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Optimization of Functional Food Ingredients and Their Processing Levels for Preparation of Vermicelli Using RSM

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Abstract

Vermicelli is prepared using whole or refined wheat flour. Response surface methodology (RSM) is the tool used for process optimization that explores relationship between several processes and responses. In present study, different variants of heart healthy vermicelli containing functional ingredients were developed to get an optimum recipe which is low in fat. Best variant was selected by semi trained panel using 9 point hedonic test and optimized having process variables- amount of flax seeds, orange juice and flax seed soaking time and responses- fat, crude fibre and overall acceptability. On the basis of ANOVA and regression coefficients applied, some optimum solutions were obtained. The best recipe of highest desirability was chosen and its overall attributes were evaluated through 5 point composite rating scale. Nutritional analysis of the optimum recipe was done. Results for ANOVA stated that process variables had a significant effect on the response; crude fibre ($p<0.05$). Results for regression coefficients suggested a fair fit of the model. The optimum solution obtained was- 12 g flax seeds, 10.59 hours soaking time and 20 ml orange juice and 1.97 fat, 0.90 crude fibre and 8.17 overall acceptability. The optimum recipe was low in fat, high in fibre and highly acceptable.

Keywords: Flax seeds, Functional foods, Optimization, Response surface methodology, Vermicelli,

Introduction

Traditional foods are expression of culture, history and life style. Challenges ahead in the development of heritage foods are value addition, convenience and health promotion. Vermicelli is a traditional Indian product prepared using whole or refined wheat flour. Hard dough is prepared, cold extruded and dried in the sun (Mogra and Midha 2013). Cereal grains are generally used as major raw material for development of extruded snack foods due to their good expansion characteristics because of high starch content (Kumar et al 2010). Extrusion has become a very important role in food processing operation. Today, the food extruder is used to produce pasta, ready-to eat cereals, snacks, confectionery products, modified starches for soup, baby food and instant foods, beverage bases and texturized vegetable proteins. It minimizes energy, time and cost (Vijayarani et al 2012). In contrast to most dietary supplements, functional foods are components of the usual diet that may have special disease prevention attributes and are the topic of current traditional scientific investigation (Choudhary and Tandon 2009). The health benefits and disease-preventive effects of functional foods have primarily been in several areas. These include treatment of cancer, atherosclerosis and other cardiovascular diseases (CVD), the process of ageing, and immune response- enhancing effect, as well as diabetes, among others (Lobo et al, 2010). Thus, value addition of functional foods can play a beneficial role in maintaining the heart health. The use of flaxseed has been advocated to combat CVD due to its high α- linolenic acid (ALA) content (Levya et al 2010). Orange contains vitamin C, carotenoids, and flavonoids, which are cardioprotective. Cholesterol lowering effect of orange is produced by limonene (Parle and Chaturvedi 2012).

Applications of science and technology within the food system have allowed production of foods in adequate quantities to meet the needs of society, as it has evolved (Floros 2008). One of the recent techniques being used for development of optimum food products to enhance their nutritional quality is process optimization. Response surface methodology (RSM) is a powerful mathematical model with a collection of statistical techniques where in, interactions between multiple process variables can be identified with fewer experimental trials (Karuppaiya et al 2010). In order to formulate and test ingredients that will be used, many food processing industries use statistical approaches such as RSM in their research department in order

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to achieve the best formulation in relation to sensory acceptance, shelf life, nutritional demands, and physicochemical stability of product. RSM has important application in the design, development and formulation of new products, as well as in the improvement of existing product design. Therefore, technological unit operations and system set up can also be optimized, decreasing thus the volume of experiments and ingredients, time, chemicals, total financial input, energy, etc. (Jambrak 2012). In food research studies, RSM is frequently used to optimize the efficiency of the ingredients such as fibres, improvers, composite flours, optimization in food processes like product development, functional food preparation, etc., as well as in optimizing processing conditions (Das et al 2012). Central composite design (CCD) is a technique used commonly for RSM. It is a design of experimental technique (Raungmee and Sangwichein 2013).

Several studies have been conducted related to process optimization of food product development. Karrupaiya et al. (2010) conducted a study on optimization of process variables using RSM for ethanol production from cashew apple juice by *Saccharomyces cerevisiae* to obtain optimum conditions to get maximum ethanol concentration. Emire and Tiruneh (2012) conducted a study on optimization of formulation and process conditions to produce gluten-free bread from sorghum using RSM. Das et al. (2012) conducted a study to see the effect of baking conditions on the physical properties of herbal bread using RSM. But, apart from these studies, there is no study related to optimization of food products incorporating functional ingredients to enhance their nutritional properties contributing to produce healthy heart food products. Thus, the present study was conducted with the objectives to prepare low fat vermicelli with value addition of flax seeds and orange juice and to conduct statistical process optimization of food products for amount and pretreatment of functional ingredients using RSM. The optimum recipe was subjected to sensory as well as nutritional analysis to ensure its beneficial role in maintaining healthy heart.

