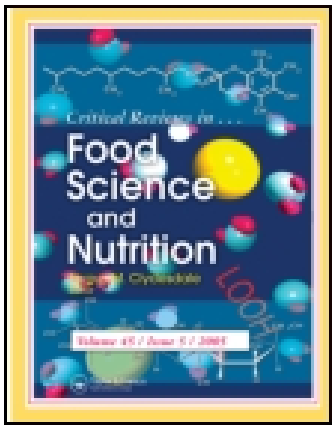

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Technology for the Manufacture of Diabetic Rosogolla

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Technology for the Manufacture of *Diabetic Rosogolla*

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Diabetic Rosogolla was manufactured by using low-fat cow milk. Six different combinations viz. type of chhana and two different concentrations (40° and 50° Brix) of cooking medium. All of the experimental samples and control were analyzed for physico-chemical, textural, and sensory properties. A 40° Brix concentration of cooking medium was preferred to give a highly acceptable Diabetic Rosogolla. The average composition of Diabetic Rosogolla is moisture—52.20%, fat—4.46%, protein—12.78%, sorbitol—29.66%, and ash—0.89%. Similarly, the rheological properties were hardness—7.85 N, cohesiveness—0.54, springiness—6.06 mm, gumminess—3.8 N, chewiness—26.07 Nmm, fracture force—4.1 N, adhesiveness—0.0272 Nmm, and stiffness—2.17 N/mm. This protocol can be adopted at commercial level and be used to serve the customers who desire fewer calories but cannot resist having the sweets after their meal.

Keywords Chhana, sorbitol, *diabetic rosogolla*

INTRODUCTION

Traditional Indian dairy products have great significance as they account for over 90% of all dairy products consumed and about 45–50% of the total milk produced is utilized in this process (Aneja et al., 2002; Kumar et al., 2005). Share of traditional dairy products is estimated at over Rs. 400 billion in 2001 (Patil, 2005). The demand of *Rosogolla* is likely to increase up to 6 thousand metric tones by the year 2009 (Mishra, 2000). Every ninth individual is suspected to suffer from cardiovascular diseases and around 67.08% people suffer from it in India (Chatterjee, 2007). Looking to the need, the Indian government has now permitted use of sweeteners in 25 food items including traditional sweets like halwa, gulab jamun, and *Rosogolla* (George et al., 2006). Keeping in mind the above status, the present study was planned which will also help in formulation of standards for the *Diabetic Rosogolla*.

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MATERIALS AND METHODS

Live Stock Research Station, Anand Agricultural University (AAU) of Anand, India provided fresh raw cow milk (4.5% fat, 8.5% milk solid not fat, and 0.16% acidity) was preheated and fat was separated to obtain skim milk (0.1% fat, 8.9% MSNF, and 0.17% acidity). Both, raw cow milk and skim milk were filtered through muslin cloth and pasteurized at 72°C for 15 s and stored at 4°C until used. Sorbitol (70% liquid), was supplied by Darshan Chemicals, Anand, India and Aspartame by Nutrasweet-12 USA.

Preparation of Chhana and Rosogolla

Experimental chhana and *Rosogolla* was prepared by the method as shown in Figure 1, while Control (CR) chhana and *Rosogolla* (C) was prepared in the same manner with the milk fat standardized to 4% and coagulation was carried out at 70° to 72°C. 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 sorbitol of 40° Brix and 50° Brix concentration were coded as SF_{41} and SF_{51}. Similarly, *Rosogolla* made from F_2 and F_3 chhana were coded as SF_{42} and SF_{52} and SF_{43} and SF_{53}, respectively. *Diabetic Rosogolla* was soaked in 40° Brix of sorbitol added with 14.3 g aspartame per liter.

