RESEARCH PAPER | Engineering | Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

Process Re-Engineering for the Manufacture of Shrikhand

KEYWORDS: Shrikhand, concentrated milk, whey, dahi

Rashmi Chauhan
Dairy Engineering Department, SMC College of Dairy Science, Anand Agricultural University, Anand.

Sunil Patel
Dairy Engineering Department, SMC College of Dairy Science, Anand Agricultural University, Anand.

A G Bhadania
Dairy Engineering Department, SMC College of Dairy Science, Anand Agricultural University, Anand.

Suneeta Pinto
Dairy Technology Department, SMC College of Dairy Science, Anand Agricultural University, Anand.

ABSTRACT *Shrikhand, a fermented indigenous milk product, which is manufactured using the traditional method results in generation of shrikhand whey which is difficult to dispose off. Moreover, there is a loss of considerable amount of milk solids in the whey. The present investigation was planned to standardize a process for manufacture of shrikhand without generation of whey. Three sources of concentrated milks were screened for their suitability for manufacture of such shrikhand. Based on the sensory evaluation scores, reconstituted concentrated skim milk (RCSM) was selected. From amongst various cultures screened, it was found that acceptable quality dahi could be prepared from RCSM using Layofast YL 348 F (DVS) Culture Deposit No. C091423A (Sacco) 1 % (w/w) of RCSM using an incubation temperature of 40±1 ˚C. Nine combinations of shrikhand were prepared using RCSM at three levels of totals solids viz. 30, 35 and 40% and three levels of sugar viz. 45, 50 and 55% w/w of dahi. The physico-chemical and sensory properties of experimental shrikhand were investigated. A combination of 35% TS in RCSM and addition of 50% w/w sugar had significantly (P<0.05) higher overall acceptability scores compared to all the other treatments. It was found that product in which 50 % sugar was replaced with liquid glucose yielded an acceptable product. The total solids, protein and ash content of such shrikhand was found to be significantly (P<0.05) higher whereas sucrose content was significantly (P<0.05) lower than shrikhand made using traditional process. Satisfactory quality shrikhand was produced without generation of whey from RCSM.*

Introduction

Shrikhand is an indigenous fermented and sweetenedv milk product having a typical pleasant sweet-sour taste (Aneja et al 2002). Although largely produced on small scale adopting age-old traditional methods, shrikhand is now commercially manufactured in organized dairy sector to cater to the growing demand (Rao and Raju 2003). Indian milk products are becoming increasingly popular and if made on commercial scale by organized dairy plants have great potential to capture the market at premium prices (Pal and Raju 2007). The traditional method for the manufacture of shrikhand involves the preparation of curd or dahi by culturing cow or buffalo milk with natural starter (curd of the previous batch). After a firm curd is formed, it is transferred in a muslin cloth and hung for 12-15 h to remove free whey. The semi-solid mass obtained is called "chakka". The chakka is mixed with required amount of sugar, colour, flavoring materials and spices and blended to smooth and homogenous consistency. Finally, the product is cooled to a low temperature (≤10°C) before it is ready for consumption (Bhattacharya et al., 1972; Rangappa and Achaya, 1974; Parikh 1977; Upadhyay and Dave, 1977; Patel and Chakraborty, 1988). Aneja et al. (1977) developed a semi – mechanized method for the manufacture of shrikhand which led to its production on commercial scale. Sharma and Reuter (1992) made a successful attempt to develop UF-chakka for subsequent use in shrikhand preparation using ceramic membrane module. Using this method, whey was removed in the form of permeate. The factors such as quality of milk, composition of milk used, heat treatment of milk, preparation of dahi, removal of whey, composition of chakka and types of additives are very important influencing the quality of the final product. The traditional method of shrikhand making has some weaknesses such as disposal of whey and loss of milk solids in the whey. In order to overcome the limitations of the traditional method, some attempts have been made to reduce fat losses in whey by preparing curd from skim milk. The use of skim milk for curd making also increases the rate of whey expulsion from the curd (Aneja et al., 1977; Patel, 1982).

The preparation of chakka by traditional method requires considerable long time to remove whey from the curd. This unit operation requires process re-engineering to reduce total solid losses from the curd. Further, the disposal of whey removed from the curd is a serious problem at many places even in organized dairy plants. Therefore, the present work was planned to develop a process for the manufacture of shrikhand without generation of whey.

