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Development and studies on sweet corn blend milk yogurt

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Abstract
The market potential of total dairy based fermented product was estimated to be around Rs.5, 20,780 crores in 2011. Yoghurt is one of the important fermented products. It has numerous health benefits and it is widely consumed product in India. The sweet corn has excellent nutritive value. Cow milk (4.5%) & sweet corn milk mixture was taken at different combinations ratios (20:80, 40:60, 60:40, 80:20, 70:30 and 100:0). The blend of 30% sweet corn milk and 70% cow milk (4.5%) was used for the development of probiotic sweet corn blend milk yoghurt. The premix was fermented with 2% probiotic culture: *Streptococcus thermophilus* MTCC 1938 and *Lactobacillus acidophilus MTCC 447* at 42ºC for 4h. It was stored for 16 days under refrigerated condition. The product characteristics like pH, whey drainage, Syneresis, water holding capacity, total soluble solids and colour were measured during 16 days of storage studies. The statistical significance of different composition on properties was done by one way ANOVA ($p < 0.05$). All the parameters showed significance with respect to composition Based on all the results, the product had good physio-chemical characteristics.

Keywords: sweet corn; cow milk (4.5%); *Streptococcus thermophilus, Lactobacillus acidophilus*

Introduction
Sweet Corn *(Zea mays* L. ssp. saccharata) is one of the largest vegetable crops grown. Primary interest has been directed to carbohydrates, since in the milky stage, when the grain is harvested for food use, carbohydrates determine flavor and texture [1]. Corn kernels have a high nutritional value. They contain large amounts of proteins, and most vitamins and microelements. They are also rich in sugars. Sweet corn, used as a vegetable, is suitable for direct consumption as its kernels, at milk ripeness, are soft and contain 74–76% of water. Moreover, kernels of very sweet varieties contain many sugars easily soluble in water (6–12%).Valuable components of sweet corn kernels include also such microelements as selenium, chromium, zinc, copper, nickel and iron.

India ranks first in terms of milk production and accounts for 15% of the global production. India is the world's largest and fastest growing markets for milk and milk products. The present annual milk production in India accounts to 117 million tons from 2010. According to India's NDDB, the total dairy production is estimated to be growing at 4 percent annually and further forecasted to increase to record 121.5 million tons by 2011 [2]. But lactose intolerance, cholesterol content, and allergenic milk proteins are found to be the major drawbacks related to the intake of milk. It is found that 70% of the world's adults react badly to milk but it does not necessarily mean they will react to yoghurt. Individuals who are sensitive to lactose have been found to tolerate yoghurt much better than equivalent amounts of milk due to lower levels of lactose. Yoghurt as health food has attracted the attention of the middle class in India because of increased disposable income and better health-benefit awareness. The yoghurt drinks are also becoming popular among consumers.

Products like spiced buttermilk and flavoured lassi of several brands are available in new-style grocery stores. It is estimated that 7% of the total milk is utilized for yoghurt /curd/ chakka production in the country. Despite the many varieties, yogurt can be classified by the physical characteristic of the gel into two types, set or stirred. Set yogurt is fermented in the container; and stirred yogurt is fermented in a large tank, and then transferred to containers. Drinking yogurt is a variation of stirred yogurt with low viscosity. Yogurt is produced in full, medium and low fat varieties; and may be either plain or with added fruit and flavor. Several workers have investigated animal-milk or soy-milk yogurts, but little work has been done on corn–milk yogurt. The industrial production of yogurt has increasingly developed worldwide due to the

nutritional benefit of milk constituents and live lactic acid bacteria (LAB). However, consumption of cows' milk is avoided by vegetarian people and people who are allergic to cows' milk. Thus, there have been many attempts to make yogurt from a variety of food resources. Production of yogurt from corn milk was aimed to combine the good sensory characteristics of the corn milk with the well-known yogurt flavor [3].

Materials and Methods

Materials

Milk (4.5% fat) and sweet corn were obtained from local market. *Streptococcus thermophilus MTCC 1938 and Lactobacillus acidophilus MTCC 447* were used to prepare sweet corn blend milk yoghurt.

