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Baby Corn Candy: Development and Assessment of Nutritional, Sensory and Storage Quality

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A B S T R A C T

The quality of baby corn candy prepared with four different sugar concentrations (20/30/40°B, 30/40/50°B, 40/50/60°B and 50/60/70°B) in two different shapes (Rectangular and Whole) was evaluated for acceptability and storage stability. The sensory scores of rectangular shaped candies prepared from 40/50/60°brix scored between "like very much to like extremely" in terms of overall acceptability (8.2) compared to other treatments. Optimum sugar concentration of 40/50/60°brix with 24 hours steeping resulted in water loss and solid gain of 32.25 % and 7.33 %, respectively. The analyzed nutritional quality of 40/50/60°brix rectangular candy is as follows; ash (2.2%), fat (0.5%), protein (1.93 %), crude fiber (1.95 %), carbohydrate (86.0 %), calcium (24 mg), magnesium (85.33 mg), iron(0.23 mg) and phosphorus (64.13 mg) contents. From storage studies, it was revealed that the rectangular candy has better sensory traits when stored for six months in MPP pouches at ambient condition with good retention of flavor, taste and texture without any adverse effect on nutritional quality. Consumer acceptability for school children's conducted in three different locations at V.C. Farm, Hassan and Mandya indicated that maximum number (82.2 %) of consumers rated the candy as "very good" followed by good (11.1%) and not good (6.6%), respectively.

Introduction

Baby corn (*Zea mayz* L.) is the small young ear before pollination and is an important vegetable product (Lekagul, 1994). Corn has wider adaptability, high yielding ability and fast growing habit and hence emerged as a potential alternative crop to diversify sustainable agriculture. In India baby corn production and processing industries are still in early stage which needs to be developed through combined efforts of producers, processers and consumers. Baby corn and its processed products are being exported from India to many other countries with Thailand and Taiwan being the largest exporters (Aggarwal and Kaur, 2010).

Baby corn is a very economic crop as the farmers get an estimated net income of Rs. 16,000/- per acre from single crop (Kapoor, 2002). The lack of knowledge about the use and economic importance of baby corn and non-availability of appropriate production technology are the major constraints for its popularization among Indian maize growers.

However, baby corn cultivation is now picking up in Meghalaya, Western Uttar Pradesh, Haryana, Maharashtra, Karnataka and Andhra Pradesh (Kheibari *et al.,* 2012). Majority of baby corn produced is going for raw cob consumption as a safe vegetable and it also finds place in most of the restaurants, hotels and motels as decorative crispy vegetable in salad, soup, pickles, pakodas, vegetable biryani, pasta, chutney, cutlets, chat, dry vegetable kofta, curry, manchurian, raita, jam, murabba, burfi, halwa, kheer, deep fried baby corn with meat, rice and other favorite dishes (Asaduzzaman *et al.*, 2014).

Baby corn nutritive value is quite comparable to any other seasonal vegetable. Besides proteins, vitamins and iron, it is one of the richest sources of phosphorous and easy to digest. It is the most "safe" vegetable to eat as it is almost free from residual effects of pesticides due to wrapping of young cob with husk and well protected from insects and diseases (Kawatra and Sehgal, 2007). Baby corn can be consumed either raw or cooked. Processing of baby corn into value added and shelf stable products are needed as fresh corns begin to deteriorate quickly after harvest. In order to overcome this problem, timely harvesting of baby corns within 2-3 days of silk emergence (1-2cm) is suggested. In spite of its popularity as a fresh vegetable in Asia, systematic research on the processing, preservation and storage behavior to extend the nutritional and agricultural potential of this crop is lacking. Since baby corn has typical bland taste huge scope exists for value added products. Various products can be prepared by adopting low cost technologies which in turn increase the income of farming community. Traditional low cost processing technologies are available for preservation of fruits and vegetables like drying, dehydration, pickling, brining, fermenting and osmotic dehydration. The most widely used method for preservation of fruits and vegetables is osmotic dehydration. During osmotic treatment several flows occur simultaneously; loss of water from the product to the hypertonic solution, solute impregnation from the solution to the food matrix and additionally, loss of other compounds (mainly soluble solids) from the product to the solution (Chenlo *et al.*, 2002). Literature on osmotically dehydrated product preparation from fruits and vegetables is available in large numbers such as cashew apple, pineapple slices, West Indian cherry, pineapple cubes, tomato candy and ginger candy (Azoubel and Murr, 2003; Thakor and Sawant, 2008; Silva *et al.*, 2012; Paul, 2014; Hasanuzzaman *et al.*, 2014 and Patil *et al.*, 2015), respectively. However, osmotic dehydration of baby corn with different ratios of sugar concentration and its acceptability as candy has not been studied. Hence, this study was taken up to assess the suitability of baby corn for candy preparation and its quality in terms of sensory, nutritional and microbial load.