Materials and methods

Fresh, raw mixed (cow and buffalo) milk was obtained from Anubhav Dairy, Anand. The average fat and SNF content of the milk was 5.3±0.2 % and 8.6±0.05 % respectively. The milk was separated in an open discharge 'Alfa Laval' power driven mechanical cream separator, Model, C.L.O. 180520 to obtain about 40-45% fat cream and skim milk. The cream was separated in the same cream separator to obtain 73-75 % fat. The cream so obtained was pasteurized at 80 oC and cooled immediately to 4 ± 2 oC. For manufacture of shrikhand three types of concentrated milk were used viz. open pan concentrated skim milk, vacuum concentrated skim milk and reconstituted concentrated skim milk (RCSM). Three levels of concentration of total solids (TS) i.e. 30 (TS1), 35 (TS2) and 40 (TS3) % were

Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

tried for all sources of concentrated milk. Open pan concentrated milk was prepared from skim milk by heat desiccation in a steam jacketed stainless steel open pan operated at 0.5 kg/cm2 steam pressure with continuous manual stirring and scrapping. The process of heating stirring was continued till the product acquired desired concentration. For manufacture of vacuum concentrated milk, the skim milk (0.1% milk fat and 9.1 % MSNF) was forewarmed (85 °C/10 min) and pre-concentrated to the desired TS level in vacuum pan operated at 62 cm of Hg. The third type of concentrated skim milk was prepared from reconstitution of Sagar brand skim milk powder having TS 96.5 %, protein 35 %, ash 8.4 %, fat 1.00 % and 52 % carbohydrate and an insolubility index of 0.5 ml. Cultures were procured from Sacco srl, via Manzonil 29/A 22071 Cadorago (Co), Italy viz. Layofast YL 348 F (Sacco), Layofast YL 480 F (Sacco), Layofast YL 478 F (Sacco) and CHN-11 (Chr. Hansen). Good quality granular sugar (M grade, Madhur brand) and liquid glucose (Gujarat Ambuja Ltd., Ahmedabad) having DE 38-44 were used as sweeteners.

Preparation of shrikhand without generation of whey

Preparation of dahi: All the three types of concentrated skim milks viz. open pan concentrated skim milk, vacuum concentrated skim milk and reconstituted concentrated skim milk (RCSM) were preheated to 40+1 °C and inoculated with starter cultures which were added @ 1 % of the concentrated milk (1 UC culture was added in 100 ml autoclaved skim milk). It was incubated at 40+1 °C till the desired firmness with an acidity of about 2.0 % lactic acid (LA) was obtained.

Mixing and blending of dahi with other ingredients: The dahi prepared from concentrated milks was mixed with a calculated amount of cream (to get 6% fat in shrikhand). The blend was passed through a colloidal mill to get a fine a homogenous consistency. Three levels of sugar i.e. 45(S1), 50 (S2) and 55 (S3) % were used for the manufacture of shrikhand. After addition of sugar to the dahi, the contents were blended in a Hobart mixer at the lowest speed for 15 min. Freshly ground cardamom was added @ 0.15% (w/w) of shrikhand.

Packaging and storage of shrikhand: All the samples of shrikhand were packed in polystyrene cups (previously sanitized in about 150 ppm chlorine solution for 10 min and then drained). The samples were stored at refrigerated temperature (i.e. 4±2°C) till use.

Analysis

Representative samples of RCSM and cream used for shrikhand making were analysed for fat (IS: 1224, Part-I, 1977), total protein (IS: 1479, Part-II, 1961) and titratable acidity (IS: 1479, Part-I, 1960). The total milk solids were determined by Mojonnier milk tester, Model-D, as per standard procedure (Laboratory Manual, Milk Industry Foundation, 1959). Representative samples of dahi were analysed for acidity and total solids. The total solids of the shrikhand was determined by standard procedure using Mojonnier Milk Tester Model-D (Laboratory Manual, 1959). Fat content of shrikhand was determined as per the modified Gerber fat test for shrikhand. Total nitrogen/ protein of shrikhand was determined by semi-microkjeldahl method (IS: 1479-Part-II, 1961), using Kjel-plus unit (Model-KPS 006L, M/s.Pelican Instruments, Chennai). Total sugar (lactose + sucrose) in the shrikhand was determined as per the method prescribed in Indian Standards (IS: 2802, 1964). Ash content of all the samples was determined by procedure described in BIS (IS: 1547-1985). The acidity of shrikhand was determined by method described in BIS (IS: 1166-1968) for condensed milk. The pH of shrikhand was measured using Knick Protavo 907 MULTI digital pH meter. The method described by Franklin and Sharpe (1963) for cheese was used. The water activity 25°C was measured using Rotronic Hygroskop Model: Hygrolab – 3 (M/s. Rotronicag, Switzerland) connected to sensing element (AW – DIO). Compression testing of shrikhand was done using Food Texture Analyzer (M/s. Lloyd Instruments, LRX Plus, England; Sr. No. 160374) using 50 Newton (N) load cell. The samples were tempering at 23±1°C for half an hour in an air-conditioned room (23±1°C, 55±1 % RH).

Sensory evaluation

Sensory quality of shrikhand was evaluated by a panel of seven judges selected on the basis of duo- trio test. The score card suggested by BIS (IS: 15348, 2003) was used for recording the scores of shrikhand. The organoleptic evaluation of shrikhand (~ 10°C) was carried out in a sensory evaluation laboratory

Microbiological analysis

The samples were transported, stored and handled as described in BIS (IS:5404 - 1969). Suitable dilutions were selected based on preliminary trials. Phosphate buffer solution used for serial dilution was prepared as described in BIS (IS : 5401 - 1969). The SPC, coliform and yeast and mold count counts were determined using the procedure described in BIS Handbook, BIS Part XI: 1981), IS:5401 (1969) and IS:5403-(1969) respectively.

