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ORIGINAL ARTICLE

Studies on Physico-Chemical Properties of Sweet Corn Milk

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ABSTRACT

The studies on physico-chemical properties of sweet corn milk, two type milk produced from sweet corn i.e. from un-boil corn i.e. corn milk -1 and sweet corn milk from boil corn i.e. corn milk -2 recorded the mean corrected pH meter reading value at 6.12 and 6.08 with the acidity at 0.20 and 0.19. The mean viscosity of sweet corn milk as 1.32 and 1.55 the range between 0.28 to 0.35 in corn milk -1 and in corn milk -2 0.50 to 0.58, respectively. The moisture content in sweet corn milk 1 & 2 mean value was 90.07 and 90.38 with respect to 1.08 and 1.17 fat content observed in corn milk. The protein content was registered 1.93 and 1.25 in corn milk 1&2 respectively lower protein content in sweet corn milk as compared with natural milk. The ash content ranged between 0.55 to 0.62 in corn milk -1 and in corn milk -2 ranges was 0.50 to 0.60, the mean value of ash content in corn milk 1&2 as 0.55 and 0.58 respectively. The total sugar ranged between 6.25 to 6.35 and 5.70 to 5.80, the mean value at 6.30 and 5.75 in corn milk 1&2 respectively. The total solids content in corn milk 1&2 registered the mean value at 9.93 and 9.62 in corn milk. Registered the colloidal stability of corn milk 1&2 measure the colloidal stability in cm with the time interval of 0, 3, 6, 9 and 12 hr, in corn milk -1 C.S was 10.00, 9.00, 8.71, 5.20 and 5.00. And in corn milk -2, C.S was 10.00, 9.50, 9.10, 8.87 and 7.50 at room temperature. And colloidal stability of corn milk 1&2 at refrigerator condition was 10.00, 9.50, 9.00, 8.67, and 7.50 and 10.00, 9.77, 9.60, 9.50 and 9.10 respectively. The heat stability of corn milk -1 was 3 min and 6 min at 60^0 c respectively and at 100^0 c was 2 min and 3 min, respectively.

KEY WORDS- *Sweet corn, Sweet corn milk, Physicochemical parameters*

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INTRODUCTION

Maize (*Zea mays*) is one of the important food crops in India. Corn grains contain carbohydrate in the form of starch, sucrose, fiber, and pentosan. The botanical name of Sweet corn is *Zea mays rugosa* and it is popularly known by many names as Indian corn, sweet corn, sugar corn, pole corn or even just corn. It is a variety of maize with high sugar content. Sweet corn (*Zea mays Saccharata*) and corn milk which is noted for its aroma and sweet taste contain saturated fatty acids (palmitate and stearat) and unsaturated fatty acids (oleat and linoleat). The corn protein has good amino acid composition, although it contains a little part of lysine and triphthopan. A 100 gm of corn milk contained 24 IU of vitamin A, 0.020 mg of vitamin B_1, 0.030 mg of vitamin B_2, 0.020 mg of vitamin B_6, 3.7 mg of vitamin C and 0.520 mg of niacin and very popular, especially among health conscious consumers, since it has nutritional benefits over other types of vegetable drink, it is also low in saturated fat and cholesterol. Due to its pleasant taste and nutritive value, it overcomes the problems of lactose intolerance and saturated fat of cow milk (USDA, 2004). Corn grains can be processed into corn milk, corn milk powder, corn-yoghurt, corn flakes, etc. which has healthy function, because it does not contain cholesterol. As the very few work has been found on use of sweet corn milk for preparation of dairy products except sweet corn milk yoghurt (Piyawan *et al*., 2010). To check the possibility of use of sweet corn milk in milk products, it is essential to develop the method of its preparation, know the physic-chemical properties of sweet corn milk. The importance of physico-chemical properties to the processor are to developed quality product, to evaluate the effect of processing on textural quality of product and to access the standards of raw materials. Till today, very little information is available on the physicochemical properties of sweet corn milk. The finding of this research may provide sufficient basis to conclude that use of sweet corn milk and modern processing technology for its production with acceptable quality at cheaper price as compared to whole milk could be manufactured and marketed in India. Possibility of reducing the price of milk and milk products is to

replace the commercially expensive milk products in part or whole by using cheaper edible non-milk origin ingredients like corn. The non-dairy solids can be successfully substituted in place of milk solid for preparing milk products. Such production will be comparatively cheap and within the purchasing power of the weaker sections of society who normally cannot purchase milk products.

Practices of converting milk into various milk products have developed years ago. It may be due to the milk is considered to be an adequate source of valuable macronutrients (fat, protein, lactose), vitamins and micronutrients (minerals), making it a 'whole some food' and perishable nature. It can serve as an excellent carrier product for extra nutrients and if enriched or fortified, it can satisfy the nutritional needs of the population. But dramatic increases in the cost of milk production due to the limited land availability, low milk production per animal, high cost for livestock management and more intention of farmer on agriculture than dairying have sent prices of milk, milk ingredients and milk products skyrocketing and threatening the profitability of this business (Wang, 1980). In spite of remarkable increase in milk production, the milk and milk products are out of reach of the vulnerable groups of weaker section of society due to its high cost. Such situation will be remain as it is, if the alternative will not come in coming days. This calls for development of low cost and healthy substitute for milk and milk products.

