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DEVELOPMENT OF PROCESSING METHOD FOR SWEETENED CONDENSED CORN MILK

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Abstract

The experiment was undertaken to develop the processing method for sweetened condensed milk from corn to enhance the diversified use of corn. After extracting the milk from milky/dough stage corn (after 5 to 6 weeks of sowing), it was processed into condensed milk. The sweetened condensed corn milk prepared from the combination of 80% sugar of total extracted milk with carboxymethyl cellulose (CMC) at 0.3% of milk obtained the highest acceptability rank (8.67, "like very much" to "like extremely") after 8 weeks of storage at ambient condition. The minimum microbial load was observed in the combination of 85% sugar and 0.3% CMC of corn milk which followed by 80% sugar and 0.3% CMC of corn milk combination during storage. The retention of vitamin C (5.88 mg/100g) and vitamin A (ß- carotene, 6.98 µg/100g) was found better in the condensed corn milk prepared with the combination with 80% sugar and 0.3% CMC of corn milk after 8 weeks.

Keywords: Processing techniques, sweetened condensed milk, sweet corn, shelf life.

Introduction

Sweet corns (*Zea mays saccharata* Sturt.) are special varieties of maize having high content in sugar and carbohydrate due to altered endosperm starch synthesis (Zhang *et al.*, 2017). It has multiple nutritional compositions which provide benefits to the body. Recently, it is one of the most important food crops on the dining table in developed countries as well as developing countries because of its high nutritional value and good taste.

In Bangladesh maize/corn is an important food crops because of its diversified use. In 2016-2017, the total production of maize in the country is about 3025 thousand MT from 963 thousand acres of land (BBS, 2017). Maize provides several opportunities for Bangladeshi farmers to increase their income from its use in poultry feed, fish feed, or cattle feed, and its mixture with wheat flour for chapatti where as sweet corn is used widely as a side dish, soups, salads or

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casseroles. Its kernels being consumed both as fresh produce and in processed products. In case of processing, sweet corn is harvested at a relatively immature stage. Growers produce sweet corn for direct consumption, thus they harvest kernelled cobs for industrial processing. Sweet corn belongs very short optimum harvest maturity and its quality changes rapidly. Its kernels are watery and lack sweetness. Overmature corn is rather starchy than sweet, tough, and the kernels are often dented (Motes *et al.*, 2007).

Condensed milk is an important processed product which generally prepared from milk or milk whey powder. It is used to make different food items but the nutritional value is not rich whereas demand is so high. But, the processed sweet corn has higher antioxidant activity (Dewanto *et al.*, 2002) and it has economic impact to create job opportunity to the processing industry, direct sales and employment income. Also, less attention has been paid to the nutritional quality and health benefits of sweet corn compared to other vegetables. So, this research work on sweet corn into sweetened condensed corn milk was conducted for enhancing diversified use of corn.

Materials and Methods

Milky stage maize was collected from the commercial field nearby Joydebpur Sadar in the district of Gazipur. Husks and silk was removed from corn and then washed with water. Kernels from the cob were cut with the help of sharp knife. The kernels were squeezed using juice extractor and the extracted corn milk was filtered with thin white cloth. The filtrate corn was taken in a double kettle and heated at around 70-80^0 C to make the TSS 17^0 Brix. Then, the sugar was added and heated at 80-90^{0}C until it reached to 65^0 Brix. Now, CMC and lactose (0.5% of corn milk) was added with sugar syrup. After stirring, salt (0.25% of corn milk) and glucose syrup (4% of corn milk) were added and heated again until it reached to 72-75^0 Brix. The solution was then blended for homogenization. Finally, the mixture was pasteurized at 70^0 C for 5 minutes and then was added 1000 ppm potassium meta-bisulphite (KMS). The hot poured condensed corn milk kept into glass container and sealed immediately. The prepared condensed milk was stored at ambient temperature to determine its acceptability and keeping quality. The stored samples were analyzed at 2 weeks interval. The experiment was laid in Completely Randomized Design (CRD) with factorial (two factors). The treatments and factors were as follows:

Factor A (sugar percentage)

T_1 = 75% sugar (of corn milk), T_2 = 80% sugar (of corn milk), T_3 = 85% sugar (of corn milk), Factor B (CMC percentage), C_1 = 0.2% CMC (of corn milk), C_2 = 0.3% CMC (of corn milk)

Nutritional quality

Total soluble solids (TSS), reducing sugar and total sugar content

The total soluble solids (TSS) content was measured from composite corn sample of each replicate by using a temperature-compensated automatic refractometer (Model NR151) and expressed degree brix (°Brix). The other physico-chemical properties of sweet corn milk were evaluated by adopting the standard procedure such as fat by Mojonnier extraction method (AOAC, 2000), protein content by AOAC (1965) method, total sugar, moisture, total ash and total solids content determined by the volumetric (Lane-Eynon) method as described by Ranganna (2007).