Statistical Analysis

Factorial Completely randomized design (FCRD) and completely randomized design (CRD) were used for the analysis of data (Steel and Torrie, 1980).

Results and discussion

To select the most suitable form of concentrated milk for manufacture of shrikhand without generation of whey, shrikhand was manufactured using three different sources of concentrated milk viz. open pan concentration of skim milk, vacuum concentration of skim milk and reconstituted concentrated skim milk (RCSM). The traditional method of shrikhand manufacture requires minimum of 30 % total solids in chakka. Therefore, based on preliminary studies, three levels of total solids in concentrated milks were used i.e. 30 % (TS1), 35 % (TS2) and 40 % (TS3) for each concentrated milk. The experimental shrikhand were compared with control. Control shrikhand was prepared using the procedure described by Miyani et al. (1984). Four replications were conducted. The products were subjected to sensory evaluation and the results are presented in Table 1.

It can be seen from the Table 1 that all treatments used had significant ($P<0.05$) effect on sensory scores of shrikhand. The overall acceptability scores of shrikhand, which was made from open pan concentrated skim milk and vacuum concentrated skim milk were significantly lower as compared to control. The product prepared from open pan concentrated milk had brown colour and pronounced caramelized flavor which was not liked by judges. Products prepared from vacuum concentrated skim milk had loose body which was disliked by majority of judges. It can be seen from Table 1 that the flavor and colour and appearance scores of shrikhand prepared from reconstituted concentrated skim milk having 35 % TS were at par ($P>0.05$) with control. However, the body and texture scores were significantly ($P<0.05$) lower compared to control. The lower body and texture scores resulted in

Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

significantly lower overall acceptability score of the product. The experimental product made from reconstituted concentrated skim milk had comparatively better scores compared to the other 2 sources of concentrated milks viz. open pan concentrated milk and vacuum concentrated milk. Patel and Chakraborty (1985) also reported that the reconstituted skim milk is the effective alternative to fresh skim milk for shrikhand making. Based on the results obtained RCSM was selected and used in the next part of the study. The proximate composition and acidity of RCSM with different TS levels are given in Table 2.

Selection of culture

Commercial method of manufacture of shrikhand involves preparation of dahi using dahi cultures, which grows at lower total solids of milk. Manufacture of dahi using concentrated milks requires specific cultures, which can grow at higher total solids levels. Preliminary trials were conducted using different cultures either alone or in combinations. These cultures were Layofast YL 348 F (Sacco), Layofast YL 480 F (Sacco), Layofast YL 478 F (Sacco), CHN-11. RCSM (30, 35 and 40% TS) were inoculated with these cultures @ 1% (w/w) and dahi was prepared by incubating at 40 + 1 C. It was found that amongst the various cultures and their combinations tried, acceptable quality dahi was obtained when Layofast YL 348 F (Sacco) was used a culture. An acidity of ~2.0 % LA was obtained within 18 h of incubation. The higher incubation time could to attributed to the higher total solids of RCSM compared to skim milk. In addition to this, the culture Layofast YL 348 F(Sacco) produced the curd without whey separation and good gel strength. Hence, it was selected and used in the next part of the study. The Layofast YL 348 F (Sacco) culture, which consists of specifically selected strains of Streptococcus thermophilus, Lactobacillus delbrueckii ssp. bulgaricus and Lactobacillus delbrueckii ssp. Lactis, was selected based on the firmness of the curd and development of required acidity in the curd.

Dahi was prepared from RCSM (30, 35 and 40% TS) using the selected starter culture Layofast YL 348 F(Sacco). The incubation period required for setting of curd was 18-20 h at 40+1 ˚C. It was found that dahi prepared using RCSM (30% TS) had an average acidity of 1.70 ± 0.03 and the dahi had a comparatively weaker body and slight whey expulsion from curd was observed. Similarly when RCSM (40% TS) was used, it resulted in a product with an average acidity of 1.98 ± 0.02. The dahi had a firm body, however it was criticized for its chalky texture and pronounced powdery taste. However, when RCSM (35% TS) was used, it resulted in a product with superior body and texture and pleasant sweet sour flavour with a mean acidity of 1.85 ± 0.01.

To optimize the level of sugar and TS of RCSM, shrikhand was prepared using three levels of sugar viz. 45, 50 and 55% (w/w of dahi) and three TS levels in RCSM viz. 30, 35 and 40 %. Nine different experimental shrikhand were replicated three times in the present study. The influence of different levels of sugar and TS in RCSM on compositional parameters, acidity, pH were studied. The shrikhand samples were subjected to sensory evaluation.

Effect on the composition, acidity and pH of shrikhand

The data on average TS, fat, protein, total sugar, ash, acidity and pH of experimental shrikhand made with imposition of different treatments is presented in Table 3. It can be seen from Table 3 that the TS in shrikhand varied from 56.47 % to 62.87 % which were significantly (P<0.05) affected by levels of sugar and total solids of RCSM. The total sugar content in shrikhand varied from 42.22 to 46.09 %. The fat content of shrikhand was significantly affected by levels of sugar but effect of total solids on fat content was found non-significant (P>0.05). The effect of sugar and TS levels on protein, total sugar, ash, acidity and pH content of shrikhand was found significant (P<0.05).

