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Optimisation of the formulation of fibre incorporated reduced calorie herbal *rasmalai*[#]

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Abstract

The present study was carried out to optimise the process of manufacturing of fibre incorporated reduced calorie herbal rasmalai. Ocimum tenuiflorum (Tulasi) extract, Withania somnifera (ashwagandha) root powder and Plantago ovata (isabgol) were the variables in the rasmalai balls studied by employing the 3-factors Central Composite Rotatable Design (CCRD). Optimisation of sucralose content in concentrated milk was carried out by Kruskal Wallis test. The formulation with tulasi extract (6.951%), ashwagandha root powder (0.423%) and isabgol (0.583%) in the rasmalai ball with 100 ppm sucralose in the sweetened concentrated milk was found highly suitable for optimisation of fibre incorporated reduced calorie herbal rasmalai. The desirability index of optimised fibre incorporated reduced calorie herbal rasmalai was 0.90.

Keywords: *Rasmalai*, *tulasi extract, ashwagandha root powder, isabgol*

The rapidly growing population in the developing countries is facing acute shortage of protein in their diet, which inadvertently has led to an increase in the instances of malnutrition (Ur-Rehman *et al.,* 2007; Singh *et al.*, 2016). Functional foods are products that have been enriched with added nutrients or other substances that are considered to provide health benefits over and above their basic nutritional value (Kumar *et al.*, 2014). The herbal products are gaining more popularity as functional food over synthetic products in the world market due to some side effect of synthetic products in the body (Amirdivani, 2008; Singh and Kumar, 2013).

[#]*Part of M. Tech (Dairy Tech) thesis submitted to Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala*

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India's market potential and current growth rate of traditional dairy products is unparallel and all set to boom further under the technology of mass production. Dairy industry is looking forward to develop functional products such as low-calorie herbal products (Singh and Singh, 2014). Sucralose is a zero-calorie artificial sweetener with very little after taste as compared to other artificial sweeteners and provides good acceptance to the products. *Rasmalai* is a *chhana* based dairy dessert served by dipping in sweetened concentrated milk and in chilled condition. It is a very delicate, spongy and chewy sweet that has a delectable taste (Aneja *et al.,* 1990; Sharma, 2004; Ambili *et al*., 2023).

In view of above an attempt was made to develop a process for manufacturing of dietetic herbal *rasmalai* with the incorporation of herbs *viz*., *tulasi*, *ashwagandha* root powder and isabgol (dietary fibre) and reducing the calorie of the product by replacing cane sugar with sucralose in concentrated milk so that it could be a new value added and functional product for dairy and food industry. The proposed objective of the formulation is to develop a product with enhanced nutritional benefits which might offer same delicacy as a traditional ethnic food.

Materials and methods

Preparation of fibre incorporated herbal rasmalai

Cow and buffalo milks required for the manufacture of r*asmalai* was procured from Dairy Plant, Kerala Veterinary and Animal Sciences University (KVASU), Mannuthy. The rest of the ingredients including dried *tulasi* leaves, *ashwagandha* root powder and isabgol were purchased from the local market, Mannuthy, Thrissur. *Rasmalai* was prepared as per the procedure standardised by Sharma (2004) and Ambili *et al*. (2023) with slight modifications. Standardised cow milk (3.2% fat and 8.3% SNF) was coagulated with citric acid (2% concentration) to obtain *chhana*. Later, isabgol as dietary fibre (0.583%), *tulasi* extract at 6.951% (3°Bx) and *ashwagndha* root powder (0.423%) was added based on the weight of *chhana.* Flattened *chhana* balls (15-20 g) were portioned and cooked in sugar syrup (50 °Bx) for 15-20 minutes and then soaked in sugar syrup of 40 °Bx for 20 minutes. Sweetened concentrated milk (buffalo milk concentrated to 1/3rd of initial volume) for the soaking of *rasmalai* balls was prepared by replacing the sugar completely with sucralose at different levels like T2 (100 ppm), T3 (200 ppm), T4 (300 ppm) and T5 (400ppm). The treatments were compared with T1, control (5% sugar) and the obtained sensory scores were subjected to statistical analysis (Kruskal Wallis) and the best level of sucralose was selected and the *rasmalai* balls were dipped in the selected milk.