Materials and Methods

Baby corns were harvested from the Experimental plots of the All India Coordinated Research Project on Maize, Zonal Agricultural Research Station, V.C. Farm, Mandya. The selected baby corns (two days after silk emergence) were de husked and the silk was removed by hand. The freshly harvested baby corns were analyzed for physical parameters such as length and breadth using Vernier calipers (Mitutoyo Digimatic Caliper) and weight of the corn with and without husk was weighed in grams using electronic weighing balance. The nutritional composition of fresh baby corn was analyzed as per Ranganna (2001).

Preparation of baby corns

For osmotic dehydrated candy preparation, two different shapes were made; Whole (W)

baby corns were trimmed to get uniform sized corns of 7-8 cm length and 1.04-1.05 cm breadth and rectangular (R) pieces with 4.0 cm length and 1.04 cm breadth.

Method of candy preparation

Prior to osmotic dehydration, two types of corns (W and R) were weighed and subjected to hot water blanching three minutes along with addition of 0.2 % sodium meta-bi-sulphate (KMS) to the boiling water.

To standardize the recipe for preparation of baby corn candy, the W and R baby corns were steeped in four different combinations of sugar concentrations(20/30/40°B, 30/40/50°B, 40/50/60°B and 50/60/70°B) for 24 hrs in each concentration to facilitate osmosis by keeping the sample to solution ratio as 1:3.

Citric acid and KMS were added to osmotic solution at the rate of 0.05% to enhance the keeping quality of the candy. The osmosed baby corns were dried at 60°C for 8 hrs to reach final moisture content of 10-11 per cent.

Osmotic dehydration characteristics

The pattern of osmosis in terms of weight reduction (WR), solid gain (SG) and water loss (WL) were determined for selected candy by employing equations provided by Patil *et al.*, (2015).

$$\text{Weight reduction (\%)} = \frac{W_2 - W_1}{W_1} \times 100$$

$$\text{Solid gain (\% wb)} = \frac{(W_3 - W_1 \times (100 - M_1)/100)}{W_1} \times 100$$

Water loss (% wb) = WR+SG

W_1= Initial weight of the sample (g)

W_2= Final weight of the sample after osmosis (g)

W_3= Oven dried weight of the sample after osmosis (g)

M_1= Initial moisture content of the sample before osmosis (% wb).

Sensory evaluation

In order to select the best acceptable product, eight osmotically dehydrated candies (Rectangular candy; RC and Whole candy; WC) were subjected to sensory evaluation by semi trained judges. Panelists (N=21) were provided with coded samples along with glass of water and instructed to rinse and swallow water between the samples. Panelists were given written instructions and asked to evaluate the products for acceptability based on its appearance, color, taste (aroma and sweetness), texture and overall acceptability on nine-point hedonic scale (Amerine *et al.*, 1965).

Nutritional composition of baby corn candy

Developed baby corn candies were assessed for nutritional composition as per Ranganna (2001).

Storage study

RC and WC were packed in MPP (Metalized Polyester Polyethylene laminate) pouches and stored under room temperature (25-30^{o} C, 65 % RH) for a period of six months to assess the shelf life of the products.

Assessment of bio-chemical and sensory quality

The parameters such as pH, moisture, titrable acidity and ash (Ranganna, 2001) as well as acceptability of candy in terms of sensory

parameters were assessed every month during storage (0-6 months).

Analysis of nutritional composition

Based on the biochemical and sensory quality, only one type of candy was taken for assessment of nutritional composition such as proximate, calcium and phosphorus (AOAC, 1995), carbohydrate and mineral contents (Livesey, 2001). Magnesium and iron contents were determined by Versanate titration and Wong's method, respectively. Vitamin C content in fresh baby corn and candies was analyzed by 2, 6-dichlorophenol indophenol titration method as quoted by Ranganna (2001).

Microbial analysis

Microbial load including bacteria, moulds and yeasts of stored candies were analysed according to APHA (1984) by drawing the samples every month.

