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Optimisation of value added *Gulab Jamun* by utilising dairy by-products[#]

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Abstract

Gulab Jamun is an Indian traditional sweet made with dhap variety of khoa and maida. This study is aimed at utilising dairy by-products like ghee residue and buttermilk powder in the development Gulab Jamun, whereby increasing the biological value of the sweet and aimed at effective reduction of dairy waste. Computation of the optimised solution was done using these three variables namely, ghee residue, maida and sweet cream buttermilk powder (SCBMP) and five responses consisting of sensory characteristics (flavour, body and texture, colour and appearance, sweetness and overall acceptability) with Central Composite Rotatable Design (CCRD) of Response Surface Methodology (RSM). The optimum level of the variables was obtained as ghee residue, maida and SCBMP at 12.98%, 10.1% and 25.45%, respectively, at 99.1% desirability and all the responses fitted well into the quadratic equation with R^2> 0.90.

Keywords: *Central composite rotatable design, ghee residue, Gulab Jamun, sweet cream buttermilk powder*

Gulab Jamun is an Indian traditional dessert which is also celebrated as the queen of Bengal sweets. This *khoa* based sweet is made with *dhap* variety of *khoa* and *maida,* and is usually consumed slightly hot/warm. As per Ghosh (1983), good quality *Gulab Jamun* must have a light brown colour, smooth and spherical shape, soft and spongy body and should not contain lumps

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or a hard core. According to Selvanayagan (1983), the ideal frying temperature - time of *Gulab Jamun* was 140°C for 7 minutes. It has a shelf life of five to seven days in sugar syrup at room temperature (Pal, 2000). As per BIS standards (1986), the product should have a moisture content of not more than 30 per cent and milk fat content of not less than eight per cent.

Incorporating dairy by-products in traditional dairy sweets to increase the functional attributes of the existing product is an ideal way of by-product utilisation, especially since traditional dairy products contribute to 50 per cent share of Indian dairy product market (Vaswani, 2002). Whey, *ghee* residue, buttermilk, etc. are some of the commercially important dairy by-products. The solids not fat (SNF) part of cream, coagulated out during *ghee* preparation is known as *ghee* residue (Janghu *et al.,* 2014). It is rich in milk proteins, phospholipids and nitrogenous compounds which contribute towards its antioxidant properties (Santha and Narayanan, 1979). Sweet cream buttermilk (SCBM) is a by-product obtained during the butter-manufacturing. It has significant amount of milk fat globule membrane (MFGM) material, which remains from the butter-making process (Walstra *et al.,* 2005). Due to higher content of proteins, glycoproteins and phospholipids in MFGM, buttermilk has excellent emulsifying properties (Elling *et al*., 1996; Corredig and Dalgleish, 1997; Wong and Kitts, 2003) and good water holding capacity (Raval and Mistry, 1999; Turcot *et al*., 2001). These by-products are of high nutritive value and when discharged carelessly in to water bodies these may release some harmful gases which can change the taste, odour, colour and turbidity of water bodies (Srivastava*,* 2020).

In the current study, efforts were taken to develop a standardised process for the preparation of *Gulab Jamun* with addition of other health beneficial dairy by-products such as *ghee* residue and sweet cream buttermilk powder.

Materials and methods

The study was carried out in the Dairy Technology Department, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy.

Raw materials

Buffalo milk khoa, base material for *Gulab Jamun*, was procured from Kerala Veterinary and Animal Sciences University Dairy plant. *Ghee* residue and whey were also collected from Kerala Veterinary and Animal Sciences University Dairy plant. Sweet cream buttermilk powder was procured from Vidhya dairy, Anand, Gujarat. Baking powder and *maida* used for the preparation were procured from the local market.