Non-dairy ingredients find a critical role in synergy of the chemical constituents of dairy foods to enhance their sensory, nutritional profile, at the same time influencing the cost of the resultant product. The search for a new and unconventional source of protein, carbohydrates, fat, vitamins, minerals and other health beneficial ingredients to meet the requirement of the ever expanding population is the urgent need of the present day and future also. Some people are more sensitive about consuming milk and milk products due to health consciousness, keeping away from saturated fats, cholesterol, lactose (for those ailing from lactose intolerance) etc. (Hirpara *et al.,* 2011). Now a days, nutrition scientists and dieticians have recommended minimum level of milk and milk product to be included in the food items of daily consumption (Burrington, 1999). By considering this facts alternatives to animal milk has been tried by different food researchers and scientist which fulfilled the consumer's life style, their demographics, socio-economic, cultural background and their environment.

Hence, efforts have been made to prepare milk using sweet corn milk after thinking the significance of traditional knowledge, their combination with scientific know-how and the demand from consumers for variety and health conscious.

MATERIAL AND METHODS

The material used and methods employed during the course of present investigation for preparation sweet corn milk from sweet corn are as under.

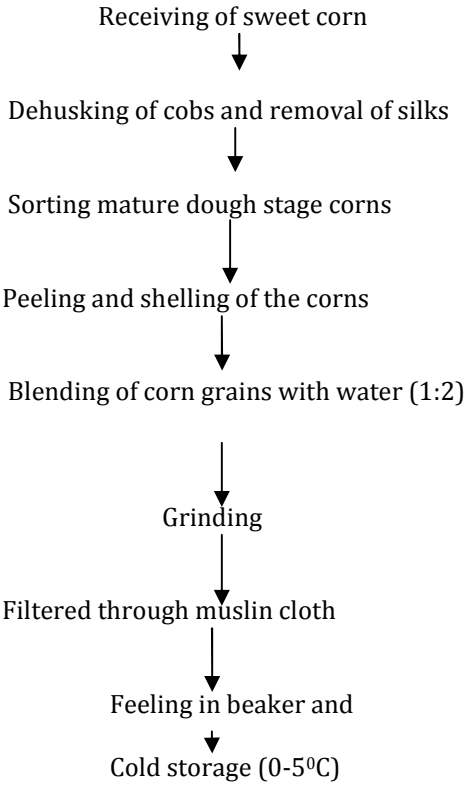
Sweet corn

Fresh sweet corn variety Masti (F1, Hybrid) of Nuziveedu seeds Pvt. Ltd was purchased from the local market of Latur city and used for the experimental purpose. The sweet corn was selected at dough stage (milky) for milk preparation.

Preparation of sweet corn milk:

The sweet corn milk was prepared as per the method Piyawan *et al*. (2010) with slight modification. The sweet corn variety, Masti (F1, Hybrid) of Nuziveedu seeds Pvt. Ltd was use after harvested on the 23rd day (at dough stage). Masti (F1, Hybrid) variety of maize is mostly grown in the local area of Marathwada region of Maharashtra state. To prepare the corn milk, the sweet corn cobs were firstly husked and then washed with water. The seeds were then separated from the cleaned cobs using knives. The sweet corn milk was prepared by two ways, first the fresh raw corn seeds (dough stage) was directly extracted using a fruit extractor to produce milk. In second method, before extracting, the seed was boiled in water for 5 minutes at 100^{o}C and then extracted. In both type, the proportion of seed and water was kept 1:2, as shown in Figure. The corn milk solution was then filtered through a clean muslin cloth and stored at 5°C until use.

A. Flow chart for preparation of sweet corn milk



Chemical analysis

The physico-chemical properties *of* sweet corn milk were evaluated by adopting the standard procedure such as Fat by mojonnier extraction method (A.O.A.C, 2000), Protein content by A.O.A.C. (1965) and Lowry method (1951), Total sugar, moisture, Total ash and total solid content determined by the volumetric (lane-Eyon) method as a described in IS: SP (partXI) 1981.

Heat stability

Heat stability measured as per the Nayak *et al.* (2004) in terms of the heat coagulation time (HCT). Heat stability of milk was determined in a thermostatically controlled water bath maintained at 60 ± 1 ^{0}C and 100 ± 1 ^{0}C. It comprised 10 ml sample into each of two 25 ml glass tubes fitted in the frame of a rocking mechanism holding several such tubes and continuously dipping them into the water bath and raising out of it permitting visual observation of the sample condition while maintaining it at water bath temperature. The end point reached when the fluid sample showed clear signs of coagulation as perceived visually was noted to give the heat coagulation time (HCT) at 60 ± 1 ^{0}C and 100 ± 1 ^{0}C.

