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STANDARDIZATION OF BOTTLING PROCESS FOR SWEET CORN

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Abstract
The study was undertaken to standardize the method for bottling process of sweet corn to enhance the diversified use of corn. In Bangladesh, corn has multifarious uses such as human consumption, poultry and dairy farm, fish feed preparation, etc. Actually, the lack of proper processing practices a lot of corn has lost from harvest to storage. Milky stage corn was collected from the farmer's field. For bottling process, the sweet corn was processed for blanching the ears at 85^0C for 4 minutes in the boiling water. There are five treatments using various sugar percentages with fixed amount of salt, potassium meta-bisulphate and citric acid was used for the experiment. Three bottles each of treatment were randomly selected each month for physical observation as well as analyzed for chemical composition of processed bottles. Among the observations, the total soluble solid was slightly decreased and substantial reduction was noted in the contents of an ascorbic acid (vitamin C) and β-carotene (vitamin A), p^H as well as acidity of the samples during storage up to 3 months. However, the suitable formulation of bottling process was found in treatment T_3; and these are 3% Sugar, 0.5% salt, 750 ppm potassium meta-bisulphate and 0.2g Citric acid. Using such formulation the processed sweet corn is stored well up to three month at ambient condition.

Keywords: bottling, sweet corn, stages, ascorbic acid, β-carotene, TSS, appearance

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1.INTRODUCTION

Maize or corn is one of the important cereals crop in Bangladesh. The total production of maize in Bangladesh is about 1018 thousand metric tons from 409 thousand acres of land (BBS, 2011). After the creation of the Bangladesh Agricultural Research Institute (BARI) in 1976, BARI felt there was potential to develop maize as an important high-yielding cereal crop. Maize became an emerging key mandate crop of BARI and programs were developed for crop improvement, crop management, and subsequent area expansion. From 2000 onwards, maize became a lucrative cash crop with a huge and expanding market demand, particularly to the farmers of northern and western Bangladesh. The crop has higher grain yield, yield stability, and profitability compared with the two other principal winter cereal crops: *Boro* (irrigated) rice and wheat. In Bangladesh, hybrid maize is grown mostly in the winter (*Rabi*) season (during November-April) after the harvest of *transplanted* rice. At that time, cool temperature prevails during early phases of crop development and the field duration of winter hybrid maize is long; around 145 days. The widespread use of high rates of fertilizer along with irrigation help ensure high grain yields (with a current 2005-07 national mean grain yield of around 5.7 t/ha) (Ali *et al*., 2008) Additionally, increasing area is coming under *Kharif-I* (March-June) maize, mainly after the harvest of potato. 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. Additionally, extra value is obtained by some farmers in Bangladesh by feeding green maize leaves and stems to dairy cattle.

Maize has multifarious uses. Actually every part of the maize plant is useful. Green cobs of maize are cooked by roasting or boiling in

water. The top green portion of the plant after harvest of the cob is fed to cattle as fodder, and the dry portion of the stem along with fibrous roots are used as fuel. The greatest advantage of maize over rice and wheat is its high bio-mass potential. Its grain contains more calories on an equivalent dry-weight basis (Kaul and Ralunan, 1987). It is also of interest to report that calorie yield in maize is two and halftimes higher than local and HYV paddy (Karim, 1992). The present consumption statistics suggested that about three-fourths of the country's corn production is used as animal feeds especially by poultry farms (Iqbal, 1997). Over time, the maize requirement is likely to rise gradually due to the establishment of new poultry farms and higher rates of consumption of maize instead of wheat by the small farms. Furthermore, with the growth of national income and urbanization, demand for livestock products will grow at a faster rate and therefore, more maize will be needed. The income elasticity for meat and eggs was estimated to 1.35 (Hossain, 1989). Maize users report that its consumption help increases milk yield as well as fat content. Zaher (1995) suggests that maize can be used as a fish ingredient as well.

From the above justifications, bottling is a way of processing food to extend its shelf life. The idea is to make food available and edible long after the processing time. Therefore, processing of sweet corn into bottle product enhance the diversified use of corn.