Preliminary trials

Ghee residue, *maida* and sweet cream buttermilk powder were added to khoa at levels ranging from 5 to 20% (Ranu *et al.* 2012), 5 to 30% (Yawale, 2012) and 0 to 50% (Chaudhari, 2017), respectively. Baking powder was added at different levels (0.5% by weight of the product) to prepare the dough. Minimum and maximum levels of the incorporation were selected by verifying the levels of each ingredient within the range specified (by varying the levels of one ingredient keeping the other ingredients constant in the dough). The selection of the levels of addition of all the ingredients were based on sensory attributes and the scores obtained were then statistically analysed by Kruskal Wallis test.

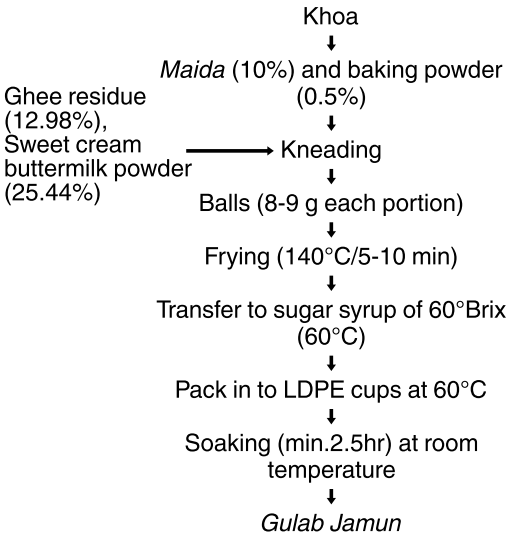
Statistical analysis

Gulab Jamun was optimised by Central Composite Rotatable Design (CCRD) of RSM software. Based on the different treatment combinations as suggested in RSM software, samples were prepared and sensory evaluation was conducted by an expert panel of 5 judges using 9-point hedonic scale. The sensory scores thus obtained were fed to the RSM software as responses to optimise the level of addition of ingredients. The optimised levels of all the ingredients and magnitude of the responses were then validated.

Manufacturing of Gulab Jamun

Gulab Jamun was prepared as per the

procedure standardised by Joshi *et al.* (2009) with minor modifications (Fig. 1).



Results and discussion

Gulab Jamun was prepared and optimised using RSM, in two stages i.e., preliminary trial and optimisation trials. A three factor CCRD was adopted employing a quadratic model. The levels of three factors were optimised by maximization of the sensory responses through fitting of quadratic models by numerical optimisation command of Design Expert software.

Selected levels after preliminary trials

Preliminary trials were conducted to select the minimum and maximum level of ingredients that can be incorporated in to the product. The selection of the levels was based on sensory responses which were further analyzed by Kruskal Wallis test. The addition of *ghee* residue was done at the levels between 5 to 20% and the best textural properties were obtained with the levels between 10% and 20%. Higher levels of addition of *ghee* residue caused a pronounced sour flavour in the product which was also reported by Sojan *et al.* (2021) with increased rate of addition of *ghee* residue in cakes and muffins. The range of addition of *maida* was restricted to 8 to 16% as higher rates of addition were found to impart a gummy texture to the final product. This is in agreement with the observations made by Joshi *et al.* (2009) who studied the influence of different ingredients, including *maida*, in *Gulab Jamun*. Level of sweet cream buttermilk powder was fixed at 12.5 to 37.5% beyond which there was significant lowering of textural properties. Similar effects were reported by Zhao *et al.* (2020) in his work in yoghurt.

Optimisation of quantity of ghee residue*, maida and sweet cream buttermilk powder by response surface methodology*

From the preliminary trials, the minimum and maximum levels of *ghee* residue, *maida* and SCBMP were selected as 10% and 20%, 8% and 20%, 12.5% and 37.5%, respectively. When these levels were given to CCRD of RSM, the output showing upper and lower limits of the ingredients (Table 1) and the CCRD of three factors containing 20 runs along with their responses of the sensory attributes are displayed in Table 2.

The design matrix of the three factors in CCRD of RSM along with the sensory scores corresponding to the parameters (flavour, body and texture, colour and appearance, sweetness and overall acceptability) is presented in Table 2. In the recommended quadratic model, F values for all the characteristics were greater than tabled F- value ($p<0.01$) showing that the developed model is significant.

