

# Optimization of Roasted Linseed Powder (RLSP) Incorporated Dalia Porridge Food Using Response Surface Methodology

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**Abstract:** 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. 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. 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 dalia porridge food using Response Surface Methodology. In order to optimize the dalia porridge, the optimum condition of broken wheat 40g, RLSP 10g, moong dal 16.55g and broken rice 15g respectively. Corresponding to these values of process variables, the values of CHO 85.63g, protein 28.57g, omega 3 fatty acid 33.12mg and overall acceptability 8. The overall desirability was 63% respectively.

**Keywords:** *Linum Usitatissimum*, seeds, Designer food, Dalia porridge

## 1. Introduction

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 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). 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 countries for meeting the challenges of hunger and starvation (Apat, 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 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 dalia porridge food using Response Surface Methodology

## 2. Materials and Methods

### Selection of processed Linseed powder (LSP) rich in omega 3 fatty acid for incorporation in Dalia Porridge foods

The best processing method which yields high omega 3 fatty acid (Linolenic acid) was selected for the development of Dalia Porridge 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 shown in table-1.

**Table 1:** Recipes selected for omega 3 fatty acid enrichment

Type of Food	Products	Main ingredients
Supplementary food	Dalia porridge	Broken wheat Roasted linseed powder, Moong dal and Broken rice

**Omega 3 fatty acid enriched Supplementary food (Dalia Porridge) Ingredients**

Ingredient	Weight (g)	Broken wheat	Variable
Broken rice		Variable	
RLSP		Variable	
Moong dal		Variable	
Milk		60ml	
Sugar		30g	

**Preparation:** Roast the broken wheat in a pan. When half done, add dhal and continue roasting till light brown. Add water to the above, cook till soft and slightly thick. Remove it from fire. Add milk and sugar. Boil for a few minutes and serve it.

**Optimization of Roasted Linseed powder (RLSP) incorporated dalia porridge**

The levels of these variables along with experimental plan consisting of two variables at four levels have been presented in table-2.

**Table 2:** Observed values of dependent variables for RLSP incorporated dalia porridge in different runs of optimization experiments

Variables	Symbols		Coded level					
			-β	-1	0	+1	+β	
Broken wheat	A		25	30	35	40	45	
RLSP	B		25	20	15	10	5	
Moong dal	C		10	15	20	25	30	
Broken rice	D		20	15	10	5	0	
Design point	Uncoded				Coded			
	A	B	C	D	a	B	c	d
V1	30	10	15	5	-1	-1	-1	-1
V2	40	10	15	5	+1	-1	-1	-1
V3	30	20	15	5	-1	+1	-1	-1

V4	40	20	15	5	+1	+1	-1	-1
V5	30	10	25	5	-1	-1	+1	-1
V6	40	10	25	5	+1	-1	+1	-1
V7	30	20	25	5	-1	+1	+1	-1
V8	40	20	25	5	+1	+1	+1	-1
V9	30	10	15	15	-1	-1	-1	+1
V10	40	10	15	15	+1	-1	-1	+1
V11	30	20	15	15	-1	+1	-1	+1
V12	40	20	15	15	+1	+1	-1	+1
V13	30	10	25	15	-1	-	+1	+1
						1		
V14	40	10	25	15	+1	-1	+1	+1
V15	30	20	25	15	-1	+1	+1	+1
V16	40	20	25	15	+1	+1	+1	+1
V17	25	15	20	10	-β	0	0	0
V18	45	15	20	10	+β	0	0	0
V19	35	5	20	10	0	-β	0	0
V20	35	25	20	10	0	+β	0	0
V21	35	15	10	10	0	0	-β	0
V22	35	15	30	10	0	0	+β	0
V23	35	15	20	0	0	0	0	-β
V24	35	15	20	20	0	0	0	+β
V25	35	15	20	10	0	0	0	0
V26	35	15	20	10	0	0	0	0
V27	35	15	20	10	0	0	0	0
V28	35	15	20	10	0	0	0	0
V29	35	15	20	10	0	0	0	0
V30	35	15	20	10	0	0	0	0

