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Development of ready to cook little millet *Bisibelebath* mix using response surface methodology

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Abstract
Bisibelebath, is a spicy rice-based meal with its origin in the state of Karnataka made of rice, lentils, spices and vegetables. In the present study, little millet was replaced with rice and an attempt was made to develop ready to cook (RTC) *Bisibelebath* mix using little millet and other ingredients. Little millet varies from rice in structural characteristics; therefore it is essential to standardize the millet and pulse ratio using Response Surface Methodology (RSM). The optimization of RTC little millet *Bisibelebath* mix was achieved using little millet, red gram dhal and spice mixture as ingredient variables and sensory attributes were selected as responses. Over 15 different combinations, sensory scores ranged from appearance 6.29-8, colour 6.56-8.01, consistency 6.54-8.12, flavour 6.63-8.05, taste 5.89-8.11 and overall acceptability 6.36-7.95. The optimized solution was 50g little millet and red gram dhal and 15.36g spice mixture with best fit desirability of 0.9.

Keywords: ready-to-cook, response surface methodology, little millet, overall acceptability, *Bisibelebath*

1. Introduction
Panicum sumatrense L., is known as little millet. It is grown throughout India to limited extent up to altitudes of 2100 m. It has received comparatively little attention from plant breeders. The plant varies in height between 30 and 90 cm. The seeds of little millet are smaller than that of common millet (Santosh, 2004) [1]. When compared with the other cereals, the nutritional quality of little millet grain is found to be superior. As per Gopalan *et al.,* (2010) [2], it is a cheap source of energy (341 k cal/100g), protein (7.7 g/100g), crude fiber (7.6 g/100g) and minerals (1.5 g/100g), particularly rich in iron (9.30mg/100g) compared to raw rice (0.7mg/100mg). Even the content of other nutrients such as niacin, pantothenic acid and folic acid, calcium, iron, potassium, phosphorus, magnesium and zinc are fairly good in little millet. (Vachanth *et al.*, 2010) [3]. Apart from this, little millet also contains adequate amounts of antioxidants and photochemical (Pradeep *et al.,* 2011) [4].

Rising income levels and busy lifestyles of consumers had made to develop ready to cook (RTC) food products over the last few years in India. Conveniences or Ready-to-cook foods are those which are processed or prepared to be ready to cook with very little additional effort (Sharma *et al.,* 2009) [5]. Some of the ready to cook convenient mixes prepared in India over the last few years are Instant *Dhokla* (Lohekar and Arya, 2014) [6], halwa mix by ragi, wheat, sorghum and soybean (Goswami *et al.,* 2017) [7] and instant soup powder (Anita *et al.,* 2016) [8]. *Bisibelebath* is a spicy rice-based meal with its origin in the state of Karnataka made of rice, lentils, spices and vegetables (Shelar, 2016) [9]. From the times immoral traditional breakfast *Bisibelebath*, is prepared with combination of rice and pulse in the ratio of 2:1. In the present study, little millet was replaced with rice and an attempt was made to develop *Bisibelebath* mix. From the previous reviews it is clear that RTC mix from little millet in the preparation of *Bisibelebath* has not been reported and is open for research. However, RTC mixes from other grains are available plenty, and as little millet varies from rice in structural characteristics; therefore it is essential to standardize the millet and pulse ratio using Response Surface Methodology (RSM).

RSM is a statistical technique that has been successfully used in the development and optimization of cereal products (Gallagher *et al.,* 2003) [10]. RSM consists of a group of mathematical and statistical procedures that can be used to study the relationships between one or more dependent variables and independent variables (Murphy *et al.,* 2004) [11]. The relative contribution of predictor variables to product characteristics can be evaluated and it allows optimizing the ingredient levels (Crowley *et al.,* 2001) [12]. By using RSM more than one response can be studied (Josephine *et al.,* 2014 and Gan *et al.,* 2007) [13, 14]. Some of the convenient food products were developed using Response surface methodology covers vast array of ready to eat (RTE) items such as potato snack, ready to reconstitute appetizer mix, ready to drink appetizer beverages, RTE soup mix and RTE healthy extruded snacks by Nath *et al.,* 2012 [15], Wadikar *et al.,* 2011 [16], Karuna *et al.,* 2018 [17] and Kaushik *et al.,* 2017 [18] respectively. In order to achieve optimization, the advantages of RSM reduce the number of trials and provide multiple regression approach (Pritam *et al.,* 2013) [19]. As per the previous reviews it can be observed that, products such as

