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Effect of pre-treatment and packaging on quality of β-carotene rich mango powder

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ABSTRACT

Pre standardized mango & carrot (80:20) blended pulp was treated with different proportion of maltodextrin MD (drying aid) and tri-calcium phosphate, TCP (anti-caking agent) along with control and dried in a mechanical drier into thin layer at 58±2°C for 12 h, to obtain a moisture content of 4-5 percent. The dehydrated material was grounded in a laboratory powder mill and sieve with 30 mesh sieve. The powder was packed in 200 gauge HDPE and 400 gauge LDPE pouches with two made of pack AP&NP and was stored at low temperature (7°C) and ambient condition (18-35°C) up to 6 months for storage study. The powder was evaluated for its quality characteristics in respect of acidity, sugars, antioxidant, phenol, ascorbic acid, non-enzymatic browning (NEB) before packaging and during storage. To reduce powder stickiness and caking requires amount of MD and TCP were optimized on the powder properties. The amount of MD (0.25 kg per kg dry mango solids) and TCP (0.15 kg per kg dry mango solids) with the values of degree of caking (19.25%) and stickiness point temperature (45.34°C) were found to be optimum for reducing the powder stickiness, caking and nutritional parameters. The adsorption isotherm of powder was found to be type-II sigmoid and 200 g HDPE as packaging material followed by storage at low temperature were selected as best process.

Key words: *Magnifera indica*, carrot, total carotenoids, phenols, sensory score.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruit of Asia and currently ranks fifth in total production among the major fruit crops (Hymavathi and Khader, 6). There is great variation in β-carotene content in mango (800 µg/100 g in Mulgoa to 1,300 µg/100 g in Alphonso) depending on the cultivar, climatic conditions, ripening stages and storage conditions. With the increasing demand for β-carotene as pro-vitamin A and antioxidant in human health, development of more and more β-carotene rich food is essential (Klaui and Bauernfeind, 10). Some of the mango cultivars like 'Langra' 'Banganpalli' and 'Chausa' lack intense colour and are not suitable for processing unless blended with cultivars having more colour (β-carotene) such as 'Dashehari' or 'Bombai Green'.

Drying is one of the most economical methods for preservation of fruit pulp for longer time. But, sugar-rich foods such as fruit pulp and juices are difficult to dry as they contain low molecular weight components like fructose, glucose, sucrose, citric acid *etc*. Ingredients such as maltodextin and food-grade anti-caking agents like tricalcium phosphate are generally added to prepare fruit powders (Jaya and Das, 8). Knowledge of water activity a_w and optimum concentration of anti-caking agent is one of the useful measurements to decide the stability of foods, and selection of storage conditions for new products. Free flowing difficulty and caking problems in powders are generally occurs due to absorption of moisture by the food product from its surrounding atmosphere. These changes can be controlled after providing adequate packaging and accurate equilibrium moisture contents at various relative humidity and temperatures. The present paper deals with optimization of anti-caking agent concentration, adsorption, packaging and storage requirement of β-carotene rich mango powder.

MATERIALS AND METHODS

The fruits of mango cv. Langra were procured from the local market of Delhi and the carrot roots (var. Nantes) were procured from the demonstration plot of the Division of Vegetable Science, ICAR-IARI, New Delhi. The fully ripe mango fruits and sound carrot roots were selected and washed with water thoroughly to remove adhering dirt and dust and then dried under the fan. The mango fruits were peeled and sliced manually by using a stainless steel knife. The slices were then fed into a pulping machine to make mango pulp. Carrot roots were scraped and sliced longitudinally and core was removed. The carrot slices were heated with the addition of 20-25% water until soft and then blended by using a mini blender for obtaining fine carrot pulp. The pulp of both mango

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and carrot was heated at 85ºC for 10 min. to sterilize separately and then filled in pre-sterilized bottles for further use in the experiment.

With dominant flavor & taste of mango pre standardized blend of mango and carrot (80:20) was treated with Tricalcium phosphate (TP) and Maltodextin (MD) for reducing level of stickiness, caking and hygroscopicity from different concentrations of TP and MD. The treated material was subjected for drying in a cabinet dryer, (Kilburn Make Model-0248) at temperature of 60 ± 2^{o}C, up to 4-5% of moisture content and the dried material was scraped and ground into powders with the help of mixer grinder (Sumit, New Delhi). Then, powder was subjected for physical properties and powder quality assessment.

