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Optimization of cow milk Kheer Mohan using response surface methodology

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Abstract
Kheer Mohan is a traditional chhana-based sweetmeat widely consumed in eastern Rajasthan, valued for its caramelized flavor, characteristic brown color, granular texture, and moderate sweetness. Traditionally made using buffalo milk, this study explores the formulation of Kheer Mohan using cow milk, which offers nutritional advantages such as lower fat content and better digestibility, along with increasing availability in India. The objective was to optimize the product's formulation using Response Surface Methodology (RSM) through a Central Composite Rotatable Design (CCRD).Key variables studied included sugar syrup concentration, semolina level, and cooking time. Results revealed that increasing sugar syrup concentration and extending cooking time significantly enhanced the product's sensory attributes, including texture, flavor, and color. The optimized formulation involved a sugar syrup concentration of 68°Brix, 6% semolina (based on chhana weight), and a cooking time of 104 minutes. The final product showed a desirable composition with 63.93% total solids, 3.42% fat, 6.33% protein, 0.54% ash, 0.87% lactose, and 52.76% sucrose. Shelf-life evaluation indicated that the product remained organoleptically acceptable for 30 days at 30°C and 60 days at 4°C, with superior stability observed when stored in syrup. This study highlights the potential of cow milk as a viable alternative for producing Kheer Mohan with acceptable sensory and nutritional quality, while supporting value addition and diversification in the organized dairy sector.

Keywords: *Kheer Mohan*, *Chhana*, Response surface methodology, optimization

Introduction

Milk has historically been a vital part of human diets and economies, serving both nutritional and cultural roles across civilizations. India stands as the leading global milk producer, contributing approximately 239.3 million tonnes annually (DAHD, 2024). This production stems from various dairy animals, including buffaloes (non-descript: 13.83%, indigenous: 31.49%), cows (exotic: 2.10%, crossbred: 31.11%, indigenous: 11.36%, non-descript: 10.11%), and goats (3.36%) (DAHD, 2024). Due to climatic challenges such as high ambient temperatures, surplus milk is traditionally processed into a wide range of indigenous dairy products. These help in preserving milk's nutritional value while extending its shelf life.

Among these products, milk-based sweets occupy a prominent place in Indian culture, often associated with religious ceremonies, festivals, and social gatherings. It is estimated that over half of the total milk produced in India is converted into traditional sweets by local artisans and small-scale producers (Aneja *et al*., 2002) [1]. Additionally, studies have shown that more than 90% of dairy product consumption in India is in the form of sweet-based items (Singh *et al*., 2007) [13].

One such product is chhana, an acid-coagulated milk derivative that forms the base for several popular Indian sweets. According to Sahu and Das (2007) [10], around 6% of the total milk production is processed into chhana, with the market for chhana-based sweets reaching an estimated 1 million tonnes, valued at around ₹7,00,000 crores. These traditional milk sweets have sustained consumer interest due to their distinct flavors, textures, and cultural relevance. The rising Indian diaspora and growing global interest in traditional ethnic foods are further expanding the international market for these products.

A notable example is Kheer Mohan, a sweetmeat made from chhana, which holds cultural significance in the eastern regions of Rajasthan. Its popularity is attributed to its appealing taste and unique physical properties (Meena *et al*., 2012) [9]. While production techniques using buffalo milk have been standardized (Shrimali, 2013) [12], there has been little research on developing or optimizing cow milk-based versions of this sweet.

With cow milk becoming more accessible and being known for its health benefits—such as lower fat content and different nutritional profiles—there is a growing interest in adapting traditional recipes accordingly. Developing Kheer Mohan using cow milk not only supports health-conscious consumption patterns, but also contributes to value addition and diversification in the dairy sector. Additionally, traditional sweets made in the unorganized sector often suffer from inconsistent quality, lack of hygiene, adulteration, and limited shelf life (Barnwal and Sen, 2014) [2]. Therefore, transitioning such products to the organized sector with standardized production methods is crucial for ensuring quality and meeting market demands.

To achieve this, Response Surface Methodology (RSM) offers a scientifically robust approach. RSM allows for the analysis of interactions among multiple variables and helps identify the optimal conditions for product development and process efficiency (Dean *et al*., 2017) [6]. It has gained popularity in recent years as a method for optimizing food formulations and improving product quality.

Given these factors, the present study aims to develop and optimize a formulation of Kheer Mohan using cow milk by employing RSM. This research seeks to create a standardized, nutritious, and market-ready variant of this traditional sweet, thus supporting both domestic consumption and export potential.

Materials and Methods

Raw Materials

Fresh raw cow milk was procured from the experimental dairy herd of the National Dairy Research Institute (NDRI), Karnal, Haryana, India. The milk was standardized to 3.5% fat and 8.5% solids-not-fat (SNF) using skim milk powder (SMP) and skimmed milk obtained through centrifugal separation. Commercially available medium-grade semolina (suji) and arrowroot powder were procured from the local market in Karnal and used as ingredients for product formulation.

