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Full Length Research Paper

Changes in microflora of steeped and cured baby corn (*Zea mays* L.)

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The quantitative changes in micro flora in steeped and cured baby corn during storage were studied. Baby corn cobs blanched and unblanched were steeped in different solutions with varying concentrations of sodium chloride (2 to 8%) and acetic acid (0.5, 0.75 and 1.0%). Sodium chloride at 5, 10, 15 and 20% was used for curing (dry salting) of both blanched and unblanched cobs. During steeping preservation, higher total plate count (7.0 x 10^2 to 9.9 x 10^1 CFU/g) was found with lower salt (2 - 5%) and acid (0.5%) concentrations. Significant ($P \leq 0.05$) decrease in total plate count was found in samples of baby corn steeped in solutions containing higher concentrations of salt (6 - 8%) and acid (0.75 to 1.0%). Curing of blanched baby corn with 15% salt showed longer shelf life (45 days). However curing process of baby corn was found to be short-term preservation method. Practical applications: The sanitary quality of steeped and cured baby corn was ascertained by enumeration of micro flora in halophilic (2 to 8% sodium chloride) and acidic conditions (0.5, 0.75 and 1.0% acetic acid) during storage. This study illustrated the type of micro flora that grows in steeped baby corn at different concentrations of steeping solutions of sodium chloride (2 to 8%) and acetic acid (0.5, 0.75 and 1.0%). It also showed that baby corn steeped in solutions containing higher concentrations of salt (6 - 8%) and acid (0.75 to 1.0%) had lower total plate count and at lower concentrations of salt (2 - 5%) and acid (0.5%) had higher total plate count. Curing of blanched baby corn with 15% salt showed longer shelf life (45 days). If we use beyond 15% concentration of salt, product goes mushy.

Key words: Baby corn, steeping, curing, sodium chloride, acetic acid, microbiological assay.

INTRODUCTION

Baby corn is almost sweet corn and harvested just as it has begun to develop. Specialized cultivars of sweet corn are employed for its production, although one can produce baby corn from standard varieties as well. Baby corn is high in folate and B-vitamins group, 4 ounces provides 31% of the RDA. It is a good source of several other nutrients too. The same serving size also provides 13% of the potassium, 14% of the B-6, 10% of the riboflavin, 17% of the vitamin C and 11% of the fiber adults need each day. Yellow corn contains carotenoids, these are the substances that help prevent coronary artery disease, certain cancers and cataracts (Carol et al., 1999).

Baby corn preserved in brine and packed in glass jars is of higher quality. Although product is available directly from Thailand in this form, at least one U.S. processing firm purchases canned product, then re brines and packs it in glass jars. Baby corn in glass jars is a specialty item found mostly in gourmet supermarkets. Individually quick frozen (IQF) baby corn, which is used most often as an ingredient for prepared foods, has possibly the smallest U.S. market relative to other processed baby corn because of its high price. Baby corn adds a special, gourmet touch to many dishes and salads. Its miniature size is appealing, as is the taste, color and crunch (Anonymous, 1995).

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. Baby corn is a very economic crop as the farmers get an estimated net income of Rs. 16000 per acre from single crop (Kapoor,

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2002). They could be benefited by taking 3 or more crops from same piece of land as this crop matures with in 60 days. Staggered sowing of crop can be done to maintain the supply as per the market requirements (Sharma et al., 2001).

High cost of packaging material, storage, transportation and high energy requirements are some limiting factors of canning and freezing which motivate us to develop low cost technologies like steeping and curing of baby corn. Even the farmers can also be benefited by adopting these low cost technologies at their farm gate and can fetch remunerative prices from their produce. But it is mandatory to have microbiological assay of the product for domestic as well as export marketing (CAC/GL 21-1997). Therefore, the study was planned with the objective of analyzing the microbiological changes in steeped and cured baby corn.

MATERIALS AND METHODS

Studies on development of low cost technologies for preservation and processing of baby corn, that is, steeping and curing and changes in their microflora were carried out in the department of food science and technology, Punjab agricultural university, Ludhiana.

