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RESEARCH ARTICLE

OPTIMIZATION OF ROASTED LINSEED POWDER (RLSP) INCORPORATED CHAPPATHI FOOD USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

Flaxseed (*Linum Usitatissimum)* is generally cultivated for linen fiber or for oil from its seeds. Flaxseed is richest source of alpha-linolenic acid, lignans and other nutritional components. Diet is one of the most important factors that are necessary for the better health of an individual. Provision of diet for the maintenance of physical and mental health is a basic right of an individual and the outcome of factors related to diet on health has been matter of concern since ancient times. The incorporation of flaxseed into diet can help to have a superior taste in regularly consumed dishes. The reddish brown flaxseed grains have a pleasant flavour and taste resembling nuts and its utilization is simple in different products. Considering the above facts, this study was under taken with special interest in the development of omega 3 fatty acid enriched designer food. The aim of the study to optimize roasted linseed powder (RLSP) incorporated Chappathi food using Response Surface Methodology. In order to optimize the Chappathi, the optimum condition of wheat flour 80g and RLSP 20g respectively. Corresponding to these values of process variables, the values of CHO 67.61g, protein 17.71g, omega 3 fatty acid 63.57mg and overall acceptability 9. The overall desirability was 0.54 respectively.

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INTRODUCTION

The emphasis on health and nutrition increased in the late twentieth century which provided a tremendous opportunity to the food manufacturers for marketing healthy food products. At present functional foods play a significant role in the development of functional foods. The consumers demand has increased for a product with taste, safety, convenience and nutrition. Thus nutrition has emerged an added dimension in the chain of food product development (Shahidi, 2002). Diet is one of the most important factors that are necessary for the better health of an individual. Provision of diet for the maintenance of physical and mental health is a basic right of an individual and the outcome of factors related to diet on health has been matter of concern since ancient times. There are many foods which are associated for health benefits and used or sold under a variety of names like designer foods, novel foods, medical foods, nutraceutical and functional foods. The search for novel high-quality but cheap sources of protein and energy has been attaining popularity in developing counties for meeting the challenges of hunger and starvation (Apata, 1990). The flaxseed is one of the grains gaining popularity in this respect.

Flaxseed (*Linum Usitatissimum)* is generally cultivated for linen fiber or for oil from its seeds which is also called as linseed oil. The flax has been used as a precious nutritional product and as a traditional medicine from ancient times. Flaxseed is richest source of alpha-linolenic acid, lignans and other nutritional components. The protein content of flaxseed was recorded about 20 per 100 grams of dried grain. Flaxseed has an amino acid profile comparable to that of soybean flour and contains no gluten (Hongzhi *et al.,* 2004). The incorporation of flaxseed into diet can help to have a superior taste in regularly consumed dishes. The reddish brown flaxseed grains have a pleasant flavour and taste resembling nuts and its utilization is simple in different products. Response Surface Methodology (RSM) is the most widely used statistical technique for optimization. It can be used to evaluate the relationship between a set of controllable experimental factors and observed results. The interaction among the possible

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influencing parameters can be evaluated with limited number of experiments. It has been successfully employed for optimization in many bioprocesses (Basantpure *et al.,* 2003). Considering the above facts, this study was under taken with special interest in the development of omega 3 fatty acid enriched designer foods and its therapeutic uses. The aim of the study to optimize roasted linseed powder (RLSP) incorporated Chappathi food using Response Surface Methodology.

MATERIALS AND METHODS

Selection of processed Linseed powder (LSP) rich in omega 3 fatty acid for incorporation in Chappathi food

The best processing method which yields high omega 3 fatty acid (Linolenic acid) was selected for the development of Chappathi food based on the fatty acid profile results obtained from GC-MS analysis (Parameshwari and Nazni, 2015).

Selection of designer foods for enriched omega 3 fatty acid

The recipes selected for the enrichment of omega 3 fatty acid were supplementary food, habitual food, novel food, traditional sweet and savory snack shown in Table 1.

Table 1. Recipes selected for omega 3 fatty acid enrichment

Type of Food	Products	Main ingredients
Habitual food	Chappathi	Wheat flour Roasted linseed powder

b) Omega 3 fatty acid enriched Habitual Food (Chappathi)

The habitual food chosen for omega 3 fatty acid enrichment was chappathi. Wheat was milled with suitable quantities of linseed to obtain omega 3 enriched flour, such that one chappathi would provide at least one third the daily suggested omega 3 fatty acid intake. The chappathi was prepared following the procedure of Autin and Ram (1971) and subjected to sensory evaluation.