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

A = Broken wheat -35 \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

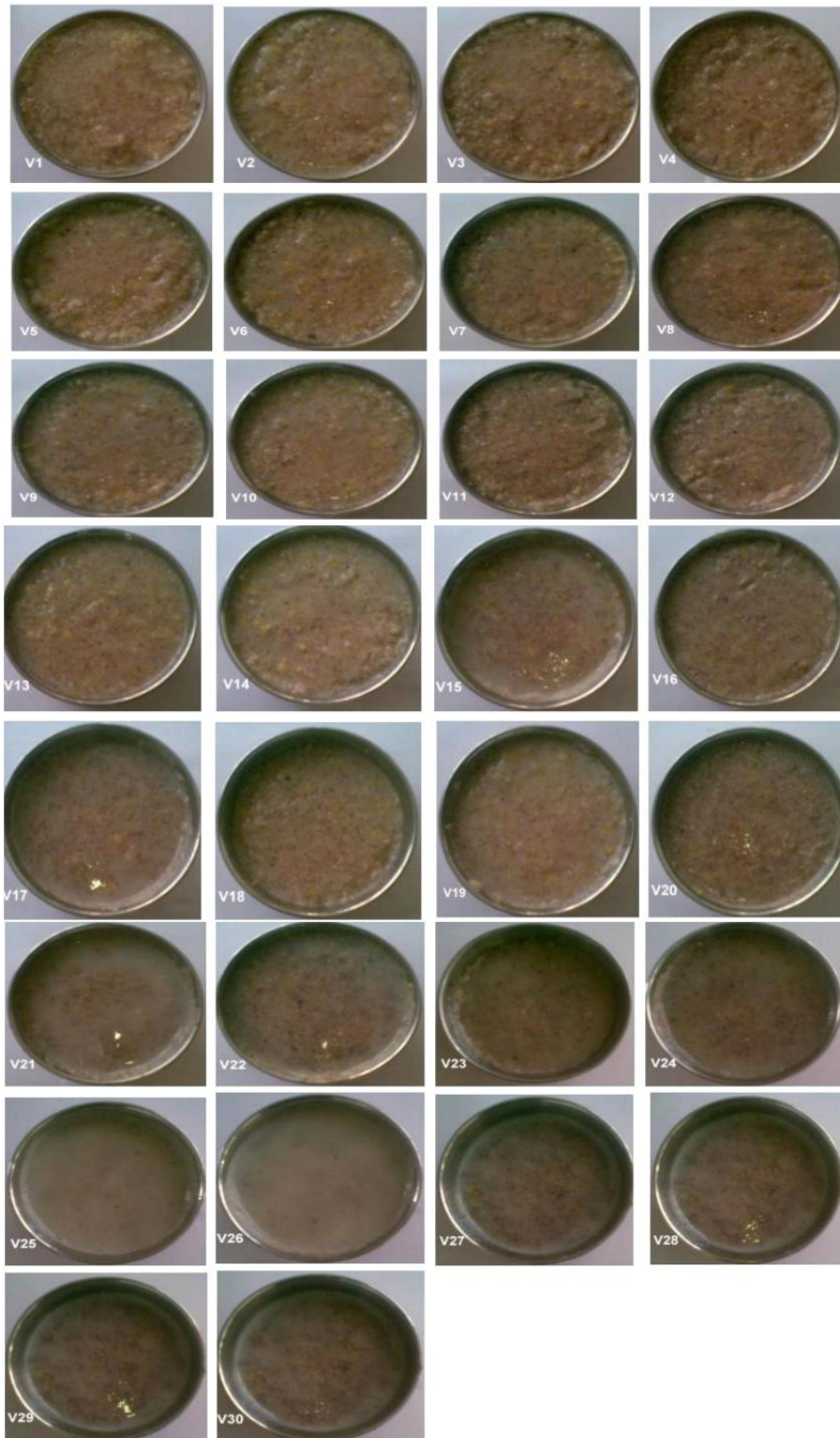
B = Roasted linseed powder -15/5

C = Moong dal-20 /5

D = Broken rice -10 /5

Response surface methodology was applied to the experimental data using a commercial statistical package (Design expert, Trial version 8.0, State Ease Inc., Minneapolis, IN statistical software) for the generation of response surface plot and optimization of process variables.