i.e. biscuits (Hemalatha *et al.,* 2011) [20], anaras (Ninganagoudar *et al.,* 2012) [21], bread (Mannuramath, 2013) [22], little millet flakes (Kotagi *et al.,* 2011) [23], ready to eat sports food mix (Roopa *et al.,* 2011) [24] is been developed using little millet. As it is one of the promising source of nutrient, there is need to develop highly nutritious easily digestible little millet breakfast items by standardizing the proportion for millet and dhal, and therefore the present study was carried out to develop Ready to cook *Bisibelebath* mix using Response surface Methodology RSM.

2. Materials and methods

2.1 Materials

Little millet was procured from Shakthi farms, Mysuru, and good quality raw materials i.e., fresh vegetables, dry commodities such as red gram dhal, salt, tamarind, refined sunflower oil and other spices were procured from the local market of Mysuru in single a lot.

2.2 Methodology

a) Methodology for RTC mix

Little millet and red gram dhal were dry roasted at 60°C for 5 mins and 10mins respectively

↓

Red gram dhal were grounded to coarse powder to reduce its size according to size of little millet

↓

All the spices were dry roasted individually at 40-60°C for 15mins till the pleasant aroma comes out of it and subsequently blended in prestige mixer grinder

↓

Little millet, red gram dhal and spice mixture were mixed according to the formulation obtained through RSM software

↓

The mixes were packed and stored in metalized polyester polyethylene pouches till sensory evaluation

b) Methodology for *Bisibelebath preparation* using RTC mix

Mustard seeds and dry chillies were added along with oil to the Pressure cooker

↓

Bisibelebath mix was roasted in that for 5mins and vegetables were added

↓

Salt, tamarind water and filter water (In the ratio of 1: 6 for millet + dhal: water) were also added as per study design

↓

Pressure cooked for 10mins and served in hot condition for sensory evaluation

2.2 Experimental design

A central composite rotatable design of experiments was set up using design expert version 7.1.5 from Stats ease Inc; USA was used to construct as well as to analyze the design for product optimization. Little millet, red gram dhal and spice mixture (Table 1), were the independent variables and appearance (score), colour (score), consistency (score), flavour (score), taste (score) and overall acceptability (score) were selected as the responses. A five level design with three variables leading 15 combinations was used. It included four factorial points, six axial points and five central points. The 15 formulations were prepared and were evaluated for overall acceptability.

Table 1: Experimental design for little millet *Bisibelebath* with process variables and their levels

Process variables	-1.414 (α point)	-1 (factorial point)	0 (centre point)	+1 (factorial point)	+1.414 (α point)
Little millet (g)	43.79	50	65	80	86.21
Red gram dhal (g)	23.79	30	45	60	66.21
Spice mixture (g)	7.93	10	15	20	22.07

X_1	X_2	X_3	Runs
± 1	± 1	± 1	4
± 1.414	0	0	2
0	± 1.414	0	2
0	0	±1.414	2
0	0	0	5

2.3 Organoleptic Evaluation

The developed Ready to cook mix of little millet *Bisibelebath* was served to semi trained panelists for organoleptic evaluation on a nine point hedonic scale, with score 9 as excellent and score 1 as disliking. Sensory evaluation was carried by 25 semi trained panel members. The sensory properties such as appearance, colour, consistency, flavour, taste and overall acceptability of finished product were evaluated on the basis of 9 point hedonic scale (Devaki and Premavalli, 2012) [25].