Packaging Material

Unprinted stand-up pouches consisting of 12 µm PET laminated with 125 µm white, five-layer high-barrier film were used for packaging. These were procured from M/s Alpha Packaging, New Delhi.

Preparation of *Kheer Mohan*

The preparation of *Kheer Mohan* followed the standardized method depicted in Figure 1.1. Standardized cow milk was filtered, heated to 98°C, and then cooled to 85°C. A 1% (w/v) tartaric acid solution, preheated to 85°C, was added gradually with gentle stirring until coagulation was complete, as indicated by the appearance of greenish whey. The coagulum was allowed to settle undisturbed for 5–10 minutes, then collected, washed with potable water (25°C), and pressed under a weight equivalent to five times its mass for 2 hours to obtain chhana.

Measured quantities of chhana were blended with 10% sugar (w/w chhana basis), semolina (4–6%), and arrowroot (0.4%). The mixture was kneaded thoroughly into a uniform dough. Individual portions of 21 g were shaped into spherical balls. These were cooked in sugar syrup (60–70°Brix) for 90–120 minutes, with syrup concentration maintained by intermittent addition of water. Post-cooking, two packaging methods were followed:

Without syrup (A): Cooked balls were soaked in 50°Brix syrup for 12 hours, drained for 30 minutes, then packed in stand-up pouches.

With syrup (B): Cooked balls were packed directly in pouches and hot (80°C) sugar syrup (50°Brix) was added prior to sealing.

All samples were stored at 30±1 °C (ambient) and 4±1 °C (refrigerated) for shelf-life evaluation.

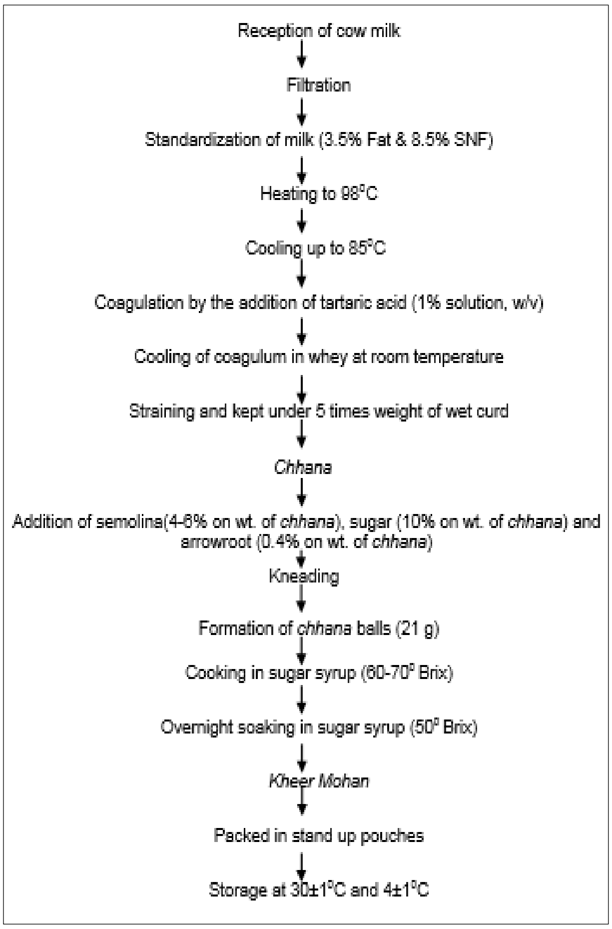


Fig 1: Process Flow daigram of khee Mohan production

Chemical Analysis

Fat and total solids content of milk, and moisture, fat, protein, ash content of *Kheer Mohan*, along with pH and titratable acidity of chhana, were determined using standard protocols described by FSSAI (2016).

Sensory Evaluation

Sensory attributes—flavour, body & texture, colour & appearance, sweetness, juiciness, and overall acceptability—were evaluated by a trained panel from the Dairy Technology Division. A 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) was used for general liking, and a 5-point intensity scale for specific attribute strength. Samples were tempered to 30±1 °C prior to evaluation.

Colour Measurement

The colour of *Kheer Mohan* was measured using a HunterLab ColourFlex colorimeter (Hunter Associates

Laboratory Inc., USA) with Universal Software v4.10. Measurements were recorded in CIELAB color space: L* (lightness), a* (red-green), and b* (yellow-blue). Each sample was placed in a 2 cm-deep glass cell and tapped ten times to remove air gaps. Calibration was done using standard black and white tiles. Readings were taken in triplicate.