Sensory attributes of fibre incorporated reduced calorie herbal rasmalai

Sensory evaluation was performed by a panel of five semi expert judges from Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology, KVASU, Mannuthy, Thrissur (India). Samples for analysis were coded with three-digit random numbers and placed in closed containers. Sensory evaluation was carried out at 5 °C and relative humidity of 68 %. Hedonic rating (9-point scale; 1=dislike extremely, 9=like extremely) was used for rating flavour, colour and appearance, body and texture, sweetness and overall acceptability. Each panellist was given three replications for every sample and necessary training was imparted to avoid any biasing during the evaluation of the sample.

Statistical analysis

Response Surface Methodology (RSM) was used to optimise the various ingredients of r*asmalai* ball. A Central Composite Rotatable Design (CCRD) was used to design experiments consisting of three independent factors. The experimental data obtained from the design were analysed by the package Design-Expert® version 8.7.1 software, Stat-Ease, Inc., Minneapolis, MN, USA using the following second order polynomial equation:

$$Yi = \beta o + \text{“}\beta i\, Xi + \text{“}\beta ii\, Xi2 + \text{“}\beta ijXiXj$$

Where, Yi was the predicted response, βo was a constant, βi was the linear coefficient, βii was the iith quadratic coefficient and βij was ijth interaction coefficient, and XiXj were

independent variables.

Kruskal Wallis test was used to determine the optimum concentration of sucralose in the sweetened concentrated milk based on the sensory scores.

Results and discussion

Optimisation of ingredients in rasmalai ball

Using CCRD, levels of variables *viz*., *tulasi* extract, *ashwagandha* powder and isabgol were selected through 20 experiments (Table 1). The optimisation of the ingredients in the ball was carried out on the basis of sensory scores (Table 2). Table 3 displays the estimated quadratic polynomial model regression coefficients for the response variables together with the accompanying R^2, adj-R^2, Pred-R^2, Coefficients of Variation (CV), and PRESS values. The limitations chosen for ingredient optimisation and the outcomes of optimised levels and estimated optimal response values using the desirability function are depicted in Tables 4 and 5, respectively. The effect of variables on sensory scores of fibre incorporated reduced calorie herbal r*asmalai* is presented below.

Flavour

The scores obtained for the sensory attribute, flavour of herbal *rasmalai* ranged from 6 to 7.7. The quadratic equation obtained by the Response Surface Application (RSA) of the data showing the effect of *tulasi* extract (A), *ashwagandha* root powder (B) and isabgol (C) could be presented as follows:

Flavour = 7.48+ 1.069*A+ 1.018*B +3.027*C +1.065*AB - -0.100*AC+0.250*BC- 0.063*Â²- 1.403*B^2– 2.206*C^2

F- Value of 43.91 was significant whereas lack of fit was found to be non-significant. Coefficient of determination (R^2) was found to be 97.5 per cent which showed 97.5 per cent variations in the response detailed by the variables in the model. Adequate precision ratio of 18.60 was obtained which indicates an adequate signal. The F-value for the flavour in the table was more than the tabled value at 5 per cent level of significance ($p<0.05$). Acceptance of the response, flavour to guide the design is indicated by the value obtained for the determination coefficient (R^2) 0.975 with satisfactory precision 18.60. The p values for the factors indicated that there is significant impact for *tulasi* extract, a*shwagandha* root powder and isabgol on the flavour score of herbal r*asmalai*. At quadratic levels, all the three ingredients positively affected the flavour scores. David (2015) in *shrikhand* and Dhole *et al*. (2022) in flavoured milk observed a similar effect on addition of *tulasi* extract and *ashwagandha* root powder, respectively.