RESULT AND DISCUSSION

Standardization of method for preparation of sweet corn milk:

The sweet corn milk was prepared as per the method Piyawan *et al*. (2008) and sample prepared in lab are shown in Plate 1.

Preheat treatment of corn seed:

The sweet corn milk was prepared by two ways, first the fresh raw corn seeds (dough stage) was directly extracted using a fruit extractor to produce as sweet corn milk of un-boiled corn (SCMUBC) i.e. Corn milk-1. In second method, before, extracting the seed was boiled in water for 5 minutes at 100^{o}C and then extracted called as sweet corn milk of boiled corn (SCMBC) i.e. Corn milk-2. The proportion of seed and water was kept 1:2. as shown in Figure 3.1. The corn milk was then filtered through a clean muslin cloth and stored at 5°C until further use. The milk prepared by boiling seed showed more viscosity, uniform consistency and similarity with cow milk. Both types of milk were considered for further study.

Optimization of addition of water:

The quantity of water to be add during the preparation of sweet corn milk was tried in the proportion of corn seed: water as 1:1, 1:1.5, 1:2 and 1:2.5. At proportion 1:1 and 1:1.5 the consistency of corn milk was found very high, not match with normal milk and found difficult for staining. Whereas, at 1:2.5 proportion much thin milk was obtained. Acceptable quality of sweet corn milk was obtained at the ratio of seed: water as 1:2.

Physico-chemical analysis of sweet corn milk:

The importance of physico-chemical properties to the processor is to developed quality product, to evaluate the effect of processing on textural quality of product and to access the standards of raw materials. The requisite samples of developed sweet corn milk were subjected for the proximate analysis viz. fat, protein, total sugar, moisture, ash, total solids and physical properties i.e. acidity, pH, viscosity, colloidal stability and heat stability.

The results obtained on account of this parameter are presented in forthcoming tables.

Acidity of sweet corn milk:

It was observed from Table no. 1 that the mean value for acidity content in corn milk-1 and corn milk-2 were as 0.20 and 0.19, respectively. The acidity express in total titratable acidity in corn milk which was observed more as compared to cow milk and buffalo milk. There was significant difference observed between both types of milk prepared without preheat treatment and with preheat treatment to corn seed i.e. boiling of seed for 5 min at 100^0C. As it may be observed from table 1 that the value of titratable acidity was observed higher than cow and buffalo milk's acidity. Higher acidity may be due to the different ingredient particularly carbohydrates and protein content in sweet corn milk as mentioned by Omueti and Ajomale (2005) and supported by Hosney, 1994.

Table No. 1: Per cent acidity content in sweet corn milk:

Type of Milk	**Replications**				**Mean**	**Cow milk** De (2009)	**Buffalo milk** De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	0.16	0.22	0.25	0.20	0.20^a	0.13	0.15
Corn Milk-2 (SCMBC)	0.16	0.18	0.22	0.22	0.19^b		
S.E ± 0.0118					CD @ 5per cent = 0.0410		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance.

Omueti and Ajomale (2005) prepare the three type of milk i.e. soy-corn milk white, (SCMW), soy-corn milk yellow (SCMY), soymilk (SM) sample from soybean and corn grains and reported that the acidic nature of maize proteins (zein) could be responsible for the higher total acidity of the soy-corn milk types compared with the value of soymilk (Hosney, 1994). Maske (1997) and Harjai and singh (2007) observed lower acidity than corn milk in case of safflower milk i.e. 0.12 per cent and found the values of the acidity 0.14 to 0.16 per cent in soya milk.

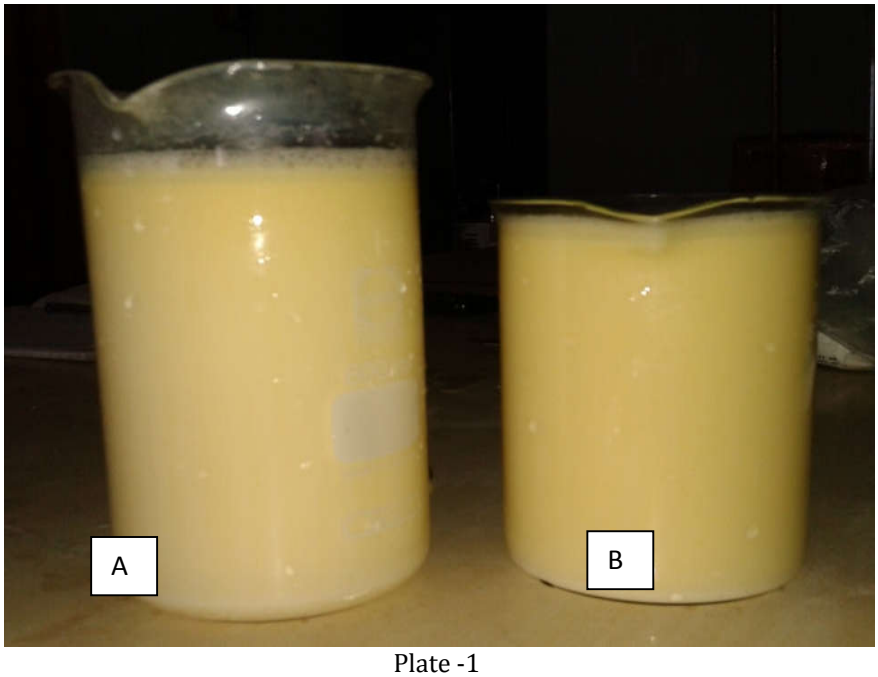


Plate -1

A- Sweet corn milk of un-boiled corn, B- Sweet corn milk of boiled corn.

