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INFLUENCE OF SUGAR AND JAGGERY SYRUP ON QUALITY AND MICROBIAL CHARACTERISTICS OF OSMO-DEHYDRATED CARROT CUBES DURING STORAGE

Nikhet Rafiq[1], Neeraj Gupta[1]*, Monika Sood[1], Julie D. Bandral[1] and Vikas Gupta[2]
[1]Division of Post Harvest Management, Chatha, SKUAST- Jammu, J&K 180009, India
[2]Basmati Rice Research Centre, Chakroi, R.S Pura, SKUAST-Jammu, J&K, 180009, India
*Corresponding author E-mail: neeruguptapht@gmail.com
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ABSTRACT

The present investigation was carried out in the Division of Post Harvest Management, Chatha, SKUAST-Jammu during the year 2021-2022. Carrot cubes were dipped in different concentration (50, 60 and 70^0 Brix) of sugar and jaggery syrups for the preparation of osmo- dehydrated carrot cubes. 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 microbial characteristics at an interval of one month. Storage studies indicated that there was significant decrease in ascorbic acid, crude protein, crude fibre and crude fat content while as reducing and total sugars increased. The stored osmo-dehydrated carrot cubes were found microbiologically safe. The cost of production of osmo-dehydrated carrot cubes per 100 g comes to be ≠ 48.89.
***Keywords*: **Osmo-dehydrated, carrot cubes, jaggery, sensory attributes, storage.

Introduction

Carrots are healthy vegetables, but this agricultural product has low value when they are sold as a raw commodity. To become value-added agricultural products, the value of raw carrots has to be increased through the addition of ingredients or processes that make them more attractive to the buyer. Increasing the added value of the carrots requires the development of food products that considering the voice of the customer (Meister and Kava, 2006). Its maximum retention is of outmost importance for the preservation of the attractive appearance and dietary value of the product. Carrots have a moisture content of 80–90% (wet basis) at the time of harvest. They are seasonal in nature and highly susceptible to moisture loss leading to wilting and loss of fresh appeal. Osmotic dehydration is a non-thermal treatment, the aim of which is to modify the composition of food material by partially removing water and impregnating it with solutes, without affecting the material's structural integrity. Osmotic dehydration (OD), a technique used to produce high or intermediate moisture products, involves immersing pieces of food in a hypertonic solution. Such processes allow the adjustment of the physical-chemical properties of food by reducing water content and simultaneously incorporating ingredients or additives with antioxidant or other preservative properties into the food (Torreggiani and Bertolo, 2001). Osmotic dehydration is one of the simple and inexpensive processes, which offers a way to make available the low cost, highly perishable and valuable crop available for the regions away from production zones and during off season. Osmotic dehydration with different concentrations to ensure the desired nutritional and sensory properties of dried product. The aim of this study was to influence of sugar and jaggery syrup on quality and microbial characteristics of osmo-dehydrated carrot cubes during storage.

Materials 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 and cut into 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 carrots spread 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-dehydrated carrot samples were weighed, packed in polypropylene bags and stored under ambient conditions for 3 months. The osmo-dehydrated carrots cubes were analysed at an interval of 0, 1, 2 and 3 months of storage for quality and microbial characteristics. Reducing sugar, total sugar and ascorbic acid were measured by Ranganna, 1986. Crude protein was measured by Sadasivam and Manickam, 2008. Crude fibre and crude fat content was estimated by AOAC, 2012. 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.

Results and Discussion

Reducing sugar

The data in Table 1 depicted a significant increase in reducing sugar content during the different storage periods. Initially, the maximum and minimum reducing sugar content of 38.79 and 6.48 per cent recorded in treatment T_4 (70 ^{o}Brix sugar syrup) and control, respectively. After three months of storage period, treatment T_4 (70 ^{o}Brix sugar syrup) recorded significantly higher value of 40.73 per cent followed by T_3 (60 ^{o}Brix sugar syrup) and lowest value of 6.97 per cent in control. On the basis of treatment mean values, it was observed that reducing sugar content of 39.28 per cent was highest in treatment T_4 (70 ^{o}Brix sugar syrup) and lowest (6.77 per cent) in control. The increase in reducing sugar might be due to hydrolysis of non-reducing sugars into reducing sugars. Similar observations were also supported by Mondal *et al.* (2017) in aonla candy and Selvakumar and Tiwari (2018) in carrot slices.