Colour and appearance

The colour and appearance scores obtained for r*asmalai* varied from 7.8 to 6.6. The model showed a significant F- value of 17.66 whereas lack of fit was found to be non-significant. A coefficient of determination (R^2) of 94 percent was obtained which indicates 94 percent variations in the response were shown by the variables in the model. Adequate

Table 1. The Central Composite Rotatable Design (CCRD) for three factors

Standard order	A: *Tulasi* extract (%)	B: *Ashwagandha* root powder (%)	C: Isabgol (%)
1	4	0.2	0.5
2	10	0.2	0.5
3	4	1	0.5
4	10	1	0.5
5	4	0.2	1
6	10	0.2	1
7	4	1	1
8	10	1	1
9	3.05178	0.6	0.75
10	10.9482	0.6	0.75
11	7	0.0735704	0.75
12	7	1.12643	0.75
13	7	0.6	0.420981
14	7	0.6	1.7902
15	7	0.6	0.75
16	7	0.6	0.75
17	7	0.6	0.75
18	7	0.6	0.75
19	7	0.6	0.75
20	7	0.6	0.75

Table 2. Sensory characteristics of *rasmalai* ball with different levels of *tulasi* extract, a*shwagandha* root powder and Isabgol

Standard order	Response 1	Response 2	Response 3	Response 4	Response 5
	Flavour	Colour and Appearance	Body and Texture	Sweetness	Over all Acceptability
1	7.4	7.8	7.2	7.6	7.5
2	7.6	7.3	7.6	7.8	7.8
3	6.8	7.4	6.8	7.3	6.8
4	6.9	6.7	6.8	7	6.4
5	6.3	7.3	6.7	6.7	7
6	6.1	7.4	7.1	6.9	6.9
7	6.1	7.3	7	6.4	6.7
8	6.5	7.5	7.5	6.8	7
9	7.4	7.5	7.8	7.4	7.5
10	6	7.1	6.7	6.5	6.6
11	7.7	7.5	7.8	7.6	7.9
12	6.5	6.6	6.2	6.8	6.2
13	7.4	7.5	7.6	7.8	7.7
14	6.8	6.8	6.7	7	7.1
15	7.5	7.6	7.3	7.5	7.5
16	7.3	6.9	7.5	7	6.8
17	7.4	7.5	7.6	7.8	7.7
18	6.8	6.7	6.8	6.6	6.7
19	7.6	7.6	7.7	7.5	7.5
20	6.9	6.8	6.9	7	6.7

precision ratio 13.61 was obtained which indicates an adequate signal.

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

Colour and Appearance= 7.51 +0.355*A -0.562 *B +4.407*C +0.010 *AB +0.016*AC -0.125 *BC -0.033 *A^2 +0.299*B^2-3.389*C^2

The F-value for colour and appearance was more than the tabled F-value at five per cent level of significance ($p<0.05$). The determination coefficient (R^2) of 0.94 with adequate precision of 13.61 clearly suggests the adoption of this response *viz*., colour and appearance to guide this design. The p value of the colour and appearance indicated that *tulasi* extract, *ashwagandha* root powder and isabgol had significant impact on the colour and appearance scores of herbal r*asmalai*. Factors A and C had positive effect on colour and appearance while the factor B affected scores negatively at quadratic levels. A similar trend was also reported by Kumar *et al*. (2013) in the development of herbal ice cream by addition of *tulasi* extract.

Body and texture

The highest score for body and texture was 7.8 while lower score of 6.2. The model showed a significant F- value of 13.93 whereas lack of fit was found to be non-significant. A coefficient of determination (R^2) of 92.6 percent was obtained which indicated 92.6 per cent variations in the response were detailed by the variables in the model. Adequate precision ratio of 13.93 was obtained which indicates an adequate signal.

