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Study of Manufacture and Shelf-Life of Indian Dietetic and Diabetic *Rosogolla*

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Abstract: Dietetic and diabetic *Rosogolla* was manufactured by using low-fat cow milk. Twelve different combinations viz., type of chhana, cooking medium (double refined cane sugar syrup and sorbitol solution) and two different concentrations (40° and 50° Brix). All of the experimental samples and control samples were then analyzed for physico-chemical, textural and sensory properties. A 40° Brix concentration irrespective of the type of cooking medium was preferred to give a highly acceptable *Rosogolla*. The average composition of dietetic and diabetic *Rosogolla* is, moisture-49.83 and 52.20%, fat-4.66 and 4.46%, protein-11.85 and 12.78%, sucrose/sorbitol-32.41 and 29.66% and ash-0.90 and 0.89%, respectively. The hot *Rosogolla* of both types were packed in polyethylene terepthalate (PET) jars and stored for 40 days and 6 days at refrigerated (7±2°C) and room (26±2°C) temperature respectively. During storage pH of dietetic, diabetic and control *Rosogolla*, decreased, while free fatty acids, 5-hydroxy methyl furfural and soluble nitrogen content increased with the advancement of the storage irrespective of the storage temperature. Total viable count and yeast and mould count increased slowly in the samples stored at 7±2°C, but very sharply when stored at 26±2°C. Coliform count in both temperatures was observed to be zero.

Key words: Dietetic *Rosogolla*, diabetic *Rosogolla*, FFA, HMF, textural properties, consumer preference, cost

INTRODUCTION

Indigenous dairy products have played an important role in socio-economic life of Indians since time immemorial and they account for over 90% of all dairy products consumed (Aneja *et al*., 2002; Singh *et al*., 2007). About 45 to 50% of milk produced in the country is converted into indigenous products and the consumption is likely to grow at an annual rate of more than 20% and the demand for *Rosogolla* may increase up to 6000 metric tones by the year 2009 (Mishra, 2000; Kumar *et al*., 2005). Traditionally, preparation of *Rosogolla* involves manufacturing of Chhana, a co-precipitate obtained by heat and acid precipitation of milk, kneading it into smooth paste, forming it into small balls of about 6 to 7 g each, cooking the balls in boiling sugar syrup (50 to 55° Brix) followed by its soaking in sugar syrup (35 to 40° Brix) for overnight. Various types of *Rosogolla* are available in the market viz., ordinary, sponge, canned and diabetic *Rosogolla*, which may be further classified

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as small, normal and large categories depending on size of balls and ingredients used. Diabetic *Rosogolla* is specially made for people who are suffering from diabetes. Here instead of sucrose, alcoholic sugar such as sorbitol is used (Adhikhari *et al*., 1992; Natarajan and Balachandran, 2006; Pal and Londhe, 2006; Karunaithy *et al*., 2007; Sachdeva and Reuter, 2007; Sahu and Jha, 2009; Bandyopadhyay *et al*., 2005, 2008). It is estimated that the raw material cost of *Rosogolla* is 33% of the sale price, while that for western dairy products are relatively much higher varying from 77 to 80% (Chandan *et al*., 2002). In India 29.66% people eat out frequently and about 48.14% of the population consumes high-fat diet (Chatterjee, 2007). This habit along with no exercise has created a situation in which every ninth individual is suspected for having cardiovascular diseases (CVD). It is estimated that the death caused due to CVD may rise to 40% by the year 2015. *Rosogolla* faces a problem of high sugar content (i.e., about 50%), as diabetic people cannot enjoy the sweet. Nonetheless, consumers who want the taste of sweetness without added energy may select non-nutritive sweeteners to assist in the management of weight, diabetes and CVD (Arora *et al*., 2006; George *et al*., 2006; Kroger *et al*., 2006). Hence for diabetic and health conscious consumers reformulation of *Rosogolla* is required. This offers an opportunity for the development and commercial manufacture of Dietetic and Diabetic *Rosogolla* that could fit easily into the dietary guidelines of diabetic and patients suffering from cardio vascular diseases. The present investigation was carried out with the objectives of studying the technological aspect of manufacture of Chhana from milk with a low-fat and evaluate their performance on quality of *Rosogolla*, effect of replacement of sucrose with Sorbitol and non-nutritive sweetener for cooking and or soaking purpose, physico-chemical and sensory characteristics and the cost effectiveness.

MATERIALS AND METHODS

The present investigation was carried out in the Department of Dairy Technology, S.M.C. College of Dairy Science, Anand in the year 2007-08. The fresh raw cow milk (4.5% fat, 8.5% MSNF and 0.16% acidity) was obtained from the Live Stock Research Station, Anand Agricultural University, Anand. Raw cow milk was preheated to 65°C and separated to obtain skim milk (0.1% fat, 8.9% MSNF and 0.17% acidity) for carrying out experimental trials. Raw cow milk and skim milk were filtered through muslin cloth and immediately pasteurized at 72°C for 15 sec and stored at 4°C for 2-3 h. Double refined cane sugar was obtained from the local market of Ahemdabad and sorbitol (70% liquid), was supplied by Darshan Chemicals, GIDC, Anand. Aspartame was procured from Nutrasweet-12 USA. PET jars were obtained from Anand market, which were sterilized using 100 ppm available chlorine solution.