Preparation of Corn milk

To prepare the corn milk, the corn cobs were firstly husked, the silks removed and washed with water. The seeds were then separated from the cleaned cobs using knives. The corn seeds were grinded using a grinder. 50 ml of water was added for 100 g of corn seeds during grinding. The slurry was then filtered using a filter to produce a milk solution. The corn milk solution was heated to 80°c for 10 mins and stored at -18°C until use. Both corn and sweet corn milk were prepared by this method.

Starter culture preparation

Stock culture

The Slant cultures of *Streptococcus thermophilus MTCC 1938 and Lactobacillus acidophilus MTCC 447* were grown by inoculating into M17 broth and MRS medium respectively for 18 h at 37°C. One loop of each culture was transferred into 10 ml of litmus milk prepared by mixing 16% (w/v) skim milk powder (SMP) and 0.3% (w/v) yeast extract. The inoculated culture was incubated for 18 h at 37°C and stored at 5°C until use.

Mother culture

An individual mother culture was freshly prepared before conducting the experiment by inoculating one loop of stock culture into 100 ml of sterilized milk medium containing 16% (w/v) SMP and 0.1% (w/v) yeast extract. The inoculated culture was incubated at 37°C for 18 h and kept at 5°C until use.

Standardization and preparation of cow milk blended Sweet corn milk yoghurt

The standardization of the blend was done with various proportions of cow milk and sweet corn milk such as 100:0, 80:20, 70:30, 60:40, 40:60 and 20:80. The blends were chosen in such a way that the final volume was fixed as 100 ml. The blends were added and mixed with skim milk powder so as to maintain the total solids to 14%. The premixes were pasteurized by holding the temperature at 90ºC for 5 minutes. Then they were allowed to cool down to 40ºC, which was checked using a thermometer. Each combination was inoculated with 2% (w/v) each probiotic cultures (*Streptococcus thermophilus* and *Lactobacillus acidophilus)*. The cultures and mixed properly and was incubated at 42ºC for 4 hours without any disturbance. The final product obtained was a set-yoghurt.

Table 1: Blending of various proportions of cow milk and Sweet corn milk

Sample No.	Cow Milk (A)	Cow Milk Total Solids (TS_A) g	Sweet Corn Milk (B)	Sweet Corn Milk Total Solids (TS_B) g	Total Solids (TS_A +TS_B) g	Skim Milk Powder (SMP) g
1.	100	13	0	0	13	1
2.	80	10.5	20	1.47	11.97	2.03
3.	70	9.1	30	2.6	11.7	2.3
4.	60	7.7	40	3.72	11.42	2.58
5.	40	5.2	60	5.26	10.46	3.54
6.	20	2.6	80	7.84	10.44	3.56

Fig 3.1A: Yoghurt made with 80:20 of cow milk & sweet corn milk

Fig 3.1.B: Yoghurt made with 70:30 of cow milk & sweet corn milk

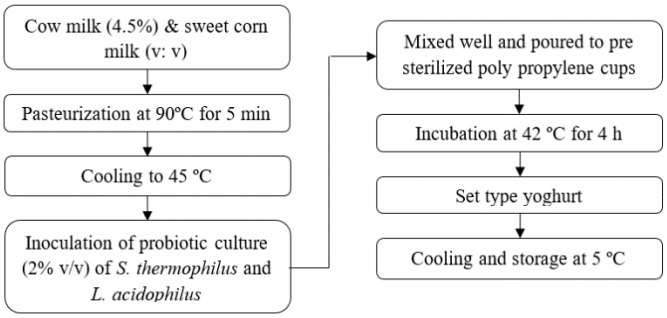

Fig 3.2: Optimized flow diagram for preparation of Sweet corn milk blend cow milk yoghurt

Physico-chemical analysis

pH

The pH of the sample was determined by using pH meter. The samples of fermented milks were filled in clean 100 ml glass beakers with gentle pressing so that no air pockets remained. The temperature for measuring the pH was maintained uniformly for all the samples. The electrodes were inserted into the product at appropriate places. Average of three pH readings was taken to establish the correct pH. The electrodes were cleaned after every observation.