Vitamin C content

Vitamin C or ascorbic acid content was determined according to Ranganna (2007) using 10 g samples of corn blended for 2 minutes and homogenized with 50 mL of 3% cold metaphosphoric (HPO_3). Then, samples were filtered through Whatman filter paper No. 2. The clear supernatant samples were collected for assaying ascorbic acid and then 10 ml of aliquot samples was titrated with 0.1% 2,6-dichlorophenolindophenol solution until the filtrate changed to pink color persisted for at least 15 seconds. The titer value was recorded for each aliquot sample. Prior to titration 2,6-dichlorophenolindophenol solution was calibrated by ascorbic acid standard solution and the results were expressed as mg/100g.

Vitamin A (ß-carotene) content

The estimated ß-carotene was determined by the extraction of 3 g composite blended corn sample with acetone (Fisher Scientific Ltd., UK), and petroleum ether. It was further purified with acetone, methanolic KOH and distilled water. The resulting solution were filtered with anhydrous sodium sulphate and read on a Spectrophotometer (T-80, PG Instrument Ltd., UK) at 451 ηm against petroleum ether as a blank. A standard graph was prepared using synthetic crystalline total carotene (Fluka, Germany) dissolved in petroleum ether and its optical density was measured at 451 ηm (Alasalvar *et al.*, 2005) and total carotenoids were expressed as (ug/100g).

The physicochemical parameters (moisture content, protein, fat, starch) as shown in Table 1 of corn at different stage of maturity were also determined by using NIR Grain Analyzer in the quality control laboratory of Postharvest Technology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur. Microbial load (bacteria and fungi) was estimated in the stored condensed corn milk by the method described by Sony *et al.*, (2013) at weekly intervals by adopting pour plate method using serial dilution technique.

Sensory Evaluation and Statistical Analysis

Stored condensed milks were examined by a panel of judges comprising of 10 experienced scientific staffs for the product's color, flavor, sweetness and overall acceptance. Hedonic scale was used to evaluate the tasted samples during storage. In this scale 'like extremely', is given the highest score of '9' and 'dislike extremely' is given the lowest score '1'. Others are given intermediate scores. The data was analyzed for Analysis of Variance (ANOVA) in Completely Randomized Design (CRD) under computerized statistical methods of M-Statc and Duncan's Multiple Range Test (DMRT) was used to compare parameters among the mean value.

Results and Discussion

The physicochemical parameters of corn at different stage of maturity are presented in the Table 1 and the physicochemical properties of the extracted milk from the corn are shown in the Table 2. The organoleptic attributes of the corn condensed milk prepared from the combination of sugar and CMC percentage of corn milk were evaluated. Comparative sensory evaluation of different quality attributes of the corn condensed milk according to the opinion of test panel judges comprising 10 members are presented in Table 3. It was noticed that nobody disliked the products prepared from the combinations. It was also observed that color and flavor have no effect on the acceptability of condensed milk prepared from any of the combinations (Table 3). Only sweetness and overall acceptability of the condensed milk had significant effect on its evaluation for overall acceptance. The result also stated that the combinations of 80% sugar with 0.3% CMC (T_2C_2) scored highest overall acceptance (8.67, 'like very much' to 'like extremely') followed by the combination of 85% sugar with 0.2% CMC (T_3C_1).

Table 1. Physico-chemical parameters of corn at different stage of maturity

Corn	Moisture (%)	Protein (%)	Fat (%)	Starch (%)	Others such as total sugar, crude fibre, ash (%)
Milky stage	51.90	4.50	2.70	20.10	20.80
Matured stage	40.80	9.80	1.10	28.86	18.74

Table 2. Physico-chemical parameters of extracted corn milk

Parameter	Value
Moisture (%)	90.05
Protein (%)	1.87
Fat (%)	1.09
Sugar (%)	6.25
Ash (%)	0.54
Acidity (%)	0.17
pH	6.13
Viscosity in centipoise (cps)	1.35

Table 3. Sensory evaluation of corn condensed milk during storage period

Treatments combinations	Sensory/Organoleptic attributes			
	Color	Flavor	Sweetness	Overall acceptability
T_1C_1 = 75% Sugar + 0.2 % CMC	5.33b	6.33b	5.33b	5.33b
T_1C_2 = 75% Sugar + 0.3 % CMC	5.33b	7.00ab	5.67b	5.67b
T_2C_1 = 80% Sugar + 0.2 % CMC	7.67a	7.33ab	8.00a	8.33a
T_2C_2 = 80% Sugar + 0.3 % CMC	8.00a	7.67a	8.33a	8.67a
T_3C_1 = 85% Sugar + 0.2 % CMC	7.33a	7.33ab	5.00b	5.67b
T_3C_2 = 85% Sugar + 0.3 % CMC	8.00a	7.67a	5.33b	5.33b
CV (%)	10.73	9.23	14.54	13.63
Level of significance	ns	ns	*	*