Materials and methods

The central aim of the food product development was to devise vermicelli to fulfill the essential nutritional needs while preventing the severity of heart disease and to also ensure that the recipes were low cost, palatable and easy to cook. The raw ingredients for the purpose of food product development were purchased from the local market of BanasthaliVidyapith. Flax seeds of good brand were obtained from the general store, New Delhi.

Development and standardization of food products

The standard vermicelli recipe was prepared using wheat flour, gram flour and defatted soy flour. The variations were in the amount of flax seeds, soaking time of flax seeds and amount of orange juice that were added to the dough. Variant I was prepared adding 8 g of flax seeds with 6 hours of soaking time and 20 ml of orange juice; variant II was prepared adding 10 g of flax seeds with 8 hours of soaking time and 30 ml of orange juice; variant III was prepared adding 12 g of flax seeds with 10 hours of soaking time and 40 ml orange juice and variant IV was prepared adding 15 g of flax seeds with 12 hours of soaking time and 50 ml of orange juice to the dough. The dough was extruded to make vermicelli which were thereafter dried and roasted. In order to conduct sensory evaluation, vermicelli was sauted with vegetables and then cooked by simmering until all the water was absorbed.

Sensory evaluation

The best variant of the vermicelli was selected on the basis of overall acceptability using 9 point hedonic test (Dharampal et al 1995). This was conducted by a 15 membered semi trained panel which was selected using triangle test. In this test, the panelists were asked to measure the degree of pleasurable and unpleasurable experience of food products on a nine point hedonic rating scale from "like extremely" to dislike extremely". The former carried a score of 9 while latter was scored as 1. The 5 point composite rating scale was conducted to evaluate the optimum precooked vermicelli for low fat food on the basis of their organoleptic characteristics. The 5 point composite rating scale was conducted to judge the food products on the basis of sensory attributes; appearance, colour, taste, texture and after taste. In this test, the panelists were asked to measure the specific characteristics of a product which were rated separately. Each of these attributes was rated on 5 point scale with 5 considered as "excellent" and 1 considered as "poor.

Process optimization

The process optimization of best selected variant of vermicelli was conducted. RSM that explores the relationship of several independent variables with response variables to get an optimum solution was employed in this study. CCD was used to design the experiments compromising of three independent processing parameters (table 1). The effect of these process variables were seen on the response variables; fat, crude fibre and overall acceptability. The experiment sheet of 20 variants with different

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process variables was generated. The response variables were to be estimated and entered in the sheet. There were 6 experiments at centre point to calculate the repeatability of the method. This data was subjected to analysis of variance (ANOVA) one way analysis and regression coefficients (R^2) to get the optimum response. A good model must be significant and the lack of fit must be insignificant. Coefficient of determination (R^2) values should be close to 1. The predicted R^2 value should be in reasonable agreement with adjusted R^2 (Bunkar et al 2012). R^2 can be defined as the ratio of explained variation to the total variation which was a measure of the degree of fit (Chan et al 2009). The coefficient of variation (CV) describes the extent to which the data are dispersed (Liyana-pathirapa and Shahidi 2005).

Data analysis

The experiments were performed and responses were fitted in the design. After each individual experiment, responses were analyzed to assess the effect of independent variables on them. Numerical optimization technique of the design expert software (7.0) was used for simultaneous optimization of the multiple responses.

Physicochemical analysis

The physicochemical analysis of the optimum recipe was conducted to evaluate the nutritional adequacy of the food product. Moisture and ash were estimated by the standard procedure provided in NIN (2003). Protein was estimated using microkjeldhal method using kel plus. Fat was determined by the Blorr method in which fat dissolved in solvent (petroleum ether) is estimated out by vaporizing the solvent. Crude fibre was estimated using acid and alkaline digestion method. Iron was estimated using Wong's method, calcium and vitamin C were determined by titrametric method (NIN 2003).

Results and discussion

The standard recipe was the most acceptable food product with highest mean scores of 8.26. The mean scores of standard and variants were in between 7.06 to 8.26. The variants obtained comparatively lower scores on hedonic scale. The best selected recipe for the vermicelli was variant II with 10 g flax seeds, 8 hours soaking time of flax seeds and 30 ml orange juice with the highest mean score of 8.06. The lowest mean score was obtained by variant III that had 12 g flax seeds with 10 hours soaking time and 40 ml orange juice. Rathi and Mogra (2013) conducted a study on sensory evaluation of biscuits prepared with flaxseed flour (20%, 30% and 40%). Results of sensory evaluation revealed that the overall acceptability of biscuitsranged from 8.6 to 6.4. This indicated that the recipes were found to fall under the category of liked very much to like slightly. As the level of flaxseed was increased to 40 percent, decrease in all sensory attributes was noticed. The results were similar to the present study.

The best recipe was optimized using CCD. Three factors were studied to get the optimum values. The experimental sheet of different process variables; amount of flax seeds and orange juice with soaking time was generated and the responses; estimated fat, crude fibre and overall acceptability were entered in the sheet (table 2). The data was analyzed on the basis of ANOVA and regression coefficients. The effect of different process variables were studied on different responses to obtain an optimum solution.

