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Research Article

Evaluation of whey protein concentrate as a functional ingredient on quality of goat milk *rasogolla* - an Indian dessert

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Abstract
In the literature, a variety of dairy products are made from goat milk; however, information related to the manufacture of *rasogolla* from goat milk is very scant. During preliminary trials, it was observed that *chhena* prepared from goat milk was not suitable for the preparation of *rasogolla* because it has a very soft and sticky body that is difficult to handle. Therefore, this investigation was conducted to formulate an acceptable quality goat milk *rasogolla* using whey protein concentrate (WPC) as a functional ingredient. Chhena (also known as Indian cottage cheese, a heat- and acid-coagulated indigenous dairy product) was prepared from fresh Surati goat milk (3.5% fat/8.5% milk solids-not-fat (MSNF). Twelve batches of *rasogolla* were prepared from *chhena* coagulated at three temperatures viz. 75, 80 and 85ºC containing WPC at 4 levels (i.e., 0, 0.25, 0.50 and 0.75% w/w of milk). *Rasogolla* prepared from *chhena* containing 0.50% WPC in milk and coagulated at 80°C was preferred the most with respect to all the sensory attributes evaluated. It had significantly (P<0.05) highest sucrose content, i.e., 35.73% and a higher sugar absorption ratio, i.e., 2.63, compared to all the other experimental samples. The composition of drained samples of goat milk *rasogolla* was as follows: moisture 50.07%; protein 7.04%; fat 6.44%; ash 0.45% and sucrose 35.73%. The pH was 6.34 and acidity was 0.76% lactic acid. Based on the results obtained in this study, a method was developed for the preparation of acceptable quality goat milk chhena and *rasogolla.*

Keywords: *Chhena*, Goat milk, *Rasogolla*, Whey protein concentrates

INTRODUCTION

Rasogolla, also known as the “King of traditional Indian sweets”, is very popular all over India, particularly West Bengal and Odisha. Traditionally, *rasogolla* preparation involves various steps, such as manufacturing *chhena*, a coprecipitated product obtained from heat and acid coagulation of milk. Small balls of kneaded *chhena*, approximately 10 to 12 g each, are formed and cooked under controlled conditions in boiling sugar syrup (approximately 60° Brix) followed by overnight soaking in sugar syrup (approximately 40°Brix) (Aneja *et al*., 2002).

Goat milk has traditionally been known for its medicinal properties and has recently gained attention in human health due to its easy digestibility and health-promoting traits. Goat milk has advantages over cow or human milk in having higher digestibility of protein and fat, alkalinity, buffering capacity, and certain therapeutic values in medicine and human nutrition. Goat milk helps to increase the pH of the bloodstream. It is the only dairy product with the highest amount of L-glutamine. Acidic blood and low intestinal pHlevels have been associated with fatigue, headaches, muscle aches and blood sugar imbalances (Mwenze, 2015). Oligosaccharides from goat milk have been shown to have an anti-inflammatory effect. The expected decrease in body weight, increased colonsize and extension of necrotic lesions are prevented by oligosaccharides (Lara-Villoslada *et al*., 2006). The proteins αs1 casein and β-lactoglobulin are important allergens in cow milk allergies. Since the content of αs1 casein is very high in cow milk but relatively low in goat milk, the latter has been suggested as an alternative milk source for cow milk allergies (Tomotake *et al*., 2006). Goat milk is rich in medium chain triglycerides(MCTs), including caproic, caprylic and capric acids. These MCTs have a lowering effect on plasma cholesterol in rat models and act as antiatherogenic agents (Davenport, 2002).

A variety of dairy products are made from goat milk; however, information related to the manufacture of *rasogolla* from goat milk is very scant in the literature. Bhargava *et al.* (1992) reported that the use of goat milk with 3.0 to 4.0% fat resulted in a spongy *rasogolla* of acceptable quality. During preliminary trials, it was observed that *chhena* prepared from goat milk was not suitable for preparing *rasogolla* because it has a very soft and sticky body that is difficult to handle. This could be partly attributed to the fact that goat milk has a slightly lower casein content than cow milk, with a very low proportion or absence of αs1-casein and a higher degree of casein micelle dispersion (Remeuf and Lenoir, 1986; Vegarud *et al*., 1999). Average size of fat globules is 3.5 μm in goat milk. Because of the presence of smaller fat globules, goat milk is considered naturally homogenized milk (Park and Guo, 2006b). In preliminary observations in our laboratory, it was observed that the *chhena*prepared goat milk was very soft, so expulsion of whey was very difficult. *Chhena* with such defects gave serious problems in kneading and making *rasogolla* balls. *Rasogolla* prepared from goat milk *chhena* had a hard body and coarse texture with surface cracking. Sometimes it was observed that during cooking, the balls disintegrated.

WPC has been used in many food applications as a functional ingredient due to its highly nutritional, biological and excellent functional properties. WPC has been used in cheese manufacturing because it increases its yield and improves its organoleptic characteristics (Korhonen *et al*., 1998; Vidigal*et al*., 2012). Pinto *et al.* (2008) reported that *chhena* prepared from buffalo milk incorporated with WPC had a positive effect on the sensory characteristics *of rasogolla* when WPC was incorporated in milk at 0.75% (w/w of milk). David (2016) reported that acceptable quality *rasogolla* can be made from cow milk *chhena* incorporated with 0.5% WPC. Patel (2017) made good-quality *rasogolla* from *chhena* incorporated with 0.75% WPC. Hence, this investigation was conducted to formulate an acceptable quality of*rasogolla* from goat milk using WPC as a functional ingredient.