The interaction effect of sugar levels and total solids on fat, total sugar, ash and pH of shrikhand was found non-significant (P>0.05) and the interaction effect of sugar levels and total solids on total solids, protein and acidity of shrikhand was found significant (P<0.05). It can be seen from the table that there was a progressive decrease in fat content of shrikhand with increase in sugar level. It was also noticed that with increase in total solids content of RCSM the protein content of shrikhand increased at all three levels of sugar.

According to FSSAI (2011) the total solids content of shrikhand should be less than 58%. The treatment combinations TS1S1 and TS1S2 did not meet the FSSAI requirement with respect to total solids. However, all other combinations met the minimum 58 % TS requirement of the product. According to FSSAI the protein content of shrikhand should not be less than 9 % on dry matter basis. It means that the protein content of the shrikhand should be not less than 5.22 % at total solids content 58 % of the product. The values of average protein content of shrikhand were well above the minimum required viz. 7.22 %, 8.58 % and 9.64 % for TS1, TS2 and TS3 respectively.

It can be seen from Table 3 that the ash content of experimental shrikhand varied from 1.68 % to 2.41 %. According to FSSAI (2011), the ash content of shrikhand should not be more than 0.9 % on DMB. It means that the ash content of the shrikhand should be not be more than 0.52 % at total solids content of 58 % of the product. However the ash content of all the samples was higher than required limits. All the samples failed to meet the FSSAI (2011) requirement with respect to ash content. Since there was no drainage of whey during manufacture of shrikhand, all the ash contained in the RCSM was retained in the product. However, the acidity values of all the experimental samples were within the limit suggested by FSSA, i.e. not more than 1.4% LA. Published data on proximate composition of shrikhands prepared from concentrated milks without generation of whey are not available for comparison, however the values obtained for fat and TS in the present study are very close to those reported by Aneja et al., (2002).

Effect on sensory attributes of shrikhand

The average sensory scores of experimental shrikhand are given in Table 4. It can be seen from the table that addition of different levels of sugar as well as various levels of TS in RCSM had significant effect (P < 0.05) on flavor, body and texture and overall acceptability scores of shrikhand. The shrikhand manufactured using 35% total solids in RCSM with 50 % sugar gave maximum flavor score of the product. The interaction effect of level of sugar and total solids on flavor, body and texture and overall acceptability scores was also found significant (P<0.05). It is evident from the Table 4 that use of different levels of sugar and total solids had non-significant effect on colour and appearance score of shrikhand. The interaction effect of levels of sugar and total solids was found non-significant on colour and appearance score of shrikhand. It can be observed from the Table that samples containing 50

Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

% sugar was significantly preferred over 45 % and 55 % sugar based on the overall acceptability scores. A similar trend was also noticed with the use of different TS levels of RCSM. The RCSM having total solids 35% (81.22) was significantly preferred over 30% (70.44) and 40% (77.11). The interaction effect of sugar and level of total solids (S×TS) was also significant ($P < 0.05$) on overall acceptability score of shrikhand.

The shrikhand prepared form RCSM having 30 % TS had weak body and slight whey expulsion from curd. The powdery taste was noticed in the shrikhand manufactured from 40 % TS. The shrikhand made form RCSM having 35 % TS had good sensory attributes compare to 30 and 40 % TS. Shrikhand prepared using RCSM having 35% TS and 50 % sugar addition yielded the most acceptable product in terms of sensory attributes.

In the next part of the study, an attempt was made to compare the acceptability of shrikhand prepared using the developed method i.e. using a combination S2TS2 (50 % sugar, 35 % TS in RCSM) with shrikhand manufactured using traditional method i.e. control shrikhand. Control shrikhand was prepared using the method given by Miyani (1982). The control product and developed shrikhand were subjected to sensory evaluation and the results are shown in Table 5.

It is observed from the Table 5 that both treatments had significant ($P < 0.05$) effect on flavor, body & texture and total score of the product but non-significant effect on colour and appearance score of the product. Therefore, the experimental product is statistically same as control in terms of colour and appearance. The shrikhand prepared from treatment S2TS2 had lower total score than control product due to slight weak body & texture as well as inferior flavor of the product. So, there was need to improve sensory attributes the experimental product (S2TS2).The use of liquid glucose, which is commonly used in many confectionaries, is one of the option to replace part of the sugar in the product. Corn syrups are viscous, the relative viscosity depending on the relative degree of conversion (Dextrose Equivalent, DE), temperature and solids content. As viscosity increases, chewiness, body and texture, smoothness increases. Corn syrups have a clean taste and are generally less sweet than sucrose, but combination of corn syrup and sucrose have greater sweetness than expected. Corn syrups contribute to body, mouthfeel and chewiness (Kilara, 1991). It has been reported in literature that addition of corn syrup solids in burfi resulted in improved body and texture and gave a product with good cohesive body and smooth texture. Reddy (1985) reported that replacing 50 per cent of cane sugar with corn syrup (42 DE) resulted in improved body and texture of burfi. Hence it was decided to use corn syrup as a part of replacement of sugar in the experimental S2TS2 product.