ANOVA

The results of ANOVA for the effect of process variables on fat were analyzed (table 3). The probability (p value) was greater than F value and was more than 0.05 for the model. Thus, the terms in the model had a non-significant effect on the response, fat. The lack of fit was significant, indicating that the model did not fit the data well. The results of effect of process variables on response, crude fibre (table 4) revealed that the probability (p value) was less than F value ($p<0.05$) for the model. Thus, the terms in the model had a significant effect on the response, crude fiber. The lack of fit was significant, indicating that the model did not fit the data well. The results for the effect of process variables on overall acceptability (table 5) indicated that there was no F value or p value for the model. Thus, the terms in the model had neither a significant effect, nor a non-significant effect on the response.

Regression coefficient (R^2)

The parameters obtained by fitting of fat, crude fibre and overall acceptability data are presented in table 6, along with the regression coefficients of intercept, linear, quadratic and crossproduct terms of model. The R^2 values were 0.5716 and 0.6070 for fat and fibre respectively, suggesting a fair fit of the model. The higher CV values for fat and fibre indicated that the results were comparatively less precise and reliable. The lower CV value for overall acceptability indicated that the result was precise and reliable.

Effect of process parameters on fat

The regression equation describing the effect of the process variables on fat of vermicelli in terms of actual level of the variables are given as:

Fat=26.93010-4.28633*Flaxseed-
1.67784*Soakingtime+0.4146*Orangejuice+

0.035000*Flaxseed*Soakingtime+7.33333E–00*Flaxseed*Orangejuice-0.031375*Soakingtime*Orangejuice+0.16781*Flaxseed^2+0.11693*Soakingtime^2-2.19936E-003*Orangejuice^2

The interactive effect of process variables, flax seeds and soaking time on the fat content (figure 1) depicted that the minimum of fat content (1.59589 g) was obtained at amount of flax seeds being 10.50 g and soaking time being 9-10 hours. The maximum of fat content (3.22531 g) was obtained at amount of flax seeds being 9.00-9.75 g and soaking time being 11-12 hours. The interactive effect of process variables, flax seed and orange juice on the fat content (figure 2) revealed that the minimum of fat content (2.10437 g) was obtained at amount of flax seeds being 10.50 to 11.25 g and orange juice 20-25 ml. The maximum of fat content (2.92599 g) was observed at amount of fax seeds, 9.00-9.75 g and orange juice, 30-35 ml. The interactive effect of process variables, soaking time and orange juice on fat content (figure 3) indicated that the minimum of fat content (1.63115 g) was observed at the soaking time of 9 hours and orange juice, 20-25 ml. The maximum of fat content (3.22703 g) was obtained at soaking time of 8-9 hours and orange juice, 35-40 ml.

Effect of process parameters on crude fibre

The regression equation describing the effect of the process variables on crude fibre content of vermicelli in terms of actual level of the variables are given as:

Fibre=-1.77387+0.092268*Flaxseed-0.065060*Soakingtime+0.11297*Orange juice+0.020000*Flexseed*Soakingtime–6.83333E–033*Flaxseed*Orangejuice–4.25000E-033*Soakingtime*Orange juice

The interactive effect of process variables, soaking time and flax seeds on the fibre content (figure 4) indicated that the minimum of fibre content (0.4432589 g) was obtained at the amount of flax seeds, 9.00-9.75 g and soaking time of 10 hours. The maximum of fibre content (0.914302 g) was obtained at 11.25-12.00 g flax seeds and 11-12 hours soaking time. The interactive effect of process variables, flax seeds and orange juice (figure 5) revealed that the minimum of fibre content (0.488073 g) was observed at 9.00-9.75 g flax seeds and 25-30 ml orange juice. The maximum of fibre content (0.824206 g) was observed at 11.25-12.00 g flax seeds and 20-25 ml orange juice. The interactive effect of process variables, soaking time and orange juice on fibre content (figure 6) indicated that the minimum of fibre content (0.681794 g) was obtained at 9 hours soaking time and 30-35 ml orange juice. The maximum of fibre content (0.962008 g) was obtained at 11-12 hours soaking time and 20-25 ml orange juice.

Effect of process parameters on overall acceptability

The regression equation describing the effect of the process variables on overall acceptability of vermicelli in terms of actual level of the variables are given as:

Overall acceptability = +8.17700

Optimization of process parameters

Numerical optimization was carried out for the process parameters to obtain the optimum product for low fat recipe. To perform this operation, design expert software was used for simultaneous optimization of multiple responses. The desired goals for each factor and response were chosen (table 7). The software generated 10 optimum conditions of process variables with the predicted values of responses (table 8). Solution 1, having the maximum desirability value, along with the minimum fat content, maximum fibre content and maximum overall acceptability was selected as optimum for vermicelli as low fat diet.

