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Technology for Development of Turmeric Burfi

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Abstract:
This study aimed to develop a functional turmeric-enriched Burfi by incorporating turmeric powder in the range of 0.25–0.75% on the basis of milk, during the boiling stage to reduce its inherent bitterness, and enriching with 0.01% saffron to enhance flavour and mask residual off-notes. A central composite rotatable design using response surface methodology was employed to optimize turmeric and sugar (5–7%) levels, based on sensory attributes (colour & appearance, flavour, sweetness, body & texture, overall acceptability) and instrumental hardness. Developed quadratic models exhibited strong predictability (R^2 = 0.90–0.97, adequate precision = 6.6–21.3). Results revealed that sugar significantly enhanced sweetness and texture, while turmeric negatively affected flavour and acceptability at higher concentration levels; saffron and boiling of turmeric effectively mitigated the bitter astringent note of turmeric powder. Instrumental hardness decreased with increasing sugar and turmeric concentrations. The optimized formulation achieved high sensory scores, and enhanced antioxidant activity (~81% DPPH inhibition), and appealing texture. Thys turmeric Burfi represents a novel health-focused adaptation of a traditional sweet, offering both functional benefits and consumer appeal.

Introduction:
Burfi is a traditional Indian dairy sweet prepared primarily from khoa, a partially desiccated milk product known for its soft texture, fine grains, and rich taste. It is widely consumed in various forms and holds significant cultural and commercial importance in India's dairy sector. With India being the largest milk-producing country globally, traditional milk-based sweets like Burfi continue to serve as an important avenue for utilizing surplus milk solids, contributing to the value addition of milk and supporting a robust indigenous dairy market (Londhe and Pal, 2007; NDDB Statistics, 2023).
In recent years, there has been growing consumer interest in functional foods, which offer health benefits beyond basic nutrition. This has created new opportunities to fortify traditional dairy products with bioactive components, thereby aligning them with modern health trends (Martirosyan and Singharaj, 2016; Sawale et al., 2013). Herbs and spices are integral to such innovations due to their long history of culinary and medicinal use. They are rich in biologically active compounds such as flavonoids, terpenoids, polyphenols, carotenoids, and curcumins, which exhibit antioxidant, anti-inflammatory, antitumorigenic, and hypolipidemic properties (Basak et al., 2010; Guldiken et al., 2018).
Among these, turmeric (Curcuma longa) stands out as a golden-yellow spice extensively used in Indian cuisine and Ayurvedic medicine. Turmeric contains curcumin and over 700 other bioactive compounds, including diphenyl alkanoids, terpenoids, flavonoids, and alkaloids, which collectively confer potent antioxidant, anti-inflammatory, antimicrobial, and anticancer activities (Jyotirmayee et al., 2020; Tanvir et al., 2017). Turmeric acts as a powerful scavenger of reactive oxygen species such as superoxide anion,

hydroxyl radicals, and peroxynitrite (Araujo and Leon, 2001). Its inclusion in dairy products has been explored to enhance nutritional value and prolong shelf life by reducing lipid oxidation (Prasad, 2017). Studies have demonstrated successful incorporation of turmeric in products like paneer, ghee, yogurt, lassi, and milk, resulting in improved functional properties while retaining acceptable sensory qualities.

Turmeric's intense flavour and colour can sometimes lead to sensory challenges. To address this, saffron (Crocus sativus) has been incorporated at low levels (around 0.01%) to mask the characteristic bitterness of turmeric, contributing additional antioxidant and mood-enhancing benefits through its crocin and safranal components (Bhowmik et al., 2009). Using saffron blends can be a practical approach in maintaining desirable sensory profiles though it may increase formulation costs marginally.

The development of such herbal-infused dairy products aligns well with emerging consumer preferences for natural additives over synthetic antioxidants like BHT and BHA, which have potential health concerns (Wojdylo et al., 2007; Khoobchandani et al., 2010). Natural herbs not only stabilize fat-rich products by retarding auto-oxidation but also introduce additional health-promoting bioactives (Sawale et al., 2020; Muzolf and Stuper, 2021).

Against this backdrop, the present study was undertaken to formulate and optimize a turmeric-enriched Burfi by integrating turmeric powder at varying concentrations, supplemented with saffron for flavour balance. Using Response Surface Methodology (RSM), the product was optimized for variables against sensory responses and physical property hardness. The optimized Burfi was then evaluated for its proximate composition along with physico-chemical and bio-functional properties, shelf stability, and cost of production. This work aims to cater to the growing demand for functional, health-promoting traditional foods while maintaining the cultural and sensory essence of Burfi.

