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Storage stability of osmo-convective dried beetroot candy

Bhupinder Singh, HK Sharma and Ravinder Kaur

Abstract
Osmo-convective dehydration of beetroot candy is an interesting alternative for the development of confectionary-based functional food with extended shelf life. Osmo-convective dehydrated beetroot candy was packed in three different packaging materials *viz*., HDPE, LDPE and LAP and stored at room temperature (25-35 ºC, RH 50-70%). Changes in physico-chemical properties of beetroot candy were evaluated during storage (at 0, 1, 2, 3, 4, 5 and 6 months). During storage, moisture content, colour, and betalain content of beetroot candy were varied depending upon the type of packaging material. Beetroot candy, packed in LDPE showed considerable changes in physicochemical properties during storage. The magnitude of changes in physicochemical properties of beetroot candy as well as sensory attributes during storage suggested that laminated aluminum package (LAP) was best for long term storage of beetroot candy.

Keywords: Beetroot candy, storage, LDPE, LAP

1. Introduction

Total production of fruits and vegetable production in India was 257.12 million ton and total demand was 239.80 million ton during the year 2014-15 (Anon, 2016) [2]. India contributes 8 percent of world fruit production and 15 percent of world vegetable production (Anon, 2011) [1]. India is the second major producer of fruits and vegetables and ranks next to China in the world. Fruits and vegetables are wasted due to lack of facilities, thus, the processing of fruits and vegetables is meaningful option to secure the perishables from deterioration.

Beetroot among the root vegetables is consumed as raw, converted to juice drink, use as salads, as a vegetable dish and processed at home scale as pickles. Fruit and vegetable juices have become important in recent years due to overall increase in natural juice consumption as an alternative to the traditional caffeine containing beverages such as coffee, tea, or carbonated soft drinks (Kaur *et al*., 2009) [5]. The nutritional constituents of beetroot are soluble and insoluble dietary fibers, antioxidants, significant amount of vitamin C and vitamins B_1, B_2, niacin, B_6, B_{12} whilst the leaves are an excellent source of vitamin A (Peter *et al.*, 2011) [3]. It is among the sweetest of vegetables, containing more sugar even than carrots or sweet corn. Recent findings rank beetroots among the ten most potent antioxidant vegetables that are used as a treatment for fevers and constipation, amongst other ailments (Halvorsen *et al*., 2002) [4].

Osmotic dehydration is one of these methods which is simple, inexpensive process and retains relatively all the quality attributes of product (Shi and Le-Maguer, 2002) [6]. Researchers have reported flow of natural solutes**,** such as sugars, organic acids, minerals and salts leaching from the food into the solution (Lazarides *et al*., 1997; Waliszewski *et al*., 2002) [7, 8], is quantitatively negligible, but may be important for the organoleptic and nutritional value of the product (Singh *et al*. 1999 ;Sablani *et al*. 2002) [10, 9]. This pre-treatment can also minimize drying color losses (Nsonzi and Ramaswamy, 1998) [11], as well as reduce nutrient losses (Shi *et al*., 1999) [6]. The osmotic dehydration, combined with convective dehydration can be utilized for the preparation of candy.

Candy is a sweet food prepared from fruits or vegetables by impregnating them with sugar syrup concentrations from 30-70º Brix for different period followed by draining of excessive syrup and then drying the product to a shelf stable state. Fruits and vegetables like apples (Bidaisee and Badrie, 2001) [13], mango (Ribeiro and Sabaa-Srur, 1999) [14], guava (Chandu and Prasad, 2006) [15], ginger (Gupta *et al.*, 2012) [20], carrot (Durrani *et al*., 2011) [16], amla (Adsare *et al*.,2016) [17], and citrus peels (Mehta and Bajaj, 1984) [18], have been used to prepare candies. Madan and Dhawan (2005) [19] have prepared carrot candies by sugar and jaggery syrups. Fresh coconut powder was used for enrolling sugar candies. Candies packed in polyethylene bags scored above 7 on a 9-point hedonic scale for sensory attributes even on 60th day of storage at room temperature.

Durrani *et al*., (2011) [16] concluded that candy can be preserved safely for 6 months in both glass and LDPE packaging materials at room temperature. Gupta *et al*., (2012) [20] developed osmo-convective dehydration process for the development of honey-ginger candy. The investigation with respect to candies from fruits and vegetables is a matter of research and has been undertaken by researchers (Mehta and Bajaj, 1984 [18]; Ribeiro and Sabaa-Srur, 1999 [14]; Bidaisee and Badrie, 2001 [13]; Chandu and Prasad, 2006 [15]; Durrani *et al*., 2011 [16]; Adsare *et al*., 2016) [17]. But, the beetroot candy and its storage stability is a new concept hence present work was undertaken to study the preparative method of beetroot candy and its storage stability.