Table 1. The coded and actual levels of *ghee* residue (GR), *maida* and sweet cream buttermilk powder (SCBMP)

Coded level Factor	Lower limit	Factorial point	Centre coordinate	Factorial point	Upper limit
	-2	-1	0	+1	+2
A: *Ghee* residue (%)	4.88	10	15	20	30.11
B: *Maida* (%)	5.27	8	12	16	18.73
C: SCBMP (%)	3.98	12.5	20	37.5	46.02

Table 2. The Central Composite Rotatable Design (CCRD) for three factors and their sensory responses

Std	GR (%)	*Maida* (%)	SCBMP (%)	Flavour	Colour & Appearance	Body & Texture	Sweetness	Overall acceptability
1	10	8	12.5	8.5	8.69	8.25	8.5	8.5
2	25	8	12.5	7.12	7.62	6.62	7.62	6.75
3	10	16	12.5	6.5	6.5	6	7.62	6.62
4	25	16	12.5	7	7.25	6.75	7.37	6.87
5	10	8	37.5	8.37	8.62	8.36	7.87	7.87
6	25	8	37.5	6.95	7	5.83	7.67	6.25
7	10	16	37.5	8.58	8.5	8.47	7	8.42
8	25	16	37.5	7.5	7.75	7.58	7	7.5
9	4.89	12	25	8.17	8.42	8.3	8.33	8.25
10	30.11	12	25	7.5	8	7.58	7.5	7.42
11	17.5	5.27	25	8.5	8.67	8.17	8.3	8
12	17.5	18.73	25	7.33	7	7.17	7	7
13	17.5	12	3.98	7	6.87	6.5	6.87	7
14	17.5	12	46.02	7.83	8	7.67	7.5	7.67
15	17.5	12	25	8.83	8.83	8.83	9	8.67
16	17.5	12	25	9	8.83	9	9	9
17	17.5	12	25	8.83	8.83	8.83	9	8.67
18	17.5	12	25	9	8.5	8	9	8.33
19	17.5	12	25	8.67	8.5	8.83	8.5	8.83
20	17.5	12	25	8.5	8.5	9	8.83	8.83

Flavour

Flavour, one of the most sensory parameters, is a combination of odour and taste. The given response surface equation was generated to forecast the change in flavour with various amounts of factors:

Flavour = 8.808- 0.330*A- 0.244*B +0.269*C +0.278*AB - 0.203*AC + 0.360*BC - 0.362*AÂ² -0.334*BÂ² - 0.511*CÂ²

The average flavour scores of *Gulab Jamun* ranged from 6.50 to 9.00 (Table 2). The determination coefficient (R^2) was 0.94 indicating that 94% of the variability in the response could be explained by the design. The adequate precision of 11.24 firmly suggests the adoption of this response viz. Flavour to guide this design. Since the lack of fit test resulted in a F value that is non-significant, it was evident that the model is authentic enough for forecasting the flavour of *Gulab Jamun*. The p-value of the flavour model showed that the impact of *ghee* residue, *maida* and SCBMP was significant ($p<0.05$) on the flavour score of *Gulab Jamun*. The SCMBP positively affected the flavour score at quadratic levels whereas both *ghee* residue and *maida* negatively affected the flavour scores (Fig 2a, 2b and 2c). From these figures, it can be inferred that the selected levels of *ghee* residue and *maida* did not contribute to any off flavour in the product yet they had reduced the flavour scores. The interaction effect of *ghee* residue and SCBMP had a negative effect and was found to be non-significant. In conformity to the present findings, El-Kholy *et al.* (2014) had also reported that addition of sweet buttermilk to ice cream had improved its flavour intensity. Similarly, improved flavor intensity by replacing the 10 to 40 % of refined wheat flour with *ghee* residue in cake and muffin was reported by Ranjan *et al.* (2020).