MATERIALS AND METHODOLOGY

The turmeric Burfi was formulated using full cream milk (6% fat and 9% SNF) obtained from the Department of Dairy Processing and Operation, SMC College of Dairy Science, Anand. Sugar (M30 grade) of Madhur brand, manufactured by Shree Renuka Sugar Ltd., Mumbai, was procured from the local market of Anand and used as a sweetening agent. Turmeric powder (Everest brand) was used in the formulation, sourced from Everest Food Products Pvt. Ltd., Krushal Centre, G.M. Road, Maharashtra. Natural flavouring was imparted using saffron, which was purchased from the local market of Anand.

Preparation Method

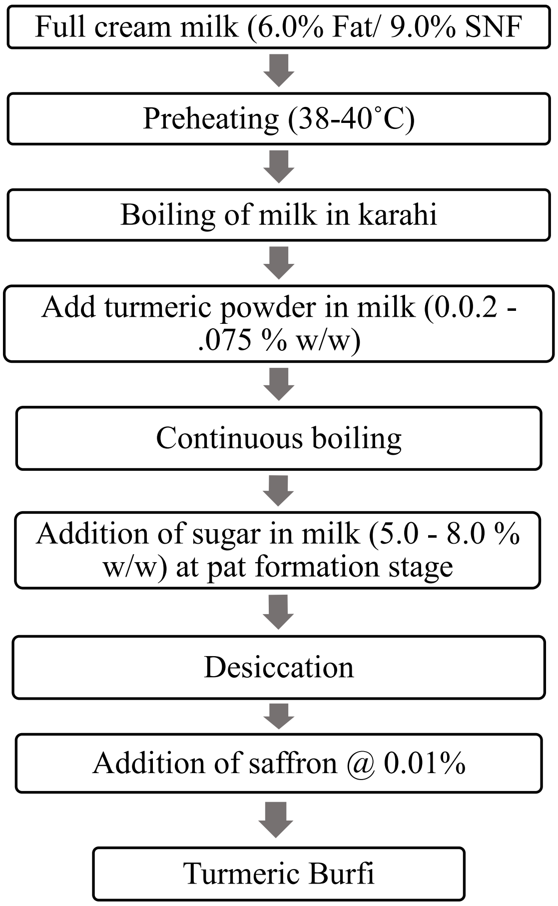


Figure 1: Flow diagram for turmeric Burfi

The full cream milk (6.0% fat, 9.0% SNF) was taken in a heavy-bottomed karahi. Once the milk began boiling, turmeric powder was added at a varying concentration of milk. Sugar in varying concentration and saffron powder solution were added at the pat formation stage. After desiccation, the turmeric Burfi was transferred into a previously sterilized and sanitized stainless-steel tray and allowed to set and cool. The following day, the Burfi was cut into 2×2 cm pieces and was served to panel of judges.

Composition Analysis: Turmeric Burfi was analyzed for proximate composition, physico-chemical properties, and microbial quality. Moisture, fat, protein, and total ash were determined using standard procedures as per FSSAI (2022), physico-chemical properties analyzed using reference methods and Microbiological quality was assessed by determining aerobic plate count, coliform count and yeast and mold count (FSSAI, 2024).

Sensory evaluation: The sensory evaluation of turmeric Burfi was conducted by a panel of 10 trained judges using a 9-point hedonic scale (Meilgaard et al., 1999). Samples were evaluated for colour and appearance, flavour, sweetness, body and texture, and overall acceptability. Judges recorded their scores on a sensory evaluation score card. Saline water was provided to cleanse the palate before and after each tasting. Mean scores were calculated for each parameter to assess overall preference.

Texture Profile Analysis: Texture measurements of Burfi samples were carried out using a Lloyd Instrument (Model No. 01/2962, Hampshire, UK) equipped with a 5.0 KN probe operating at a speed of 20.0 mm/min. Before testing, the Burfi samples were tempered at 23±1°C for one hour. Hardness was measured in a controlled environment maintained at 23±1°C and 65±1% relative humidity. Cubes of Burfi measuring 20 mm on each side were placed uniformly on the compression support plate and compressed to 70% of their original height. For each Burfi sample, five samples were tested, and the average of these readings was taken as the final value.