Preparation of Chhana and *Rosogolla*

Experimental chhana and *Rosogolla* was prepared by the method as shown in Fig. 1 which was modified from the methods as reported by various scientists (Aneja *et al*., 2002; Arora *et al*., 1996; Bandyopadhyay *et al*., 2005) while Control *Rosogolla* (C) was prepared in the same manner, except that the milk fat was standardized to 4% and coagulation was carried out at 70 to 72°C. Three replications were carried out and chhana made from milk containing 1, 2 and 3% milk fat were coded as F_1, F_2 and F_3 respectively. *Rosogolla* made from F_1 chhana and cooked in Double Refined (DR) cane sugar syrup of 40 and 50° concentration were coded as LF_{41} and LF_{51}, respectively, similarly when sorbitol was used as cooking medium they were coded as SF_{41} and SF_{51}. In the same manner *Rosogolla* made from F_2 chhana were coded as LF_{42} and LF_{52}, SF_{42} and SF_{52} when DR syrup and sorbitol were

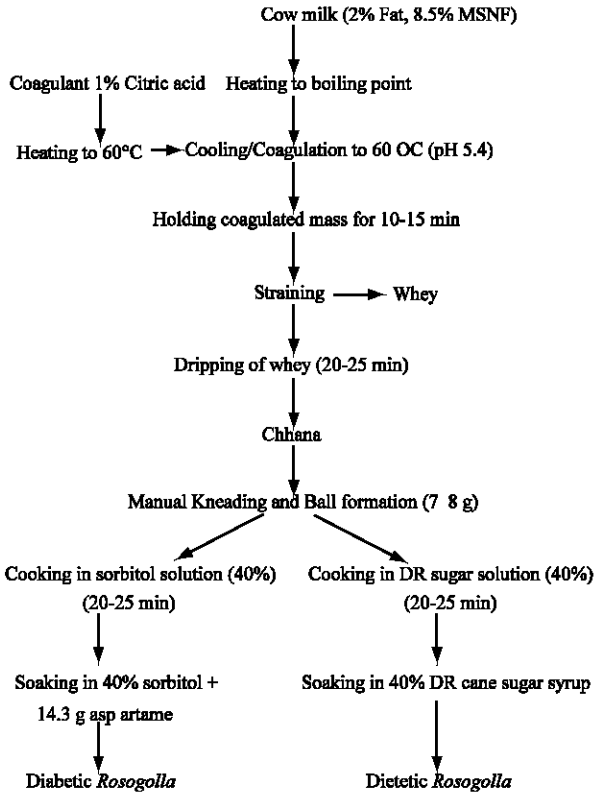

Fig. 1: Flow diagram for preparation of diabetic and dietetic rosogolla

used as cooking medium. Similarly, LF_{43} and LF_{53}, SF_{43} and SF_{53} code were given for *Rosogolla* cooked in DR syrup and sorbitol made from F_3 chhana. Dietetic *Rosogolla* (DTR) and Diabetic *Rosogolla* (DBR) were soaked in 40° Brix of DR cane sugar syrup and sorbitol added with 14.3 g aspartame, respectively.

Physico-Chemical Analysis

All the fresh and stored *Rosogolla* samples were subjected for physico-chemical analysis by Indian Standards Institution (ISI: 4079, 1967), textural, sensory evaluation and microbial count. 5-Hydroxy Methyl Furfural (HMF) content was determined as suggested by Keeney and Bassette (1959) and expressed as μmol/100 g. Free Fatty Acids (FFA) content expressed as % oleic acid, was determined by the method suggested by Deeth and Fitz-Gerald (1976). The soluble nitrogen (Soluble N) content was determined by the procedure outlined by Kosikowski (1982) and expressed as per cent. Total Viable Count (TVC) and coliform count were determined by using the procedure as mentioned in ISI (IS 4079, 1967) and yeast and mould as mentioned in by Indian Standards Institution (ISI) (IS 5403, 1969). Yield (g L^{-1} of milk) of *Rosogolla* was calculated by taking the difference of weight of *Rosogolla* after soaking of the chhana ball.

Texture Analysis

Textural properties were determined using a Universal Testing Instrument, Model-LRS Plus (Lloyd Instruments, England) equipped with a 50 N cell. Cylindrical samples

(20 mm diameter, 15 mm height) were drawn using a cork borer at 20°C and were compressed at speed of 1 mm sec^{-1} upto 25% of its original height.

Sensory Evaluation

Rosogolla samples were evaluated by a panel of five judges from Department of Dairy Technology. The score card used for judging contained 45 marks for body and texture, 35 marks for taste and smell and 20 marks for color and appearance.

Consumer Preference

A consumer preference study was carried out with DTR, DBR and market sample (Haldiram Brand) by serving to 200 consumers, from three different places (i.e., 100 from Anand and 50 each from Baroda and Nadiad), representing different segments of society for their liking of *Rosogolla*. A nine-point Hedonic scale was used for the preference study. In order to known the percentage of acceptance regardless of age and place, the results obtained were arranged using a frequency distribution technique.