Colour and appearance

The following response surface equation was generated to forecast the variation in colour and appearance with various amounts of factors:

Colour and appearance = 8.67 -0.249*A -0.347*B +0.272*C +0.336*AB -0.256*AC +0.399*BC -0.168*A^2 -0.301*B^2 -0.442*C^2

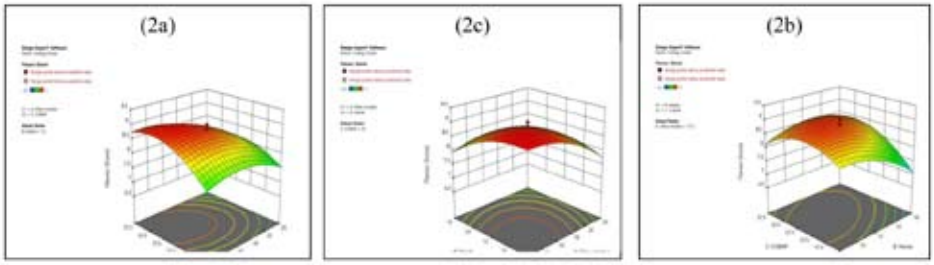


Fig. 2. Response surface plots for flavour score of dietetic *Gulab Jamun* added with *ghee* residue, *maida* and Sweet cream buttermilk powder

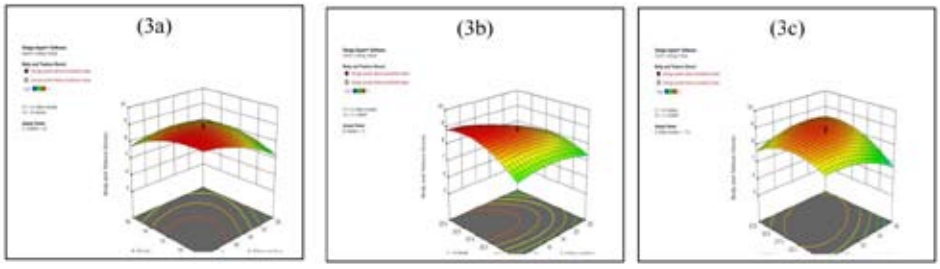


Fig. 3. Response surface plots for colour and appearance score of dietetic *Gulab Jamun* added with *ghee* residue, maida and Sweet cream buttermilk powder

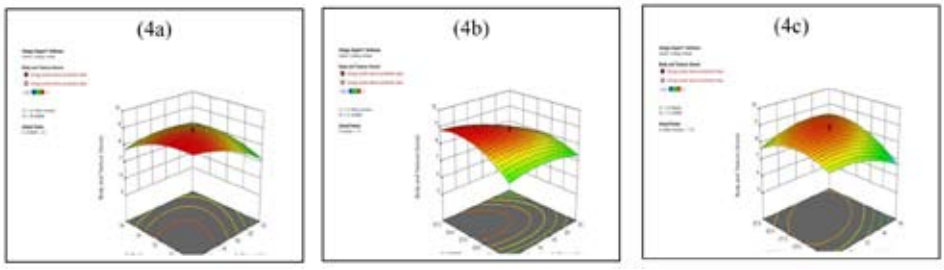


Fig. 4. Response surface plots for body and texture score of dietetic *Gulab Jamun* added with *ghee* residue, maida and Sweet cream buttermilk powder

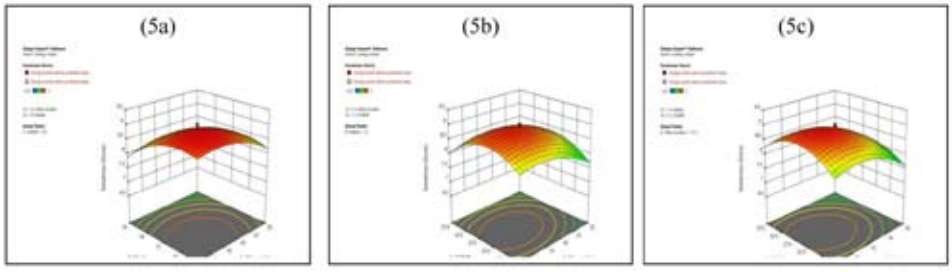


Fig. 5. Response surface plots for sweetness score of dietetic *Gulab Jamun* added with *ghee* residue, maida and Sweet cream buttermilk powder

