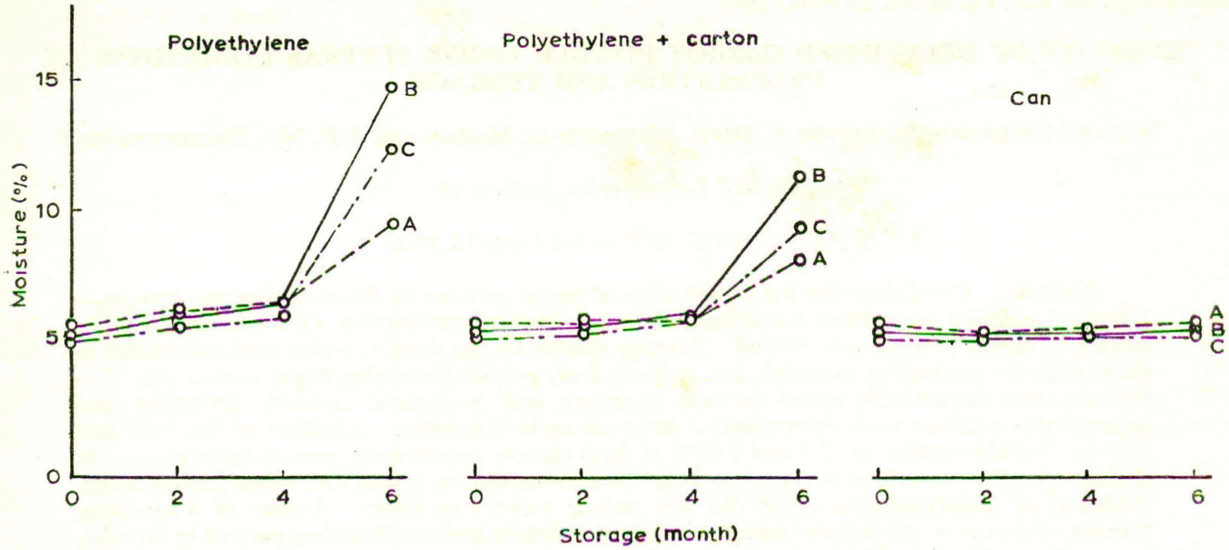

Fig. 1. Changes in moisture content of carrot powder packed in various packing materials and stored at room temperature.

pared from the powder and presented to a panel of judges for taste evaluation. Judges were asked to score the quality as good, satisfactory or poor according to their liking for colour, consistency and taste of the dish. The dish was prepared by mixing 60 g carrot powder and 100 g sugar in 1 litre milk and boiling the slurry for 10 min. The dish was cooled and presented to the panel for evaluation.

Results

Preparation of the Carrot Powder. It was found that a good quality powder could be prepared under the conditions stated above. Addition of rice flour proved quite helpful in the drying operation. The carrot slurry without rice flour had a tendency to stick to the drums resulting in a typical flavour of burnt sugars.

Effect of Packaging on Moisture Content During Storage. The moisture content of carrot powder samples packed in different packing materials after storage for various time intervals is shown graphically in Fig. 1. The samples stored in polyethylene and polyethylene plus carton gained moisture throughout the storage period. However, the moisture uptake was quite slow during the early period of storage up to 4 months, particularly for samples packed in polyethylene plus carton. After this period there was rapid increase in the moisture content of the samples, more so for samples packed in polyethylene alone. The abrupt changes in the moisture content of the samples can be attributed to the humid conditions during the months of July and August due to the rains. It is interesting to note that the sample A containing rice flour, irrespective of the materials of packing, was less hygroscopic under the conditions of storage. The moisture content of the samples packed in hermetically sealed cans, on the other hand, remained almost unchanged throughout the storage period.