Cost Estimation

Cost of *Rosogolla* was estimated upon the quantity obtained from 100 L of standardized milk (2% milk fat). Yield of DTR and DBR was 85 and 81 kg, respectively.

Experimental Design

The data obtained during investigation was analyzed using Completely Randomized Design (CRD), Factorial Completely Randomized Design (FCRD) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Physico-Chemical Characteristics of Rosogolla

The mean values for fat, protein, sugar (sucrose/sorbitol), ash and moisture content are presented in Table 2.

Fat and Protein Content of *Rosogolla*

The average fat content of *Rosogolla* made from F_1, F_2 and F_3 chhana was 2.35, 4.75 and 6.81%, respectively whereas; same *Rosogolla* had 16.41, 12 and 11.33% protein content (Table 1). An increasing trend in fat content and decrease in protein content of *Rosogolla* was observed with the increasing fat content of milk used for chhana making. The results obtained for the experimental samples are in full agreement for good acceptability with those reported values of fat as 4.2 to 4.6% by Gangopadhyay *et al*. (2005) and Bandyopadhyay *et al.* (2008), but in contradiction with those reported by Desai *et al*. (1993). Minimum fat and protein level permitted by ISI (IS 4079, 1967) is 5.0% and it is observed that the values for LF_{42} and SF_{42} *Rosogolla* are well below for fat and above for protein content.

Moisture and Sucrose/Sorbitol Content of *Rosogolla*

The average moisture content of *Rosogolla* made from F_1, F_2 and F_3 chhana was 50.73, 52.69 and 43.60%, respectively. For the same *Rosogolla*, sucrose/sorbitol content was 30.03, 29.62 and 36.61%, respectively (Table 1). The moisture content of C was statistically lower as compared to LF_{52} and SF_{52} and higher to those obtained from F_3 chhana. The moisture and sucrose/sorbitol content of all the experimental samples was well below the maximum level permitted by ISI (IS 4079, 1967) which is 55 and 45%, respectively and in agreement with those reported by Sahu and Jha (2009).

Table 1: Physico-chemical characteristics and yield of *Rosogolla*

Treatments		Physico-chemical characteristics: Moisture (%)	Fat (%)	Protein (%)	Sucrose/Sorbitol (%)	Ash (%)	Yield (g L^{-1} of milk)
LF_{41}		50.75(±0.45)	02.16(±0.08)	16.77(±0.67)	31.06(3.91)	0.82(±0.03)	406.6(±5.45)
LF_{51}		49.67(±1.06)	02.50(±0.25)	15.82(±0.67)	31.16(±0.93)	0.83(±0.09)	370.2(±4.46)
SF_{41}		51.80(±1.09)	02.16(±0.08)	16.88(±0.54)	28.27(±1.92)	0.87(±0.01)	410.3(±3.47)
SF_{51}		50.69(±0.72)	02.60(±0.65)	16.16(±0.74)	29.65(±1.20)	0.90(±0.09)	352.8(±4.23)
LF_{42}		49.83(±1.45)	04.66(±0.23)	11.85(±1.31)	32.41(±0.96)	0.90(±0.02)	490.3(±6.85)
LF_{52}		54.80(±0.95)	04.96(±0.38)	12.13(±0.25)	27.15(±1.57)	0.95(±0.01)	450.1(±4.57)
SF_{42}		52.20(±1.16)	04.46(±0.23)	12.78(±0.38)	29.66(±1.35)	0.89(±0.02)	512.8(±2.88)
SF_{52}		53.60(±1.25)	04.90(±0.3)	11.24(±0.85)	29.29(±1.33)	0.97(±0.02)	421.4(±4.45)
LF_{43}		41.14(±1.14)	06.70(±0.15)	11.51(±0.62)	39.13(±1.40)	0.98(±0.05)	422.7(±6.52)
LF_{53}		43.08(±0.42)	06.93(±0.21)	11.06(±0.44)	37.92(±0.87)	1.00(±0.06)	469.2(±2.85)
SF_{43}		44.66(±1.13)	06.70(±0.15)	11.52(±0.47)	36.12(±1.57)	0.99(±0.05)	394.9(±2.33)
SF_{53}		45.53(±2.11)	06.93(±0.46)	11.23(±0.48)	35.28(±2.22)	1.02(±0.07)	437.0(±3.48)
C		49.10(±1.25)	07.16(±0.23)	08.69(±0.45)	45.42#(±1.71)	1.09(±0.01)	469.6(±3.66)
$CD_{(0.05)}$		3.30	0.34	0.76	9.53	0.07	4.54
Factorial mean values							
Type of Chhana (F)	F_1	50.73	2.35	16.41	30.03	0.85	384.9
	F_2	52.69	4.75	12.00	29.62	0.92	468.6
	F_3	43.60	6.81	11.33	36.61	0.99	430.9
Type of cooking medium (M)	LF	48.26	4.65	13.19	32.80	0.91	434.8
	SF	49.76	4.62	13.30	31.37	0.94	421.5
Concentration of syrup (L)	L_1	48.45	4.47	13.55	32.44	0.90	439.6
	L_2	49.56	4.80	12.94	31.74	0.94	416.7
$CD_{(0.05)}$	F×M	NS	NS	NS	NS	NS	6.42
	F×L	NS	NS	NS	NS	NS	6.42
	M×L	NS	NS	NS	NS	NS	5.24
	F×M×L	NS	NS	0.76	NS	NS	9.08