Statistical Analysis

The minimum and maximum levels of turmeric powder and sugar were selected based on preliminary trials. A central composite rotatable design (CCRD) under response surface methodology (RSM) was used to optimize these two factors for the development of turmeric Burfi. The CCRD for two factors included a total of 13 experimental combinations covering the lower and upper limits, along with their corresponding responses for selected sensory attributes and Hardness (Table 1). The experimental data were analyzed using Design Expert® software (version 13.0.1.0, Stat-Ease, Inc., Minneapolis, USA). For each response, a general second-order polynomial equation was fitted in the form:

$$Y = a0 + a1x1 + a2x2 + a11x1^2 + a22x2^2 + a12x1x2 + \text{Error term}$$

where Y is the predicted response; a0 represents the intercept; a1 and a2 are linear coefficients; a11 and a22 denote quadratic coefficients; and a12 is the interaction coefficient for turmeric powder (x1) and sugar (x2) levels. The adequacy of each model was assessed through the coefficient of determination (R^2) and analysis of variance (ANOVA) using the F-value to determine statistical significance. The influence of the independent variables on each response was interpreted at significance levels of $P<0.01$ and $P<0.05$. Additionally, a t-test assuming equal variance was performed using Microsoft Excel to compare predicted values with actual experimental results.

Result and Discussion

The optimization of turmeric Burfi was carried out based on its sensory qualities, specifically colour & appearance, flavour, sweetness, body & texture, overall acceptability, as well as its instrumental hardness. The study utilized a central composite rotatable design (CCRD) of the response surface methodology (RSM) to optimize the levels of turmeric powder and sugar. Successive regression analysis of the data produced quadratic models for each response. The coefficient of determination (R^2) values for the fitted models ranged from 85.37% to 97.0%, indicating that a high proportion of variability was explained by the models (Table 2). The model F-values were found to be significant for all responses, confirming the adequacy of the models. Non-significant lack of fit demonstrated that the models were suitable for prediction within the experimental range. The adequacy of the models was further supported by the adequate precision values (APV), which ranged from 6.55 to 21.27, well above the minimum requirement of 4, signifying an adequate signal-to-noise ratio. These results clearly indicate that the developed quadratic models were robust and can be effectively used to predict and optimize the quality attributes of turmeric Burfi formulated with varying levels of turmeric powder and sugar.

Table 1: Experimental design matrix, sensory and hardness attributes of turmeric Burfi

Run	A: Turmeric powder	B: Sugar	C&A Score	Flavour Score	Sweetness Score	B&T Score	Overall Acceptability Score	Hardness Value (N)
1	0.75	5.00	7.70	7.20	7.85	7.35	7.45	16.87

2	0.50	4.59	8.10	7.80	7.85	7.35	7.80	26.96
3	0.25	7.00	8.30	8.30	8.10	7.90	8.20	18.76
4	0.14	6.00	8.40	8.20	8.15	8.00	8.14	15.38
5	0.85	6.00	7.60	7.10	7.90	8.13	7.46	24.39
6	0.25	5.00	8.53	7.89	7.67	8.03	7.46	27.65
7	0.50	6.00	8.49	8.24	8.39	8.39	8.29	15.53
8	0.50	7.41	8.17	8.17	8.17	7.89	8.27	14.08
9	0.50	6.00	8.43	8.35	8.35	8.10	8.14	16.69
10	0.50	6.00	8.50	8.27	8.35	8.27	8.18	18.34
11	0.75	7.00	8.13	8.10	8.18	8.27	8.10	18.10
12	0.50	6.00	8.77	8.47	8.52	8.35	8.64	18.04
13	0.50	6.00	8.54	8.25	8.29	8.16	8.27	20.17

Effect of different variables on colour and appearance

Colour and appearance is the foremost sensory parameter influencing consumer perception and acceptance of any food product. In turmeric Burfi, the colour and appearance scores of experimental samples ranged between 7.70 and 8.53 on a 9-point hedonic scale (Table 1). The highest score was recorded for Burfi prepared with 0.25% turmeric powder and 5% sugar, while the lowest was observed for the sample with 0.85% turmeric powder and 6% sugar. The Burfi samples with higher turmeric levels tended to exhibit an intense yellow shade which, beyond a certain point, appeared less appealing to the judges.

The regression model equation in actual variables for predicting the colour and appearance score is presented in Table 3. The fitted quadratic model for this attribute was found to be significant, with a high R^2 value of 0.85, explaining about 85% of the variation in the data (Table 2). The adequate precision value (APV) was 6.56, indicating a satisfactory signal-to-noise ratio for model reliability.