Even the osmotic exudate (sugar syrup obtained after draining of baby corn) was examined every month for clarity, visual growth of microorganisms, changes in pH and TSS content.

Consumer acceptability

The best acceptable candy was distributed to school children (n=30) at three locations such as V.C. Farm, Hassan and Mandya to elicit the consumer acceptability of the product by rating the product as "very good", "good" and "not good".

Statistical analysis

The data was subjected to ANOVA for preliminary sensory evaluation and nutritional composition studies while two-way ANOVA was used for storage study of two shapes of candies as per Steel *et al.*, (1997) for determining the effect of storage on different quality parameters.

Results and Discussion

Physical characteristics of fresh baby corn

Physical characteristics of fresh baby corn revealed that the average weight of baby corn with husk, without husk and weight of husk and silk were in the range of 48.86, 8.06 and 40.80 g, respectively. The average length and breadth of fresh baby corn were found to be 7.16 and 1.04 cm, respectively. Similar results for length and breadth were reported by Aggarwal and Kaur (2010) for baby corn harvested after two days of silk emergence.

Nutritional composition of fresh baby corn

The nutritional quality of baby corn is presented in Table 1. The fresh baby corn had a moisture content of 86.41%. The crude protein, fat, crude fiber, ash and carbohydrates were in the range of 2.90, 0.90, 3.42, 1.34 and 9.13, respectively.

The mineral and energy contents in this study were in the range of 25.77 mg for calcium, magnesium (85.87 mg), phosphorus (84.10 mg), iron (0.32 mg) and energy (56.55 k.cal). Our findings are in accordance with the values reported by Anuradha (2012) for carbohydrate, protein, calcium, phosphorous and iron contents in fresh baby corn.

Development and osmotic dehydration characteristics of baby corn candy

Prior to candy preparation, the baby corns were subjected to water blanching containing 0.2 % KMS solution for three minutes was found to be sufficient to retain the colour of the product. However, Aggarwal and Kaur (2010) reported four minutes water blanching

time was optimum to retain the colour of the product which increase the permeability of the skin and prevent the browning reactions. On the contrary, Singh *et al.,* (2007) reported blanching followed by dipping in 0.3% solution of KMS for 3 min helps to retain the colour and vitamins. Beneficial effect of blanching with KMS/sulphitation on retention of ascorbic acid content of dried product was also observed by many workers (Sethi, 1986; Tripathi *et al.,* 1988; Sagar and Kumar, 2006; Singh *et al.,* 2006b) which may be due to inactivation of oxidase enzyme.

After blanching, baby corns were steeped in four different sugar concentrations as depicted in Figure 1. As the sugar concentration increased, the water loss and solid gain also increased, but the increased solid gain (50/60/70°B) resulted in too sweet candies which were not acceptable by the panelists. Hence, the optimum concentration of sugar was found in 40/50/60°B with 24 hrs steeping resulted in 35.26 % of water loss and 7.33 % of solid gain.

The increase in water loss and sugar gain with increase in syrup concentration was due to increased osmotic pressure in the syrup which increased the driving force available for water transport. Similar results were noticed by Patil *et al.,* (2015) for osmotically dehydrated ginger candy. This trend was also in agreement with potato (Biswal and Bozorgmehr, 1991) and banana slices (Pokharkar *et al.,* 1997).

Highest moisture loss; over 50% of the initial moisture was removed in osmotic dehydration of cran-berries, reducing initial moisture content from 88% to a final 43.4% after osmotic dehydration of 24 hrs in particular sugar concentration. Similar pattern was observed in this study. Steeping in osmotic solution for 24 hrs was found to be optimum for good quality product yield in baby corn candy. Candies subjected to longer duration (>24 hrs) were darker in colour and emitted an unpleasant odour. Hence, in this study 24 hrs period of steeping in each concentration (40, 50 and 60° brix) was followed. The osmotic exudate (syrup) obtained after osmosis of baby corns can be used as juice by diluting with water in the ratio of 1:3.

Effect of different sugar concentrations on sensory attributes of baby corn candies

Perusal of Table 2 revealed that WC and RC prepared from 40/50/60°B sugar concentration (T_6 and T_5) got significantly good sensory scores for the sensory attributes like appearance (8.25 and 7.25), colour (8.30 and 6.80), taste (8.5 and 6.7), flavor (8.87 and 7.0), texture (8.3 and 6.8) and overall acceptability (8.2 and 7.0) compared to rest of the treatments studied (T_1-T_8).