Total sugar

It is evident from the data in Table 1 that initially the highest amount of total sugar content of 60.21 per cent was recorded in treatment T_4 (70 ^{o}Brix sugar syrup) and the lowest of 8.79 per cent observed in control. As the storage period advanced, total sugar content increased to 62.82 per cent as recorded in treatment T_4 (70 ^{o}Brix sugar syrup) and the minimum of 9.97 per cent recorded in control after three months of storage. The storage mean values of the total sugar content of osmo-dehydrated carrot cubes increased significantly from 48.80 to 50.76 per cent. However, the interaction between the treatments and storage period differed significantly at 5 per cent level of significance.

Bishnoi *et al.* (2018) reported that increase in level of sugars can be attributed to loss of moisture from the products and hydrolysis of starch and pectin into simple sugars. Similar observations were also reported by Kour *et al.* (2021) while studying the storage changes in osmo-dried plum and they also reported an increasing trend in the total sugars.

Ascorbic acid

The data pertaining to ascorbic acid in Table 2 depicted that at beginning, statistically higher ascorbic acid content (3.89 mg/100 g) was recorded in T_2 (50 ^{0}Brix sugar syrup) and the lowest 2.40 mg/100 g in control. The ascorbic acid content decreased significantly during three months of storage. After three months of storage period, the maximum value (2.67 mg/100 g) was recorded in T_2 (50 ^{0}Brix sugar syrup) whereas, the lowest value of 2.17 mg/100 g was observed in control. In treatment mean values, the highest value of ascorbic acid found in treatment T_2 (50 ^{0}Brix sugar syrup) and lowest in control having values of 3.27 and 2.29 mg/100 g, respectively. The storage mean values of ascorbic acid content significantly decreased from 2.99 to 2.38 mg/100 g during three months of storage. The interaction between the treatment and storage period was also found significant at 5 per cent level of significance.

Nazaneen *et al*. (2015) reported that decrease in ascorbic acid might be due to thermal degradation during dehydration process and subsequent oxidation during storage. Similar findings have been reported by Gupta *et al.* 2020 in osmo-dried peel sticks from galgal.

Crude protein

The data pertaining to the effect of treatment and storage on crude protein in osmo-dehydrated carrot cubes have been presented in Table 2. The statistically higher crude protein (3.97 per cent) recorded initially in treatment T_5 (50 ^{o}Brix jaggery syrup) and the lowest (1.96) in control. After three months of storage period, treatment T_5 (50 ^{o}Brix jaggery syrup) and control recorded maximum and minimum crude protein content of 3.52 and 1.53 per cent, respectively. The maximum overall treatment mean content of 3.75 per cent was recorded in T_5 (50 ^{o}Brix jaggery syrup) and the lowest of 1.75 per cent in control, respectively.

A significant decrease in crude protein content was observed with the progress in storage period. The mean values of storage period showed a decreasing trend from the initial level of 3.20 to 2.84 per cent after the three months of storage. The interaction between the treatments and storage period was found to be significant at 5 per cent level of significance.

The decrease in crude protein content might be because of Millard reaction, which results in complex changes in food due to reaction between carbohydrates and proteins. Similar findings were also reported by Munaza (2018) while working on value added products from quince.

Crude fibre

The experimental values of crude fibre under different treatments and storage are presented in Table 3. At beginning, the minimum crude fibre content of 2.90 per cent recorded in control and maximum was observed in treatment T_2 (50 ^{o}Brix sugar syrup) of 3.20 per cent. After three months of storage, control recorded minimum and treatment T_2 (50 ^{o}Brix sugar syrup) observed maximum values to the tune of 2.55 and 3.08 per cent, respectively. The mean values of storage period showed a significant decreasing trend from the initial levels of 3.05 to 2.63 per cent. The treatment, storage as well as interaction between treatment and storage periods was found to be significant.

Tadesse *et al*. (2015) reported that decrease in the crude fibre with the increase in the osmotic strength could be due to the increase in the ash content due to diffusion of solutes on osmotic treatment. These results are also in agreement with the findings of Hasanuzzaman *et al*. (2014) who reported a decrease in crude fibre content with an increase in syrup concentration while preparing tomato candy.