Among the variables, turmeric powder had a significant ($p < 0.05$) negative linear effect, suggesting that increasing turmeric concentration decreased the colour and appearance score. Sugar also showed a significant ($p < 0.05$) negative quadratic impact, indicating that very high sugar levels slightly reduced visual appeal. The interaction of turmeric and sugar was non-significant, implying that their combined influence was minimal and is presented in Figure 2.

Similar findings were reported by Buch (2014), who observed reduced paneer colour scores with increasing turmeric concentration, and by Prasad (2017) in Burfi, where higher turmeric levels diminished visual appeal. These observations highlight the need to maintain turmeric within optimal levels to achieve a desirable bright appearance without overly intense coloration.

Table 2: P values and partial coefficients of the regression equation for the suggested models related to the sensory qualities of turmeric Burfi

Terms	Color & Appearance Score	Flavour Score	Sweetness Score	Body & Texture Score	Overall Score	Hardness (N)
Intercept	8.06	8.05	8.24	8.12	8.16	18.61
A: Turmeric	-0.2101*	-0.2391*	-0.0288	-0.0091	-0.1761*	-0.8208*

B: Sugar	-0.1614*	0.2326*	0.1382*	0.2457*	0.2051*	-2.3835*
AB	0.0575	0.1871*	-0.2300*	0.1738*	0.1298*	-0.9225
A²	-0.2086*	-0.2876*	-0.2035*	-0.0912	-0.2335*	-1.6586*
B²	-0.2857*	-0.0436	-0.0985*	-0.3576*	-0.1035*	0.0284
R²	0.8537	0.9693	0.8985	0.9341	0.9421	0.9258
F-value	8.17	44.23	12.39	19.84	22.76	17.47
Adeq Precision	6.5583	21.2768	10.2268	12.6854	14.1417	15.2202
Suggested Model	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic	Quadratic
*: $p < 0.05$; APV= Adequate Precision Value, R^2 = Coefficient of determination						

Figure 2: Response surface plot of colour and appearance

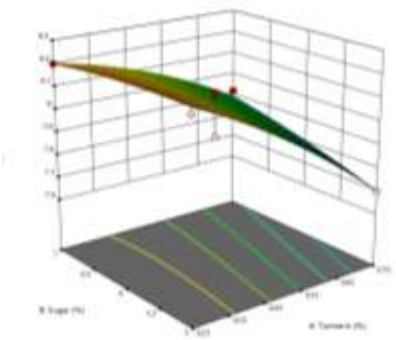
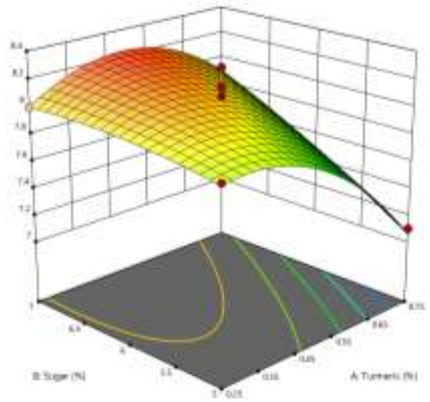


Figure 3: Response surface plot of flavour



Effect on Flavour Score

Flavour is a critical sensory characteristic that combines taste and aroma, directly affecting consumer acceptability. The flavour scores of turmeric Burfi ranged from 7.20 to 8.47 (Table 1). The minimum flavour was observed in the sample with 0.75% turmeric and 5% sugar, while the highest score was seen with 0.50% turmeric and 6% sugar. The fitted quadratic regression model showed a very high R^2 value of 0.97, accounting for 97% of the variation, with an APV of 21.28, indicating excellent model adequacy (Table 2). The regression equation for flavour is provided in Table 3.

Turmeric had a significant ($p < 0.05$) negative linear effect, indicating that increasing turmeric reduced flavour scores, likely due to its characteristic bitter and earthy notes. Sugar showed a significant ($p < 0.05$) positive linear effect, enhancing flavour by increasing sweetness. The interaction between turmeric and sugar was also significant and positive, suggesting that appropriate sugar levels could partially mask the less desirable notes of turmeric. At the quadratic level, turmeric had a significant negative effect, indicating that excessive turmeric sharply reduced flavour. Such effect also could be seen in Figure 3.

To mitigate the bitter notes imparted by turmeric, saffron was incorporated at the rate of 0.01%, which helped improve the overall flavour profile. It is suggested for commercial applications to use saffron to achieve flavour masking effects of turmeric, which can improve appearance though affecting cost of production marginally.