Texture Profile Analysis (TPA)
Textural properties including hardness, cohesiveness, springiness, gumminess, and chewiness were analyzed using a TA-XT2i Texture Analyzer (Stable Micro Systems, UK) in double compression mode with a P/75 cylindrical probe at a speed of 1 mm/s. Tempered (25±1 °C for 1 hour) samples were measured under controlled conditions (25±1 °C; 65±1% RH). Six replications were conducted per treatment, and mean values were reported

Statistical analysis
Various levels of semolina, sugar syrup concentration and cooking time were employed to RSM in order to determine their optimum level. The experiments were carried out using central composite rotatable design (CCRD). The central values of three independent variables were coded as A, B, C decided to be, sugar syrup concentration (°Brix), cooking time (min) and semolina level (%), respectively. Their range and levels are given in Table 2.0. Total 20 experiments were carried out in randomized order which includes; 12 factorial, 2 axial and 6 central points (Table 1). It was assumed that response (y) is a function of experimental variables (A, B, C) i.e., y= f (A, B, C). Second order polynomial models were developed by multiple regression technique for each of the response using a Design Expert (version 9.0.7.1) software package.

$$y = \beta_0 + \beta_1 * A + \beta_2 * B + \beta_3 * C + \beta_{12} * A * B + \beta_{13} * A * C + \beta_{23} * B * C + \beta_{11} * A^2 + \beta_{22} * B^2 + \beta_{33} * C^2$$

Where, β_0 is the intercept; β_1, β_2, β_3, are the first order coefficients; β_{12}, β_{13}, β_{23}, are the interaction coefficients and β_{11}, β_{22}, $\beta_{33}$are the coefficients of quadratics terms.
Adequacy of model was evaluated using F-ratio, while the effect of the variables at linear, quadratic and interaction levels on individual responses was described using 95 and 99% levels of confidence.

Table 1: Coded and actual levels of sugar syrup concentration (°Brix) and cooking time (min), semolina level (% by weight of *chhana*) formulation: RSM experiment (CCRD*)

Coded level → Factor↓	**Axial point (min)**	**Factorial point**	**Centre coordinate**	**Factorial point**	**Axial point (Max)**
	-2	**-1**	**0**	**+1**	**+2**
Sugar syrup concentration (°Brix)	56.59	60	65	70	73.41
Cooking time, (min)	79.77	90	105	120	130.23
Semolina level (% by weight of *chhana*)	3.32	4	5	6	6.68

Results and Discussion
Process optimization for manufacture of Kheer Mohan
In order to optimize the process for Kheer Mohan production, product was made using the process outlined in Figure 1 on each levels of independent variables as per different runs of experimental design (Table 2) and the effect of sugar syrup concentration, semolina level, cooking time on all responses were recorded as well as described in Table 3. The developed second order polynomial models were regressed for all the responses for the manufacture of Kheer Mohan table 2. The sensory attributes of cow milk-based *Kheer Mohan* varied notably across different experimental treatments. The minimum flavour score (2.12) was recorded at 56.59°Brix sugar syrup, 105 minutes cooking time, and 5% semolina, whereas the maximum flavour score (4.83) was observed at 65°Brix, 105 minutes, and 3.32% semolina. Shrimali *et al*. (2015) [11] also reported comparable findings, observing the highest flavour score for buffalo milk-based *Kheer Mohan* when cooked in sugar syrup with a concentration of 65° Brix.For body and texture, the scores ranged from 2.10 (at 60°Brix, 90 min, 6% semolina) to 4.88 (at 65°Brix, 105 min, 6.68% semolina). Table 2
Colour and appearance scores (Table 2) were lowest (1.97) at 65°Brix, 79.77 min, and 5% semolina, and peaked at 4.79 with 65°Brix, 105 min, and 3.32% semolina. Sweetness ranged from 3.29 (at 56.59°Brix, 105 min, 5% semolina) to 4.97 (at 65°Brix, 105 min, 6.68% semolina), while juiciness varied from 3.26 (same condition as lowest sweetness) to a maximum of 4.99 (also at 65°Brix, 105 min, 6.68% semolina).

The overall acceptability (Table 2) was lowest (2.10) at 65°Brix, 79.77 min, and 5% semolina, while the highest score (4.81) was observed at 65°Brix, 105 min, and 3.32% semolina. These findings indicate that 65°Brix sugar syrup, 105 minutes of cooking, and a moderate level of semolina (around 3.3–6.7%) yielded the most desirable sensory characteristics.
The instrumental color measurements and texture analysis (Table 2) of *Kheer Mohan* revealed substantial variation based on sugar syrup concentration, cooking time, and semolina level. Lightness (L*) values ranged from a minimum of 36.14 (at 65°Brix, 130.23 min, 5% semolina) to a maximum of 50.12 (at 56.59°Brix, 105 min, 5% semolina), indicating that higher syrup concentration and longer cooking time resulted in darker product color. Redness (a*) values were lowest (11.02) at 70°Brix, 90 min, 4% semolina, and highest (14.71) at 65°Brix, 105 min, 5% semolina, suggesting deeper red tones at higher cooking times and moderate syrup levels. Yellowness (b*) ranged from a minimum of 17.93 (at 60°Brix, 90 min, 4% semolina) to a maximum of 45.68 (at 65°Brix, 130.23 min, 5% semolina), with higher yellowness associated with prolonged cooking and intermediate syrup concentrations. Hardness values varied significantly, with the lowest value of 37.35 N recorded at 65°Brix, 79.77 min, 5% semolina, and the highest value of 66.96 N at 65°Brix, 130.23 min, 5% semolina, indicating increased firmness with extended cooking time.
These results demonstrate Table 3 that cooking time and syrup concentration notably influence the color development and textural firmness of *Kheer Mohan*, with longer cooking