Plate – 1 (Dalia Porridge)



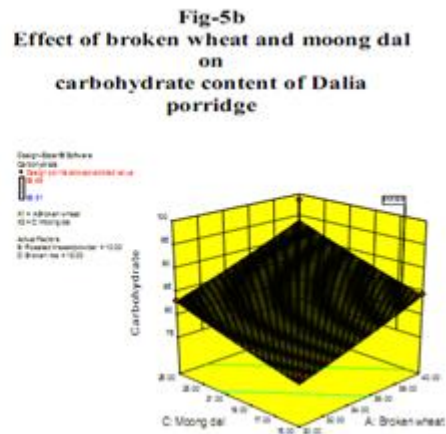
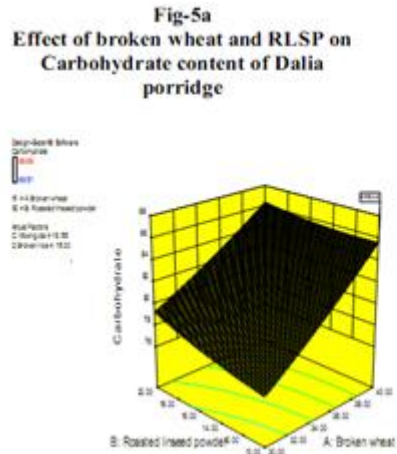
### 3. Results and Discussion

#### Optimization of RLSP Incorporated Supplementary Food (Dalia Porridge)

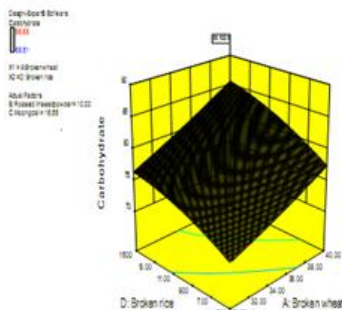
The dalia porridge prepared with the help of broken wheat (A), RLSP (B), moong dal (C) and broken rice (D) was characterized for its physiochemical and organoleptic characteristics. Carbohydrate (Y1), protein

(Y2), Omega 3 fatty acid (Y3) and Overall acceptability (Y4) was measured as response variables. Overall Proximate and Sensory Properties of RLSP Incorporated Supplementary Food (Dalia Porridge). The proximate and sensory properties of RLSP incorporated supplementary food was given in table-3.

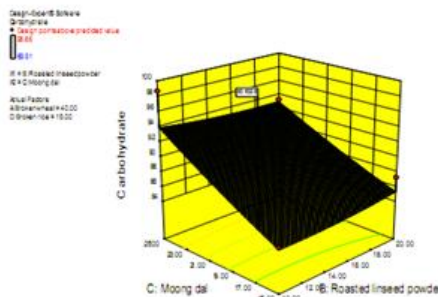




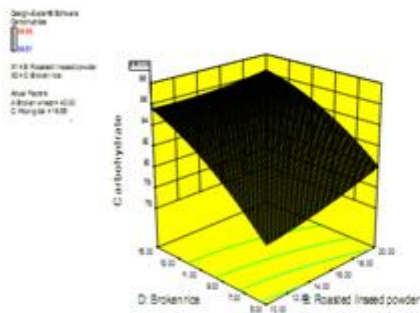
**Fig-5c**  
 Effect of broken wheat and broken rice on carbohydrate content of Dalia porridge



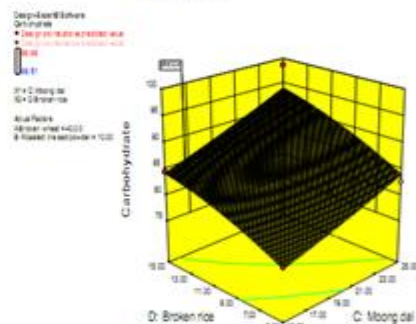
**Fig-5d**  
 Effect of RLSP and moong dal on carbohydrate content of Dalia porridge



**Fig-5e**  
 Effect of RLSP and broken rice on carbohydrate content of Dalia porridge



**Fig-5f**  
 Effect of moong dal and broken rice on carbohydrate content of Dalia porridge



**b) Protein**

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table-16.