NB.
1 = Dislike extremely,
2 = Dislike very much,
3 = Dislike moderately,
4 = Dislike slightly,
5 = Neither like nor dislike,
6 = Like slightly,
7 = Like moderately,
8 = Like very much,
9 = Like extremely
* = Significant at 5% level of probability,
ns = Not significant at 5% level of probability

The changes in various chemical and physio-chemical parameters of the corn condensed milk and stored in ambient temperature are also presented in Table 4, Table 6 and Table 7. The total soluble solids initially adjusted in formulations showed a negligible change throughout the storage period at ambient condition. From the Table 4, it was noticed that the initial adjusted TSS was 68^o Brix and after 2, 4, 6 and 8 weeks of storage the TSS were slightly decreased. The decrease of TSS might be due to the conversion of sugar during the storage periods.

Table 4. Change in total soluble solid (TSS, ^{o}Brix) of corn condensed milk during storage

Treatments combinations	Storage periods, week				
	Initial	2	4	6	8
T_1C_1=75%Sugar+0.2%CMC	68.0	67.1d	66.8c	66.2d	65.8c
T_1C_2=75%Sugar+0.3%CMC		67.1d	66.7c	66.3d	65.8c
T_2C_1=80%Sugar+0.2%CMC		67.4c	67.2b	66.8c	66.5b
T_2C_2=80%Sugar+0.3%CMC		67.6b	67.2b	66.9c	66.6b
T_3C_1=85%Sugar+0.2%CMC		67.8ab	67.6a	67.2b	66.9a
T_3C_2=85%Sugar+0.3%CMC		67.9a	67.6a	67.4a	66.8a
CV (%)		0.14	0.15	0.15	0.15
Level of significance		*	*	*	*

* = Significant at 5% level of probability

The microbial (bacteria and fungi) population enumerated during storage is presented in Table 5. The microbial counts of the condensed corn milk of various combinations were not found initially but it increased slowly during storage. No microorganism was traceable initially due to the higher dilution used for the enumeration. The corn condensed milk prepared from the combination of 85% sugar and 0.3% CMC showed minimum of microbial counts followed by 80% sugar and 0.3% CMC combination during storage. The prepared corn condensed milk stored at ambient condition exhibited higher microbial population than that stored in refrigerator. In general, the microbial population of the condensed milk was low at 4 weeks storage at ambient conditions and quite low even at the end of 8 weeks of storage in refrigerator though there was a significant increase in microbes in the non-refrigerated products. The higher concentration of sugar in the milk and the preservative (KMS) added while preparing the condensed milk might have prevented the growth of microbes.

Table 5. Microbial population (CFU/10^{-6}) of corn condensed milk during storage

Treatments combinations	Storage periods, week								
	Initial	2		4		6		8	
		Ambient	Refrigerated	Ambient	Refrigerated	Ambient	Refrigerated	Ambient	Refrigerated
75%Sugar+0.2%CMC	0	0	0	2	0	12	0	50	5
75%Sugar+0.3%CMC		0	0	2	0	12	0	42	5
80%Sugar+0.2%CMC		0	0	1	0	7	0	22	3
80%Sugar+0.3%CMC		0	0	1	0	5	0	15	1
85%Sugar+0.2%CMC		0	0	1	0	5	0	15	1
85%Sugar+0.3%CMC		0	0	0	0	5	0	12	1

A substantial reduction was noted in ascorbic acid (vitamin C) and β-carotene (vitamin A) contents of the samples during storage as shown in the Table 6. However, the maximum retention of vitamin C and β-carotene were observed in T_2C_2 (5.88 mg/100g and 6.98 µg/100g) followed by T_2C_1 (5.85 mg/100g and 6.78 µg/100g) and T_3C_1 (5.78 mg/100g and 6.96 µg/100g) combination, respectively after 8 weeks of storage (Table 6). The reduction could be occurred due to both oxidative and non-oxidative changes. Such changes altered the color of the product and lowered the flavor and nutritive value of the product.