Body and Texture =7.55 +0.532*A +1.651*B +1.159*C -0.083 *AB -0.033*AC+0.500 *BC -0.034 *A^2-1.589*B^2-1.758*C^2

The F-value for body and texture was more than the tabled F-value at five per cent level of significance ($p<0.05$). The coefficient of determination (R^2) of 0.92 with adequate precision of 13.51 firmly suggests the adoption

Table 3. Estimated parameters of model for sensory attributes and responses of fibre incorporated herbal *rasmalai* balls with different levels of *tulasi* extract, *ashwagandha* root powder and Isabgol

Partial Coefficients	Sensory characteristics				
	Flavour	Colour and Appearance	Body and Texture	Sweetness	Over all Acceptability
Intercept	7.48	7.51	7.55	7.63	7.60
A- Tulasi extract	1.069**	0.355**	0.535^{ns}	0.873^{ns}	0.920*
B- *Ashwagandha* root powder	1.018**	-0.562*	1.651**	0.626^{ns}	2.126**
C- Isabgol	3.027**	4.407**	1.159**	4.220*	1.224**
AB	1.065^{ns}	0.010^{ns}	-0.083^{ns}	0.031^{ns}	-0.010^{ns}
AC	-0.100^{ns}	0.016^{ns}	0.033^{ns}	-0.016^{ns}	-0.050^{ns}
BC	0.250^{ns}	-0.125^{ns}	0.500^{ns}	-0.125^{ns}	-0.875^{ns}
A^2	-0.063**	-0.033**	-0.034**	-0.060**	-0.065**
B^2	-1.403**	0.299^{ns}	-1.589**	-0.679^{ns}	-1.531**
C^2	-2.206*	-3.389**	-1.758^{ns}	-3.125*	-0.687^{ns}
Lack of fit	2.01^{ns}	1.46^{ns}	1.10^{ns}	0.89^{ns}	1.57^{ns}
Model F value	43.91**	17.66**	13.93**	12.01**	22.19**
R^2	0.975	0.94	0.92	0.91	0.95
Press	0.811	0.759	1.34	1.66	1.18
Adeq. Press	18.60	13.61	13.51	9.24	15.43

Figures are the Mean ± Standard error of six replications, *- 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. Constraints and criteria for optimisation of *Rasmalai* ball with different levels of t*ulasi* extract, a*shwagandha* root powder and isabgol

Constraints	Goal	Lower Limit	Upper Limit
Tulasi extract (%)	In range	4	10
Ashwagandha root powder (%)	In range	0.2	1
Isabgol	In range	0.5	1
Flavour	Maximize	6	7.7
Body and Texture	Maximize	6.2	7.8
Colour and Appearance	Maximize	6.6	7.8
Sweetness	Maximize	6.4	7.8
Overall Acceptability	Maximize	6.2	7.9

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 herbal *rasmalai*. The p-value of the body and texture model showed that factors *ashwagandha* root powder (B) and isabgol had a significant impact on body and texture whereas impact of *tulasi* extract (A) was non-significant at quadratic levels. All the three factors had a positive impact on the body and texture score of herbal r*asmalai*. Trivedi *et al.* (2014) and Indu and Awasthi (2018) reported observations contradictory to this.

Sweetness

The model showed a significant F-value of 12.01 whereas lack of fit was found to be non-significant. Coefficient of determination (R^2) was found to be 91.5 per cent which showed 91.5 per cent variations in the response detailed by the variables in the model.

$$\text{Sweetness} = 7.63 + 0.873*A + 0.626*B + 4.220*C + 0.031*AB - 0.016*AC - 0.125*BC - 0.060*A^2 - 0.679*B^2 - 3.125*C^2$$

Highest score obtained for sweetness was 7.8 while the minimum score was 6.4.