**Table 16:** ANOVA and Coefficient for Protein content of RLSP incorporated Dalia porridge

Source	Coefficient	Sum square	df	F value	P value
Model	1513.11	15.46	14	1.08	0.443
A	15.36	0.80	1	0.15	0.701
B	1085.42	-6.73	1	10.81	0.005*
C	58.41	1.56	1	0.58	0.457
D	2.32	0.31	1	0.023	0.881
A2	108.42	0.99	1	1.08	0.315

B2	99.87	1.91	1	0.99	0.334
C2	100.13	1.91	1	1.00	0.334
D2	156.59	2.39	1	1.56	0.231
AB	4.04	-0.50	1	0.040	0.844
AC	3.96	0.50	1	0.039	0.845
AD	4.12	-0.51	1	0.041	0.842
BC	3.96	-0.50	1	0.039	0.845
BD	3.96	0.50	1	0.039	0.845
CD	4.04	-0.50	1	0.040	0.844
Lack of fit	1506.15	-	10	-	-
R2	0.50	-	-	-	-
Adj R2	0.03	-	-	-	-
Pred R2	-1.87	-	-	-	-
Adeq prec	3.79	-	-	-	-

A-Broken wheat  
 B-Roasted linseed powder  
 significant  
 C-Moong dal  
 D-Broken rice

df- Degree of freedom  
 \*-5% level of

interactions of all the variables have the negative effect but AC and BC have the positive effect on protein content. The effect of broken wheat, RLSP, moong dal and broken rice on protein has been shown in fig 6a-6f.

The protein content of the developed dalia porridge was range from 14.6 to 46.69g. The developed model for dalia porridge in the form of uncoded (actual) process variables as follows:

$$Y_2 (\text{Protein}) = 167.16 - 5.30A - 2.73B - 2.94C - 1.035D + 0.08A^2 + 0.08B^2 + 0.08C^2 + 0.09D^2 + 0.02AB + 0.02AC - 0.02AD - 0.02BC + 0.02BD + 0.02CD.$$

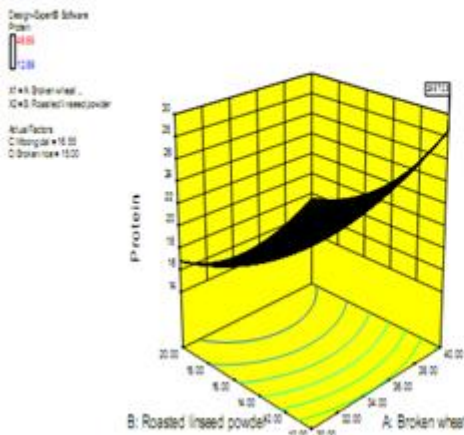
In coded form of process variables, the model equation is as follows:

$$y_2 (\text{Protein}) = 15.46 + 0.80a - 6.73b + 1.56c + 0.31d + 1.99a^2 + 1.91b^2 + 1.91c^2 + 2.39d^2 - 0.50ab + 0.02ac + 0.50ad - 0.51bc - 0.50bd - 0.50cd.$$

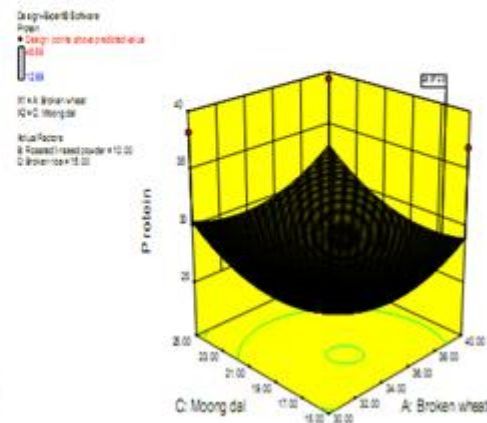
The magnitude of P and F value in table 16 indicates that the negative contribution in all the process variables. All the quadratic terms have positive effect. The