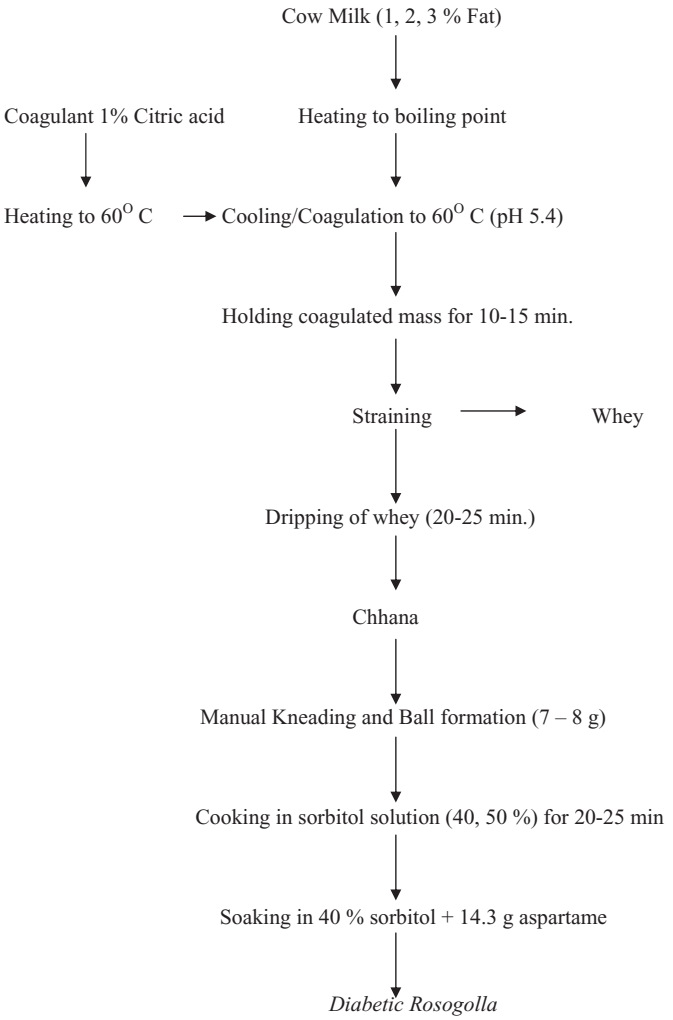

Figure 1 Flow diagram for preparation of *Diabetic Rosogolla*.

Physico-Chemical Analysis

The representative samples of cow milk and skim milk were analyzed for fat (IS: 1224, 1977), milk solid not fat (IS: 1183, 1965), titratable acidity (IS: 1479, 1961). Chhana and *Rosogolla* samples were subjected to physico-chemical analysis as per the method given in IS: 5162 (1969) and IS: 4079 (1967), respectively. Yield (g/lit of milk) of *Rosogolla* was calculated by taking difference of weight of *Rosogolla* after soaking and 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. *Rosogolla* samples were compressed up to 25% of its original height at speed of 1 mm/s.

Sensory Evaluation

A panel of five judges from Department of Dairy Technology, AAU, Anand, evaluated *Rosogolla* samples using a score card containing 45 marks for body and texture, 35 marks for taste and smell, and 20 marks for color and appearance.

Experimental Design

Completely randomized design (CRD) and factorial CRD were used to the data obtained during investigation (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Physico-Chemical Characteristics of Chhana

A statistical difference for moisture, protein, and fat content signifies the effect of fat level in milk used for chhana preparation. The moisture content of F_1 and F_2 was significantly higher than F_3 and CR chhana (Table 1). CR chhana had the highest fat content whereas, F_1 sample had the lowest fat content while, an opposite trend in protein content. The values of moisture content obtained during the present investigation were much higher than those reported by various investigators (Kundu and De, 1972; Bhattacharya and Raj, 1980a, 1980b; Katara and Bhargava, 1990; Joshi et al., 1991; Tambat et al., 1992; Devangare et al., 1995).

Yield of Chhana

Yield of chhana for CR was statistically higher than F_1, F_2, and F_3 and per cent fat recovery in F_1, F_3, and CR was significantly higher than F_2 chhana (Table 1). A decrease in yield with decrease in fat content of milk as observed in the experiment is well supported by Tambat et al. (1992). The reason for this might be presence of less number of fat globules, which resulted in less entrapment of milk protein through their association.