Crude fat

It is evident from the data in Table 3 that the crude fat content of all the treatments decreased during three months of storage period. Initially, crude fat content in osmo-dehydrated carrot cubes ranged from 1.82 to 2.47 per cent. After one month of storage period, maximum and minimum crude fat content observed in treatment T_5 (50 ^{o}Brix sugar syrup) and control having values of 2.72 and 1.74, respectively which decreased to 2.49 and 1.43 in treatment T_5 (50 ^{o}Brix sugar syrup) and control, respectively. In treatment mean values, the maximum value (2.68 per cent) recorded in treatment T_5 (50 ^{0}Brix jaggery syrup) followed by T_2 (50 ^{0}Brix jaggery syrup) value as 2.48, while as lowest value of 1.65 per cent recorded in control. The mean values of crude fat content decreased from 2.46 to 2.15 per cent during three months of storage. The interaction between storage and treatment was also found to be significant at 5 per cent level of significance.

The decrease in fat content during storage was mainly due to oxidation because fats slowly take up oxygen and become rancid when it is stored and ultimately reduced. Similar findings were also reported by Hasanuzzaman *et al.* (2014) in tomato candy.

Microbial studies

All the samples were found to be free from microbial count upto two months of storage (Table 4). However, after three months of storage, the highest microbial count of 1.40×10^6 cfu/g recorded in control which was followed by T_5 (50 °Brix jaggery syrup) and T_6 (60 °B jaggery syrup) whereas the lowest of 0.22×10^6 cfu/g recorded in T_4 (70 °Brix sugar syrup), which was followed by T_3 (60 °Brix sugar syrup) and T_2 (50 °Brix sugar syrup), with the values of 0.24 and 0.28×10^6 cfu/g, respectively. An acceptable count of microbes was also observed in osmo-dried peel flakes from eureka lemon by Kour *et al*. (2020).

Cost of production

Cost of production of osmo-dehydrated carrot cubes is based upon the fixed and variable costs (Table 5). The cost of production of osmo-dehydrated carrot cubes of treatment T_4 (70 ^{0}Brix sugar syrup) which was adjudged as the best in terms of sensory evaluation was based upon the cost of all ingredients used and some other factors. The cost of production of osmo-dehydrated carrot cubes per 100 g comes to be ≠ 48.89. Since, the cost of production has been calculated on the laboratory scale basis; further reduction in cost of production on large scale can be expected.

Conclusion

It is therefore concluded from the present study that carrot (*Daucus carota* L.) root vegetable grown extensively in the tropical region during winter season and being perishable it can be used successfully for the preparation of osmo-dehydrated carrot cubes to increase its shelf life, nutritional value, flavour, odour and preventing spoilage from microbial contamination. Osmo-dried carrot cubes prepared from dipping in 70^{0}Brix sugar syrup have good-shelf life for a period of three months in polypropylene bags without adversely affecting their quality and microbial characteristics.

Table 1 : Effect of treatment and storage period on reducing and total sugar of Osmo-dehydrated carrot cubes

Treatments	Reducing sugar (%)					Total sugar (%)				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	6.48	6.74	6.89	6.97	6.77	8.79	9.23	9.52	9.97	9.38
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	36.59	36.67	36.98	37.41	36.91	52.96	53.67	54.58	55.48	54.17
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	37.63	38.18	38.67	39.79	38.57	56.13	56.73	57.76	58.61	57.31
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	38.79	38.91	39.29	40.73	39.28	60.21	61.12	61.93	62.82	61.52
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	34.95	35.53	35.74	37.19	35.70	51.12	51.73	52.47	53.34	52.17
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	35.73	36.89	36.97	37.23	36.64	53.25	53.97	54.32	54.12	53.92
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	36.63	36.91	37.41	37.92	37.22	59.12	59.72	60.63	60.97	60.11
Mean	32.40	32.75	33.01	33.89		48.80	49.45	50.17	50.76	
CD (5%)										
Treatments	0.04					0.02				
Storage	0.03					0.02				
Treatment x Storage	0.08					0.04				

Table 2 : Effect of treatment and storage period on ascorbic acid and crude protein of Osmo-deydrated carrot cubes