The protein content increased with the increase in broken wheat up to 40g, but increase in Roasted Linseed Powder did not show any positive effect on increasing the protein content (Fig-6a). The effect of protein content increased gradually by the addition of broken wheat and moong dal, but both the ingredients showed a positive effect on protein content of the product (Fig-6b). In fig-6c showed a positive increase in the protein content of the product by broken wheat and broken rice. The protein content increased in moong dal upto 30-32g but increase in Roasted Linseed Powder did not show any positive effect on increasing the protein content (Fig-6d). In fig-6e showed an increased with the increase in protein content of broken rice when compared to roasted linseed powder. The increase in the protein content was showed by the addition of broken rice and moong dal in dalia porridge (Fig-6f).

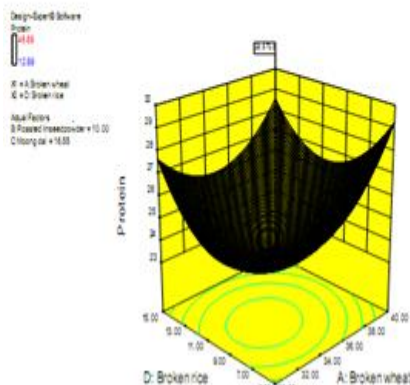
**Fig-6a**  
 Effect of broken wheat and RLSP on protein content of Dalia porridge



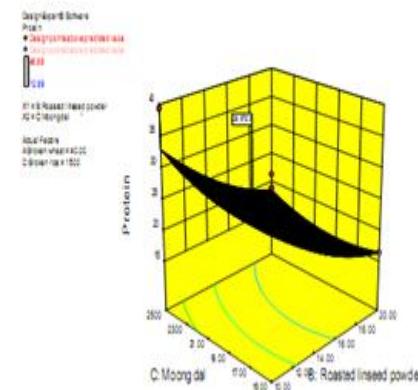
**Fig-6b**  
 Effect of broken wheat and moong dal on protein content of Dalia porridge



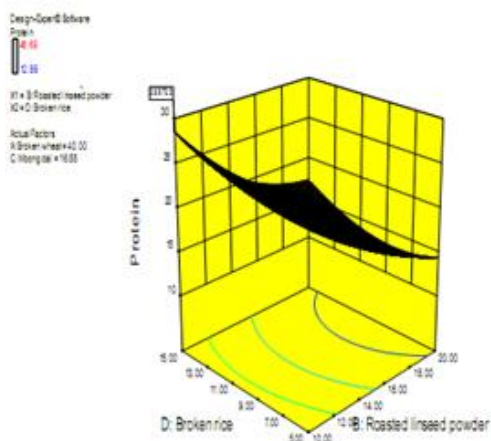
**Fig-6c**  
 Effect of broken wheat and broken rice on protein content of Dalia porridge



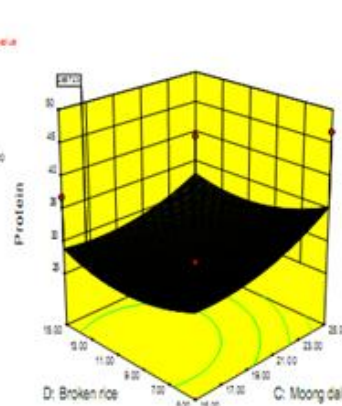
**Fig-6d**  
 Effect of RLSP and moong dal on protein content of Dalia porridge



**Fig-6e**  
 Effect of RLSP and broken rice on protein content of Dalia porridge



**Fig-6f**  
 Effect of moong dal and broken rice on protein content of Dalia porridge



**c) Omega 3 Fatty Acids**

The values of regression coefficients, sum square, F values and P values for coded form of process variables are presented in table-17.