Physico-Chemical Characteristics of **Rosogolla**

The mean values for fat, protein, sorbitol, ash, and moisture content are presented in Table 2. The type of chhana had a significant effect on the fat, protein, moisture, sorbitol, and ash content of *Rosogolla*. The average fat content of *Rosogolla* made from F_1, F_2, F_3, and CR chhana was 2.38%, 4.68%, 6.81%, and 7.16% respectively whereas; same *Rosogolla* had 16.52%, 12.01%, 11.37%, and 8.69% protein content. The average moisture content of *Rosogolla* made from F_1, F_2, and F_3 chhana was 51.24%, 52.90%, and 45.09%, respectively. For the same *Rosogolla* the value for sorbitol content was 28.96%, 29.47%, and

Table 1 Physico-chemical characteristics, recovery of milk constituents and yield of chhana[$]

Treatment	Moisture %	Fat %	Protein %	Ash %	% recovery of Fat	% recovery of Protein	% recovery of T.S.	Yield %
F_1	64.62	7.16	25.37	1.88	90.14	95.59	46.25	12.43
F_2	62.22	11.80	23.96	1.78	79.77	96.02	48.62	13.53
F_3	58.81	18.53	19.57	1.82	87.69	84.22	50.84	14.20
CR	57.47	22.76	17.96	1.80	93.14	89.07	55.68	16.36
$CD_{(0.05)}$	1.86	0.87	1.04	NS	9.21	4.75	1.97	0.47

[$]Average of three replications.
F_1, F_2, F_3, and CR, Chhana prepared from milk of 1%, 2%, 3%, and 4% fat, respectively.
T.S., total milk solids.

35.70%, respectively. The moisture content of C was statistically lower as compared to SF_{52} and higher to those obtained from F_3 chhana. Ash content of C was found to be statistically higher than other samples. A significant increasing trend in fat and sorbitol content and decrease in protein and moisture 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 with those reported values of fat as 4.2–4.6% by Kanwal et al. (1980), but in contradiction with those reported by Desai et al. (1993) for samples procured from market. The moisture and sorbitol content of all samples was well below the maximum level permitted by ISI (IS: 4079, 1967), and in agreement with those reported by Bhattacharya and Raj (1980a). A highly negative correlation was observed between fat and protein content and between moisture and sorbitol content. Ash content exhibited a positive and highly significant correlation with fat and sorbitol content (Table 5).

Table 2 Physico-chemical characteristics and yield of *diabetic Rosogolla*[$]

Treatment	Physico-chemical characteristics: Moisture %	Fat %	Protein %	Sorbitol %	Ash %	Yield g/L of milk
SF_{41}	51.80	02.16	16.88	28.27	0.87	410.3
SF_{51}	50.69	02.60	16.16	29.65	0.90	352.8
SF_{42}	52.20	04.46	12.78	29.66	0.89	512.8
SF_{52}	53.60	04.90	11.24	29.29	0.97	421.4
SF_{43}	44.66	06.70	11.52	36.12	0.99	394.9
SF_{53}	45.53	06.93	11.23	35.28	1.02	437.0
C	49.10	07.16	08.69	45.42	1.09	469.6
$CD_{(0.05)}$	3.30	0.34	0.76	9.53	0.07	4.54
	Factorial mean values					
Type of chhana (F)						
F_1	51.24	2.38	16.52	28.96	0.88	381.55
F_2	52.90	4.68	12.01	29.47	0.93	467.10
F_3	45.09	6.81	11.37	35.70	1.00	415.95
Concentration of syrup (L)						
L_1	49.55	4.44	13.72	31.35	0.91	439.33
L_2	49.94	4.81	12.87	31.40	0.96	403.73
$CD_{(0.05)}$						
F×L	NS	NS	NS	NS	NS	6.42

[$]Average of three replications.
NS, nonsignificant.