MATERIALS AND METHODS

Fresh Surati goat milk was obtained from the livestock research station of Anand Agricultural University. The fat and MSNF (milk solids-not-fat) contents of the milk varied from 3.5 to 4.2% and 8.5 to 8.7%, respectively. The milk was pasteurized at 75°C for 15 seconds and stored at 4±2°C until use. WPC-80 was obtained from Charotar Casein Company, Malharpura, Nadiad, Gujarat, India, and had a protein content of 80.30%. Citric acid, supplied by Loba-Chemical Pvt. Ltd., was used as a coagulant. Double refined cane sugar from Madhur Brand, Shri Renuka Sugars Ltd., Karnataka, was used.

Method for manufacture of goat milk chhena

Goat milk (3.5% milk fat and 8.5% MSNF) was preheated to 45°C. To prepare *chhena,* calculated quantity of WPC-80 at different rates viz. 0, 0.25, 0.50 and 0.75% w/w of goat milk respectively was blended with lukewarm milk at approximately 40°C (approximately 50 times its weight) and allowed to hydrate completely for 30 min before mixing in milk. Goat milk was preheated to 90°C for 5 min and cooled to the desired coagulation temperature (viz. 75, 80 or 85°C). Coagulation was carried out by adding 1.0% freshly prepared citric acid solution until clear whey was obtained with constant stirring. Coagulation was performed by keeping the speed of stirring milk during the addition of the coagulant sufficient to disperse the coagulant until clear whey was obtained. The content was allowed to stand for 5 min., followed by draining of whey using a clean muslin cloth. The coagulated mass was allowed to hang for further draining until the dripping of free whey completely stopped (i.e., approximately 15 to 20 min.) to obtain *chhena*. At this point the pH of whey was approximately 5.4 to 5.5. Goat milk *chhena* obtained were allowed to further drain until the dripping of free whey completely ceased (i.e., approximately 20 to 30 min.). On completion of draining *chhena,* lots were packaged in polyethylene pouches and stored in a refrigerator (7±2°C) until further use.

Method of manufacture of *rasogolla*

The goat *chhena* prepared as outlined above served as the base for the preparation of *rasogolla*. Sugar solution (50°Bx) was used for cooking and soaking *rasogolla*. Boiling sugar solutions were clarified by adding a few ml of skim milk, boiling it for approximately 3 minutes, and then straining it through a muslin cloth. The final concentration of the sugar syrup was measured with the help of a pocket refractometer (Hand Refractometer, Erma,Japan, range 28 to 62°Bx). *Chhena* was properly kneaded to a smooth paste before cutting it into small pieces of 10 to 12 g each. Each portion was rolled between palms to form balls of approximately 15 mm diameter. It was ensured that each ball had asmooth surface with no cracks. Approximately 2 liters of freshly clarified 50° Brix sugar solution was brought to boil in a stainless-steel vessel (23 cm diameter and 23 cm depth). *Chhena* balls were gently dropped into the boiling sugar solution. The temperature of the boiling sugar syrup was between 105 and 107°C. Heating was regulated to impart a stable foam on the surface of the syrup during cooking. Balls were gently stirred with a perforated ladle every 5 min. Cooking of the balls was done in a closed vessel, except for the first 5 min. of cooking, which was done keeping the vessel open. During cooking, to compensate for the loss of water, approximately 30 to 40 ml of hot water (80°C) was added intermittently at an interval of approximately 5 min. so that the concentration of the boiling syrup remained almost constant. A cooking time of approximately 15 min. was required for complete texturization of *rasogolla* balls. After completion of cooking, heating was stopped, and the *rasogolla* balls were transferred to the 40°Brix clarified hot (60°C) sugar solution using a perforated ladle. The *rasogollas* were then allowed to cool to room temperature, and soaking in sugar solution was performed overnight before sensory evaluation and sampling for chemical analysis.

Chemical analysis

Rasogolla samples for chemical analysis were prepared according to the method described in IS:4079,1967 (R2000). *Rasogolla* samples were kept at 40°C for 20 min. before transferring on a sieve of approximately one square cm mesh such that all the rasogollas were in one layer. The syrup was then allowed to drain for 10 min. in a container. The samples were crushed to a smooth, homogenous paste before subjecting them for analysis. The moisture, fat and sucrose contents of *rasogolla* were determined as per the method prescribed in IS:4079,1967 (R2000). Protein content in *rasogolla* was determined by semimicro Kjeldahl method IS:4079-1967, using Kjel-plus digestion system (M/s Pelican Instruments, Chennai, Model-KES 20LVA DLS) and Kjel-plus semiautomatic distillation system (M/s Pelican Instruments, Chennai, Model- Distil M).

Ash content was determined according to the method prescribed in the Association of Official Agricultural Chemists (Association of Official Agricultural Chemists,1984).

The pH of the *rasogolla* samples was measured using a Systronic digital pH meter, Model

335. The method described by Franklin and Sharpe (1963) for cheese was used. The homogenate prepared by diluting 20 g of sample in 20 ml of glass distilled water was subjected to pH measurement. The acidity of the *chhena* and *rasogolla*samples was estimated according to the procedure specified for *chhena/paneer*under IS:10484,1983 (R2005). The sugar absorption was calculated by dividing the weight of drained *rasogolla* by the weight of *chhena* used.

Sensory evaluation

Chhena and *rasogolla* samples were tempered to 25±2°C before judging. In isolated booths illuminated with incandescent light maintained at 23±2°C, sensory analysis of samples was performed. Samples were served in petri dishes. The plates were labelled with three-digit codes. The order in which samples were presented was randomized across subjects. Subjects in one session assessed a maximum of 5 samples.

