

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(12): 1071-1081
www.biochemjournal.com
Received: 01-09-2024
Accepted: 04-10-2024

Dev Raj
Department of Post Harvest
Technology, ASPEE College of
Horticulture, Navsari
Agricultural University,
Navsari, Gujarat, India

Pooja Naik
Department of Post Harvest
Technology, ASPEE College of
Horticulture, Navsari
Agricultural University,
Navsari, Gujarat, India

Effects of sorbitol concentration and packaging material on quality of carrot candy during storage

Dev Raj and Pooja Naik

DOI: <https://doi.org/10.33545/26174693.2024.v8.i12n.3355>

Abstract

The present investigation was aimed to develop a methodology for carrot candy by using of sorbitol as a humectant and packaging materials and to study the storage stability of developed products. The experiment was conducted with fifteen different treatment combinations using five levels of humectants (sorbitol) [without sorbitol (H₁), 5% (H₂), 10% (H₃), 15% (H₄) and 20% (H₅) and three levels of packaging materials (polyethylene (P₁), poly propylene (P₂) and aluminium laminate (P₃)]. The results of present investigation indicated that the acceptable quality carrot candy can be prepared when coated with 10%, dried at 60 °C for 5 hours and packed in aluminium laminate packaging material. The carrot candy prepared from this treatment possess higher carotene content, sensory score while lower moisture content, water activity, non-enzymatic browning (NEB) and exhibited minimum changes in nutritional as well as sensory attributes during six months' storage. The cost of production for carrot candy 50 g pack of carrot candy was worked out Rs.15.40. Thus, prepared products can commercially be explored by food processing industry to ensure better returns to growers, processors and consumers as well.

Keywords: Humectant, carrot candy, storage, quality, packaging materials

Introduction

The health and nutritional benefits of the carrot, its commercialization and industrialization in the form of different products is very important in fulfilling the nutrient requirements of the people particularly as a cheap source of vitamin A. It also contains a good source of ascorbic acid, vitamin K, dietary fiber and potassium. There is an appreciable amount of vitamin B₁, B₂, B₆, B₁₂ and minerals. Carrot contains 86 percent moisture, 10.6 g carbohydrates, 0.2 g fat, 1.2 g fiber, 1890 µg carotene, 0.04 g thiamine, 0.02 g riboflavin, 0.6 g niacin, 530 mg phosphorus, 1.1 g minerals and 3 mg per 100 g vitamin C (Gopalan *et al.* 2004) [10]. Moreover, carrots are known to contribute 14 to 17 percent of the total vitamin A consumption (Heinonen 1990 and Block, 1994) [11, 6]. Carotenoid helps in preventing heart diseases, improve vision, help in reducing blood sugar and reduce colon cancer (Bast *et al.* 1998 and Bramley 2002) [5, 7]. Carrots are being consumed in various forms *viz.*, salad, soup, stews, curries, pies and sweetmeats. They are cooked and processed into various value added products *viz.*, canned carrots, chips, *kheer*, *halwa*, powder, juice, beverages, wine, preserve, intermediate moisture products like, jam etc. but a present not being used for candy preparation. Candy is a sweet product prepared from fruits or vegetables by impregnating them with sugar syrup followed by draining of excessive syrup and then drying the product to a shelf stable state. The maintenance of colour, texture, taste and aroma are major problems in preparation of candy. There is urgent need to standardize the process for preparation of candy from carrots. The use of humectants could be applied to prevent this problem. Sugar alcohols, such as, sorbitol and maltitol are bulk sweeteners with good taste and reduced calories. So, the present investigation was carried out to study the effect of sorbitol as a humectant and packaging materials on quality of carrot candy.

Materials and Methods

Raw Materials

Fresh matured but tender, disease, pest and injury free, orange colored carrots (*cv.* Chantney) were selected and purchased from Morarji yard, APMC, Navsari. The carrots were cleaned, sorted and used for preparation of the carrot candy.

Corresponding Author:
Dev Raj
Department of Post Harvest
Technology, ASPEE College of
Horticulture, Navsari
Agricultural University,
Navsari, Gujarat, India

Experiment was carried out in Centre of Excellence on Post Harvest Technology, Department of Post Harvest Technology, ASPEE College of Horticulture and forestry, N.A.U., Navsari.

Experimental Details

Carrot candy was prepared using different concentrations of humectant and different packaging materials. A total of 15 different treatment combinations used in experiment as detailed in Table 1 were comprised of two different factors. The detail of treatment factors and treatment combinations are given ahead. The experiment for preparation of carrot candy was carried out with three repetitions.

Factor 1: Sorbitol conc. (H)	Factor 2: Packaging material (P):
H ₁ – Control	P ₁ - Poly ethylene (PE)- 300 gauge
H ₂ – 5%	P ₂ - Poly propylene (PP)-400 gauge
H ₃ – 10%	P ₃ - Aluminum Laminate (AL)-300 gauge
H ₄ – 15%	
H ₅ – 20%	

Table 1: Detail of treatment combinations used for preparation of carrot candy

Sr. No.	Treatment combinations	Treatment details
1.	H ₁ P ₁	Without sorbitol and PE
2.	H ₁ P ₂	Without sorbitol and PP
3.	H ₁ P ₃	Without sorbitol and AL
4.	H ₂ P ₁	5% sorbitol and PE
5.	H ₂ P ₂	5% sorbitol and PP
6.	H ₂ P ₃	5% sorbitol and AL
7.	H ₃ P ₁	10% sorbitol and PE
8.	H ₃ P ₂	10% sorbitol and PP
9.	H ₃ P ₃	10% sorbitol and AL
10.	H ₄ P ₁	15% sorbitol and PE
11.	H ₄ P ₂	15% sorbitol and PP
12.	H ₄ P ₃	15% sorbitol and AL
13.	H ₅ P ₁	20% sorbitol and PE
14.	H ₅ P ₂	20% sorbitol and PP
15.	H ₅ P ₃	20% sorbitol and AL

Methodologies for Candy preparation

The carrots were washed with running tap water. The carrots were cut into 15×15mm ± 1mm pieces followed by blanching at 85 °C for 3 minutes. After that blanched carrot pieces were given osmotic dip treatment for overnight using 50 °Brix sugar syrup containing 1000 ppm potassium metabisulphite (KMS) and 2000 ppm citric acid. After 24 hours, syrup was drained out; TSS and weight of syrup were recorded. The TSS of drained out syrup was raised 10 °Brix by adding table sugar and then pieces were again kept in syrup for overnight. The process was repeated till the TSS of syrup reached to 70 °Brix. Then pieces were rinsed in luke warm water and drained followed by coating with different concentrations of humectant *i.e.* sorbitol (5, 10, 15 and 20%) for 10 seconds. After coating treatments pieces were dried in hot air cabinet tray drier at temperature of 60 °C for 8 hours. After dehydration, samples of carrot candy were packed in the different packaging materials (polyethylene, polypropylene and aluminium laminate), sealed air tight and stored at room temperature for further analysis and to record observations. Principal steps used for preparation of carrot candy have been presented in Fig 1.

