EFFECT OF STORAGE AND PACKAGING MATERIAL ON PHYSICO-CHEMICAL AND ORGANOLEPTIC ATTRIBUTES OF HONEY AND SUGAR-BASED CARROT CANDY

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ABSTRACT: Vegetables and their processed products constitute pivotal component of healthy diets for humans. Carrots are widely processed into varied products including juices, dehydrated carrots, beverages and candy. A research study was designed and executed for developing sugar and honey based carrot candy. Candy syrup comprising of candy, honey and sugar was prepared in three combinations; carrot and honey 200 g each (F_1), carrot and sugar 200 g each (F_2) and carrot (200 g), sugar and honey 100g each (F_3). The developed carrot candy was packed in polyethylene bags of low density (T_1), transparent plastic jars (T_2), transparent glass jars (T_3) and aluminum foil (T_4). The response variables included physicochemical characteristics (pH, total soluble solids, carbohydrates, acidity, moisture content and ascorbic acid) and sensory attributes (color, texture, taste and acceptability). All packaging materials remained effective in significantly extending carrot candy's storage life. However, transparent plastic jars (T2) remained unmatched for retaining physicochemical and sensory properties in sense of overall acceptability (7.5b). In conclusion, transparent as well as glass bottles may be suggested for carrot candy packaging in order to preserve them for about 60 days.

Keywords: Honey, Carrot candy, Packaging material, physicochemical attributes.

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INTRODUCTION

Candy is fruit or vegetables based sweet food which is prepared by their impregnation with sugar syrup subsequently dried to impart shelf stability. The peel of different vegetables and fruits such as mangoes, guava, citrus, cherry, pineapple, papaya, apples, ginger and carrots have recently find their use in preparing and preserving candies (Chandu and Prasad, 2006; Jothi *et al.,* 2014). Among vegetables, carrots are grown worldwide owing to being nutritious, rich in carotene, vitamins and minerals along with hiving antioxidant properties (Eim *et al.,* 2011). Carrot has become a constituent of human diets either in raw form or as processed stuffs such as juice, salad etc. (Kumar *et al.,* 2012). Some of the processed products of carrots include candy, beverages, juice and dehydrated carrots (Mridula, 2011). Currently, raw carrots and its processed products are in high demand due to having anticancer effect imparted by β-carotene content through antioxidant activities.

One of the pertinent losses of large quantities of carrot is attributed to its perishable nature, while inappropriate storage conditions and handling methods even make the matter worse. Such as situation necessitates carrot preservation and processing to develop value added products such as candies which are not only nutritious but also hygienic. Carrot processing involves sun-drying, canning, juice extraction and preparing semi-moistened processed food products (Sharma *et al.,* 2012). Jaggery mixed with sugar syrups in appropriate mixtures can be used to prepare carrot candy (Madan and Dhawan, 2005). White sugar finds its use as sweetener and also improves various functional properties of the carrot candy (Baek *et al.,* 2004). However, honey which is natural sweetener can be alternatively or in combination with white sugar can be used. Universally, honey has proved its higher potential to act against microbes and other harmful fungal pathogens. In addition, honey can improve the texture and quality carrot processed food products. Besides, honey use in preparing different types of bakery products such as biscuits, cakes and cookies tend to improve the nutritional status as well as their flavor. Thus, in order to prepare processed food product of carrot along with its effective preservation, a study was executed to develop sugar and honey based carrot candy along with evaluating different packaging materials.

MATERIALS AND METHODS

The research project was executed at the Department of Food Science and Technology, University of the Poonch Rawalakot AJK, Pakistan.

Preparation of the Samples: Freshly ripened carrots (*Doucus carota*), sugar and honey were purchased locally from the general market. Through washing of carrots in tap-water was done and after peeling, inedible parts were

removed. Subsequently, carrot pieces were made and blanched for 5 min following by drying by spreading those on clean cloth. After blanching, prickled pieces of carrots were placed in a solution comprising of sugar and honey for 12 hours at the room temperature. After that, carrot pieces were separated from the solutions and again boiling of syrups was done. Cooling of syrup was done for 24 hours and thereafter, carrot pieces were again placed in syrup. Syrup containing carrot pieces was cooked until candy reached to 70 °Brix and subsequently those pieces were allowed to dry at room temperature un-till they attained non sticky appearance. The packing of carrot candies was performed in air tight transparent glass and plastic jars, low density polyethylene (LDPE) pouches and aluminum foil. These were stored at ambient temperature.

