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Arvind Kumawat
Assistant Manager, Jaipur Zila Dugdh Utpadak Sahakari Sangh Ltd, Jaipur, Rajasthan, India

Kavita Kumari Solanki
Assistant Manager, Jaipur Zila Dugdh Utpadak Sahakari Sangh Ltd, Jaipur, Rajasthan, India

Prashant Minz
Dairy Engineering Division, ICAR- National Dairy Research Institute Karnal, Haryana, India

Prateek Singh Panwar
Process Engineer, GEA Process Engineering (India) Pvt Ltd., Vadodara, Gujarat, India

Corresponding Author:
Arvind Kumawat
Assistant Manager, Jaipur Zila Dugdh Utpadak Sahakari Sangh Ltd, Jaipur, Rajasthan, India

Chemical evaluation of rabri optimized through milk flake formation system

Arvind Kumawat, Kavita Kumari Solanki, Prashant Minz and Prateek Singh Panwar

Abstract
Rabri is a dessert made by simmering full fat milk until it turns thick and layers of cream are formed. The traditional method of rabri preparation is done in small batches and is time-consuming**.** In the present study, a milk flake formation system was designed for production of rabri and chemical properties of rabri were studied. The system consists of a vertical scraped surface heat exchanger, scraper blade assembly, drive motor, milk-distributing unit and control unit**.** Fixed parameters were steam pressure (1.5 kg⁄cm2), scraper speed (130 rpm) and milk flow rate (400 l/h). The developed system was evaluated, and the variable parameters were the type of milk (buffalo milk and cow milk***)*** and initial total solids of concentrated milk (18, 22, 26 and 30%). Buffalo milk at 26% total solids (T.S.) was found as an optimized parameter based on numerical optimization (desirability = 65%). The responses for this study were acidity, total solids (T.S.), moisture, FFA (free fatty acids), protein HMF (Hydroxyl Methyl Furfural) and water activity properties.

Keywords: Acidity, moisture, FFA, HMF

Introduction
Rabri is a traditional Indian milk product have creamy white to caramelized colour, possesses viscous body containing several layers of clotted cream with a chewy texture. It has a pleasant caramelized sweet flavour (Rajorhia, 1995) [15]. Rabri, a sweetened indigenous milk product is a synonymous of clotted cream (De, 1980). Rabri consists of two components viz. clotted cream layer and sweetened condensed milk.

Rabri prepared by traditional method is unhygienic, non-uniform in quality, has low keeping quality and involves labour and energy intensive method of production (Chauhan *et al*., 2014).

Rangappa and Achaya (1971) [18] studied that during rabri preparation, milk is not stirred, and the solid product is separated from the milk by peeling off thin film of coagulated material successively from the surface using bamboo splints. These skins are laid aside on the cooler side of the pan. When the milk has been reduced to about one-fifth to one-eighth of its initial volume, the pan is removed from the fire and whole mass is gently mixed without injuring the flakes. Sugar is then added and product allowed to be cooled. The weight of rabri will be one fourth to one third of the milk used. In traditional method yield of rabri is 25-28% yield in case of buffalo milk (Ranganadham *et al*., 2016) [17].

Gayen and Pal (1991) [7] attempted standardization of rabri for manufacture and storage. There was a large variation in the rabri sample obtained from the market and standardize method for the production of rabri was developed in order to get uniform quality product. Milk (2% fat) was concentrated upto 35% TS using Scraped Surface Heat Exchanger (SSHE) and alternatively that milk was concentrated using conventional vacuum pan. Concentrated milk was heated up to 90 °C followed by addition of sugar @ 12% of the finished product. The mixture was cooled to 70 °C and calculated amount of preformed malai added to it. Malai was prepared from the buffalo milk testing 15% fat in a steam jacketed kettle.