Partial replacement of sugar with liquid glucose

Shrikhand (S2TS2) was prepared using different levels of liquid glucose as replacement of sugar 30 %, 40 %, 50 % and 60 % based on the preliminary trials. The additional amount of liquid glucose was added in the product to get equivalent sweetness of liquid glucose as like sucrose. It was calculated based on the relative sweetness of sucrose and liquid glucose i.e. 1:0.74.

The products were subjected to sensory evaluation and the results are presented in Table 6. It can be observed from the Table 6 that all treatments and control had significant ($P<0.05$) effect on flavor, body & texture and total score of the product. The colour and appearance score of shrikhand was not affected by control and treatments. The body and texture of shrikhand prepared form 50 % sugar replacement with liquid glucose was good compared to others. The flavor scores of 40 %, 50 % and 60 % replacement were statistically at par. The shrikhand prepared from 50 % sugar replacement with liquid glucose got higher overall sensory than all other sugar replacements and statistically at par with control. Based on overall acceptability of the shrikhand prepared form the combination S2TS2 (50 % sugar, 35 % TS in RCSM) with 50% sugar replacement by liquid glucose yielded most acceptable product.

The average chemical composition of the developed shrikhand which was manufactured without whey generation was total solids 60%, protein (DMB%): 18.11, Fat(DMB): 9.33%, total sugar (DMB): 69% and ash (DMB): 3.63%. Thus, the shrikhand which was prepared using the modified method without generation of whey met all the legal requirements with respect of FSSAI (2011) except for ash content, which was higher than the suggested limits.

Optimized process for the manufacture of shrikhand without generation of whey

Thus shrikhand without generation whey was manufactured using the combination S2TS2 (50 % sugar, 35 % TS in RCSM) with 50% sugar replacement by liquid glucose. The yield of shrikhand made from above combination was 1.47 kg/kg RCSM. The average values of the chemical composition of the developed shrikhand i.e. S2Ts2 and control (C) i.e. shrikhand prepared using traditional method are collated in Table 7. It can be seen from the table that the total solids content of S2Ts2 was significantly ($P<0.05$) lower than control. The milk fat and FDM was also significantly ($P<0.05$) lower than control. A comparison of S2Ts2 with control revealed that S2Ts2 had significantly higher ($P\leq0.05$) protein and PDM (protein on dry matter basis) content compared to control which was almost two times the protein content present in control. The sucrose content of the control was almost 11% higher than S2Ts2 and was found to be significantly ($P\leq0.05$) higher than the S2Ts2. The ash content of S2TS2 was almost 4 times higher than control. Such differences in the compositional attributes of the S2Ts2 and control could have resulted due to the different in manufacturing procedures.

Conclusion

Acceptable quality of shrikhand without generation of whey was successfully manufactured from reconstituted concentrated skim milk (RCSM) by adopting the technology standardized in the study. For the manufacture of shrikhand without generation of whey, starter culture Layofast YL 348 F (Sacco) can be used for preparation of dahi from RCSM. The shrikhand prepared from dahi which was made from RCSM with 35 % TS and 50 % level of sugar in the dahi gave better quality attributes in the product. Replacement sugar at the rate of 50 % with liquid glucose can improve the acceptability of the product.

Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

Table 1: Effect of open pan concentrated skim milk on sensory scores of shrikhand

Treatments	Sensory scores			
	Flavor score (50)	Body & texture (30)	Colour & appearance (15)	Total score* (100)
Open pan concentrated skim milk				
30% TS	18.83 ± 1.61	11.23 ± 1.12	8.00 ± 0.46	43.07 ± 2.27
35% TS	16.23 ± 1.12	14.70 ± 0.36	6.23 ± 0.31	42.17 ± 1.40
40% TS	12.40 ± 0.95	17.37 ± 0.71	4.50 ± 0.70	39.27 ± 2.08
Control	44.93 ± 0.40	27.40 ± 0.66	14.13 ± 0.21	91.47 ± 0.96
CD(0.05)	2.09	1.44	0.86	4.27
Vacuum concentrated skim milk				
TS_1	26.50 ± 0.50	16.40 ± 0.79	10.33 ± 0.74	60.10 ± 1.57
TS_2	32.53 ± 1.55	19.17 ± 0.76	8.40 ± 0.55	66.23 ± 1.62
TS_3	28.83 ± 1.25	24.50 ± 0.50	7.20 ± 0.53	59.20 ± 1.90
Control	44.50 ± 1.32	26.80 ± 0.30	13.43 ± 0.53	89.73 ± 1.53
CD(0.05)	2.30	1.17	0.89	3.13
Reconstituted concentrated skim milk (RCSM)				
TS_1	38.87 ± 1.20	18.83 ± 1.60	12.77 ± 0.75	75.47 ± 3.40
TS_2	45.10 ± 0.79	22.00 ± 1.00	12.83 ± 0.57	84.93 ± 1.36
TS_3	35.17 ± 1.30	27.43 ± 0.93	8.63 ± 0.78	76.23 ± 2.04
Control	45.53 ± 1.10	27.77 ± 0.25	13.60 ± 0.20	91.90 ± 1.04
CD(0.05)	2.10	1.99	1.17	4.07