and higher Brix levels contributing to darker color tones and increased product hardness.

Effect of sugar syrup concentration, semolina level, cooking time on sensory scores of Cow milk Kheer mohan

Regression analysis (Table 3) demonstrated high model adequacy in predicting various sensory attributes of *Kheer Mohan*, with R^2 values ranging from 0.77 to 0.97, all significant (*p*<0.05 or *p*<0.01), and non-significant lack-of-fit in all cases. Adequate precision values exceeded the threshold of 4, confirming strong predictive capacity. Flavour scores ranged from 2.15 to 4.81. The model (R^2 = 0.94, *p*<0.01) showed that sugar syrup concentration and cooking time had highly significant (*p*<0.01) positive linear effects, while semolina level had a significant negative effect. Quadratic terms for sugar syrup and cooking time were significantly negative (*p*<0.01). The interaction between sugar syrup concentration and cooking time had a highly significant (*p*<0.01) negative effect. These findings align with Yadav *et al.* (2012), indicating enhanced flavour with longer cooking times. Body and Texture Scores ranged from 2.0 to 5.0. The model (R^2 = 0.95, *p*<0.01) indicated highly significant (*p*<0.01) positive linear effects of sugar syrup concentration and cooking time, with both showing negative quadratic effects (*p*<0.01). Semolina level had no significant effect. A significant negative interaction was found between sugar syrup and cooking time (*p*<0.01), while sugar syrup and semolina interaction was positively significant (*p*<0.05). Shrimali *et al* 2015 [12] also found that semolina level had non-significant effect on sensory attributes of buffalo milk kheer mohan.

Colour and Appearance score The colour and appearance model showed strong predictability (R^2 = 0.96, *p*<0.01). Sugar syrup concentration and cooking time had highly significant (*p*<0.01) positive linear and negative quadratic effects. Shrimali *et al* found similar trend in case of buffalo milk kheer mohan. Semolina had no significant effect. Interaction between sugar syrup and cooking time was significantly negative (*p*<0.01), while other interaction terms were non-significant. Sweetness The sweetness model was significant (R^2 = 0.81, *p*<0.05). Sugar syrup concentration (*p*<0.05) and semolina level (*p*<0.01) had significant positive linear effects, while only sugar syrup concentration showed a highly negative quadratic effect (*p*<0.01). All interaction effects were non-significant. Juiciness scores were well predicted by the model (R^2 = 0.77, *p*<0.01). Sugar syrup concentration (*p*<0.05) and

Table 2: Sensory and Physical characteristics of Kheer mohan prepared with different levels of sugar syrup concentration(A), semolina level(c), cooking time(B)

Variables			Flavour	Body and Texture	C&A*	Sweet-ness	Juici-ness	O.A.**	L*	b*	a*	Hardness(N)
A	B	C										
60	90	4	2.80	2.90	2.66	3.90	3.88	2.79	47.12	11.07	17.93	42.70
70	90	4	3.72	3.68	3.55	3.93	3.90	3.65	41.27	11.02	25.15	39.15
60	120	3	4.47	4.30	4.35	4.17	4.15	4.37	43.08	13.42	37.50	57.19
70	120	4	4.10	3.70	3.95	4.04	4.05	3.98	36.26	13.10	27.59	64.10
60	90	6	2.26	2.10	2.15	4.56	4.58	2.67	49.21	11.11	24.90	42.16
70	90	6	3.85	3.90	3.67	4.57	4.59	3.81	42.16	12.96	23.00	46.14
60	120	6	4.01	4.05	3.99	4.65	4.68	4.02	41.58	12.89	45.18	61.59
70	120	6	4.18	4.10	3.99	4.71	4.72	4.09	39.18	14.06	36.05	63.13
56.59	105	5	2.12	2.10	3.06	3.29	3.26	2.96	50.12	12.95	31.84	52.52
73.41	105	5	4.10	4.10	4.00	4.48	4.47	4.07	39.75	11.55	21.90	59.74
65	79.77	5	2.15	2.19	1.97	4.44	4.42	2.10	49.14	11.28	18.25	37.35
65	130.23	5	3.06	3.14	2.95	4.39	4.41	3.05	36.14	14.65	45.68	66.96
65	105	3.32	4.83	4.81	4.79	4.36	4.32	4.81	40.16	11.73	19.53	56.50
65	105	6.68	4.79	4.88	4.66	4.97	4.99	4.78	39.87	13.14	32.50	55.48
65	105	5	4.40	4.33	4.15	4.71	4.50	4.33	42.41	13.64	26.27	53.11
65	105	5	4.75	4.82	4.65	4.88	4.89	4.74	44.16	14.57	26.15	55.24
65	105	5	4.50	4.50	4.39	4.61	4.52	4.46	42.69	14.71	27.11	55.84
65	105	5	4.30	4.38	4.16	4.64	4.42	4.48	43.87	14.69	25.97	54.06
65	105	5	4.70	4.78	4.66	4.63	4.64	4.71	42.15	13.86	29.03	50.33
65	105	5	4.70	4.79	4.66	4.74	4.83	4.71	47.12	11.07	17.93	42.70