Formulation of syrup

F_1 =Carrot and honey 200 g each
F_2 =Carrot and sugar 200 g each
F_3 =Carrot 200 g and sugar + honey 100 g each

Treatments for study of storage life

T_0= Control
T_1= Low density polyethylene bag (LDPE)
T_2 = Transparent plastic jar
T_3 = Transparent Glass Jar
T_4 = Aluminum foil

Product analysis during storage: Carrot candies were packed using packaging materials of different nature and subsequently analysed for their impact on physico-chemical (pH, total soluble solids, carbohydrates, acidity, moisture content and ascorbic acid) and sensory attributes (color, texture, taste and acceptability).during storage (2-months) at room temperature at the interval of 15 days.

Physico-chemical analysis: The pH, total soluble solids, carbohydrates, acidity, moisture content and ascorbic acid were determined by employing the standard method as outlined by AOAC (2012). The total carbohydrates of carrot candies was assessed by flowing the methodology suggested by Ranganna (1986).

Organoleptic evaluation: The evaluation of carrot candies with respect to organoleptic characteristics (color, texture, taste and acceptability) was conducted through a panel comprising of five judges, who were chosen from the Department of Food Science and Technology. The 9-point Hedonic scale put into practice for estimation of organoleptic characteristics as suggested by Larmond (1977). The coded numbers were allotted to each and every sample and subsequently presented to the panel members. The members of the judging panel used water to rinse mouth after checking each sample. As far as sensory parameters of carrot candied were concerned, evaluation was done at the interval of 15 days.

Statistical analysis: All the samples were analyzed in triplicate and statistical analyses of collected data was performed by using statistical software "Statistix 8.1" by employing complete randomized design (CRD) in factorial arrangement at probability level of 5%.

RESULTS AND DISCUSSIONS

Physico-chemical evaluation: The formulation F_3 for honey and sugar-based carrot candy was selected and finalized based upon physico-chemical and organoleptic properties. The selected samples of carrot candy were stored using different packaging materials for the duration of 60 days. The results revealed that total soluble solids, pH (Table 1), and ascorbic acid (Table 2) contents of carrot candies under all treatments decreased significantly during initial two months of storage. However, the minimum decline in total soluble solids were recorded in T_2 and T_3, which might be attributed to slower rate of metabolic activities caused by atmospheric conditions. Previously, high temperature has also been reported to reduce total soluble solids contents of food products during storage (Shobha *et al.*, 2018 and Rosa *et al.*, 2001). Similar findings were also reported by Zeeshan *et al.* (2017) and Arthey *et al.* (2005), who inferred that total soluble solids higher retention depicted slower rate of chemical alternations occurring in the cell wall structure and its resultant breaking down into simpler sugars. These findings are also in line with those of Hussain *et al.* (2001) and Ibrahim (2005), who reported significant decline total soluble solids and ascorbic acid of food products during storage. The decrease in pH was might be owing to degradation of acids and oxidation (Hayat *et al.*, 2005). On the other hand, the highest ascorbic acid retention was attributed to declining respiration as well as ascorbic acid oxidation of carrot candies (Katk *et al.*, 2018, Rathore *et al.*, 2009). Moreover, the ascorbic acid decrease in T_0 (control) was probably the result of decreased oxidation which led to declined ascorbic acid contents during storage (Kiranmai *et al.*, 2018, Hayat *et al.*, 2005).

It was also recorded that acidity (Table 1), moisture content (Table 1) and total carbohydrates (Table 2) along with reducing sugar contents (Table 2) of carrot candies were boosted up during the storage period. The least increment of acidity was recorded for T_2 (transparent plastic jar), which was probably owning to lesser oxidation as well as diminishing acids contents caused by decreased activity of microbes (Martinez *et al.*, 1997), whereas increment of titrable acidity and total carbohydrates was perhaps resulted by acids degradation into sugars as earlier reported by Kishore *et al.*, (2016), Drake and Sprayed (1983) and Tripathi and Bhargava, (1993). The lowest increment in moisture content was recorded for T_2 (transparent plastic jar), while similar research findings have been by Madan and Dhawan

(2005). It has also been inferred that rapid rate of respiration in carrot candies and increment in metabolic activities, led to higher moisture content (Madam and Dhawn, 2005). Increment in total carbohydrates as recorded for T_2 (transparent plastic jar) might be attributed to significantly higher polysaccharides hydrolysis and decrease in acidity and other associated physiological changes due to packaging materials (Shailendra and Pandey 2017; Durrani *et al.,* 2011). In addition, respiration occurring in stored carrot candies and acids oxidation could also be the reasons behind changes in total carbohydrate contents (Abdellaou *et al., 2018*; Sabir *et al.,* 2006; Bhajwa and Gupta, 2007).