A study was conducted on optimization of extruded product pasta by Gupta and Shivhare. (2012) who conducted a study on optimization of process variables for the development of flax seed and deffated flaxseed based pasta. Central Composite Rotatable Design (CCRD) was used to optimize process parameters for development of flaxseed and defatted flaxseed based pasta products, by response surface methodology with three variables at five levels. The low and high levels of the variables were 70 to 90g for semolina; 10 and 30g for flaxseed or defatted flaxseed; 15 and 20% water (% of amount of semolina and flaxseed) for flaxseed based pasta, and 20 and 30% water (% of amount of semolina and flaxseed) for defatted flaxseed based pasta. The optimum values for process variable for maximum possible gelatinization, color parameter (L*), overall acceptability, minimum free fatty acid, and color parameter (a*) are semolina 90g, flaxseed 15g and water* 20 for flaxseed based pasta, and semolina 87.79g, flaxseed 15g and water* 30 for defatted flaxseed based pasta, where L* means lightness, with 100 for white, 0 for black; a* indicates redness when positive, and greenness when negative, b* indicates yellowness when positive, and blueness when negative and * Water (ml)=% of Semolina (g)+Defatted Flaxseed (g).

Trevisan and Areas (2012) conducted a study on development of corn and flaxseed snacks

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with high fibre content using RSM. In this study, the production of a high-fibre content snack food from a mixture of corn and flaxseed flours was optimized by response surface methodology. The independent variables considered in this study were: feed moisture, process temperature and flaxseed flour addition, as they were found to significantly impact the resultant product. These variables were studied according to a rotatable composite design matrix (21.68, 21, 0, 1, and 1.68). Response variable was the expansion ratio since it has been highly correlated with acceptability. The optimum corn flaxseed snack obtained presented a sevenfold increase in dietary fibre, almost 100% increase in protein content compared to the pure corn snack, and yielded an acceptability score of 6.93. This acceptability score was similar to those observed for corn snack brands in the market, indicating the potential commercial use of this new product, which can help to increase the daily consumption of dietary fibre.

Organoleptic attributes

The sensory attributes of optimized vermicelli were evaluated using 5 point composite rating scale. The results revealed that the mean scores of all the attributes were above 4. The acceptability of vermicelli for appearance, colour, taste, texture and after taste was better with mean scores of 4.1, 4.0, 4.1, 4.2 and 4.3 that indicated the higher acceptability of the optimum food product. Bhise and Kaur (2013) conducted a study on development of functional chapatti from texturized deoiled cake of sunflower, soybean and flaxseed. Their results revealed that the chapattis were highly acceptable on the basis of colour, appearance, texture and flavour which were similar to the results of the present study. Masoodi and Bashir (2012) conducted a study on fortification of biscuit with flaxseed, biscuit production and quality evaluation, in which the biscuits with standard recipe and varying levels of flaxseed flour were acceptable on the basis of colour, texture, aroma and taste. These results were similar to the present study.

Physicochemical analysis

The physicochemical properties of the optimum recipe were assessed to evaluate the food nutritionally. On the overall basis, the food product was found to be nutritionally adequate with moisture content of 4.54 g/100 g and ash content of 1.98 g/100 g. Good amount of protein content of 23.18 g/100 g was present. Fat content of 1.97 g/100 g and fibre content of 0.90 g/100 g was estimated. Fair amount of iron content of 3.11 mg/100g, calcium content of 174.14 mg/100g and vitamin C content of 25.02 g/100g was present. The energy (calculated) was 249.95 kcal. Rao et al. (2013) conducted a study on preparation and storage stability of flaxseed chutney powder, a functional food adjunct. The results for the proximate analysis of flaxseed flour indicated that moisture was 5.4 g/100 g, total ash was 2.4 g/100 g and protein was 24.2 g/100 g which were similar to the results of present study. Giacomino et al. (2013) conducted a study on extruded flax seed meal enhances the nutritional quality of cereal based products. The results for proximate analysis of the extruded meal indicated that moisture was 6.49 g/100 g; ash was 3.23 g/100 g; protein was 26.35 g/100 g and energy was 353 kcal/ 100 g. These results were almost similar to the present investigation.

Conclusion

Vermicelli was optimized using RSM and the effect of three process variables; amount of flax seeds and orange juice and soaking time of flax seeds was assessed on the response variables; fat, crude fibre and overall acceptability. The optimum solution obtained for the low fat food was 12 g flax seeds, 10.59 hours soaking time and 20 ml orange juice and 1.97 fat, 0.90 crude fibre and 8.17 overall acceptability. The optimum recipe is low in fat, high in fibre and highly acceptable which apart from providing nutritional benefits is also beneficial for maintaining the healthy heart of the consumers. It can be easily consumed as foods add on without altering the diet of a person. Thus, the optimum recipe is easily acceptable.

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Table 1. Levels of process factors to optimize vermicelli

Factor	Units	Low level (-1)	High level (+1)	(-) Alfa	(+) Alfa
Flax seeds (A)	g	9	12	7.97731	13.0227
Soaking time (B)	Hours	8	12	6.63641	13.3636
Orange juice (C)	ml	20	40	13.1821	46.8179