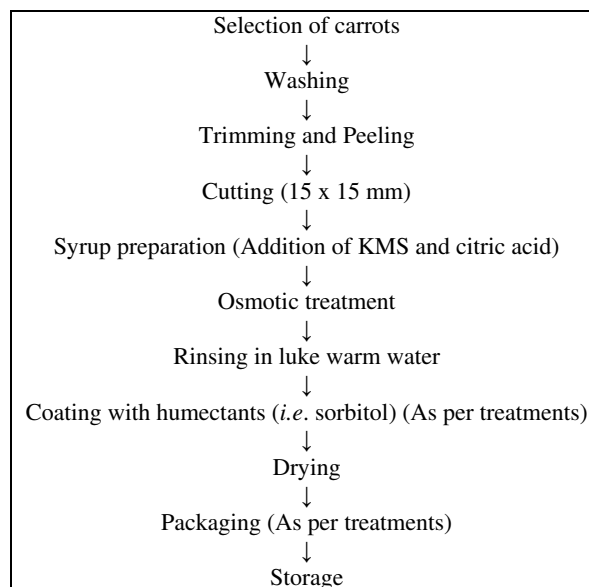


Fig 1: Principal steps used for preparation of carrot candy

Quality parameters

Ten carrots were selected randomly from the whole lot for determining the physical characteristics. The moisture was estimated by drying the weighted samples in hot air oven at 70±2 °C to a constant weight (AOAC, 1984) [3]. The total soluble solids (TSS) of the samples were determined with the help of hand refractometer and expressed as °Brix (Ranganna, 1997) [27]. The titratable acidity, sugars, ascorbic acid and crude fibre content were determined by the method as detailed by Ranganna (1997) [27]. Proteins and beta-carotene contents were determined by method as detailed by Sadasivam and Manickam (1996) [29]. The candy was evaluated for sensory qualities on the basis of overall acceptability by a panel of 7-10 judges on a 9-point Hedonic scale (Amerine *et al.* 1965) [2]. The data pertaining to physico chemical characteristics of candy were analysed statistically by following completely randomized design (Panse and Shukhatme, 1967) [20].

Result and Discussion

Physico-Chemical Attributes of Fresh Carrots

The physico-chemical characteristics of fresh carrots which were used for the preparation of fresh-cut carrot pieces, candy and instant carrot *halwa* mix powder are given in Table 2. The data on physical parameters of fresh carrots revealed the mean weight, peeling and trimming losses of the carrots in the range of 75.45 g and 7.40 percent having orange colour of skin/peel and flesh. The data on chemical parameters of carrots revealed mean moisture, TSS, acidity, reducing sugars, non-reducing sugars, total sugars, beta-carotene, proteins, crude fibre, ascorbic acid in the range of 9.53 °Brix, 0.12%, 2.74%, 4.15%, 6.89%, 38.65 mg/100 g, 0.95%, 1.80% and 3.91 mg/100 g, respectively. Our result in present investigation for physico-chemical parameters of carrots are similar to earlier studies as reported by Gopalan *et al.* (2004) [10]. The chemical constituents of carrot reported to contains 86% moisture with 9.55 °Brix TSS, 2.77% reducing sugars, 6.92% total sugars, 0.12% acidity, 10.6 g carbohydrates, 0.2 g fat, 1.2 g fiber, 3965 micro g beta-carotene and 3 mg per 100 g vitamin C (Gopalan *et al.*, 2004) [10]. Sharma *et al.* (2012) [33] also reported similar variations for moisture (86% to 88%), carbohydrate (6 to 10.6%), crude fiber (1.2 to 2.4%), total sugars (5.6%), beta-

carotenes (39.6 mg/100 g). The perusal of data pertaining to mass transfer-in and mass transfer-out for carrot candy show that candy prepared by using 1 kg of syrup (50°B) containing 1000 ppm KMS per 1kg pieces had 12.71% mass transfer-in and 21.5% mass transfer-out during the osmotic process. It might be due to solute gain from osmotic solution of higher concentration difference. Similar reason of high concentration difference between the beetroot and osmotic solution were reported earlier by Falade and Igbeka *et al.* (2007) [9]. The mass transfer-out might be due to the high osmotic strength exerts high osmotic pressure which results in exudation of higher water contents out of the cells, thus higher mass transfer-out.

Table 2: Physico-chemical characteristics of fresh carrots

Parameters*	Mean
Weight of carrot (g)	75.45
Peeling and trimming loss (%)	7.40
Skin / peel colour, visual	Orange
Flesh colour, visual	Orange
Moisture (%)	86.12
TSS(°Brix)	9.53
Acidity (%)	0.12
Reducing sugars (%)	2.74
Non-Reducing sugars (%)	4.15
Total sugars (%)	6.89
Beta-carotene (mg/100 g)	38.65
Proteins (%)	0.95
Crude fibre (%)	1.80
Ascorbic acid (mg/100 g)	3.91
Mass transfer- In during candy preparation (%)	12.71±1.3
Mass transfer- Out - In during candy preparation (%)	21.5±2.46

Quality Parameters of candy

1. Yield of Candy

The perusal of data pertaining to yield of carrot candy has been presented in Table 2. Data showed that among different concentrations of sorbitol (humectant), yield of carrot candy (H) varied from 67.86 percent to 71.66 percent, with minimum yield in carrot candy prepared without using sorbitol (H₁) and maximum yield in carrot candy prepared with coating of 20% sorbitol (H₅). Similar observations were recorded by Naik *et al.* (2018) [16] for carrot candy Kishore *et al.* (2016) [12] for guava.

Table 3: Effect of sorbitol concentrations on yield of carrot candy

Treatments	Yield (%)
H ₁ -Control	67.86
H ₂ - 5% Sorbitol	68.75
H ₃ - 10% Sorbitol	70.10
H ₄ -15% Sorbitol	71.09
H ₅ - 20% Sorbitol	71.66

2. Moisture content

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials, storage and their interactions on moisture content of carrot candy has been presented in Table 4.

Effect of sorbitol: Data shows that among different concentrations of sorbitol (humectant), the mean moisture content of carrot candy (H) varied significantly from 11.99 percent to 14.35 percent, with minimum moisture content in carrot candy prepared without coating of sorbitol (H₁) and maximum moisture content in carrot candy prepared with

coating of 15% sorbitol (H₄). Similar observations were reported by Richa *et al.* (2017) [28] for *khoa*. The addition of humectant resulted significant decrease in moisture content due to the incorporation of humectant such as sorbitol, sorbitol and mannitol (80:20), maltodextrin and polydextrose, and polydextrose. The moisture content reduction can be attributed to the property of binding of free water by the humectant.

Effect of packaging material: Data showed that among different packaging treatments, mean moisture content of carrot candy (P) among different packaging materials varied significantly from 13.48 percent to 13.95 percent, with minimum moisture content in carrot candy which was packed in polypropylene bag (P₂) and maximum moisture content in carrot candy packed in aluminium laminate bag (P₃). Similar observations were reported by Alam *et al.* (2015) [1] for rice based snack. The higher average moisture content in aluminium laminated packaging material is due to less reduction during storage period of 6 months.

Effect of storage period: Data depicts that storage of carrot candy resulted significant decrease in mean moisture content (S) from initial value of 12.94 percent to 14.37 percent after six months of storage. Similar observations were reported by Prasad (2015) [23] for water melon rind candy. The decrease in moisture content during storage might be due to evaporation of moisture from candy due to low relative humidity in storage area and movement of moisture outside of the packaging material due to its water vapor permeability.