The sensory panel (n=10) was composed of staff members and postgraduate students working in the SMC College of Dairy Science, Anand, Gujarat. The selection criterion was that the subject had to be regular consumers of the product as well as their similar behaviour between sensory evaluation sessions. During the assessment sessions, 25 g of *chhena* and *rasogolla* (one ball) in petri dishes with lids were served for sensory evaluation, and panellists were asked to evaluate the sample. Panellists were instructed to use lukewarm water as a rinsing agent as and when necessary.

The sensory attributes of the *chhena* as measured by the characteristics of the *chhena,* which were flavour, body and texture, colour and appearance and overall acceptability, were evaluated using a 9-point hedonic scale.

Statistical analysis

The mean values generated from the analysis of duplicate samples of *rasogolla*, obtained in three replications, were subjected to statistical analysis using a completely randomized design (CRD) developed by Anand Agricultural University, Anand.

RESULTS AND DISCUSSION

The influence of the incorporation of WPC at different rates and varied coagulation temperatures on the moisture, protein, fat, sucrose and ash contents of goat milk *rasogolla* is depicted in Table 1.

Moisture

Incorporation of WPC in *chhena* showed a significant (P<0.05) effect on the moisture content of *rasogolla*. Experimental samples of *rasogolla* that were prepared from *chhena* without the addition of WPC had significantly (P<0.05) higher moisture content, i.e., 53.83% compared to samples incorporated with WPC.

The data presented in Table 1 reveal a significant (P<0.05) decrease in the moisture content of *rasogolla* with an increase in coagulation temperature. The moisture content of rasogollae decreased from 53.86% at a 75°C coagulation temperature to 46.93% at an 85°C coagulation temperature. The average moisture content of goat milk *rasogolla* coagulated at 75°C was

53.86%, which was significantly (P<0.05) higher than that of samples coagulated at 80 and 85°C. The interactions between WPC and coagulation temperature showed a significant (P<0.05) effect on the moisture content of goat milk *rasogolla*. From Table 1 it can be directly observed that sample *rasogolla* made from *chhena,* which was made from (0% WPC using and coagulation temperature of 75°C) had significantly (P<0.05) higher moisture content compared to all the other experimental samples. *Rasogolla* made from *chhena* with incorporation of 0.75% WPC coagulated at 85°C had a significantly (P<0.05) low moisture content compared to all the other samples. Table 1 shows that all the experimental *rasogolla* except the sample coagulated at 75°C containing 0% WPC met the requirements with respect to BIS (4079-1967) (R2000) standards for canned *rasogolla,* which permits a maximum moisture content of 55%. There are no data available for comparison of goat milk *rasogolla* made from *chhena* incorporated with different rates of WPC and varied coagulation temperatures.

Bhargava *et al.* (1992) prepared *chhena* from goat milk standardized to 3 and 4% fat. The average moisture content of goat milk *rasogolla* prepared from the *chhena* samples ranged from 48.0 to 52.3%. An almost similar trend is observed in the current experiment. David (2016) also reported that incorporating WPC in cow milk *rasogolla* had a significant effect on moisture content. He reported that incorporation of WPC decreased the moisture from 51.2 to 38.4%. The differences in results obtained could be attributed to the type of milk used and the type of WPC used.

Protein

Incorporation in WPC in goat milk *chhena* had a significant (P<0.05) effect on the protein content of goat milk *rasogolla*. From Table 1, it can be observed that there was a progressive increase in protein content in *rasogolla* when the level of WPC increased. *Rasogolla* made from the incorporation of 0.75% WPC in milk used for *chhena* making had significantly (P<0.05) higher protein content, i.e., 11.94% compared to *rasogolla* made from *chhena* prepared from milk incorporated with 0.0, 0.25, and 0.50% WPC.

Rasogolla made from *chhena* coagulated at 75°C and 85°C were found to be at par (P>0.05) with each other in terms of their protein content, while *rasogolla* made from *chhena* coagulated at 80°C had significantly (P<0.05) lower protein content compared to *chhena* samples coagulated at 75 and 85 °C. *Rasogolla* made from incorporation of 0.75% WPC and 85 °C coagulation had significantly (P<0.05) higher protein content, i.e., 12.35% compared to all the other samples.

Tarafdar*et al.* (2002) reported that the average protein content in *rasogolla* available in the Bangladesh local market was 6.6 to 6.8%. In the present study, higher values for protein were recorded, i.e., 8.74 to 12.23%. There are no data available for comparison of goat milk *rasogolla* made from the incorporation of different rates of WPC and varied coagulation temperatures. The minimum protein level permitted by IS 4079-1967 (R2000) is 5.00%, and it can be observed from Table 1 that the per cent protein content valuesof all experimental *rasogollas* were well above the prescribed limits for protein.

David (2016) made *rasogolla* from cow milk with the incorporation of WPC, and he reported that the addition of WPC in milk leads to increased protein content in *chhena* and *rasogolla*. Kankhare*et al.* (2019) made baby *rasogolla* from cow milk with the addition of WPC and reported the addition of increased protein content in *rasogolla*. Theaverage protein content in Baby *rasogolla* was reported to be 5.16 to 14.94%. Patel (2017) made mixed milk *rasogolla* with the addition of WPC, and he reported that the average protein composition in *rasogolla* was 5.52 to 6.47%. The results obtained in this study are similar to those reported by David (2016), Patel (2017) and Kankhare *et al.* (2019)

Fat

Table 1 shows that as the level of WPC increased, there was a progressive increase in the average fat content of goat milk *rasogolla* viz. 6.83 (0.0% WPC) to 9.89 (0.75% WPC). *Rasogolla* samples made from incorporation 0.75% WPC had significantly (P<0.05) higher average fat, i.e., 9.89% compared to other level of WPC viz. 0.00, 0.25 and 0.50% studied.