2. Material and method

2.1 Preparation *of* beetroot candy

Beetroot was procured from the local farmers of Sangrur (India) and washed properly and cut into cubes of 1cm ×1cm×1cm size with the help of cutter equipped with a knife moving perpendicularly to a horizontal base. The initial moisture content of natural beetroot cubes was found in between 85.71 to 86.29% (w.b).

Optimization of osmotic dehydration process was carried out with the purpose of maximizing water loss, solute gain and quality of the product. The optimum conditions were 60°Bx osmotic solution concentration, 55° C osmotic solution temperature and 180 min process duration at fruit to solution ratio 1:4 (w/w) (Singh *et al*., 2013) [21]. Osmotic pre-treatment at optimum conditions, reduced the moisture content of the beetroot candy to 74.86 % (w.b) and the solid content increased to 25.14 %.(Singh *et al*., 2013) [21]. To prepare a shelf stable beetroot candy, osmotic dehydrated beetroot was dehydrated up to a final moisture content, 9±1% (w.b.) at an air temperature of, 65°C and air velocity of 1.6 m s^{-1} (Singh *et al*., 2016) [22]. For candying, osmo-convectively dried beetroot cubes were immersed in sucrose syrup (70°Bx) for 5minutes at boiling temperature. After draining the syrup, the beetroot cubes were rolled in finely ground sugar.

2.2 Packaging and storage of dehydrated samples

The osmo-convective dehydrated beetroot candy was packed into 150 gauge High Density Polyethylene (HDPE), 200 gauge Low density Polyethylene (LDPE) and 160 gauge laminated aluminum packages (LAP) were stored at room temperature (25- 35°C, RH 50-70%).The samples were withdrawn after a regular interval of one month and were analyzed for moisture content, colour values, betalain content and sensory parameters**.** A schematic representation for the preparation of beetroot candy is shown in Fig. 1.

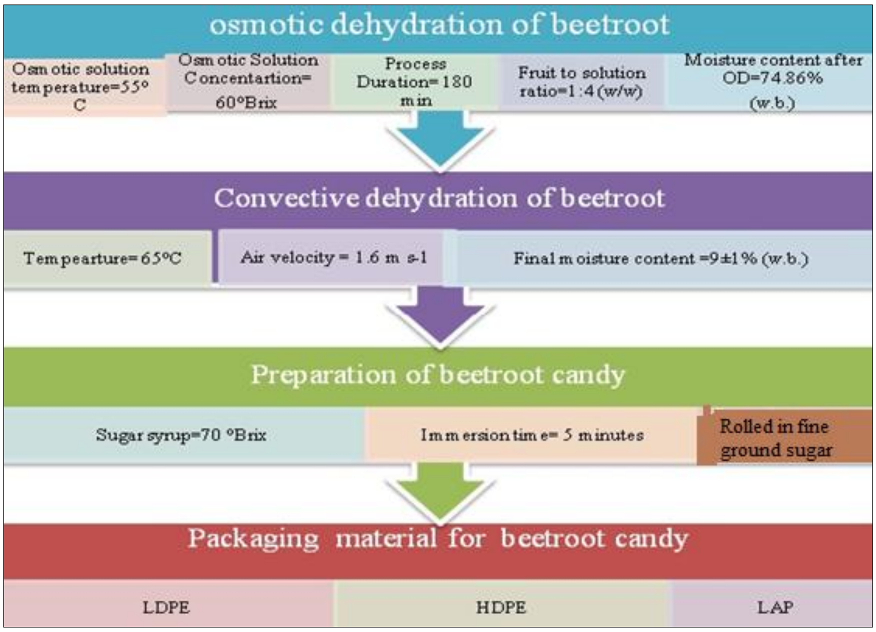

Fig 1: Osmo-convective dehydration process for beetroot candy.