Standardization of method of steeping preservation of baby corn

For standardization of steeping preservation of baby corn (*Zea mays L.*, family *Poaceae*) (Thavaprakaash et al., 2006), steeping solutions with varying concentrations of acetic acid, LR (SD Fine Chemical, Mumbai) that is, 0.5 to 2.0% and sodium chloride, that is, 2 to 8% were prepared. The fresh solution was analyzed for acidity, salt and total soluble solids. Baby corn cobs were dehulled manually. Silk was removed. Known amount (100 g) of blanched and unblanched baby corn cobs were filled into glass jars of 9 each treatment. Steeping solution (200 ml) was added to the jars and was marked accordingly. Jars were closed with air tight lids. Samples were kept both at room temperature (12 - 36°C) and refrigera-tion temperature (2 - 5°C). The changes in composition, that is, salt, acid and total soluble solids of solutions and corn cobs were studied. Optimum concentration of solution was found by equilibrium attained in the samples.

Salt and acid analysis

Salt (as sodium chloride), total soluble solids and titratable acidity of steeped, fresh baby corn and steeping solution were analyzed by following the methods described by Ranganna (2004).

Salt content of cobs and steeping solution was estimated by titrimetric method using silver nitrate solution (0.1 N) was used to estimate. Known weight (2 g or 2 ml) of crushed cobs was diluted to volume 50 ml using distilled water. Then known volume of aliquot was titrated against silver nitrate solution (0.1 N) using potassium chromate as indicator till the reddish brown tinge persisted after brisk shaking. Blank determination was carried out using water only.

The total soluble solids (°Brix) were determined using hand refractometer with range 0 - 32°B (Erma, Tokyo) and readings were expressed as °B at 20°C temperature using reference tables.

Titratable acidity was determined by titrating known quantity of water extract of cob (10 ml) against standardized 0.1 N NaOH using a few drops of 1.0% phenolphthalein solution as indicator to pink end-point which should persist for 15 s. Results were expressed as percent anhydrous acetic acid for fresh baby corn and as percent anhydrous acetic acid for steeped baby corn.

Microbiological analysis

Total plate counts (TPC)

The microbiological analysis and enumeration of raw and steeped baby corn was conducted by standard pour plate method (APHA, 1984) using nutrient agar and glucose yeast extract agar medium by serial dilution method. Aseptically 10 g of sample was mixed in 90 ml of distilled water by blending in magnetic stirrer for half an hour. This 10^{-1} dilution was further diluted aseptically. After transferring 1 ml of diluted samples in petri plates, molten agar was poured. The plates were swirled clockwise and anti clockwise for uniform mixing. After solidification of the medium in the plates, the plates were incubated at 37°C in inverted position for 48 h. After incubation, colonies were counted and expressed as:

TPC (cfu/g) = mean colony count x dilution factor

Statistical analysis

The data on microbial quality of cured and steeped baby corn were statistically analyzed and subjected to analysis of variance (ANOVA) using factorial experiments in completely randomized design (CRD) (Singh et al., 1991).

RESULTS AND DISCUSSION

Standardization of the method of steeping preservation

For standardization of the method of steeping preservation, both blanched (blanching treatment standardized at 4.0 min with peroxidase enzyme test) and unblanched samples were kept at room and refrigeration temperatures (Tables 1 - 4). 3 main parameters studied were total soluble solids (°Brix), acetic acid and salt along with the visual observation for appearance. It was observed that changes in TSS of steeping solutions varied with the initial concentrations of TSS in the solution during storage. There was a decline in TSS of solution during storage at higher concentrations > 7.2% while there was an increase in the TSS at lower concentrations < 6.5%. There were very slight changes in TSS of solution in the range of 7.0 to 7.2% showing that equilibrium TSS for baby corn was in this range. The pattern of changes in TSS, salt and acid were almost similar in steeping solution used both for blanched and unblanched baby corn kept at room and refrigeration temperature. The changes in TSS of solutions may be attributed to the penetration of salt and acid into the baby corn from the solution or to the leaching of soluble material from baby corn into steeping solution and also due to the osmosis (Ramah et al., 1999 and Sandhu and Aggarwal, 2001). However, there were abnormal changes in TSS of steeping solutions in which fungal growth took place, which might have altered the composition of steeping solution.

Table 1. Initial and final *composition of steeping solution used for unblanched baby corn kept at room temperature.