Rasogolla made from *chhena* coagulated using different coagulation temperatures had a significant (P<0.05) effect on the fat content of *rasogolla*. There was an increase in fat content when the coagulation temperature was increased from 75°C to 85°C, i.e., 6.89 to 9.11%, respectively. *Rasogolla* made from *chhena* coagulated at 85°C had significantly (P<0.05) higher fat 9.11% compared to goat milk *rasogolla* prepared from *chhena* coagulated at 75 and 80°C. The interaction between the level of WPC in milk and coagulation temperature had a significant (P<0.05) effect on the fat content of goat milk *rasogolla*. The data presented in Table 1 revealed that milk samples made from milk containing 0.75% WPC and 85°C coagulation temperature had significantly (P<0.05) higher fat contents than all the other experimental samples.

The minimum fat level permitted by IS 4079-1967 (R2000) for canned *rasogolla* is 5.00%, and it can be observed from Table 1 that the values for fat content of all experimental *rasogollas* were well above the prescribed limits for fat as per Bureau of Indian Standards.

Bhargava *et al.* (1992) made *rasogolla* from goat milk and reported that the average fat content in goat milk *rasogolla* was 6.52 to 7.58%. Most similar results were reported in our experiment when *rasogolla* prepared from *chhena* coagulated at coagulation temperatures of

Table 1. Influence of levels of WPC and coagulation temperature on compositional attributes of *rasogolla*

Level of addition of WPC (%w/w of	Coagulation Temperature °C			Average for WPC
	75°C	80°C	85°C	
Moisture (%)				
0	57.51±0.14	53.19±0.29	50.78±0.45	53.83
0.25	54.42±0.60	51.27±0.27	48.94±0.37	51.54
0.50	52.72±0.40	50.07±0.23	45.66±0.50	49.48
0.75	50.79±0.54	46.07±0.46	42.35±1.09	46.40
Average for coagulation temperature	53.86	50.15	46.93	
CD (0.05) W=0.17; T = 0.20; WXT=0.35				
Protein (%)				
0	8.74±0.55	6.81±0.08	7.76±0.15	7.77
0.25	8.99±0.23	7.43±0.08	8.55±0.19	8.32
0.50	8.70±0.41	7.04±0.28	10.19±0.20	8.64
0.75	12.25±0.42	11.21±0.57	12.35±0.78	11.94
Average for coagulation temperature	9.67	8.12	9.71	
CD (0.05) W=0.14; T = 0.16; WXT=0.28				
Fat (%)				
0	6.22±0.41	6.63±0.82	7.65±0.17	6.83
0.25	6.40±0.13	7.16±0.82	8.30±0.20	7.28
0.50	6.16±0.30	6.44±0.25	9.49±0.19	7.36
0.75	8.79±0.33	9.88±0.50	11.00±0.72	9.89
Average for coagulation temperature	6.89	7.52	9.11	
CD (0.05) W=0.12; T = 0.13; WXT=0.23				
Sucrose (%)				
0	26.50±1.20	32.69±0.38	32.63±0.24	30.61
0.25	29.12±0.95	33.45±0.35	32.82±0.10	31.80
0.50	31.52±0.89	35.73±0.66	32.74±0.16	33.33
0.75	27.26±0.56	31.52±0.76	31.92±0.63	30.23
Average for coagulation temperature	28.60	33.35	32.53	
CD (0.05) W=0.23; T = 0.26; WXT=0.46				
Ash (%)				
0	0.58±0.04	0.51±0.006	0.58±0.01	0.55
0.25	0.49±0.01	0.50±0.005	0.61±0.02	0.53
0.50	0.38±0.02	0.45±0.01	0.65±0.01	0.50
0.75	0.54±0.3	0.68±0.04	0.74±0.05	0.65
Average for coagulation temperature	0.50	0.53	0.64	
CD (0.05) W=0.009; T = 0.011; WXT=0.019				
Source	SEm	CD (0.05)		CV (%)
WPC (W)	0.009	0.027		
Coagulation temperature (T)	0.011	0.033		
W x T	0.019	0.058		5.96

Each observation is mean ±SD, n=4; W= Level of WPC; T=coagulation temperature; a-d values to same superscript in each column do not differ significantly (P<0.05); A-B values with the same superscript in each row do not differ significantly (P<0.05)

75 and 80°C, while in *rasogolla* samples prepared from *chhena* coagulated at 85°C, the fat content was slightly higher than the range given by them. This could be attributed to the lower moisture content in such samples, as seen earlier.

David (2016) made *rasogolla* from cow milk with the addition of WPC, and they reported that the addition of WPC in milk leads to increased fat content in *rasogolla*. The average value of fat in *rasogolla* was 3.68 to 7.17%, and this statement was supported by Kankhare *et al.* (2019), who made baby *rasogolla* from cow milk with incorporation of WPC. They found that when the level of WPC increases, the fat content of *rasogolla* was also increased, and the reported value was 5.04 to 6.11%. Patel (2017) made *rasogolla* from mixed milk with incorporation of WPC, and he reported that the average value of fat was 6.81 to 8.69% in *rasogolla*.