pH of sweet corn milk

It was noticed from Table no. 2 that the range value for pH of corn milk-1 and corn milk-2 were as 5.99 to 6.40 and 6.00 to 6.22, respectively. More variation observed in case of corn milk prepared from sweet corn without boiling treatment as compared to corn milk type -2. It may be due to the boiling effect in type -2 milk resulted to denaturation and uniform stability of corn ingredient and the reduction of acidic components in case of type -2 milk or react with other ingredients. The average mean values of pH were 6.12 and 6.08 in type -1 and type -2 milk, respectively. There was significant difference observed between both types of milk prepared without preheat treatment and with preheat treatment to corn seed i.e. boiling of seed for 5 min at 100^0C. As may be observed from Table 4.2 that the value of pH of sweet corn milk was lower than cow and buffalo milk pH. Lower value of pH than cow and buffalo milk may be due to the less protein content in sweet corn milk as compared to cow and buffalo milk as also mentioned by Piyawan *et al.* (2010), and Rehman *et al* (2007) observed higher pH value i.e. 6.9 and 6.74 in sweet corn milk and soya milk, respectively, might be due to the dilution factor of corn milk and different ingredient used in their milk, respectively.

Table No. 2: pH of sweet corn milk:

Type of Milk	Replications				Mean	Cow milk Rehman *et al.* (2007)	Buffalo milk De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	6.19	6.00	6.20	6.10	6.12^a	6.90	6.71
Corn Milk-2 (SCMBC)	6.00	6.11	6.22	6.00	6.08^b		
S.E± 0.0773					C.D @ 5per cent =0.2674		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance.

Gesinde *et al.* (2008) analyzed for quality and quantity of soymilk produced from four varieties of soybeans; TGX196-2E, TGX536-02D, TGX923-2E and one designated as local reported that the pH value of milk samples were natural TGX196-2E had pH 6.77, TGX536-02D pH 6.61, and the local sample had pH 6.57.

Viscosity of sweet corn milk:

It was observed from Table 3 that the mean value for viscosity of corn milk-1 and corn milk-2 were as 1.32 and 1.55 Cps, respectively. The viscosity of sweet corn milk were within the range of 1.28 – 1.35 Cps in type-1 and from 1.50 - 1.58 Cps in type -2 milk. This difference of viscosity of corn milk-1 and corn milk -2 might be due to the gelatinization of corn starch during boiling process in corn milk -2. Ignatius *et al* (2010), noted viscosity of soy-corn milk varied within the range of 176.65–180.40 Cps which was higher than this study. They concluded in their study that higher sweet corn proportion resulted in to the higher viscosity of soy-corn milk. The higher value for this study may be due to the water absorption rate by starch during pre-heat treatment. The viscosity of corn milk -1 and corn milk -2 was found lower than the cow milk and buffalo milk viscosity.

Table No. 3: Viscosity of sweet corn milk in centipose (Cps):

Type of Milk	Replications				Mean	Cow milk Mohmad *et al* (2008)	Buffalo milk Mohmad *et al* (2008)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	1.28	1.32	1.35	1.33	1.32^a	1.38	1.52
Corn Milk-2 (SCMBC)	1.50	1.58	1.56	1.55	1.55^b		
S.E± 0.0159					C.D @ 5per cent = 0.0550		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance.

Harjai and Singh (2007) prepare the soymilk from different verities of soybean and reported that the viscosity values were maximum (5.77 Cps) and minimum (4.37 Cps) for soy milk preparation from varieties PS-1042 and PS-1347 respectively.

Cruz *et al.* (2007) studied the effect of ultra high pressure homogenization (UHPH) at 200 m pa and 300 m pa on soymilk and to compared with the soymilk base product (BP) and ultra high temperature (UHT) treated soymilk with ultra high pressure homogenization treated soymilk and reported that BP soymilk was only submitted to the action a colloidal mill to obtain a coarse emulation which later would be finely homogenization, however the viscosity of the UHT soymilk was significantly ($p<0.05$) lower than UHPH soymilk which presented the same viscosity values in the two performed treatment at 200 m pa and 300 m pa.