Table 6. Change in vitamin C (mg/100g) and vitamin A (µg/100g) of condensed corn milk during storage

Treatments combinations	Storage periods, week				
	Initial	2	4	6	8
	Vitamin C (mg/100g)				
T_1C_1=75%Sugar+0.2%CMC	7.12	6.89	6.48	6.12	5.78
T_1C_2=75%Sugar+0.3%CMC	7.18	6.78	6.38	6.10	5.72
T_2C_1=80%Sugar+0.2%CMC	7.18	6.68	6.32	6.08	5.85
T_2C_2=80%Sugar+0.3%CMC	7.08	6.78	6.46	6.04	5.88
T_3C_1=85%Sugar+0.2%CMC	7.20	6.94	6.56	6.14	5.78
T_3C_2=85%Sugar+0.3%CMC	7.18	6.88	6.52	6.15	5.84
CV (%)	3.49	3.66	4.03	4.40	4.50
Level of significance	ns	ns	ns	ns	ns
	Vitamin A (β-carotene, µg/100g)				
T_1C_1=75%Sugar+0.2%CMC	8.98	7.85c	6.78c	6.65b	6.25c
T_1C_2=75%Sugar+0.3%CMC	9.12	8.32b	7.18bc	6.96ab	6.38bc
T_2C_1=80%Sugar+0.2 CMC	9.56	8.64ab	7.52ab	6.90ab	6.78ab
T_2C_2=80%Sugar+0.3%CMC	9.68	8.78ab	7.82a	7.08ab	6.98a
T_3C_1=85%Sugar+0.2%CMC	9.72	8.90a	7.98a	7.18a	6.96a
T_3C_2=85%Sugar+0.3%CMC	9.78	8.88a	7.94a	7.32a	6.94a
CV (%)	2.64	2.93	3.32	3.57	3.72
Level of significance	ns	*	*	ns	*

In Table 7 it is stated that the total sugar content was decreased and reducing sugar was increased in all the treatment combinations of the condensed milk throughout the storage period. Decreases in total sugars in the corn condensed milk might be due to the significant increases in reducing sugars (USDA-ERS, 2015) by acid hydrolysis of total and non-reducing sugars and thereby inversion of total and non-reducing sugars to reducing sugars (Martin *et al.,* 2000). The composition of processed condensed milk is presented in Table 8.

Table 7. Change in reducing sugar (%) and total sugar (%) of condensed corn milk during storage

Treatments combinations	Storage periods, week				
	Initial	2	4	6	8
	Reducing sugar (%)				
T_1C_1=75%Sugar+0.2%CMC	3.82a	3.88	3.96	4.01	4.12
T_1C_2=75%Sugar+0.3%CMC	3.84a	3.90	3.98	4.10	4.15
T_2C_1=80%Sugar+0.2% CMC	3.66b	3.68	3.76	3.82	3.94
T_2C_2=80%Sugar+0.3%CMC	3.58b	3.70	3.82	3.85	3.96
T_3C_1=85%Sugar+0.2%CMC	3.65b	3.68	3.78	3.82	3.88
T_3C_2=85%Sugar+0.3%CMC	3.60b	3.70	3.82	3.85	3.90
CV (%)	1.35	6.65	6.49	6.40	6.26
Level of significance	*	ns	ns	ns	ns
	Total sugar (%)				
T_1C_1=75%Sugar+0.2%CMC	48.12c	47.98c	47.78c	47.14c	46.88c
T_1C_2=75%Sugar+0.3%CMC	48.08c	47.74c	47.64c	47.54bc	47.12bc
T_2C_1=80%Sugar+0.2 CMC	49.38bc	49.08bc	48.88bc	48.76bc	48.64bc
T_2C_2=80%Sugar+0.3%CMC	50.12b	49.87b	49.68b	49.15b	48.82b
T_3C_1=85%Sugar+0.2%CMC	55.05a	54.76a	54.24a	53.25a	52.67a
T_3C_2=85%Sugar+0.3%CMC	53.40a	53.18a	52.84a	52.62a	52.48a
CV (%)	1.97	1.98	1.99	2.01	2.02
Level of significance	*	*	*	*	*

* = Significant at 5% level of probability, ns = Not significant at 5% level of probability

Table 8. Composition of the processed condensed milk from corn

Parameter	Value
Total soluble solids (%)	65.80-68.00
Protein (%)	4.95
Fat (%)	3.07
Total sugar (%)	46.88-55.05
Ash (%)	1.54
Acidity (%)	0.17
pH	6.03

Conclusion

It was found that the combination of 80% sugar and 0.3% CMC of extracted corn milk is the best formulation for preparing sweetened condensed corn milk by the judgment of overall consumer's preference. The quality attributes of the processed product exhibited good shelf life up to 8 weeks at ambient conditions. The processing of corn into condensed corn milk will intensify the diversified use of sweet corn in the country as well as in the globe. Agro-processors, traders, entrepreneurs, SME people may utilize this technology commercially as an alternate use of condensed milk prepared mostly by milk or milk products. It will also create opportunity to export the product in the foreign market because of its nutritive value.

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