2.4 Results and discussion

The study ranges in the experimental design for the independent variables little millet (A), red gram dhal (B), Spice mixture (C) were 43.79-86.21g, 23.79-66.21g and 7.93-22.07g respectively. The response observed for sensory score of 15 experimental design points are summarized in Table 2. Among 15 combinations the scores for different sensory parameters ranged from 6.29-8 for appearance, colour 6.56-8.01, consistency 6.54-8.12, flavour 6.63-8.05, taste 5.89-8.11 and overall acceptability 6.36-7.95. Regression analysis revealed that a linear polynomial model was found suitable for both responses the generic equation of the linear model is:

$$Y = \beta o + \sum_{i=1}^{n} \beta i \, Xi \qquad (1)$$

$$Y = \beta o + \sum_{i=1}^{n} \beta i \, Xi + \sum_{i=1}^{n} \beta ii \, Xi2 + \sum_{i \neq j=1}^{n} \beta ij \, XiXij \qquad (2)$$

Where, βo was the value of the fitted response at the center point of the design, i.e., point (0, 0, 0); βi, βii and βij were the linear, quadratic and cross product (interaction effect) regression terms respectively and 'n' denoted the number of independent variables.

Table 2: Experimental design for little millet *Bisibelebath*

Runs	Variable levels (uncoded)		Responses						
	X_1	X_2	X3	Y_1	Y2	Y3	Y_4	Y_5	Y_6
	Little millet	Red gram dhal	Spice mixture	Appearance	Colour	Consistency	Flavour	Taste	OAA*
	(g)	(g)	(g)	(Score)	(Score)	(Score)	(Score)	(Score)	(Score)
1	80	60	10	7.01±0.52	7.11±0.52	6.54±0.52	6.63±0.59	5.89±0.82	6.36±0.24
2	80	30	20	7.58±0.53	7.45±0.52	7.67±0.52	7.34±0.84	7.31±0.86	7.38±0.52
3	50	60	20	7.66±0.32	7.86±0.42	7.80±0.85	8.04±0.64	7.78±0.82	7.91±0.63
4	50	30	10	6.29±0.35	7.15±0.65	7.26±0.75	7.97±0.68	8.10±0.75	7.09±0.54
5	43.79	45	15	7.10±0.52	8.01±0.72	8.12±0.65	7.96±0.51	8.11±0.68	7.95±0.84
6	86.21	45	15	7.96±0.65	7.68±0.82	7.58±0.89	7.87±0.52	7.84±0.45	7.75±0.75
7	65	23.79	15	7.67±0.65	7.31±0.88	6.79±0.74	7.08±0.62	7.23±0.65	7.03±0.52
8	65	66.21	15	6.96±0.75	7.94±0.78	7.75±0.24	6.83±0.51	7.24±0.32	6.91±0.48
9	65	45	7.93	7.01±0.82	6.56±0.52	6.87±0.57	6.87±0.85	6.90±0.55	7.06±0.89
10	65	45	25.07	7.09±0.55	7.47±0.46	6.95±0.68	8.05±0.56	6.69±0.34	7.20±0.65
11	65	45	15	7.40±0.42	7.70±0.84	6.98±0.36	7.08±0.84	7.63±0.45	7.33±0.57
12	65	45	15	7.67±0.25	7.63±0.58	7.58±0.75	7.04±0.51	7.73±0.65	7.68±0.53
13	65	45	15	7.54±0.65	7.75±0.52	7.54±0.89	7.50±0.56	7.03±0.45	7.42±0.68
14	65	45	15	8.00±0.41	7.65±0.57	7.33±0.54	7.58±0.58	7.63±0.54	7.61±0.89
15	65	45	15	7.58±0.86	7.73±0.65	7.37±0.86	7.21±0.84	7.60±0.57	7.70±0.65

*OAA- Overall acceptability

The analysis of variance was calculated for each selected model and the effects of the independent variables using little millet, red gram dhal and spice mixture on the response at linear, quadratic and interactive levels are presented in Table 3. The sign and magnitude of the coefficients indicated the effect of the variable on the responses. Negative sign of a coefficient at linear level indicated decrease in response with an increase in level of the variable where as at interactive level; level of one variable could be increased while that of the other decreased to obtain the same response.