These findings agree with earlier studies. Buch (2014) reported that flavour scores in paneer declined with increasing turmeric content, and only lower levels maintained high acceptability. Similarly, Prasad (2017) and Mervat et al. (2007) found flavour reductions in turmeric-enriched Burfi and yogurt, respectively. Maji et al. (2018) observed a steep decrease in flavour scores in herbal lassi as turmeric extract levels rose. This consistent pattern across dairy products is likely linked to the active compounds in turmeric—such as polyphenols, terpenes, and alkaloids—which contribute to its intense and sometimes overpowering taste.

Effect on Body and Texture Score

Body and texture is an important parameter contributing to the mouthfeel and structural quality of Burfi. In this study, the body and texture scores varied from 7.35 to 8.39 (Table 1). The lowest score was observed in Burfi containing 0.75% turmeric and 5% sugar, while the highest was found in the sample with 0.50% turmeric and 6% sugar.

The regression equation for body and texture is given in Table 3. The model was highly significant with an R^2 of 0.93 and APV of 12.68, indicating its suitability for prediction (Table 2).

Sugar showed a significant ($p < 0.05$) positive linear effect, improving the texture by contributing to better crystallization and mouthfeel. The quadratic effect of sugar was significantly negative, suggesting that excessive sugar levels could reduce body and texture scores, likely by making the product overly soft. The interaction between turmeric and sugar was significant and positive, indicating a mild synergistic effect on texture. Turmeric alone showed no significant linear impact but had a negative quadratic effect (Figure 4).

These findings are consistent with previous reports. Buch (2014) observed declining body and texture scores in paneer with higher turmeric levels. Similarly, Prasad (2017) and Mervat et al. (2017) found that increased turmeric reduced texture scores in Burfi and yogurt, respectively. Maji et al. (2018) also documented a gradual decline in the body and texture of herbal lassi as turmeric extract levels rose. This underscores the importance of carefully balancing sugar to achieve the desired texture in Burfi, while being mindful of turmeric's indirect effects when combined with sweeteners.

Figure 4: Response surface plot of body and texture

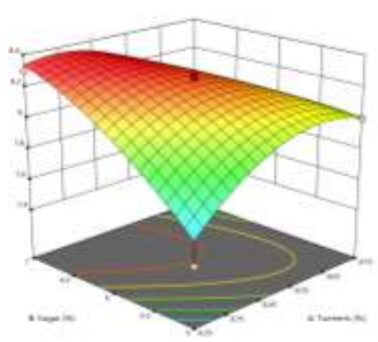
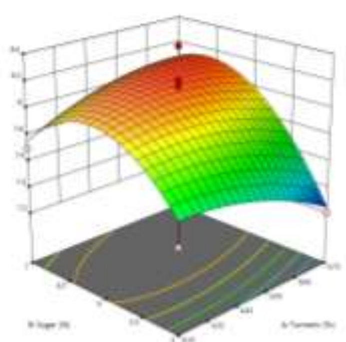


Figure 5: Response surface plot of sweetness



Effect on Sweetness Score

Sweetness is a fundamental attribute influencing the palatability and consumer liking of confectionery products. In turmeric Burfi, the sweetness scores ranged between 7.67 and 8.52 on a 9-point hedonic scale (Table 1). The minimum sweetness score was recorded for the Burfi sample prepared with 0.25% turmeric powder and 5% sugar, while the maximum was observed in the sample with 0.50% turmeric powder and 6% sugar.

The fitted quadratic model for sweetness was found to be statistically significant, with a high coefficient of determination ($R^2 = 0.90$), accounting for about 90% of the variation in sweetness scores (Table 2). The adequate precision value (APV = 10.23) indicated a satisfactory signal-to-noise ratio, supporting the model's adequacy for navigating the design space.

Regression analysis revealed that sugar had a significant ($p < 0.05$) positive linear effect, clearly indicating that increasing sugar concentration improved sweetness perception (Table 2 & 3). On the other hand, turmeric powder showed a non-significant linear effect on sweetness but exhibited a significant negative quadratic impact, suggesting that at higher concentrations, turmeric might introduce bitterness that slightly masks the sweet taste (Figure 5). Moreover, the interaction term (AB) was significant and negative, implying that when both turmeric and sugar levels were increased simultaneously, there was a slight reduction in perceived sweetness, likely due to the dominating taste characteristics of turmeric at higher levels.

These findings are in line with earlier work by Prasad (2017), who observed that while sugar primarily dictated the sweetness in Burfi, increased turmeric levels beyond a threshold slightly reduced sweetness perception. Similarly, Maji et al. (2018) reported that in herbal lassi fortified with turmeric extract, excessive turmeric concentration dulled the sweetness profile, likely due to the masking effects of its pungent compounds.