Table 5. Solution obtained after response surface analysis

Sl. No	*Tulasi* extract (%)	*Ashwagandha* root powder (%)	Isabgol (%)	Desirability (%)
1	6.951	0.423	0.583	0.90

Table 6. Effect of different levels of sucralose on sensory characteristics of sweetened concentrated milk

Parameter	T1	T2	T3	T4	T5	Chi square
Flavour	8.35±0.10^{a}	7.45±0.12^{a}	7.1±0.06^{ab}	6.64±0.08^{ab}	6.09±0.05^{b}	22.713**
Colour and appearance	8.35±0.15	8.2±0.09	8.29±0.08	8.27±0.09	8.17±0.09	1.682ns
Body and Texture	8.2±0.09^{a}	7.4±0.13^{ab}	7.38±0.11^{ab}	7.37±0.16^{b}	7.36±0.13^{ab}	11.806*
Sweetness	8.55±0.17^{a}	8.35±0.10^{a}	8.05±0.05^{ab}	6.75±0.11^{ab}	5.9±0.13^{b}	21.038**
Overall Acceptability	8.5±0.14^{a}	8.25±0.10^{a}	7.45±0.17^{ab}	7.07±0.09^{ab}	6±0.08^{b}	21.489**

Figures are the Mean ± Standard error of six replications, * significant at five per cent level ($p<0.05$), ** significant at one per cent level ($p<0.01$), ns- non-significant ($p\geq0.05$

The effect of three factors on sweetness is showed in the table F-value for sweetness was more than the tabled F- value at five per cent level of significance ($p< 0.05$). The coefficient of determination (R^2) of 0.91 with adequate precision of 9.24 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 clear that the model is authentic enough for forecasting the sweetness of herbal *rasmalai*. The p-value of the sweetness model showed that factors *tulasi* extract(A) and ashwagandha root powder (B) had non-significant ($p>0.05$) effect while isabgol (C) had a significant effect on the sweetness score of herbal r*asmalai*. At quadratic level, all the factors had a positive effect on the sweetness. Suryawanshi*et al.* (2020) in *rasogolla* and Kumar *et al.* (2013) in herbal ice cream observed effects contradictory to this.

Overall acceptability

The sensory scores obtained for overall acceptability ranged from 6.20 to 7.9. F- value of model was 22.19 whereas lack of fit was found to be non-significant. Coefficient of determination (R^2) of 95.2 per cent was obtained indicating 95.2 per cent variations in the response detailed by the variables in the model. Adequate precision ratio of 15.43 was obtained which indicates an adequate signal.

Overall acceptability= 7.60 +0.920*A +2.126*B +1.224*C -0.010 *AB -0.050*AC -0.875 *BC -0.065 *A^2-1.531*B^2-0.687*C^2

The F-value for overall acceptability was more than the tabled F-value at five per cent level of significance ($p< 0.05$). The coefficient of determination (R^2) of 0.95 with adequate precision of 15.053 firmly suggests the use of this response *viz*. overall acceptability to guide the design. The p-value of the overall acceptability model indicated that all the three factors had significant ($p<0.05$) effect on the overall acceptability score of herbal *rasmalai*. The impact of all the factors *viz., tulasi* extracts (A), *ashwagandha* root powder (B) and isabgol (C) on the sensory score of overall acceptability was positive at quadratic levels. Husain and David (2018) observed similar trend on addition of *tulasi* extract and *ashwagandha* root powder whereas Suryawanshi *et al*. (2020) reported contradictory to this.

Sweetened concentrated milk for the soaking of *rasmalai* balls was prepared by replacing the sugar completely with sucralose at different levels like T2 (100 ppm), T3 (200 ppm), T4 (300 ppm) and T5 (400ppm). The treatments were compared with control (5% sugar) and the obtained sensory scores were