Treatments	Ascorbic acid (mg/100g)					Crude protein (%)				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	2.40	2.37	2.21	2.17	2.29	1.96	1.83	1.69	1.53	1.75
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	3.89	3.74	2.79	2.67	3.27	3.80	3.62	3.49	3.32	3.56
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	3.63	3.54	2.61	2.53	3.08	3.30	3.21	3.14	3.08	3.18
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	3.41	3.37	2.54	2.49	2.95	2.92	2.81	2.74	2.63	2.78
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	2.76	2.63	2.52	2.43	2.59	3.97	3.83	3.69	3.52	3.75
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	2.51	2.47	2.31	2.27	2.39	3.47	3.32	3.23	3.12	3.29
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	2.32	2.26	2.19	2.13	2.23	2.99	2.89	2.78	2.68	2.84
Mean	2.99	2.91	2.45	2.38		3.20	3.07	2.97	2.84	
CD (5%)										
Treatments	0.05					0.05				
Storage	0.03					0.04				
Treatment x Storage	0.09					0.10				

Table 3 : Effect of treatment and storage period on crude fibre and crude fat of Osmo-dehydrated carrot cubes.

Treatments	Crude fibre (%)					Crude fat (%)				
	Storage period (Months)					Storage period (Months)				
	0	1	2	3	Mean	0	1	2	3	Mean
T_1: Control	2.90	2.58	2.41	2.32	2.55	1.82	1.74	1.59	1.43	1.65
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	3.20	3.11	3.04	2.97	3.08	2.62	2.53	2.41	2.34	2.48
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	3.09	2.93	2.86	2.73	2.90	2.49	2.37	2.26	2.19	2.33
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	3.01	2.82	2.71	2.61	2.78	2.34	2.23	2.17	2.10	2.21
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	3.16	3.09	2.64	2.59	2.87	2.87	2.72	2.64	2.49	2.68
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	3.05	2.84	2.72	2.67	2.82	2.61	2.54	2.43	2.31	2.47
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	2.96	2.71	2.63	2.52	2.70	2.47	2.32	2.24	2.17	2.30
Mean	3.05	2.86	2.71	2.63		2.46	2.35	2.25	2.15	
CD (5%)										
Treatments	0.02					0.02				
Storage	0.01					0.01				
Treatment x Storage	0.03					0.03				

Table 4 : Effect of treatment and storage period on microbial count (10^6x cfu/g) of osmo-dehydrated carrot cubes

Treatment	Microbial count (10^6x cfu/g)				
	Storage period (month)				
	0	1	2	3	Mean
T_1: Control	ND	ND	ND	1.40	0.35
T_2: Dipping in 50 ^{0}Brix Sugar Syrup	ND	ND	ND	0.28	0.07
T_3: Dipping in 60 ^{0}Brix Sugar Syrup	ND	ND	ND	0.24	0.06
T_4: Dipping in 70 ^{0}Brix Sugar Syrup	ND	ND	ND	0.22	0.05
T_5: Dipping in 50 ^{0}Brix Jaggery Syrup	ND	ND	ND	0.42	0.11
T_6: Dipping in 60 ^{0}Brix Jaggery Syrup	ND	ND	ND	0.39	0.10
T_7: Dipping in 70 ^{0}Brix Jaggery Syrup	ND	ND	ND	0.36	0.09
Mean	ND	ND	ND	0.47	

Table 5 : Cost of production of osmo-dehydrated carrot cubes

Ingredients	Rate@	T_4: Dipping in 70 ^{0}Brix Sugar Syrup	
		Quantity	Amount (≠)
(A)Variablecost			
(a)Costof input			
Carrot	20/ kg	1/kg	20
Sugar	45/ kg	1400/g	63
Citric acid	120/kg	0.5/g	0.06
Packaging material LDPE pouches	0.5/pouches	3	1.50
Totalcost			84.56
(b)Cost of labourandfuel	@ 15%		12.68
Totalvariablecost	a+b		97.24
(B)Fixedcost			
Machinerydepreciation @10% on thetotal machinerycost of 50,000for300working days in a year	@ 10%	5000	
Machinerydepreciationfor one day		16.66	
(C)Profitof totalvariablecost andfixedcost	@ 15%	17.08	
(D)GST of totalvariablecost, fixed costand profit	@ 12%	15.71	
GrandTotal for 300 g product		**146.69**	
Cost per pouch of 100 g		**48.89**	

Conflicts of Interest:

The author claims no conflicts of interest to conduct this research work.

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