2.2.1 Moisture content

The moisture content of candy was determined by standard oven method. The Samples was dried at **105** ± 2°C in hot air oven till the constant weight (Rangana, 1986)**.**

2.2.2 Colour measurement

Color of beetroot candy was measured using Hunter Lab Color Mini Scan XE Plus colorimeter (Reston, VA). The instrument was standardized each time with a black and a white tile. The color values were expressed as L (rightness/darkness), a (redness/greenness) and b value (yellowness/blueness), respectively. Total colour difference (ΔE) was calculated:-

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

2.2.3 Betalain content

Quantification of betalains (BT) was performed by the spectrophotometric method as described by Cai *et al*., (1999) [24] and Cassano *et al*., (2007) [25] using UV-VIS spectrophotometer (Hach DR 6000, Germany). Pigments were extracted from the sample with methanol at pH 6.5. The determination of betalain concentration, i.e. violet and yellow pigments, was calculated in terms of betacyanin (BC) and indicaxanthin-I (IX) respectively. Pigment content calculations were based on the absorptivity values A, which were 1120 for betacyanin (at 538 nm) and 750 for indicaxanthin-I (at 480 nm). Methanol was used as blank. The betalain content collectively along with betacyanin and indicaxanthin, expressed as mg/L, and was calculated individually by using the following equation proposed by *Cai et al*., (1999) [24].

$$B = \frac{A \times DF \times MW \times 1000}{\varepsilon \times L}$$

Where A is the absorption at 538 and 480 nm for betacyanins and indicaxanthins, respectively; DF is the dilution factor and L the path length of the cuvette (1cm). For MW and ε, the molecular weights (550 and 308) and extinction coefficients (60,000 and 48,000 L $mol^{-1}cm^{-1}$) of the representative compounds betacyanin and indicaxanthin have been considered (Cai *et al*. 1999; Cassano *et al*. 2007) [24, 25].

2.3 Sensory evaluation

Sensory evaluation was carried out to determine the effect of storage on the quality attributes of osmo-dehydrated beetroot candy. Various organoleptic attributes like color, flavour, texture, and overall acceptability of beetroot candy were evaluated by the semi- trained panel. Attributes were scored for degree of liking on 9-point hedonic scale in which 1 was rated disliked extremely and 9 = liked extremely.

3. Results and discussion

3.1 Moisture content

The variation in moisture content of beetroot candy during storage is depicted in Table 1. There was a gradual increase in moisture content of the beetroot candy packed in LAP, HDPE, and LDPE. The moisture gain by candy, packed in LDPE and HDPE **was** more than the LAP, and the moisture content values after 180 days of storage were 14.86, 14.12and 12.92% (wb), respectively. The possible reason for an increase in moisture content of the candy during storage may be due to the migration of moisture through the packages which have a different degree of permeability to water vapor. The LDPE film allows higher permeability to moisture transfer from the external environment into the product as compared with other films (Robertson, 2010) [26]. Durrani *et al*, (2011) [16] reported the gradual increase in moisture content, 28% of fresh candy, which increased to 32.5% in glass jar and up to 33.0% in LDPE pouch on 180th day. Madan and Dhawan (2005) [19] have reported moisture content values of 16.2, 14.2 and 21.0%, respectively in fresh carrot candies in sugar and coconut powder and jaggery. Gupta *et al* (2012) [20] reported moisture content of 3-5% (wb) in osmo-convective dehydrated ginger candy.

3.2 Effect of storage on betalain content of beetroot candy

The initial betalain content of control sample was 68.57 mg/100gm of dry matter. The results indicated that maximum degradation of betalain content of beetroot candy was observed in LDPE, 56% followed by HDPE, 47%, whereas minimum degradation 44 % of betalain was found in LAP during storage. This is due to the good barrier properties of laminated aluminum packages and HDPE than LDPE against oxygen transfer (Robertson, 2010) [26]. Total betalain content decreased significantly with storage time in all the packaging materials. At the end of six months of storage, retention of total betalain content was more in laminated aluminum packages followed by HPDE and LDPE. Betalain degradation may be affected by storage temperature and increase in moisture content of candy during storage. Due to the water-dependent hydrolytic reactions, water activity is another major factor for betacyanin susceptibility towards aldimine bond cleavage. This assumption was substantiated by incrementing stability of betacyanins with increasing dry matter and minimizing moisture content (Cai and Corke, 1999) [24]. Beetroot candy has lesser juice matrix whereas juice matrix was supposed to partly prevent hydrolytic cleavage of the aldimine bond (Megard, 1993) [29], and to favor deviating reaction mechanisms such as decarboxylation and dehydrogenation (Herbach *et al*., 2005) [30]. Considerable betalain degradartion may also result in the presence of betalain degrading enzymes. Both membrane-bound and cell wall-bound peroxidases were identified in red beet (Wasserman and Guilfoy, 1984) [31].