Moisture content in sweet corn milk:

The result from Table 4 revealed that the range value of moisture content in corn milk type-1 and corn milk type-2 were 90.05 to 90.10 and 90.33 to 90.44 per cent, respectively. The mean value of moisture content in corn milk -1 and corn milk-2 were as 90.07 and 90.38 per cent, respectively. The moisture content in corn milk -1 was significantly higher as compared with corn milk -2 as well as cow milk and buffalo milk also. The significant difference between corn milk -1 and corn milk -2 might be due to the boiling processes of corn grain in corn milk -2.

Table No. 4: Moisture content in sweet corn milk:

Type of Milk	Replications				Mean	Cow milk De (2009)	Buffalo milk De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	90.07	90.10	90.05	90.06	90.07[a]	83.40	84.2
Corn Milk-2 (SCMBC)	90.33	90.40	90.44	90.35	90.38[b]		
SE± 0.019					CD @ 5per cent = 0.07		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance.

Kolapo and Oladimeji (2008) produced the milk sample from 75 per cent soybean and 25 per cent maize grains and reported that the moisture content of soy milk and soy-corn milk increased thermodously after processing.

Fat content in sweet corn milk:

The fat content in sweet corn milk of corn milk -1 and corn milk -2 are presented in Table 5. The mean value of fat content of corn milk type-1 and corn milk type-2 were 1.08 and 1.17, respectively. The range values of fat in corn milk -1 and corn milk -2 were 1.05 to 1.10 and 1.10 to 1.22 respectively. Fat content in corn milk -2 was significantly higher at ($p < 0.05$) than corn milk -1 but lower than cow milk and buffalo milk. The lower value of fat content in corn milk due to the less fat content in sweet corn as compared to cow and buffalo milk.

Table No. 5: Fat content in sweet corn milk:

Type of Milk	Replications				Mean	Cow milk Rehman *et al.* (2007)	Buffalo milk De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	1.05	1.10	1.09	1.08	1.08[a]	3.80	6.6
Corn Milk-2 (SCMBC)	1.20	1.22	1.18	1.10	1.17[b]		
S.E ± 0.0201					C.D @ 5per cent = 0.0695		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

The values recorded for fat content in the present investigation are comparable with findings of Piyawan *et al.,* (2010) and variation with Harjai and singh (2007) and Kolapo and Oladimeji (2008). The variation of fat content in sweet corn milk with other workers may be due to the different ingredient they used for their study.

Piyawan *et al*. (2010) studied the characteristics and shelf life of corn milk yogurt, reported that the fat content of the corn milk yogurt was about one-tenth that of cow milk yogurt. This was because the fat content of corn milk was only 1.05 per cent.

Harjai and singh (2007) prepare the soymilk from different verities of soybean and reported that the fat content of various soymilk samples were statistically different ($p<0.05$). Soymilk prepared from variety PS-1368 exhibited maximum fat content.

Kolapo and Oladimeji (2008) produced the milk sample from 75 per cent soybean and 25 per cent maize grains and reported that the fat content were significant lower ($p<0.05$) than these of soybean and maize grains. The fat content of soy-corn milk was improved by following fortification.

Protein content in sweet corn milk:

Protein content in milk samples obtained from sweet corn milk type-1 and sweet corn milk type -2 are reported in Table 6. The range value of per cent protein content in corn milk-1 and corn milk-2 were 1.88 to 2.05 and 1.20 to 1.32 per cent, respectively. The mean value of protein content in corn milk-1 and corn milk-2 were as 1.93 per cent and 1.25 per cent, respectively. It was clearly observe from Table 4.6 protein content in corn milk -1was higher than corn milk -2 but lower in than the cow milk and buffalo milk as

well as soymilk reported by Ignatius *et al.* (2010). This lower contents of protein in sweet corn milk due to the content of less protein in sweet corn grain.

Table No. 6: Per cent protein content in sweet corn milk:

Type of Milk	Replications				Mean	Cow milk Rehman *et al.* (2007)	Buffalo milk De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	2.05	1.92	1.88	1.90	1.93[a]	3.30	3.90
Corn Milk-2 (SCMBC)	1.20	1.32	1.23	1.25	1.25[b]		
SE± 0.0355					CD @ 5per cent = 0.1230		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

Kolapo and Oladimeji (2008) produced the milk sample from 75per cent soybean and 25per cent maize grains and reported that the protein content were significant lower ($p<0.05$) than cow and buffalo milk. Omueti and Ajomale (2005) prepare the three type of milk sample from soybean and corn grains and reported that the protein was lowest ($p<0.05$) in soy-corn milk yellow (SCMY) and soymilk (SM) which had similar value difference and observed in the protein content may be attributed to varietal effects of protein content of maize comparative level of protein in soy-corn milk type and soymilk.
Ignatius *et al.* (2010) reported that the protein content of soy-corn milk varied between 1.06 per cent and 1.17 per cent (w/v), which were significantly affected by the ratio of soybean and sweet corn. It was decreased with higher proportion of sweet corn, which due to protein content of soybean is higher than that of sweet corn.