2. MATERIALS AND METHODS

Milky stage maize was collected from the field. Husks and silk was removed from corn and it was washed with water. Kernels from the cob were cut with the help of sharp knife. For bottling, blanch the ears for 4 minutes in the boiling water. After that the ears were cooled in ice water for at least 5 minutes and drain out the water. For bottling the corn, put the blanched corn and solution were filled in standard size food grade bottles, leaving 1-inch head space. After that potassium meta-bisulphate (KMS) and citric acid was added with solution. Bottles were then boiling in water for 10 minutes. After boiling, bottles were then cooled in water and maintain a center bottle temperature of 33-45^{0}C. Three bottles each of treatment were randomly selected each month for physical observation as well as analyzed for chemical composition of processed bottles.

The experiment was laid in completely randomized design (CRD) and the treatments are as follows:

T_1 = 2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid

T_2 = 2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid

T_3 = 3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid

T_4 = 3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid

T_5 = 0.5% salt+750ppm KMS+0.2g Citric acid

Finally, food grade standard glass container was used to fill boiled sweet corn and sealed by manual immediately. The processed bottles were stored at ambient temperature to determine its acceptability and keeping quality. The stored bottles were analyzed at every month for total soluble solids (TSS) in percentage, P^H, titratable acidity (%), β-carotene and vitamin C (mg/100g) by the procedure described by Mahadevan and Sridhar (1982) and Ranganna (1995). The physicochemical parameters of corn at different stages of maturity were also determined by using NIR Grain analyzer in the quality control laboratory of Postharvest Technology Division, BARI, Gazipur.

Data Analysis

Stored bottles were examined by a panel of judges comprising of scientific staff for their cloudiness, flavor, taste and overall acceptance. Hedonic scale was used to make the different parameters. 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 were analyzed for ANOVA in completely

randomized design (CRD) under computerized statistical methods of m-stat and Duncan's Multiple Range Test (DMRT) was used to compare the means.

3. RESULTS AND DISCUSSION

The physicochemical parameters of corn at different stage of maturity are presented in the Table 1.

Table 1: Nutritional composition of fresh corn at different stage of maturity

Corn	Year	Protein (%)	Fat (%)	Starch (%)	Dietary fiber (%)
Milky stage	2012-2013	6.4	3.4	49.1	2.7
	2013-2014	6.2	3.3	48.1	2.9
Matured stage	2012-2013	5.8	3.7	58.6	3.5
	2013-2014	5.5	3.5	58.0	3.1

The changes in various chemical and physicochemical parameters of the processed sweet corn bottles stored in ambient temperature are also presented in Table 2 and Table 3. The total soluble solids initially adjusted in formulations showed a negligible change throughout the storage period at ambient conditions. From the Table 2, it was observed that the TSS was slightly decreased up to 3 months of storage. The decrease of TSS might be due to the conversion of sugar during the storage periods. In the year 2013-2014, the TSS values was higher than the year of 2012-2013, it could be due to early stage of crop harvest. A substantial reduction was noted in ascorbic acid (vitamin C) and β-carotene (vitamin A), p^H and acidity of the samples during storage as shown in the Table 2. However, the maximum retention of vitamin C, β-carotene and p^H were observed in treatment T_3 (3% Sugar+ 0.5% salt+750ppm KMS+0.2g Citric acid) followed by treatment T_4 (3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid) after 3 months of storage (Table 2) for both years. On the other hand, acidity was observed high in the treatment T_4 than the treatment of T_3. The reduction could be due to both oxidative and non-oxidative changes as described by Eskin (1979) and Land (1962). Such changes altered the color of the product and lowered the flavor and nutritive value of the product. After 1 month storage; treatment T_5 color was cloudy, off flavor, gas formation and microbial infestation were seen, and finally the product was spoiled.