Since the dry product was found difficult to grind, it was kept in an environment condition for 30-45 minutes to equilibrium moisture and then ground in a laboratory powder mill (3375-E10 Model -4) and sieved with 30 mesh sieve. The powder was packed in the packaging material of 200 gauge high density polyethylene (HDPE) and 400 gauge low density polyethylene (LDPE) pouches (8 × 6 cm size) of each packaging material with two mode of packing such as Air Pack (AP) and Nitrogen Pack (NP) and stored at room temperature (RT) (18 -35^{o}C,50-60% RH), and low temperature (LT) (7^{o}C,85% RH) (Ranganna, 14). The product was withdrawn for analysis at 0,2, 4 and 6 months interval during the storage study.

Moisture content was determined by drying a known weight of the sample in an oven at 60±2 ºC to a constant weight. The results were expressed as percent moisture content (Ranganna, 14). Reducing and total sugars were determined by using Shaffer-Somogyi micromethod (Ranganna,14). Titratable acidity was estimated by titrating a known aliquot of the sample against the standard sodium hydroxide solution using phenolphthalein as an indicator (Ranganna, 14). Ascorbic acid was measured by titrating the samples against 2,6-dichlorophenolindophenol dye and non-enzymatic browning was measured in terms of optical density at 420 nm of an aliquot of 60% alcoholic extract (Ranganna,14). Total phenols were determined by Folin-Ciocalteu method (AOAC, 2). Total antioxidant power was determined by using FRAP method (Benzie and Stain, 3). Sensory evaluation: Sensory evaluation of powder was done by Hedonic procedure (Amerine et al., 1).

Known weight (5 g powder) was placed in oven at 102±2^{0}C for one h. Then sample was removed, cooled at room temperature, weighed and transferred into a sieve of 500 µm size. The sieve was then shacked for 5 min in a shaking apparatus. The weight of the powder remaining on sieve was weighed. Degree of caking DC (%) was calculated by using the equation as DC = c/d × 100. Where, d(g) is amount of the powder used sieving and c(g) is amount of powder left on the sieve after sieving.

Five g of powder having the known amount of moisture content was taken into a test tube of the apparatus developed by the present authors after slightly modification in the apparatus developed (Jaya and Das, 8) for the measurement of sticky point temperature Ts (^{o}C). Statistical analysis of variance technique of β-carotene rich mango powder was done as suggested by Panse and Sukhatme (Panse and Sukhatme, 13). Means and standards error were calculated and analysis of variance on the data were performed. The experiment was conducted two times with three replicated for each treatment. The powder prepared by treating with combination of 1.5% TP and 2.5% MD was found to be the best and used for adsorption isotherms. Procedure was followed for adsorption isotherms of β-carotene rich mango powder at 20, 30, and 40 °C (Iglesias and Chirife, 7). Approximately two grams β-carotene rich mango powder was filled in sterilized glass weighing bottles and were placed in six separate vacuum desiccators containing saturated salt solutions (LiCl, $MgCl_2$, $Mg(NO_3)$, NaCl, KCl and KNO_3) for maintaining RH levels from 10 to 95% (Greenspan, 5). The air inside of the desiccators was sucked partially to maintain a partial vacuum with the help of a vacuum pump. All six desiccators were kept in an incubator thermostatically controlled at 20°C and the gain or loss in weights of all the samples in each desiccators were taken at two days interval until the sample attained equilibrium moisture content (EMC). The attainment of EMC was ascertained when three consecutive weight measurements showed a constant weight. The same experiment was conducted for sorption process at 30 and 40ºC by changing the temperature of the incubator

RESULTS AND DISCUSSION

Effect of TP & MD on nutritional quality of powder is given in Table 1. The nutritional value of the powder in respect of acidity, ascorbic acid, reducing and total sugars, carotenoids, β-carotene, total phenols, total antioxidant power (HAP/ HPAP) decreased significantly with increase in percentage of MD in the powder. This may be due to substitution of massive amount of mango and carrot pulp by an inert substance (MD). However, NEB of powder in above treatments was much lower as compared to control. This might be due to weaker chemical kinetics for non-enzymatic browning reactions, between sugars, acids, ascorbic acid, β-carotene, amino acids etc. and

Table 1. Effect of tricalcium phosphate (TP) and maltodextrin (MD) on chemical composition of β- carotene rich mango powder (DW basis).