3.3 Changes in colour during storage

Color is an important quality characteristic of fruit and vegetable products which influences the consumer acceptability. Color changes of beetroot candy during storage using different packaging materials are presented in Table 1. During storage, there was a decrease in L*,a* and b* values. L* value decreased from 29.5(control sample) to 25.7, 25.5 and 25.1 in LAP, HDPE, and LDPE, respectively at the end of 6 months of storage. The decrease in L*value may be attributed to brown pigment formation during the storage due to presence of sugars which support the formation of brown pigments (Moreno *et al*., 2000) [27]. Initial colour values a*, b* of control samples (at zero day of storage) were 28.8 and 5.4, respectively for beetroot candy. The decrease in a* value was observed with increase in storage time and final is a* value, 22.8 was observed after sixth month of storage period for beetroot candy packed in LAP (Table1). The changes in a* value may be due to decrease in betacyanin pigment during storage. Red colour of beetroot is contributed by betacyanin pigment a compound from a set of water-soluble nitrogen-containing pigments known as betalains (Rebecca *et al*., 2010) [28]. Temperature, moisture content, betacyanin decolouring enzymes are considered the major factor in the betacyanin degradation (Jackman nad smith, 1996) [33]. The decolouring enzymes are activated at 30-40ºC and at high moisture content (Whitaker, 1996) [32]. A decrease of the b* value was also observed during storage under different packaging materials. The highest b* value of beetroot candy at the end of 6^{th} month was 3.2 when packed under LAP. Beetroot candy had low b*value, which is attributed to lesser amount of betaxanthins pigments (yellow). Further, a decreasing trend in b* value during storage may be attributed to decrease in amount of betaxanthins pigments that is supported by the decreasing trend of betalain pigment during storage (Table 1). It is reported that the yellow pigments of beet root, betaxanthins, are more stable than the betacyanins (red pigments), but the degradation of both the pigments are proportional (Gokhale and Lele, 2011) [34]. As a whole, the colour change (ΔE) of beetroot candy was also calculated and found to increase with storage time during six month of storage period. The highest 'ΔE' value of beetroot candy was observed as 3.60 for LDPE packed sample at room temperature. It was observed that change in color values was minimum for the candy samples stored in LAP. The minimum color change in LAP may be due to lower air permeability and moisture content migration rate**.**

3.4 Sensory quality of beetroot candy

The samples packed during storage in laminated aluminum packages had higher scores than HDPE and LDPE packed samples (Table 2). The average score of colour of beetroot candy packed in laminated aluminum packages after sixth month was 7.49 compared to 7.38 and 7.35. when packed in HDPE and LDPE. These results are in similar line with colour L*, a* and b* values (Table 1) for the beetroot candy. Flavour of osmo-convective dried beetroot candy packed in laminated aluminum packages was scaled higher compared to beetroot candy packed in HDPE and LDPE. Similar trend was observed for texture, when osmo-convective dried beetroot candy was packed in aluminum laminated packages. The overall acceptability was the highest for beetroot candy, packed in laminated aluminum packages, followed by HDPE packed beet root candy, and LDPE packed beetroot candy.

ANOVA for sensory parameters (Table 3) indicated that the types of packaging material and storage time significantly ($P<0.01$) affected the colour, flavour, texture and overall acceptability of beetroot candy during storage.

Table 1: Changes in physicochemical properties of beetroot candy during storage at room temperature.

			Storage period (months)						
	Packaging material	**Hunter Colour Lab values**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Moisture Content ,% (W.b)	**LDPE**		9.12	10.72(±0.03)	11.94(±0.03)	12.98(±0.11)	13.97(±0.04)	14.38(±0.15)	14.86(±0.13)
	HDPE		9.12	10.34(±0.04)	11.05(±0.03)	12.47(±0.32)	13.21(±0.02)	13.98(±0.23)	14.12(±0.28)
	LAP		9.12	09.87(±0.07)	10.73(±0.02)	11.52(±0.10)	12.45(±0.04)	12.89(±0.27)	12.92(±0.14)
Hunter lab values	LDPE	l	29.5(±0.15)	27.8(±0.17)	27.1(±0.06)	26.09(±0.17)	26.3(±0.08)	26(±0.13)	25.1 (±0.08)
		a	28.8(±0.26)	28.3(±0.29)	27.6(±0.65)	27.2(±0.31)	26.8(±0.15)	23.9(±0.17)	22.6(±0.13)
		b	5.4(±0.17)	4.6(±0.15)	4.4(±0.23)	3.6 (±0.18)	3.4(±0.46)	2.9 (±0.26)	2.9 (±0.14)
		ΔE	----	1.73	2.14	2.44	2.66	3.30	3.60
	HDPE	l	29.5(±0.15)	27.8(±0.17)	27.4(±0.45)	27.3(±0.22)	26.8(±0.17)	26.3(±0.28)	25.5(±0.07)
		a	28.8(±0.16)	28.2(±0.21)	27.5(±0.44)	27(±0.34)	26.6(±0.25)	23.8(±0.17)	22.7(±0.13)
		b	5.4(±0.17)	4.6(±0.15)	4.4(±0.23)	3.6 (±0.18)	3.4(±0.46)	2.9 (±0.26)	2.9 (±0.14)
		ΔE		1.78	1.89	2.23	2.54	3.25	3.54
	LAP	l	29.5(±0.15)	27.8(±0.23)	27.6(±0.35)	27.5(±0.12)	27.2(±0.22)	26.2(±0.38)	25.7(±0.17)
		a	28.8(±0.16)	28.1(±0.21)	27.5(±0.44)	27(±0.34)	26.6(±0.25)	23.8(±0.17)	22.8(±0.13)
		b	5.4(±0.17)	4.6(±0.15)	4.6(±0.23)	4(±0.46)	3.8 (±0.26)	3.3(±0.21)	3.2 (±0.14)
		ΔE		1.78	2.10	2.28	2.46	3.24	3.46
Betalain content g/100 gm of dry matter	LDPE		68.57±(0.39)	45.82(±0.17)	42.53(±0.45)	39.27(±0.22)	34.37(±0.17)	28.46(±0.28)	26.15(±0.07)
	HDPE		68.57±(0.31)	55.82(±0.10)	52.53(±0.39)	49.27(±0.20)	44.37(±0.27)	39.46(±0.24)	36.15(±0.17)
	LAP		68.57±(0.32)	57.32(±0.12)	54.34(±0.47)	50.41(±0.18)	46.55(±0.30)	43.35(±0.29)	40.51(±0.11)