The protein content of the corn milk was higher than that was reported by Ignatius *et al.* (2010), Kolapo and Oladimeji, 2008; Omueti and Ajomale, 2005. This might be due to different methods and ingredient used to produce corn milk.

Ash content in sweet corn milk:

It was observed from table No. 7 that the mean value for ash content in corn milk-1 and corn milk-2 were as 0.58 and 0.55, respectively, which differ significantly from each other. Ash content in sweet corn milk was lower than normal milk of cow and buffalo, this result due to the less mineral content in corn milk -1 and corn milk -2 as compared to normal milk. The range of ash content in both types of milk (SCMUBC) and (SCMBC) were as 0.55 to 0.60 and 0.50 to 0.60 per cent respectively. The difference between corn milk-1 and corn milk -2 may be due to the retainted of mineral more in corn milk -2 than corn milk -1.
Kolapo and Oladimeji (2008) produced the milk sample from 75per cent soybean and 25per cent maize grains and reported that the ash content of soy milk, soy-corn milk were significant lower ($p<0.05$) these of soybean and maize grains.
Gesinde *et al.* (2008) produced and analyzed the quality and quantity of the milk from four varieties of soybean and reported that the ash content in milk from each variety of soybean was 0.21per cent.

Table No. 7: Per cent ash content in sweet corn milk:

Type of Milk	Replications				Mean	Cow milk Rehman *et al.* (2007)	Buffalo milk De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	0.60	0.58	0.62	0.55	0.58[a]	0.70	0.82
Corn Milk-2 (SCMBC)	0.55	0.58	0.50	0.60	0.55[b]		
SE ± 0.0187					CD @ 5per cent =0.0645		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

Total sugar content in sweet corn milk:

It was noticed from Table 8 that the mean value of total sugar content in corn milk type-1 and corn milk type-2 were 06.30 per cent and 05.75 per cent, respectively. Total sugar content varied from 6.25 – 6.35 per cent in sweet corn milk type-1 and 5.70 – 5.80 per cent in sweet corn milk type-2. As compared with cow milk and buffalo milk higher total sugar content in sweet corn milk type -1 and sweet corn milk type -2. Higher value in corn milk may be due to the more starch content in sweet corn seed.

Table No. 8: Per cent total sugar content in sweet corn milk:

Type of Milk	Replications				Mean	Cow milk De (2009)	Buffalo milk De (2009)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	6.25	6.35	6.28	6.32	06.30[a]	4.9	5.2
Corn Milk-2 (SCMBC)	5.75	5.70	5.80	5.75	05.75[b]		
SE ± 0.02					CD @ 5per cent = 0.07		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

Ignatius *et al.* (2010) developed low alfatoxin soy-corn milk and optimised of soybean and sweet corn ratio and study stability during storage. They also reported the high total sugar content in soy-corn milk due to starch content and natural sugar in sweet corn are higher than that of the soybean.

Total solids content in sweet corn milk:

It was observed from Table no. 9 that the mean value for total solid content in corn milk-1 and corn milk-2 were 09.93 per cent and 09.62 per cent, respectively. There were significant difference between the mean value of both sweet corn milk type -1 and sweet corn milk type-2. Higher value as 09.93 was observed in sweet corn milk type-1 than sweet corn milk type-2 might be due to the more nutrients extracted due to preheat treatment of corn seeds. Similarly, the total solid content in both type milk (SCMUB) and (SCMBC) was lower as compared with cow milk and buffalo milk due to high proportion of protein, fat and minerals in cow and buffalo milk.

Table No. 9: Per cent total solid content in sweet corn milk:

Type of Milk	Replications				Mean	Cow milk Rehman *et al.* (2007)	Buffalo milk Zeki *et al.* (2013)
	R1	R2	R3	R4			
Corn Milk-1 (SCMUBC)	9.90	9.95	9.97	9.90	09.93[a]	12.90	17.21
Corn Milk-2 (SCMBC)	9.60	9.63	9.67	9.60	09.62[b]		
SE ± 0.01272					CD @ 5per cent = 0.059512		

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance.

Omueti and Ajomale (2005) prepare the three type of milk i.e. soy-corn milk white, (SCMW), soy-corn milk yellow (SCMY), soymilk (SM) sample from soybean and corn grains and reported that the relative density values of all milk types were not significantly different from each other the result could not be attributed to uniform dispersion of solutes rather than the magnitude of total solids which varied with milk types. Lwoha and Umunnakwe (1997) The difference between the values of total solids for soy-corn milk types SCMW and SCMY and SM could be attributed to higher level of suspended particles in the soy-corn milk types than in soymilk (Nelson *et al* -1976)

Ignatius *et al.* (2010) reported that the total solids of soy-corn milk varied between 11.1 per cent and 11.9 per cent, which were lower than that produced using dried field corn about 12.20 per cent (Kolapo and Oladimeji, 2008). This might be due to the lower content of protein, which contributes to the total solids. However, the total solid were higher than that of soy-corn milk produced using freshly green harvested corn which within a range of 8.82–9.38 per cent (Omueti and Ajomale, 2005) the sugar added to the soy-corn milk formula contributed to the higher total solids.

