Development and Shelf Stability of Natural Fibre Rich Retort Pouch Ready to Eat Products

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Abstract: The new frontier in the food research is the role of non nutritive components in human health. In the recent past, the importance of dietary fibre in the diet has been increased as a functional ingredient which has opened up a potential market for fibre rich products. The by products available during processing of plant foods are considered as promising source of functional fibres. The aim of the present study was to develop fibre rich products using the natural fibre such as ashgourd (*Benincasa hispida)* fibre, with high soluble fibre fraction. Ready-to-eat fibre rich Bisi bele bath and vegetable pulav were developed with the optimization of fibre using statistical design software. Fibre, fat and spice mixtures were independent variables with the other components as fixed factors. Since the product acceptance is more dependent on volatile compound form intern the flavour, as well as depends on the test, appearance, colour, texture which are the sensory attributes, total volatiles and sensory attributes were selected as responses. While in the fibre rich vegetable pulav water, fibre and spice mixtures were the independent variables. Both the products were showing good acceptability i.e. in the case of bisi bele bhath 7.1 and in the case of vegetable pulav 6.5 on a 9 point hedonic scale after 6 months of storage at room temperature. The dietary fibre profile of bisi bele bhath was 1.1% soluble fibre and 4.4% insoluble fibre while vegetable pulav had 6.2% insoluble and 1.54% soluble fibre fraction. The products were safe and had an established shelf life of 6 months.

Keywords: Natural fibre, RSM, Retort processing, dietary fibre, sensory analysis.

1. INTRODUCTION

The recent strategy of understanding utilizing fibre sources and possibility of their incorporation in foods and the functionalities along with their health benefits are on the increased awareness for keeping good health as well as to have beneficial effects against several diseases such as cardiovascular diseases, diverticulitis, diabetes, etc., [1,2]. The recommended level of dietary fibre in diet is 25-30gm per day [3] but considering the regional variation, environmental effects, economical factors and food habits, the normal diet may have fibre less than 15 to 20gm which necessitates the fibre incorporation into processed foods. The literature on fibre rich foods generally reflects to bakery products [4-7]. But the natural fibre sources includes fruits (apple, banana, grapes, apricot, orange, pineapple, strawberries. etc), vegetables (potato, carrot, corn, peas, tomato. etc), cereals (corn, oats, barley, etc). Prachi and Premavalli (2010) [8] have reported on the properties of ashgourd and radish fibres. The same authors have studied the functional properties of four natural fibres and reported on the hypoglycemia effect of these fibres. Incorporation of natural fibres in cookies, vermicelli, kheer and fried snacks has been studied by Prachi (2010) [9]. The fibre rich foods have greater impact for the retort process foods or in the packed rations of defence supplies but jawans deployed at high altitudes face constipation, anorectal problems to overcome these problems fibre rich product development needs an attention to satisfy the defence community. In order to provide fibre rich products the present investigation on the fibre rich ready to eat foods development has been attempted.

Retort processing has been widely used as one of the important food processing techniques to get microbiologically safe products with acceptable quality. The research on retort processed foods is on the continuous phase preferment in its quality, packaging used in range of different product. [10-12] and Defence Food Research Laboratory has made it possible for commercial availability and is being used by defence personnel deployed at inhospitable condition. However, the fibre rich products requirement necessitates the development of these products which reflects on the type of fibre, processing, modification as well as organoleptic quality for the good acceptability of the product. In the present study the development of ready to eat fibre rich bisi bele bhath and vegetable pulav have been done using statistical software for optimization process and the storage stability of the products has been addressed.

2. MATERIALS AND METHODS

2.1. Raw Materials

Heterogeneous vegetarian products such as vegetable pulav and bisi bele bhath were prepared

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ISSN: 2223-3806 / E-ISSN: 1927-5951/14

using raw materials such as rice, dhal, beans, carrot, potato, onion, ginger, spices, hydrogenated fat, green pea, ghee, salt, and ashgourd fibre. The above said good quality raw materials were procured from Mysore market. Tender and fresh vegetables were cleaned in running water and removed the skin and seeds and cut into small pieces.

2.2. Processing of Ashgourd

Ashgourd was deskined and removed the rind portion and cut into small pieces and blanched at 90°C for 3 minutes. Ashgourd juice was extracted with the help of juice extractor (RayLons Metal Works, Bombay, India). To obtain ashgourd fibre, the residue was dried and powdered. Ashgourd powder was sieved through 60 mesh sieve (60 mesh particle size) and was used for the development of the product. The chemicals and reagents used for the analysis were of AR grade.

2.3. Packaging Material

The multilayer pouches of 12 µm, polyester/12µm aluminum foil/75µm cast polypropylene (PET/Al.foil/CPP) with the capacity of 300g and a dimension of 15 X 20cm was used for the MRE retort pouches.

2.4. Filling and Sealing

300g of the final product (i.e. bisi bele bhath and vegetable pulav) were filled manually and the entrapped air squeezed out manually before sealing the top of the pouch hermetically by an impulse heat sealer (M/S sunray industries, Mysore).