Sucrose

As seen in Table 1, there was an increase in sucrose content when WPC was added up to the 0.50% level; thereafter, at a higher rate of addition of WPC, there was a decrease in sucrose content. A similar trend was observed with coagulation temperature. *Rasogolla* made from the incorporation of 0.50% WPC had a significantly (P<0.05) higher sucrose content, i.e., 33.33% compared to *rasogolla* made from other level of WPC, i.e., 0, 0.25 and 0.75% (w/w of milk). *Rasogolla* made from *chhena* coagulated at 80°C had significantly (P<0.05) higher sucrose content 33.35% compared to *rasogollas* prepared using other coagulation temperature, i.e., 75 and 85°C. The interaction effect shown in Table 1 shows that the combination of WPC at coagulation temperatures of 0.50% and 80°C, i.e., R8 had the highest sucrose content (35.73%), which was significantly (P<0.05) higher than all the other experimental samples.

Patel (2017) made *rasogolla* from mixed milk with the incorporation of WPC in milk at levels ranging from 0 to 1.25% w/w of milk, and he reported that when the level of WPC increased in *rasogolla,* the sucrose content of *rasogolla* also increased up to a certain level, i.e., up to 0.75% level after that it start decreasing. There are no data available for comparison of goat milk *rasogolla* made from incorporation of different rates of WPC and varied coagulation temperatures. However, the maximum sucrose level permitted by IS 4079-1967 (R2000) was 45.00%, and it was observed from Table 1 that the % sucrose contents of all *rasogolla* were well within the prescribed limits for sucrose.

Ash

As seen in Table 1, there was a decrease in ash content when WPC was added up to 0.50%; thereafter, at a higher rate of addition of WPC, there was an increase in ash content. When the coagulation temperature increased the ash, the content was increased in *rasogolla*. Goat milk *rasogolla* samples made from the incorporation of 0.75% WPC had significantly (P<0.05) higher ash content, i.e., 0.65% compared to samples made from other levels of WPC, i.e., 0, 0.25 and 0.5%.Goat milk *rasogolla* samples made from *chhena* which was coagulated at 85 °C had significantly (P<0.05) higher average ash content of 0.64% compared to *rasogolla* prepared from *chhena* using lower temperatures, i.e., 75 and 80°C. The interaction effect shown in Table 1 shows that *rasogolla* samples prepared from *chhena* using a combination of WPC at coagulation temperatures of 0.75% and 85°C had the highest ash content (0.74%), which was found to be significantly (P<0.05) higher than all the other experimental samples.

Patel (2017) made *rasogolla* from mixed milk with the incorporation of WPC in milk. He reported that when the level of WPC increases in *rasogolla*, the ash content of *rasogolla* decreases up to a certain level, i.e., 0.75% after that it start increasing. In our studies, the average ash content in goat milk *rasogolla* made with the incorporation of WPC and coagulation temperature varied from 0.38 to 0.74%. These values are lower than those reported by Patel (2017) for mixed milk *rasogolla* made from the incorporation of WPC. Patel (2017) reported an average value of 0.76 to 0.96% ash. There are no data available for comparison of goat milk *rasogolla* made from incorporation of different rates of WPC and varied coagulation temperatures.

Influence of varied levels of WPC and coagulation temperature on the sugar absorption ratio of goat milk *rasogolla*

Table 2 shows the data on the average sugar absorption ratio of goat milk *rasogolla* made with the imposition of different treatments, viz. level of WPC and coagulation temperature. The sugar absorption was calculated by dividing the weight of drained *rasogolla* by the weight of *chhena* used.

Table 2 shows that the sugar absorption ratio of the experimental rasogolla samples ranged from 1.60 to 2.63. From Table 2, it can be seen that with an increase in the level of WPC, there was a progressive increase in the sugar absorption ratio of goat milk *rasogolla* up to 0.50% WPC. Thereafter, there was a decrease in the sugar absorption ratio. The average sugar absorption ratio of goat milk *rasogolla* samples made by adding 0.50% WPC was 2.28, which was significantly (P<0.05) higher than that of samples containing 0, 0.25 and 0.75% WPC.

The data presented in Table 2 show that there was a significant (P<0.05) increase in the sugar absorption ratio of goat milk *rasogolla* with an increase in the temperature of coagulation up to 80°C above this temperature, and there was a significant (P<0.05) decrease in the sugar absorption ratio. The average sugar absorption ratio of goat milk *rasogolla* samples made using *chhena* coagulated at 80°C was 2.28, which was significantly (P<0.05) higher than that of goat milk *rasogolla*s made from *chhena* coagulated at temperatures of 75 and 85°C.

The interaction effect of the level of WPC and coagulation temperature had a significant (P<0.05) effect on the average sugar absorption ratio of goat milk *rasogolla*. Experimental sample R8, i.e., *rasogolla* made from goat milk *chhena* incorporated with 0.50% WPC in milk and coagulated at 80°C had significantly (P<0.05) higher sugar absorption ratio, i.e., 2.63 compared to all the other experimental samples.

There are no data available for comparison of goat milk *rasogolla* made from *chhena* incorporated with different rates of WPC prepared using varied coagulation temperatures or goat milk *rasogolla* prepared from *chhena* using varying coagulation temperatures. However, the value for the sugar absorption ratio obtained in this experiment is comparable with Patel (2017), who reported that the addition of WPC in mixed milk increased the sugar absorption ratio of *rasogolla* from 2.40 to 2.65 in the control and samples prepared from *chhena* containing 0.75% WPC in milk. A similar trend was observed by David (2016), who reported that the addition of WPC to cow milk increased the sugar absorption ratio of *rasogolla*.