Sample code	Composition of steeping solution						Type of spoilage	Visual Appearance of fungus/ turbidity in days
	TSS (^oBrix)		NaCl (%)		CH_3COOH (%)			
	I	F	I	F	I	F		
1	2.1	3.2	2.02	0.81	0.87	0.36	Fungus	8
2	3.0	4.4	2.04	0.98	1.26	1.56	Browning	
3	3.2	4.2	1.99	0.96	1.56	1.50	Browning	
4	3.5	4.2	2.04	1.40	2.01	1.47	Browning	
5	4.2	5.4	3.92	2.97	1.08	0.88	Fungus + turbidity	10
6	5.0	5.6	4.15	2.12	1.44	1.06	Browning	
7	5.2	5.8	4.03	2.83	1.56	1.33	Browning	
8	5.6	6.2	4.27	3.48	2.10	1.58	Browning	
9	6.6	6.4	6.23	5.29	0.81	0.83	Turbidity + fungus	7
10	7.0	7.1	6.26	5.91	1.14	1.09	Browning	
11	7.0	7.2	6.40	5.83	0.56	1.21	Browning	
12	7.2	7.2	6.19	5.74	2.13	1.45	Browning	
13	8.0	7.8	8.13	6.89	0.78	0.79	Turbidity	9
14	8.6	8.4	7.98	6.81	1.17	1.11	Browning	
15	9.2	9.8	8.13	6.76	1.56	1.15	Browning	
16	9.2	9.8	8.16	7.15	2.07	1.43	Browning	
CD($P \leq .05$)	T-0.231 C- 0.816 $x10^{-1}$ TxC - 0.32		T-.23 $x10^{-1}$ C-0.82 $x10^{-2}$ TxC 0.32 $x10^{-1}$		T-.23 $x10^{-1}$ C-0.82 $x10^{-2}$ TxC - .326 $x10^{-1}$			

Treatments (T), Composition (C)
* Average of 3 values. Final composition after 45 days

Table 2. Initial and final *composition of steeping solution used for blanched baby corn kept at room temperature.

Sample code	Composition of steeping solution						Type of spoilage	Visual Appearance of fungus/ turbidity in days
	TSS (^oBrix)		NaCl (%)		CH_3COOH (%)			
	I	F	I	F	I	F		
1	2.1	3.2	2.02	1.36	0.87	0.79	Turbidity	12
2	3.0	3.4	2.04	1.39	1.26	1.18	No	
3	3.2	4.0	1.99	1.77	1.56	1.28	No	
4	3.5	4.2	2.04	1.78	2.01	1.65	No	
5	4.2	5.2	3.92	3.05	0.88	0.64	Turbidity	16
6	5.0	5.8	4.15	3.53	1.44	0.77	No	
7	5.2	5.8	4.03	3.70	1.56	1.09	No	
8	5.6	6.0	4.27	3.78	2.10	1.67	No	
9	6.5	6.8	6.23	4.8	0.81	0.63	Slight turbidity	18
10	7.0	7.2	6.26	5.2	1.14	0.71	No	
11	7.0	7.2	6.11	5.4	1.56	1.13	No	
12	7.2	7.4	6.19	5.65	2.13	1.62	No	
13	8.0	8.2	8.13	6.28	0.78	0.40	No	
14	8.6	9.0	7.98	6.14	1.17	0.69	No	
15	9.2	9.0	8.13	6.55	1.56	0.90	No	
16	9.2	9.2	8.16	6.64	2.07	1.44	No	
CD($P \leq 0.05$)	T-0.23 C-0.816 x 10^{-1} T x C - NS		T-0.245 x 10^{-1} C-0.868 x 10^{-2} TxC-0.347 x 10^{-1}		T-0.229 x 10^{-1} C-0.812 x 10^{-2} TxC - .325 x 10^{-1}			

Treatments (T), Composition (C)
Average of 3 values. Final composition after 45 days.

Initial sodium chloride content of steeping solution varied from 1.10 to 8.16%. The final concentration of sodium chloride in steeping solution decreased in all packages both in unblanched and blanched samples kept at room and refrigeration temperature. The absorption of sodium chloride by baby corns was higher at

Table 3. Initial and final *composition of steeping solution used for unblanched baby corn kept at refrigeration temperature.