2.5. Retort Processing of Bisi Bele Bhath and Vegetable Pulav

Retort pouch processing of bisi bele bhath and vegetable pulav were carried out in a laboratory model still steam air retort. The retort was equipped with facility for using compressed air for over head pressure and high pressure water circulating pump for cooling under pressure. The temperature of the product was continuously recorded during heat processing, through copper Constanta thermo couples, placed at the geometric centers of the pouches. In order to determine the slowest heating zone (SHZ), thermocouples were placed at the geometric center of the filled pouches and placed at the geometric center of the retort. A reference thermocouple was also placed in the retort to monitor its temperature. All the thermocouples were connected to a data logger (Model: CTF 9004, M/S. ELLAB, DENMARK). The temperature of the pouches and retort was calculated from the thermo-electro-motive-force at regular intervals. The f_o value was calculated from the temperature and time data. The pouches were initially heated till their inside temperature reaches 100°C. Subsequently the pressure was raised from 01 lbs to 20 lbs gauge pressure. The processing was carried out to achieve a f_0 value of 5 (for bisi bele bhath) and 5.6 (for vegetable pulav) to achieve commercial sterility [10]. After attaining the required f_0 value, the pouches were cooled by allowing water, maintaining the overall pressure at 15 lbs for 4 to 5 min. and taken out.

3. RESULTS AND DISCUSSION

3.1. Products Development

Primarily, the different sources of vegetable fibre i.e., ashgourd fibre, pea peel fibre and radish fibre were incorporated in the development of retort processed bisi bele bhath and vegetable pulav. Considering the eye appeal, the taste, flavour and acceptance, ashgourd fibre incorporated product rated as the best, Prachi and Premavalli (2010) [8] have also reported that ashgourd fibre had the best properties for incorporation in to food product. The optimization of fibre level has been achieved using RSM with the help of design expert statistical software.

For the development of retort processed fibre rich bisi bele bhath, ashgourd fibre, fat and spice mixture were taken as independent variables, and taste, flavour, colour, texture, overall acceptability and total volatiles were taken as responses, while for the vegetable pulav, ashgourd fibre, spice mixture and water were taken as independent variables, and taste, flavour, colour, texture, overall acceptability and total volatiles were taken as responses and the optimal ranges of the variables are given in Tables **1** and **2**. The experimental central composite rotatable design was used without blocking. The numbers of design points were obtained on basis of the number of independent variables decided. For the development of bisi bele bhath, a 6 level full central composite design was used with 3 independent variables. The design considered 8 factorial points, 6 axial points and 6 central points leading to 20 sets of experiments [13]. For the development of vegetable pulav, a 5 level small central composite design was used with 3 independent variables. The design considered leading 4 factorial points, 6 axial points and 5 central points leading to 15 sets of experiments.

Table 1: Process Variables their Levels and Experimental Design for Bisi Bele Bhath

Process variables	- 1.6879 (augmented form)	-1 (factorial point)	0 (centre point)	+1 (factorial point)	+1.6879 (augmented form)
Ashgourd fibre (gm)	4.89	10	17.5	25	30.11
Fat (gm)	11.59	15	20	25	28.41
Spice mixture (gm)	1.95	4	7	10	12.05

Table 2: Process Variables their Levels and Experimental Design for Vegetable Pulav

Process variables	-1.4142 (augmented form)	-1 (factorial point)	0 (centre point)	+1 (factorial point)	+1.4142 (augmented form)
Ashgourd fibre (gm)	5.86	10	20	30	34.14
Spice mixture (gm)	0.29	0.50	1.00	1.50	1.71
Water (ml)	25.86	30	40	50	54.14

The regression analysis of the responses 20was conducted by fitting to the suitable model represented by the following equation

$$Y = \beta_o + \sum_{i=1}^{n} \beta_{i\,xi} + \sum_{i=1}^{n} \beta_{ii\,xi^2} + \sum_{i \neq j=1}^{n} \beta_{ii\,xi\,xij}$$

where, $ß_o$ was the value of the fitted response at the center point of the design, while $ß_i$, $ß_{ii}$, and $ß_{ij}$ were the linear, quadratic and interactive-effect regression terms, respectively, and *n* denoted the number of independent variables i.e. in this case *n* is 3, and x_i, x_{ij} are independent variables in coded values represented by X_1, X_2 and X_3.

Table 3: Actual Experimental Combinations and Response Values for Bisi Bele Bhath

		Variable 1	Variable 2	Variable 3	Response 1	Response 2	Response 3	Response 4	Response 5	Response 6
Std	Run	Fibre	Fat	Spice Mixture	Taste	Flavour	Colour	Texture	OAA*	Total Volatiles
		gm	gm	gm	Score	Score	Score	Score	Score	%
18	1	30.11	20	7	6	6.2	6.2	6	6.1	0.046
19	2	17.5	28.41	7	6.5	6.9	7.2	7.4	7	0.059
8	3	25	25	4	6.1	6.5	6.5	6.3	6.4	0.040
12	4	10	15	4	6.3	6.6	6.8	6.9	6.8	0.041
7	5	17.5	20	7	6.75	7	6.8	6.9	6.9	0.066
11	6	17.5	20	12.05	7.38	7.2	7.4	7.2	7.13	0.072
14	7	17.5	20	7	6.89	7	7.1	7.1	7	0.062
16	8	4.89	20	7	7.5	8	7.8	7.6	7.8	0.069
15	9	17.5	20	7	6.62	6.8	6.7	6.9	6.8	0.069
3	10	17.5	20	7	6.88	6.6	6.8	6.5	6.9	0.060
17	11	10	25	4	6.8	6.9	6.9	6.7	6.9	0.051
2	12	17.5	20	7	6.7	6.8	6.7	6.6	6.8	0.052
13	13	17.5	20	7	6.7	6.9	6.6	6.7	6.7	0.043
4	14	25	25	10	6.2	6	6.36	6.2	6.34	0.052
1	15	10	15	10	7.4	7.8	7.65	7.5	7.76	0.077
5	16	25	15	10	6.3	6.2	6.3	6.5	6.4	0.059
9	17	25	15	4	6.2	6.1	6.2	6.2	6.3	0.042
6	18	17.5	11.59	7	6.61	6.7	6.8	6.8	6.9	0.062
20	19	10	25	10	7.54	7.7	7.6	7.5	7.74	0.070
10	20	17.5	20	1.95	6.1	6.5	6	7	6.2	0.020