Colloidal stability of sweet corn milk:

The colloidal stability of corn milk was determined by placing the milk samples in graduated tubes having 15 cm height and 2 cm internal diameter held in racks in the refrigerator and room temperature condition at undisturbed condition. The time was recorded required to separate two layers of visible line of demarcation between the settled and remaining portion of the milk solution was measured in (height in cm). The observation was taken at a time interval of 0, 3, 6, 9, and 12 hrs, respectively. It is reveled from Table 10 (A_1) that the combination value for time required to separate the two layers i. e. colloidal stability of corn milk-1 at a room temperature were as 10.00, 9.00, 8.70, 5.20, and 5.00 cm and corn milk-2 were as 10.00, 9.50, 9.10, 8.80 and 7.50 cm, for 0, 3, 6, 9 and 12 hr, respectively. The overall colloidal stability of corn milk-1 (7.585 cm) was found lower than corn milk-2 (8.995 cm) showing significant difference between each other at ($p < 0.05$). It means that corn milk was stable for 3 hrs only and then starts destabilization. There were no significant difference between corn milk -1 and corn milk -2 at 0, 3 and 6hrs. Whereas significant difference were observed after 6 hrs i.e. 9 and 12 hrs. The rate of destabilization was more in case of corn milk -1 as compared to corn milk -2. It may be due to the more stability of starch and protein in case of boiling condition as the effect of heat treatments. The stability of corn milk may be increased after use of stabilizer, which needs to be investigating.

Table No. 10. (A1): Average Colloidal stability of sweet corn milk at room temperature (cm):

Treatment	Colloidal Stability
A) Type of Milk	
1) Corn milk -1(SCMUBC)	7.585[a]
2) Corn milk -2 (SCMBC)	8.995[b]
SE ± 0.215	CD @ 5per cent = 0.623
B) Hours	
1) 0 hr	10.00[a]
2) 3 hr	9.25[ab]
3) 6 hr	8.90[b]
4) 9 hr	7.03[c]
5) 12 hr	6.25[c]
SE± 0.342	CD @ 5per cent = 0.993
Interaction A x B	
SE± o.484	CD @ 5per cent = 1.405

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

Table No. 10. (A2): Internal effect of colloidal stability of milk samples in hours

Type of milk	Hours				
	0	3	6	9	12
Corn milk -1 (SCMUBC)	10[a]	9[a]	8.70[a]	5.20[a]	5[a]
Corn milk -2 (SCMUBC)	10[a]	9.5[a]	9.1[a]	8.8[b]	7.5[b]
SE± 0.484					CD @ 5per cent = 1.405

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

The colloidal stability of corn milk at 5^0C condition showed in table No. 4.10 (B_1). The observations were taken same as colloidal stability at room temperature i.e. 0, 3, 6, 9, and 12 hrs time intervals respectively. The combination value of mean for colloidal stability of corn milk-1 were 10.00, 9.5, 9.00, 8.86 and 7.5 cm and corn milk-2 were as 10.00, 9.77, 9.60, 9.50 and 9.10 for 0, 3, 6, 9 and 12 hr, respectively(Table B2). The colloidal stability were significant differ for all time interval except 3 and 6 hrs. The overall colloidal stability of corn milk -1 and corn milk -2 were 8.935 and 9.595 cm at refrigerator condition, which differ significantly ($p<0.05$). There were no significant difference between corn milk -1 and corn milk -2 at 0, 3, 6 and 9 hrs for refrigerator condition. Whereas significant difference were observed only at 12 hrs. The rate of destabilization was also more in case of corn milk -1 as compared to corn milk -2 in refrigerator condition. From the going result it is concluded that the colloidal stability of corn milk was higher at refrigerator condition than room temperature and sweet corn milk had given preheat treatment was more stable than unheated sweet corn milk.

Table No. 10. (B1): Average Colloidal stability of sweet corn milk at refrigerator condition (cm):

Treatment	Colloidal Stability
A) Type of Milk	
1) Corn milk -1(SCMUBC)	8.935
2) Corn milk -2 (SCMBC)	9.595
SE ± 0.113	CD @ 5per cent = 0.329
B) Hours	
1) 0 hr	10.00[a]
2) 3 hr	9.63[ab]
3) 6 hr	9.30[b]
4) 9 hr	9.08[c]
5) 12 hr	8.30[c]
SE± 0.178	CD @ 5per cent = 0.519
Interaction A x B	
SE± 0.251	CD @ 5per cent = 0.730

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

Table No. 10. (B2): Internal effect of colloidal stability of milk samples in hours at refrigerator condition (cm)

Type of milk	Hours				
	0	3	6	9	12
Corn milk -1 (SCMUBC)	10[a]	9.5[b]	9.00[c]	8.86[d]	7.5[e]
Corn milk -2 (SCMUBC)	10[a]	9.77[b]	9.60[c]	9.50[d]	9.10[f]
SE±0.251				CD @ 5per cent = 0.730	

The values with different small letters superscripts row wise differ significantly at 5per cent level of significance

The result of colloidal stability of this study is agreed with the following workers.