Traditionally rabri is prepared in karahi by halwais. Milk is slowly evaporated without being stirred with frequent scraping at the bottom. Traditionally made out of cast iron, karahi look like woks with steeper sides. These shallow pans can be made of stainless steel, copper, and non-stick surfaces, both round and flat-bottomed. For large scale production of rabri, vacuum concentration of milk followed by blending with required quantities of sugar and malai was attempted by Gayen and Pal (1991) [7]. Bandyopadhyay and Mathur (1987) [1] reported use of a steam jacketed kettle for concentrated milk in the preparation of concentrated

Milk products. Saroj *et al*. (2010) [11] optimized the process parameters of three stage scraped surface heat exchanger for continuous rabri production. Chopde *et al*., (2016) [4] develop a method for rabri by integrating scraped surface heat exchanger with conical process vat.

The composition of rabri depends on the initial composition of milk, degree of concentration of the milk solids and percentage of sugar added. Composition of rabri is varying widely from place to place and from manufacturer to manufacturer because of the use of unorganized and non-standard method of production of rabri. Many researchers had done work for determining the composition of Rabri. The body and texture characteristics are important consideration in preparation of rabri. The samples having hard layers of malai (clotted cream) along with some liquid portion is the important feature of the product. Rabri should have a slight cooked aroma and pleasant, sweet creamy taste. The colour should be light yellow to white with slight tinge of browning.

Materials and Method

Preparation of rabri: Rabri was made through mechanized system i.e. milk flake formation system. The setup of milk flake formation system has been described by Kumawat *et al*. (2022) in detail. Optimization of process parameter was done through Design Expert 10 statistical analysis software.

Chemical Properties

Acidity

Weigh accurately about 10 gm of the material in a suitable dish or basin. Add 30 ml of warm water. Add 1 ml of phenolphthalein indicator. Shake well and titrate against standard NaOH solution. Complete the titration in 20 seconds. Keep a blank by taking 10 gm of material diluted with 30 ml of water in another dish for comparison of colour.

$$\text{Titrable acidity as lactic acid} = \frac{9 \times A \times N}{W}$$

A = Volume of standard NaOH required for titration
N = Normality of Standard NaOH solution
W = weight of the sample taken for testing

Total Solids

Total solids content of rabri was determined by the method recommended by BIS for the milk (IS: SP-18, 1981) with slight modification in quantity of samples taken. Approximately 3 gm of sample was accurately weighed into an aluminium dish. Then the dish was placed on a boiling water bath for about 60 min. with careful stirring of mixture. Then the bottom of the dish was wiped and transferred into hot air oven maintained at 102 °C±1 for 1.5 hr. After complete drying, the dish was removed, placed in an efficient desiccator, allowed to cool and weighed. The process of heating, cooling and weighing was repeated till consecutive weights agreed to within 0.5 mg.

$$\text{TS (\%, by mass)} = \frac{W_3 - W_1}{W_2 - W_1}$$

Where,
W1 = weight of dish with glass rod (g)
W2 = weight of dish and glass rod with rabri before drying (g)
W3 = weight of dish and glass rod with rabri residues after drying (g)

Moisture

Moisture content was determined as:

Moisture % = 100 – TS%.

FFA (Free fatty acid)

The method given by Deeth *et al*. (1975) [6] was adopted for free fatty acid determination in concentrated milk with following modifications. Concentrated milk diluted with warm distilled water to 1:1 w/w. From this dilution 5 ml was taken in a 35 ml test tube and mixed with 10 ml of extraction mixture (isopropanol: pet ether: 4 N H_2SO_4, 40: 1 0: 1) Pet. ether (6 ml) and water (4 ml) were added and the stopper test tube shaken vigorously for 15 seconds The two layers are allowed to settle (5-10 min) and an aliquot of the upper layer was withdrawn and transferred to a 50 ml conical flask. After addition of 2 drops of 1% methanolic α-naphthol phthalein (or 6 drops of 1% methanolic phenolphthalein) the solution was titrated with 0.02 N methanolic KOH. A blank, in which milk was replaced with water, is to obtain the background titration. The free fatty acid content of concentrated milk was obtained from the formula given below:

$$\text{Free Fatty Acid (\%)} = [(T \times N) / (P \times V)] \times 10^3$$

Where,
T = is the net titration volume,
N= is the normality of the methanolic KOH,
P= is the proportion of the upper layer titrated
V= is the volume of milk.