Sample code	Composition of steeping solution							Visual appearance of fungus/ turbidity in days
	TSS (^oBrix)		NaCl (%)		CH_3COOH (%)		Type of spoilage	
	I	F	I	F	I	F		
1	2.1	2.8	2.02	1.39	0.51	0.34	Browning + turbidity	30
2	3.0	3.4	2.04	1.41	1.26	1.09	Browning	
3	4.2	4.2	4.42	3.15	0.49	0.31	Browning + turbidity	30
4	5.0	5.0	4.15	3.04	1.14	0.87	Browning	
5	6.8	7.0	6.23	4.21	0.53	0.35	Browning	
6	7.2	7.2	6.26	4.38	1.14	0.89	Browning	
7	8.8	8.8	8.13	6.38	0.54	0.38	Browning	
8	9.0	9.0	8.09	6.41	1.07	0.81	Browning	
CD ($P \leq 0.05$)	T-0.23 C-0.117 T x C - NS		T-0.23 x 10^{-1} C-0.118 x 10^{-1} T x C -0.333 x 10^{-1}		T-0.23 x 10^{-1} C-0.117 x 10^{-1} T x C - 0.332 x 10^{-1}			

Treatments (T), Composition (C)
*Average of 3 values. Final composition after 45 days

Table 4. Initial and final *composition of steeping solution used for blanched baby corn kept at refrigeration temperature.

Sample code	Composition of steeping solution							Visual Appearance of fungus/ turbidity in days
	TSS (^oBrix)		NaCl (%)		CH_3COOH (%)		Type of spoilage	
	I	F	I	F	I	F		
1	2.1	2.8	2.02	1.38	0.51	0.34	Turbidity	30
2	3.0	3.6	2.04	1.41	1.26	1.09	No	
3	4.2	4.4	3.92	3.05	0.49	0.31	Turbidity	30
4	5.0	5.0	4.15	3.04	1.14	0.87	No	
5	6.8	7.2	6.23	4.40	0.53	0.35	No	
6	7.2	7.2	6.26	4.38	1.14	0.89	No	
7	8.8	8.8	8.13	6.45	0.54	0.38	No	
8	9.0	9.0	8.09	6.51	1.07	0.86	No	
CD ($P \leq 0.05$)	T-0.23 C-0.118 T x C - NS		T-0.23 x 10^{-1} C-0.116 x 10^{-1} T x C -0.330 x 10^{-1}		T-0.25 x 10^{-1} C-0.127 x 10^{-1} T x C - NS			

Treatments (T), Composition (C)
*Average of 3 values. Final composition after 45 days.

was higher at higher concentrations. Blanched samples resulted in less absorption of sodium chloride as compared to unblanched baby corns, whereas difference in temperature of storage had no effect on absorption of sodium chloride and acetic acid. The less absorption in the blanched samples may be due to coagulation of proteins by heat treatments, thus forming a protective layer to resist the penetration of salt into the cobs (Sandhu and Aggarwal, 2001).

Acetic acid and refrigeration temperature was found more effective in controlling the fungal growth than sodium chloride (Sandhu and Aggarwal, 2001). Turbidity decreased with increase in acetic acid concentration in steeping solution. Sandhu and Aggarwal (2001) also found acetic acid more effective in controlling the fungal growth than sodium chloride in steeped mushrooms. Among varied initial compositions, optimum acetic acid concentration was found to be 0.75% along with 6.0% of sodium chloride. Fungal growth was observed in different samples after different time intervals during storage. Time interval (days) after which the fungus appeared in storage is given in Tables 1 - 4, along with their sample codes. Discoloration was started immediately after steeping in all unblanched samples kept at room temperature.

Microbiology of steeped baby corn

Shelf life evaluation of steeped samples of baby corn at monthly interval showed marginal increase in microbial load on storage. Total plate count was found to decrease with increase in salt (2 - 8%) and acid (0.5 - 1%) concentration. During storage TPC was found to increase significantly ($P \leq 0.05$) at all concentrations of salt and acid in all the samples. Elevated total plate count was found at

Table 5. Effect of storage on total plate count (cfu/g) of blanched steeped baby corn cobs.