*Including 5 marks which was allotted to packaging score for all the samples.
Each observation is mean +SD of 4 replications

Table 2 Physico-chemical properties of reconstituted skim milk

Treatments	% Fat	%Total protein	% Total solids	% Ash	Acidity (% LA)
TS_1 (30 %)	0.30 ± 0.10	9.90 ± 0.25	30.3 ± 1.00	1.70 ± 0.10	0.59 ± 0.02
TS_2 (35 %)	0.37 ± 0.15	11.50 ± 0.30	35.1 ± 1.20	2.00 ± 0.05	0.65 ± 0.01
TS_3 (40 %)	0.50 ± 0.10	13.00 ± 0.15	39.8n ± 1.10	2.30 ± 0.12	± 0.02

Each observation is mean +SD of 4 replications

Table 3 Influence of different levels of TS and sugar on composition of shrikhand

Levels of sugar (S)	% Total solids in shrikhand			
	Levels of total solids in RCSM (TS)			Average (S)
	30 % (TS_1)	35 % (TS_2)	40 % (TS_3)	
S1 : 45 %	56.47±0.11	59.43±0.25	61.57±0.05	59.15
S2 : 50 %	57.43±0.15	60.00±0.26	62.50±0.10	59.97
S3 : 55 %	58.60±0.10	61.27±0.25	62.87±0.15	60.91
Average (T)	57.50	60.23	62.31	
CD (0.05) TS = 0.17; S = 0.13; S x T= 0.30				
% Fat				
S1 : 45 %	5.93±0.15	5.93±0.15	6.00±0.10	5.96
S2 : 50 %	5.87±0.25	5.60±0.10	5.70±0.20	5.72
S3 : 55 %	5.53±0.11	5.30±0.10	5.23±0.21	5.36
Average (T)	5.78	5.61	5.64	
CD (0.05) TS = NS; S = 0.12; S x T= NS				
% Protein				
S1 : 45 %	7.51 ± 0.36	8.80 ± 0.20	9.91 ± 0.30	8.74
S2 : 50 %	7.25 ± 0.25	8.62 ± 0.35	9.60 ± 0.36	8.49
S3 : 55 %	6.90 ± 0.30	8.31 ± 0.46	9.41 ± 0.25	8.21
Average (T)	7.22	8.58	9.64	
CD (0.05) TS = 0.027; S = 0.013; S x T= 0.031				
% Total sugar				
S1 : 45 %	42.22 ± 0.10	42.57 ± 0.18	43.25 ± 0.42	42.35
S2 : 50 %	42.57 ± 0.32	43.74 ± 0.36	44.86 ± 0.29	43.72
S3 : 55 %	44.48 ± 0.21	45.69 ± 0.27	46.09 ± 0.07	45.42
Average (T)	43.09	44.00	44.73	
CD (0.05) TS = 0.23; S = 0.17; S x T= NS				
% Ash				
S1 : 45 %	1.80 ± 0.03	2.13 ± 0.08	2.41 ± 0.02	2.11
S2 : 50 %	1.75 ± 0.02	2.04 ± 0.03	2.34 ± 0.01	2.04
S3 : 55 %	1.68 ± 0.05	1.97 ± 0.02	2.26 ± 0.03	1.97
Average (T)	1.74	2.05	2.34	
CD (0.05) TS = 0.03; S = 0.02; S x T= NS				
% Acidity				

Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

S1 : 45 %	1.16 ± 0.01	1.30 ± 0.01	1.37 ± 0.004	1.27
S2 : 50 %	1.13 ± 0.02	1.23 ± 0.01	1.34 ± 0.002	1.23
S3 : 55 %	1.08 ± 0.005	1.19 ± 0.002	1.28 ± 0.004	1.18
Average (T)	1.12	1.24	1.33	
CD (0.05) TS = 0.06; S = 0.05; S x T= 0.01				
pH				
S1 : 45 %	4.32 ±0.04	4.28±0.02	4.21±0.05	4.27
S2 : 50 %	4.41±0.02	4.37±0.02	4.33±0.02	4.37
S3 : 55 %	4.61±0.02	4.58±0.02	4.52±0.02	4.57
Average (T)	4.45	4.41	4.35	
CD (0.05) TS = 0.03; S = 0.02; S x T= NS				

Each observation is mean +SD of 4 replications. S = level of sugar; T = level of TS in RCSM

Table 4 Influence of different levels of TS and sugar on sensory attributes of shrikhand