Table 3: Regression coefficients and ANOVA of fitted quadratic model for and sensory and physical characteristics of Kheer mohan

Partial coefficients	Flavour	B&T	C&A	Sweet-ness	Juici-ness	O.A.	L*	a*	b*	Hardness(N)
Intercepts	4.55	4.59	4.44	4.70	4.63	4.57	43.11	14.37	26.99	53.63
A- Sugar syrup conc (^{0} Brix)	0.41**	0.39**	0.26**	0.14*	0.15*	0.26**	2.90**	0.022^{ns}	2.23**	1.54^{ns}
B- Cooking time (min)	0.41**	0.38**	0.43**	0.038^{ns}	0.046^{ns}	0.38**	-3.04**	0.95**	7.43**	9.20**
C Semolina level (%)	-0.062**	-0.02^{ns}	-0.068^{ns}	0.25**	0.27**	-0.019^{ns}	0.29^{ns}	0.35*	3.13**	0.60^{ns}
AB	-0.34**	-0.39**	-0.35**	-0.014^{ns}	-0.012^{ns}	-0.29**	0.46^{ns}	-0.12^{ns}	-3.04**	1.00^{ns}
AC	0.15^{ns}	0.21*	0.13^{ns}	0.020^{ns}	0.015^{ns}	0.092^{ns}	0.40^{ns}	0.42^{ns}	-1.04^{ns}	0.27^{ns}
BC	3.125E-003^{ns}	0.091^{ns}	8.750E-003^{ns}	-0.017^{ns}	-0.023^{ns}	-0.036^{ns}	-0.20^{ns}	-0.19^{ns}	1.41^{ns}	-0.38^{ns}
A^2	-0.46**	-0.50**	-0.32**	-0.29**	-0.27**	-0.35**	0.64^{ns}	-0.75**	0.22^{ns}	0.32^{ns}
B^2	-0.64**	-0.66**	-0.70**	-0.097^{ns}	-0.071^{ns}	-0.68**	-0.17^{ns}	-0.49**	2.02**	-1.08^{ns}
C^2	0.14^{ns}	0.11^{ns}	0.10^{ns}	-0.010^{ns}	0.014^{ns}	0.10^{ns}	-1.10*	-0.68**	-0.084^{ns}	0.27^{ns}
Model F	19.15	21.45	28.37	4.82	3.91	42.08	19.39	11.14	31.14	17.28
R^2	0.9452	0.9508	0.9623	0.8128	0.7787	0.9743	0.9458	0.9093	0.9655	0.9396
APV	14.45	14.45	19.34	8.63	8.06	22.82	15.072	9.897	20.777	15.596
** Significant at 1% level (*p*<0.01); * Significant at 5% level (*p*<0.05); ^{ns}, Non-Significant(p>0.05), B&T-Body and texture, C&A – colour and appreance,O.A-overall acceptability										

semolina level (p<0.01) had significant positive linear effects, while cooking time had no significant linear effect. Only sugar syrup concentration showed a significant negative quadratic effect (p<0.01), and all interactions were non-significant. Overall Acceptability The highest R^2 value (0.97, p<0.01) was obtained for overall acceptability. Sugar syrup concentration and cooking time had highly significant (p<0.01) positive linear effects and negative quadratic effects. Semolina level and its interactions were non-significant. However, the interaction between sugar syrup concentration and cooking time had a highly negative effect (p<0.01). Sensory Characteristics of Rasogolla with a sugar Concentration of 60 Brix was found significantly highest with colour and appearance, aroma, tastes and body and texture. (Begum *et al*. 2020) [3]

The final regression equation in terms of coded variables for Sensory and physical attributes of cow milk *Kheer mohan* is given below:

Table 4: The multiple regression equation generated to predict the sensory scores, physical colour values