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

Table 4: Actual Experimental Combinations and Response Values for Vegetable Pulav

		Factor 1	Factor 2	Factor 3	Response 1	Response 2	Response 3	Response 4	Response 5	Response 6
Std	Run	A:Fibre	B:Spice Mixture	C:Water	Taste	Flavour	Colour	Texture	OAA*	Total Volatiles
		gm	gm	ml	Score	Score	Score	Score	Score	%
8	1	30	0.5	50	6.63	6.92	6.73	6.6	6.71	0.044
9	2	30	1.5	30	6.52	7.02	6.93	6.6	6.81	0.069
7	3	20	1	40	6.9	7	7.2	7.2	7.2	0.026
6	4	10	0.5	30	7.5	7.22	7.18	7.4	7.41	0.028
14	5	20	1	54.14	6.75	7	7.09	7	7	0.056
12	6	5.86	1	40	7.8	7.5	7.59	7.5	7.69	0.016
2	7	20	1	40	6.89	7.2	7.3	7.3	7.2	0.021
10	8	10	1.5	50	7.4	7.32	7.33	7.4	7.31	0.114
3	9	20	1	40	7	7	7.1	7	7.1	0.021
1	10	20	0.29	40	6.88	6.9	6.89	7.1	6.89	0.016
15	11	20	1.71	40	7	7.2	7.19	7.3	7.19	0.109
4	12	20	1	40	7.2	7	7.2	7.3	7.1	0.021
13	13	20	1	25.86	7	7.1	7.09	6.9	6.99	0.047
11	14	20	1	40	7.1	7.2	7	7.1	7.2	0.029
5	15	34.14	1	40	7.1	6.5	6.59	6.4	6.59	0.028

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

The experimental central composite rotatable design with independent variables and responses for bisi bele bhath and vegetable pulav are given in Tables **3** and **4** respectively. Since sensory analysis is an important criteria for the product acceptance, it has been taken as the response, over the 20 combinations in bisi bele bhath, scores of, taste ranged from 6 to 7.54, flavour ranged from 6 to 8, colour from 6 to 7.8, texture from 6 to 7.6, overall acceptability ranged from 6.1 to 7.8 and total volatiles ranged from 0.020 to 0.077%. Over the 15 combination in vegetable pulav scores of, taste ranged from 6.63 to 7.8, flavour from 6.5 to 7.5, colour from 6.59 to 7.59, texture 6.4 to 7.5, over all acceptance score ranged from 6.51 to 7.69 and total volatiles ranged from 0.016 to 0.114%.

Quadratic response surface models were selected for all the responses in both the fibre rich RTE products. The adequacy was calculated by F ratio, mean, standard deviation, coefficient correlation (Tables **5** and **6** for bisi bele bhath and vegetable pulav respectively) and lack of fit test. The mean values and standard deviation for taste, flavour, colour, texture, aver all acceptance and total volatiles in bisi bele bhath were 6.67±0.15, 6.82±0.16, 6.82±0.20, 6.83±0.28, 6.84±0.083 and 0.056±0.0075 respectively and in vegetable pulav it was 7.04±0.13, 7.07±0.11, 7.09±0.10, 7.07±0.12, 7.09±0.057 and 0.043±0.0052. All the selected models were statistically significant. The regression coefficient, correlation for the responses were 0.93 for taste, 0.95 for flavour, 0.98 for over all acceptance and 0.94 for taste 0.90 for flavour, 0.93 for colour, 0.95 for texture, 0.98 for over all acceptance and 0.99 for total volatiles in vegetable pulav indicating that all the values were more than 90%, except 0.89 for colour, 0.8 for texture, 0.84 for

Table 5: Coefficient of Second Order Polynomial Regression Models for Fibre Rich Bisi Bele Bhath

Coefficient	Taste	Flavor	Colour	Texture	OAA*	T. Volatiles
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
R^2 %	93.59	95.68	89.6	80.54	98.51	84.67
p%	<0.0001	<0.0001	<0.0001	<0.05	<0.0001	<0.01
Mean	6.67	6.82	6.82	6.83	6.84	0.056
SD±	0.15	0.16	0.20	0.28	0.083	0.0075
F-value	31.63	24.62	18.66	4.60	73.27	6.14

SD – Standard deviation.
*Over all acceptability (OAA) scored on nine point Hedonic scale.