Table 2: Change in total soluble solid (TSS), vitamin C, β-carotene p^H, acidity of bottling sweet corn

Treatments	2012-2013				2013-2014			
	Storage period, months				Storage period, months			
	0	1	2	3	0	1	2	3
TSS								
2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	5.25^b	5.15^b	4.92^b	4.81^b	6.92^b	6.53^b	6.11^b	5.53^c
2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	6.14^a	6.03^a	5.98^a	5.72^a	6.89^b	6.62^b	5.91^c	5.78^b
3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	6.46^a	6.15^a	6.02^a	5.86^a	7.11^a	6.92^a	6.21^b	5.93^a
3.5% Sugar + 0.5%	6.66^a	6.32^a	5.98^a	4.97^b	7.21^a	7.03^a	6.54^a	6.03^a

Treatments	2012-2013				2013-2014			
	Storage period, months				Storage period, months			
	0	1	2	3	0	1	2	3
salt+750ppm KMS+0.2g Citric acid								
0.5% salt+750ppm KMS+0.2g Citric acid	3.41	3.05	-	-	4.62^{c}	3.51^{c}	-	-
CV (%)	4.51	3.41	8.58	5.08	0.92	1.31	1.08	1.34
Vitamin C (mg/100gm)								
2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	6.88	6.26^{b}	5.65^{b}	4.74^{c}	6.39^{d}	6.21^{c}	5.95^{b}	5.43^{d}
2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	7.21	6.33^{b}	6.12^{a}	5.76^{ab}	7.11^{bc}	6.13^{cd}	5.89^{bc}	5.78^{b}
3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	7.53	6.74^{a}	6.25^{a}	6.13^{a}	7.23^{a}	6.84^{a}	6.27^{a}	6.17^{a}
3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	7.15	6.64^{a}	5.98^{ab}	5.17^{bc}	7.20^{ab}	6.69^{b}	5.92^{b}	5.63^{c}
0.5% salt+750ppm KMS+0.2g Citric acid	7.27	6.19	-	-	7.09^{c}	6.11^{d}	-	-
CV (%)	3.35	2.11	3.15	8.24	0.71	0.63	1.01	0.88
β-carotene (µg/100g)								
2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	50.94	45.75	40.12^{b}	30.49	46.68^{d}	44.53^{e}	40.97^{d}	39.68^{d}
2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	45.89	45.19	40.32^{b}	30.64	56.01^{b}	52.67^{c}	50.28^{c}	46.01^{c}
3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	55.46	50.18	45.66^{a}	35.58	56.8^{a}	54.30^{a}	52.53^{a}	48.18^{a}
3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	55.12	45.96	35.31^{c}	30.75	56.05^{b}	53.66^{b}	51.55^{b}	47.05^{b}
0.5% salt+750ppm KMS+0.2g Citric acid	50.08	40.69	-	-	50.05^{c}	47.07^{d}	-	-
CV (%)	6.55	6.35	3.00	6.53	0.19	0.18	0.17	0.22
p^{H}								
2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	6.75^{a}	5.58^{b}	5.12^{b}	4.96^{b}	5.85^{b}	5.77^{bc}	4.64^{b}	4.15^{b}
2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	6.55^{a}	5.43^{bc}	5.10^{b}	4.86^{b}	6.02^{a}	5.95^{a}	4.58^{b}	4.02^{c}
3% Sugar + 0.5% salt+750ppm KMS+0.2g	6.85^{a}	6.11^{a}	6.02^{a}	5.98^{a}	5.98^{a}	5.83^{b}	5.23^{a}	4.98^{a}

Treatments	2012-2013				2013-2014			
	Storage period, months				Storage period, months			
	0	1	2	3	0	1	2	3
Citric acid 3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	6.43[a]	5.32[c]	4.87[b]	3.62[c]	5.56[c]	5.71[c]	4.69[b]	3.96[c]
0.5% salt+750ppm KMS+0.2g Citric acid	3.41	3.05	-	-	4.65[d]	4.35[d]	-	-
CV (%)	7.99	2.02	4.28	7.96	0.89	0.72	1.31	1.15
Acidity (%)								
2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	0.12	0.12	0.11	0.10[c]	0.14	0.15[c]	0.16[a]	0.14[a]
2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	0.11	0.12	0.12	0.11[b]	0.12	0.13[e]	0.13[b]	0.12[b]
3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	0.12	0.12	0.13	0.12[a]	0.13	0.14[d]	0.15[a]	0.13[ab]
3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	0.11	0.13	0.12	0.12[a]	0.15	0.16[b]	0.16[a]	0.14[a]
0.5% salt+750ppm KMS+0.2g Citric acid	0.11	0.11	-	-	0.16	0.17[a]	-	-
CV (%)	8.70	12.24	11.02	16.02	14.29	6.67	6.41	7.35