Chemical parameter	Treatment								$CD_{0.05}$
	Control	1.5% TP	5% MD	1.5% TP 2.5% MD	1.5% TP 5% MD	1.5% TP 10% MD	1.5% TP 15% MD	1.5% TP 20% MD	
Moisture (%)	4.53^{a}	4.43^{a}	5.88^{b}	4.67^{a}	4.74^{a}	5.64^{b}	5.66^{b}	5.69^{b}	0.35
Acidity (%)	1.35^{g}	1.20^{f}	1.18^{ef}	1.14^{de}	0.99^{cd}	0.81^{b}	0.69^{a}	0.65^{a}	0.05
Ascorbic acid (mg/100 g)	83.74^{f}	76.67^{e}	76.08^{e}	76.60^{e}	67.37^{d}	56.80^{c}	50.01^{b}	43.55^{a}	4.4
Reducing sugars (%)	16.51^{e}	15.35^{d}	15.52^{d}	14.66^{b}	15.04^{cd}	14.60^{bc}	14.00^{b}	12.35^{a}	0.52
Total sugars (%)	75.40^{f}	71.52^{e}	59.18^{d}	60.35^{d}	48.81^{cd}	47.39^{c}	38.77^{b}	29.70^{a}	2.67
Total carotenoids (mg/100 g)	105.60^{g}	98.38^{f}	83.89^{d}	88.80^{e}	81.27^{d}	62.47^{c}	42.03^{b}	35.99^{a}	3.20
β-carotene (mg/100 g)	48.99^{g}	45.49^{f}	39.28^{e}	41.46^{e}	37.01^{de}	32.05^{c}	26.18^{b}	19.58^{a}	2.76
NEB Index	0.095^{g}	0.079^{f}	0.058^{e}	0.056$^{\underline{d}}$	0.055^{cd}	0.052^{b}	0.057^{ed}	0.041^{a}	0.002
Total phenols (mg/100 g)	63.33^{f}	53.32^{e}	50.12^{e}	52.26^{e}	44.08^{d}	36.76^{c}	28.87^{b}	11.33^{a}	3.31
HAP (μmol Fe^{2+}/100 g)	22.84^{f}	21.03^{e}	18.79^{de}	18.99^{de}	17.42^{c}	16.22^{c}	14.07^{b}	12.17^{a}	1.56
HPAP (μmol Fe^{2+}/100 g)	98.14^{d}	76.42^{c}	61.30^{bc}	73.02^{c}	76.42^{c}	48.99^{b}	35.30^{ab}	25.84^{a}	16.58
Hg (%)	26.19	19.12	18.86	13.36	11.61	11.05	9.39	7.96	2.116
Dc (%)	32.05	21.12	23.68	19.25	17.71	15.15	14.09	13.64	3.109
Ts(^{o}C)	39.32	40.80	39.78	45.34	46.05	46.79	46.18	46.37	1.568
Overall acceptability	6.53	6.72	6.94	7.39	7.28	6.78	6.56	6.39	NS

Mean values (n=3) in rows with different characters are significantly different (p = 0.05); HG = Hygroscopicity, DC = Degree of caking, T_s = Sticky point temp.

contact ability between them which have reduced the oxygen due to interference of MD and cause the low NEB in the powder.

The critical points for HG and DC decreased nearly 50 % along with relatively high values of T_s of the powder treated with 1.5 % TP + 2.5 % MD and 1.5 % TP + 2.5 % MD as compared to control. This might be due to positive effects of TP and MD on the physical properties of the powder. As TP acts as anti caking agent and MD as anti stickiness agent, therefore, both combinations might have lead to above result (Jaya et al, 9). However, a small decreasing trend for HG and DC was observed with increasing the amount of MD in the powder prepared by treating of 1.5 % TP + 10 % MD, 1.5 % TP + 15 % MD, 1.5 % TP + 20 % MD. This might be due to more amounts of single sugars, acids which contributed mainly hygroscopicity, caking of the powder substituted by MD. Similar observation have been reported in vacuum dried mango powder(Jaya et. al., 9). Overall sensory score of powder was significantly higher in the powder treated with 1.5 % TP + 2.5 % MD and 1.5 % TP + 2.5 % MD as compared to control and other treatments. This may be due to an appropriately mutual compensated balance between content of carotenoids/β-carotene and value of NEB which might have contributed better appearance of the powder.