Whey drainage

Whey drainage was removed from the corn milk yogurt, using a syringe within 24 h after the yogurt fermentation was completed. The relative amount of whey drained off (in ml per 100 ml of initial sample) was calculated as the whey drainage. This method was modified from the method of Fiszman *et al* [4].

Total soluble solids

The total soluble solids were measured by methods outlined in AOAC[5] by Refractometer. The glass slide of Refractometer was cleaned thoroughly with water and wiped with paper before and after use. About 1 g of sample was placed in glass slide and the lid was closed slowly. The brix value was measured by viewing it under bright white light.

Syneresis

The analysis was carried out within 24 h after the yogurt fermentation was completed. The analysis was done using a Whatman filter paper number 1 to cover a Buchner funnel. After that, 20 g of the yogurt was spread in a thin layer to cover the surface of the filter paper. The liquid that passed through the filter paper was collected and recorded. The percentage syneresis was calculated as the weight of the liquid divided by the weight of the initial sample, multiplied by 100. This method was modified from the method of Wu [6] *et al*., to measure the syneresis of corn milk yogurt.

Water holding capacity

The water holding capacity was measured by a centrifuge method according to a modified method of Parnell-Clunies[7] *et al*. Within 12 h of the production of corn milk yogurt, a 10 g sample was centrifuged at 2,000 g for 60 min at 10°C. The supernatant was then removed within 10 min and the wet weight of the pellet was recorded. The water holding capacity was expressed as the percentage of pellet weight relative to the original weight of corn milk yogurt.

Color

Color of corn milk yogurt was measured by Hunter colour lab device (Minolta Data Processor DP-301, Chroma Meter CR-300 Series, Japan), using the CIE L*a* b scale values.

Results and Discussion

1. Effect on pH in Sweet corn blend milk yoghurt during 16 days of storage studies

During acidification of milk, the pH decreases from 6.7 to less than or equal to 4.6. Gelation occurs at pH 5.2 to 5.4 for milk that was given a high heat treatment. Milk casein was a source of amino acids and nitrogen for growth of LAB [8, 9]. Previous work discovered that both sodium caseinate and whey protein hydrolysate could enhance lactic acid production in soymilk yogurt [10]. In case of cow milk yogurt, however, whey protein stimulated the growth of yogurt starter bacteria that produce lactic acid [11].