NS: Non-significant

Table 2: Textural properties of *Rosogolla*

Treatment		Hard. N	Coh.	Spr.mm	Gum.N	Chew.Nmm	Frac.N	Adhe.Nmm	Stiff.N/mm
LF_{41}		6.91±0.69	0.51±0.07	5.96±0.71	3.4±0.30	24.34±2.89	4.6±0.85	0.0460±0.0033	1.34±0.13
LF_{51}		7.15±2.55	0.54±0.04	5.72±0.19	4.3±0.90	25.88±3.62	1.7±0.45	0.0439±0.0035	1.70±0.20
SF_{41}		5.88±0.50	0.61±0.01	5.94±0.08	3.6±0.25	21.68±1.20	4.6±2.79	0.0153±0.0102	1.03±0.51
SF_{51}		6.38±1.30	0.58±0.06	5.67±0.31	3.5±0.65	23.09±4.46	1.2±1.68	0.0155±0.0109	2.20±1.10
LF_{42}		6.78±0.62	0.48±0.10	5.72±0.11	3.2±0.35	18.92±2.98	3.9±0.30	0.0526±0.0059	0.95±0.06
LF_{52}		9.81±0.97	0.51±0.06	5.64±0.22	4.7±0.30	25.47±2.19	3.1±0.30	0.0309±0.0070	2.36±0.10
SF_{42}		7.85±0.30	0.54±0.08	6.06±0.21	3.8±0.30	26.07±4.57	4.1±3.10	0.0272±0.0215	2.17±1.08
SF_{52}		8.18±2.40	0.54±0.09	5.83±0.24	4.5±0.80	27.73±4.02	2.4±2.39	0.0891±0.0252	2.57±1.28
LF_{43}		8.48±1.89	0.50±0.06	5.76±0.03	4.6±0.40	26.41±2.49	4.0±0.50	0.0453±0.0107	1.63±0.23
LF_{53}		9.82±1.41	0.41±0.11	5.36±0.57	5.0±0.25	23.40±9.71	6.7±1.00	0.0457±0.0023	2.13±0.08
SF_{43}		13.69±1.02	0.55±0.02	5.70±0.17	7.3±0.10	29.75±1.70	7.8±5.38	0.0375±0.0301	3.05±1.52
SF_{53}		6.67±2.90	0.57±0.14	5.73±0.56	3.6±0.55	27.49±3.86	6.0±3.58	0.0298±0.0121	1.23±0.61
C		5.55±1.20	0.51±0.13	5.86±0.31	2.5±0.50	14.39±2.41	2.6±1.61	0.0781±0.0730	0.79±0.39
$CD_{0.05}$		2.41	NS	NS	1.31	6.45	1.0	0.01	0.28
Factorial mean values									
Type of Chhana (F)	F_1	6.58	0.56	5.82	3.70	23.75	3.25	0.020	1.56
	F_2	8.15	0.52	5.81	4.05	24.51	3.37	0.050	2.06
	F_3	9.66	0.51	5.63	5.12	26.76	6.12	0.040	2.01
Type of cooking medium (M)	LF	8.16	0.49	5.69	4.20	24.07	4.00	0.037	1.68
	SF	9.66	0.57	5.82	4.38	25.97	4.35	0.036	2.04
Concentration of syrup (L)	L_1	8.26	0.53	5.86	4.31	24.53	4.83	0.030	1.69
	L_2	8.00	0.52	5.66	4.26	25.51	3.51	0.042	2.03
$CD_{(0.05)}$	F×M	NS	NS	NS	NS	NS	2.30	0.01	0.20
	F×L	1.70	NS	NS	NS	NS	2.30	0.01	0.20
	M×L	1.38	NS	NS	1.00	NS	1.00	NS	0.16
	F×M×L	2.40	NS	NS	NS	NS	3.20	0.01	0.28

NS: Non-significant, Hard: Hardness, Coh: Cohesiveness, Spr: Kpringiness, Gum: Gumminess, Chew: Chewiness, Frac: Fracture force, Adhe: Adhesiveness, Stiff: Stiffness

Ash Content of *Rosogolla*

Use of 50° Brix concentrated cooking medium was found to give significantly higher ash content in 40° Brix concentrated syrup (Table 1). Ash content of all the samples was in full agreement with those reported by Desai *et al.* (1993), Mathur and Singh (2001) and Haque *et al.* (2003).

Yield of *Rosogolla*

Type of chhana had a significant effect on the yield of *Rosogolla* (Table 1). Yield of *Rosogolla* made from F_2 and CR chhana was significantly higher than F_1 and F_3 (Table 2). Yield of *Rosogolla* for all the experimental samples were far lesser than 690 g L^{-1} of milk.

The interaction effect of F×M, F×L, M×L and F×M×L was found to be non-significant for all the physico-chemical properties but significant for yield. F×M×L showed a significant effect for protein content of *Rosogolla.*

Texture Analysis of *Rosogolla*

The quality of product is monitored not only by the sensory properties but also by their rheological/textural profile.

