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Effect of storage on chemical characteristics of osmo-dried carrot cubes

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ABSTRACT

The present investigationwas conducted in the Division of Food Science and Technology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, Chatha during the year 2021-2022. In the present study, the selection of carrots of uniform size, thickness and colour washed with plain water, pricked and cut in to uniform cubes, then the carrot cubes blanched for 2-3 min and dipped in sugar and jaggery syrup concentrations (50, 60 and 70 ^{o}Brix) for 24 hours, respectively. After dipping, the syrup was drained out and the carrot cubes dried in cabinet tray drier (55-60^{o}C) for 4-5 hours. The osmo-dehydrated carrot cubes were cooled at room temperature and the prepared cubes packed in polypropylene bags and stored for three months to ascertain the changes in chemical and sensory characteristics at an interval of one month. With the advancement of storage period, an increasing trend was observed in TSS, carbohydrate and hunter colour value a, however a decreasing trend in L* (lightness) and B* (Blueness), moisture and titratable acidity content. On the basis of overall acceptability, the osmo-dehydrated carrot cubes prepared from the treatment T_4 (70 ^{o}Brix sugar syrup) adjudged to be the best as compared to the other treatments.*

Keywords: Osmo-dehydrated carrot cubes, jaggery, sensory attributes, storage.

INTRODUCTION

Carrot (*Daucus carota* L.) is a popular vegetable with excellent nutritional value andpractical use. Carrot is a member of the Umbelliferae family, genus Daucus and species Carota. Carrot is the most important biennial winter root vegetable crop. It has rich source of genetic resources for β-carotene, lycopene, lutein and anthocyanin in orange, red, yellow and black colour of carrot, respectively. The carrots are the unique roots high in carotenoids and have a distinct flavour due to the presence of terpenoids and polyacetylenes. It is an excellent source of vitamin A and a good source of dietary fibre and potassium. Apart from carrot roots being traditionally used in salad and preparation of curries in India, these could commercially be converted into nutritionally rich processed products like juice, concentrate, dried powder, canned, preserve, candy, pickle, and *gazrailla* (Sharma *et al.,* 2012). It also contains sugar like sucrose, glucose and fructose. Carrots are a good source of vitamin K and vitamin B_6. Carrots are rich sources of moisture content 89.35 per cent, total solids 10.65 per cent, TSS 8.73 °Brix, carotenoids 9.83 mg/100 g, titratable acidity 0.16 per cent, reducing sugars 1.79 per cent, non-reducing sugars 4.20 per cent and total sugars of 5.99 per cent (Selvakumar and Tiwari, 2018). Carrots areconsumed either raw or cooked and processed into value added products *viz.* canned carrots, chips, candy, kheer, halwa, powder juice, juice, beverages, preserve and intermediate moisture product (Raees-uland Prasad, 2015).

Dehydration is the process of water removal from the food under controlled conditions like temperature, relative humidity and air flow etc. The main objectives of dehydration are to reduce the bulk weight and to reduce water activity (Nazaneen *et al.,* 2015). Osmotic dehydration is a non-thermal process for a partial dehydration of plant tissue. It is also called a "dewatering impregnation soaking process", since along with the water removal there is a simultaneous impregnation of the tissue with the solutes present in the osmotic solution (Nowacka *et al.,* 2021). Carrot being a perishable and seasonalcrop, it is not possible to make it readily available throughout the year (Sra *et al.*, 2011). So, osmotic dehydration of carrot cubes during the main growing season is one of the important alternatives for preservation and to reduce the post harvest losses due to wastage.

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MATERIAL AND METHODS

Fully matured carrots of uniform size and colour were selected. Carrots were weighed using electronic balance, washed thoroughly with tap water. The washed carrots were first peeled and then pricked with stainless steel knife andcut in to uniform cubes. Then the carrot cubes blanched for 2-3 minutes. After that carrot cubes were dipped in osmotic solution of sugar and jaggery having different concentrations *viz* 50, 60 and 70 °Brix, respectively for 24 hours. After completion of dipping time, sugar and jaggery syrups were drained and the osmosed cubes of carrotsspread on stainless steel trays which were kept in a cabinet tray drier for dehydration. Carrot cubes were thoroughly air dried at 55-60°C till the slices reached the desired moisture content (14-15%). After drying, the osmo-dried carrot samples were weighed, packed in polypropylene bags and stored under ambient conditions for 3 months (Fig. 1). The osmo-dried carrots were analysed at an interval of 0, 1, 2 and 3 months of storage forchemical andorganoleptic characteristics. Colour was expressed in Hunter Lab units L* (lightness or brightness),a* (redness/greenness) and b* (yellowness/ blueness) as per the procedure coined by Patras *et al.* (2009).Moisture, Total soluble solid and titratable acidity were measured by Ranganna, 1986. Carbohydrate was measured by AOAC, 2012.As per the procedure coined by Amerine *et al.* (1965), score of 5.5 and above was reflected as acceptable. The experiment was laid out in factorial CRD with six treatments and replicated thrice. The data obtained were statistically analysed as per the procedure of Gomez and Gomez (1984) using OPSTAT software.