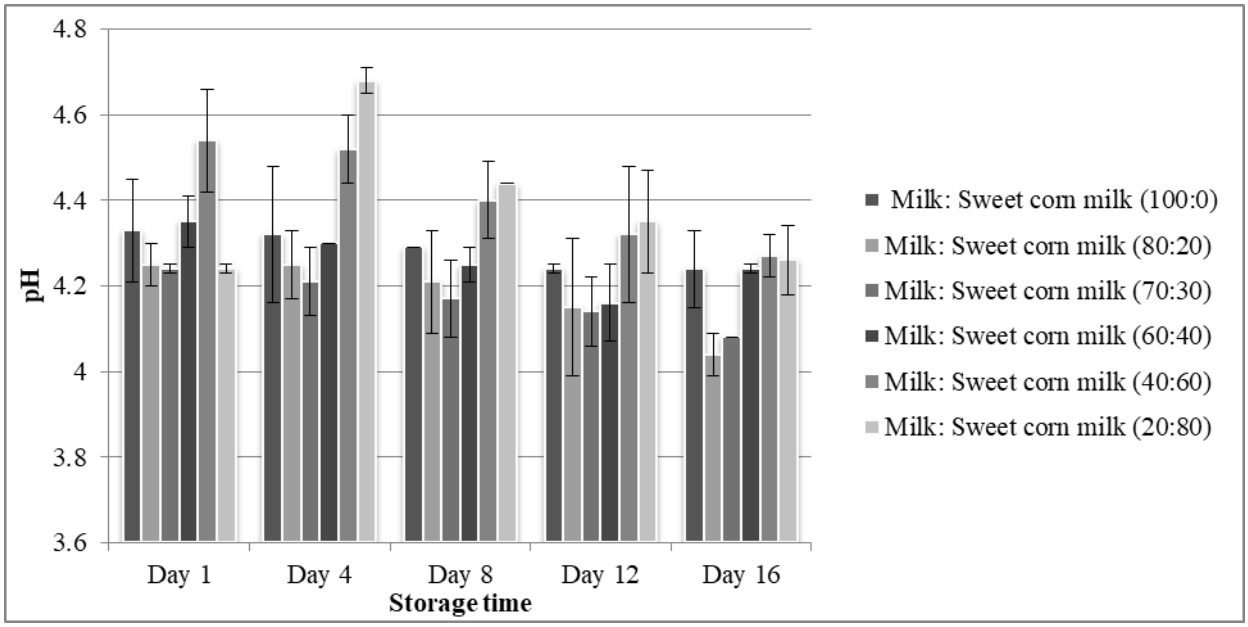

Fig 1: Effect on pH in Sweet corn blend milk yoghurt during 16 days of storage studies

The composition with higher concentration of milk sugar showed better acid production. From the graph, composition containing 80 and 70 % of cow milk with 20 and 30 % of sweet corn milk showed a similar trend of decrease in pH values throughout the storage studies. from the graph, the pH values for different combinations of cow milk (4.5% fat) and sweet corn milk like 100:0, 80:20, 70:30, 60:40, 40:60 and 20:80 in day 1 and day 16 are 4.33± 0.12, 4.25 ± 0.05, 4.24 ± 0.01, 4.35 ± 0.06, 4.54± 0.12, 4.24 ± 0.01 and 4.24 ± 0.09, 4.04 ± 0.05, 4.08± 0.00, 4.24 ± 0.01, 4.27 ± 0.05,and 4.26 ± 0.08 respectively

2. Effect on whey drainage in Sweet corn blend milk yoghurt during 16 days of storage studies

Spontaneous whey separation is related to an unstable network, which can be due to an increase in the rearrangements of the gel matrix or it can be induced by damage to the weak gel network [12].

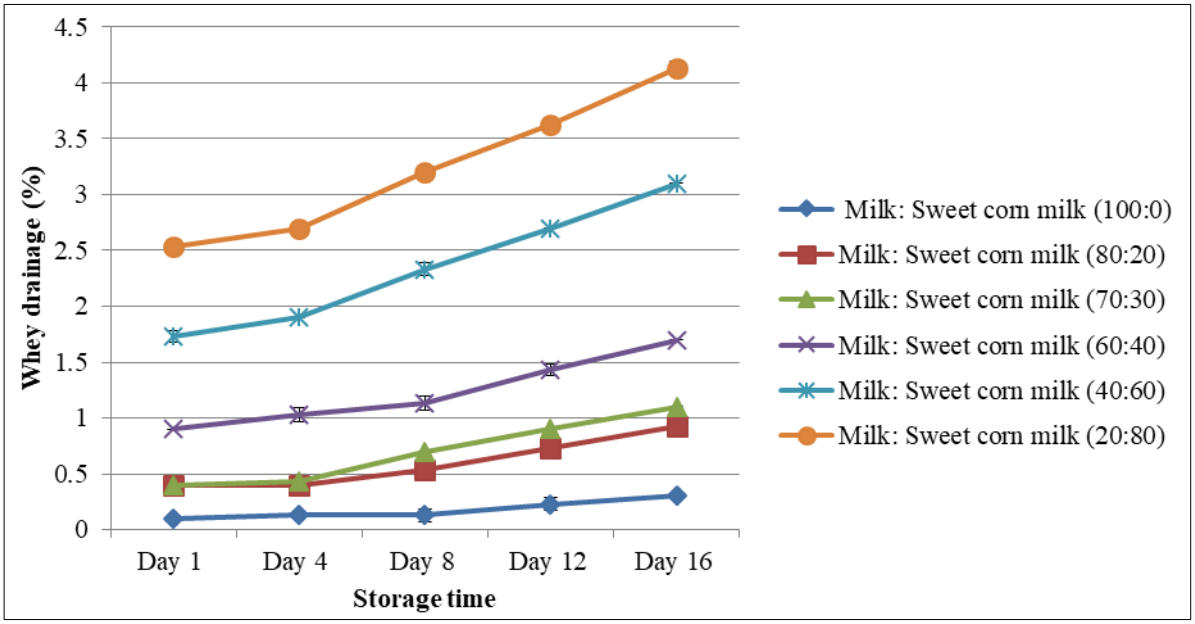

Fig 2: Effect on whey drainage in Sweet corn blend milk yoghurt during 16 days of storage studies