Table 2. Ingredients

Ingredient	Weight (g)
Wheat	Variable
RLSP	Variable
Salt	To taste

Preparation

Dissolve salt in a little water and add to sieved flour to make a firm dough and knead well. Kept it stand for ½ hour. Divide into small balls and roll in dry flour. Dust a flat board with flour and with rolling pin, roll into a ball of dough into a chappathi 1/8" thickness. Cook lightly on both sides on a flat heated iron plate and puff over burning.

Optimization of RLSP Incorporated Chappathi

The levels of these variables along with experimental plan consisting of two variables at three levels have been presented in Table 3.

Table 3. Observed values of dependent variables for RLSP incorporated Chappathi in different runs of optimization experiments

Variables	Symbols	Coded level		
		–1	0	+1
Wheat Flour	A	80	85	90
RLSP	B	20	15	10
Design point	Uncoded		Coded	
	A	B	A	B
V1	80	10	–1	0
V2	90	10	+1	0
V3	80	20	–1	+1
V4	90	20	+1	+1
V5	77.93	15	- β	0
V6	92.07	15	+ β	0
V7	85	7.93	0	- β
V8	85	22.07	0	+ β
V9	85	15	0	0
V10	85	15	0	0
V11	85	15	0	0
V12	85	15	0	0
V13	85	15	0	0

For the preparation of chappathi, wheat flour and roasted linseed powder are optimized using central computation rotator design (Plate 1). The variables were standardized to simplify computation and deduce their relative effect of variables on the responses.

A= Wheat flour – 85/ 5
B= Roasted linseed powder– 15 / 5

The magnitude of the coefficients in second order polynomial shows the effect of that variable on the response. The relationship between standardized variables value is given as. Response surface methodology was applied to the experimental data using a commercial statistical package (Design expert, Trial version 8.0, tate Ease Inc., Minneapolis, IN statistical software) for the generation of response surface plot and optimization of process variables.

RESULTS AND DISCUSSION

Optimization of RLSP Incorporated Habitual Food (Chappathi)

The chappathi prepared with the help of wheat flour (A) and RLSP (B) was characterized for its physiochemical and organoleptic characteristics. Carbohydrate (Y1), rotein (Y2), Omega 3 fatty acid (Y3) and Overall acceptability (Y4) was measured as response variables.

Overall Proximate and Sensory Properties of RLSP Incorporated Habitual Food (Chappathi)

The proximate and sensory properties of RLSP incorporated habitual food was shown in Table 4.

The carbohydrate content of the chappathi ranges from 24.23 to 66.84g, protein 16.58 to 19.99g, omega 3 fatty acids 62.13 to 65.67mg and overall acceptability may range from 8 to 9 respectively.