Hardness

Hardness for C sample was significantly lower than all the experimental *Rosogolla* samples which varied from 5.88 to 13.69 N. Type of chhana had a significant effect while an increasing trend was observed with the increasing fat content of milk used for chhana making (Table 2).

Cohesiveness

The cohesiveness of control *Rosogolla* was found to be at par with those of experimental *Rosogolla* which varied from 0.41 to 0.61 (Table 2). *Rosogolla* made from F_1 chhana had higher cohesiveness value followed by F_2 and F_3 (Table 2). According to report available the results were well in accordance with those reported by Desai *et al.* (1993) and Patil (2002).

Springiness

Springiness of all experimental samples varied from (5.36 to 6.06 mm) and non-significantly different from that of Control (Table 2). The springiness of *Rosogolla* made from F_1 and F_2 chhana was higher than those *Rosogolla* made from F_3 but lower than Control *Rosogolla* (Table 2). The results were as like that of Control sample and were well above 3.82 to 5.0 mm as reported by Adhikhari *et al.* (1992), Patil (2002), Bandyopadhyay *et al.* (2005, 2008) and Karunanithy *et al.* (2006).

Gumminess

It can be seen from Table 2, that the treatments applied had shown a significant effect on gumminess of *Rosogolla*. The value of gumminess for Control sample was 2.5 N, which was significantly lower than (LF_{51}, SF_{41}, LF_{52}, SF_{42}, SF_{52}, DF_{43}, SF_{43} and SF_{53}) the experimental *Rosogolla* samples and in accordance within the range 2.98 to 4.69 N reported by Desai *et al.* (1993), 3.62 N by Adhikhari *et al.* (1992).

Chewiness

Chewiness of experimental samples varied from 18.92 to 29.75 Nmm and was significantly higher than control *Rosogolla* (Table 2). The recorded values were higher than the values

(5.80 to 18.00 Nmm) reported by Adhikhari *et al.* (1992), Patil (2002) and Karunanithy *et al.* (2006). The possible reason for higher chewiness might be the high moisture and protein and low fat content.

Fracture Force

The value of fracture force was affected by the treatments applied (Table 2). An increasing trend in fracture force, with the increase in fat content of milk from 2 to 3% used for chhana making was observed.

Adhesiveness

From the Table 2, it is clear that adhesiveness of *Rosogolla* was significantly affected by the type of chhana and *Rosogolla* made from F_1, F_2 and F_3 chhana had significantly lower adhesiveness than the Control (Table 2).

Stiffness

The value of stiffness of all the experimental *Rosogolla* samples were significantly higher than control sample (Table 2).

The interaction effect of F×L, M×L and F×M×L were found to give a significant effect on hardness, fracture force of *Rosogolla*. In case of gumminess is only significant for M×L while adhesiveness is only significant for F×L, F×M×L. None of the interactions significantly affected the cohesiveness, springiness and chewiness of *Rosogolla.*

Sensory Evaluation of *Rosogolla*

Body and Texture Score

A non-significant effect of the treatment applied during making of experimental *Rosogolla* was observed (Table 3). The Control sample scored an average of 39.05, which was higher than experimental sample (except LF_{42} and LF_{43}).

Table 3: Sensory evaluation of *Rosogolla*[$]

Sample		Body and texture	Taste and smell	Color and appearance	Overall acceptability
LF_{41}		36.26(±3.40)	30.75(±3.02)	16.45(±2.40)	83.46(±8.12)
LF_{51}		35.33(±3.30)	30.00(±1.12)	16.33(±1.25)	81.66(±4.55)
SF_{41}		31.80(±5.10)	26.40(±6.41)	13.17(±3.36)	71.38(±4.45)
SF_{51}		36.55(±9.11)	27.81(±3.87)	15.68(±0.91)	80.42(±2.07)
LF_{42}		41.01(±0.18)	31.99(±0.66)	18.38(±0.50)	91.38(±1.14)
LF_{52}		36.00(±5.5)	29.56(±2.10)	17.33(±0.75)	82.90(±7.50)
SF_{42}		37.55(±0.77)	28.98(±1.77)	17.35(±1.87)	83.50(±4.94)
SF_{52}		36.73(±2.16)	28.13(±0.96)	16.71(±0.78)	81.58(±3.39)
LF_{43}		39.75(±0.77)	31.65(±0.50)	17.81(±0.67)	89.21(±1.57)
LF_{53}		37.41(±1.70)	29.10(±0.65)	16.45(±1.17)	82.96(±2.80)
SF_{43}		34.25(±3.42)	25.50(±1.45)	14.21(±120)	73.96(±4.98)
SF_{53}		35.18(±0.40)	27.73(±0.96)	15.51(±2.13)	78.43(±4.06)
C		39.05(±2.36)	30.11(±4.05)	17.01(±1.72)	83.99(±6.61)
$CD_{(0.05)}$		NS	3.53	2.23	10.17
Factorial mean values					
Type of Chhana (F)	F_1	34.98	28.74	15.41	79.14
	F_2	37.82	29.67	17.44	84.10
	F_3	36.65	28.49	16.00	81.14
Type of cooking	LF	37.62	30.51	17.12	85.26
medium (M)	SF	35.34	27.42	15.44	77.66
Concentration of	L_1	36.77	29.21	16.23	81.66
syrup (L)	L_2	36.20	28.72	16.33	81.26
$CD_{(0.05)}$	F×M	NS	NS	NS	NS
	F×L	NS	NS	NS	NS
	M×L	NS	1.94	1.29	5.87
	F×M×L	NS	NS	NS	NS

[$]Average of three replications, NS: Non-significant

Taste and Smell Score

It can be seen from Table 3, that the treatments showed a significant effect and the score of control was statistically similar to all of the experimental *Rosogolla* samples and SF_{43} scored the lowest amongst all.