Optimum RH 38.5% with 5.30% moisture were found to be the best for packaging of the β-carotene rich mango powder. The isotherms constructed using the data showed that all the samples followed the sigmoid shapes which are described as type II isotherms (Labuza et. al., 11). Food moisture isotherms and the equations that describe this relationship in equipment design for drying, packing and storage prediction of shelf life and determination of critical moisture and a_w, for acceptability of products that deteriorate mainly by moisture gain (Palou and Argaiz, 12). Similar result has been reported on storage stability of vacuum dehydrated ripe mango mix powder (Hymavathi, and Khader, 6). At higher levels of RH, the product had a tendency to absorb moisture and with additional moisture pick up, the product became browning and caking formation

Effect of packaging and storage on quality characteristics of β-carotene rich mango powder is given in Table 2. Moisture content increased with increase in storage period. Increase in moisture during storage periods is attributed to slight pickup of moisture by the powder. Analogous observations have been reported by (Sharma *et al.*, 16) in Hill lemon juice powder. Packaging, storage period and temperature affected the moisture content significantly. Moisture content was less in the powder

Table 2. Effect of packaging and storage of quality characteristics of value added β-carotene -rich mango powder during storage (DWB).

Parameter	Storage period	Initial value	Storage temp. $CD_{0.05}$	Packaging and storage temperature								Mode of pack $CD_{0.05}$	Packaging $CD_{0.05}$
				200 g HDPE				400 g LDPE					
				AP		NP		AP		LP			
				RT	LT	RT	LT	RT	LT	RT	LT		
Moisture (%)	2	3.86	0.029	5.02	4.60	5.23	4.59	4.90	4.36	4.99	4.46	NS	0.041
	4			5.51	4.87	5.35	4.84	5.17	4.70	5.43	4.76		
	6			6.14	5.33	6.14	5.31	6.09	5.27	6.07	5.22		
Acidity (%)	2	1.14	0,013	1.13	1.12	1.13	1.18	1.13	1.18	1.11	1.19	0.013	NS
	4			1.16	1.19	1.13	1.17	1.16	1.17	1.15	1.16		
	6			1.32	1.39	1.30	1.41	1.31	1.38	1.28	1.42		
Ascorbic acid (mg/100g)	2	69.53	2.01	48.05	57.59	50.95	56.52	49.47	57.99	50.82	55.41	NS	NS
	4			25.42	39.87	25.10	37.87	27.71	41.48	25.88	37.78		
	6			16.41	34.99	16.10	34.96	18.77	37.50	16.34	35.17		
Reducing sugar (%)	2	12.42	0.55	13.12	12.64	12.65	13.19	13.07	12.33	12.24	11.89	NS	NS
	4			13.96	15.75	12.84	15.63	13.41	14.69	12.74	15.19		
	6			15.84	20.03	13.91	19.26	14.74	18.14	14.20	19.66		
Total sugars (%)	2	56.73	0.54	51.81	52.00	52.86	52.41	42.87	52.44	52.44	50.38	NS	0.76
	4			47.70	48.03	47.04	47.68	46.38	48.80	47.06	46.99		
	6			44.46	46.80	43.81	45.62	42.53	47.80	44.41	46.21		
Total phenol (mg/ 100 g)	2	53.14	0.76	49.31	52.56	48.85	53.57	48.66	53.41	49.45	54.73	NS	NS
	4			35.74	39.03	36.85	41.52	36.05	40.33	36.57	41.40		
	6			33.22	37.30	34.85	40.27	33.83	38.98	34.46	39.31		
Total carotenoids (mg/100 g)	2	76.49	1.77	66.75	73.01	67.55	73.13	69.91	71.33	69.70	74.28	NS	NS
	4			55.19	65.98	48.14	66.05	57.78	64.48	67.64	67.16		
	6			46.27	63.43	45.83	64.10	47.35	64.11	47.28	64.58		
ß-carotene (mg/100 g)	2	53.14	1.14	45.26	49.50	34.36	49.62	47.43	48.36	47.25	50.34	NS	NS
	4			33.87	40.54	26.83	40.59	35.52	39.58	35.57	41.19		
	6			26.94	38.06	16,50	30.09	27.61	39.09	27.57	39.37		
Total antioxidant (mg/100 g)	2	19.45	0.27	16.36	17.38	15.50	17.98	16.52	17.70	16.76	18.26	NS	NS
	4			15.51	17.04	15.42	18.02	16,38	17.65	15.22	17.21		
	6			14.12	15.36	14.54	15.77	14.23	15.80	14.73	16.16		
NEB OD (at 420 nm)	2	0.064	0.005	0.073	0.069	0.079	0.070	0.072	0.067	0.072	0.069	NS	NS
	4			0.124	0.093	0.135	0.095	0.120	0.091	0.118	0.093		
	6			0.164	0.111	0.180	0.100	0.154	0.110	0.152	0.108		