Table 3: Regression equation for predicting sensory score and hardness of turmeric Burfi

Property	Equation
Colour & appearance	$8.06 - 0.2101A + 0.0386B + 0.0575AB - 0.0391A^2 - 0.0141B^2$
Flavour	$8.05 - 0.2391A + 0.2326B + 0.1871AB - 0.2876A^2 - 0.0436B^2$
Body & texture	$8.12 - 0.0091A + 0.2457B + 0.1738AB - 0.0912A^2 - 0.3576B^2$
Sweetness	$8.24 - 0.0288A + 0.1382B - 0.2300AB - 0.2035A^2 - 0.0985B^2$
Overall acceptability	$8.16 - 0.1761A + 0.2051B + 0.1298AB - 0.2335A^2 - 0.1035B^2$
Hardness	$18.61 - 0.8208A - 2.3800B + 0.7350AB + 0.3954A^2 - 0.8710B^2$

Effect of different variables on overall acceptability score

Overall acceptability represents a holistic measure of all sensory attributes, integrating flavour, texture, appearance, and sweetness into a single consumer-oriented judgment. In the present study, overall acceptability scores for turmeric Burfi varied from 7.45 to 8.64 (Table 1). The lowest score was obtained for the Burfi prepared with 0.75% turmeric and 5% sugar, whereas the highest overall acceptability was recorded for the sample containing 0.50% turmeric and 6% sugar.

The quadratic regression model developed for overall acceptability exhibited a high degree of fit, with an R^2 of 0.94, accounting for approximately 94% of the variability, and an adequate precision value (APV = 14.14), reflecting strong model predictability (Table 2).

Among the independent variables, sugar exerted a significant ($p < 0.05$) positive linear effect, enhancing overall acceptability by improving sweetness and balancing other sensory attributes. In contrast, turmeric had significant ($p < 0.05$) negative linear and quadratic effects, suggesting that increased turmeric levels consistently reduced overall acceptability (Figure 6), likely due to its characteristic bitter and pungent notes becoming more pronounced. Interestingly, the interaction between turmeric and sugar was found to be significant and positive, indicating that appropriate sugar levels could partially mask the less desirable attributes of turmeric, thereby improving the overall sensory appeal of the Burfi.
These observations are consistent with the reports of Buch (2014) and Prasad (2017), who noted a decrease in overall acceptability of paneer and Burfi, respectively, as turmeric concentration increased. Maji et al. (2018) also documented a similar decline in the overall acceptability of herbal lassi enriched with turmeric extract. This underscores the need for careful optimization of turmeric and sugar levels to achieve a balanced product that maximizes consumer liking.

Effect of different variables on hardness

Hardness, measured instrumentally, is a critical textural property that affects bite quality and consumer satisfaction. In turmeric Burfi, the hardness values ranged from 14.08 N to 27.65 N (Table 1), indicating notable variation in firmness across formulations. The softest sample was prepared with 0.50% turmeric and 7.41% sugar, whereas the hardest sample was associated with 0.25% turmeric and 5% sugar.
The regression model for hardness demonstrated excellent adequacy, with a high R^2 value of 0.93, explaining approximately 93% of the variability in hardness, and an adequate precision value (APV = 15.22), confirming the reliability of the predictions (Table 2).
Sugar showed a significant ($p < 0.05$) negative linear effect on hardness, indicating that increasing sugar concentration led to softer Burfi. This could be attributed to the hygroscopic nature of sugar, which retains moisture and thereby reduces firmness. Turmeric also displayed a significant negative linear effect (Figure 7), suggesting that higher turmeric levels contributed to a softer texture, potentially due to interference with the crystallization of solids. The quadratic term of turmeric was significantly negative, highlighting that at elevated levels, turmeric markedly decreased hardness, leading to a product with a softer bite. However, the interaction term was not statistically significant, implying that turmeric and sugar largely influenced hardness independently within the tested range.hese results align with findings by Prasad (2017) who reported that increased turmeric content in Burfi tended to reduce firmness. This highlights the importance of maintaining sugar and turmeric concentrations within optimal ranges to ensure the desired textural integrity of turmeric Burfi. Table 4 dictates the data obtained through regression equations (predicted value) and was compared with actual data obtained from products evaluation. As it is seen from the Table 4 that variations in predicted and actual values was non-significant signifying the correctness of the model.