Table 6: Coefficient of Second Order Polynomial Regression Models for Fibre Rich Vegetable Pulav

Coefficient	Taste	Flavor	Colour	Texture	OAA*	T. Volatiles
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
R^2 %	94.26	90.84	93.83	95.34	98.52	99.01
p%	0.0127	0.0374	0.0150	0.0078	0.0005	0.0002
Mean	7.04	7.07	7.09	7.07	7.09	0.043
SD±	0.13	0.11	0.10	0.12	0.057	5.285
F-value	9.13	5.51	8.46	11.36	37.03	55.55

SD – Standard deviation.
*Over all acceptability (OAA) scored on nine point Hedonic scale.

total volatiles in bisi bele bhath and lack of fit was highly non-significant.

The multiple coded equations in terms of coded factors generated for the responses for bisi bele bhath and vegetable pulav are shown below.

Bisi Bele Bhath

Taste = $+ 6.76 - 0.42 X_1 + 0.019 X_2 + 0.31 X_3$
$-0.018 X_1^2 - 0.087 X_2^2 - 0.021 X_3^2$
$-0.11 X_1 X_2 - 0.20 X_1 X_3 - 0.045 X_2 X_3$

Flavour = $+6.86 - 0.53 X_1 + 0.054 X_2 + 0.20 X_3$
$+0.047 X_1^2 - 0.059 X_2^2 - 0.041 X_3^2$
$+0.000 X_1 X_2 - 0.30 X_1 X_3 - 0.13 X_2 X_3$

Colour = $+6.79 -0.46 X_1 + 0.079 X_2 + 0.28 X_3$
$+0.052 X_1^2 + 0.052 X_2^2 - 0.054 X_3^2$
$+0.039 X_1 X_2 - 0.20 X_1 X_3 - 0.049 X_2 X_3$

Texture = $+6.79 -0.45 X_1 + 0.045 X_2 + 0.14 X_3$
$-0.055 X_1^2 + 0.051 X_2^2 + 0.051 X_3^2$
$+0.000 X_1 X_2 -0.15 X_1 X_3 -0.025 X_2 X_3$

OAA = $+6.85 -0.48 X_1 + 0.021 X_2 +0.25 X_3$
$+0.030 X_1^2 + 0.030 X_2^2 -0.071 X_3^2$
$-0.0000 X_1 X_2 - 0.22 X_1 X_3 -0.035 X_2 X_3$

Total Volatiles = $+ 0.059 – 0.0062 X_1 – 0.00815 X_2 + 0.012 X_3$
$- 0.00488 X_1^2 + 0.0057 X_2^2 – 0.00461 X_3^2$
$- 0.0015 X_1 X_2 - 0.00315 X_1 X_3 - 0.0028 X_2 X_3$

Vegetable Pulav

Taste = $+7.03 - 0.25 X_1 + 0.042 X_2 - 0.088 X_3$
$+ 0.19 X_1^2 - 0.068 X_2^2 - 0.10 X_3^2$
$- 0.091 X_1 X_2 + 0.095 X_1 X_3 + 0.19 X_2 X_3$

Flavour = $+7.06 - 0.35 X_1 + 0.11 X_2 - 0.035 X_3$
$- 0.011 X_1^2 + 0.014 X_2^2 + 0.014 X_3^2$
$- 0.035 X_1 X_2 + 0.056 X_1 X_3 - 0.20 X_2 X_3$

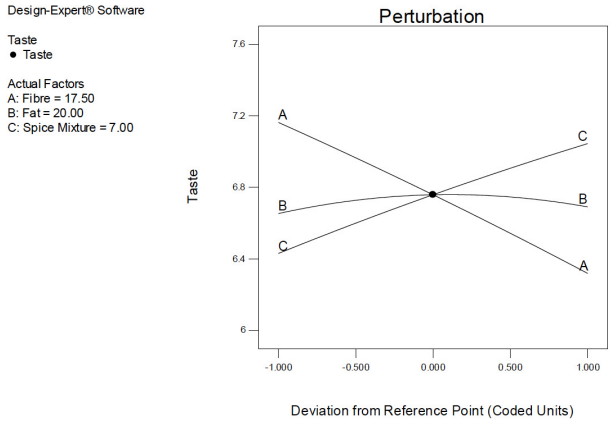
Colour = $+7.16 - 0.35 X_1 + .11 X_2 + 0.000 X_3$
$-0.032 X_1^2 - 0.057 X_2^2 - 0.032 X_3^2$
$+ 0.012 X_1 X_2 + 0.019 X_1 X_3 - 0.14 X_2 X_3$

Texture = $+7.17 - 0.39 X_1 + 0.071 X_2 + 0.035 X_3$
$- 0.10 X_1^2 + 0.020 X_2^2 - 0.10 X_3^2$
$+ 0.035 X_1 X_2 + 0.071 X_1 X_3 + 0.011 X_2 X_3$