Flavour	+4.55+0.41 * A+0.41 * B-0.062 * C-0.34 * AB+0.15 * AC+3.125E-003 * -0.46*A2-0.64 * B2+0.14 * C2
Colour and apprence	+4.44+0.26 * A+0.43 * B-0.068 * C-0.35 * AB+0.13 * AC+8.750E-003 * BC-0.32 * A2-0.70 * B2+0.10 * C2
Body and Texture	+4.59+0.39 * A+0.38 * B-0.022 * C-0.39 * AB+0.21 * AC+0.091 * BC-0.50 *A2-0.66 * B2+0.11 * C2
Sweetness	+4.44+0.26 * A+0.43 * B-0.068 * C-0.35 * AB+0.13 * AC+8.750E-003 * BC-0.32 * A2-0.70 * B2+0.10 * C2
Juiciness	+4.63+0.15 * A+0.046 * B+0.27 * C0.012 * AB+0.015 * AC-0.023 * BC-0.27 * A2-0.071 * B2+0.014 * C2
Over acceptability	+4.57+0.26 * A+0.38 * B0.019 * C-0.29 * AB+0.092 * AC0.036 * BC-0.35 * A2-0.68 * B2+0.10 * C2
L* value	+43.11-2.90 * A-3.04 * B+0.29 * C+0.46 * AB+0.40 * AC-0.20 * BC+0.64 * A2-0.17 * B2-1.10 * C2
b* value	+26.99-2.23 * A+7.43 * B+3.13 * C-3.04 * AB-1.04 * AC+1.41 * BC+0.22 * A2+2.02 * B2-0.084 * C2
a* value	+14.37+0.022 * A+0.95 * B+0.35 * C-0.12 * AB+0.42 * AC-0.19 * BC-0.75 * A2-0.49 * B2-0.68 * C2

Effect of sugar syrup concentration, semolina level, cooking time on sensory scores of Cow milk Kheer mohan

Regression analysis (Table 3.0) demonstrated strong model predictability for colour parameters, with R^2 values of 0.94, 0.90, and 0.90 for L*, a*, and b* values, respectively (p<0.01), and non-significant lack-of-fit in all cases, confirming model adequacy. L* Value

Sugar syrup concentration had a highly significant (p<0.01) positive linear effect, while cooking time had a significant (p<0.01) negative linear effect. Semolina level had no significant linear effect, but showed a significant (p<0.05) negative quadratic effect. All interaction terms and other quadratic effects were non-significant. Maximum L* value was observed at 65°Brix, 5% semolina, and 105 min, while the minimum occurred at 70°Brix, 4% semolina, and 90 min (Table 3.0). a* Value

Cooking time and semolina level showed significant (p<0.05) and highly significant (p<0.01) positive effects, respectively, in linear terms, while sugar syrup concentration had no significant linear effect. All interaction effects were non-significant. Quadratic terms for sugar syrup concentration, cooking time, and semolina level were all highly negatively significant (p<0.01), indicating a curvilinear trend in redness. Table 3.0) b* Value

All three independent variables had highly significant (p<0.01) positive effects on b* values in linear terms. Interaction between sugar syrup concentration and cooking time had a highly significant (p<0.01) negative effect, whereas other interactions were non-significant. Among quadratic terms, only cooking time exhibited a highly significant (p<0.01) positive effect; sugar syrup concentration and semolina level had no significant quadratic influence. Table 3.0)

Effect on hardness (N) of cow milk *Kheer mohan*

The hardness value of *Kheer mohan* prepared with different levels of sugar syrup concentration, semolina and cooking time range from 37.35 to 66.96 N (Table 2.0). Highest hardness (N) value was observed at 65^0Brix sugar syrup concentration, 5% semolina level and 130.23 min cooking time, while lowest value was observed at 65^0 Brix sugar syrup concentrations, 5% semolina level and 79.77 min cooking time.

The regression analysis of data (Table 3.0) revealed that the R^2 (0.93) was (highly significant (p<0.01) and the lack of fit test was non-significant, indicating that the model is efficient to predict hardness value of *Kheer mohan* prepared with any combination of the variables levels within the range evaluated. Table 3.0)

Among three variables only cooking time had highly positive significant (p<0.01) effect on hardness value of *Kheer mohan* at linear terms, but other two variables showed non-significant effect on hardness value. All variable had non-significant effect on hardness value in interaction as well as quadratic terms. Sugar syrup concentration also had significantly (p