Pinto *et al.* (2008) also reported that incorporation of WPC in buffalo milk up to a rate of 1.00% for *chhena* production resulted in an increased sugar absorption ratio of *rasogolla,* i.e., 2.37 in the control to 2.65 in samples containing 1.00% WPC 35. Thereafter, higher levels of addition of WPC, i.e., Rates of 2.00 and 3.00% resulted in a decrease in the sugar absorption ratio. Thus, the results obtained in this part of the study corroborate those reported by Pinto *et al.* (2008).

pH and acidity (% Lactic acid)

The average pH and acidity of goat milk *rasogolla* as affected by varying levels of WPC and coagulation temperature are presented in Table 2. The range of mean pH values of the different *rasogolla* samples under study was 6.11 (R11) to 6.70 (R3), and the range of acidity was 0.72 (R3) to 0.78% LA (R10). The average % acidity and pH of *rasogolla* as affected by additives are presented in Table 2. The ranges of mean values for acidity and pH of different *rasogolla* under study were 0.72 (R3) to 0.78% LA (R10) and 6.11 (R11) to 6.70 (R3), respectively. The highest values for acidity (0.78% LA) and pH 6.70 were observed in R10 and R3, respectively, whereas the lowest values for acidity, i.e., 0.72% LA and pH, i.e., 6.11 were observed in *rasogolla* samples R3 and R11, respectively. Incorporation of different levels of WPC had a significant ($P<0.05$) effect on the pH and acidity of *rasogolla*. Incorporation of WPC resulted in a lower pH and higher acidity compared to the control. *Rasogolla* made from 0.75% WPC had significantly ($P<0.05$) lower pH and significantly ($P<0.05$) higher acidity compared to other levels of WPC studied, i.e., 0, 0.25 and 0.50%.

Rasogolla samples made from *chhena* coagulated at higher temperatures had significantly ($P<0.05$) higher pH and lower acidity values than samples prepared using *chhena* coagulated at lower temperatures. *Rasogolla* samples made from *chhena* coagulated at 85 °C had significantly higher ($P>0.05$) pH and significantly

Table 2. Influence of levels of WPC and coagulation temperature on pH and acidity of *rasogolla*

Level of addition of WPC (% w/w of milk)	Coagulation Temperature °C			Average for WPC
	75°C	80°C	85°C	
pH				
0	6.40±0.01	6.55±0.03	6.70±0.08	6.55
0.25	6.30±0.01	6.45±0.04	6.46±0.11	6.41
0.50	6.24±0.03	6.34±0.03	6.39±0.13	6.32
0.75	6.16±0.02	6.11±0.08	6.17±0.12	6.15
Average for coagulation temperature	6.28	6.36	6.43	
CD (0.05) W=0.02; T = 0.03; WXT=0.05				
Acidity (% LA)				
0	0.74±0.02	0.73±0.02	0.72±0.08	0.73
0.25	0.75±0.04	0.74±0.06	0.73±0.07	0.74
0.50	0.77±0.02	0.76±0.03	0.74±0.06	0.76
0.75	0.78±0.03	0.77±0.02	0.75±0.06	0.77
Average for coagulation temperature	0.76	0.75	0.73	
CD (0.05) W=0.006; T = 0.007; WXT=0.013				
Sugar absorption ratio				
0	1.60±0.08	2.17±0.04	2.16± 0.02	1.98
0.25	1.80±0.08	2.27±0.05	2.18±0.01	2.08
0.50	2.03±0.09	2.63±0.12	2.17±0.02	2.28
0.75	1.65±0.04	2.03±0.08	2.08±0.07	1.92
Average for coagulation temperature	1.77	2.28	2.15	
Source	SEm	CD (0.05)		CV (%)
WPC (W)	0.02	0.07		
Coagulation temperature (T)	0.02	0.08		
W x T	0.04	0.14		4.11

Each observation is mean ±SD, n=4; W= Level of WPC; T=coagulation temperature; a-d values to same superscript in each column do not differ significantly ($P<0.05$); A-B values with the same superscript in each row do not differ significantly ($P<0.05$)

(P<0.05) lower acidity compared to samples prepared from *chhena,* which was coagulated at 75 and 80 °C. The interaction effect between WPC and coagulation temperature was nonsignificant (P>0.05) for both the pH and acidity of *rasogolla*.

The pH and acidity obtained for *rasogolla* samples in the present investigation are comparable with the results obtained by Haque *et al.* (2003), who reported a pH value of 6.50 and acidity of 0.71% LA in *rasogolla* made from mixed milk. Patel (2017) reported that the addition of WPC in mixed milk decreases the pH and increases the acidity of *rasogolla*. The average pH and acidity values reported were 6.53 to 6.04 and 0.72 to 0.77% LA, respectively. Almost similar values of pH and acidity of *rasogolla* were reported in our research.

David (2016) made *rasogolla* from cow milk with addition of WPC and they reported that addition of WPC increased the acidity and this statement was corroborated by Kankhare*et al*. (2019) who made baby(very small sized balls)*rasogolla* from cow milk with incorporation WPC and they found that when level of WPC increases the acidity of *rasogolla* was also increased. There appear to be no data on the pH and acidity of *rasogolla* as affected by the addition of WPC (w/w), and the coagulation temperature of goat milk is not available for comparison.

Effect of varying levels of WPC and coagulation temperature on the sensory scores of goat milk *rasogolla*

Colour and appearance

The data presented in Table 3 are the average values for the color and appearance scores of *rasogolla* made with different treatment combinations. The data presented in Table 3 show that incorporation of WPC significantly (P<0.05) improved the color and appearance scores of *rasogolla*. *Rasogolla* made from *chhena* containing 0.50% WPC had a significantly higher 7.28 average sensory score compared to other levels of WPC. The coagulation temperature had a significant (P<0.05) effect on the color and appearance score of *rasogolla*. *Rasogolla* made from *chhena* coagulated at 80°C had significantly higher colour and appearance scores than other coagulation temperatures. Beyond 80°C coagulation temperature had dull color observed.