**Table 17:** ANOVA and Coefficient for omega 3 fatty acids content of RLSP incorporated Dalia porridge

Source	Coefficient	Sum square	df	F value	P value
Model	31.35	409	14	3.29	0.0001**
A	3.67	322.37	1	3.63	0.0001**
B	1.90	86.64	1	9.75	0.0001**
C	0.00	0.00	1	0.00	1.000
D	0.00	0.00	1	0.00	1.000
A2	8.33	1.90	1	2.14	0.164
B2	8.33	1.90	1	2.14	0.164
C2	8.33	1.90	1	2.14	0.164
D2	8.33	1.90	1	2.14	0.164
AB	0.00	0.00	1	0.00	1.000
AC	0.00	0.00	1	0.00	1.000
AD	0.00	0.00	1	0.00	1.000
BC	0.00	0.00	1	0.00	1.000
BD	0.00	0.00	1	0.00	1.000
CD	0.00	0.00	1	0.00	1.000
Lack of fit	-	1.33	10	-	-
R <sup>2</sup>				1.00	
Adj R <sup>2</sup>				1.00	
Pred R <sup>2</sup>				1.00	
Adeq prec				6953.85	

A-Broken wheat  
 B-Roasted linseed powder  
 C-Moong dal  
 D-Broken rice

df- Degree of freedom  
 \*\*-1% level of significant

The omega 3 fatty acid content of the developed dalia porridge was range from 24.02 to 38.68mg. The

developed model for dalia porridge in the form of uncoded (actual) process variables as follows:

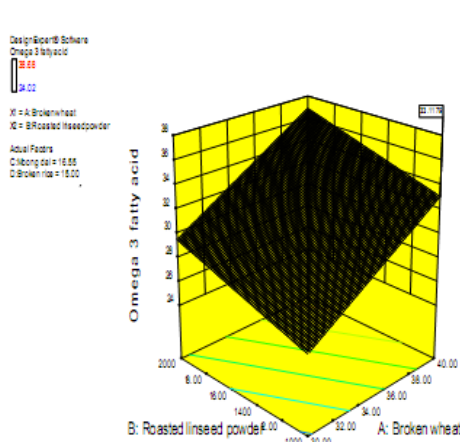
$$Y_3 (\text{Omega 3 fatty acid}) = 0.060 + 0.730A + 0.379B - 1.333C - 6.667D + 3.333A^2 + 3.333B^2 + 3.333C^2 + 3.333D^2 + 9.149AB + 5.509AC + 5.407AD + 7.748BC + 7.726BD + 8.049CD.$$

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

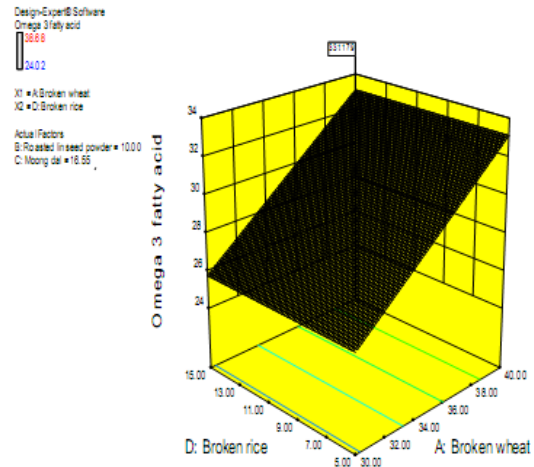
$$y_3 (\text{Omega 3 fatty acid}) = 31.35 + 3.67a + 1.90b + 0.00c + 0.00d + 8.33a^2 + 8.33b^2 + 8.33c^2 + 8.33d^2 - 0.00ab + 0.00ac + 0.00ad - 0.00bc - 0.00bd - 0.00cd.$$

The magnitude of P and F value in table 17 indicates that the positive contribution in in the broken wheat and RLSP while the moong dal and broken rice has been shown in fig 7a-7f. The omega 3 fatty acid content increased with the increase in broken wheat up to 40g, but increase in Roasted Linseed Powder did not show any positive effect on increasing the omega 3 fatty acid content (Fig-7a). The effect of omega 3 fatty acid content increased rapidly by the addition of broken wheat than moong dal, but both the ingredients showed a positive effect on omega 3 fatty acid content of the product (Fig-7b). In fig-7c showed a positive increase in the omega 3 fatty acid content of the product by broken wheat and broken rice. The omega 3 fatty acid content increased in moong dal upto 30-32g but increase in Roasted Linseed Powder did not show any positive effect on increasing the omega 3 fatty acid content (Fig-7d). In fig-7e showed an increased with the increase in omega 3 fatty acid content of broken rice when compared to roasted linseed powder. The omega 3 fatty acid content was showed a negative effect by the addition of broken rice and moong dal in dalia porridge (Fig-7f).