The treatments with 20/30/40°B, 30/40/50°B of sugar concentrations were found to be of less sweet, while 50/60/70°B was found to be too sweet. Even the tomato candies prepared with 40 % sugar solution was more acceptable than candy with 50 % and 60 % sugar as reported by Hasanuzzaman *et al.,* (2014).

In this study, 40/50/60°B sugar concentration was found to yield optimum sweetness with maximum water removal and good sensory attributes. Hence, it was taken for further quality analysis.

Nutritional composition of baby corn candy

The nutritional composition of baby corn candy is depicted in Table 1. The baby corn candy contained calcium (24 mg), magnesium (85.33 mg), iron (0.23 mg) and phosphorus (64.13 mg). Similar observations for nutritional composition of jack fruit candy were recorded by Sreedevi *et al.,* (2012) and Sharma *et al.,* (2006).

Fig.1 Osmotic dehydration characteristics of rectangular baby corn in different sugar concentrations

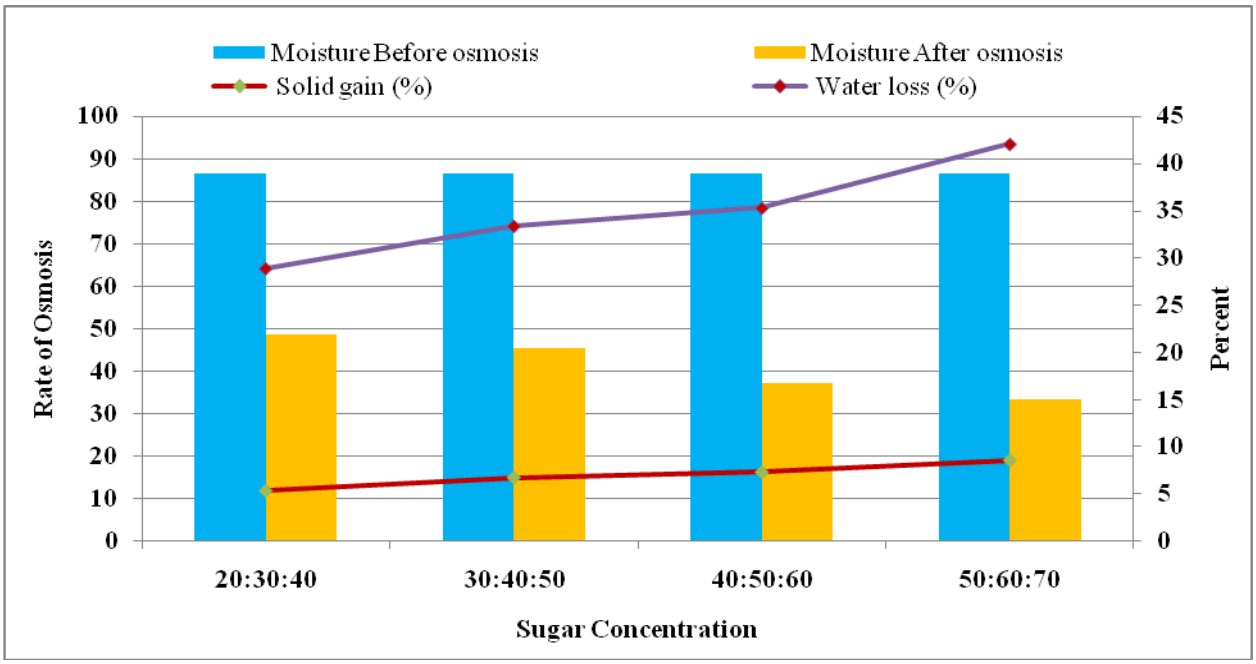
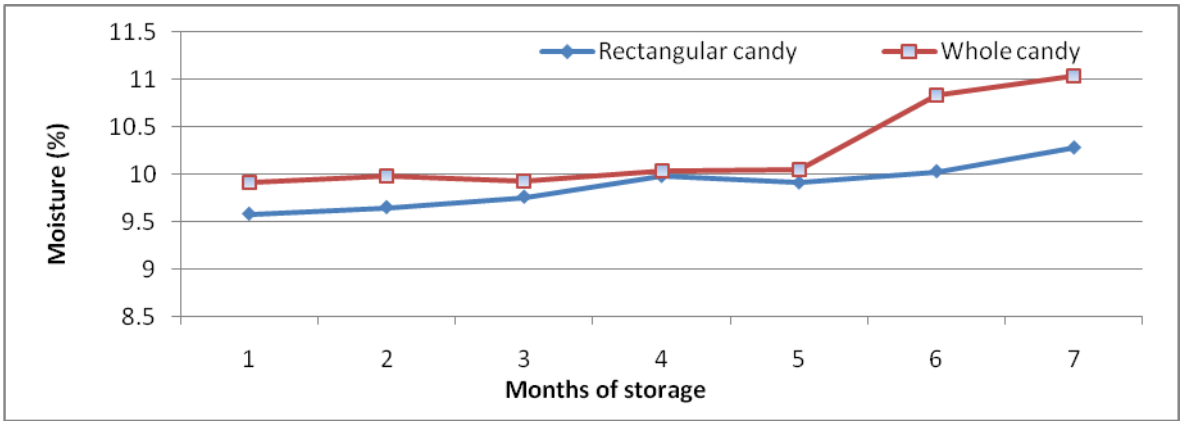
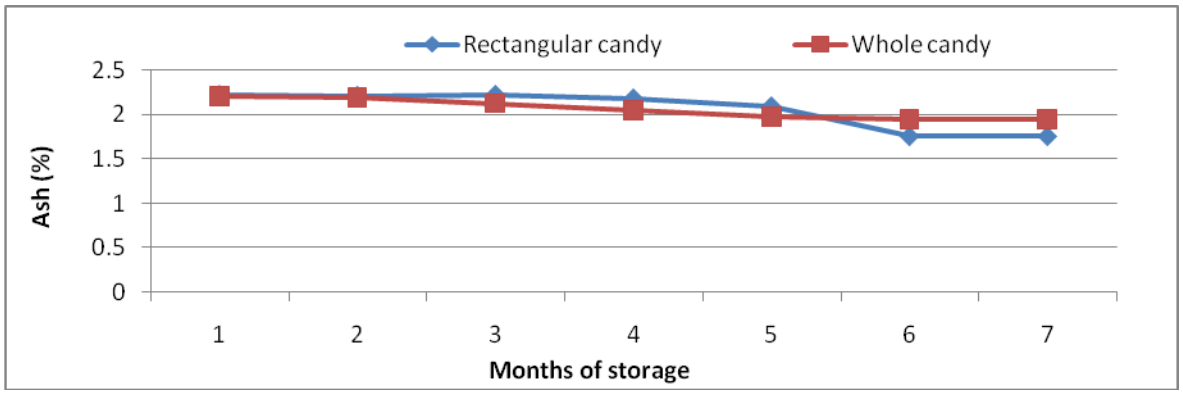
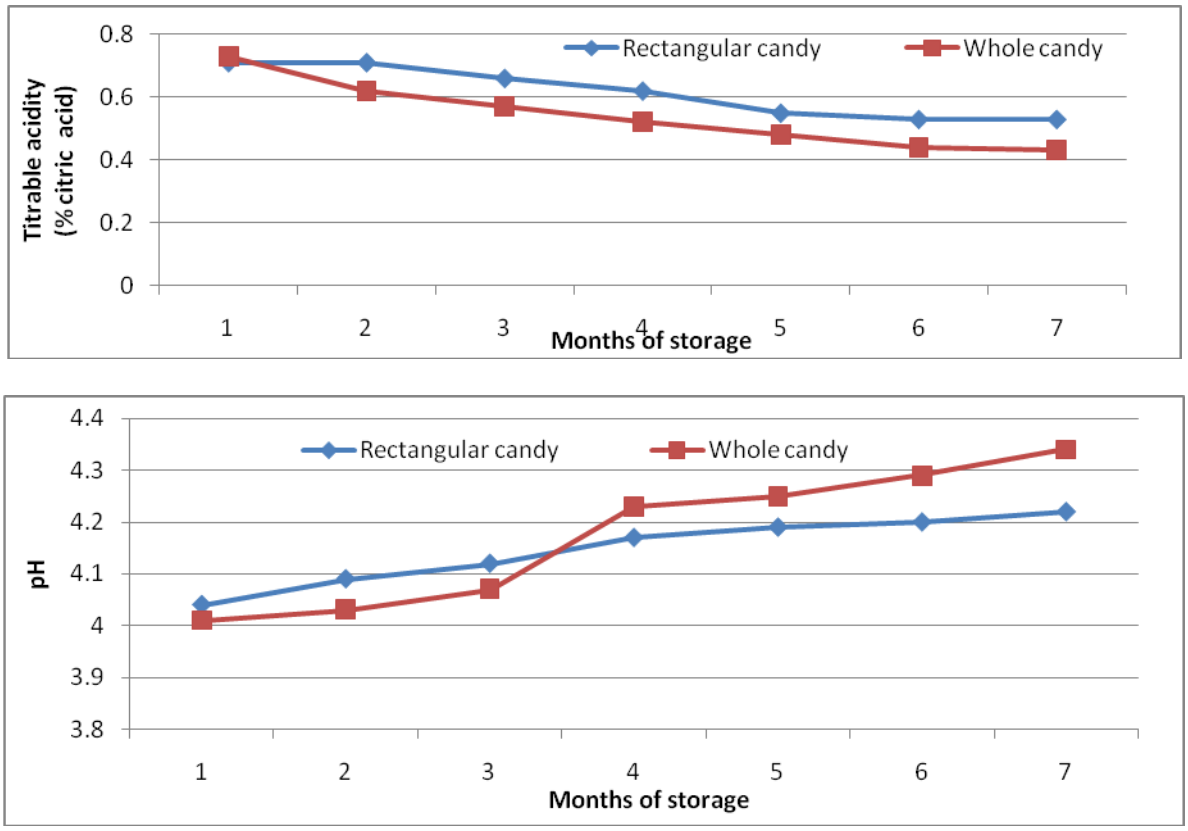