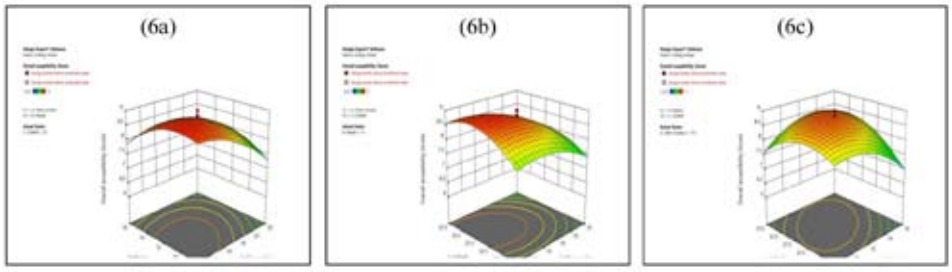


Fig. 6. Response surface plots for overall acceptability score of dietetic *Gulab Jamun* added with *ghee* residue, maida and Sweet cream buttermilk powder

The sensory scores for colour as well as appearance of *Gulab Jamun* ranged from 6.50 to 8.83 (Table 2). The determination coefficient (R^2) of 0.94 with required precision of 13.10 firmly suggests the adoption of this response viz. colour and appearance to guide this design. Lack of fit test resulted in a non-significant F value hence the model is accurate enough for forecasting the colour and appearance of *Gulab Jamun*. The p-value of the colour and appearance model showed that the impact of *ghee* residue, *maida* and SCBMP was significant ($p<0.05$) on the colour and appearance score of *Gulab Jamun*. Only SCBMP positively affected the colour and appearance score at quadratic levels (Fig 3a, 3b and 3c). All the three factors were significant ($p>0.05$) at squared level. The interaction effect of *ghee* residue and SCBMP had a negative impact on the colour score whereas effect of interaction of ghee residue and *maida* showed a positive effect. Borawake and Bhosale (1996) also reported that an increase in the amount of GR decreased the colour and appearance scores in nankhatai type cookies and sponge cakes.

Body and texture

The acceptability of any food is affected by its body and texture. The given response surface equation was generated to forecast the change in flavour with various amounts of factors:

Body and texture = 8.757 -0.405*A -0.143*B +0.337*C +0.504*AB -0.319*AC +0.496 *BC -0.340*AÂ² -0.436*BÂ² -0.643 *CÂ²

The sensory scores for body and texture of *Gulab Jamun* ranged from 6.93 to 8.68 (Table 2). The coefficient of determination (R^2) of 0.92 with adequate precision of 10.05 firmly suggests the adoption of this response viz. body and texture to guide this design. Since the lack of fit test resulted in a non-significant F value, it was evident that the model is accurate enough for forecasting the body and texture of *Gulab Jamun*. The p-value of the body and texture model showed that *ghee* residue and SCBMP had significant ($p<0.05$) effect, whereas *maida* had a non-significant ($p>0.05$) effect on the body and texture score of *Gulab Jamun*. The SCBMP positively affected the body and texture score at quadratic levels whereas all other ingredients showed a negative effect (Fig 4a, 4b and 4c). The interaction of *ghee* residue and SCBMP had a significant negative effect on the score. Interactions of *ghee* residue and *maida,* and *maida* and SCBMP showed a significant positive effect. Improved textural properties in cheese and ice cream, on addition of buttermilk were reported by Hickey *et al*. (2018) and Shibu *et al*. (2000), respectively. Dua *et al.* (2018) found that increasing the level of addition of GR in burfi had a negative effect on its body and texture.