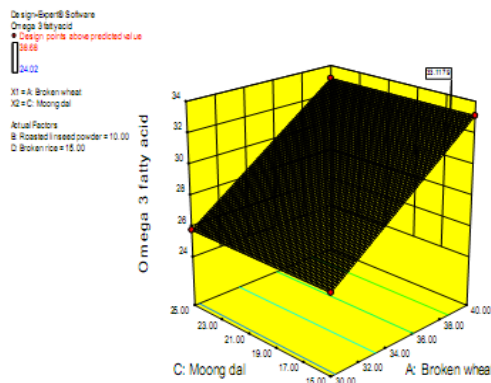
**Fig-7a**  
 Effect of broken wheat and RLSP  
 on  
 omega 3 fatty acid content of Dalia  
 porridge



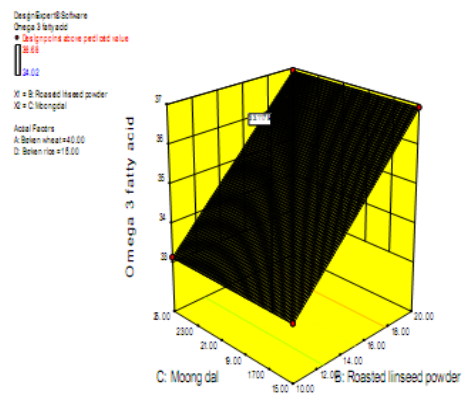
**Fig-7c**  
 Effect of broken wheat and broken rice  
 on omega 3 fatty acid content of Dalia  
 porridge



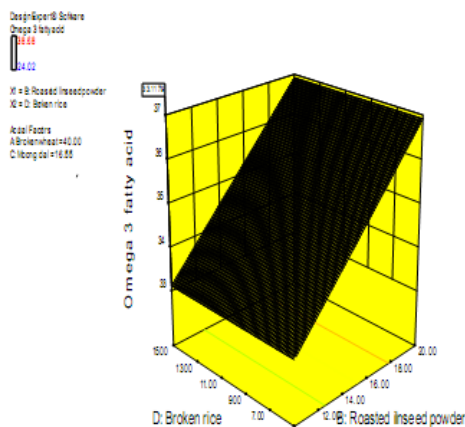
**Fig-7b**  
 Effect of broken wheat and moong  
 dal on  
 omega 3 fatty acid content of Dalia  
 porridge



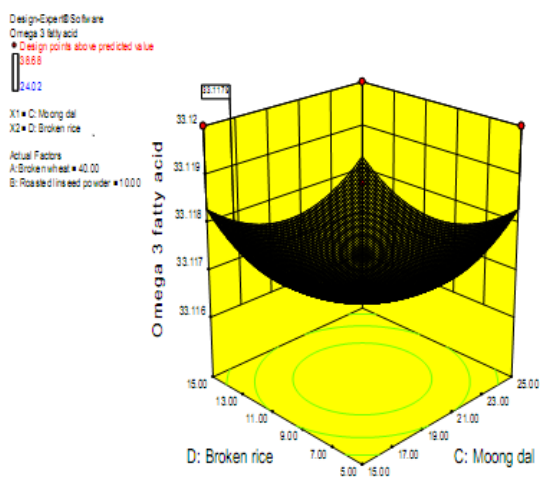
**Fig-7d**  
 Effect of RLSP and moong dal on  
 omega 3 fatty acid content of Dalia  
 porridge