Color and Appearance Score

Cooking of chhana balls markedly alters the color and appearance of the *Rosogolla*. All of the experimental *Rosogolla* and were statistically similar to Control *Rosogolla* except SF_{41} and SF_{43} (Table 3).

Overall Acceptability

The overall acceptability score of *Rosogolla* was found to be influenced significantly by the treatments given during the study (Table 3). Overall acceptability scores experimental *Rosogolla* varied from 71.38 to 91.38 and except SF_{41} all were statistically at par with Control.

From the results delineated in Table 3, it is evident that the interaction effect of M×L caused a significant effect on all the sensory properties except body and texture. Similarly, the interaction effect of F×M, F×L and F×M×L was found to be non-significant.

Changes in Physico-Chemical Properties of Rosogolla During Storage

pH

The change in pH of *Rosogolla* are depicted in Table 4. The pH of DTR and Control are higher than the pH of DBR during all storage period at both temperature as reported by Arora *et al.* (1995, 1996) and Singh *et al.* (2007).

Free Fatty Acids (FFA)

The FFA content of DTR and Control are higher than the FFA of DBR irrespective of storage temperature at all storage periods (Table 4). Such an increase has also been reported by Arora *et al.* (1995, 1996) and Singh *et al.* (2007). The interaction effect of TXP was found significant ($p \leq 0.05$).

5-Hydroxymethyl Furfural (HMF)

HMF content of all the samples irrespective of storage temperature and type was found to increase with duration of storage (Table 5). The observations are well supported by the

Table 4: Influence of treatment and storage period on pH and FFA (% oleic acid) of *Rosogolla*

Treatment		P¥ at 7±2°C						P¥ at 26±2°C			
(T)		0	10	20	30	40	Mean for T	0	3	6	Mean for T
DTR	pH	6.24	6.23	6.20	6.18	6.15	6.20	6.24	6.14	6.05	6.14
	FFA	5.80	5.82	5.84	5.87	5.91	5.85	5.80	6.20	7.40	6.40
DBR	pH	6.18	6.13	6.09	6.07	6.04	6.10	6.17	6.08	5.90	6.05
	FFA	4.67	4.70	4.73	4.76	4.87	4.75	4.67	5.61	6.36	5.56
Control (C)	pH	6.20	6.17	6.14	6.10	6.07	6.14	6.20	6.15	5.98	6.11
	FFA	5.93	5.96	5.99	6.02	6.04	5.99	5.94	6.42	7.51	6.57
Mean for P	pH	6.21	6.17	6.14	6.12	6.08		6.20	6.12	5.98	
	FFA	5.47	5.49	5.52	5.55	5.61		5.47	6.07	7.09	

$CD_{(0.05)}$	pH at 7±2°C	pH at 26±2°C	FFA at 7±2°C	FFA at 26±2°C
T	0.03	0.04	0.26	0.36
P	0.02	0.03	0.01	022
T×P	NS	NS	0.02	NS

P: Storage period, ¥: Days, DTR: Dietetic *Rosogolla*, DBR: Diabetic *Rosogolla*, NS: Non-significant

findings of Arora *et al.* (1995, 1996) and Singh *et al.* (2007). The increase in HMF content was in order C>DTR>DBR after 40 days and DTR>C>DBR after 6 days of storage at 7±2°C and 26±2°C, respectively.

Soluble Nitrogen (Soluble N)

The soluble N content was found to increase with increase in storage period irrespective of storage temperature and type (Table 5). The results are in conjunction with the observations made by Arora *et al.* (1995, 1996) and Singh *et al.* (2007). The interaction effect of (TXP) for storage at refrigeration temperature was found to be significant ($p \leq 0.05$), while non-significant in the case of room temperature storage.

Effect of Storage on Sensory Attributes of *Rosogolla*

Body and Texture Score

The body and texture scores of *Rosogolla* declined with the advancement of storage period regardless whether it was stored at refrigeration or room temperature (Table 6). The keeping quality wise the product followed pattern of DTR>DBR>C for storage at 7±2°C and 26±2°C.