Effect of interactions: Interaction of sorbitol concentrations and storage depicted variations in moisture content from 11.29 percent to 15.43 percent during six months storage, with minimum decrease in moisture from 14.03 percent (H₂S₁) to 13.20 percent (H₂S₄) in carrot candy prepared with coating of 5% sorbitol and maximum decrease from 15.43 percent (H₅S₁) to 12.89 percent (H₅S₄) in carrot candy prepared with coating of 20% sorbitol. Interaction of packaging material and storage depicted variations in moisture content from 12.52 percent to 14.37 percent, with minimum decrease in moisture from 14.37 percent to 13.48 percent (P₃S₁ to P₃S₄) in carrot candy which was packed in aluminium laminated bag, whereas maximum decrease in moisture was observed from 14.37 percent to 12.80 percent in carrot candy packed in polyethylene bag (P₁S₁ to P₁S₄) after six months of storage. Interaction of sorbitol (humectant) and packaging material depicted variations in mean moisture in carrot candy from 14.82 percent to 11.78 percent, with minimum moisture content (11.78 percent) in carrot candy prepared by without sorbitol coating and packed in polypropylene packaging material (H₁P₂) and maximum moisture content (14.82 percent) in carrot candy prepared with coating of 10% sorbitol and packed in polyethylene bag (H₃P₃). Further, interaction of sorbitol concentration, packaging material and storage depicted variations in moisture content from 11.03 percent to 15.43 percent in carrot candy during a period of six months, with minimum decrease 14.70 percent to 14.19 percent in carrot candy prepared with coating of 10% sorbitol and packed in aluminium laminated (H₃P₃S₁ to H₃P₃S₄) and maximum decrease 15.43 percent to 12.10 percent in carrot candy prepared with coating of 20 % sorbitol and packed in

polypropylene bag ($H_5P_2S_1$ to $H_5P_2S_4$). Similar observations were recorded by Naik *et al.* (2018) ^[16] for carrot candy, Raj *et al.* (2015) ^[26] for osmo-air dehydrated apricot, Prasad (2015) ^[23] for water melon candy, and Nayak *et al.* (2012) ^[19] for aonla candy. The decrease in moisture might be due

to evaporation of moisture from candy due to low relative humidity in storage area and permeability of the packaging material towards moisture transmission. Interactions of, $P \times S$, $H \times S$ and were found to have significant effects, while $H \times P$ and $H \times P \times S$ were found to non-significant effects.

Table 4: Effect of sorbitol concentration and packaging materials on moisture of carrot candy

Sorbitol concentration (H)	Packaging material (P)	Moisture (%)					
		Storage month (S)				Mean (HP) Mean (H)	Mean (P)
		S ₁ :0 M	S ₂ :2 M	S ₃ :4 M	S ₄ :6 M		
H ₁ - control	P ₁ – PE	12.65	12.16	11.90	11.03	11.94	13.59
	P ₂ – PP	12.65	12.36	11.06	11.03	11.78	13.48
	P ₃ – AL	12.65	12.55	12.01	11.82	12.26	13.95
	Mean (HS)	12.65	12.36	11.66	11.29	11.99	
H ₂ - 5%	P ₁ – PE	14.03	13.36	13.13	13.03	13.39	
	P ₂ – PP	14.03	13.03	13.53	13.23	13.46	
	P ₃ – AL	14.03	13.76	13.52	13.35	13.67	
	Mean (HS)	14.03	13.39	13.39	13.20	13.50	
H ₃ - 10%	P ₁ – PE	14.70	14.43	14.03	14.00	14.29	
	P ₂ – PP	14.70	14.40	14.10	13.06	14.07	
	P ₃ – AL	14.70	14.50	14.27	14.19	14.42	
	Mean (HS)	14.70	14.44	14.13	13.75	14.26	
H ₄ - 15%	P ₁ – PE	15.05	14.50	14.10	13.30	14.24	
	P ₂ – PP	15.05	14.50	14.03	13.20	14.20	
	P ₃ – AL	15.05	14.70	14.54	14.14	14.61	
	Mean (HS)	15.05	14.57	14.22	13.55	14.35	
H ₅ - 20%	P ₁ – PE	15.43	14.33	14.06	12.66	14.12	
	P ₂ – PP	15.43	14.10	14.04	12.10	13.92	
	P ₃ – AL	15.43	15.00	14.94	13.91	14.82	
	Mean (HS)	15.43	14.48	14.34	12.89	14.29	
Mean (S)		14.37	13.85	13.55	12.94		
P×S	P ₁	14.37	13.76	13.44	12.80		
	P ₂	14.37	13.68	13.35	12.52		
	P ₃	14.37	14.10	13.86	13.48		
	H	P	H×P	S	H×S	P×S	H×P×S
S.E m. ±	0.084	0.065	0.147	0.071	0.159	0.123	0.276
CD at 5%	0.244	0.189	NS	0.199	0.446	0.346	NS
CV%	3.73				3.50		

3. Water activity

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials, storage and their interactions on water activity of carrot candy has been presented in Table 5.

Effect of sorbitol: Data shows that among different concentrations of sorbitol (humectant), the mean water activity of carrot candy (H) varied significantly from 0.47 to 0.56, with minimum water activity in carrot candy coated 10% sorbitol, whereas maximum water activity in carrot candy coated with 5% sorbitol. Increasing the amount of humectant (sorbitol or glucose syrup) in the mixtures could reduce a_w of the osmo-dried products. Similar observations were recorded by Korsrilabut *et al.* (2010) ^[13] and Naknaen *et al.* (2016) ^[18] for IMF banana slices.

Effect of packaging material: Data showed that among different packaging treatments, mean water activity of carrot candy (P) in different packaging materials varied significantly from 0.49 to 0.53, with minimum water activity in carrot candy which was packed in aluminium laminated packaging material (P₃) and maximum water activity in carrot candy packed in polyethylene and poly propylene packaging material (P₁) and (P₂). Similar observations were recorded by Panwar *et al.* (2013) ^[21] for aonla slices.

Effect of storage period: Data depicts that storage of carrot candy resulted significant increase in mean water activity (S) from initial value of 0.45 to 0.60 after six months of storage. The increase in water activity during storage also observed by Swain *et al.* (2014) ^[37], it might be due to migration of water vapour from the storage environment into the packaging material.

Effect of interactions: Interaction of sorbitol concentrations and storage depicted variations in water activity from 0.40 to 0.64 during six months storage, with minimum increase in water activity from 0.40 (H₃S₁) to 0.55 (H₃S₄) in carrot candy coated with 10% sorbitol and maximum increase from 0.48 (H₂S₁) to 0.64 (H₂S₄) in carrot candy coated with 5% sorbitol. Interaction of packaging material and storage depicted variations in water activity from 0.45 to 0.63, with minimum increase in water activity from 0.45 (P₃S₁) to 0.54 (P₃S₄) in carrot candy which was packed in aluminium laminated bag, whereas maximum increase in water activity was observed from 0.45 to 0.63 in carrot candy packed in polypropylene bag (P₂S₁ to P₂S₄) after six months of storage. Interaction of sorbitol (humectant) and packaging material depicted variations in mean water activity in carrot candy from 0.43 to 0.57, with minimum water activity (0.43) in carrot candy coated with 10% sorbitol and packed in aluminium laminated packaging material (H₃P₃) and maximum water activity (0.57) in carrot candy prepared

coated with 5% sorbitol and packed in polyethylene packaging material (H_2P_1). Further, interaction of sorbitol concentration, packaging material and storage depicted variations in water activity from 0.40 to 0.66 in carrot candy during a period of six months, with minimum increase 0.40 to 0.47 in carrot candy coated with 10% sorbitol and packed in aluminium laminated packaging material ($H_3P_3S_1$ to

$H_3P_3S_4$) whereas, maximum increase 0.43 to 0.66 in carrot candy coated with 20% sorbitol and packed in polypropylene packaging material ($H_5P_2S_1$ to $H_5P_2S_4$). The increase in water activity during storage it might be due to release of bound water by growth of micro-organisms. Effects of all interactions were found significant effects.