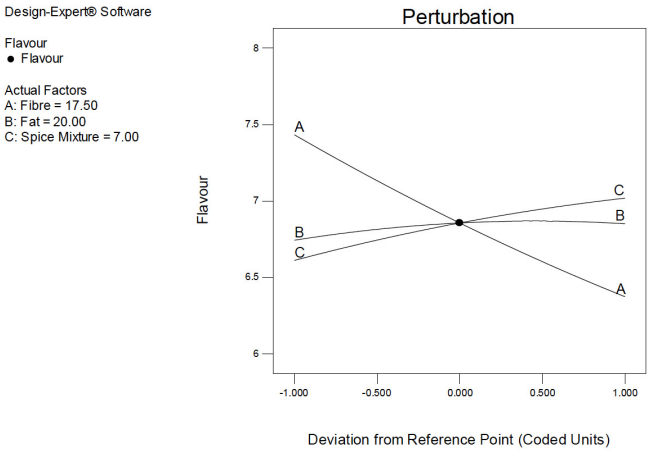
OAA = $+ 7.15 - 0.39 X_1 + 0.11 X_2 + 0.035 X_3$
$+ 0.036 X_1^2 - 0.046 X_2^2 - 0.069 X_3^2$
$+ 0.054 X_1 X_2 + 0.11 X_1 X_3 - 0.089 X_2 X_3$

Total Volatiles = $+ 0.022 + 0.0042 X_1 + 0.033 X_2 + 0.0032 X_3$
$+ 0.0011 X_1^2 + 0.021 X_2^2 + 0.016 X_3^2$
$- 0.012 X_1 X_2 + 0.00513 X_1 X_3 + 0.011 X_2 X_3$

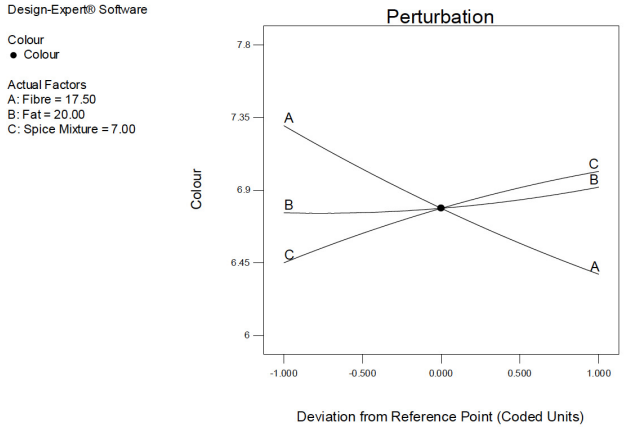
Figures **1a** to **1f** and **2a** to **2f** represents the changes in responses of RTE fibre rich for bisi bele bhath and vegetable pulav respectively with respect to fibre, fat and spice mixture in for bisi bele bhath and fibre, spice mixture and water in vegetable pulav. It is