All linear, quadratic and interactive effects were calculated for each model. Quadratic response surface models were selected for all the responses. The adequacy was calculated by F-ratio, mean, standard deviation, coefficient correlation and lack of fit test. R^2 value was more than 90% showed fitness of the polynomial regression models for describing the effect of variables and lack of fit was highly non-significant. The regression coefficient, correlation coefficients for the responses were 0.99 for colour, 0.96 for overall acceptability, 0.93 for appearance, flavour and taste, and 0.92 for consistency Table 3.

Table 3: Coefficient of second order polynomial regression models little millet *Bisibelebath*

Coefficient	Appearance	Colour	Consistency	Flavour	Taste	OAA
	Y_1	Y2	Y_3	Y_4	Y_5	Y_6
β_0	7.64	7.69	7.36	7.29	7.51	7.55
β_1	0.304^d	-0.116^c	-0.190	-0.031	-0.095	-0.070
β_2	-0.251	0.222^b	0.339^d	-0.088	0.003	-0.042
β_3	0.028	0.321^a	0.028	0.417^d	-0.074	0.049
β_{11}	-0.052	0.075^c	0.240^d	0.308^d	0.233^d	0.146^d
β_{22}	-0.159	-0.034	-0.049	-0.171	-0.136	-0.293^c
β_{33}	-0.292^c	-0.339^a	-0.229^d	0.081	-0.356^d	-0.213^d
β_{12}	-0.456^d	0.059	-0.389^d	0.222^c	-0.349	-0.410^d
β_{13}	-0.451^d	0.130^d	0.486^d	0.071	0.438	0.007
β_{23}	0.144	-0.004	0.021	0.478^d	0.574^d	0.244
R^2 %	92.98	99.47	91.62	92.68	93.44	95.80
P%	<0.05	<0.0001	<0.05	<0.05	<0.05	<0.01
Mean	7.37	7.53	7.34	7.40	7.38	7.35
SD	0.20	0.04	0.21	0.22	0.25	0.15
F-value	7.35	104.7	6.07	7.03	7.90	12.68

Values with different superscripts are significant at the level, a: p<0.0001, b: p<0.001, c: p<0.01, d: p<0.05

The closer the value of R^2 to unity, the better the empirical models fits the actual data. On the other hand, the smaller the value of R^2 the less relevance the dependent variables in

The model have in explaining the behavior of variations (Mendenhall, 1975) [26]. The fitted models are represented by the following equations:

$$\text{Appearance} = 7.64 + 0.304\,X_1 + 0.251\,X_2 + 0.028\,X_3 - 0.052\,X_1^2 - 0.159\,X_2^2 - 0.292\,X_3^2 - 0.456\,X_1X_2 - 0.451\,X_1X_3 + 0.144\,X_2X_3 \quad R^2 = 0.93$$

$$\text{Color} = 7.69 - 0.116\,X1 + 0.222\,X2 + 0.321\,X_3 + 0.075\,X_1^1 - 0.034\,X_2^2 - 0.339\,X_3^2 + 0.059\,X_1X_2 + 0.130\,X_1X_3 - 0.004\,X_2X_3 \quad R^2 = 0.99$$

$$\text{Consistency} = 7.36 - 0.190\,X_1 + 0.339\,X_2 + 0.028\,X_3 + 0.240\,X_1^2 - 0.049\,X_2^2 - 0.229\,X_3^2 - 0.389\,X_1X_2 + 0.486\,X_1X_3 + 0.021\,X_2X_3 \quad R^2 = 0.92$$