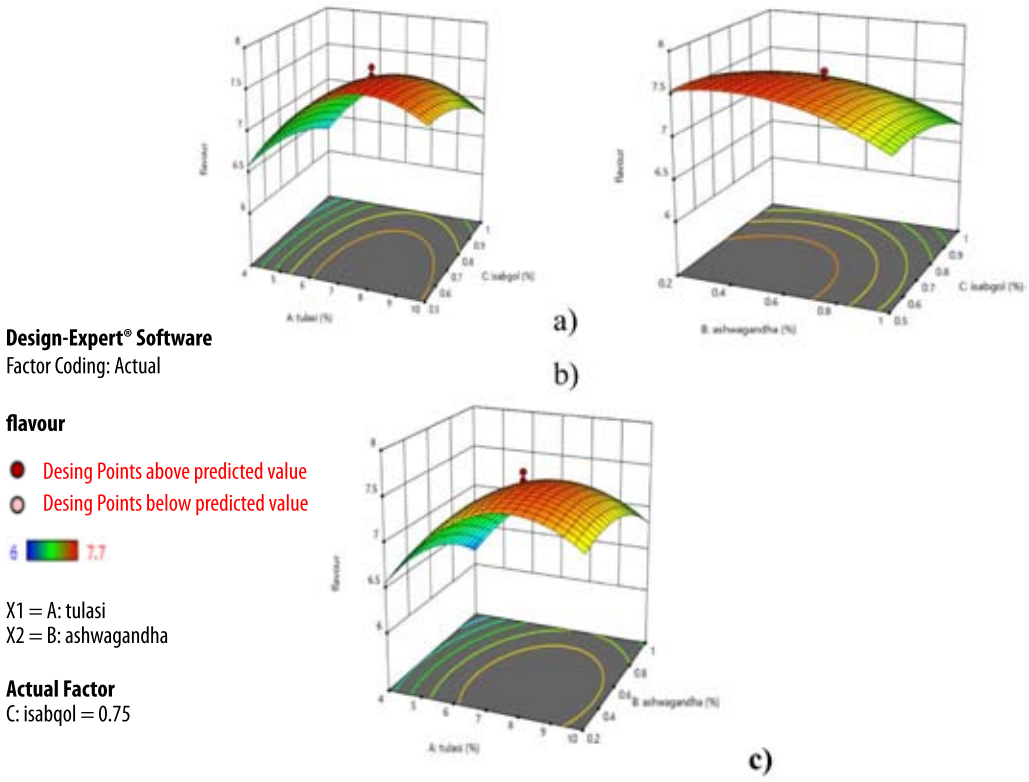

Fig. 1. Response surface plots for flavour score of fibre incorporated reduced calorie herbal *rasmalai*

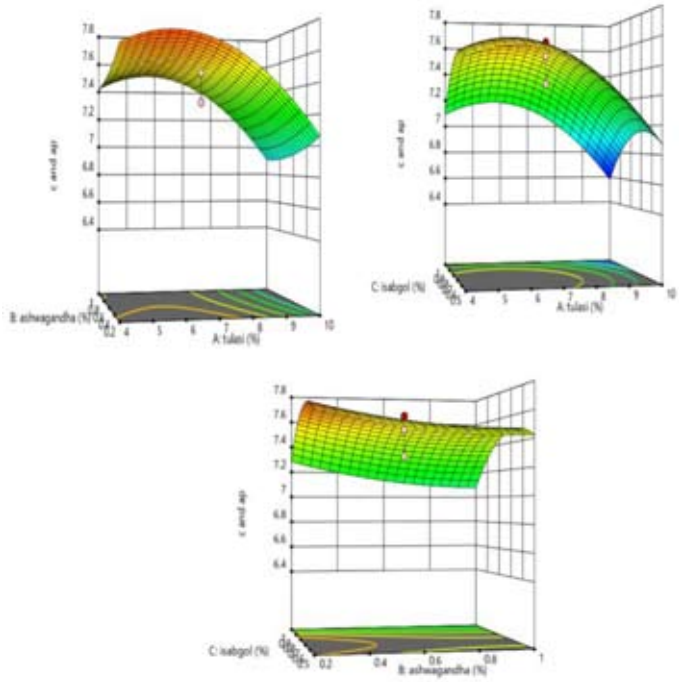

Fig. 2. Response surface plots for colour and appearance scores of fibre incorporated reduced calorie herbal r*asmalai*