Plate 1. Chappathi

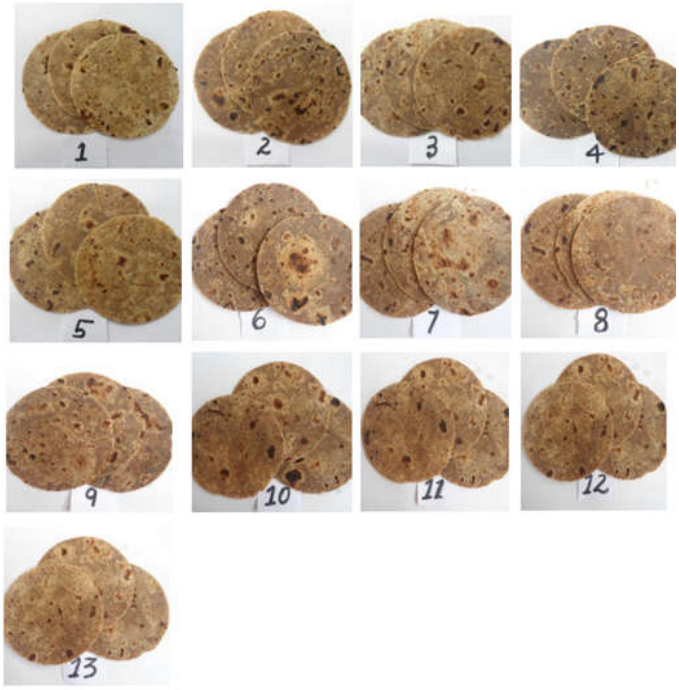

Table 4. Proximate and sensory properties of RLSP incorporated Habitual food

S.No	Uncoded value		CHO	Protein	Omega 3 fatty acids	Overall acceptability
	A	B				
1.	80	10	63.12	19.99	62.46	8
2.	90	10	66.3	18.27	64.36	8
3.	80	20	64.18	17.55	63.26	9
4.	90	20	63.28	18.58	62.13	8
5.	77.93	15	64.66	18.86	63.03	8
6.	92.07	15	66.04	17.14	63.93	8
7.	85	7.93	24.23	19.45	65.67	8
8.	85	22.07	66.84	18.17	63.79	8
9.	85	15	65.3	17.73	63.59	8
10	85	15	63.28	16.58	64.13	8
11.	85	15	64.3	17.58	64.13	8
12.	85	15	63.28	16.98	64.13	8
13.	85	15	64.1	17.58	64.13	8

A – Wheat flour
B –Roasted linseed powder

Diagnostic Checking of Fitted Model and Surface Plot for All Y Responses

Regression analysis indicated that the fitted quadratic model accounts that about 58% of carbohydrate (R2>0.58), 88% of protein (R2>0.88), 67% of omega 3 fatty acids (R2>0.67) and 59% of overall acceptability (R2>0.59) of the developed RLSP incorporated chappathi.

a) Carbohydrate

The values of regression coefficients, sum of squares, F values and P values for coded form of process variables are presented in Table 5.

The carbohydrate content of the developed chappathi was range from 24.23 to 66.84g. The developed model for chappathi in the form of uncoded (actual) process variables as follows:

Y1 (Carbohydrate) = 739.33-18.62A+13.40B+0.11A2 -0.28B2 -0.04AB

In coded form of process variables, the model equation is as follows:

y1 (Carbohydrate) = 64.05+0.53a+7.29b+2.84a 2 -7.06b2 -1.02ab

Table 5. ANOVA and Coefficient for Carbohydrate content of RLSP incorporated Chappathi

Source	Coefficient	Sum square	df	F value	P value
Model	878.70	64.05	5	1.92	0.209
A	2.24	0.53	1	0.024	0.880
B	424.86	7.29	1	4.64	0.068
A^2	56.24	2.84	1	0.61	0.458
B^2	347.14	-7.06	1	3.79	0.092
AB	4.16	-1.02	1	0.045	0.837
Lack of fit	638.01	-	3	302.38	0.0001**
R^2	0.578				
Adj R^2	0.277				
PredR^2	-1.988				
Adeq prec	4.749				

**-1% level of significant
A-Wheat flour
B-Roasted linseed powder
*-5% level of significant
df- Degree of freedom

The magnitude of P and F value in table 21 indicates that the negative contribution in wheat flour while the RLSP have the positive effect. The quadratic terms have positive effect in wheat flour but RLSP have the negative effect on carbohydrate. The interactions of AB have the negative effect on carbohydrate. The effect of wheat flour and RLSP has been shown in Fig. 9.

The carbohydrate content increased with the increase in wheat flour up to 65g, but increase in Roasted Linseed Powder also show positive effect on increasing the carbohydrate content (Fig.1).

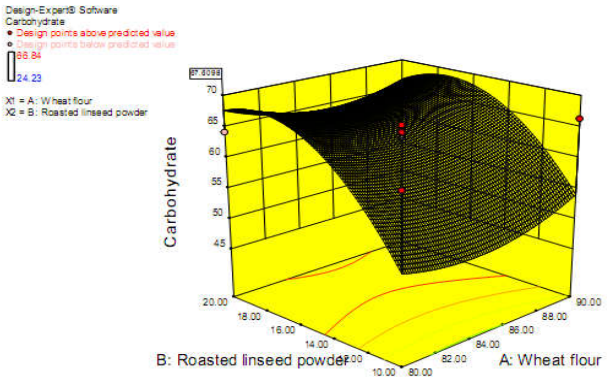

Fig. 1. Effect of wheat and RLSP on carbohydrate content of Chappathi

b) Protein

The values of regression coefficients, sum squares, F values and P values for coded form of process variables are presented in Table 6.