Yield of Rosogolla

Yield of *Rosogolla* made from F_2 and CR chhana was at par and significantly higher than F_1 and F_3 (Table 2). The yield of C *Rosogolla* was statistically lower as compared to SF_{52}. Yield of *Rosogolla* for all the experimental samples were far lesser than 690 g/L of milk as reported by Bhattacharya and Raj (1980a).

The interaction effect of F×L was found to be nonsignificant for all the physico-chemical properties but significant for yield.

Texture Analysis of Rosogolla

The quality of product is monitored not only by the sensory properties but also by their rheological/textural profile. The value of hardness for C sample was significantly lower than all the experimental *Rosogolla* samples which varied from 5.88 to 13.69 N. The cohesiveness of C *Rosogolla* was found to be at par with those of experimental *Rosogolla* which varied from 0.51 to 0.61. *Rosogolla* made from F_1 chhana had higher cohesiveness value followed by F_3 and F_2. Springiness of all experimental samples varied from (5.67 to 6.06 mm) and springiness of *Rosogolla* made from F_1 and F_2 chhana was higher than those made from F_3. Treatments applied had shown a significant effect on gumminess of *Rosogolla* and the value of Control sample (2.5 N) was significantly at par with SF_{51}.

An increasing trend in hardness of *Rosogolla* was observed with the increasing fat content of milk used for chhana making while opposite is true for cohesiveness. This view is also in agreement with the results reported by Adhikari et al. (1992), Desai et al. (1993), Gupta et al. (1993), Hove and Das (1995) and Patil (2002). A nonsignificant effect for springiness of *Rosogolla*, suggested that all the experimental samples were as like that of Control sample and were well above 3.82–5.0 mm as reported by Adhikari et al. (1992), Patil (2002) and Karunanithy et al. (2006) but lower than 8.2–9.0 mm as reported by Desai et al. (1993) and Hove and Das (1995). The recorded gumminess of Experimental *Rosogolla* was in accordance within the range 2.98–4.69 N reported by Desai et al. (1993), 3.62 N by Adhikari et al. (1992), but lower than those reported by (0.76 N) Karunanithy et al. (2006).

Chewiness of experimental samples varied from 21.68 to 29.75 Nmm and was significantly higher than Control *Rosogolla*

Table 3 Textural properties of *diabetic Rosogolla*[$]

Treatment	Hard. (N)	Coh.	Spr. (mm)	Gum. (N)	Chew. (Nmm)	Frac. (N)	Adhe. (Nmm)	Stiff. (N/mm)
SF_{41}	5.88	0.61	5.94	3.6	21.68	4.6	0.0153	1.03
SF_{51}	6.38	0.58	5.67	3.5	23.09	1.2	0.0155	2.20
SF_{42}	7.85	0.54	6.06	3.8	26.07	4.1	0.0272	2.17
SF_{52}	8.18	0.54	5.83	4.5	27.73	2.4	0.0891	2.57
SF_{43}	13.69	0.55	5.70	7.3	29.75	7.8	0.0375	3.05
SF_{53}	6.67	0.57	5.73	3.6	27.49	6.0	0.0298	1.23
C	5.55	0.51	5.86	2.5	14.39	2.6	0.0781	0.79
$CD_{(0.05)}$	2.41	NS	NS	1.31	6.45	1.0	0.01	0.28
	Factorial mean values							
Type of chhana (F)								
F_1	6.13	0.59	5.80	3.55	22.38	2.91	0.0154	1.61
F_2	8.01	0.54	5.94	4.15	26.90	3.25	0.0580	2.37
F_3	10.18	0.56	5.71	5.45	28.62	6.90	0.0330	2.14
Concentration of syrup (L)								
L_1	13.71	0.56	5.90	4.90	25.83	5.50	0.0260	2.08
L_2	7.07	0.56	5.74	3.88	26.10	3.20	0.0440	2.00
$CD_{(0.05)}$								
F×L	1.70	NS	NS	NS	NS	2.3	0.01	0.20