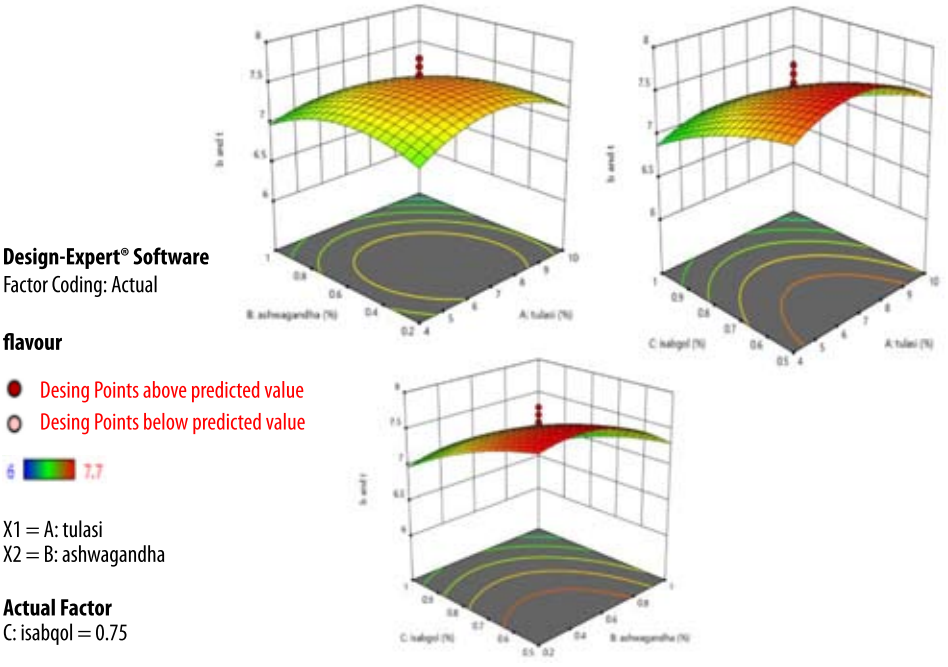

Fig. 3. Response surface plots for body and texture scores of fibre incorporated reduced calorie herbal r*asmalai*

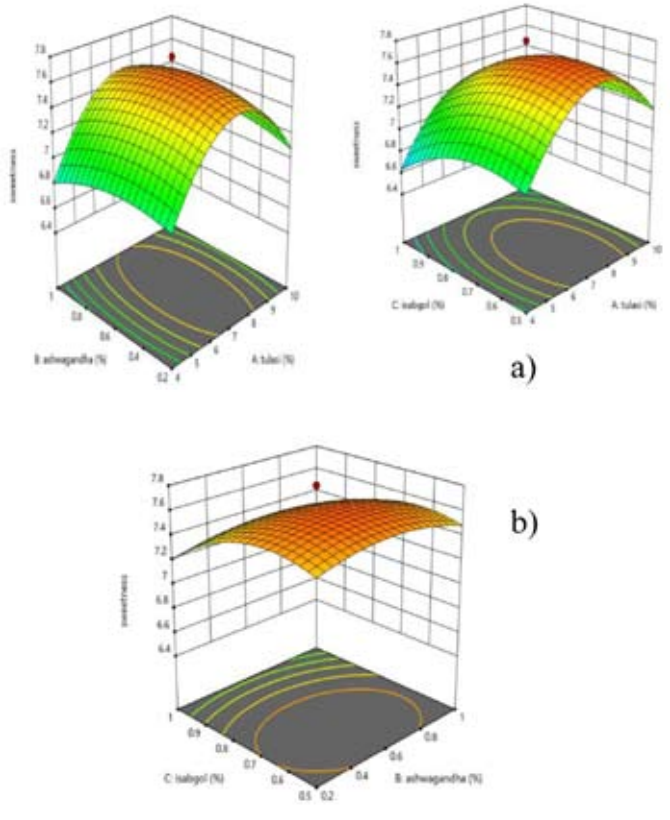

Fig. 4. Response surface plots for sweetness score of fibre incorporated reduced calorie herbal r*asmalai*