Table 5: Influence of treatment and storage period on HMF (μmol/100 g) and soluble N (%) of *Rosogolla*

		P[¥] at 7±2°C						P[¥] at 26±2°C			
Treatment (T)		0	10	20	30	40	Mean for T	0	3	6	Mean for T
DTR	HMF	1.03	1.46	1.73	2.23	2.51	1.79	1.04	2.23	3.51	2.25
	S.N	156.6	169.2	178.5	198.9	216.3	184	156.7	178.2	216.9	182.4
DBR	HMF	0.85	1.09	1.61	1.84	2.22	1.52	0.85	2.11	3.28	2.08
	S.N	143.0	157.2	166.2	177.4	205.2	169	143.0	163.3	199.1	167.1
Control (C)	HMF	1.15	1.55	1.96	2.32	2.62	1.92	1.15	2.36	3.59	2.36
	S.N	173.0	191.6	208.8	225.7	239.1	207	173.0	201.8	231.9	202.1
Mean for P	HMF	1.01	1.37	1.77	2.13	2.45		1.01	2.23	3.46	
	S.N	157.5	172.7	184.5	200.7	220.2		157.5	181.1	215.9	

$CD_{(0.05)}$	HMF at 7±2°C	HMF at 26±2°C	Soluble N at 7±2°C	Soluble N at 26±2°C
T	0.03	0.16	10.53	13.58
P	0.03	0.10	1.89	3.03
TXP	0.05	NS	3.28	NS

P: Storage period, [¥]: Days, DTR: Dietetic *Rosogolla,* DBR: Diabetic *Rosogolla*, NS: Non-significant, S.N: Soluble N

Table 6: Influence of treatment and storage period on body and texture and taste and smell

		P[¥] at 7±2°C						P[¥] at 26±2°C			
Treatment (T)		0	10	20	30	40	Mean for T	0	3	6	Mean for T
DTR	B and T	41.68	36.93	34.23	31.92	31.80	35.31	40.78	36.45	33.57	36.93
	T and S	31.83	31.42	22.75	20.63	19.74	25.27	31.16	22.32	16.30	23.26
DBR	B and T	37.55	34.73	32.52	32.59	27.23	32.92	35.88	32.33	31.40	33.20
	T and S	28.99	26.83	23.90	18.48	22.40	24.12	27.99	18.17	14.13	20.09
Control (C)	B and T	39.05	35.08	27.42	27.75	26.75	31.21	37.55	32.11	27.08	32.24
	T and S	30.28	28.45	25.12	21.78	18.45	24.82	28.95	17.78	12.45	19.72
Mean for P	B and T	39.43	35.58	31.39	30.75	28.59		38.07	33.63	30.68	
	T and S	30.37	28.90	23.92	20.30	20.20		29.37	19.42	14.29	

$CD_{(0.05)}$	B and T at 7±2°C	B and T at 26±2°C	T and S at 7±2°C	T and S at 26±2°C
T	1.74	1.13	NS	1.81
P	2.17	1.45	1.81	1.08
T×P	NS	2.51	3.14	NS

P: Storage period, [¥]: Days; DTR: Dietetic, *Rosogolla* DBR: Diabetic *Rosogolla* NS: Non-significant; B and T: Body and Texture, T and S: Taste and Smell

Taste and Smell Score

During storage, *Rosogolla* undergoes various physico-chemical and microbial changes which tends to affect the taste and smell of the product. The taste and smell score of *Rosogolla* during storage, regardless of temperature decreased (Table 6).

Color and Appearance Score

DTR, DBR and C *Rosogolla* were found to score more than 60% marks for (i.e., 12.00 out of 20) and were acceptable on 40th day of storage but in case of those stored at 26±2°C scored below rejection point after 6 days (Table 7).

Overall Acceptability

The overall acceptability score decreased with the increase in storage, regardless of temperature (Table 7). DTR and DBR scored well above the rejection point (60.00 out of 100) after 40 days of storage. While all the samples stored at 26±2°C failed to score above the rejection point.

Changes in Microbiological Quality of Rosogolla During Storage

Total Viable Count (TVC)

Total viable count at both refrigeration and room temperature were found to increase with the increase in storage period (Table 8). Such increase in TVC is also reported by Singh *et al.* (2007), but was in contrast with those reported by Arora *et al.* (1995, 1996).

Yeast and Mould Count

The yeast and mould count of *Rosogolla* during storage increased with the progress of storage (Table 8). DTR, DBR and C *Rosogolla* were free from yeast and mould up to 10 days of storage at 26±2°C but were apparent after further storage. Such increase in yeast and mould was also reported by Singh *et al.* (2007).

Coliform Count

Rosogolla samples stored at 7±2 and 26±2°C temperature were found to be free from coliform at the end of 40 days and 6 days of storage.

The interaction effect of (TXP) for storage at 7±2°C was found to be significant for increase in TVC and yeast and mould count.

Table 7: Influence of treatment and storage period on color and appearance score and overall acceptability of *Rosogolla*

Treatment (T)		P¥ at 7±2°C 0	10	20	30	40	Mean for T	P¥ at 26±2°C 0	3	6	Mean for T
DTR	C and A	17.94	17.12	17.90	14.42	13.18	16.11	17.28	15.45	11.34	14.69
	OA	91.45	85.47	74.89	66.97	64.71	76.70	89.22	74.22	59.20	74.21
DBR	C and A	17.35	16.18	14.65	15.68	13.18	15.41	16.28	14.85	10.46	13.86
	OA	83.89	77.75	71.07	66.75	62.81	72.45	80.15	65.35	55.66	67.05
Control (C)	C and A	17.35	16.68	15.35	15.35	14.01	15.75	16.01	14.01	10.05	13.35
	OA	86.68	80.18	67.88	64.88	59.21	71.77	82.51	63.90	49.58	65.33
Mean for P	C and A	17.55	16.66	15.97	15.15	13.46	15.75	16.52	14.77	10.61	
	OA	87.34	81.13	71.28	66.20	62.25		83.96	67.82	54.81	