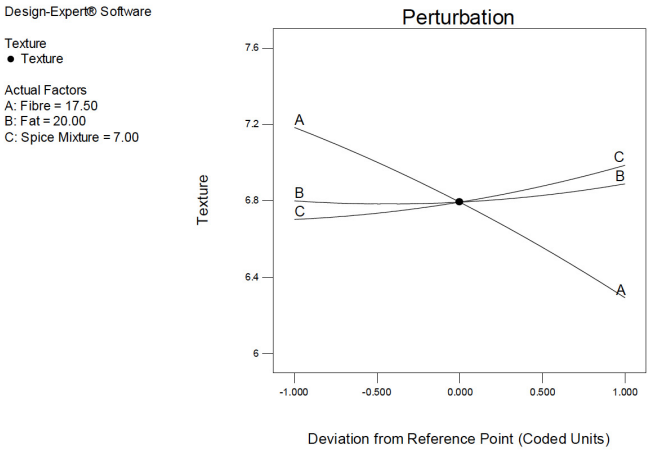
(a) Taste



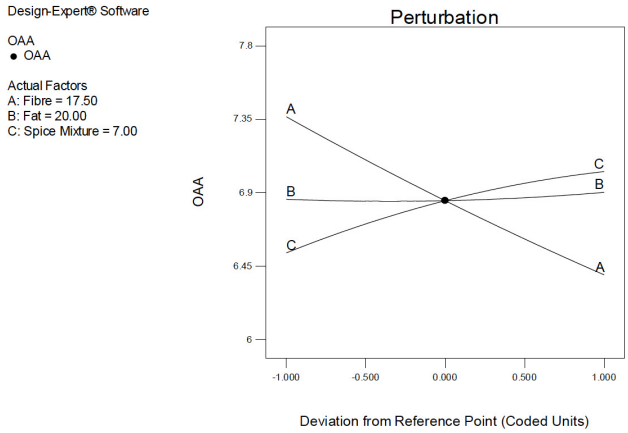
(b) Flavour



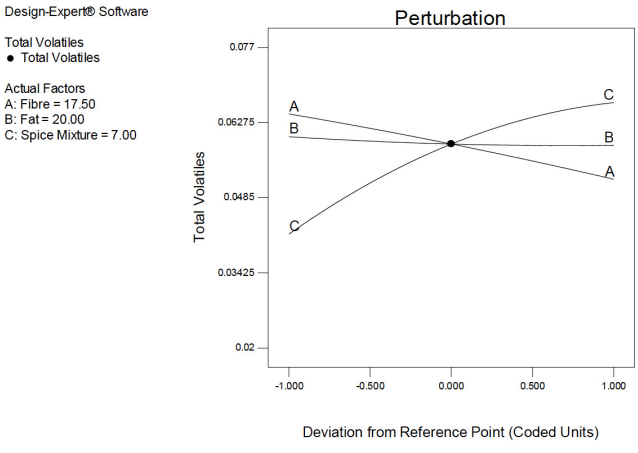
(c) Colour



(d) Texture

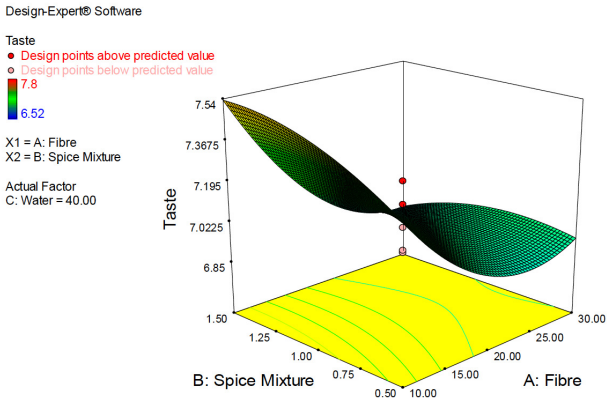


(e) OAA

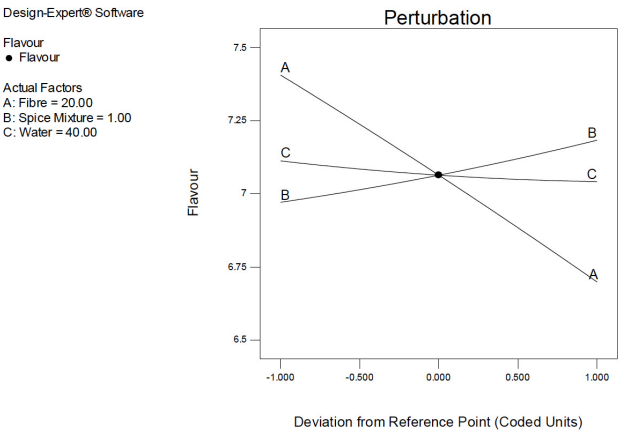


(f) Total Volatiles

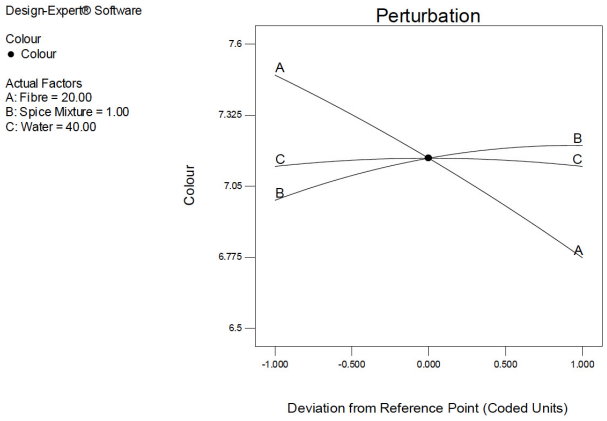
Figure 1: Perturbation graphs depicting effect of independent variables on responses of the RTE Fibre rich bisi bele bhath.



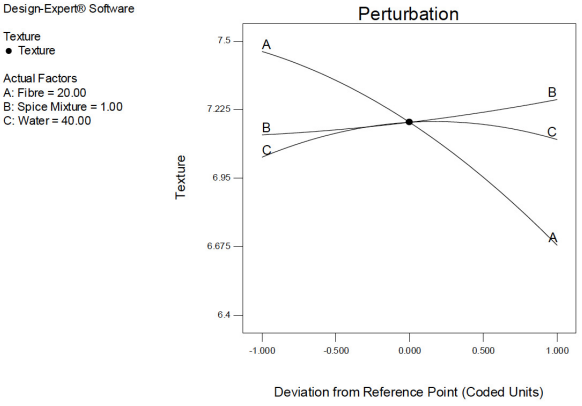
(a) Taste



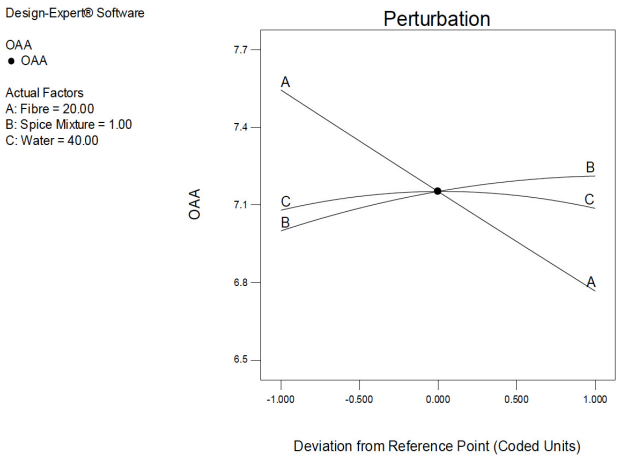
(b) Flavour



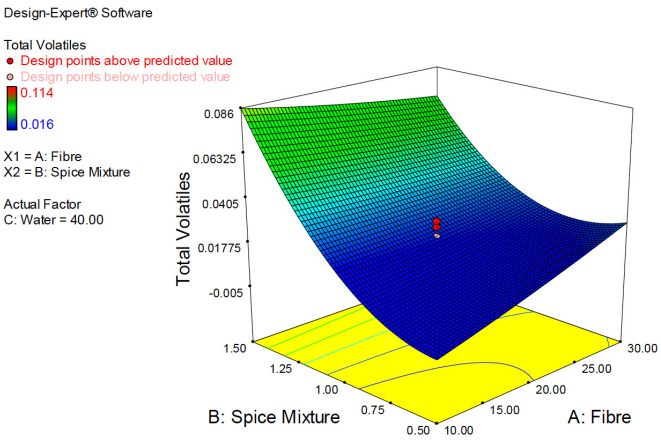
(c) Colour



(d) Texture



(e) OAA



(f) Total Volatiles

Figure 2: Perturbation and 3D graphs depicting effect of independent variables on responses of the RTE Fibre rich vegetable pulav.