Sweetness

The quadratic equation obtained, showing the effects of the three factors ghee residue, *maida* and SCBMP on sweetness is as given

Sweetness = 8.89 -0.200*A -0.356*B -0.037*C +0.104*AB +0.116*AC -0.051*BC -0.328*A^2 -0.422*B^2 -0.586*C^2

The sensory scores for sweetness of *Gulab Jamun* ranged from 6.87 to 9 (Table 2). The coefficient of determination (R^2) of 0.93 with adequate precision of 9.28 firmly suggests the use of this response viz. sweetness to guide the design. Since the lack of fit test resulted in a non-significant F value, it was evident that the model is accurate enough for forecasting the sweetness of *Gulab Jamun*. The p-value of the sweetness model showed that all the factors had a non-significant ($p>0.05$) effect on the sweetness score of *Gulab Jamun*. All the factors negatively affected the sweetness score at quadratic levels (Fig 5a, 5b and 5c). The interaction effect of *maida* and SCBMP had a negative effect on the scores. Similar inferences on sweetness were reported by Kumari (2013) on khoa based sweets prepared with low calorie sweetener.

Overall acceptability

The acceptability of any food is affected by its overall acceptability. The given quadratic equation was generated to forecast the change in overall acceptability with various amounts of factors:

Table 3. Regression coefficients and ANOVA of fitted quadratic model

Partial Coefficients		Sensory characteristics			
	Flavour	Colour and Appearance	Body and Texture	Sweetness	Overall Acceptability
Intercept	8.808	8.670	8.757	8.890	8.730
A-*Ghee* residue	-0.330**	-0.249**	-0.405**	-0.200*	-0.398**
B-*Maida*	-0.244**	-0.347**	-0.143 ns	-0.356**	-0.120 ns
C-SCBMP	0.269**	0.272**	0.337*	-0.037 ns	0.178 ns
AB	0.278*	0.336**	0.504**	0.104 ns	0.338*
AC	-0.203 ns	-0.256*	-0.319*	0.116 ns	-0.130 ns
BC	0.360**	0.399**	0.496**	-0.051 ns	0.445**
A^2	-0.362**	-0.168*	-0.340**	-0.328**	-0.343**
B^2	-0.334**	-0.301**	-0.436**	-0.422**	-0.461**
C^2	-0.511*	-0.442**	-0.643**	-0.586**	-0.520**
Lack of fit	3.17 ns	3.19 ns	1.22 ns	2.75 ns	3.08 ns
Model F value	16.10	16.45	12.56	14.83	13.31
R^2	0.935	0.9367	0.919	0.9303	0.9229
Press	0.877	0.8798	0.846	0.8675	0.8536
Adeq.Press	11.24	13.10	10.05	9.28	10.14

*- significant at five per cent level ($p<0.05$),

**- significant at one per cent level ($p<0.01$), ns - non-significant ($p\geq0.05$)

Table 4. Suggested solutions from RSM

Sl. No.	*Ghee* residue (%)	*Maida* (%)	SCBMP (%)	Desirability
1	12.981	10.206	25.449	0.991
2	13.015	10.244	25.518	0.984

Table 5. Verification of the optimum formulation

Attributes	Predicted value	Observed value	t-value
Flavour	8.64	8.55 ± 0.03	1.28 ns
Colour and Appearance	8.74	8.67 ± 0.04	0.58 ns
Body and Texture	8.70	8.60 ± 0.07	1.07 ns
Sweetness	8.71	8.59 ± 0.09	1.25 ns
Overall Acceptability	8.69	8.51 ± 0.09	1.20 ns

Figures are the Mean ± Standard error of six replications, ns-non-significant ($p \geq 0.05$)

Overall acceptability = 8.73 -0.398*A -0.120*B +0.178*C +0.338*AB -0.130*AC +0.445*BC -0.343*A^2 -0.461*B^2 -0.520*C^2