Protein

The Kjeldahl method was used for estimation of protein content in rabri. A food is digested with a strong acid so that it releases nitrogen which can be determined by a suitable titration technique. The amount of protein present was then calculated from the nitrogen concentration of the food. It is usually considered to be the standard method of determining protein concentration. Because the Kjeldahl method does not measure the protein content directly a conversion factor *(F)* is needed to convert the measured nitrogen concentration to a protein concentration. A conversion factor of 6.25 (equivalent to 0.16 g nitrogen per gram of protein) is used for many applications, however, this is only an average value, and each protein has a different conversion factor depending on its amino-acid composition. The Kjeldahl method can conveniently be divided into three steps: digestion, neutralization and titration.

HMF (Hydroxyl Methyl Furfural)

Milk is usually subjected to heat treatment. To ensure microbial safety before consumption. In all type of heat treatment maillard reaction occurs in milk. The HMF content indicate the severity of treatment. HMF when combined with 2-TBA produces yellow colour. Spectrophotometer at maximum absorbance of 443 nm was used to quantify the HMF content. The total HMF and free HMF content was calculated by using following equation

$$\text{Total HMF}\left(\mu\frac{\text{mol}}{\text{l}}\right) = (\text{Absorbance} - 0.055) \times 87.5$$

$$\text{Free HMF}\left(\mu\frac{\text{mol}}{\text{l}}\right) = (\text{Absorbance} - 0.015) \times 81$$

Water activity

Water activity of the rabri was measured by using a rotronic water activity meter.

Optimization of process parameters

Design Expert 10 statistical analysis software was used for the optimization of process parameters. The software prepared the factorial experimental design, and after trials, data were analyzed. Only significant parameters were considered during the optimization process.

Experimental procedure

Trials were planned according to the experimental design shown in table 1.

Table 1: Experimental design

Process Parameters		Levels
Variable parameters	Type of milk	Buffalo milk
		Cow milk
	Milk T.S.	18%
		22%
		26%
		30%
Fixed parameters	Scraper speed	RPM-130
	Steam pressure	1.5
	Milk flow rate	400 l/h

Results & Discussion

In the present study milk flakes formation system was designed, fabricated and chemical properties evaluated. The main objective of this investigation was evaluating the chemical properties of rabri produced through milk flakes formation system.

Performance evaluation of milk flakes formation system

Performance of milk flakes formation system was evaluated at different type of milk (Buffalo milk and cow milk) and feed total solids content (18, 22, 26, and 30%). Following responses were measured during performance evaluation of the developed system.

Acidity

The acidity of rabri was obtained as 0.34±0.04% LA (Table 2). Kaushik *et al*. (2016) [10] also found out acidity of rabri as 0.30±0.15 which is almost similar to us.

Table 2: Acidity of rabri

S.N.	Acidity (%L.A.)	Mean±SD
1	0.34	0.34±0.04
2	0.36	
3	0.40	
4	0.29	
5	0.32	

Total solids

Rabri samples were evaluated for total solids content and results are shown in table. The minimum percentage of total solids content of rabri was observed as 48.51% and the maximum 51.61% (Table 3). The results of the present study (50.22±1.75 average) were lower than reported by Rai *et al*. (2017) [16], (i.e., 67.48±0.301).

Table 3: Total solids content of rabri

S.N.	(W1)	(W2)	(W3)	%T.S.	Mean±S. D
1	24.922	27.022	26.006	51.61	50.22±1.75
2	20.899	23.086	22.033	51.85	
3	24.076	26.4	25.213	48.92	
4	19.893	22.253	21.038	48.51	

Moisture

Variation in the moisture content of Rabri observed in the present study is presented in table

The result revealed that the concentration of moisture in Rabri ranged from 48.39 to 51.49%. This variation could be attributed to undefined heat treatment applied to the product during its manufacturing. Similar trend of variation was also reported in the Rabri samples obtained from Delhi and Karnal i.e., 44.71 and 50.16%, respectively (Gayen and Pal, 1991) [7]. However, the overall mean values of moisture (50.24±1.82%) in Rabri observed in the present study (Table 4) showed the higher percentage than the reported values of Prasad (1997) [14] i.e. 27.90% and 30.00%, respectively.