The graph shows an increase in whey drainage in higher proportion of sweet corn milk of value 4.1 ml at end of 16 of storage studies. The whey drainage was higher in composition consisting of higher proportion of sweet corn milk. The decrease in milk proportion affected the strength of gel being formed. During storage time the increase in wheying off is observed in all the samples. The samples containing 20 and 30 % of sweet corn milk showed less change comparative to that of high concentration. Milk protein enhances the gel consistency leading to les wheying off.

3. Effect on total soluble solids in Sweet corn blend milk yoghurt during 16 days of storage studies

Robinson [13] noted that the minimum solid concentration of cow milk yogurt was 8.2-8.65%, but the consistency of yogurt was greatly improved when the solids increased from 12 to 20%. Total soluble solids are measure of soluble compounds present. From the graph, yoghurt made with 70 % cow milk showed the changes as 8.67± 0.29, 8.67± 0.29, 9.16 ± 0.28, 9.5± 0.0, and 9.67± 0.29. The change in soluble solids can be attributed by the high acid content in the yoghurt which influences the components of the yoghurt to be solubilized during the storage time.

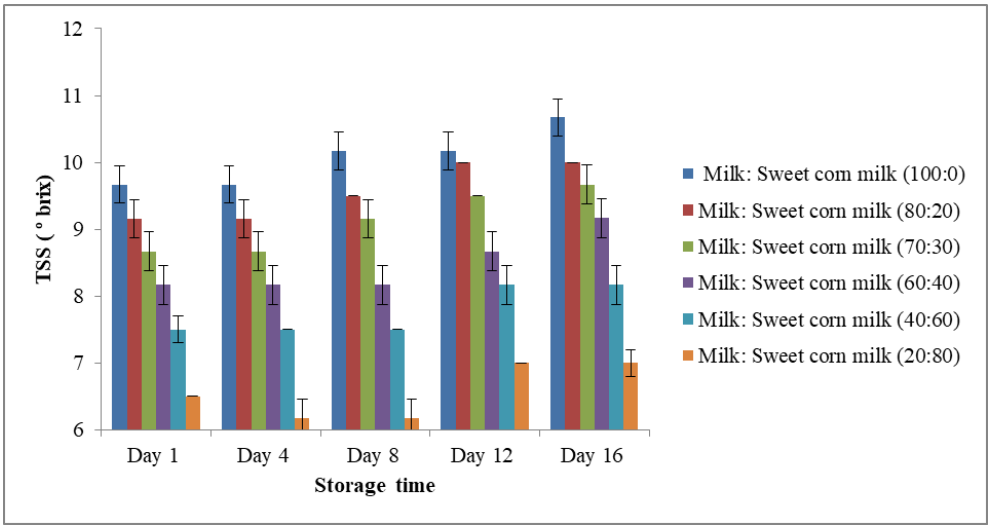

Fig 3: Effect on TSS in Sweet corn blend milk yoghurt during 16 days of storage studies

4. Effect on syneresis in Sweet corn blend milk yoghurt during 16 days of storage studies

In acid casein gels, the pore size is a reflection of the type of gel microstructure formed during the acidification process. Rearrangements in acid gel networks can cause ongoing fusion of casein particles and breakage of casein strands making up the network.