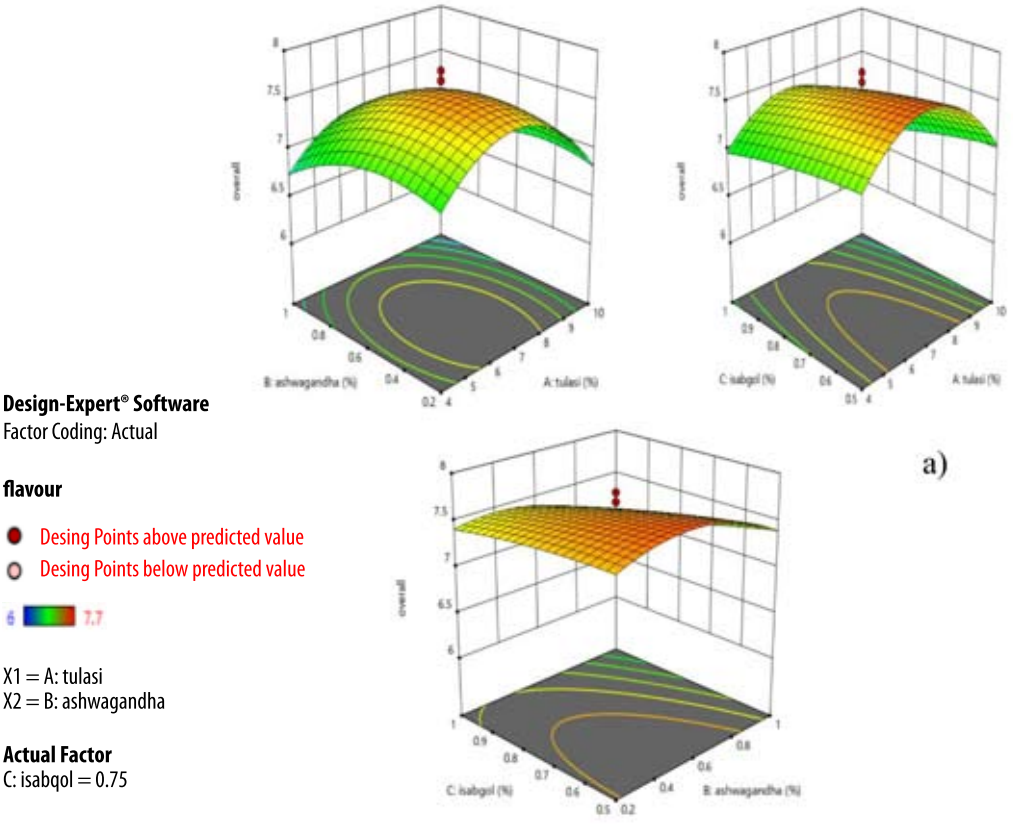

Fig.5. Response surface plots for overall acceptability score of fibre incorporated reduced calorie herbal r*asmalai*

subjected to statistical analysis (Kruskal Wallis). The effect of varying levels of sucralose on the sensory characteristics of *rasmalai* is given in the Table 6. T2 (100 ppm) got maximum sensory scores for the entire sensory attribute except colour and appearance. It was also most similar to control with non-significant difference from T1 in terms of all the sensory attributes. Hence T2 was selected as the optimum level of sucralose for the sweetened concentrated milk in the development of fibre incorporated reduced calorie herbal *rasmalai*.

Conclusion

RSM was used to estimate the optimal amounts of *tulasi* extract, *ashwagandha* root powder and isabgol for the production of herbal *rasmalai* balls and sweetened concentrated milk through Kruskal Wallis test based on sensory attributes. Out of 20 formulations for the optimisation of the ball, first formulation had the highest desirability (0.90) when compared to others. Hence, the *rasmalai* ball with 0.951 per cent *tulasi* extract, 0.423 per cent *ashwagandha* root powder and 0.583 per cent isabgol and sweetened concentrated milk with 100 ppm sucralose was selected for the formulation of fibre incorporated reduced calorie herbal r*asmalai*. The added herbs and reduced calorie may help to increase the product acceptability especially among health-conscious consumers.

Acknowledgments

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Conflict of interest

The authors declare that they have no conflict of interest.

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