Selection of uniform size, thickness, colour carrots
⇩
Washing
⇩
Peeling of carrot
⇩
Remove top and bottom of root
⇩
Preparation of carrot cubes
⇩
Sugar and jaggery syrup preparation of different concentration (50, 60 and 70 °Brix)
⇩
Immersion of carrot cubes in sugar/jaggery syrup (24 h)
⇩
Draining (to remove excess sugar syrup)
⇩
Spreading of carrot cubes in trays
⇩
Hot air drying (55-60°C)
⇩
Packaging the osmo-dried carrot cubes in polypropylene bags
⇩
Storing the product at room temperature

Fig. 1: Flow chart for osmo-dehydrated carrot cubes

RESULT AND DISCUSSION

Moisture content

Perusal of data in Table 1 indicated that moisture content of osmo-dehydrated carrot decreased significantly during storage of three months. Initially, the highest moisture content of 13.94 per cent was recorded in treatment T_5 (50 ^{o}Brix jaggery syrup) followed by the treatment T_2 (50 ^{o}Brix sugar syrup) and lowest (5.93) per cent in control. After three months of storage, the highest moisture content of 13.21 per centrecorded in treatment T_5(50 ^{o}Brix jaggery syrup) and the lowest (5.46 per cent) in control. During storage period of three months, the mean values of moisture content of carrot cubes showed a decreasing trend from initial value of 12.41 to 11.78 per cent. The interaction effect between the treatment and

Table 1: Effect of treatment and storage period on moisture and L* (Lightness) of Osmo-dried carrot cubes

Treatments	Moisture (%)					L* (Lightness)				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	5.93	5.80	5.65	5.46	5.71	45.56	44.86	43.72	43.21	44.34
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	13.79	13.62	13.34	13.06	13.45	54.83	54.16	53.73	53.39	54.03
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	13.36	13.16	12.84	12.62	13.00	53.76	53.41	53.12	52.92	53.30
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	12.92	12.67	12.43	12.09	12.53	53.08	52.76	52.34	51.83	52.50
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	13.94	13.69	13.37	13.21	13.55	54.02	53.43	53.27	52.78	53.38
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	13.70	13.53	13.29	13.15	13.42	53.10	52.76	52.43	52.13	52.61
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	13.26	13.06	12.90	12.85	13.02	52.37	52.13	51.8	51.53	51.96
Mean	12.41	12.22	11.97	11.78		52.39	51.93	51.49	51.11	
CD (5%)										
Treatments	0.03					0.05				
Storage	0.02					0.04				
Treatment x Storage	0.06					0.10				

storage was found to be significant at 5 per cent level of significance. The decrease in moisture content might be due to the fact that with an increase in syrup concentration, the rate of osmosis increases that leads to decrease in moisture content. These results are in conformation with the findings of Priyanka *et al.* (2020) in standardization of process for preparation of osmo-dried guava slices andThippanna and Tiwari (2015) in osmotically dehydrated banana.

Hunter colour values (L*, a* and b*)

The data depicted a significant decrease during threemonthsofstorage (Table 1). Initially, the lowest L* value of (45.56) was recorded in control whereas, highest L* value of 54.83 found in T_2 (50 °Brix sugar syrup). After one month of storage, the maximum value of 54.16 recorded in T_2 (50 °Brix sugar syrup) whereas the minimumvalue of 44.86 was observed in control. Same trend was observed after two and three months of storage. In treatments, maximum mean values of 54.03 recorded in T_2 (50 °Brix sugar syrup) and lowest of 44.34 was observed in control. The mean values of L*decreased from 52.39 to 51.11 during three months of storage period.

It is evident from the data (Table 2) that initially the highest value of 19.52 recorded in treatment T_7 (70°Brix jaggery syrup) and the lowest (16.10) observed in control. As the storage period advanced, a* value increased to 20.26 in treatment T_7 (70^{o}Brix jaggery syrup) and the minimum (16.81) in control after three months of storage. The storagemeanvalues increased significantly from 18.00 to 18.75.