Response	P Value	Predicted Value *	Actual Value @	Cal. t-Value#	Level of Significance
Color & Appearance	0.10	8.10	8.22	1.98	NS
Flavour	0.11	8.04	8.15	1.90	NS
Sweetness	0.69	8.18	8.19	0.42	NS
Body&Texture	0.30	8.05	8.14	1.13	NS
Overall Acceptability	0.13	8.13	8.25	1.77	NS
Hardness	0.10	19.39	20.59	1.94	NS

* Predicted values of Design Expert 13.0.1.0 package
@ Actual values are average of seven trials for optimized product
\# t-values at 5 per cent level of significance
NS = non-significant
Tabulated t-value = 2.447 (cal. t-value less than tabulated value)

Table 4 Comparison of predicted v/s actual values of responses for optimization of turmeric Burfi

igure 6: Response surface plot of overall acceptability

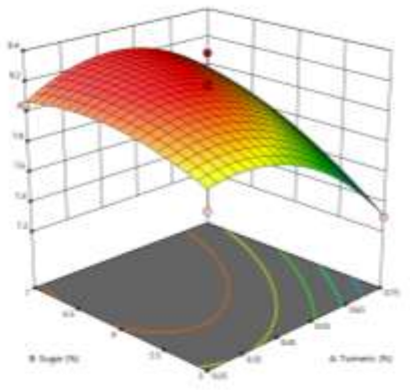
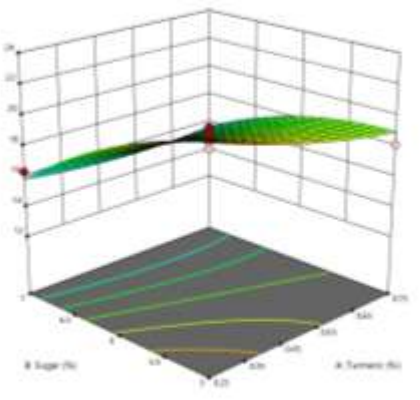


Figure 7: Response surface plot of hardness



Optimization of product formulation for turmeric powder Burfi

The optimization of turmeric powder Burfi formulation was carried out using numerical optimization techniques. The primary aim was to determine the most suitable levels of turmeric powder and sugar to achieve high sensory scores along with desirable textural attributes. During this process, turmeric powder and sugar were maintained within the ranges of 0.25–0.75% and 5.00–7.00% per cent, respectively (Table 5). Sensory parameters such as colour & appearance, flavour, sweetness, body & texture, overall acceptability, along with instrumental hardness, were all kept within targeted limits to ensure a well-balanced product. Based on the given limits and conditions, RSM suggested the best possible solution for turmeric Burfi having turmeric concentration of 0.4 per cent and 5.76 per cent of sugar on milk basis.

Table 5: Criteria/responses chosen for optimization of Turmeric Burfi

Sr No.	Name	Unit	Goal	TP *Burfi*		Import-ance
				Lower Limit	Upper Limit	
1.	A: Turmeric powder	%	in range	0.25	0.75	3
2.	B: Sugar	%	in range	5.00	7.00	3
3.	Colour & Appearance Score	Out of 9	in range	7.67	8.30	3
4.	Flavour Score	Out of 9	in range	7.10	8.29	3
5.	Sweetness Score	Out of 9	in range	7.45	8.30	3
6.	Body & Texture Score	Out of 9	in range	7.20	8.21	3
7.	Overall Acceptability Score	Out of 9	in range	7.30	8.19	3
8.	Hardness (N)	N	in range	13.58	22.46	3

Analysis of turmeric Burfi:

The turmeric Burfi was analyzed for its proximate composition, physico-chemical properties, antioxidant activity, water activity, and hardness (Table 6). It contained 19.20 ± 0.45% moisture, indicating adequate retention of water that could be due to fibre present in turmeric, which contributed to the soft body of the product. The fat content was 17.95 ± 0.25%, essential for rich flavour, smooth texture, and overall energy value. Protein was 15.20 ± 0.30%, contributing to nutritional quality of the Burfi. The ash content was 3.05 ± 0.02%, representing the mineral content present in turmeric, which may be attributed partly to the turmeric addition. The total carbohydrates, estimated by difference, were 44.60 ± 0.16%, providing sweetness and bulk to the product.