Levels of sugar (S)	Flavor score (50)			
	Levels of total solid in RCSM (TS)			Average (S)
	30 % (TS_1)	35 % (TS_2)	40 % (TS_3)	
S1 : 45 %	36.67 ±0.05	43.00±0.02	35.33±0.04	38.33
S2 : 50 %	40.33±0.02	48.67±0.02	37.17 ±0.02	42.06
S3 : 55 %	35.00±0.02	38.67±0.02	34.67±0.02	36.11
Average (T)	37.33	43.45	35.72	
CD (0.05) TS = 1.19; S = 0.92; S x T= 2.07				
Colour and appearance score (15)				
S1 : 45 %	12.50±1.32	11.67±0.76	11.33±1.04	11.83
S2 : 50 %	11.83±0.76	11.50±1.32	10.83±1.04	11.39
S3 : 55 %	12.00±0.50	11.17±0.76	10.67±1.04	12.28
Average (T)	12.11	11.45	10.94	
CD (0.05) TS = NS; S = NS; S x T= NS				
Body and texture score (30)				
S1 : 45 %	20.33±1.26	22.50±1.32	27.17±1.04	23.33
S2 : 50 %	16.83±1.76	21.50±2.29	25.33±1.53	21.22
S3 : 55 %	10.83±1.26	20.00±1.00	23.83±1.26	18.22
Average (T)	16.00	21.33	25.44	
CD (0.05) TS = 1.45; S = 1.12; S x T= 2.51				
Overall acceptability score (100)				
S1 : 45 %	74.50±2.18	82.17±2.36	78.83±1.26	78.50
S2 : 50 %	74.00±1.80	86.67±2.04	78.33±1.60	79.67
S3 : 55 %	62.83±2.52	74.83±2.93	74.17±1.04	70.61
Average (T)	70.44	81.22	77.11	
CD (0.05) TS = 2.34; S = 1.81; S x T= 4.05				

Each observation is mean +SD of 4 replications. S = level of sugar; T = level of TS in RCSM

Table 5 Comparison of sensory attributes of experimental product (S2TS2) with control

Treatments	Sensory score			
	Flavor score (50)	Body & texture (30)	Colour & appearance (15)	Total score (100)
S_2TS_2	42.87 ± 0.32[a]	23.07 ± 0.67[a]	13.30 ± 0.62	84.23 ± 2.27[a]
Control	46.60 ± 0.95[b]	27.40 ± 0.96[b]	14.00 ± 0.51	93.00 ± 0.96[b]
CD(0.05)	1.62	1.88	NS	3.32

***Thetotalscoreisinclusiveofpackagescore(5)**

Each observation is mean ±SD of 4 replicate experiments (n=4); Superscript letters following numbers in the same column denote significant difference (P<0.05)

Table 6: Sensory scores of shrikhand manufactured with different levels of sugar replacement with liquid glucose

Treatments (% Sugar replacement)	Sensory scores			
	Flavor score (50)	vBody & texture (30)	Colour & appearance (15)	Total score (100)
30 %	43.83 ± 1.00[b]	21.50 ± 0.86[d]	12.83 ± 0.15	83.17 ± 1.27[c]
40 %	43.73 ± 0.40[b]	24.00 ± 1.00[c]	13.17 ± 0.28	85.90 ± 1.84[b]
50 %	44.23 ± 0.58[b]	28.07 ± 0.90[a]	13.30 ± 0.26	90.60 ± 1.63[a]
60 %	42.60 ± 0.52[b]	25.70 ± 1.15[b]	13.27 ± 0.23	86.57 ± 1.24[b]
Control	46.10 ± 1.49[a]	28.27 ± 0.64[a]	13.53 ± 0.35	92.90 ± 1.2[a]
CD(0.05)	1.65	1.68	NS	2.56

***The total score is inclusive of package score (5).**

Each observation is mean ±SD of 4 replicate experiments

Volume : 6 | Issue : 7 | July 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

(n=4); Superscript letters following numbers in the same column denote significant difference (P<0.05)

Table 7 Comparison of composition of developed shrikhand with control shrikhand prepared using traditional method

	Constituents (%)									
	TS	Fat	FDM	Protein	PDM	Sucrose	Sucrose (DMB)	Ash	Ash (dmb)	Total carbohydrates
Control – C	58.28± 0.03[a]	6.23± 0.03[a]	10.68± 0.01[a]	5.82± 0.01[a]	9.98± 0.02[a]	41.43± 0.10[a]	71.08± 0.11[a]	0.57± 0.02[a]	0.97± 0.03[a]	44.63± 0.02[a]
S2Ts2	60.00± 0.03[b]	5.60± 0.02[b]	9.33± 0.02[b]	10.87± 0.02[b]	18.11± 0.03[b]	30.30± 0.10[b]	50.50± 0.12[b]	2.18± 0.02[b]	3.63± 0.04[b]	41.35± 0.02[b]
CD(0.05)	0.28	0.11	0.14	0.17	0.13	0.66	0.33	0.04	0.21	0.13

Each observation is mean ±SD of 7 replicate experiments (n=7); Superscript letters following numbers in the same column denote significant difference (P<0.05); FDM – fat on dry matter.