Table 5: Effect of sorbitol concentration and packaging materials on water activity (a_w) of carrot candy

Sorbitol concentration (H)	Packaging material (P)	Water activity (a_w)					
		Storage month (S)				Mean (HP) Mean (H)	Mean (P)
		S1:0 M	S2:2 M	S3:4 M	S4:6 M		
H_1 - Control	P_1 – PE	0.46	0.50	0.56	0.60	0.53	0.53
	P_2 – PP	0.46	0.45	0.50	0.56	0.49	0.53
	P_3 – AL	0.46	0.48	0.50	0.53	0.49	0.49
	Mean(HS)	0.46	0.48	0.52	0.56	0.51	
H_2 - 5%	P_1 – PE	0.48	0.50	0.65	0.66	0.57	
	P_2 – PP	0.48	0.52	0.64	0.66	0.58	
	P_3 – AL	0.48	0.53	0.57	0.59	0.54	
	Mean(HS)	0.48	0.52	0.62	0.64	0.56	
H_3 - 10%	P_1 – PE	0.40	0.45	0.52	0.60	0.49	
	P_2 – PP	0.40	0.43	0.50	0.60	0.48	
	P_3 – AL	0.40	0.42	0.44	0.47	0.43	
	Mean (HS)	0.40	0.43	0.49	0.55	0.47	
H_4 - 15%	P_1 – PE	0.48	0.48	0.56	0.65	0.54	
	P_2 – PP	0.48	0.53	0.60	0.66	0.57	
	P_3 – AL	0.48	0.49	0.51	0.57	0.51	
	Mean(HS)	0.48	0.50	0.56	0.63	0.54	
H_5 - 20%	P_1 – PE	0.43	0.45	0.57	0.60	0.51	
	P_2 – PP	0.43	0.50	0.56	0.66	0.54	
	P_3 – AL	0.43	0.44	0.49	0.52	0.47	
	Mean (HS)	0.43	0.46	0.54	0.59	0.51	
Mean (S)		0.45	0.48	0.54	0.60		
P×S	P_1	0.45	0.48	0.57	0.62		
	P_2	0.45	0.49	0.56	0.63		
	P_3	0.45	0.47	0.50	0.54		
	H	P	H×P	S	H×S	P×S	H×P×S
S.E m. ±	0.003	0.003	0.0068	0.003	0.007	0.005	0.012
CD at 5%	0.011	0.009	0.020	0.009	0.020	0.016	0.035
CV%	4.60					4.24	

4. TSS

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials, storage and their interactions on TSS of carrot candy has been presented in Table 6.

Effect of sorbitol: Data shows that among different concentrations of sorbitol (humectant), the mean TSS of carrot candy (H) varied significantly from 69.70 °Brix to 71.51 °Brix, with minimum TSS in carrot candy coated with 15% sorbitol (H_4) and maximum TSS in carrot candy without coating of sorbitol (H_1). Similar observation was recorded by Naknaen *et al.* (2016) [18] for cantaloupe. Increase in TSS was due to the hydrolysis of sucrose.

Effect of packaging material: Data showed that among different packaging treatments, mean TSS of carrot candy (P) in different packaging materials varied significantly from 70.59 °Brix to 70.54 °Brix, with minimum TSS in

carrot candy which was packed in polyethylene (P_1) and polypropylene packaging material (P_2) and maximum TSS in carrot candy packed in aluminium laminated packaging material (P_3). Similar observations were reported by Sharma *et al.* (2000) [34] for osmo-air dried apricot. However, effect of packaging material treatments was found to have non-significant.

Effect of storage period: Data depicts that storage of carrot candy resulted significant increase in mean TSS (S) from initial value of 70.08 °Brix to 70.83 °Brix after six months of storage. The increase in TSS during storage might be attributed to conversion of polysaccharides into reducing sugars and evaporation of moisture content. Similar observations were reported by (Raj *et al.* 2018) [25] for water melon rind candy, (Priya and Khatakar 2013) [24] for aonla preserve, (Phisut *et al.* 2013) [22] for cantaloupe candy and (Prasad 2015) [23] for watermelon rind candy.

Table 6: Effect of sorbitol concentration and packaging materials on TSS of carrot candy

Sorbitol concentration (H)	Packaging material (P)	TSS (°Brix)					
		Storage month (S)				Mean (HP) Mean (H)	Mean (P)
		S1:0 M	S2:2 M	S3:4 M	S4:6 M		
H ₁ - Control	P ₁ – PE	71.33	71.40	71.96	71.99	71.67	70.54
	P ₂ – PP	71.33	71.40	71.51	71.62	71.47	70.54
	P ₃ – AL	71.34	71.36	71.40	71.47	71.39	70.59
	Mean (HS)	71.33	71.39	71.62	71.69	71.51	
H ₂ - 5%	P ₁ – PE	71.20	71.26	71.30	71.33	71.27	
	P ₂ – PP	71.20	71.40	71.46	71.50	71.39	
	P ₃ – AL	71.20	71.24	71.40	71.42	71.31	
	Mean (HS)	71.20	71.30	71.38	71.42	71.33	
H ₃ - 10%	P ₁ – PE	70.33	70.36	70.40	70.46	70.39	
	P ₂ – PP	70.33	70.36	70.40	70.56	70.41	
	P ₃ – AL	70.33	70.32	70.39	70.51	70.39	
	Mean (HS)	70.33	70.35	70.40	70.51	70.40	
H ₄ - 15%	P ₁ – PE	70.13	70.25	70.54	67.44	69.59	
	P ₂ – PP	70.13	70.29	70.55	67.50	69.62	
	P ₃ – AL	70.13	70.15	70.22	69.07	69.89	
	Mean (HS)	70.13	70.23	70.44	68.00	69.70	
H ₅ - 20%	P ₁ – PE	70.10	70.27	70.39	68.40	69.79	
	P ₂ – PP	70.10	70.24	70.35	68.52	69.80	
	P ₃ – AL	70.10	70.12	70.19	69.46	69.97	
	Mean (HS)	70.10	70.21	70.31	68.79	69.85	
Mean (S)		70.62	70.70	70.83	70.08		
P×S	P ₁	70.62	70.71	70.92	69.92		
	P ₂	70.62	70.74	70.85	69.94		
	P ₃	70.62	70.64	70.72	70.39		
	H	P	H×P	S	H×S	P×S	H×P×S
S.E m. ±	0.393	0.304	0.681	0.327	0.732	0.567	1.267
CD at 5%	1.132	NS	NS	0.917	NS	NS	NS
CV%	3.34					3.11	