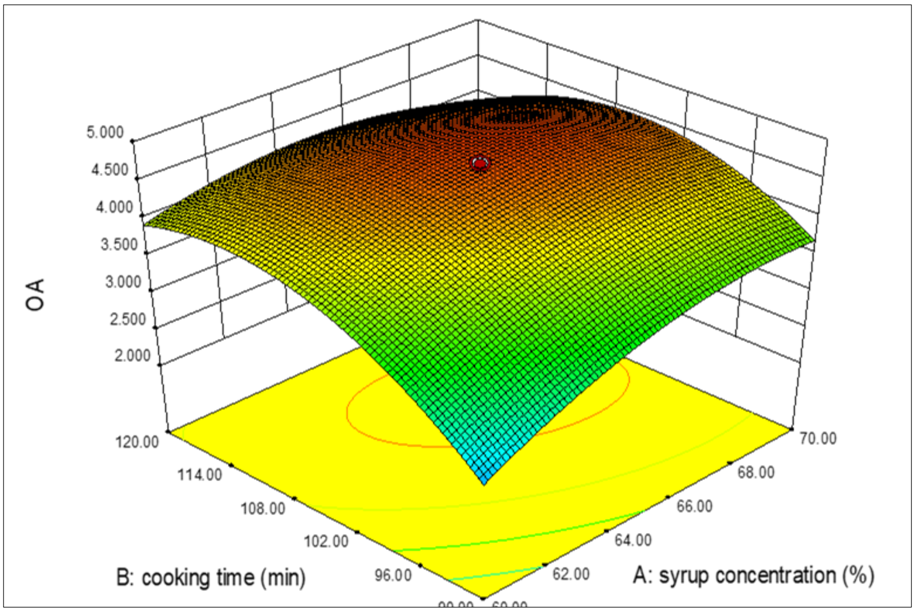
The final regression equation in terms of coded variables for hardness value of *Kheer mohan* is given below: Hardness = +53.63+1.54 * A+9.20 * B+0.60 * C+1.00 * AB+0.27 * AC-0.38 * BC+0.32 * A2-1.08 * B2+0.27 * C2

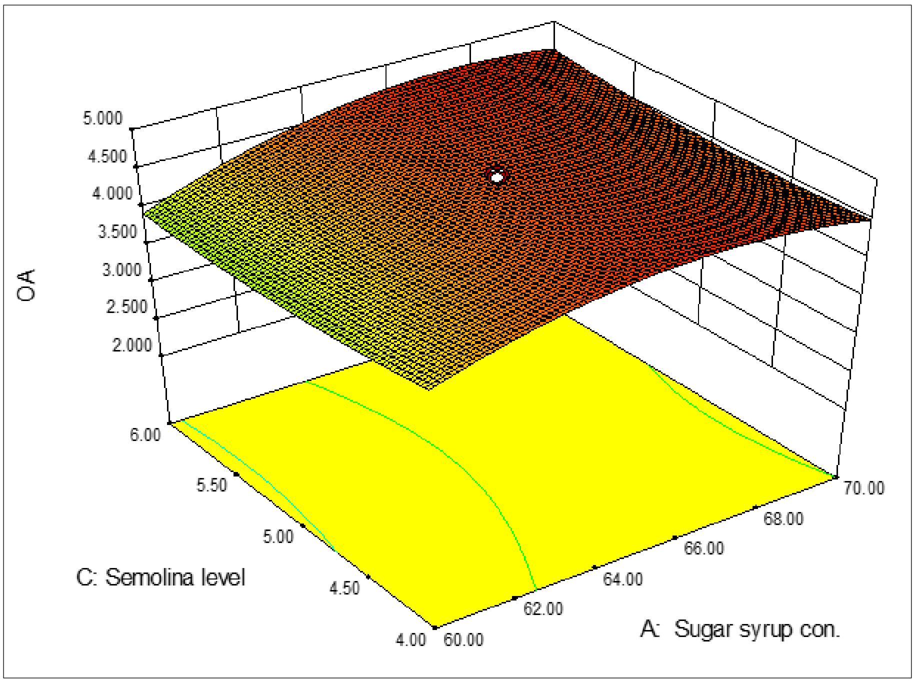
Optimized Solutions and Their Validation

Based on the experimental trials, values of the responses were fed in design expert software version 9.0.2.0. The criteria for selection of optimum level of three independent variables are as shown in Table 5.0. Final six optimized solutions obtained with desirability value of 0.804, 0.804,0.804,0.804,0.803 and 0.803, For the validation of the optimized solution, product was prepared using optimum combination of independent variables in triplicates and evaluated for all the responses as observed value. The predicted values were then compared with these observed values, results shown in Table 6.0. Finally, observed and predicted values were subjected to t-test which indicated that there was non-significant difference among them and validated the optimized levels of sugar syrup concentration, semolina and cooking time as obtained by the design expert software.