Loss of β-Carotene During Drying and Storage. The loss of β-carotene during drum-drying of carrots and during subsequent storage in various packing materials under ambient conditions are respectively shown in Tables 1 and 2. The loss of β-carotene during drum-drying for the samples B and C was almost the same (13.6%). These results agree with the findings that metabisulphite is ineffective in controlling oxidative changes in dehydrated potato and carrot powder.[5] Loss of β-carotene in sample A containing flour was minimum (8%) during drum-drying. This shows the protective role of rice flour against oxidation of β-carotene under the conditions. During storage, however, there was great loss of β-carotene in all the

TABLE 1. PRETREATMENTS OF CARROTS ON THE LOSS OF β-CAROTENE DURING DRUM-DRYING.

Sample	β-Carotene (mg/kg)*		Loss (%)
	Fresh carrots	Dried carrots	
A	597·8	550·3	8·0
B	620·0	535·6	13·7
C	693·0	599·0	13·6

*Results expressed on dry basis.

TABLE 2. LOSSES IN β-CAROTENE DURING STORAGE OF CARROT POWDER IN VARIOUS PACKING MATERIALS AND STORED AT ROOM TEMPERATURE.

Sample	Packing material	% Loss during storage (months)*		
		2	4	6
A	Polyethylene	28·2	53·5	84·6
	Poly + carton	28·3	48·1	85·5
	Poly + can	28·3	42·4	71·7
B	Polyethylene	31·4	53·9	84·7
	Poly + carton	30·0	44·7	80·7
	Poly + can	28·7	44·9	70·8
C	Polyethylene	40·3	57·5	83·7
	Poly + carton	39·6	51·8	84·2
	Poly + can	36·7	48·1	72·5

*Initial carotene content A, 550·3; B, 535·6 and C, 599·0 on dry basis (mg/kg).

samples packed in different materials. At the end of 2 months, the loss was minimum in sample A and maximum in sample C. The difference in the retention of the carotene among the samples decreased with time and after 6 months there was no significant difference in this respect in the three samples. The effect of the non-metallic packing materials, also, was noticeable only up to 4 months when the loss of β-carotene was slightly less in samples packed in polyethylene plus carton than those packed in polyethylene alone. The loss of β-carotene was, however, minimum all the time in the samples packed in hermetically sealed cans. At the end of 6 months, the loss of β-carotene was 72% in samples packed in hermetically sealed cans as against 81–85% in samples packed in other materials.

Browning. Browning data for drum-dried carrot powder is shown in Table 3. Most browning occured during drying in samples which received no sulphite treatment (sample C). The difference between the initial browning of sample A and B becomes negligible because sample A contains about 25% rice flour on dry basis. Less browning in these samples thus indicates that sulphiting was inhibitory for the brown discoloration produced during the drying operation. During storage, all the samples, except those packed in hermetically sealed cans, underwent browning. Rate and extent of browning during storage too, were highest in sample C and lowest in sample A.

Comparison of browning in samples packed in polyethylene and carton shows the browning to be markedly higher in samples particularly B and C, packed in polyethylene plus carton than in polyethylene alone. This is rather unexpected because the samples which were packed in polyethylene plus carton gained less moisture content during storage (Fig. 1) and should show less browning. The reason for this discrepancy in respect of browning is not clearly understood. Perhaps there is a critical level of moisture content which fulfils the optimum conditions for browning of the product. It is also possible that the continuous exposure of the samples packed in polyethylene to light might have decomposed the brown pigments.

Organoleptic Evaluation. Results of organoleptic evaluation of the sweet dish prepared from the stored carrot powders are given in Table 4. It was observed that all the samples packed in cans were superior to the samples packed in other materials. Sample A was adjudged as 'satisfactory' even after storage for 6 months while other samples were poor after the same period of storage. This showed that addition of rice flour was beneficial. Also a general examination of Table 4 shows that after 4 months of storage all samples showed deterioration in organoleptic qualities except one (sample A can). The poor organoleptic quality of the samples was due to a typical hay-like off-flavour which develops during storage. Development of such off-flavour was detected by Stephan *et al.*[1] in carrot flakes canned in air, after only 2 months of storage.