Effect of interactions: Interaction of sorbitol concentrations and storage depicted variations in TSS from 68 °Brix to 71.69 °Brix during six months storage, with minimum increase in TSS from 70.33 °Brix (H₃S₁) to 70.51 °Brix (H₃S₄) in carrot candy coated with 10% sorbitol and maximum increase from 70.13 °Brix (H₄S₁) to 68.00 °Brix (H₄S₄) in carrot candy coated with 15% sorbitol. Interaction of packaging material and storage depicted variations in TSS from 69.92 °Brix to 70.92 °Brix, with minimum increase in TSS from (70.62 °Brix P₃S₁ to 70.39 °Brix P₃S₄) in carrot candy which was packed in aluminium laminated bag, whereas maximum increase in TSS was observed from 70.62 °Brix to 69.92 °Brix in carrot candy packed in polyethylene bag (P₁S₁ to P₁S₄) after six months of storage. Interaction of sorbitol (humectant) and packaging material depicted variations in mean TSS in carrot candy from 69.59 °Brix to 71.67 °Brix, with minimum TSS (69.59 °Brix) in carrot candy coated with 15% sorbitol and packed in polyethylene bag (H₄P₁) and maximum TSS (71.67 °Brix) in carrot candy without coating of sorbitol and packed in polyethylene bag (H₁P₁). Further, interaction of sorbitol concentration, packaging material and storage depicted variations in TSS from 67.44 °Brix to 71.99 °Brix in carrot candy during a period of six months, with minimum increase 71.33 °Brix to 71.99 °Brix in carrot candy without coating of sorbitol (H₁P₁S₁ to H₁P₁S₄) packed in polyethylene bag and maximum increase 67.44 °Brix to 70.13 °Brix in carrot candy coated with 15% sorbitol and packed in polyethylene bag (H₄P₁S₁ to H₄P₁S₄). The increase in TSS might be due to reduction of moisture content in

product during storage. The increase in TSS during storage in the present investigation is in line with the observation reported by (Naik *et al.* 2018) ^[16] for carrot candy, (Raj *et al.* 2015) ^[26] for osmo-air dehydrated apricot, (Nayak *et al.* 2012) ^[19] for aonla candy, (Sood 2016) ^[35] for white gourd and (Attri *et al.* 2016) ^[4] for papaya. However, effects of all interactions were found non-significant.

5. Carotene

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials, storage and their interactions on carotene content of carrot candy has been presented in Table 7.

Effect of sorbitol: Data shows that among different concentrations of sorbitol (humectant), the mean carotene content of carrot candy (H) varied significantly from 43.26 mg/100 g to 52.03 mg/100 g, with minimum carotene content in carrot candy prepared with coating of 20% sorbitol (H₅) and maximum carotene content in carrot candy prepared without coating of sorbitol (H₃). Similar observations were recorded by (Sethi and Anand 1982) ^[32] for carrot preserve.

Effect of packaging material: Data showed that among different packaging treatments, mean carotene content of carrot candy (P) in different packaging materials varied significantly from 45.84 mg/100 g to 50.71 mg/100 g, with minimum carotene in carrot candy which was packed in polyethylene packaging material (P₁) and maximum

carotene content in carrot candy packed in aluminium laminated packaging material (P₃). Almost similar observation was reported by (Sagar and Neelavathi 2005) [30] for dehydrated carrot shred.

Effect of storage period: Data depicts that storage of carrot candy resulted significant decrease in mean carotene content (S) from initial value of 43.05 mg/100 g to 53.49 mg/100 g after six months of storage. The decrease in carotene content during storage might be attributed to its sensitivity to light and oxygen. Similar findings were earlier reported by (Mehta and Bajaj 1984) [15] for citrus peel candy and (Kumar and Sagar, 2008) [14] for osmo-dried mango slices. Effect of storage level was found to have significant.

Effect of interactions: Interaction of sorbitol concentrations and storage depicted variations in carotene content from 35.48 mg/100 g to 55.47 mg/100 g during six months storage, with minimum decrease in carotene from 54.48 mg/100 g (H₁S₁) to 45.24 mg/100 g (H₁S₄) in carrot candy prepared with without coating sorbitol and maximum decrease from 55.47 mg/100 g (H₃S₁) to 47.87 mg/100 g (H₃S₄) in carrot candy prepared with coating of 10% sorbitol. Interaction of packaging material and storage depicted variations in carotene content from 40.14 mg/100 g to 53.49 mg/100 g, with minimum decrease in carotene from 53.50 mg/100 g (P₃S₁) to 48.63 mg/100 g (P₃S₄) in carrot candy which was packed in aluminium laminated bag, whereas maximum decrease in carotene was observed from

53.50 mg/100 g to 40.14 mg/100 g in carrot candy packed in polyethylene bag (P₁S₁ to P₁S₄) after six months of storage. Interaction of sorbitol (humectant) and packaging material depicted variations in mean carotene in carrot candy from 40.81 mg/100 g to 53.85 mg/100 g, with minimum carotene content (40.81 mg/100 g) in carrot candy prepared with coating of 20% sorbitol and packed in polyethylene bag (H₅P₁) and maximum carotene content (53.85 mg/100 g) in carrot candy prepared with coating of 10% sorbitol and packed in aluminium laminated bag (H₃P₃). Further, interaction of sorbitol concentration, packaging material and storage depicted variations in carotene content from 35.48 mg/100 g to 55.47 mg/100 g in carrot candy during a period of six months, with minimum decrease 55.47 mg/100 g to 51.76 mg/100 g in carrot candy prepared with coating of 10% sorbitol and packed in aluminium laminated bag (H₃P₃S₁ to H₃P₃S₄) and maximum decrease 52.76 mg/100 g to 35.48 mg/100 g in carrot candy prepared with coating of 20% sorbitol and packed in polyethylene bag (H₅P₁S₁ to H₅P₁S₄). The decrease in carotene might be due to oxidative breakdown, isomerization or enzymatic destruction of pigments as well as increasing heating time during processing and increasing temperature at ambient condition during storage. The carotene is also sensitive to heat same as an ascorbic acid. Similar findings were earlier reported by (Naik *et al.* 2018) [16] for carrot candy. The interactions of H×P, H×S, P×S and H×P×S interactions were found significant effect.