Table 6. ANOVA and Coefficient for Protein content of RLSP incorporated Chappathi

Source	Coefficient	Sum square	df	F value	P value
Model	17.29	10.22	5	10.02	0.004*
A	-0.39	1.22	1	5.97	0.044
B	-0.49	1.94	1	9.51	0.017
A^2	0.40	1.13	1	5.54	0.051
B^2	0.81	4.54	1	22.26	0.002*
AB	0.69	1.89	1	9.27	0.019
Lack of fit	-	0.47	3	0.65	0.625
R^2	0.877				
Adj R^2	0.789				
PredR^2	0.586				
Adeq prec	9.064				

A-Wheat flour
**-1% level of significant
B-Roasted linseed powder
*-5% level of significant
df- Degree of freedom

The protein content of the developed chappathi was range from 16.58 to 19.99g. The developed model for chappathi in the form of uncoded (actual) process variables as follows:

Y2 (Protein) = 184.24-3.23A-3.40B+0.02A2 +0.03B2 +0.03AB

In coded form of process variables, the model equation is as follows:

y2 (Protein) = 17.29-0.39a-0.49b+0.40a 2 +0.81b2 +0.69ab

The magnitude of P and F value in table 22 indicates that the negative contribution in all the process variables. All the quadratic and interactions terms have positive effect on protein content. The effect of wheat flour and RLSP on protein has been shown in Fig. 2. The protein content increased with the increase in wheat flour up to 90g, but increase in Roasted Linseed Powder show a positive effect on increasing the protein content (Fig.2).

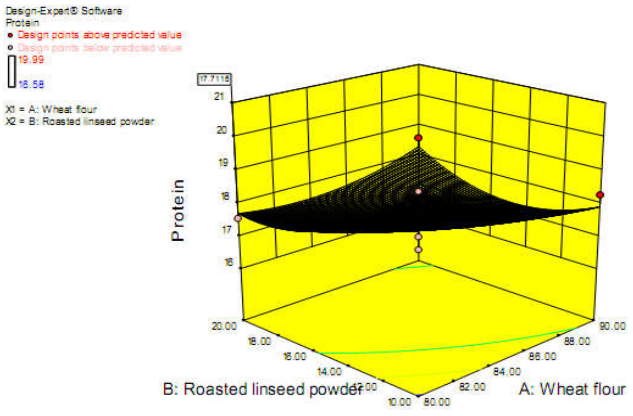

Fig. 2. Effect of wheat and RLSP on protein content of Chappathi

c) Omega 3 Fatty Acids

The values of regression coefficients, sum squares, F values and P values for coded form of process variables are presented in Table 7.

Table 7. ANOVA and Coefficient for omega 3 fatty acids content of RLSP incorporated Chappathi

Source	Coefficient	Sum square	df	F value	P value
Model	63.82	6.65	5	2.86	0.101
A	0.26	0.52	1	1.12	0.325
B	-0.51	2.09	1	4.50	0.072
A^2	-0.43	1.31	1	2.82	0.137
B^2	0.19	0.25	1	0.55	0.484
AB	-0.76	2.30	1	4.94	0.062
Lack of fit	-	2.44	3	3.97	0.108
R^2	0.671				
Adj R^2	0.437				
PredR^2	-0.878				
Adeq prec	5.478				

**-1% level of significan
AA-Wheat flour
*-5% level of significant
B-Roasted linseed powder
df- Degree of freedom

The omega 3 fatty acid content of the developed chappathi was range from 62.13 to 65.67mg. The developed model for chappathi in the form of uncoded (actual) process variables as follows:

Y3 (Omega 3 fatty acid) =-101.36+3.46A+2.24B-0.02A2 +7.63B2 -0.03AB

In coded form of process variables, the model equation is as follows:

y3(Omega 3 fatty acid) =63.82+0.26a-0.51b-0.43a 2 +0.19b2 -0.76ab

The magnitude of P and F value in table 23 indicates that the positive contribution in wheat flour and RLSP. The quadratic terms of wheat flour have the negative effect while RLSP have the positive effect. The interactive terms have the negative effect on omega 3 fatty acid. The effect of wheat flour and RLSP on omega 3 fatty acid has been shown in Fig. 3. The omega 3 fatty acid content decreased in wheat flour up to 90g, but Roasted Linseed Powder show a positive effect on increasing the omega 3 fatty acid content (Fig. 3).