Table 2. Experimental design generated and observed responses of vermicelli

	Generated			**Estimated**		
S.no.	**Flax seed (g)**	**Soaking time (hours)**	**Orange juice (ml)**	**Fat (g)**	**Crude Fibre (g)**	**Overall acceptability**
1	10.50	10.00	30.00	2.55	0.63	7.33
2	12.00	8.00	40.00	3.45	0.41	8.06
3	12.00	12.00	40.00	3.93	0.62	8.06
4	9.00	12.00	40.00	4.08	0.34	8.46
5	10.50	10.00	30.00	2.46	0.72	7.60
6	9.00	8.00	20.00	2.15	0.23	8.33
7	7.98	10.00	30.00	2.48	0.16	8.66
8	9.00	8.00	40.00	5.36	0.82	8.20
9	10.50	6.64	30.00	3.36	0.56	8.00
10	12.00	8.00	20.00	1.14	0.68	8.60
11	10.50	10.00	30.00	2.45	0.65	8.86
12	12.00	12.00	20.00	2.79	0.78	7.93
13	10.50	10.00	30.00	2.63	0.61	8.86
14	10.50	10.00	46.82	1.18	0.59	8.20
15	13.02	10.00	30.00	3.11	0.89	8.40
16	10.50	10.00	13.18	1.03	0.67	7.60
17	10.50	10.00	30.00	2.28	0.78	8.00
18	9.00	12.00	20.00	4.72	0.54	8.13
19	10.50	10.00	30.00	2.08	0.68	7.93
20	10.50	13.36	30.00	2.74	0.76	8.33

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Table 3. ANOVA for effect of process variables on fat of vermicelli (generated by Design Expert)

Source	Sum of squares	Degrees of freedom	Mean square	F value	p value Prob>5
Model	13.80	9	1.53	1.48	0.2375 NS
A	1.14	1	1.14	1.10	0.3191
B	0.41	1	0.41	0.40	0.5412
C	2.88	1	2.88	2.78	0.1261
AB	0.088	1	0.088	0.085	0.7763
AC	0.097	1	0.097	0.094	0.7659
BC	3.15	1	3.15	3.05	0.1116
A^2	2.05	1	2.05	1.99	0.1891
B^2	3.15	1	3.15	3.05	0.1114
C^2	0.70	1	0.70	0.67	0.4308
Residual	10.34	10	1.03		
Lack of fit	10.15	5	2.03	51.27	0.0003*
Pure error	0.20	5	0.040		
Core total	24.15	19			

NS-Non significant, *- significant

Table 4. ANOVA for effect of process variables on fiber of vermicelli (generated by Design Expert)

Source	Sum of squares	Degrees of freedom	Mean square	F value	p value Prob>5
Model	0.42	6	0.071	3.35	0.0322*
A	0.23	1	0.23	11.10	0.0054
B	0.017	1	0.017	0.79	0.3909
C	2.231E-003	1	2.231E-003	0.11	0.7502
AB	0.029	1	0.029	1.37	0.2636
AC	0.084	1	0.084	3.99	0.0673
BC	0.058	1	0.058	2.74	0.1218
Residual	0.27	13	0.021		
Lack of fit	0.25	8	0.032	7.99	0.0174*
Pure error	0.020	5	3.977E-003		
Core total	0.70	19			

*- significant

Table 5. ANOVA for effect of process variables on overall acceptability of vermicelli (generated by Design Expert)

Source	Sum of squares	Degrees of freedom	Mean square	F value	p value Prob>5
Model		0.000	0		
Residual		3.12	19	0.16	
Lack of fit	1.08	14	0.077	0.19	0.9937 NS
Pure error	2.04	5	0.41		
Core total	3.12	19			

NS-Non significant

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Table 6. Regression coefficients of predicted quadratic polynomial models of vermicelli (generated by Design Expert)

Coefficient	Fat	Fibre	Overall acceptability
Intercept	2.37	0.61	8.18
Linear			
A	-0.29	0.13	
B	0.17	0.035	
C	0.46	-0.013	
Quadratic			
A^2	0.38		
B^2	0.47		
C^2	-0.22		
Crossproduct			
AB	0.10	0.060	
AC	0.11	-0.10	
BC	-0.63	-0.085	
R^2	0.5716	0.6070	0.0000
Adjusted R^2	0.1861	0.4257	0.0000
CV%	36.34	23.96	4.96

R^2- Coefficient of multiple determinations; CV- coefficient of variance

Table 7. Optimization criteria for different process variables and responses of vermicelli (generated by Design Expert)

Factors/ responses	Goal	Lower limit	Upper limit	Importance
Flax seed (g)	In range	9	12	3
Soaking time (hrs)	In range	8	12	3
Orange juice (ml)	In range	20	40	3
Fat (g)	Minimize	1	3	3
Fibre (g)	Maximize	0.75	1	3
Overall acceptability	Maximize	8	9	3

Table 8. Solutions for optimum conditions of vermicelli (generated by Design Expert)

S.No.	Flax seed (g)	Soaking time (hrs)	Orange juice (ml)	Fat (g)	Crude Fibre (g)	Overall acceptability	Desirability
1	12.00	10.59	20.00	1.97988	0.905314	8.177	0.383
2	12.00	10.62	20.00	1.99924	0.908238	8.177	0.383
3	12.00	10.58	20.08	1.97991	0.903124	8.177	0.381
4	12.00	10.84	20.00	2.13428	0.927693	8.177	0.379
5	12.00	10.58	20.46	2.01006	0.897834	8.177	0.373
6	11.93	10.35	20.00	1.82726	0.872646	8.177	0.371
7	11.89	10.70	20.00	2.01954	0.896339	8.177	0.370
9	12.00	10.74	20.52	2.11339	0.911387	8.177	0.370
10	11.75	11.15	20.00	2.55772	0.941892	8.177	0.311