Table 7: Effect of sorbitol concentration and packaging materials on carotene of carrot candy

Sorbitol concentration (H)	Packaging material (P)	Carotene (mg/100 g)					
		Storage month (S)				Mean (HP) Mean (H)	Mean (P)
		S ₁ :0 M	S ₂ :2 M	S ₃ :4 M	S ₄ :6 M		
H ₁ - Control	P ₁ – PE	54.48	48.09	42.41	39.41	46.10	45.84
	P ₂ – PP	54.48	49.53	42.25	39.93	46.55	45.85
	P ₃ – AL	54.48	53.29	48.81	49.49	51.52	50.71
	Mean (HS)	54.48	50.30	44.49	42.94	48.05	
H ₂ - 5%	P ₁ – PE	53.44	50.56	45.74	42.92	48.17	
	P ₂ – PP	53.44	50.72	42.12	43.20	47.37	
	P ₃ – AL	53.44	52.53	50.31	49.40	51.42	
	Mean (HS)	53.44	51.27	46.06	45.17	48.98	
H ₃ - 10%	P ₁ – PE	55.47	53.21	49.91	45.43	51.00	
	P ₂ – PP	55.47	53.59	49.45	46.43	51.24	
	P ₃ – AL	55.47	54.61	53.54	51.76	53.85	
	Mean (HS)	55.47	53.80	50.96	47.87	52.03	
H ₄ - 15%	P ₁ – PE	51.32	42.23	41.45	37.48	43.12	
	P ₂ – PP	51.32	42.89	41.93	36.45	43.15	
	P ₃ – AL	51.32	48.65	48.10	47.01	48.77	
	Mean (HS)	51.32	44.59	43.83	40.31	45.01	
H ₅ - 20%	P ₁ – PE	52.76	38.24	36.76	35.48	40.81	
	P ₂ – PP	52.76	38.36	36.92	35.85	40.97	
	P ₃ – AL	52.76	47.02	46.78	45.48	48.01	
	Mean (HS)	52.76	41.21	40.15	38.94	43.26	
Mean (S)		53.49	48.23	45.10	43.05		
P×S	P ₁	53.50	46.47	43.26	40.14		
	P ₂	53.50	47.02	42.53	40.37		
	P ₃	53.49	51.22	49.51	48.63		
	H	P	H×P	S	H×S	P×S	H×P×S
S.E m. ±	0.245	0.189	0.424	0.232	0.519	0.402	0.899
CD at 5%	0.705	0.546	1.221	0.650	1.454	1.126	2.520
CV%	3.40				3.28		

6. Non -enzymatic Browning

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials, storage and their

interactions on NEB of carrot candy has been presented in Table 8.

Effect of sorbitol: Data shows that among different concentrations of sorbitol (humectant), the mean NEB of carrot candy (H) varied significantly from 0.16 OD_{440nm} to 0.21 OD_{440nm}, with minimum NEB in carrot candy coated with 20% sorbitol (H₅) and maximum NEB in carrot candy prepared without coating of sorbitol (H₁). Similar observation was also recorded by (Sagar and Maini 1997) ^[31] for onion slices.

Effect of packaging material: Data showed that among different packaging treatments, mean NEB of carrot candy (P) in different packaging materials varied significantly from 0.16 OD_{440nm} to 0.18 OD_{440nm}, with minimum NEB in carrot candy which was packed in aluminium laminated (P₃) and packaging material and maximum NEB in carrot candy packed in polyethylene (P₁) and polypropylene (P₂) packaging materials. Similar observations were reported by (Kumar and Sagar, 2008) ^[14] for osmo-vac dehydrated mango slices and (Durrani *et al.* 2011) ^[8] for carrot candy.

Effect of storage period: Data depicts that storage of carrot candy resulted significant increase in mean NEB (S) from initial value of 0.14 OD_{440nm} to 0.21 OD_{440nm} after six months of storage. The increase in NEB content during storage might be due to increase of reducing sugar during storage. Increase in NEB during storage was also reported by (Nayak *et al.* 2012) ^[18] for aonla candy.

Effect of interactions: Interaction of sorbitol concentrations and storage depicted variations in NEB from 0.13 OD_{440nm} to 0.27 OD_{440nm} during six months storage, with minimum increase in NEB from 0.15 OD_{440nm} (H₂S₁) to 0.20 OD_{440nm}

(H₂S₄) in carrot candy coated with 5% sorbitol and maximum increase from 0.16 OD_{440nm} (H₁S₁) to 0.27 OD_{440nm} (H₁S₄) in carrot candy prepared without coating of sorbitol. Interaction of packaging material and storage depicted variations in NEB from 0.14 OD_{440nm} to 0.23 OD_{440nm}, with minimum increase in NEB from 0.14 OD_{440nm} (P₃S₁ to P₃S₄) to 0.18 OD_{440nm} in carrot candy which was packed in aluminium laminated packaging material, whereas maximum increase in NEB was observed from 0.14 OD_{440nm} to 0.23 OD_{440nm} in carrot candy packed in polyethylene packaging material (P₁S₁ to P₁S₄) after six months of storage. Interaction of sorbitol (humectant) and packaging material depicted variations in mean NEB in carrot candy from 0.15 OD_{440nm} to 0.23 OD_{440nm}, with minimum NEB (0.15 OD_{440nm}) in carrot candy coated with 10% sorbitol and packed in aluminium laminate (H₃P₃) and carrot candy coated with 20% sorbitol and packed in aluminium laminated (H₅P₃). Whereas, maximum NEB (0.23 OD_{440nm}) in carrot candy prepared without coating of sorbitol and packed in polyethylene packaging material (H₁P₁). Further, interaction of sorbitol concentration, packaging material and storage depicted variations in NEB from 0.13 OD_{440nm} to 0.30 OD_{440nm} in carrot candy during a period of six months, with minimum increase 0.14 OD_{440nm} to 0.16 OD_{440nm} in carrot candy coated with 10% sorbitol and packed in aluminium laminated packaging material (H₃P₃S₁ to H₃P₃S₄) and maximum increase 0.16 OD_{440nm} to 0.30 OD_{440nm} in carrot candy without coating of sorbitol and packed in polyethylene packaging material (H₁P₁S₁ to H₁P₁S₄). Similar observation was recorded by (Priya and Khatkar 2013) ^[24] for aonla preserve. All interactions were found significant effects.

Table 8: Effect of sorbitol concentration and packaging materials on NEB of carrot candy

Sorbitol concentration (H)	Packaging material (P)	NEB (OD _{440nm})					
		Storage month (S)				Mean (HP) Mean (H)	Mean (P)
		S1:0 M	S2:2 M	S3:4 M	S4:6 M		
H ₁ - Control	P ₁ – PE	0.16	0.20	0.25	0.30	0.225	0.182
	P ₂ – PP	0.16	0.15	0.25	0.27	0.204	0.177
	P ₃ – AL	0.16	0.16	0.20	0.23	0.187	0.161
	Mean (HS)	0.157	0.169	0.229	0.267	0.205	
H ₂ - 5%	P ₁ – PE	0.15	0.14	0.15	0.20	0.158	
	P ₂ – PP	0.15	0.13	0.16	0.22	0.163	
	P ₃ – AL	0.15	0.16	0.17	0.18	0.164	
	Mean (HS)	0.149	0.142	0.157	0.198	0.162	
H ₃ - 10%	P ₁ – PE	0.14	0.18	0.20	0.21	0.180	
	P ₂ – PP	0.14	0.18	0.19	0.21	0.179	
	P ₃ – AL	0.14	0.15	0.15	0.16	0.152	
	Mean (HS)	0.141	0.166	0.178	0.195	0.170	
H ₄ - 15%	P ₁ – PE	0.14	0.15	0.20	0.21	0.173	
	P ₂ – PP	0.14	0.15	0.20	0.22	0.178	
	P ₃ – AL	0.14	0.15	0.16	0.18	0.155	
	Mean (HS)	0.137	0.150	0.189	0.199	0.169	
H ₅ - 20%	P ₁ – PE	0.13	0.14	0.20	0.21	0.171	
	P ₂ – PP	0.13	0.15	0.15	0.21	0.160	
	P ₃ – AL	0.13	0.14	0.15	0.17	0.147	
	Mean (HS)	0.130	0.145	0.166	0.196	0.160	
Mean (S)		0.143	0.155	0.184	0.211		
P×S	P ₁	0.143	0.161	0.196	0.226		
	P ₂	0.143	0.151	0.189	0.224		
	P ₃	0.143	0.151	0.167	0.183		
	H	P	H×P	S	H×S	P×S	H×P×S
S.E m. ±	0.0008	0.0007	0.0015	0.0011	0.0024	0.0019	0.0041
CD at 5%	0.0023	0.0020	0.0043	0.0030	0.0067	0.0053	0.0114
CV%	3.34				4.15		

7. Overall acceptability

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials, storage and their interactions on overall acceptability of carrot candy has been presented in Table 9.