clear from Figures **1a** to **1f** and **2a** to **2c** that spice mixture concentration influenced all the parameters. As there was increase in spice mixture there was increase in sensory score and total volatiles where as it was found that as fibre concentration increased it decreased the sensory scores in both the products,

while fat concentration had lesser influence in the fibre rich RTE bisi bele bhath.

3.2. Optimization of Independent Variable

Numerical optimization of independent variables, ashgourd fibre, fat and spice mixture and ashgourd fibre, spice mixture and water in RTE fibre rich bisi bele bhath and vegetable pulav were optimised using design expert statistical software. The criteria used along with the predicted and actual values of response are given in Tables **7** and **8** for bisi bele bhath and vegetable pulav respectively. The aim of the experiment was to develop an acceptable fibre rich RTE product with maximizing the sensory score. The solution obtained was 10gm ashgourd fibre, 20gm and 10gm spice mixture with best fit desirability of 0.976 for bisi bele bhath and 10gm ashgourd fibre, 0.5gm spice mixture and 30 ml water is the best fit desirability of 0.861 for vegetable pulav.

Table 7: Predicted and Actual Response Values for Bisi Bele Bhath

Responses	Predicted	Actual
Taste (Score)	7.60	7.98
Flavour (Score)	7.89	8.30
Colour (Score)	7.76	8.26
Texture (Score)	7.51	8.26
Overall Acceptability (Score)	7.67	7.98
Total Volatiles (%)	0.02	0.095

Table 8: Predicted and Actual Response Values for Vegetable Pulav

Responses	Predicted	Actual
Taste (Score)	7.54	8.01
Flavour (Score)	7.17	7.59
Colour (Score)	7.17	7.54
Texture (Score)	7.38	7.81
Overall Acceptability (Score)	7.39	7.59
Total Volatiles (%)	0.025	0.044

Optimised results for bisi bele bhath and vegetable pulav were, taste 7.65 and 7.54, flavour 7.89 and 7.18, colour 7.73 and 7.18, texture 7.53 and 7.39 overall acceptance, 7.76 and 7.39 and total volatile 0.075 and 0.025 respectively. The predicted responses value as against actual value for responses as shown in Tables **7** and **8** were in concurrence with each other, hence the similar fitted models are suitable for predicting the responses.

3.3. Storage Stability of the Products

The optimised batch of fibre rich products were kept for the storage stability studies at three different temperatures such as +5°C, RT (15-34°C) and 37°C and analysed periodically. At 10% ashgourd fibre addition, the products were well accepted. The proximate composition of both the control i.e., without added fibre and experimental i.e., with added fibre is given in the Table **9** RTE bisi bele bhath contains about 3 to 3.5gm protein, 6.4 to 6.85 % of fat with energy value of 118 kcals per 100gm, while RTE vegetable pulav had 3 to 3.4 gm protein, 6.9 to 7.6 % of fat with energy value of 164 kcals per 100gm. It was observed that the changes in these parameters between control and fibre added RTE products are not significant. However, the dietary fibre profile shows the increased level of fibres in experimental samples as expected (Table **10**). The most important observation is that in RTE bisi bele bhath the dietary fibre was 4.5% in control sample, while it was 5.53% in fibre added sample. The soluble fibre was 1.1% as against 0.6% in control samples. Similarly insoluble fibre increase was by 1.66% in fibre rich product. In the case of vegetable pulav the total fibre increase was 3.24% in experimental sample with 2.1% of insoluble fibre and 1.1% of soluble fibre fraction.

The result of organoleptic evaluation in terms of colour, flavour, taste, texture, and overall acceptability on 9 point hedonic scale are given in Tables **11** and **12**. In general, the sensory score have decreased with the storage period as well as increased temperature of storage reflecting their effects relatively, in RTE fibre rich bisi bele bhath, the rate of decrease in the score of sensory attribute were lower than in RTE fibre rich vegetable pulav. In fibre rich RTE bisi bele bhath, the scores remained at 6.8 to 6.9 on 9 point hedonic scale showing the good acceptance of the product even after 8 months of storage at all temperatures.

However, fibre rich vegetable pulav showed an acceptability score upto 6 months storage at higher temperature, while, at lower temperatures of storage the samples were acceptable. Both the samples were microbiologically safe with respect to TPC, yeast and moulds, coliforms, and spores in stored samples and thus fibre rich products can have a shelf life of 6 months at 37ºC, while 8 months at lower temperatures of storage.