Sensory evaluation: Data pertaining to sensory characteristics of carrot candy depicted a significant impact of ingredient composition and packaging material treatments. The selected samples of carrot candy with coded numbers were presented to judges. It was observed that color quality of carrot candies deteriorated during storage (Table 3). The lowest color deterioration was recorded in T_2, which was might be owing to reduced decomposition of carotenoids. These findings are in line with those of Agar *et al.* (1995), Batu and Thompson (1998) and Gaurav *et al.* (2017) who reported that colour change in preserved food stuffs was evident due to change of carotenoids.

It was also recorded that taste of carrot candy also decreased during storage period (Table 3). The highest color retention was recorded for T_2 (transparent plastic jar), which might be attributed to sweetness increment caused by starch conversion into sugars leading to significant increment in total sugar in stored carrot candies (Manhajn, 1994). The highest taste sdeterioration was observed for T_0 (control) and this was probably caused by structural polysaccharides degradation and reduction of carbohydrates into structural units which led to reduced taste of carrot candies during the storage (Kays, 1991). It was also recorded that texture of stored carrot candies got significantly affected during storage period (Table 3). The presence sugars as well as polyethylene might be attributed to maintenance of stored carrot candies texture. These findings are in agreement with the conclusion of Antunes *et al.,* (2003), Ibrahim, (2005) and Arthery (2005). The maximum score for overall acceptability (Table 3) of carrot candy was due to inclusion of honey and packaging in airless glass jars which slowed down the chemical changes on carrot candies during storage period. However, metabolic changes taking place during storage in structural polysaccharides leading to sugars and organic acids reduction caused reduction in the taste of stored carrot candies. Water evaporation from stored carrot candies was probably another reason for reduction in overall acceptability of carrot candies.

Table 1: Effect of treatments and storage on physic-chemical contents (Total Soluble Solids, pH Acidity, and Moisture Content) of carrot candy.

Days	Total Soluble Solids (%)					*pH*					*Acidity* (%)					*Moisture Content* (%)				
	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_4	T_4
0	72a	71.5 ab	70 c	70 c	70.5 b	6.55 a	6.50 b	6.40 c	6.54 ab	6.40 c	0.05 c	0.05 c	0.06 b	0.07 a	0.05 c	28.0 b	29.5 a	29.0 ab	29.2 ab	28.5 b
15	71a	70 ab	69.5 b	69.5 b	70 ab	6.3 c	6.35 b	6.38 b	6.46 a	6.32 c	0.06 b	0.06 b	0.06 b	0.08 a	0.06 b	29.5 a	29.8 a	29.3 ab	29.6 b	28.9 c
30	70a	69 b	69 b	69.5 ab	70 a	6.0 d	6.30 b	6.35 ab	6.40 a	6.25 c	0.09 a	0.08 b	0.07 c	0.09 a	0.08 b	31 a	30.2 ab	29.5 b	30 b	30.1 ab
45	69a	69 a	69 a	69 a	69 a	5.75 c	6.27 b	6.32 ab	6.36 a	6.20 b	0.09 ab	0.08 b	0.07 c	0.10 a	0.08 b	32.7 a	30.6 b	29.8 c	30.2 bc	30.3 bc
60	68c	68.5b	69.5 a	69 ab	69 ab	5.5 c	6.20 b	6.30 a	6.30 a	6.15 b	0.09 b	0.09 b	0.08 c	0.12 a	0.09 b	33.3 a	31.0 b	30 c	30.3 c	30.5 b
%dec/Inc	**5.56**	**4.20**	**0.71**	**1.43**	**2.13**	**16.03**	**4.62**	**1.56**	**3.67**	**3.91**	**80.00**	**80.00**	**33.33**	**71.43**	**80.00**	**18.93**	**5.08**	**3.45**	**3.77**	**7.02**

Results are expressed as means of three replications (n=3). Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean; T_0= Control; T_1= Low density polyethylene bag (LDPE); T_2 = Transparent plastic jar; T_3 = Transparent Glass Jar; T_4 = Aluminum foil

Table 2: Effect of treatments and storage on physic-chemical contents (Total carbohydrates, Reducing sugar and Ascorbic acid) of carrot candy.