The interaction effect of WPC and coagulation temperature on colour and appearance scores was significant (P<0.05). *Rasogolla* containing WPC at 0.50% and 80° C coagulation temperature had a smooth glossy surface, white colour and round shape. Therefore, it had significantly (P<0.05) higher colour and appearance scores than all the other treatments studied. Published data on colour and appearance scores of *chhena* as affected by the use of WPC and coagulation temperature are not available for comparison.

However, Patel (2017) made *rasogolla* from mixed milk with the addition of WPC in *chhena* milk and reported that the addition of WPC improves the colour and appearance of mixed milk *rasogolla* when they added WPC at a rate of 0.75%.

Taste score

The data presented in Table 3 indicate that the addition of WPC to *chhena* milk had a significant (P<0.05) effect on the taste score of *rasogolla* made from goat milk. Experimental *rasogolla* samples made from *chhena* containing 0.50% WPC had significantly (P<0.05) higher average taste scores, i.e., 7.67 compared to the taste scores of *rasogolla* prepared using other levels of WPC viz. 0.0 0.25 and 0.75%. Coagulation temperature had a significant (P<0.05) effect on the taste score of goat milk *rasogolla*. *Rasogolla*s made from *chhena* coagulated at 80°C had significantly (P<0.05) higher taste score i.e 7.61 compared to taste scores of *rasogolla*s prepared from other levels of coagulation temperature, i.e., 75 and 85°C. Below 80°C, rasogollae with coagulation temperatures had slightly flat flavours with very little unpleasant goatyafter taste. The lower taste scores were because of the lower sugar absorption ratio (Table 3) in samples coagulated at 75 and 85°C, and the samples were excessively sweet. The interaction between different levels of WPC and coagulation temperature had a significant (P<0.05) effect on the taste score of goat milk *rasogolla*. *Rasogolla* sample R8 made from *chhena* containing 0.50% and 80°C coagulation temperatures had a significantly (P<0.05) higher taste score (7.94) than the other treatment combinations. The taste scores were positively correlated with sugar absorption ratio, protein content, fat content, sucrose content, acidity and springiness and negatively correlated with moisture content, ash content, pH, water activity, hardness, cohesiveness, chewiness and adhesiveness. The coagulation temperature and level of WPC significantly (P<0.05) affected all these parameters, as seen earlier.

Smell score

The addition of WPC to *chhena* milk had a significant (P<0.05) effect on the smell score of *rasogolla* made from goat milk, as shown in Table 3. *Rasogolla* made from *chhena* containing 0.50% WPC had a significantly (P<0.05) higher average smell score of 7.41 compared to other WPC viz levels. 0.0 0.25 and 0.75% WPC. *Rasogolla* made from *chhena* containing below 0.50% WPC had moderate goatyflovor. Similarly, coagulation temperature had a significant (P<0.05) effect on the smell score of goat milk *rasogolla*. *Rasogolla* made from *chhena* coagulated at 80°C coagulation temperature had a significantly (P<0.05) higher average smell score of 7.35 compared to other coagulation temperature levels. The interaction between different levels of WPC and coagulation temperature was found to be nonsignificant.

Body and texture score

The addition of WPC had a significant (P>0.05) effect on the body and texture scores of *rasogolla*. There was an increase in body and texture scores of *rasogolla* when the rate was increased at 0.50%. Thereafter, higher rates of WPC addition resulted in a significant (P<0.05) decrease in the body and texture scores of goat milk *rasogolla*. The average body and texture score of *rasogolla* containing WPC (0.50%) was found to be significantly (P<0.05) higher (7.21) than *rasogolla* made from other levels of WPC, viz. 0.0, 0.25 and 0.75%. Beyond 0.50% WPC, *rasogolla* made from goat milk resulted in hard bodies, and texture and breakage of *rasogolla were* also noticed during cooking. Similarly, coagulation temperature had a significant (P<0.05) effect on the body and texture score of goat milk *rasogolla*. The average body and texture scores of goat milk Rasoglla made from *chhena* coagulated at 80°C were significantly (P<0.05) higher than those of Rasoglla made from chhena coagulated at 80°C. 7.44 compared

Table 3. Influence of levels of WPC and coagulation temperature on sensory scores of *rasogolla*

Level of addition of WPC (% w/w of milk)	Coagulation Temperature °C			Average for WPC
	75°C	80°C	85°C	
Colour and Appearance #				
0	5.55±0.04	7.28±0.06	6.90±0.08	6.58
0.25	5.87±0.06	7.44±0.04	7.13±0.12	6.81
0.50	6.65±0.25	7.90±0.08	7.30±0.16	7.28
0.75	6.23±0.21	7.65±0.04	7.20±0.15	7.03
Average for coagulation temperature	6.08	7.57	7.13	
CD (0.05) W=0.04; T = 0.05; WXT=0.09				
Taste score				
0	6.75±0.40	7.36±0.04	7.25±0.25	7.12
0.25	6.67±0.26	7.53±0.05	7.50±0.08	7.23
0.50	7.38±0.06	7.94±0.07	7.69±0.07	7.67
0.75	7.19±0.07	7.63±0.12	7.22±0.30	7.35
Average for coagulation temperature	7.00	7.61	7.42	
CD (0.05) W=0.05; T = 0.06; WXT=0.10				
Smell score				
0	6.66±0.04	7.07±0.21	6.90±0.33	6.88
0.25	6.76±0.03	7.30±0.24	7.10±0.24	7.05
0.50	7.20±0.16	7.77±0.12	7.27±0.29	7.41
0.75	7.03±0.21	7.27±0.25	7.00±0.37	7.10
Average for coagulation temperature	6.91	7.35	7.07	
CD (0.05) W=0.08; T = 0.09; WXT=0.16				
Body and texture score				
0	5.65±0.04	7.15±0.04	6.85±0.04	6.55
0.25	5.86±0.05	7.38±0.06	7.07±0.05	6.77
0.50	6.18±0.08	7.98±0.04	7.48±0.6	7.21
0.75	6.47±0.25	7.27±0.05	7.00±0.36	6.91
Average for coagulation temperature	6.04	7.44	7.10	
CD (0.05) W=0.05; T = 0.05; WXT=0.10				
Overall acceptability scores				
0	6.63±0.29	7.22±0.06	7.22±0.16	7.02
0.25	6.77±0.21	7.43±0.05	7.14±0.13	7.11
0.50	7.03±0.12	7.93±0.12	7.47±0.12	7.48
0.75	7.12±0.06	7.40±0.08	7.29±0.07	7.27
Average for coagulation temperature	6.89	7.50	7.28	
CD (0.05) W=0.05; T = 0.06; WXT=0.10				