Table 8 Comparison of physico-chemical properties of developed shrikhand with control shrikhand prepared using traditonal method

	Acidity (% lactic acid)	Aw	pH	Consistency
Control	1.00±0.01[a]	0.9391±0.01	4.33±0.05	8.48±0.04[a]
S2Ts2	0.98±0.01[b]	0.9380±0.01	4.36±0.07	8.63±0.01[b]
CD (0.05)	0.014	NS	NS	0.032

Each observation is mean ±SD of 7 replicate experiments (n=7); Superscript letters following numbers in the same column denote significant difference (P<0.05)

References

1. Aneja RP, Vyas MN, Nanda K and Thareja VK (1977) Improvements in or relating to a method of separating the solids contents known as ' maska' or 'chakka' from curd and preparing a milk-based sweet known as 'shrikhand', out of the said ' maska' or 'chakka'. Indian Patent, 1977.
2. Aneja RP, Mathur BN, Chandan RC, Banerjee AK (2002) Cultured/Fermented Products. In: "Technology of Indian Milk Products" Gupta P R (ed.), A Dairy India publication, Delhi, pp 170-176.
3. Aneja RP, Vyas MN, Nanda K, Thareja VK (1977) Development of an industrial process for the manufacture of Shrikhand J Food Sci Technol (India) 14(4): 159-163
4. Bhattacharya DC, Mathur DN, Tiwari BD, Balachandram R, Srinivasan M R (1972) Studies on the method of production of Shrikhand. Annual Report, NDRI, Karnal. 161
5. BIS (1984). Bureau of Indian Standards. ISI Hand book of Food Analysis, Part 4.
6. FSSA (2011) The Food Safety and Standards Act, Chapter 2- Food Product Standards: Chakka and Shrikhand, Commercial Law Publishers (India) Pvt. Ltd, p 204
7. IS: 1224 (1997) Indian Standard, Part I Determination of fat by the Gerber method. Milk Indian standards Institution, New Delhi.
8. IS: 1479 (1960) Indian Standard, Part I Method of Test for Dairy Industry. Rapid Examination of milk. Indian standards Institution, New Delhi.
9. IS: 1479 (1961) Indian Standard, Part II Method of Test for Dairy Industry. Chemical analysis of milk, Indian standards Institution, New Delhi.
10. IS: 5401(1969) Indian Standard Methods for detection and estimation of coliform bacteria in food stuffs. Indian Standards Institution, New Delhi.
11. IS: 5403 (1969) Indian Standard Methods for yeast and mould count of food stuffs. Indian Standards Institution, New Delhi.
12. IS: 5404 (1969) Indian Standard Code for practice and handling of samples for microbiological analysis. Indian Standards Institution, New Delhi.
13. IS: 1547 (1985) Indian Standard Specifications for Infant milk foods. Bureau of Indian Standards, New Delhi.
14. IS: 2802 (1964) Specifications for ice cream. Indian Standards Institution, New Delhi.tv
15. Kilara A (1991) Sugar, corn syrup and other sweetening agents. In: Compedium on Ice cream short course . The Pennsylvania State University. Jan 7 to 17 : 51-60
16. Laboratory Manual (1959) Methods of Analysis of Milk and its Products. Milk Industry Foundation, 3rd Edn, Washington, USA, p. 283.
17. Miyani RV, Vyas SH, Upadhyay K G, Thakar PN, Solanky MJ (1984) Effect of different levels of moisture, sugar and fat on consistency of Shrikhand. Guj. Agril Uni Res J 9(2): 48-53
18. Parikh JV (1977) Method of production of Shrikhand in "Technological of Dairy Products". SBP Chemi. Engg., Series No.37: 54
19. Pal D, Raju NP (2007) Indian traditional dairy products: An overview. In Compendium: International conference on traditional dairy foods held by Dairy Technology Society of India, at NDRI, Karnal (India) on Nov 14-17
20. Patel RS, Chakraborty BK (1988) Shrikhand – A review Indian J Dairy Sci 13: 79
21. Patel RS (1982) Process alteration in Shrikhand technology. Ph.D thesis, Kurukshetra University, Kurukshetra
22. Patel RS, Chakraborty BK (1985a) Factors affecting the consistency and sensory properties of shrikhand. Egyptian J Dairy Sci 13(1): 73-78
23. Patel RS, Chakraborty BK (1985b) Use of different sources of milk solids for Shrikhand making. Egyptian J Dairy Sci 13(1): 79-84
24. Rangappa KS, Achaya KT (1974) "Indian Dairy Products". 2nd Ed. Asia Publishing House, New Delhi : 134
25. Rao KH, Raju PN (2003) Prospects and challenges for Indian dairy industry to export dairy products Indian J Dairy Biosciences 14(2): 72 – 78
26. Reddy CR (1985) Process modification for production of Khoa based sweets, Ph. D. Thesis, Kurukshetra Univ., Kurukshetra.
27. Sharma DK, Reuter H (1992) Ultrafiltration technique for Shrikhand manufacture. Indian J Dairy Sci 45 (4): 209-213
28. Steel RGD, Torrie JH (1980) Analysis of Variance. I: The one-way classification In: Principles and Procedure of Statistics: A Biometrical Approach, Chapter 7, 2nd Edn., McGraw Hill Kogakusha Ltd., Japan, pp. 137-167.
29. Upadhyay KG, Dave JM (1977) Shrikhand and its Technology Indian Dairyman 28(9): 487-489