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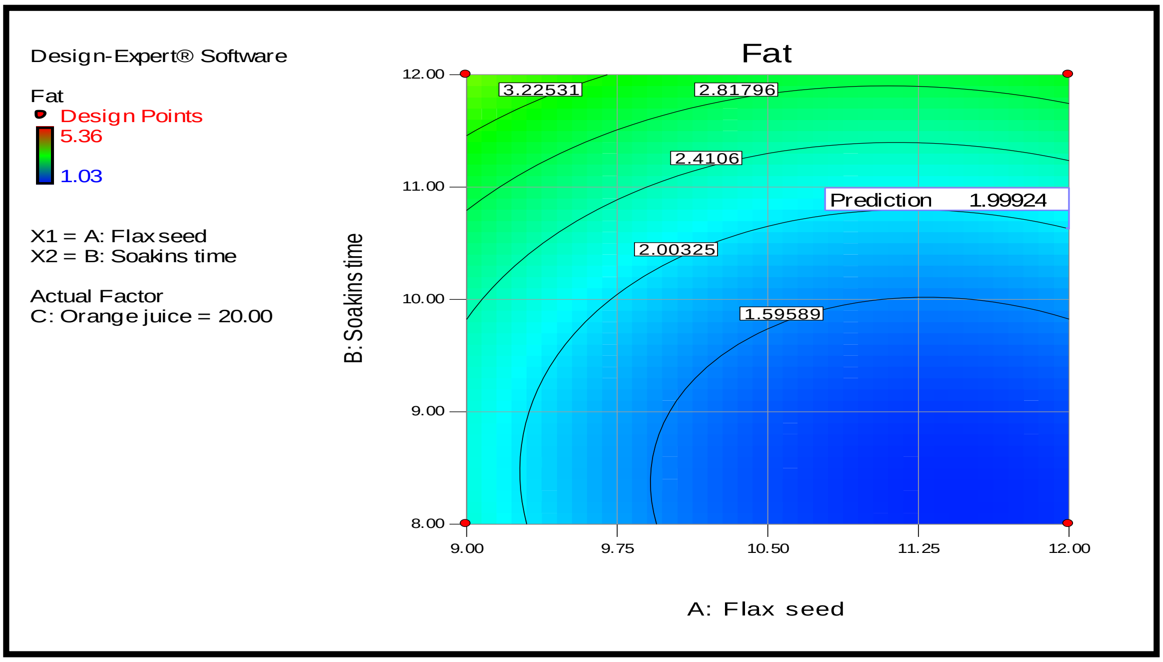

Figure 1. Interactive effect of flax seed and soaking time on fat content of vermicelli

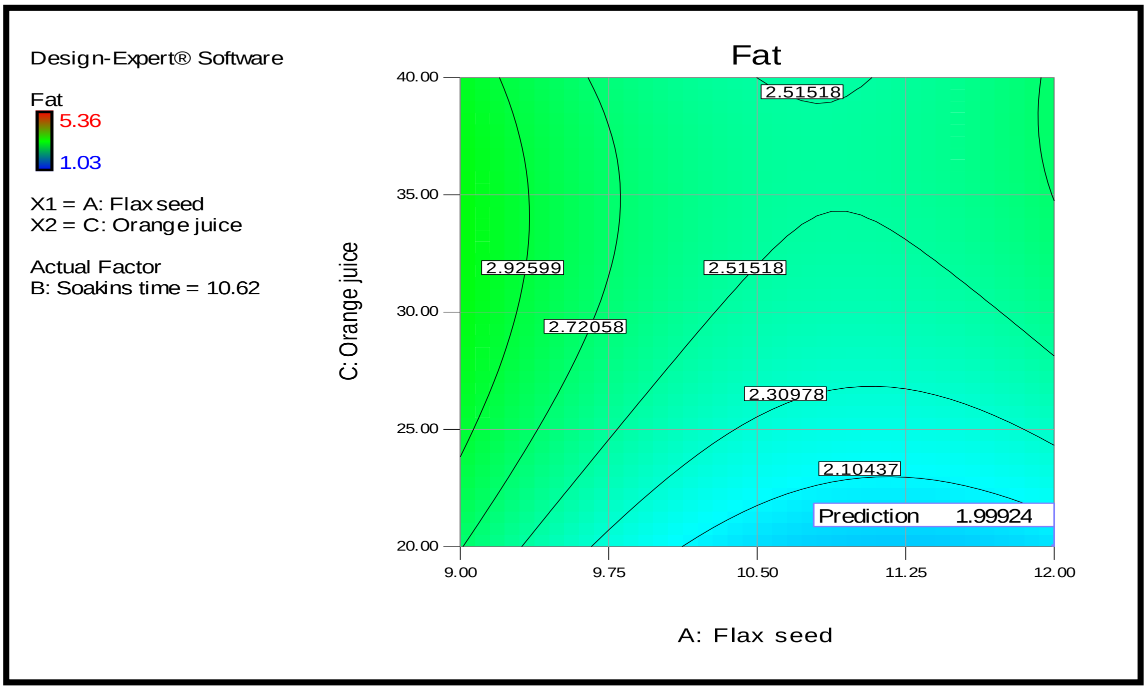

Figure 2. Interactive effect of flax seed and orange juice on fat content of vermicelli