Omueti and Ajomale (2005) prepare the three type of milk i.e. soy-corn milk white, (SCMW), soy-corn milk yellow (SCMY), soymilk (SM) from soybean and corn grains and reported the colloidal stability of these three type milk samples. The reported that colloidal stability decreased were significantly ($P<0.05$) from 0 to 72 h during storage. In all types of milk, the initial rate of colloidal stability decreased from 0 to 24 h during storage at the refrigerator and freezer.

Lwoha and Umunnakwe (1997) similar values of apparent colloidal stability were obtained for SCMW and SCMY beverages stored in the refrigerator and freezer. The results could be attributed to uniform dispersion of solutes in the two milk types during storage. It was also observed that apparent colloidal stability values remained constant for SM after 24 h of storage at 6°C and –4°C indicating that textural breakdown was complete within 24 h in this beverage. For SCMW and SCMY however, slow decline in apparent colloidal stability was observed indicating that deterioration was gradual in the maize-based beverages during storage.

Lwoha *et al.* (1997) observed that there was occurrence of higher content of starch in the SCMW and SCMY than in SM due to their carbohydrate components. Thus, the gelation of starch in the maize-based beverages under heat could also account for their observed higher colloidal stability in terms of apparent colloidal stability values compared with SM.

Ignatius *et al.* (2010) produced the nutritious soy-corn milk from combining soybean and corn grains and reported that the colloidal stability decline during storage in the refrigerator. The soy-corn milk colloid was more stable reported by Omueti and Ajomale (2005).

Heat stability of sweet corn milk:

The heat stability of sweet corn milk was determined by Nayak *et al.* (2004) with slight modification in a thermostatically controlled water bath maintained at 60 ± 1 ^{0}C and 100 ± 1 ^{0}C and presented herein Table 11 (A and B). It was observe that the mean values for heat stability of corn milk-1 and corn milk-2 milk at 60 ^{0}C and at 100 ^{0}C were 3 and 6 minutes and 2 and 3 minutes, respectively. The heat stability of both type of sweet corn milk was differ significantly 5 per cent level of significance at 60 ^{0}C and at 100 ^{0}C. The corn milk type -2 (SCMBC) was found more stable at both temperature as compared to corn milk type -1 (SCMUBC). The heat stability of sweet corn milk was lower as compared to natural milk of cow and buffalo, may be due to the pH of corn milk Raynal *et al.* (2007) and content of polyglucan in corn milk which competed with protein for water Tziboula and Muir, (1993a,b).

Gallager and Mulvihill (1997) reported the heat stability of cow milk 12-22 min with natural pH 6.65-6.7 and the pH range 7.1-7.2 the heat stability increased i.e. 30 min found more than our result.

Nayak *et al.* (2004) studied the heat stability and flow behaviour of buffalo milk added with corn starch; reported that the demonstrated that the addition of native starches to bovine milk has a detrimental effect on its heat stability.

Abd El-Salam (1965) the addition of corn starch and subsequently gelatinization at 85 ^{0}C decreased the HCT of the preheated buffalo skim milk depending on concentration of starch (1 and 2per cent, w/w) and gelatinization time (10–80 min). The higher level of starch had a greater effect, and increasing gelatinization time caused decreasing HCT for both the starch levels

Similar results were also reported by Tziboula and Muir (1993a,b) according to whom, increasing concentration of added starch (0.5–1.5per cent, w/w) caused a decrease in HCT of milk and the detrimental effect of starch additions was greater in concentrated milk even at the lowest level of addition. The cause of the reduction of heat stability of milk on starch addition was suggested to be the competition by the polyglucan with milk proteins for water.

Table No. 11. (A) Heat stability of sweet corn milk at 60 ^{0}C (In min.):

Type of Milk	Replications				Mean
	R1	R2	R3	R4	
Corn Milk-1 (SCMUBC)	3	3	3	3	3
Corn Milk-2 (SCMBC)	6	6	6	6	6

Table No. 11. (B) Heat stability of sweet corn milk @ 100 ^{0}C (In min.):

Type of Milk	Replications				Mean
	R1	R2	R3	R4	
Corn Milk-1 (SCMUBC)	2	2	2	2	2
Corn Milk-2 (SCMBC)	3	3	3	3	3

CONCLUSION

Sweet corn grains can be processed into sweet corn milk. The physic-chemical properties of sweet corn milk were comparable with cow and buffalo milk except heat stability and colloidal stability, which need to be improved by further research. The chemical composition of sweet corn milk vary as per the method of preparation particularly the amount of water added used at the time of seed extraction/ dilution and variety of corn used. The finding of this research may provide sufficient basis to conclude that use of sweet corn milk and modern processing technology for its production with acceptable quality at cheaper price as compared to whole milk could be manufactured and marketed in India, particularly weaker sections of society who normally cannot purchase milk products.

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