[$]Average of three replications.
NS, nonsignificant.
Hard, hardness.
Coh., cohesiveness.
Spr., springiness.
Gum., gumminess.
Chew., chewiness.
Frac., fracture force.
Adhe., adhesiveness.
Stiff, stiffness.

and also chewier. Fracture force of *Rosogolla* made from F_1 and F_2 chhana were similar and at par with C *Rosogolla*, whereas significantly lower than F_3 (Table 3). An increasing trend in fracture force, with the increase in fat content of milk from 2% to 3% used for chhana making was observed. The value of adhesiveness for C *Rosogolla* was significantly higher than all the experimental *Rosogolla* samples (except SF_{52}). The value of stiffness of all the experimental *Rosogolla* samples (except SF_{41}) was significantly lower than Control sample. The stiffness of experimental *Rosogolla* made from F_2 and F_3 chhana was same but significantly higher than *Rosogolla* made from F_1 chhana. The recorded values of chewiness were higher than the values (5.80–18.00 Nmm) reported by Adhikari et al. (1992), Hove and Das (1995), Patil (2002) and Karunanithy et al. (2006), while lower than 42–68 Nmm as reported by Desai et al. (1993). The possible reason for higher chewiness as compared to C *Rosogolla* might be the low moisture and fat content and high protein content. Adhesiveness of experimental *Rosogolla* was found to be higher than the value (0.01 Nmm) reported by Adhikari et al. (1992).

Table 4 Sensory evaluation of *diabetic Rosogolla*[$]

Treatment	Body and texture	Taste and smell	Color and appearance	Overall acceptability
SF_{41}	31.80	26.40	13.17	71.38
SF_{51}	36.55	27.81	15.68	80.42
SF_{42}	37.55	28.98	17.35	83.50
SF_{52}	36.73	28.13	16.71	81.58
SF_{43}	34.25	25.50	14.21	73.96
SF_{53}	35.18	27.73	15.51	78.43
C	39.05	30.11	17.01	83.99
$CD_{(0.05)}$	NS	3.53	2.23	10.17
	Factorial mean values			
Type of chhana (F)				
F_1	34.17	27.10	14.42	75.9
F_2	37.14	28.55	17.03	82.54
F_3	34.71	26.61	14.86	76.19
Concentration of syrup (L)				
L_1	34.53	26.96	14.91	76.28
L_2	36.15	27.89	15.96	80.14
$CD_{(0.05)}$				
F×L	NS	NS	NS	NS

[$]Average of three replications.
NS, nonsignificant.

The interaction effect of type of chhana and type of cooking syrup (F×L) were found to give a significant effect on hardness, adhesiveness, fracture force, and stiffness of *Rosogolla*. Whereas, the interaction non-significantly affected the cohesiveness, springiness, gumminess, and chewiness of *Rosogolla*.

Sensory Evaluation of Rosogolla

The fate of any food product has always rested on the acceptance of the product by consumers. A nonsignificant effect of the

Table 5 Regression coefficients for sensory attributes, textural properties with physico-chemical characteristics of *diabetic Rosogolla*

	Physico-chemical characteristics				
Correlation	Moisture	Fat	Protein	Sorbitol	Ash
Body and texture	−0.211	0.380	−0.520	0.435	0.274
Taste and smell	−0.057	0.014	−0.137	0.213	−0.118
Color and appearance	0.035	0.238	−0.417	0.162	0.099
Overall acceptability	−0.109	0.193	−0.333	0.237	0.046
Hardness	−0.331	0.418	−0.293	0.040	0.224
Cohesiveness	0.350	−0.423	0.445	−0.387	−0.240
Springiness	0.457	−0.396	0.278	−0.220	0.350
Gumminess	−0.364	0.305	−0.146	−0.024	0.132
Chewiness	−0.154	0.024	0.131	−0.385	−0.165
Fracture force	−0.574*	0.480	−0.252	0.268	0.269
Adhesiveness	0.018	0.363	−0.571*	0.426	0.413
Stiffness	0.020	0.118	−0.074	−0.292	0.040
Moisture	1.000*	−0.613*	0.346	−0.699**	−0.436
Fat	−0.613*	1.000**	−0.932**	0.739**	0.916**
Protein	0.346	−0.932**	1.000**	−0.660*	−0.893**
Sorbitol	−0.699**	0.739**	−0.660*	1.000**	0.739**
Ash	−0.436	0.916**	−0.893**	0.739**	1.000**