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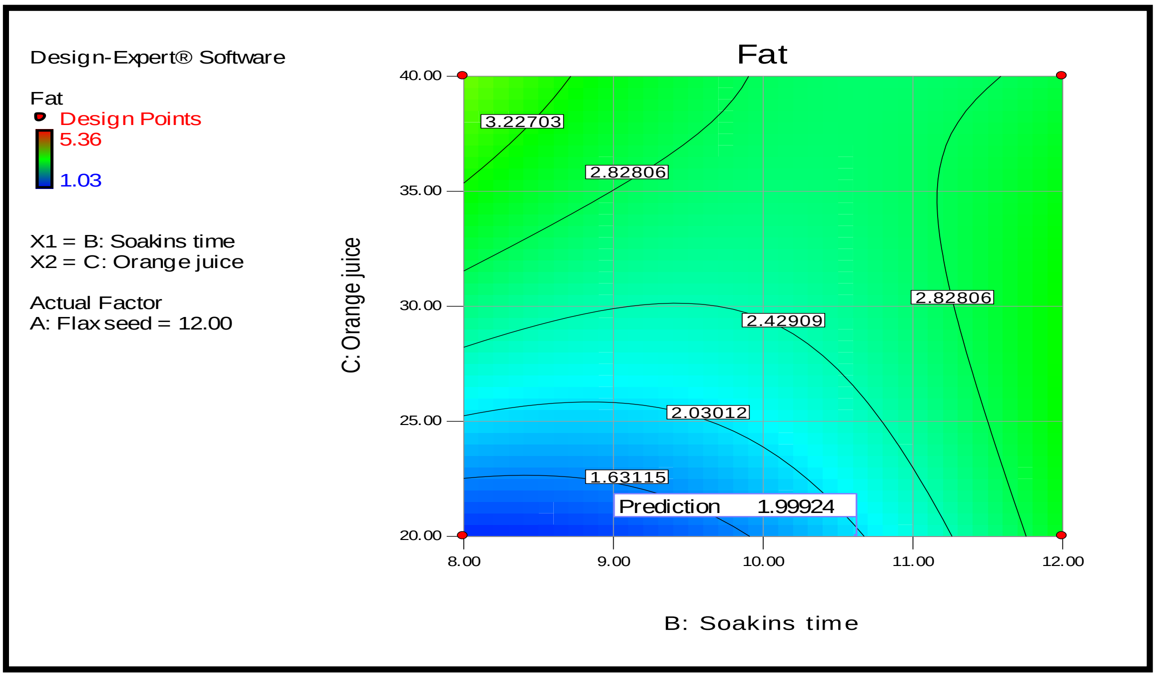

Figure 3. Interactive effect of soaking time and orange juice on fat content of vermicelli

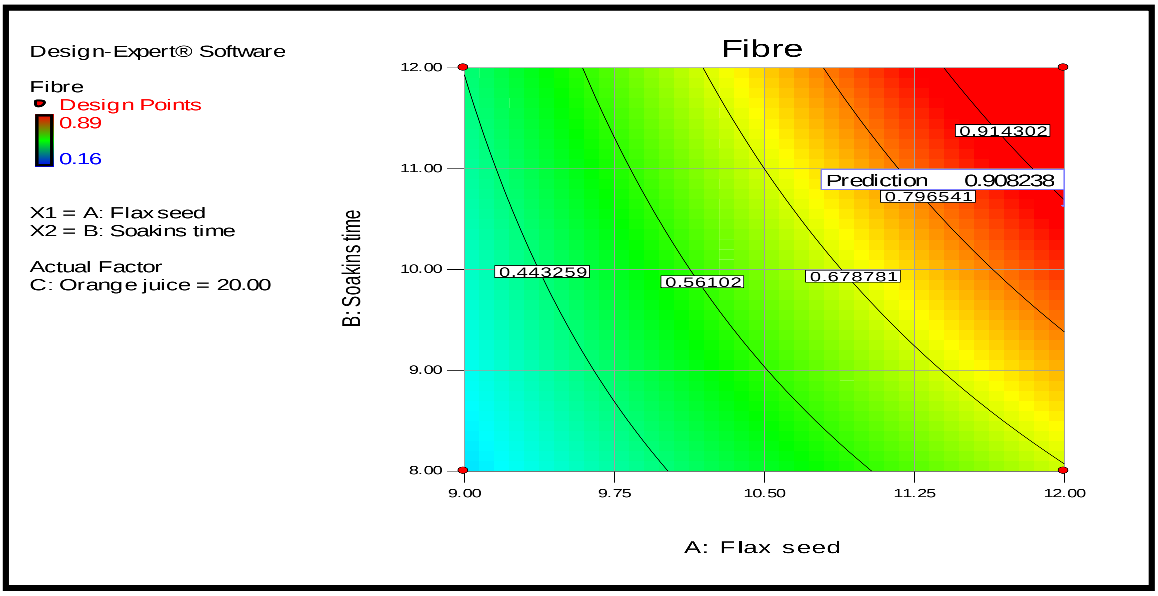

Figure 4. Interactive effect of flax seeds and soaking time on fibre content of vermicelli