Steeping solution strength		Storage period (months)				Salt means
NaCl (%)	CH_3COOH (%)	1	2	3	4	
2.0	0.50	7.0×10^2	8.4×10^2	9.6×10^2	1.3×10^3	753.44
	0.75	5.9×10^2	6.8×10^2	7.3×10^2	8.9×10^2	
	1.00	4.1×10^2	5.5×10^2	6.1×10^2	7.9×10^2	
3.0	0.50	5.6×10^2	5.9×10^2	6.2×10^2	6.8×10^2	418.472
	0.75	3.8×10^2	4.6×10^2	5.3×10^2	6.9×10^2	
	1.00	1.1×10^2	9.9×10^1	1.1×10^2	1.8×10^2	
4.0	0.50	1.4×10^2	1.8×10^2	2.1×10^2	2.3×10^2	111.555
	0.75	5.5×10^1	7.8×10^1	8.3×10^1	8.7×10^1	
	1.00	3.9×10^1	4.8×10^1	4.9×10^1	5.4×10^1	
5.0	0.50	9.9×10^1	1.2×10^2	2.3×10^2	2.7×10^2	101.722
	0.75	6.5×10^1	7.8×10^1	8.3×10^1	8.7×10^1	
	1.00	3.9×10^1	4.8×10^1	4.9×10^1	5.4×10^1	
6.0	0.50	4.4×10^1	4.8×10^1	5.2×10^1	6.0×10^1	41.250
	0.75	3.6×10^1	4.0×10^1	4.3×10^1	4.4×10^1	
	1.00	2.9×10^1	2.8×10^1	3.4×10^1	3.8×10^1	
7.0	0.50	4.0×10^1	4.6×10^1	5.0×10^1	5.4×10^1	35.500
	0.75	2.8×10^1	3.3×10^1	3.4×10^1	3.6×10^1	
	1.00	2.0×10^1	2.4×10^1	3.0×10^1	3.0×10^1	
8.0	0.50	3.6×10^1	4.2×10^1	4.5×10^1	4.8×10^1	31.416
	0.75	2.7×10^1	2.9×10^1	3.1×10^1	3.1×10^1	
	1.00	2.0×10^1	2.0×10^1	2.2×10^1	2.8×10^1	
	Storage mean	166.699	195.222	219.793	271.635	
	Acid mean	296.690	216.309	127.010		

CD ($P \leq 0.05$)
Salt: 2.486, Acid: 1.628, Storage: 1.879, Salt x acid: 4.307, Salt x storage: 4.973, Acid x Storage: 3.256
Salt x acid x storage: 8.614

Figure 1. Fungal growth steeped baby corn (unbalanced).

found at 2 - 5% sodium chloride concentration and 0.5% acetic acid concentration. The significant ($P \leq 0.05$) decrease (2.9×10^1 to 2.0×10^1 cfu/g) in total plate count was found in samples stored at higher (6 - 8%) sodium chloride concentration and (1.0%) acetic acid concentration (Table 5). Figure 1 shows the fungal growth in the steeped baby corn samples at lower concentration of salt and acid. On the basis of microbiological analysis of steeped baby corn for 4 months, the concentrations of sodium chloride and acetic acid optimized for storage of steeped baby corn are 6 - 8% and 0.75 - 1.0% respectively.

Curing of baby corn

Effect of storage and salt concentration on cured baby corn is presented in Table 6. In the experiment, it was observed that the curing process preserved cobs for short period of time even after blanching. At high salt concentration (20%) cobs dissolved due to softening effect of sodium (Figure 2) whereas at low salt concentrations (5 and 10%) fungal growth was observed. Blanched baby corn remained preserved with 15% salt concentration without any fungal growth up till 45 days. Unblanched samples were preserved for very small duration of time, that is, 2 - 15 days with salt concentrations of 5 - 20%.

Conclusion

From the studies it is concluded that in steeped baby corn, higher concentrations of salt (6 - 8%) and acid (0.75 to 1.0%) were found to contain significantly ($P \leq 0.05$) lo-

Table 6. Shelf life of cured baby corn at different salt concentrations.

Sample	Salt concentration (%)	Fungal growth (days)	Presumptive Inference
Blanched	5	6	*Fusarium* spp.
	10	30	*Aspergillus* spp.
	15	45	Fermented odour
	20	23	Cobs dissolved
Unblanched	5	2	*Fusarium* spp.
	10	12	*Aspergillus* spp.
	15	16	*Aspergillus* spp.
	20	20	*Aspergillus* spp.

Figure 2. Cured baby corn (dissolved) with 20% salt concentration.

wer micro flora, that is, total plate count from 3.6×10^1 to 2.0×10^1 CFU/g than lower concentrations of salt (2 - 5%) and acid (0.5%). The curing of blanched baby corn with 15% salt showed longer shelf life (45 days). However curing process of baby corn was found to be short-term preservation method.

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