Fig.2 Biochemical changes of rectangular and whole baby corn candies during storage







a- Whole candy and b- Rectangular candy

Fig.3 Sensory scores of candies during storage period

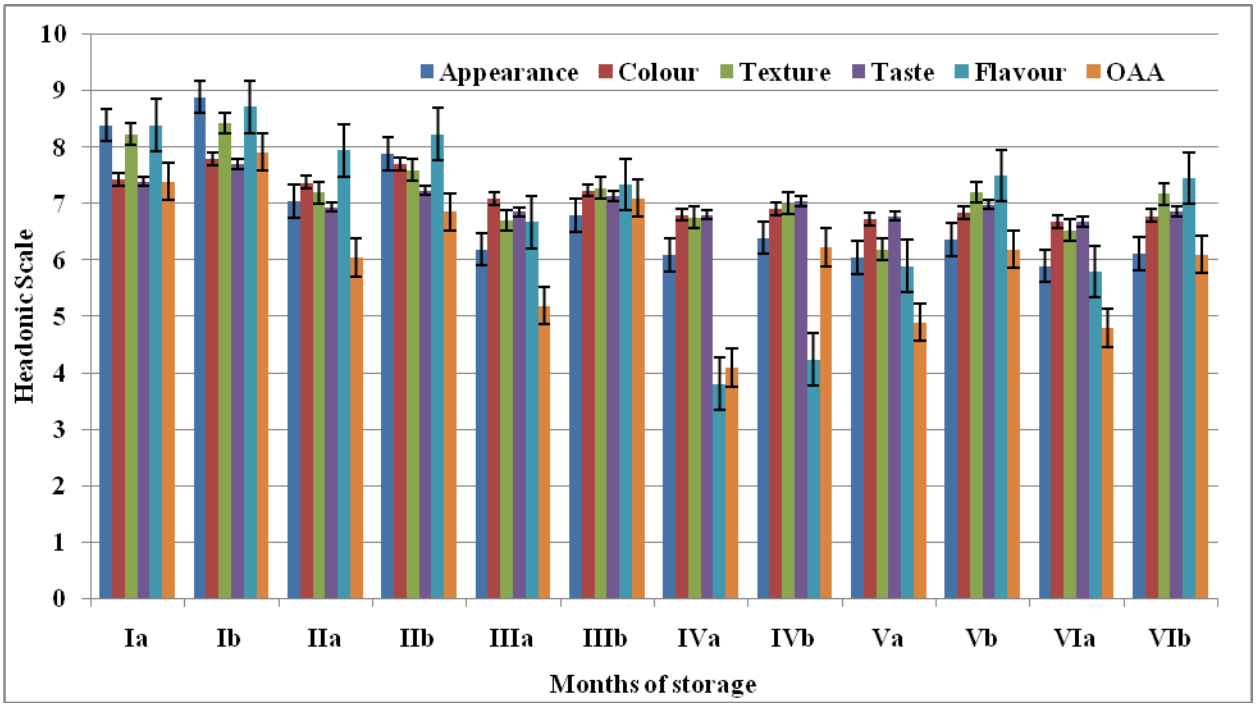


Table.1 Nutritional composition of fresh baby corn (dehusked) and baby corn candy