The sensory scores for overall acceptability of *Gulab Jamun* ranged from 6.25 to 9 (Table 2). The coefficient of determination (R^2) of 0.92 with adequate precision of 10.14 firmly suggests the use of this response viz. overall acceptability to guide the design. Since the lack of fit test resulted in a non-significant F value, it was evident that the model is accurate enough for forecasting the overall acceptability of *Gulab Jamun*. The p-value of the overall acceptability model showed that *maida* and SCBMP had non-significant ($p>0.05$) effect, whereas *ghee* residue had a significant ($p<0.05$) effect on the overall acceptability score of *Gulab Jamun*. The *ghee* residue and *maida* negatively affected the overall acceptability score at quadratic levels (Fig 6a, 6b and 6c). The interaction of *ghee* residue and *maida* had a significant negative effect on the overall acceptability score whereas the effect of interactions of *maida* and SCBMP

showed a non-significant positive effect. Similar inferences on overall acceptability scores were reported by Madenci and Bilgiçli (2014) on bread with 8% buttermilk supplementation.

The levels of three factors were optimised by maximizing the sensory responses through fitting of quadratic models by numerical optimisation. Table 4 presents the suggested solutions for the preparation of *Gulab Jamun*. The solution that got a desirability of 0.991 was selected. The optimum values selected were at 12.98% for *ghee* residue, 10.21% for *maida* and 25.45% for SCBMP.

Verification of optimum solution

The *Gulab Jamun* prepared at desired optimum level of ingredients were statistically analyzed for sensory attributes (Table 5) and it is evident that the observed values were not significantly ($p<0.05$) different from the predicted values.

Conclusion

Gulab Jamun with optimum levels of *maida* and dairy by-products like *ghee* residue and sweet cream buttermilk powder was identified by RSM. The models developed were found highly suitable for predicting the ingredient formulation by assuring an optimal sensory score of *Gulab Jamun*. Out of suggested formulations, the formulation no. 1 had maximum desirability index of 0.991 and all the responses fitted well into the quadratic equation with R^2> 0.90, hence, selected for further analysis. Therefore, the formulation with *ghee* residue (12.98%), *maida* (10.21%) and SCBMP (25.451%) was considered most suitable treatment combination for manufacturing of by-product based *Gulab Jamun.* This could also guide to product development leading to an effective way for utilising dairy by-products which are otherwise considered as dairy waste.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

BIS (1986) (IS: 11602). Specification for Packed *Gulab Jamuns*. New Delhi: Bureau of Indian Standards.

Borawake, K.A. and Bhosale, D.N. 1996. Utilisation of ghee-residue in preparation of Nankatai type cookies and sponge cakes. *Indian J. Dairy Sci.* **49**(2):114-119.

Chaudhari, B. 2017. Study on the influence of incorporation of *ghee* residue on quality of burfi. *M. Tech thesis*, Gujarat Agricultural University, Anand. 158p.

Corredig, M., and Dalgleish, D. G. 1997. Isolates from industrial buttermilk: emulsifying properties of materials derived from the milk fat globule membrane. *J. Agric. Food Chem*. **45:** 4595–4600.

Dua, S., Kumar, S., Kaur, S., Ganai, A.W. and Khursheed, I. 2018. Chemical and sensory attributes of ghee residue burfi supplemented with corn flour. *J. Pharmacog. Phytochem*. **7:** 3818-3822.

El-Kholy, A., El-Nour, A., El-Safty, M. and Mokbel, S. 2014. Utilisation of buttermilk in low fat ice cream making. *Ismailia J. Dairy Sci. Tech.* **1**(1): 11-18.

Elling, J.L., Duncan, S.E., Keenan, T.W., Eigel, W.N. and Boling, J. 1996. Composition and microscopy of reformulated creams from reduced-cholesterol butteroil. *J. Food Sci.* 61(1): 48-53.

Ghosh, B.C. 1983. Formulation and storage studies of Gulabjamun mix powder. M.Tech.thesis. National Dairy Research Institute, Karnal, 149p.