Each observation is mean ±SD, n=4; W= Level of WPC; T=coagulation temperature; a-d values to same superscript in each column do not differ significantly (P<0.05); A-B values with the same superscript in each row do not differ significantly (P<0.05); # Based on 9-point hedonic scale score card to other levels of coagulation temperature. Below 80°C, *rasogolla* were less spongy and lacked porosity and chewier and rubberier bodies. Beyond 80°C, *rasogolla* had hard and brittle and granular textures. The interaction effect between WPC and coagulation temperature had a significant (P<0.05) effect on the body and texture scores of *rasogolla*. The data in Table 3 disclose that the body and texture score was highest, i.e., 7.84 when *rasogolla* was made from *chhena* containing 0.50% WPC and 80°C coagulation temperature. This may be because it had a spongy, soft and good porous structure compared to other samples. This combination was found to be significantly (P<0.05) higher than all the other experimental samples.

The improvement in body and texture scores could be correlated with the improvement in body and texture scores of *chhena* containing additives. No published data on body and texture scores of *rasogolla* as affected by the addition of WPC and coagulation temperature are available for comparison. However, Patel (2017) made *rasogolla* from mixed milk with the addition of WPC in *chhena* milk and reported that the addition of WPC improves the body and texture of mixed milk *rasogolla* when they added WPC at a rate of 0.75%.

Overall acceptability

The mean overall acceptability scores of experimental *rasogolla* samples presented in Table 3 show that the mean value of *rasogolla* ranged between 6.63 and 7.93. The addition of WPC had a significant (P<0.05) effect on the overall acceptability scores of *rasogolla*. There was an increase in overall acceptability scores of *rasogolla* when the rate was increased at 0.50%. Thereafter, higher rates of WPC addition resulted in a significant (P<0.05) decrease in the overall acceptability scores of goat milk *rasogolla*. The average overall acceptability score of *rasogolla* containing WPC (0.50%) was found to be significantly (P<0.05) higher than that of rasogolla containing WPC. 7.48 than *rasogolla* made from other level of WPC viz. 0.0, 0.25 and 0.75%. Similarly, coagulation temperature had a significant (P<0.05) effect on the overall acceptability score of goat milk *rasogolla*. The average body and texture score of goat milk *rasogolla*made from *chhena* coagulated at 80°C had significantly (P<0.05) higher overall acceptability scores than all other levels of coagulation temperatures. The interaction effect between WPC and coagulation temperature had a significant (P<0.05) effect on the overall acceptability scores of *rasogolla*. The data in Table 3 disclosed that the overall acceptability score was highest for, i.e., 7.93 when *rasogolla* was made from *chhena* containing 0.50% WPC and 80°C coagulation temperature. This combination was found to be significantly (P<0.05) higher than all the other experimental samples. The composition of drained samples of goat milk rasogollae was: moisture 50.07%; protein 7.04%; fat 6.44%; ash 0.45% and sucrose 35.73%. The pH was 6.34 and acidity was 0.76% lactic acid.

Patel (2017) made *rasogolla* from mixed milk with the addition of WPC in *chhena* milk and reported that the addition of WPC improves the overall acceptability scores of mixed milk *rasogolla* when they added the WPC at a rate of 0.75%; thereafter, there was a decline in overall acceptability scores. Similar observations were recorded in this part of the study, where the addition of WPC improved overall acceptability scores up to the 0.5% level of addition; thereafter, there was a decrease in overall acceptability scores of *rasogolla*. There are no data on overall acceptability scores of *rasogolla* as affected by use of WPC and coagulation temperature during *chhena* making are not available for comparison. The best experimental *rasogolla* possessed a white colour, round shape, peasant flavour, soft body and maximum sponginess and was softer and smoother than all the other experimental samples.

Conclusion

Goat milk *rasogolla* prepared from *chhena* containing 0.50% WPC in milk and coagulated at 80°C was preferred the most with respect to taste, smell, body and texture, colour and appearance overall acceptability scores. It had higher sugar absorption ratio, i.e., 2.63, compared to all the other experimental samples. The samples met BIS specifications for canned *rasogolla* with respect to moisture, fat, protein and sucrose. The composition of drained samples of goat milk rasogolla was : moisture 50.07%; protein 7.04%; fat 6.44% and sucrose 35.73%. Based on the results obtained in this study, a method was developed for the preparation of acceptable-quality goat milk chhana and *rasogolla* using WPC as a functional ingredient.

Conflict of interest

The authors declare that they have no conflict of interest.

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