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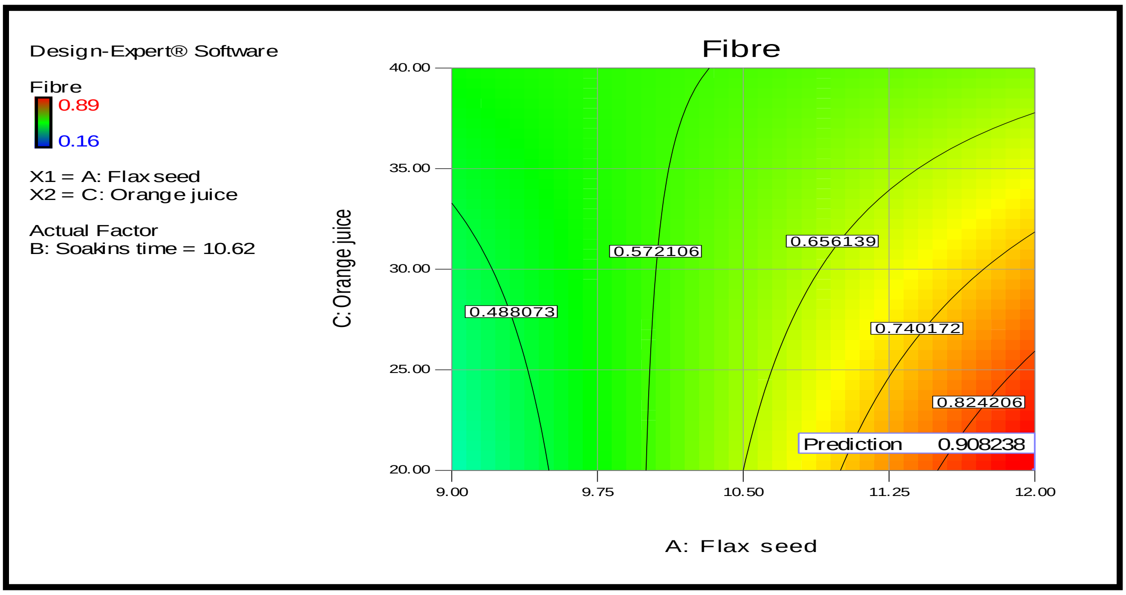

Figure 5. Interactive effect of flax seeds and orange juice on fibre content of vermicelli

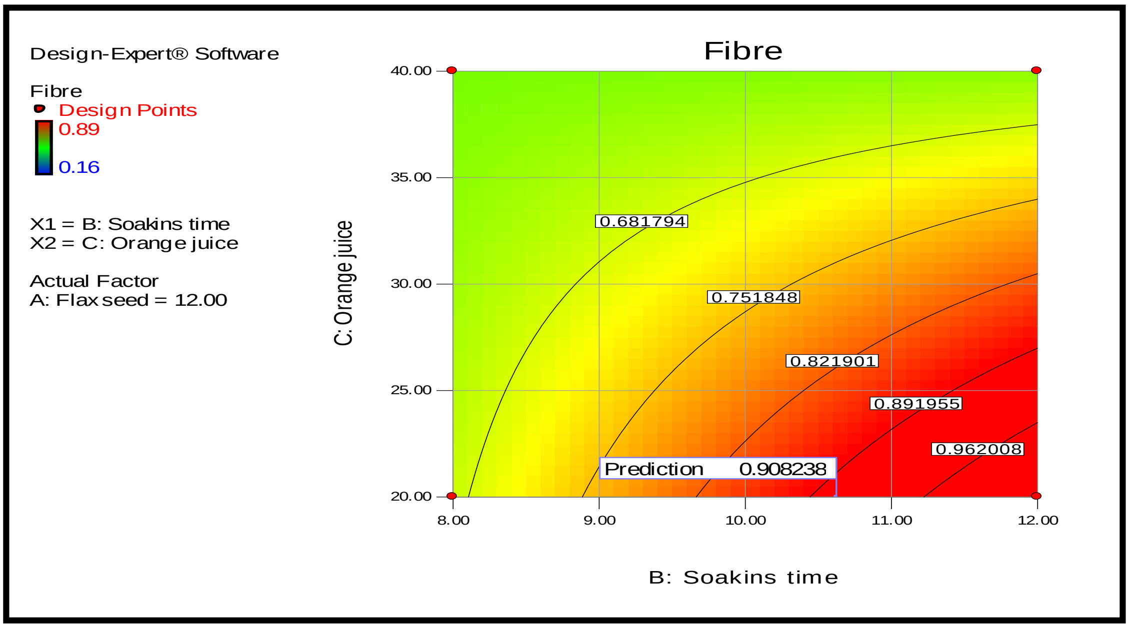

Figure 6. Interactive effect of soaking time and orange juice on fibre content of vermicelli

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