Effect of sorbitol: Data shows that among different concentrations of sorbitol (humectant), the mean overall acceptability value of carrot candy (H) varied significantly from 8.08 to 7.41, with minimum overall acceptability value in carrot candy prepared with coating of 20% sorbitol (H₅) and maximum overall acceptability value in carrot candy prepared with coating of 5% sorbitol (H₂). Similar observation was recorded by (Richa *et al.* 2017) [28]. Overall acceptability decreased due to pasty nature of product with an increase in the level of sorbitol in reconstituted *khoa*.

Effect of packaging material: Data showed that among different packaging treatments, mean overall acceptability value of carrot candy (P) in different packaging materials varied significantly from 7.72 to 7.95, with minimum overall acceptability value in carrot candy which was packed in polyethylene bag (P₁) and maximum overall acceptability value in carrot candy packed in aluminium laminated bag (P₃). Similar observation was reported by (Sutariya and Rao 2017) [36] for thirattupal. Overall acceptance scores are comprehensive evaluation of food products for acceptance. Because of decrease in all scores viz. flavour, colour and appearance and body and texture scores it was found that overall acceptability score was also affected significantly. Overall acceptability score was decreased during storage period because of loss of freshness due to moisture loss and getting dried even though sensory score was remained in acceptable limit.

Effect of storage period: Data depicts that storage of carrot candy resulted significant decrease in mean overall acceptability value (S) from initial overall acceptability value of 7.25 to 8.50 after six months of storage. The decrease in score of overall acceptability during storage could be correlated to change in colour, texture, taste and flavour of carrot candy. However, under room condition the quality was maintained to more than six months of storage. Similar observations were recorded by Naik *et al.* (2019) [17], Raj *et al.* (2015) [26] for osmo-air dehydrated apricot, Nayak *et al.* 2012.

Effect of interactions: Interaction of sorbitol concentrations and storage depicted variations in overall acceptability value from 7.10 to 8.81 during six months storage, with minimum decrease in overall acceptability value from 8.34 (H₄S₁) to 7.19 (H₄S₄) in carrot candy prepared with coating of 15% sorbitol and maximum decrease from 8.81 (H₃S₁) to 7.50 (H₃S₄) in carrot candy prepared with coating of 10%

sorbitol. Interaction of packaging material and storage depicted variations in overall acceptability value from 7.08 to 8.50, with minimum decrease in overall acceptability value from 8.50 (P₃S₁) to 7.41 (P₃S₄) in carrot candy which was packed in aluminium laminated bag, whereas maximum decrease in overall acceptability value was observed from 8.50 to 7.08 in carrot candy packed in polyethylene bag (P₁S₁ to P₁S₄) after six months of storage. Interaction of sorbitol (humectant) and packaging material depicted variations in mean overall acceptability value in carrot candy from 7.28 to 8.25, with minimum overall acceptability value (7.28) in carrot candy prepared with coating of 20% sorbitol and packed in polyethylene bag (H₁P₁) and maximum overall acceptability value (8.25) in carrot candy prepared with coating of 10% sorbitol and packed in aluminium laminated bag (H₃P₃). Further, interaction of sorbitol concentration, packaging material and storage depicted variations in overall acceptability value from 6.66 to 8.81 in carrot candy during a period of six months, with minimum decrease 8.81 to 7.81 in carrot candy prepared by with coating of 10% sorbitol and packed in aluminium laminated bag (H₃P₃S₁ to H₃P₃S₄) and maximum decrease 8.81 to 7.24 in carrot candy prepared with coating of 10% sorbitol and packed in polyethylene bag (H₃P₁S₁ to H₃P₁S₄). The effects of H×S, H×P and P×S interactions were found significant, while H×P×S interaction was found non-significant effect.

8. Total Plate Count

The perusal of data pertaining to effect of sorbitol concentrations, packaging materials and storage on TPC of carrot candy has been presented in Table 10. Data depicts that storage of carrot candy resulted significant decrease in mean TPC value from initial TPC value of 0.00 to 2.52 after six months of storage. The TSS, moisture, total sugars and reducing sugars increased gradually during storage period while acidity, carotene and ascorbic acid decreased with increase in storage time. Microbial contamination was increased during storage period due to relative humidity and moisture content balance was disturbed, a suitable moisture environment created for microbial growth. The organoleptic characteristics such as colour, texture, taste, flavour and overall acceptability decreased slightly with advancement of storage period. Likewise, throughout the storage period, carrot candy was low microbial spoilage. Carrot candy prepared with coating of 10% sorbitol and packed in aluminium laminated packaging material (H₃P₃) was found superior based on nutritional as well as sensory quality and found more shelf stable during storage compared to other treatments. The standard limit for consumption at acceptable level was observed up to 3.30×10^4 CFU/g. similar observation was reported by Naik *et al.* (2019) [17] for carrot candy.

Table 10: Effect of sorbitol concentration and packaging materials on TPC of carrot candy

Sorbitol concentration (H)	Packaging material (P)	TPC ($\times 10^4$ CFU/g)			
		Storage month (S)			
		S ₁ :0M	S ₂ :2M	S ₃ :4M	S ₄ :6 M
H ₁ - Control	P ₁ – PE	0.00	2.32	2.94	3.02
	P ₂ – PP	0.00	2.20	2.57	2.80
	P ₃ –AL	0.00	2.00	2.27	2.52
H ₂ - 5%	P ₁ – PE	0.00	0.00	0.00	2.19
	P ₂ – PP	0.00	0.00	0.00	2.11
	P ₃ –AL	0.00	0.00	0.00	2.00
H ₃ - 10%	P ₁ – PE	0.00	0.00	0.00	1.59
	P ₂ – PP	0.00	0.00	0.00	1.40
	P ₃ –AL	0.00	0.00	0.00	1.28
H ₄ - 15%	P ₁ – PE	0.00	1.44	2.54	3.24
	P ₂ – PP	0.00	1.31	2.28	3.16
	P ₃ –AL	0.00	1.29	2.14	3.10
H ₅ - 20%	P ₁ – PE	0.00	1.05	2.23	3.29
	P ₂ – PP	0.00	1.01	2.51	3.12
	P ₃ –AL	0.00	1.00	2.22	3.03

Conclusion

The findings of investigation it can be concluded that the acceptable quality carrot candy can be prepared by mixing of 1 kg syrup (50 °Brix) per kg pieces along with 1000 ppm KMS followed by gradual rise (10 °Brix) in the syrup strength up to 70 °Brix rinsing with warm water followed by coating with 10% sorbitol, drying and packing in aluminium laminate packaging material. The carrot candy prepared from this treatment possess lower moisture content, water activity, higher carotene content, higher overall acceptability and lower microbial parameter *i.e.* Total Plate Counts (TPC), non-enzymatic browning (NEB) during six months storage.