Values expressed as a means of 3 replicates (± SD)

Table 2: Effect of packaging materials and storage on the sensory attributes of osmotically dehydrated beetroot candy.

		Storage period (Months)						
Packaging material	**Sensory Score**	**0**	1	2	3	4	5	6
LDPE	Colour	8.75±0.02	8.31±0.17	8.12±0.26	8.07±0.07	7.73±0.28	7.81±0.08	7.35±0.21
	Flavour	8.40±0.13	8.52±0.01	8.36±0.18	8.14±0.40	8.24±0.15	8.26±0.12	7.76±0.19
	Texture	8.37±0.06	8.25±0.06	8.11±0.06	8.02±0.13	7.70±0.10	7.40±0.09	7.09±0.08
	Overall acceptability	8.50±0.09	8.36±0.16	8.19±0.08	8.07±0.18	7.89±0.29	7.79±0.07	7.47±0.19
HDPE	Colour	8.75±0.02	8.48±0.08	8.39±0.11	8.06±0.06	7.54±0.46	7.59±0.30	7.38±0.17
	Flavour	8.40±0.13	8.30±0.19	8.34±0.31	8.26±0.16	8.18±0.18	7.94±0.32	8.05±0.35
	Texture	8.37±0.06	8.28±0.02	8.27±0.12	8.07±0.09	8.04±0.07	7.36±0.41	7.17±0.68
	Overall acceptability	8.50±0.09	8.38±0.11	8.33±0.07	8.11±0.08	7.92±0.16	7.63±0.45	7.53±0.08
LAP	Colour	8.75±0.02	8.61±0.06	8.59±0.24	8.16±0.17	7.83±0.06	7.77±0.09	7.49±0.18
	Flavour	8.40±0.13	8.35±0.22	8.48±0.07	8.22±0.18	8.12±0.29	8.01±0.19	8.09±0.07
	Texture	8.37±0.06	8.32±0.32	8.06±0.05	7.92±0.12	7.46±0.32	7.45±0.08	7.20±0.10
	Overall acceptability	8.50±0.09	8.42±0.05	8.37±0.05	8.13±0.10	7.80±0.09	7.74±0.08	7.57±0.17

Table 3: Anova for sensory parameters of beetroot candy during storage

Source of variation	**df**	**MS**			
		Colour	**Flavour**	**Texture**	**Overall acceptability**
Packaging material (PM)	2	0.149**	0.008**	0.285**	0.020**
Storage Period (SP)	6	1.875**	0.351**	1.724**	1.136**
PM×SP	12	0.013**	0.060**	0.071**	0.018**
Error	42	0.002	0.014	0.012	0.002

** Mean significant level at p < 0.01

4. Conclusion

Beetroot candy packed in LAP under storage for 6 months at room temperature (25–35°C, RH-50-70%), observed minimum moisture gain, 3.8%, minimum color change, 3.46, and minimum degradation of betalain, 44%. Osmo-convective dehydrated beetroot candy had the higher overall acceptability in LAP followed by HDPE and LDPE packaging materials. The product can be safely preserved for 6 months at room temperature (25–35°C, RH-50-70%).

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