Table 2: Effect of treatment and storage period on a* (Redness) and b*(Blueness)of Osmo-dried carrot cubes

Treatments	a* (Redness)					b* (Blueness)				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	16.10	16.42	16.57	16.81	16.48	22.78	22.69	22.61	22.57	22.66
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	17.45	17.59	17.83	18.19	17.77	24.94	24.87	24.81	24.78	24.85
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	17.83	18.09	18.24	18.53	18.17	24.76	24.73	24.69	24.67	24.71
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	18.72	18.93	19.13	19.47	18.98	24.63	24.59	24.56	24.51	24.57
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	17.76	17.89	18.09	18.39	18.03	23.50	23.47	23.41	23.37	23.44
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	18.63	18.76	18.99	19.58	18.99	23.32	23.27	23.22	23.19	23.25
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	19.52	19.63	19.93	20.26	19.84	23.15	23.11	23.09	23.02	23.09
Mean	18.00	18.14	18.40	18.75		23.87	23.82	23.77	23.73	
CD (5%)										
Treatments	0.04					0.02				
Storage	0.03					0.01				
Treatment x Storage	0.08					0.03				

The data pertaining to b* value depicted that at beginning, the highest b* value of 24.94 was recorded in T_2 (50 °Brix sugar syrup) and the lowest of 22.78 observed in control (Table 2). The b* value decreased significantly during three months of storage. After three months of storage period, the maximum value of 24.78 observed in T_2 (50 ^{0}Brix sugar syrup) whereas, the lowest value (22.57) recorded in control. The highest value recorded in treatment T_2 (50 °Brix sugar syrup) and lowest in control having values of 24.85 and 22.66, respectively. The storage mean values significantly decreased from 23.87 to 23.73 during three months of storage period. The interaction between the treatments and storage periods was also found to be significant at 5 per cent level of significance.

This might be due to the increased rate of Maillard reaction because of the availability of more sugar. These results are in agreement with the findings of Muhamad *et al.* (2015) in watermelon rind dehydrated candyand Muzzaffar *et al.* (2016) also reported similar changes in L*, a* and b* valuesduring storage of pumpkin candy.

Table 3: Effect of treatment and storage period on TSS and titratableacidity of Osmo-dried carrot cubes

Treatments	TSS					Titratable acidity				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	15.53	16.09	16.53	17.67	16.46	1.56	1.53	1.51	1.49	1.52
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	53.51	54.17	55.42	56.13	54.81	0.67	0.63	0.61	0.58	0.62
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	64.79	66.13	67.63	68.34	66.72	0.59	0.58	0.57	0.56	0.58
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	76.43	77.21	77.93	78.46	77.51	0.54	0.53	0.53	0.52	0.53
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	51.73	52.83	53.41	54.87	53.21	0.79	0.78	0.77	0.76	0.78
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	62.81	63.54	64.27	65.36	64.00	0.73	0.71	0.70	0.69	0.71
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	74.80	73.13	72.57	71.33	72.96	0.69	0.68	0.68	0.67	0.68
Mean	57.09	57.59	58.25	58.88		0.80	0.78	0.77	0.75	
CD (5%)										
Treatments	0.02					0.01				
Storage	0.02					0.01				
Treatment x Storage	0.05					0.02				

Total soluble solids (TSS)

The data in Table 3 revealed that with the advancement of storage period, the TSS of osmo-dehydrated carrot cubes increased significantly. At the beginning, highest TSS of 76.43^{0}Brix was recorded in T_4(70 °Brix sugar syrup) and lowest value of 15.53 ^{0}Brix recorded in control. After three months of storage treatment T_4(70 °Brix sugar syrup) registered the maximum value of TSS (78.46 ^{0}Brix) followed by T_7, T_3 and T_6having values as 71.33, 68.34 and 65.36 °Brix, respectively while the lowest value (17.67 °Brix) recorded in control. In treatment mean values higher TSS was observed in T_4 (77.51 °Brix) and lowest in control (16.46 °Brix). The mean values of TSS increased from 57.09 to 58.88 °Brix during the three months of storage period. The effect of interactionbetween treatment and storage period was also found significant at 5 per cent level of significance. The possible reason for the increase in total soluble solids might be due to decrease in moisture content ordue to the partial hydrolysis of the complex carbohydrates into simple carbohydrates.

These results are in conformation with the findings of Priyanka *et al.* (2020) while working on osmo-dried guava slices, Chavan *et al.* (2010) in banana slices who reported that increase in total soluble solids might be due to reduction in moisture content during storage.