Days	*Total carbohydrates* (%)					*Reducing sugar* (%)					*Ascorbic acid* (*mg/100g*)				
	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4
0	77^{c}	78.5^{ab}	79^{a}	78.9^{ab}	78^{b}	31.9^{ab}	32.6^{a}	32.5^{a}	30^{c}	32.7^{a}	6.5^{a}	6.4^{b}	6.3^{c}	6.3^{c}	6.3^{c}
15	78.5^{b}	79^{ab}	80.3^{a}	79.3^{ab}	79^{b}	32.8^{b}	34.5^{a}	33^{ab}	30.5^{c}	33.9^{a}	6.0^{b}	6.2^{a}	6.0^{b}	6.0^{b}	6.0^{b}
30	80.2^{ab}	81.1^{a}	81^{a}	80^{b}	81^{a}	34.3^{b}	35.4^{a}	34^{b}	31.2^{c}	34.4^{b}	5.5^{ab}	5.8^{a}	5.8^{a}	5.7^{b}	5.5^{ab}
45	82.3^{b}	82.2^{ab}	81.2^{c}	81.5^{c}	83^{a}	36.4^{a}	36.5^{a}	34.5^{bc}	32^{c}	35.7^{b}	5.75^{a}	5.4^{ab}	5.2^{c}	5.6^{b}	5.3^{bc}
60	84^{b}	82.3^{c}	82^{c}	82.2^{c}	85^{a}	38.8^{a}	37^{b}	35^{c}	33.3^{d}	36.5^{bc}	4.5^{c}	5.0^{b}	5.5^{a}	5.5^{a}	5.2^{b}
%dec/Inc	**9.09**	**4.84**	**3.80**	**4.18**	**8.97**	**21.63**	**13.50**	**7.69**	**11.00**	**11.62**	**30.77**	**21.88**	**12.70**	**12.70**	**17.46**

Results are expressed as means of three replications (n=3). Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean; T_0= Control; T_1= Low density polyethylene bag (LDPE); T_2 = Transparent plastic jar; T_3 = Transparent Glass Jar; T_4 = Aluminum foil

Table 3: Effect of treatments and storage on Organoleptic Characteristics of carrot candy.

Days	*Color*					*Taste*					*Texture*					*Overall acceptability*				
	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_3	T_4	T_0	T_1	T_2	T_4	T_4
0	8.5^{c}	8.8^{a}	8.5^{c}	8.5^{c}	8.6^{b}	8.7^{ab}	8.6^{ab}	8.8^{a}	8.6^{ab}	8.5^{b}	8.0^{c}	8.3^{ab}	8.2^{b}	8.5^{a}	8.3^{ab}	8.3^{ab}	8.5^{a}	8.6^{a}	8.2^{ab}	8.5^{a}
15	8.0^{b}	8.5^{a}	8.4^{ab}	8.3^{ab}	8.5^{a}	8.2^{bc}	8.5^{ab}	8.7^{a}	8.5^{ab}	8.4^{b}	7.5^{c}	8.2^{b}	8.2^{b}	8.3^{a}	8.1^{ab}	8^{b}	8.3^{a}	8.5^{a}	8.0^{b}	8.3^{a}
30	7.5^{b}	8.3^{a}	8.2^{ab}	8.2^{ab}	8.2^{ab}	7.5^{b}	8.3^{a}	8.6^{a}	8.4^{a}	8.2^{ab}	7.0^{b}	8.1^{a}	8.2^{a}	8.2^{a}	7.9^{ab}	7.5^{ab}	8.1^{a}	8.5^{a}	7.9^{b}	8.2^{a}
45	7.1^{c}	8.2^{a}	8.0^{ab}	8.0^{ab}	8.0^{ab}	6.5^{c}	8.1^{ab}	8.6^{a}	8.2^{ab}	8.0^{b}	7.0^{b}	7.9^{ab}	8.1^{a}	8.1^{a}	7.8^{ab}	7.3^{c}	7.9^{ab}	8.3^{a}	7.8^{b}	7.9^{ab}
60	6.8^{c}	7.7^{a}	7.7^{a}	7.5^{b}	7.5^{b}	6.2^{d}	7.7^{c}	8.5^{a}	8.1^{b}	7.8^{c}	6.7^{c}	7.8^{b}	8.0^{a}	8.1^{a}	7.8^{b}	7^{c}	7.7^{b}	8.2^{a}	7.5^{b}	7.7^{b}
%dec	**20.00**	**12.50**	**9.41**	**11.76**	**12.79**	**28.74**	**10.47**	**3.41**	**5.81**	**8.24**	**16.25**	**6.02**	**2.44**	**4.71**	**6.02**	**15.66**	**9.41**	**4.65**	**8.54**	**9.41**

Results are expressed as means of three replications (n=3). Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean; T_0= Control; T_1= Low density polyethylene bag (LDPE); T_2 = Transparent plastic jar; T_3 = Transparent Glass Jar; T_4 = Aluminum foil

Conclusion: Carrot candies packed and stored using transparent plastic jar was comparatively superior and better for physicochemical and sensory characteristics.

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