Note: T_1 = 2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid
T_2 = 2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid
T_3 = 3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid
T_4 = 3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid
T_5 = 0.5% salt+750ppm KMS+0.2g Citric acid

Table 3: Physical appearance of bottled sweet corn during storage

Storage period (month)	Treat-ments	Colour	Flavour	Turbidity	Gas formation	Microbial infestation	Remarks
0	T_1	Good	Good	Clear	Nil	Nil	Good
	T_2	Good	Good	Clear	Nil	Nil	Good
	T_3	Good	Good	Clear	Nil	Nil	Good
	T_4	Good	Good	Clear	Nil	Nil	Good
	T_5	Good	Good	Clear	Nil	Nil	Good
1	T_1	Good	Good	Clear	Good	Nil	Good
	T_2	No change	Do	Do	Do	Nil	Do
	T_3	Do	Do	Do	Do	Do	Do
	T_4	Do	Do	Do	Do	Do	Do
	T_5	Cloudy	Off flavour	Precipitated	Present	Present	Spoiled

	T_1	No change	Good	Clear	Nil	Nil	Good
	T_2	Do	Do	Do	Do	Do	Do
2	T_3	Do	Do	Do	Do	Do	Do
	T_4	Do	Do	Clear	Do	Do	Do
	T_5	-	-	-	-	-	-
	T1	No change	Good	Clear	Nil	Nil	Good
3	T2	Do	Do	Do	Do	Do	Do
	T3	Do	Do	Do	Do	Do	Do
	T4	Do	Do	Do	Do	Do	Do
	T5	-	-	-	-	-	-

The organoleptic attributes of the processed bottles prepared from sweet corn and the different combination of sugar, salt, KMS and citric acid are evaluated. Comparative sensory evaluation of different quality attributes of the processed bottles of sweet corn according to the opinion of test panel judges comprising 10 members are presented in Table 4. It was observed that cloudiness, flavor, taste and overall acceptability have significant effect on its evaluation for acceptance. It was also noticed that the treatment T_3 (3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid) scored highest overall acceptance (8.2 e.g. like very much to like extremely) followed by treatment T_2 (2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid).

Table 4: Sensory evaluation of bottled sweet corn after 3 months of storage

Treatments	Sensory/organoleptic attributes			
	Cloudiness	Flavor	Taste	Overall acceptability
2% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	7.0^{b}	6.6^{c}	6.4^{c}	6.6^{c}
2.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	8.0^{ab}	7.4^{b}	7.4^{b}	7.6^{b}
3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	8.4^{a}	8.2^{a}	8.2^{a}	8.2^{a}
3.5% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid	7.0^{b}	6.8^{c}	6.4^{c}	6.7^{c}
0.5% salt+750ppm KMS+0.2g Citric acid	5.2^{c}	4.2^{d}	3.4^{d}	4.3^{d}
CV (%)	5.62	4.47	2.81	2.76

Note: 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

4. CONCLUSION

The study results showed that there was a little difference in nutrient content among the sweet corns of different maturity stage. Using different formulations, the suitable bottling process was found in treatment T_3 (3% Sugar + 0.5% salt+750ppm KMS+0.2g Citric acid). So, the sweet corn processed with 3% sugar, 0.5% salt, 750 ppm KMS and 0.2g citric acid can be stored in a bottle at ambient temperature for three (03) months. The processed corn can be used for human consumption at longer periods and it would be reduced some postharvest loses as well as extra value is obtained by some farmers in Bangladesh.

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