Titratable acidity

A perusal of data in Table 3 indicated thatthe titratable acidity content decreased significantly during the storage of three months. Initially the per cent titratable acidity ranged from 1.56 to 0.69 per cent. The highest titratable acidity of 1.56per cent was recorded in control followed by 0.79 per cent in T_5(50 ^{0}Brix jaggery syrup) and 0.73per cent in T_6 (60 ^{0}Brix jaggery syrup) whereas, the lowest titratable acidity value of 0.54per centobserved in T_4(70 ^{0}Brix sugar syrup) followed by 0.59 per cent in treatment T_3(60 ^{0}Brix sugar syrup) and 0.67 per cent in treatment T_2 (50 ^{0}Brix sugar syrup) in different osmotic treatments. After three months of storage, the highest titratable acidity of 1.49 per cent found in control whereas, the lowest titratable acidity value of 0.52 per cent in treatment T_4 (70 ^{0}Brix sugar syrup). The decrease in acidity might be due to the osmotic process which might have make water to move out of the food into the solution and leach out the natural solutes (organic acid) from the food into the solution and thus acidity is ultimately reduced. The decrease in acidity was in confirmity with the findings of Suhasini (2014) in osmo-dehydration of karonda and Kour (2021) in osmo-dried plum.

Table 4: Effect of treatment and storage period on carbohydrate and overall acceptabilityof Osmo-dried carrot cubes

Treatments	Carbohydrate					Overall acceptability				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	86.58	86.92	87.95	88.13	87.39	6.52	6.20	5.41	5.73	5.97
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	75.81	76.36	77.10	77.76	76.75	7.22	7.05	6.83	6.71	6.95
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	77.11	77.63	78.24	78.67	77.91	7.68	7.55	7.28	7.14	7.41
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	78.30	78.88	79.34	79.92	79.11	7.94	7.83	7.72	7.61	7.78
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	75.27	75.96	76.70	77.26	76.29	6.98	6.89	6.60	6.35	6.71
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	76.49	77.08	77.62	77.92	77.27	7.16	7.04	6.92	6.81	6.98
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	77.80	78.38	78.84	79.14	78.54	7.56	7.39	7.28	7.20	7.36
Mean	78.19	78.74	79.39	79.82		7.29	7.14	6.86	6.79	
CD (5%)										
Treatments			0.02					0.02		
Storage			0.01					0.01		
Treatment x Storage			0.04					0.03		

Carbohydrate

The data in Table 4 revealed that with the advancement of storage period the mean carbohydrate increased from initial level of 78.19 to 79.82. Initially the maximum value of 86.58 per cent recorded in treatment T_1 (control) and the minimum value of 75.27 per cent recorded in treatment T_5 (50 ^{0}Brix jaggery syrup). After three months of storage period the maximum value of 88.13 per cent observed in control whereas the lowest value of 77.26 per cent recorded inT_5 (50 ^{0}Brix jaggery syrup). However, the interaction between the treatments, storage and interaction between treatment and storage period also found to be significant at 5 per cent level of significance.

The increase in carbohydrate content during storage might be due to the degradationofpolysaccharideintosimplesugar. Hasanuzzaman*et al.* (2014) also reported an increase in carbohydrate content with the increase in syrup concentration while preparing tomato candy.

Overall acceptability

The effect of treatments and storage period on the mean score of overall acceptability of osmo-dehydrated carrot cubes presented in Table 4revealed that during three months of storage period overall acceptability score decreased significantly from initial value of 7.29 to 6.79. Initially, maximum and minimum scores of 7.94and 6.52 recorded in treatment T_4 (70 ^{0}Brix sugar syrup) and control, respectively. After three months of storage period, the highest value of sensory score for overall acceptability was 7.61 recorded in treatment T_4 (70 ^{0}Brix sugar syrup) followed by T_7 and T_3 with the values of 7.20 and 7.14 respectively, while the lowest value of 5.73 was observed in control. Maximum overall acceptability score recorded in treatment T_4 (70 ^{0}Brix sugar syrup) while as lowest in control having the values of 7.78 and 5.97, respectively. The interaction between the treatment and storage period was found to be significant at 5 per cent level of significance.

The mean overall acceptability decreased significantly during three months of storage period from 7.29 to 6.79. The decrease in overall acceptability score may be due to absorption of atmospheric moisture, dilution of sugars and changes in acidity, oxidation of ascorbic acid, hygroscopic nature of osmo-dehydrated product as well as changes in biochemical constituents of the product. The results are also in conformity with chibber *et al.* (2019) and Gupta *et al.* (2020) in preparation of intermediate beetroot cubes and bael preserve during three months of storage.

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