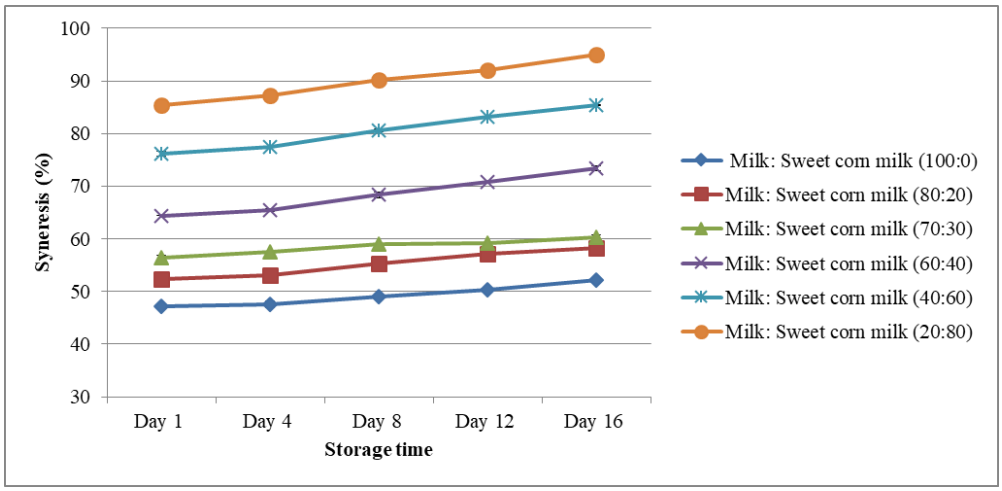

Fig 4: Effect on syneresis of probiotic Sweet corn blend milk yoghurt during storage studies

Syneresis is the result of weak gel in yoghurt. The lesser the consistency of yoghurt greater the whey discharge. The increase in syneresis was only 9.36 % for cow milk yoghurt. The blending of different ratios of corn milk resulted in increased syneresis value as 9.92 % for yoghurt made with 20 % of cow milk. But yoghurt with 30 % cow milk resulted only 6.5% increase during 16 days of storage studies.

5. Effect on water holding capacity

Zaleska, Ring, and Tomasik (2001) [14] studied a caseinate potato starch complex in yoghurt formation, the results showed that interactions between, phosphate moieties and hydroxyl groups of starch and amino moieties and peptides of caseins were involved in the complexes. They also suggested that water may potentially play an active role in the formation of the structured network. The centrifugation method is a measure of the water-holding capacity as a result of a high external force, i.e., resistance of the gel to compaction. The ability of yoghurt to hold the water can be found by this method.

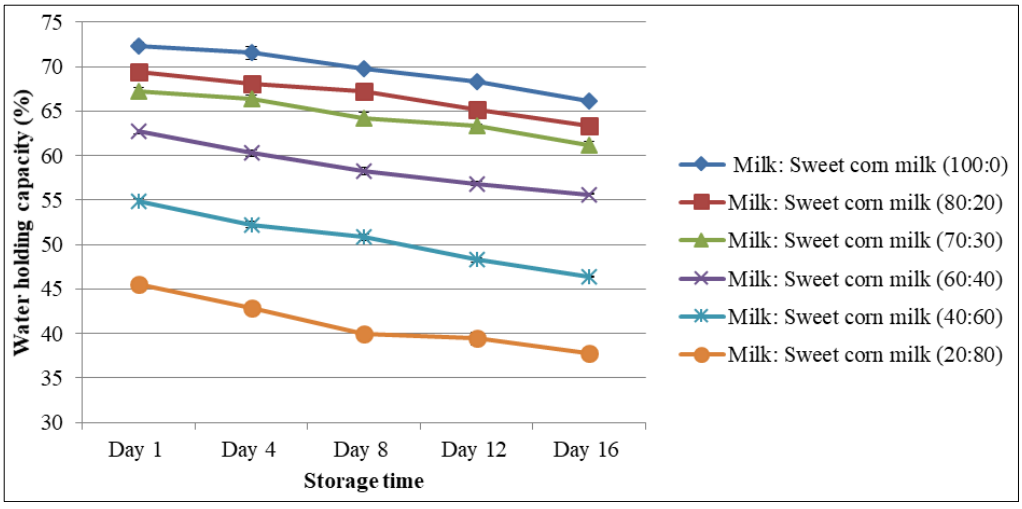

Fig 5: Effect on water holding in Sweet corn blend milk yoghurt during 16 days of storage studies