TABLE 3. BROWNING[1] OF CARROT POWDER PACKED IN VARIOUS PACKING MATERIALS AND STORED AT ROOM TEMPERATURE.

Sample	Packing material	Storage time (months) 0	2	4	6
A	Polyethylene	0·27	0·28(0·01)	0·31(0·04)	0·38(0·11)
	Poly + carton	0·27	0·28(0·01)	0·34(0·07)	0·40(0·13)
	Poly + can	0·27	0·27(0)	0·27(0)	0·28(0·01)
B	Polyethylene	0·3	0·3(0)	0·35(0·05)	0·46(0·16)
	Poly + carton	0·3	0·46(0·16)	0·52(0·22)	0·73(0·43)
	Poly + can	0·3	0·33(0.03)	0·32(0·02)	0·32(0·02)
C	Polyethylene	0·45	0·45(0)	0·49(0·04)	0·57(0·12)
	Poly + carton	0·45	0·45(0)	0·71(0·26)	0·90(0·45)
	Poly + can	0·45	0·47(0·02)	0·46(0·01)	0·46(0·01)

1. As optical density of extract at 420 nm using 1-cm thickness cell.
2. Figures in parenthesis represent the extent of browning.

TABLE 4. ORGANOLEPTIC EVALUATION OF CARROT POWDER AS AFFECTED BY STORAGE TIME.

Sample	Packing material	Storage time (months) 0	2	4	6
A	Polyethylene	Good	Good	Satisfactory	Poor
	Poly + carton	,,	,,	,,	,,
	Poly + can	,,	,,	Good	Satisfactory
B	Polyethylene	,,	,,	Poor	Poor
	Poly + carton	,,	,,	Satisfactory	,,
	Poly + can	,,	,,	,,	,,
C	Polyethylene	,,	,,	Poor	,,
	Poly + carton	,,	,,	,,	,,
	Poly + can	,,	,,	Satisfactory	,,

Discussion

All efforts made in the preservation of good quality dehydrated product must fail if the product is not packed in a suitable packing material. Since the dehydrated products are, in general, hygroscopic in nature, particularly the powdered forms with high sugars, the packing material should provide an efficient barrier to water vapour so that the product does not absorb moisture from the environment during storage. If it is not so the moisture content of the product would increase resulting in the growth of fungus and production of off-flavours.

From the overall results it may be observed that polyethylene or even polyethylene plus carton plus Cellophane cannot act as good barrier against water vapour. They can be used to pack carrot powder only in dry weather. Tin cans on the other hand are suitable packing materials as no changes took place in the moisture content of the samples.

Another observation which could be made from the results is that there was considerable loss of β-carotene (72%) after 6 months even under these conditions of packing. Also hay-like off-flavours were produced in all the samples and consequently flavour characteristics deteriorated irrespective of the packing material, as is evidenced by the organoleptic tests. This showed that oxidative changes continue so long as oxidizing conditions are present. It appears that only the creation of an inert atmosphere would check these changes, as shown by Stephan *et al.*[1] and suggested by Cruess[6] The development of hay-like 'off-flavours' in carrot powder during storage is the main problem. The cause is still under investigation.

Carotenoid oxidation compounds particularly β-ionone have been attributed to cause this 'off-flavour.'[2] Carotenoids of carrot powder are highly susceptible to oxidation. Earlier Tomkins *et al.*[7] reported that carrot powder which had been stored in air had a slight 'off' taste after only 11 days and after 20 days 'off-flavour' was more noticeable.

Addition of rice flour helps in the drying operation and also makes the carrot powder less hygroscopic. From these studies it is concluded that good quality carrot powder can be prepared but further work is required to check the production of off-flavours during storage. For longer shelf-life of carrot powder attention should be given to create conditions that do not permit oxidation of carotenoids and lipids.

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