Table 4: Moisture content of rabri

S.N.	Total solids (%)	Moisture (%)	Mean±S.D.
1	51.61	48.39	50.24±1.82
2	51.85	48.15	
3	48.92	51.08	
4	48.51	51.49	

FFA (Free fatty acids)

The microorganisms and enzymatic activities which lead to lipid hydrolysis are eliminated during preparation of rabri. The FFA content for the samples is ranged from 2.13 µg/g to 3.18 µg/g (Table 5). FFA is an indicator of deterioration of lipid component in food product and is reported to increase during heating of the milk products (Meshref and Al-Rowaily, 2008) [13]. Thus, thermal processing of rabri possibly leads to high initial content of FFA.

Table 5: FFA content of rabri

S.N.	FFA(µg/g)	Mean±SD
1	3.18	2.40±0.54
2	2.40	
3	2.13	

Protein

Rabri samples were evaluated for protein content and results are shown in table 6. The minimum percentage of protein content of Rabri was observed as 11.12% and the maximum 14.21%. Moreover, the results of the present study (12.9±1.69%, average) were higher (Table 4) than reported by De (1980), Gayen and Pal (1991) [7] and Prasad (1997) [14] (i.e. approximately 10.00%), whilst higher than reported by Rajorhia (1995) [15], (i.e. 12.00%).

Table 6: Protein content of rabri

S.N.	Sample Weight (gm)	Titrate Vol. (ml)	% Nitrogen	% Protein	Mean±SD
1	0.45	6	1.74	11.12	12.9±1.63
2	0.494	6.5	1.73	11.03	
3	0.371	6.2	2.34	14.93	
4	0.363	5.1	1.97	12.55	
5	0.424	5.6	1.85	11.80	
6	0.352	5.6	2.23	14.21	
7	Blank	0.4	0	0	
8	Blank	0.4	0	0	

HMF (Hydroxyl Methyl Furfural)

Variation in the HMF content of Rabri observed in the present study is presented in table 7.

The result revealed that the concentration of HMF in Rabri ranged from 3.94 to 4.81% (total) and 6.89 to 7.70% (free). This variation could be attributed to undefined heat treatment applied to the product during its manufacturing. However, the overall mean values of HMF 4.22±1.01% (total) and7.15±0.93 (free) in Rabri observed in the present study showed the higher percentage than the reported values of Ghayal *et al*. (2013) [8] i.e., 3.02±0.06%.

Table 7: HMF content of rabri

S. N.	Abs.	Total HMF	Free HMF	Mean±SD (Total)	Mean±SD (Free)
	443 nm	(µmol/l)	(µmol/l)		
1	0.1	3.94	6.89	4.22±1.01	7.15±0.93
2	0.09	3.06	6.08		
3	0.11	4.81	7.70		
4	0.11	4.81	7.70		

Water activity

The primary and the most important reason to study water activity is the prediction of growth of bacteria, yeast, molds which can affect its quality and can make product more unstable and hamper its shelf life (Singhdh Chawla, 2018) [2]. Water activity of rabri was found 0.96±0.008 (Table 8).

Table 8: Water activity of rabri

S.N.	Water activity	Mean±SD
1	0.97	0.96±0.008
2	0.96	
3	0.96	
4.	0.95	

Conclusion

The milk flake formation system was designed for the production of traditional milk product rabri. Traditional Indian dairy products require the pre-concentration process to convert into a delicious product. Results of the preliminary trials in steam jacketed kettle confirmed the feasibility of production of milk flake for rabri. Based on that milk flake formation system was designed and developed. The system was based on a vertical SSHE. Effect of type of milk (buffalo milk & cow milk) and different total solids concentrations of milk on were studied. The production time was reduced, and flake quantity and product yield were maximum in the case of buffalo milk. Design expert software 10 was used for the optimisation of the final product. Buffalo milk at 26% T.S. concentrations was selected for an optimized product. Various predicted value of responses was: Acidity (%LA), T.S. (%), water activity, protein (%), FFA (µg/g), and HMF (µmol/l) were 0.34±0.04, 50.24±1.82, 0.96±0.008, 12.9±1.63, 2.40±0.54, 4.22±1.01 respectively.

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