$CD_{(0.05)}$	C and A at 7±2°C	C and A at 26±2°C	OA at 7±2°C	OA at 26±2°C
T	NS	0.83	2.25	2.71
P	1.25	NS	3.83	2.46
T×P	NS	NS	NS	4.27

P: Storage period, ¥: Days, DTR: Dietetic *Rosogolla*, DBR: Diabetic *Rosogolla*, NS: Non-significant, C and A: Colour and Appearance, OA: Overall acceptability

Table 8: Influence of treatment and storage period on total viable count and yeast and mould (log cfu g^{-1}) of *Rosogolla*

Treatment (T)		P[¥] at 7±2°C						P[¥] at 26±2°C			
		0	10	20	30	40	Mean for T	0	3	6	Mean for T
DTR	TVC	4.19	4.53	4.88	5.60	6.06	5.05	4.19	5.00	6.01	5.05
	Y and M	0.00	0.00	1.25	1.31	1.37	1.31	0.00	0.00	1.34	1.34
	COLI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DBR	TVC	3.89	4.16	4.52	4.85	5.07	4.50	3.89	4.10	4.60	4.17
	Y and M	0.00	0.00	1.15	1.18	1.22	1.18	0.00	0.00	1.35	1.35
	COLI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control (C)	TVC	4.43	4.87	5.17	5.56	6.12	5.23	4.43	5.02	5.88	5.09
	Y and M	0.00	0.00	1.29	1.35	1.40	1.35	0.00	0.00	1.44	1.44
	COLI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean for P	TVC	4.17	4.52	4.86	5.33	5.75		4.17	4.71	5.49	
	Y and M	0.00	0.00	1.23	1.28	1.33		0.00	0.00	1.38	

$CD_{(0.05)}$	TVC at 7±2°C	TVC at 26±2°C	Y and M at 7±2°C	Y and M at 26±2°C
T	2.6	2.42	0.05	NS
P	0.8	1.44	0.07	0.35
TXP	1.5	2.45	0.11	1.10

[$]: Average of three replications, P: Storage period, [¥]Days, NS: Non-significant, TVC: Total Viable Count, Y and M: Yeast and Mould

Table 9: Estimated cost of production of dietetic *Rosogolla* (DTR), diabetic *Rosogolla* (DBR) and control *Rosogolla*

Particulars	Unit cost (Rs)	DTR Quantity	DTR Amount (Rs)	DBR Quantity	DBR Amount (Rs)	Control *Rosogolla* Quantity	Control *Rosogolla* Amount (Rs)
Raw Materials Cost (A)							
Cow milk (2%, 4% fat)	11 L^{-1}, 16 L^{-1}	100	1100	100	1100	100	1600
Sorbitol	35/kg	65 kg	2275	-	-	-	-
Aspartame	1200/kg	285 g	342	-	-	-	-
Double Refined sugar	30/kg	-	-	46	1380	-	-
Sugar	15/kg	-	-	-	-	60	900
Citric acid	70/kg	400 g	28	400 g	28	400 g	28
Total (A)	3745		2508		2528		
Packaging Cost (B)							
Polystyrene Cup/lid	5 each	85	425	81	405	78	390
Processing Cost (C)	0.8/L		80		80		80
Total A+B+C	4250		2993		2998		
Yield of Final Product	85 kg		81 kg		78 kg		
Cost/kg	50		37		38		

Cost Estimation

The total production cost was found to be Rs. 4250 and Rs. 2993 for LFSR and LFDR respectively (Table 9). The raw material cost constitutes 88.12 and 83.79% of product cost for LFSR and LFDR, respectively. The packaging and processing cost for both the *Rosogolla* constitutes 11.88 and 16.21%, respectively. Cost of production of Control *Rosogolla* was Rs. 38 per kg.

CONCLUSION

Dietetic and diabetic *Rosogolla* with acceptable quality can be prepared using chhana made from cow milk standardized to 2% milk fat. Chhana can be prepared by coagulating at 60°C, employing 1% citric acid maintained at same temperature and a final pH 5.4, followed by straining. Well kneaded chhana balls can be cooked and soaked at 40° Brix double refined sugar solution to obtain dietetic *Rosogolla*. Whereas, 40° Brix Sorbitol solution is required for cooking of diabetic *Rosogolla* followed by soaking in 40° Brix sorbitol solution containing 14.3 g L^{-1} aspartame. When packed in polyethylene terepthalate jars and stored

at refrigeration temperature they gave a shelf-life of more than 40 days and not more than 6 days at room temperature. Acceptance of dietetic and diabetic *Rosogolla* decreased with increase in storage period which might due various physico-chemical and microbial change, affecting the textural and thereby the organoleptical properties. The cost of DTR and DBR is Rs. 50/- and Rs. 37/, respectively. The cost of DTR was less by Rs. 1/-, while that of DBR was more by Rs. 12/- as compared to control *Rosogolla* (Rs. 38 kg^{-1}).

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