packed in 400 g low density polyethylene (LDPE) pouches with nitrogen flushed and stored at low temperature. This must be due to more resistance of LDPE film to water vapour and replacement of O_2 by nitrogen gas as compared to the high density polyethylene film pouches stored at room temperature. Similar observations have been reported by (Sharma *et al.*, 16) in Hill lemon juice powder. Titratable acidity shown an increase trend during storage. This might be due to release of acid groups of amino acids due to disappearance of basic amino groups during Maillard reaction. The increase in acidity was less in the powder packed in 400g LDPE pouches with nitrogen gas and stored at low temperature. This might have due to stable in moisture at low temperature and weaker chemical kinetics for Maillard's reactions in powder packed 400g LDPE and stored at low temperature.

Ascorbic acid content of β-carotene rich mango powder was significantly decreased with increase in storage periods and temperature. This might be due to attributed to higher rate of oxidation of ascorbic acid (Geetha *et al.*, 4). The loss of ascorbic acid content was less in the powder packed in 400g LDPE pouches as compared to 200g HDPE pouches with air pack. This might be due to the less oxidation of ascorbic acid by trapped oxygen in packaging pouches which results in the formation of less de-hydro ascorbic acid. Reducing and total sugars decreased with increase in storage periods. This might be due to invention of non reducing sugar into reducing sugar. Similar observations has been made by (Sharma *et al.*, 16) who had reported a loss of 0.63% dwb in total sugars after 6 months of storage in Hill lemon juice powder. High total carotenoids were observed in the samples packed in 400 g LDPE pouches flushed with nitrogen gas and stored at low temperature. This might be due to lesser losses in total carotenoids by the oxidation of carotenoids stored at low temperature. Less pick up the moisture (stability of water activity), low level of moisture at low temperature might have reduced the oxidations of carotenoids during storage.

Samples packed in 400g LDPE film pouches with nitrogen gas showed a lower decline in β-carotene as compared to HDPE film pouches due to less permeability to oxygen and light. Similar trend has been noticed by (Sagar and Khurdiya, 15). The non-enzymatic browning in β-carotene rich mango powder was higher in the samples packed in 200g HDPE pouches packed with air pack and stored at room temperature than stored at low temperature. This might have stronger enzymatic browning reactions in these samples under such above conditions as compared to the LDPE pouches and stored at low temperature. Total phenols content of the value added β-carotene rich mango powder decreased with increase of storage periods. This might have degradation of some unstable phenolic compounds due to the oxidation by oxygen during storage (Spanos et. al., 17). Hydrophilic antioxidant power (HAP) of value added β-carotene rich mango powder decreased significantly with increase of storage. This might have due to loss of ascorbic acid and total phenols during storage, which might be mainly responsible for HAP contribution in the powder.

The sensory quality of the powder was considerably affected by storage period and temperatures. The overall sensory scores of the products showed a decreasing trend with an advancement of storage period irrespective of storage temperature or packaging materials. Overall organoleptic score was higher in the products packed in 400g LDPE pouches packed flushed with N_2 gas. This can be attributed due to various factors such as less permeability of this film, moisture content, NEB and high β-carotene content which might have affected the texture and colour of the stored product.

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