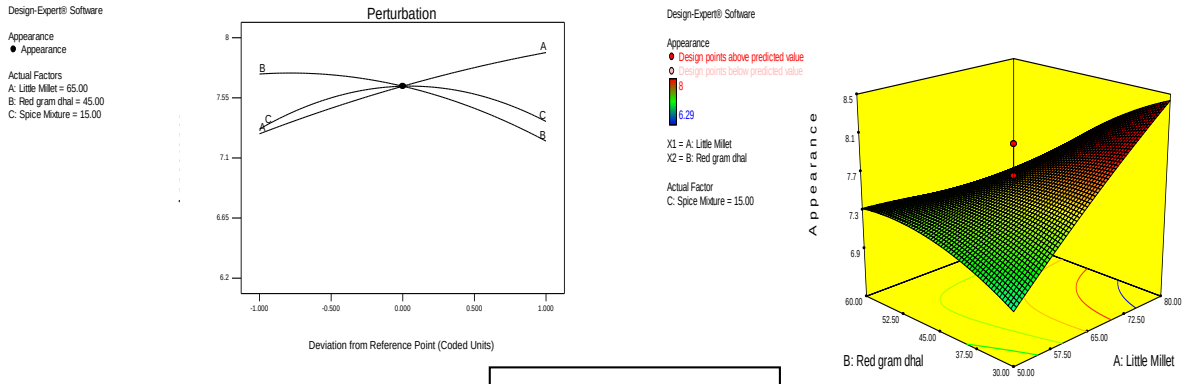
$$\text{Flavour} = 7.29 - 0.031\,X_1 - 0.088\,X_2 + 0.417\,X_3 - 0.308\,X_1^2 - 0.171\,X_2^2 + 0.081\,X_3^2 + 0.222\,X_1X_2 + 0.071\,X_2X_3 + 0.478\,X_3X_1 \quad R^2 = 0.92$$

$$\text{Taste} = 7.51 - 0.095\,X_1 + 0.003\,X_2 - 0.074\,X_3 + 0.233\,X_1^2 - 0.136\,X_2^2 - 0.356\,X_3^2 - 0.349\,X_1X_2 + 0.438\,X_2X_3 + 0.574\,X_3X_1 \quad R^2 = 0.93$$

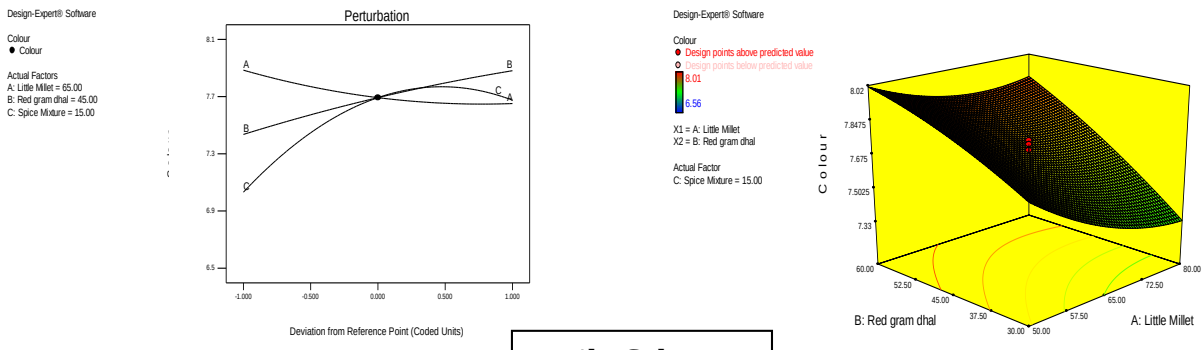
$$\text{OAA} = 7.55 - 0.070\,X_1 - 0.042\,X_2 + 0.049\,X_3 + 0.146\,X_1^2 - 0.293\,X_2^2 - 0.213\,X_3^2 + 0.410\,X_1X_2 + 0.007\,X_1X_3 + 0.244\,X_2X_3 \quad R^2 = 0.96$$