Parameters (/ 100g)	Fresh baby corn (dehusked)	Baby corn candy
Moisture (%)	86.41±0.52	9.01±0.30
Crude Protein (%)	2.90±0.02	1.93±0.01
Crude fat (%)	0.90±0.01	0.50±0.19
Crude fiber (%)	3.42±0.02	1.95±0.04
Ash (%)	1.34±0.02	2.20±0.02
Carbohydrates (%)	9.13±0.08	86.00±0.30
Calcium (mg)	25.77±1.55	24.0±0.57
Magnesium (mg)	85.87±0.50	85.33±0.52
Phosphorus (mg)	84.10±0.91	64.13±0.34
Iron (mg)	0.32±0.02	0.23±0.01
Energy (K.cal)	56.55±0.97	359±0.50

Values are mean of three replications ± SD

Table.2 Effect of different sugar concentrations on sensory attributes of baby corn candies

Treatments	Sensory parameters					
	Appearance	Colour	Taste	Flavour	Texture	Overall acceptability
T1	4.0	4.1	2.7	3.43	3.0	3.0
T2	3.8	3.0	2.7	2.8	2.8	2.7
T3	4.9	4.7	4.5	4.6	4.5	4.1
T4	4.6	5.0	3.9	4.13	3.9	3.7
T5	7.25	6.8	6.7	7.0	6.8	7.0
T6	8.25	8.3	8.5	8.87	8.3	8.2
T7	6.08	6.25	5.0	5.63	5.0	4.8
T8	5.5	5.6	4.5	4.37	4.4	4.7
Mean	5.5	5.51	4.8	5.77	4.8	4.8
F-Value	18.22*	22.52*	23.49*	19.64*	22.62*	35.34*
SEm±	0.36	0.34	0.4	0.43	0.39	0.32
CD at 5%	1.08	0.97	1.13	1.29	1.11	0.91

T_1: WC (20:30:40^oB), T_2: RC (20:30:40^oB), T_3: WC (30:40:50^oB), T_4: RC (30:40:50^oB), T_5: WC (40:50:60^oB), T_6: RC (40:50:60^oB), T_7: WC (50:60:70^oB), T_8: RC (50:60:70^oB)

* Significant at 5%

Table.3 Nutritional changes of rectangular baby corn candy during storage

Parameters	Months of storage							Mean	F-value	SEm±	CD
	0	I	II	III	IV	V	VI				
Moisture (%)	9.20	9.25	9.30	9.50	9.65	9.80	10.04	9.53	*	0.053	0.162
Fat (%)	0.66	0.57	0.51	0.48	0.43	0.38	0.33	0.48	*	0.053	0.162
Fiber (%)	3.87	3.76	3.58	3.49	3.32	3.18	2.93	3.45	*	0.063	0.191
Protein (%)	2.02	1.99	1.98	1.97	1.96	1.95	1.94	1.97	NS	0.053	0.162
Calcium (mg)	2.42	2.40	2.39	2.37	2.35	2.33	2.32	2.37	NS	0.058	0.175
Magnesium (mg)	88.00	87.90	87.40	86.70	85.80	85.20	84.90	86.56	*	0.577	1.751
Iron (mg)	0.32	0.29	0.27	0.26	0.25	0.24	0.23	0.27	NS	0.058	0.175
Phosphorus (mg)	69.30	68.50	67.20	66.80	66.60	66.40	66.20	67.29	*	0.069	0.209
Vitamin C	6.86	6.60	6.43	5.92	5.54	5.28	5.24	5.98	*	0.076	0.231