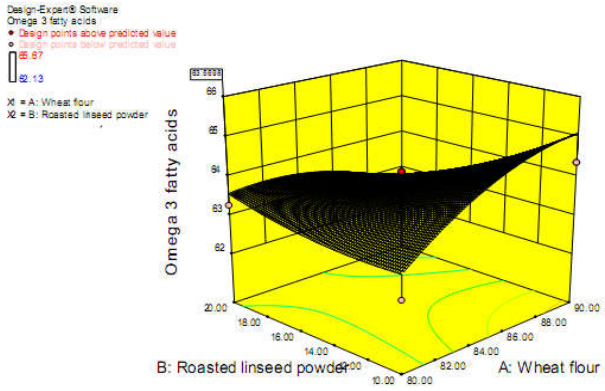

Fig. 3. Effect of wheat and RLSP on omega 3 fatty acid content of Chappathi

d) Overall Acceptability

The values of regression coefficients, sum squares, F values and P values for coded form of process variables are presented in Table 8.

Table 8. ANOVA and Coefficient for overall acceptability of RLSP incorporated Chappathi

Source	Coefficient	Sum square	df	F value	P value
Model	63.82	6.65	5	2.86	0.101
A	0.26	0.52	1	1.12	0.325
B	-0.51	2.09	1	4.50	0.072
A^2	-0.43	1.31	1	2.82	0.137
B^2	0.19	0.25	1	0.55	0.484
AB	-0.76	2.30	1	4.94	0.062
Lack of fit	-	2.44	3	3.97	0.108
R^2	0.671				
Adj R^2	0.437				
PredR^2	-0.878				
Adeq prec	5.478				

**-1% level of significan
A-Wheat flour
B-Roasted linseed powder
df- Degree of freedom

The overall acceptability of the developed chappathi was range from 8 to 9 respectively. The developed model for chappathi in the form of uncoded (actual) process variables as follows:

Y4 (Overall acceptability) = 15.62-0.30A+0.80B+2.50A2 +2.50B2 -0.01AB

In coded form of process variables, the model equation is as follows:

y4 (Overall acceptability) = 8.00-0.13a+0.12b+0.06a 2 +0.06b2 -0.25ab

The magnitude of P and F value in table 24 indicates that the negative effect for wheat flour and positive effect for RLSP. The quadratic terms have positive effect while interaction has the negative effect on overall acceptability. The effect of wheat flour and RLSP on overall acceptability has been shown in Fig.4.

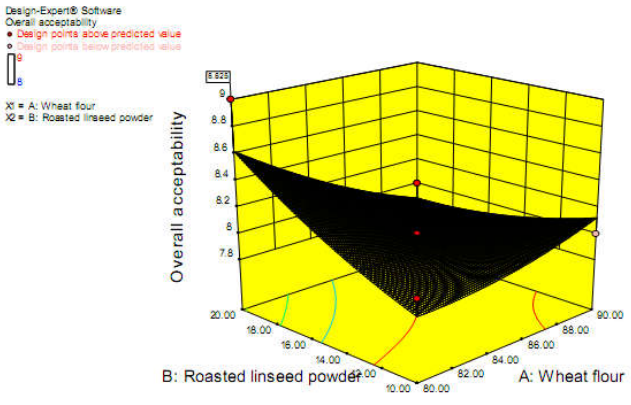

Fig. 4. Effect of wheat and RLSP on overall acceptability content of Chappathi

The overall acceptability was increased in wheat flour up to 90g, but Roasted Linseed Powder show a positive effect on increasing the overall acceptability of the product (Fig.4).

Optimization of independent variables

For the optimization variables, the responses ie) carbohydrate, protein, omega 3 fatty acid and overall acceptability were selected on the basis that these responses.

Table 9. Optimum value of process parameters responses for chappathi

Process Parameters	Target	Experimental Design		Importance	Optimum values	Desirability
Wheat flour	In range	80	90	3	80	
RLSP	In range	10	20	3	20	
		Responses		Predicted values		
CHO	Maximum	24.23	66.84	3	67.61	0.54
Protein	Maximum	16.58	19.99	3	17.71	
Omega 3 fatty acid	Maximum	62.13	65.67	3	63.57	
Overall acceptability	Maximum	8	9	3	8.62	

In order to optimize the chappathi, equal importance of 3 was given to all the two parameters and four responses. The optimum condition of wheat flour 80g and RLSP 20g respectively. Corresponding to these values of process variables, the values of CHO 67.61g, protein 17.71g, omega 3 fatty acid 63.57mg and overall acceptability 9. The overall desirability was 0.54 respectively.

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