The variation in the results showed the need of milk proteins in making a strong gel layers in yoghurt which resulted in higher holding capacity. From the graph, the holding capacity for yoghurt made with 100, 80 and 70 % of cow milk were 66.14± 0.34, 63.36± 0.24, and 61.15± 0.43 respectively. Combination made with 70 % of corn milk is found to be suitable. The decrease in holding capacity was much higher when more than 40 % of corn milk was used in yoghurt making.

6. Effect on colour in Sweet corn blend milk yoghurt during 16 days of storage studies

The table shows the color dimensions including L* (Lightness), a*(+red;-green) and b*(+yellow;-blue). L* value is associated with white and black color and the higher positive value represents whiter color. Increasing values of L* indicates higher brightness of the sample. Positive values of a* indicates red color and negative values green color. b* value is associated with blue and yellow, a higher positive value represents a more yellow color and negative value indicates blue. The color of the corn milk yogurt was noticeably more yellow as compared with the cow milk yogurt Thus, the corn milk yoghurt had higher yellow component (lower L value) than the cow milk yoghurt. Carotene, that is primarily responsible for the yellow color of corn and cow milks [15, 16], should be considerably higher for the corn milk yoghurt.

Table 2: Colour analysis in Sweet corn blend milk yoghurt during 16 days of storage studies

Milk: sweet corn milk (v/v)	L*		a*		b*	
	Day 1	Day 16	Day 1	Day 16	Day 1	Day 16
White tile	94.00 ± 0.00	94.00 ± 0.00	-0.99 ± 0.00	-0.99 ± 0.00	1.85 ± 0.00	1.86 ± 0.00
100:0	87.14 ± 0.03	85.06 ± 0.06	-2.09 ± 0.03	-2.13 ± 0.08	11.79± 0.02	12.31± 0.03
80:20	85.75 ± 0.04	83.80 ± 0.06	-2.09 ± 0.04	-1.65 ± 0.07	12.57± 0.05	13.42 ± 0.07
70:30	84.25± 0.06	81.56 ± 0.06	-1.33± 0.02	0.43± 0.07	13.64± 0.05	14.65 ± 0.02
60:40	83.90 ± 0.04	78.56 ± 0.07	-0.96 ± 0.07	1.19 ± 0.08	14.74 ± 0.04	16.15± 0.08
40:60	82.21 ± 0.04	79.78 ± 0.04	0.57 ± 0.05	0.22 ± 0.03	22.18 ± 0.05	22.60 ± 0.08
20:80	78.89 ± 0.04	76.42 ± 0.09	1.64 ± 0.03	0.95 ± 0.02	25.63 ± 0.08	23.27 ± 0.02

L* (+ lightness; - darkness), a* (+red;-green), b * (+yellow;-blue)

From the table during 16 days of storage **s**tud**y** the storage time did not significantly (P≥0.05) influence the purity and color shade of yoghurts while the lightness was reduced with longer storage time.

Conclusion

The find out the optimal concentration of cow milk and sweet corn milk required in making yoghurt, different composition of Cow milk and sweet corn milk (100:0, 80:20, 70:30, 60:40, 40:60 and 20:80) were taken. Skim milk powder was added in every composition to maintain the total solids of 14g. The yoghurt properties were studied during 16 days of storage studies. The properties like pH, whey drainage, Syneresis, water holding capacity, total soluble solids and colour were studied. Based on the results composition made with 80:20 and 70:30 of cow milk and sweet corn milk were found to be best. In aim of developing sweet corn blend milk yoghurt higher ratio of sweet corn is always preferable. So 70:30 was selected for further study. The pH, whey drainage, Syneresis, water holding capacity, total soluble solids values of this optimized composition at 16 days were 4.18± 0.00, 1.1± 0.0, 60.26± 0.41, 61.15± 0.43 and 9.67 ± 0.29 respectively.

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