Table 5: Criteria for optimization of levels of sugar syrup concentration (^{0}Brix), cooking time (min) and semolina (by % weight of *chhana*) and for *Kheer mohan*

Constraints	Goal	Lower limit	Upper limit
A: Sugar syrup conc.	Maximize	60	70
B: Cooking time	Minimize	90	120
C: Semolina level	In range	4	6
Flavour	Maximize	2.12	4.83
Body and texture	Maximize	2.1	4.88
Colour and appearance	Maximize	1.97	4.79
Sweetness	In range	3.31	4.94
Juiciness	In range	3.26	4.99
Overall acceptability	Maximize	2.10167	4.81
L* value	Target = 50.0	36.14	50.12
a* value	Target = 14.00	11.02	14.71
b* value	Target = 30.00	17.93	45.68
Hardness (N)	Target = 55	37.35	68.96





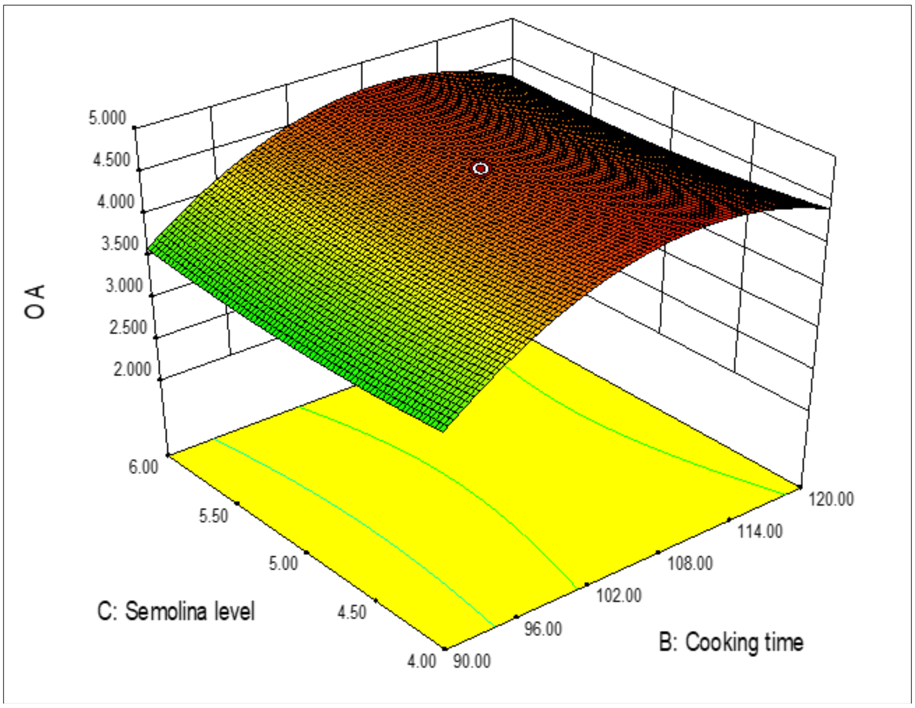


Fig 2: Response surface curve for overall accepatability (OA) of Kheer mohan as influenced by levels of sugar syrup concentration and Cooking

Table: 6: Comparison of predicted and observed values of responses to validate the optimized results

Attributes	Predicted values^	Observed values$^{(t_{0.05})}$
Flavour	4.79	4.86±0.3 NS
Body and texture	4.85	4.74±0.2 NS
Colour & appearance	4.58	4.45±0.5 NS
Sweetness	4.92	4.62±0.6 NS
Juiciness	4.91	4.66±0.4 NS
Overall acceptability	4.72	4.61±0.4 NS
L* value	41.35	36.38±1.1 NS
a* value	14.0	13.85±0.6 NS
b* value	27.8	27.88±0.3 NS
Hardness (N)	55.0	51.30±7.5 NS

^Values predicted by design expert software # Means from triplicate experiments, NS: non-significant

Chemical Composition Of Optimized *Kheer Mohan*

The optimized *Kheer mohan* was evaluated for its chemical composition as presented in Table 7.0. It had 66.93% total solid content, 3.42% fat, 52.76% sucrose, 0.87% lactose, 6.33% protein and 0.54% ash.

Table 7: Proximate composition of *Kheer mohan*

Constituent (%)	Optimized *Kheer mohan**
Total solids	66.93±0.09
Fat	3.42±0.03
Sucrose	52.76±0.07
Lactose	0.87±0.07
Ash	0.54±0.01
Protein	6.33±0.02

***** Mean± SE from three determinations

Fig 3: *Kheer mohan* prepared by optimized process

Conclusion

The study successfully optimized the process parameters for the production of *Kheer Mohan* from cow milk using response surface methodology. A combination of 68.01°Brix sugar syrup, 6% semolina, and 104 minutes cooking time yielded the best sensory and physical qualities, with a desirability of 0.804. The optimized product matched target L*, a*, b*, and hardness values, confirming model accuracy. It contained 63.93% total solids and 6.33% protein. Shelf-life evaluation revealed 60 days at 4 ± 1°C and 30 days at 30 ± 1°C in stand-up pouches. This study establishes a standardized method for commercial-scale cow milk *Kheer Mohan* Production.

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