* Significant at 5%, NS: Non significant

Biochemical changes of rectangular and whole baby corn candies during storage

The effect of storage on biochemical quality of baby corn candies is depicted in Figure 2. Increase in moisture, decrease in ash and titrable acidity was noticed in both types of candies, which was not significant. The increase in moisture content was due to permeability of MPP pouches to the air, as well as entrapment of air during sealing and handling. Even the studies of Sagar and Khurdiya (1999), Sharma *et al.*, (2000) and Sharma *et al.*, (2006) in dehydrated mango slices, dried apples and dehydrated apple rings recorded similar patterns of moisture increase during storage. Increase in pH (4.04 to 4.22 in RC, 4.01 to 4.34 in WC) was recorded during storage. The biochemical changes in baby corn candies of two shapes showed similar pattern, since the osmotic treatment, method of preparation and drying followed were similar for both the candy types, indicating non-significant difference between the products over a period of six months biochemically. Similar line of work on storage of osmotically dehydrated apricots in polythene pouch, glass jars and laminated pouches over 6 months at 13–28°C showed that laminated pouches were found to be the best packaging material with a minimum change in chemical composition and sensory attributes (Sharma *et al.*, 2000).

Sensory quality of baby corn candy during storage

The candies prepared from 40/50/60°B syrup stored in MPP pouches showed significant changes in sensory quality with respect to months (Fig. 3) when evaluated for acceptability during storage. The appearance scores decreased from 8.4 to 5.9 in WC and 8.9 to 6.12 in RC indicating that the RC scored between “slightly acceptable” to “moderately acceptable” at the end of storage period. There was no change in colour of both the candies (Fig. 3). However, texture (8.24 to 6.54), taste (7.4 to 6.69), flavor (8.4 to 5.8) and overall acceptability (7.4 to 4.8) scores of WC decreased significantly compared to RC during storage which was due to size of the WC contributed to uneven drying which in turn significantly affected the texture and taste parameters. The overall acceptability of RC was in the range of “moderately acceptable” to “like very much”. Decrease in sensory scores of baby corn candy during storage might be due to the aging of the product. Sreedevi *et al.*, (2012), Hiremath and Rokhade (2012), Chavan *et al.*, (2010) also reported similar results in jack fruit candy,

sapota candy and osmo-dried banana slices, respectively. Decrease in sensory scores during storage of apricots was noticed by Sharma *et al.,* (2000), which might be due to the reduction of SO_2 and increase of moisture in samples attributing to non-enzymatic browning, oxidation and changes in other chemical constituents of the product.

Nutritional changes of baby corn candy

Since non-significant changes were observed between two types of candies in bio-chemical and sensory parameters. RC scored fairly well during storage. Therefore, RC was taken for nutritional analysis. The changes in the nutritional content of baby corn candy are depicted in (Table 3). Significant changes in moisture, fat, fiber, magnesium, phosphorus and Vitamin C content was noticed during storage (Table 3). This was due to higher sugar addition leads to more water molecules to move out of the material and water to dissolve some of the nutrients and Vitamin C. Similar trend of decrease in ascorbic acid content was reported for guava candy by Kannan and Thirumaran (2002). Non-significant changes were observed in major nutrients and mineral content of baby corn candy during storage was observed in the study.

Microbial quality of baby corn candy during storage

The fungi (0.65 to $1.18x10^2$) and bacterial counts (0.15 to $2.17x10^3$) increased during storage, while no mould growth was noticed till the end of three months. Bacterial colonies noticed were found to be gram negative. The preservatives like citric acid and KMS added during candy preparation might have prevented the excessive growth of microbes; on the other hand the microbial counts noticed in this study might be due to the contamination occurred during handling. Similar microbial load in osmo-dehydrated candies was reported by Manimegalai *et al.,* (2001) in jackfruit bar, Chavan *et al.,* (2010) in osmo banana slices, Sreedevi *et al.,* (2012) in jackfruit candy and Hasanuzzaman *et al.,* (2014) for tomato candy.

Consumer acceptability of the candy

It was observed that the maximum number (82.2 %) of consumers rated the RC as “very good” followed by good (11.1 %) and not good (6.6 %) in three different locations.

Baby corns of rectangular pieces were successfully osmotically-dehydrated by 40/50/60°B sugar concentration, dried at 60°C for 8 hrs and stored in MPP pouches. The rectangular candies were adjudged best due to acceptable sensory attributes of colour, appearance, flavor, taste, texture, overall acceptability and their ability to retain higher percentage of nutrients. This study will help the food producer or the confectionary manufacturer to select the appropriate concentration of sugar solution for making baby corn candy and at the same time shelf life of fresh baby corns can be extended by preserving them through nutritious candy preparation.

Conflict of Interest: None declared

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