**Fig-7e**  
 Effect of RLSP and broken rice on  
 omega 3 fatty acid content of Dalia  
 porridge

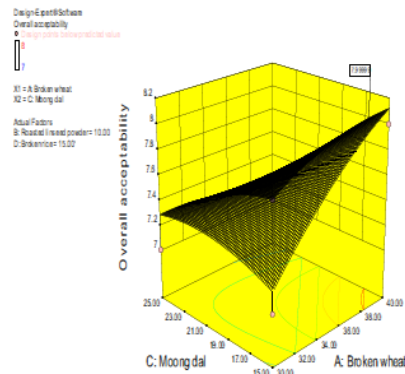


**Fig-7f**  
 Effect of moong dal and broken rice on  
 omega 3 fatty acid content of Dalia  
 porridge

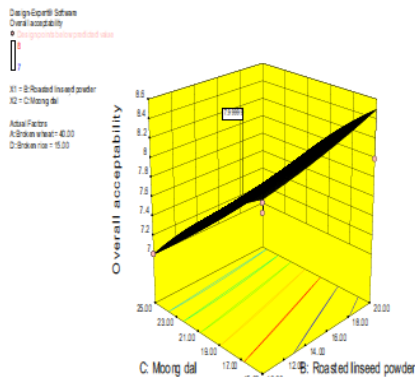




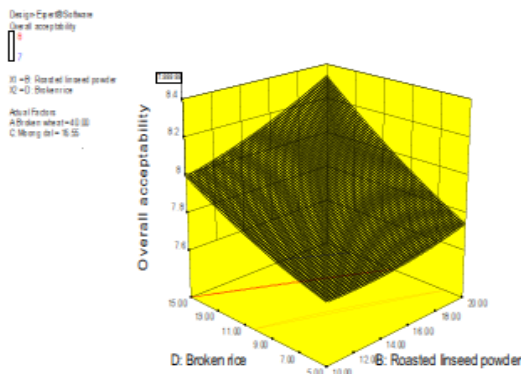
**Fig-8b**  
 Effect of broken wheat and moong dal on overall acceptability content of Dalia porridge



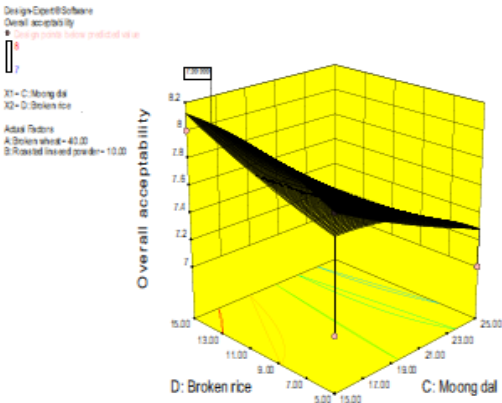
**Fig-8d**  
 Effect of RLSP and moong dal on overall acceptability content of Dalia porridge



**Fig-8e**  
 Effect of RLSP and broken rice on overall acceptability content of Dalia porridge



**Fig-8f**  
 Effect of moong dal and broken rice on overall acceptability content of Dalia porridge



**Optimization of independent variables**

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

**Table 19:** Optimum value of process parameters responses for dalia porridge

Process Parameters	Target	Experimental Design		Importance	Optimum values	Desirability
Broken wheat	In range	30	40	3	40	<b>0.63</b>
RLSP	In range	10	20	3	10	
Moong dal	In range	15	25	3	16.55	
	In range	5	15	3	15	
Responses				Predicted values		<b>0.63</b>
CHO	Maximum	69.51	98.68	3	85.63	
Protein	Maximum	12.89	46.69	3	28.57	
Omega 3 fatty acid	Maximum	24.02	38.68	3	33.12	
	Maximum	7	8	3	7.99	

Linseed contains important quantities of compounds with functional and bioactive properties, such as alpha-linolenic acid, lignans, soluble fibre and protein, whose effects on the prevention of certain non transmissible chronic diseases have been tested. These characteristics make flaxseed an attractive source of functional ingredients for the preparation of foodstuffs. In order to optimize the dalia porridge, the

optimum condition of broken wheat 40g, RLSP 10g, moong dal 16.55g and broken rice 15g respectively. Corresponding to these values of process variables, the values of CHO 85.63g, protein 28.57g, omega 3 fatty acid 33.12mg and overall acceptability 8. The overall desirability was 63% respectively.

#### 4. Acknowledgements

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