Among the physico-chemical properties, the acidity was 0.28 ± 0.02% lactic acid. The free fatty acids (FFA) measured 0.20 ± 0.02% oleic acid, reflecting good fat quality with minimal hydrolytic rancidity due to antioxidant activity of turmeric. The antioxidant activity, expressed as DPPH % inhibition, was 81.25 ± 0.70%, indicating strong free radical scavenging capacity, likely due to the presence of curcumin and other phenolic compounds in turmeric. The tyrosine value was 12.20 ± 0.50 µg/5 ml filtrate, suggesting normal levels of proteolysis. The water activity was 0.83 ± 0.01, which supports microbial stability by reducing the availability of free water for microbial growth. The hardness was 16.60 ± 0.70 N, reflecting a firm yet desirable texture suitable for Burfi consumption.

Table 6: Analysis of optimized product

Parameter	Turmeric Burfi
Proximate composition (%)	
Moisture	19.20 ± 0.45
Fat	17.95 ± 0.25
Protein	15.20 ± 0.30
Ash	3.05 ± 0.02
Total carbohydrates	44.60 ± 0.16
Physico-chemical properties	
Acidity (% LA)	0.28 ± 0.02

FFA (% oleic acid)	0.20 ± 0.02
DPPH (% inhibition)	81.25 ± 0.70
Tyrosine value (µg/5 ml filtrate)	12.20 ± 0.50
Water activity (aw)	0.83 ± 0.01
Hardness (N)	16.60 ± 0.70

Storage related changes:

The optimized product was packed in HDPE (90 µ) pouches as primary packaging and PET boxes as secondary packaging material. Turmeric Burfi was stored at 20 ± 1 °C (cabinet temperature) and tested for changes in moisture, acidity, FFA, antioxidant activity (DPPH % inhibition), water activity, hardness, and Aerobic Plate Count (APC) at an interval of 6 days. The storage study was continued until the samples became unacceptable with respect to its microbial quality (Table 7). During storage, the moisture content decreased from 19.63% to 16.02%, possibly due to gradual moisture migration or evaporation. Acidity increased from 0.28% to 0.55% and FFA rose from 0.20% to 0.45%, indicating progressive lactic acid production and fat hydrolysis. The antioxidant activity reduced from 80.45% to 59.43%, which might be due to oxidation and degradation of bioactive compounds. Water activity slightly decreased from 0.854 to 0.812, correlating with moisture loss. Hardness increased notably from 18.36 N to 35.53 N, likely because of moisture reduction leading to a firmer texture. Meanwhile, APC count rose from 0.67 to 3.88 $\log_{10}$ cfu/g at 18^{th} day, later it increased to more than the limit prescribed for Burfi as per FSSAI, reflecting steady microbial growth over the time of storage, which ultimately limited the product's shelf life up to 18 days.

Table 7: Storage related changes in optimized Burfi

Storage days	Parameter						
	Moisture	**Acidity (% LA)**	**FFA (% oleic acid)**	**DPPH (% inhibition)**	**Water activity (aw)**	**Hardness (N)**	**APC ($\log_{10}$ cfu/g)**
0	19.63 ± 0.41	0.28 ± 0.03	0.20 ± 0.01	80.45 ± 0.98	0.854 ± 0.012	18.36 ± 0.45	0.67 ± 0.18
6	18.37 ± 0.37	0.37 ± 0.01	0.27 ± 0.02	74.47 ± 1.22	0.839 ± 0.006	22.43 ± 0.59	1.25 ± 0.13
12	17.20 ± 0.70	0.48 ± 0.03	0.34 ± 0.03	64.62 ± 1.34	0.823 ± 0.008	27.88 ± 0.88	2.45 ± 0.24
18	16.02 ± 0.62	0.55 ± 0.02	0.45 ± 0.02	59.43 ± 0.81	0.812 ± 0.003	35.53 ± 0.74	3.88 ± 0.10
SEm	0.31	0.014	0.01	0.63	0.004	0.39	0.09
CD (0.05)	1.01	0.045	0.03	2.07	0.014	1.28	0.31
CV%	3.03	5.82	6.38	1.58	0.92	2.62	8.13
The values are mean±SD; n=5.							

Conclusion:

A functional turmeric-enriched Burfi was successfully developed by optimizing the proportions of turmeric powder and sugar with enhanced antioxidant properties (81.25% DPPH inhibition). Both turmeric and sugar incorporation showed significant effects on sensory parameters. The interaction effect of turmeric and sugar level was positive on hardness of the Burfi that decreased with increasing levels of both ingredients. A highly optimized solution for manufacture of functional turmeric Burfi was, 0.4 per cent turmeric powder and 5.76 per cent sugar on milk basis. The optimized product had compositional values; 19.20% moisture, 17.95% fat, 15.20% protein, and maintained highly acceptable quality for 18 days under storage conditions of 20°C.

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