References

1. Alam MS, Pathania S, Kumar S, Sharma A. Studies on storage stability of carrot pomace-chickpea incorporated rice based snacks. *Agricultural Research Journal*. 2015;52(4):73-79.
2. Amerine MA, Pangborn RM, Roessler EB. Principles of sensory evaluation of food. New York: Academic Press; 1965. p. 367-374.
3. AOAC. Official methods of analysis. 14th ed. Arlington, Virginia, USA: Association of Official Analytical Chemists; 1984.
4. Attri S, Dhiman A, Sharma R, Kaushal M. Standardization of pre-treatments for the development of intermediate moisture food products from papaya (*Carica papaya* L.). *International Journal of Food and Fermentation Technology*. 2016;6(1):143-149.
5. Bast A, Haenen GR, Van Den Berg R. Antioxidant effects of carotenoids. *Journal of International Vitamin and Nutrition Research*. 1998;68(6):399-403.
6. Block G. Nutrient sources of provitamin A carotenoids in the American diet. *American Journal of Epidemiology*. 1994;139:290-293.
7. Bramley PM. Regulation of carotenoid formation during tomato fruit ripening and development. *Journal of Experimental Botany*. 2002;53(377):2107-2113.
8. Durrani AM, Srivastava PK, Verma S. Development and quality evaluation of honey based carrot candy. *Journal of Food Science and Technology*. 2011;48(4):502-505.
9. Falade KO, Igbeka JC. Osmotic dehydration of tropical fruits and vegetables. *Food Reviews International*. 2007;23(4):373-405.
10. Gopalan C, Shastri RB, Balasubramanian SC. Nutritive value of Indian foods. Hyderabad: National Institute of Nutrition, Indian Council of Medical Research; 2004. p. 32-67.
11. Heinonen MI. Carotenoids and provitamin A activity of carrot (*Daucus carota*) cultivars. *Journal of Agricultural and Food Chemistry*. 1990;38:609-612.
12. Kishore N, Madhavi T, Edukondalu L, Gayathri RL. Development and chemical evaluation of guava candies. *International Journal of Agricultural Sciences*. 2016;8(58):3272-3277.
13. Korsrilabut J, Borompichaichartkul C, Duangmal K. Effect of invert sugar on the drying kinetics and water mobility of osmosed-air dried cantaloupe. *International Journal of Food Science and Technology*. 2010;45(7):1524-1531.
14. Kumar PS, Sagar VR. Quality of osmo-vac dehydrated ripe mango slices influenced by packaging material and storage temperature. *Journal of Food Science and Technology*.
15. Mehta U, Bajaj S. Changes in the chemical composition and organoleptic quality of citrus peel candy during preparation and storage. *Journal of Food Science and Technology*. 1984;21(6):422-424.
16. Naik PR, Nilam P, Supal D, MR. Osmotic dehydration technique used for preparation of carrot (*Daucus carota* L.) candy. *International Journal of Chemical Studies*. 2018;6(6):379-384.
17. Naik PR, Nilam P, Surela VA, Supal D. Sensory evaluation of osmotically dehydrated carrot (*Daucus carota* L.) candy. *International Journal of Chemical Studies*. 2019;7(3):3763-3768.
18. Naknaen P, Maneyam R, Kam-Onsri A. Effect of partial replacement of sucrose with humectant in the osmotic solution on the characteristics of osmo-dried cantaloupe. *International Journal of Fruit Science*. 2016;16(3):225-241.
19. Nayak P, Tandon DK, Bhatt DK. Study on changes of nutritional and organoleptic quality of flavored candy prepared from aonla (*Embllica officinalis* G.) during storage. *International Journal of Nutrition and Metabolism*. 2012;4(7):100-106.

20. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 2nd ed. New Delhi: ICAR Publication; 1985. p. 381.
21. Panwar S, Gehlot R, Siddiqui S. Effect of osmotic agents on intermediate moisture aonla segments during storage. International Journal of Agricultural and Food Science Technology. 2013;4(6):537-542.
22. Phisut N, Rattanawedee M, Aekkasak K. Effect of osmotic dehydration process on the physical, chemical, and sensory properties of osmo-dried cantaloupe. International Food Research Journal. 2013;20(1).
23. Prasad CH. Development of technology for processing and value addition of watermelon (*Citrullus lanatus*). [M.Sc. thesis]. Navsari, India: Navsari Agricultural University; 2015. 114 p.
24. Priya MD, Khatkar BS. Effect of processing methods on keeping quality of aonla (*Emblica officinalis* Gaertn.) preserve. International Food Research Journal. 2013;20(2):617.
25. Raj D, Chethan HP, Vaghashiya JM, Mayani JM, Thumar VM. Effect of different osmotic dehydration treatments on quality parameters of watermelon rind candy during storage. International Journal of Chemical Studies. 2018;6(4):1722-1730.
26. Raj D, Sharma PC, Sharera SK. Studies on osmo-air dehydration of different Indian apricot (*Prunus armeniaca* L.) cultivars. Journal of Food Science and Technology. 2015;52(6):3794-3802.
27. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. New Delhi: Tata McGraw Hill Publishing Co. Ltd.; 1997.
28. Richa B, Singh RRB, Panjagari NR, Singh AK, Hussain SA. Effect of selected humectants as water activity modifiers on the quality of model khoa system. Indian Journal of Dairy Science. 2017;70(2):145-154.
29. Sadasivam S, Manickam A. Biochemical methods. 2nd ed. New Delhi: New Age International (P) Ltd.; 1996.
30. Sagar VR, Neelavathi R. Influence of packaging materials on the quality of ready-to-eat dehydrated carrot shreds. Journal of Food Science and Technology Mysore. 2005;42(5):418-421.
31. Sagar VR, Maini SB. Studies on the packaging and storage of dehydrated onion slices. Indian Food Packer. 1997;51:5-10.
32. Sethi V, Anand JC. Studies on the preparation, quality, and storage of intermediate moisture (IM) carrot preserve. Journal of Food Science and Technology Mysore. 1982;19(4):168-171.
33. Sharma KD, Karki S, Thakur NS, Attri S. Chemical composition, functional properties and processing of carrot review. Journal of Food Science and Technology. 2012;49(1):22-32.
34. Sharma KD, Kumar R, Kaushal BBL. Effect of packaging on quality and shelf life of osmo-air dried apricot. Journal of Scientific and Industrial Research. 2000;59:949-954.
35. Sood S. Quality attributes of IMF halwa prepared from white gourd (*Benincasa hispida*). International Nutrition and Food Science. 2016;1(4).
36. Sutariya H, Rao KJ. Effect of different packaging material on physico-chemical, microbiological and sensory quality of Thirattupal during storage. International Journal of Current Microbiology and Applied Sciences. 2017;6:1529-1539.
37. Swain S, Samuel D, Kar A, Sahoo L. Optimization of color parameters and drying efficiency in osmotically pretreated microwave-assisted drying of yellow sweet pepper (*Capsicum annuum* L.) using response-surface methodology. Journal of Food Research and Technology. 2014;2(2):67-76.