**Significant at $p \leq 0.01$.
*Significant at $p \leq 0.05$.

treatment applied during making of experimental *Rosogolla* was observed for body and texture score while a significant effect on taste and smell score and color and appearance score (Table 4). The Control sample scored an average of 39.05 for body and texture, which was higher than experimental sample. The taste and smell score of Control sample was statistically similar to all of the experimental *Rosogolla* samples except SF_{41} and SF_{43}. *Rosogolla* made from F_2 chhana was significantly superior over the *Rosogolla* made from F_3, F_1, and C *Rosogolla* for color and appearance score (Table 4).

As a whole, the acceptability of *Rosogolla* exclusively depends on its organoleptic characteristics, which are based on compositional, physico-chemical as well as microbiological characteristics. The overall acceptability score of *Rosogolla* was found to be influenced significantly by the treatments given during the study (Table 4). The overall acceptability scores of all

Table 6 Regression coefficients for sensory attributes and rheological properties of *diabetic Rosogolla*

	Rheological properties							
Correlation	Hard.	Coh.	Spr.	Gum.	Chew.	Frac.	Adhe.	Stiff.
Body and texture	−0.147	−0.645*	−0.119	−0.312	−0.401	−0.234	0.481	−0.226
Taste and smell	−0.347	−0.610*	0.001	−0.467	−0.395	−0.360	0.350	−0.467
Color and appearance	−0.128	−0.637*	−0.064	−0.302	−0.221	−0.359	0.444	−0.123
Overall acceptability	−0192	−0.667*	−0.102	−0.343	−0.304	−0.314	0.403	−0.254
Hardness	1.000**	−0.224	−0.413	0.958**	0.611*	0.592*	−0.031	0.797**
Cohesiveness	−0.224	1.000**	0.546	−0.082	0.211	−0.215	−0.385	−0.008
Springiness	−0.413	0.546	1.000**	−0.396	−0.073	−0.229	0.015	−0.288
Gumminess	0.958**	−0.082	−0.396	1.000**	0.707**	0.555*	−0.091	0.803**
Chewiness	0.611*	0.211	−0.073	0.707**	1.000**	0.327	−0.232	0.714**
Fracture force	0.592*	−0.215	−0.229	0.555*	0.327	1.000**	−0.188	0.168
Adhesiveness	−0.031	−0.385	0.015	−0.091	−0.232	−0.188	1.000**	−0.059
Stiffness	0.797**	−0.008	−0.288	0.803**	0.714**	0.168	−0.059	1.000**

**Significant at $p \leq 0.01$.
*Significant at $p \leq 0.05$.
Hard, hardness.
Coh., cohesiveness.
Spr., springiness.
Gum., gumminess.
Chew., chewiness.
Frac., fracture force,
Adhe., adhesiveness.
Stiff., stiffness.

experimental *Rosogolla* varied from 71.38 to 83.50 and except SF_{41} all were statistically at par with Control. *Rosogolla* prepared from F_2 chhana was preferred over F_3, F_1, and Control *Rosogolla*. A negative correlation was observed between cohesiveness and the organoleptic characteristics (Table 6).

CONCLUSION

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 Sorbitol solution containing 14.3 g/L aspartame. Looking to the changing trends in society and the rate at which diabetes and related health problems are spreading this procedure can be used at commercial level. The results obtained during the investigation can contribute to prepare a manufacturing protocol for preparing *Diabetic Rosogolla* with different combinations of permitted artificial sweeteners and bulking agents.

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