Table 9: Proximate Composition (%) of RTE Products

Parameters → Samples ↓	Moisture	Ash	Protein	Fat	Crude Fibre
Bisi bele Bhath					
Control	78	1.39	3.21	6.45	3.01
Experimental	75	1.55	3.46	6.85	4.17
Vegetable pulav					
Control	67	1.93	3.05	6.98	4.14
Experimental	63	2.03	3.36	7.57	5.56

Table 10: Dietary Fibre (%) Profile of RTE Products

Parameters → Sample name ↓	ISDF	SDF	TDF
Bisi bele Bhath			
Control	3.9	0.6	4.5
Experimental	4.43	1.1	5.53
Vegetable pulav			
Control	4.1	0.5	4.6
Experimental	6.2	1.54	7.74

ISDF: Insoluble dietary fibre; SDF: Soluble dietary fibre; TDF: Total dietary fibre; DIFF: Difference.

Table 11: Sensory Score of Fibre Rich RTE Bisi Bele Bath During Storage Period

Period (Months)	Temperature	Flavour	Taste	Consistency	Colour	OAA
Initial	°C	8.1 ± 0.41	7.8 ± 0.49	8.0 ± 0.49	8.1 ± 0.47	7.8 ± 0.56
2	5	7.9 ± 0.15	7.8 ± 0.29	7.9 ± 0.19	7.9 ± 0.34	7.7 ± 0.28
	15-34	7.8 ± 0.28	7.5 ± 0.20	7.8 ± 0.11	7.8 ± 0.28	7.5 ± 0.36
	37	7.8 ± 0.13	7.4 ± 0.11	7.7 ± 0.16	7.8 ± 0.21	7.5 ± 0.32
4	5	7.8 ± 0.24	7.6 ± 0.12	7.8 ± 0.22	7.8 ± 0.14	7.5 ± 0.16
	15-34	7.7 ± 0.28	7.4 ± 0.23	7.5 ± 0.23	7.7 ± 0.19	7.4 ± 0.28
	37	7.6 ± 0.26	7.1 ± 0.24	7.3 ± 0.14	7.5 ± 0.21	7.0 ± 0.33
6	5	7.7 ± 0.17	7.2 ± 0.15	7.5 ± 0.15	7.6 ± 0.21	7.2 ± 0.19
	15-34	7.5 ± 0.28	7.2 ± 0.36	7.2 ± 0.05	7.2 ± 0.15	7.1 ± 0.30
	37	7.3 ± 0.19	7.0 ± 0.17	7.1 ± 0.13	7.0 ± 0.21	7.0 ± 0.36
8	5	7.5 ± 0.30	6.9 ± 0.18	7.3 ± 0.28	7.3 ± 0.15	6.9 ± 0.21
	15-34	6.8 ± 0.21	6.9 ± 0.29	7.0 ± 0.31	7.0 ± 0.16	6.8 ± 0.28
	37	6.5 ± 0.12	6.7 ± 0.10	6.8 ± 0.29	6.8 ± 0.24	6.8 ± 0.38

Table 12: Sensory Score of Fibre Rich RTE Vegetable Pulav During Storage Period

Period (Months)	Temperature	Flavour	Taste	Consistency	Colour	OAA
Initial	°C	7.8 ± 0.49	7.8 ± 0.47	8.1 ± 0.38	7.6 ± 0.28	7.6 ± 0.13
2	5	7.8 ± 0.25	7.6 ± 0.21	7.9 ± 0.11	7.5 ± 0.38	7.5 ± 0.18
	15-34	7.6 ± 0.28	7.5 ± 0.20	7.7 ± 0.15	7.3 ± 0.18	7.4 ± 0.26
	37	7.5 ± 0.33	7.5 ± 0.31	7.7 ± 0.36	7.3 ± 0.11	7.4 ± 0.29
4	5	7.5 ± 0.14	7.6 ± 0.12	7.6 ± 0.12	7.2 ± 0.16	7.2 ± 0.21
	15-34	7.3 ± 0.26	7.3 ± 0.25	7.3 ± 0.22	7.1 ± 0.29	7.1 ± 0.26
	37	7.3 ± 0.26	7.2 ± 0.34	7.2 ± 0.34	6.8 ± 0.27	6.7 ± 0.31
6	5	7.2 ± 0.37	7.3 ± 0.15	7.3 ± 0.05	6.8 ± 0.18	6.9 ± 0.16
	15-34	7.0 ± 0.28	7.1 ± 0.16	7.0 ± 0.15	6.4 ± 0.19	6.5 ± 0.32
	37	6.9 ± 0.12	7.0 ± 0.18	6.6 ± 0.13	6.1 ± 0.21	6.3 ± 0.38
8	5	7.1 ± 0.30	6.9 ± 0.17	6.9 ± 0.18	6.5 ± 0.19	6.7 ± 0.16
	15-34	6.8 ± 0.18	6.3 ± 0.15	6.3 ± 0.37	5.9 ± 0.21	6.2 ± 0.39
	37	6.1 ± 0.27	5.8 ± 0.38	5.4 ± 0.26	5.1 ± 0.20	NA

The present study is concluded with the development of promising dietary fibre RTE products with the increased fibre fractions as well as good shelf life of 6 months which may have a greater impact on health benefits on constant consumption.

ACKNOWLEDGEMENT

The authors are thankful to Director, DFRL, Mysore for constant encouragement during the investigation. The authors acknowledgement the support provided by head of packaging division and head of food preservation and sensory science division, DFRL, Mysore.

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Received on 11-12-2013 Accepted on 22-01-2013 Published on 30-04-2014

DOI: http://dx.doi.org/10.6000/1927-5951.2014.04.02.7