From the above equation, it can be concluded that at linear level little millet had positive effect on appearance and negative effect on rest of the sensory parameters in which, appearance had significant effect at the level of $p<0.05$ and colour at the level of $p<0.01$. Red gram dhal had positive significant effect on colour ($p<0.001$), consistency ($p<0.05$) and taste, and had negative effect on appearance, flavour and overall acceptability. Spice mixture had positive effect on all the responses except for taste and it was found to be significant at the levels $p<0.0001$ for colour and $p<0.05$ for flavour. In quadratic level, little millet had positive significant effect on colour at $p<0.01$ and at $p<0.05$ for consistency, flavour, taste and overall acceptability. It can be clearly observed from the Table 3, that red gram dhal and Spice mixture had negative effect on all the sensory parameters. Spice mixture had significant effect at the level of $p<0.0001$ for colour, $p<0.01$ for appearance and $p<0.05$ for consistency, taste and overall acceptability. At interactive level, little millet and red gram dhal had negative significant effect on appearance, consistency and overall acceptability at the level of $p<0.05$ and positive significant effect for flavour at $p<0.001$. Little millet and spice mixture had positive effect on all the responses except for appearance and was significant at the level of $p<0.05$ for colour and consistency. Red gram dhal and spice mixture had positive effect on all the responses except for colour and was significant at the level of $p<0.05$ for flavor and taste.

It is clear from Fig 1a to 1f, that all the three variables had effect on sensory scores. As there was increase in little millet, there was increase in appearance, as it was decreased; there was decrease in colour, consistency. It was found that a slight decrease little millet increased the scores for flavour, taste and overall acceptability. Red gram dhal had great influence on appearance, colour and consistency. Increase in red gram dhal increased the scores of colour, consistency and decrease in the level decreased the scores of appearance and flavour, while it did not show much effect on taste and overall acceptability. Spice mixture had a very great influence on flavour, it was observed that, as there was increase in spice mixture there was increase in the scores of flavour, while a slight increase in spice mixture reduced the scores of appearance, colour, consistency, taste and overall acceptability. It is noteworthy to mention that, all the three variables viz, little millet, red gram dhal and spice mixture had great influence on sensory parameters.