Hickey, C.D., O'Sullivan, M.G., Davis, J., Scholz, D., Kilcawley, K.N., Wilkinson, M.G. and Sheehan, J. J. 2018. The effect of buttermilk or buttermilk powder addition

on functionality, textural, sensory and volatile characteristics of Cheddar-style cheese. *Food Res. Int*. **103:** 468-477.

Janghu, S., Kaushik, R., Bansal, V., Sharma, P. and Dhindwal, S., 2014. Physico-chemical analysis of ghee residue and conversion into confectionary food products. *Indian J. Dairy Sci.* **67**(4): 1-6.

Joshi, M.U., Sarkar, A., Singhal, R.S. and Pandit, A.B. 2009. Optimising the formulation and processing conditions of gulab jamun: a statistical design. *Int. J. Food Properties*. **12**(1): 162-175.

Kumari, J. 2013. Studies on quality characteristics of khoa based sweets prepared with low calorie sweetener. *M.Tech. thesis*. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar. 147p.

Madenci, A.B. and Bilgiçli, N. 2014. Effect of whey protein concentrate and buttermilk powders on rheological properties of dough and bread quality. *J. Food Quality*. **37**(2): 117-124.

Pal, D. 2000. Technological advances in the manufacture of heat desiccated traditional products. *Indian Dairyman.* **52:** 37-42

Ranjan, R., Chauhan, A.K., Kumari, S.S. and Dubey, R.P. 2020. Nutritive value of ghee residue incorporated bakery product. *Indian J Dairy Sci.* **73:** 1-6.

Ranu, P., Madhvi, D. and Deepti, T. 2012. Utilisation of *Ghee* residue for the preparation of chocolate *Burfi*. *Bhartiya Krishi Anusandhan Patrika*. **27:** 175-178.

Raval, D.M. and Mistry, V.V. 1999. Application of ultrafiltered sweet buttermilk in the manufacture of reduced fat process cheese. *J. Dairy Sci.* **82**(11): 2334-2343.

Santha, I.M. and Narayanan, K.M. 1979. Studies on the constituents responsible for the antioxidant properties of ghee residue. *Indian J. Anim. Sci*. **49:** 37-41.

Selvanayagan. 1983. Studies on heat transport for making Gulabjamun. *M.Sc.thesis*. National Dairy Research Institute, Karnal. 152p.

Shibu, A.V., Kumar, C.N., Narasimhan, R. and Pugazhenthi, T.R. 2000. Substitution of Buttermilk Powder in Ice Cream. *J. Vet. Anim. Sci*. **31:** 25-27.

Sojan, A., Surendran, A. and Lukose, S.J. 2021. Effectiveness in utilisation of ghee residue in the production of cookies and biscuit in an industrial level. *Int. J. Sci. Res*. 1342-1348.

Srivastava, R.K. 2020. Treatment of Dairy Byproducts with the Conversion of Useful Bio-Products. In: Inamuddin and Asiri, A. (ed.), *Sustainable Green Chemical Processes and their Allied Applications*. Springer, Cham, pp. 267-287.

Turcot, S., Turgeon, S. L. and St Gelais, D. 2001. Effect of buttermilk phospholipid concentration in cheese milk on production and composition of low fat Cheddar cheese. *Lait.* **81**(3): 429-442.

Vaswani, L.K. 2002. Market survey and analysis. *Indian Dairyman.* **54**(2): 105-112.

Walstra, P., Wouters, J.T. and Geurts, T.J. 2005. *Dairy science and technology*. (2nd Ed.). CRC press. London. 808p.

Wong, P.Y.Y. and Kitts, D. D. 2003. Chemistry of buttermilk solid antioxidant activity. *J. Dairy Sci*. **86**(5): 1541-1547.

Yawale, P.A. 2012. Development of *khoa* powder based Gulab Jamun mix. *M.Sc. thesis*, National Dairy Research Institute, Karnal, Haryana. 86p.

Zhao, L., Feng, R. and Mao, X. 2020. Addition of buttermilk powder improved the rheological and storage properties of low-fat yogurt. *Food Sci. Nutr.* **8**(7): 3061-3069. ■