1a: Appearance



1b: Colour

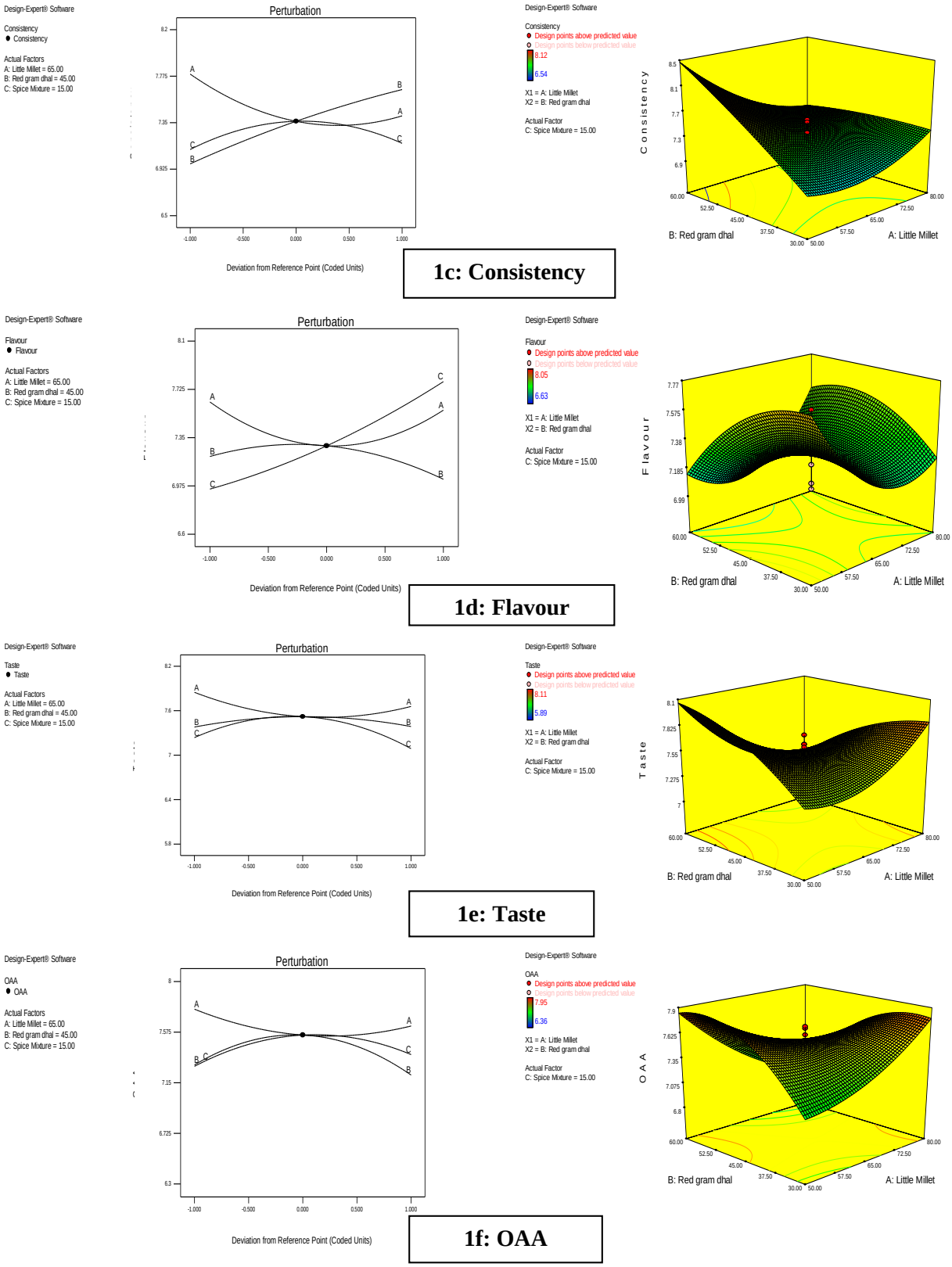


Fig 1: Perturbation and 3D graph for Sensory parameters; 1a: Appearance, 1b: Colour, 1c: Consistency: 1d: Flavour, 1e: Taste and 1f: OAA of little millet *Bisibelebath*

2.5 Optimization of independent variables

Numerical optimization of independent variables, little millet, red gram dhal and spice mixture was achieved using design expert software. The predicted and actual values of the responses are given in Table 4. The aim of the experiment was to increase overall acceptability score. The optimized solution was 50g little millet and red gram dhal and 15.36g spice mixture with best fit desirability of 0.9. The optimized results were appearance 7.37, colour 7.95, consistency 8.00, flavour 7.54, taste 7.93 and over all acceptability score of 7.87. The predicted response value as against actual value for responses as shown in Table 4 were in concurrence with each other, hence the fitted models are suitable for predicting the responses. The results of the RSM showed quadratic response

surface models were fitted for all the responses. F values were significant in all selected responses and a high R^2 value showed fitness of the polynomial regression models for describing the effect of variables.

Table 4: Predicted and Actual Responses values

Responses	Predicted	Actual (n=3)
Little millet (gm)	50.00	-
Red gram dhal(gm)	50.00	-
Spice mixture (gm)	15.36	-
Appearance (Score)	7.37	8.33 ± 0.349
Colour (Score)	7.95	8.00 ± 0.378
Consistency (Score)	8.00	8.04 ± 0.394
Flavour (Score)	7.54	7.95 ± 0.375
Taste (Score)	7.93	8.09 ± 0.403
OAA* (Score)	7.87	8.18 ± 0.376

* Over all acceptability (OAA) scored on nine point hedonic scale

Conclusion

The results of the present study indicated that the effect of little millet, red gram dhal and spice mixture were significant to all the selected responses. RSM could be useful in optimizing the little millet, red gram dhal, spice mixture with maximum retention of sensory attributes. Overall the little millet, red gram dhal was optimized with 50g and spice mixture of 15.76g with the best fit desirability of 0.94. From the study, it can be concluded that the optimized Ready to cook little millet *Bisibelebath* mix was organoleptically superior hence; it could be helpful in promoting the utilization of little millet which in turn enhances the income source for millet growing farmers.

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