International Journal of Home Science

ISSN: 2395-7476
IJHS 2016; 2(1): 85-91

www.homesciencejournal.com
Received: 17-11-2015
Accepted: 19-12-2015

S Parameshwari
Department of Home science, Mother Teresa Women's University, Research and Extension Centre, Navalar nagar, 2nd street, SS Colony, Madurai – 16, Tamil Nadu, India.

P Nazni
Department of Food Science and Nutrition Periyar University Salem-636011, Tamil Nadu, India.

Correspondence
S Parameshwari
Department of Home science, Mother Teresa Women's University, Research and Extension Centre, Navalar nagar, 2nd street, SS Colony, Madurai - 16, Tamil Nadu, India.

Optimization of roasted linseed powder (RLSP) incorporated Omapodi snacks using response surface methodology

S Parameshwari, P Nazni

Abstract
The aim of the study to optimize roasted linseed powder (RLSP) incorporated Omapodi snacks food using Response Surface Methodology. 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 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 incorporation of flaxseed into diet can help to have a superior taste in regularly consumed dishes. In order to optimize the Omapodi snacks, the optimum condition of Bengal gram flour 64 g, RLSP 20 g and gingelly seed powder 10 g respectively. Corresponding to these values of process variables, the values of carbohydrate 69.78 g, protein 16.35 g, omega 3 fatty acid 7.77 mg and overall acceptability 9. The overall desirability was 0.63 respectively.

Keywords: Omapodi snacks, seeds, Designer food, *Linum Usitatissimum*

Introduction

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 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) [6].

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) [1]. The flaxseed is one of the grains gaining popularity in this respect.

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) [3]. 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 Omapodi snacks using Response Surface Methodology.

Materials and Methods

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

The best processing method which yields high omega 3 fatty acid (Linolenic acid) was selected for the development of Omapodi snacks based on the fatty acid profile results obtained from GC-MS analysis (Parameshwari and Nazni, 2015) [5].

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
Savory snacks	Omapodi	Bengal gram flour Roasted linseed powder Gingelly seed powder

Omega 3 fatty acid enriched Savory snacks (Omapodi)

The word savory is rooted in the meaning of “tasty” or “flavorful”, but lately it‟s used to describe “salty or spicy” flavors as opposed to sweet. Essentially, savory can be seen as the opposite of sweet or “sweet-free” when we‟re talking about food. Thus, savory snacks are snacks that aren‟t sweet. As for prepared and packaged snack products, we usually think of chips, crackers, popcorn, etc. One online dictionary states that a “savory food snack” is “the FDA‟s term for crunchy junk food”.

Optimization of RLSP Incorporated omapodi

The levels of these variables along with experimental plan consisting of three variables at five levels have been presented in Table-2.

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

Variables	Symbols	Coded level				
		–β	–1	0	+1	+ β
Bengal gram flour	A	60.59	64	69	74	77.41
RLSP	B	6.59	10	15	20	23.41
Gingelly seed	C	3.29	5	7.5	10	11.70
Design point	Uncoded			Coded		
	A	B	C	a	b	c
V1	64	10	71	-1	-1	-1
V2	74	10	5	+1	-1	-1
V3	64	20	5	-1	+1	-1
V4	74	20	5	+1	+1	-1
V5	64	10	5	-1	-1	+1
V6	74	10	10	+1	-1	+1
V7	64	20	10	-1	+1	+1
V8	74	20	10	+1	+1	+1
V9	60.59	15	10	-β	0	0
V10	77.41	15	7.5	+ β	0	0
V11	69	6.59	7.5	0	-β	0
V12	69	23.41	7.5	0	+ β	0
V13	69	15	7.5	0	0	- β
V14	69	15	3.3	0	0	+ β
V15	69	15	11.7	0	0	0
V16	69	15	7.5	0	0	0
V17	69	15	7.5	0	0	0
V18	69	15	7.5	0	0	0
V19	69	15	7.5	0	0	0
V20	69	15	7.5	0	0	0

For the preparation of omapodi (Plate 1), Bengal gram flour, roasted linseed powder and gingelly seed 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= Bengal gram flour – 69 / 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

Response surface methodology was applied to the experimental data using a commercial statistical package (Design expert, Trial version 6.0, State Ease Inc., Minneapolis, IN statistical software) for the generation of response surface plot and optimization of process variables. The experiments were conducted according to Central Composite Rotatable Design (CCRD) (Khuri. AI and Cornell. JA, 1997).

C= Gingelly seed– 7.5 / 2.5

Each design point consists of three replicates. For the statistical analysis the numerical levels were standardized to –1, 0, and 1. The experiments were carried out in randomized order (Gacula and Singh, 1994) [4].

The Central Composite Rotatable Design (CCRD) was used for selecting the level of parameters in the experiments. Response surface methodology was performed using the design expert software program version 8.0.

Plate 1: OMAPODI

Optimization of RLSP Incorporated Savory Snack (Omapodi)

The omapodi prepared with the help of Bengal gram flour (A), RLSP (B) and gingelly seed powder (C) 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 Savory Snack (Omapodi)

The proximate and sensory properties of RLSP incorporated savory snack was given in table-3.

Table 3: Proximate and sensory properties of RLSP incorporated savory snack

S.No	Uncoded value			CHO	Protein	Omega 3 fatty acids	Overall acceptability
	X1	X2	X3				
1.	64	10	5	66.73	16.68	3.97	8
2.	74	10	5	71.96	18.4	3.98	9
3.	64	20	5	68.64	19.24	7.77	9
4.	74	20	5	74.72	20.96	7.78	8
5.	64	10	10	67.13	17.60	3.97	8
6.	74	10	10	73.21	19.31	3.98	9
7.	64	20	10	69.89	20.16	7.77	9
8.	74	20	10	75.97	21.87	7.78	8
9.	60.59	15	7.5	65.81	15.51	5.87	9
10.	77.41	15	7.5	76	17.78	5.88	8
11.	69	6.59	7.5	68.56	14.85	2.68	8
12.	69	23.41	7.5	73.20	11.42	9.07	8
13.	69	15	3.3	69.88	18.50	5.88	9
14.	69	15	11.7	71.98	10.04	5.88	8
15.	69	15	7.5	71.02	9.27	5.88	9
16.	69	15	7.5	71.02	9.27	5.88	8
17.	69	15	7.5	71.02	9.27	5.88	8
18.	69	15	7.5	71.02	9.27	5.88	8
19.	69	15	7.5	71.02	9.27	5.88	8
20.	69	15	7.5	71.02	9.27	5.88	9

X1 – Bengal gram flour
X2 –Roasted linseed powder
X3 –Gingelly seed powder

The carbohydrate content of the omapodi ranges from 65.81 to 76.00g, protein 9.27 to 21.87g, omega 3 fatty acids 2.68 to 9.07mg and overall acceptability may range from 8 to 9 respectively.

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

Regression analysis indicated that the fitted quadratic model accounts that about 99% of carbohydrate (R2>0.99), 75% of protein (R2>0.75), 100% of omega 3 fatty acids (R2>1.0) and 58% of overall acceptability (R2>0.58) of the developed RLSP incorporated omapodi.

a) Carbohydrate

The values of regression coefficients, sum squares, F values and P values for coded form of process variables are presented in table-4.

The carbohydrate content of the developed omapodi was range from 65.81 to 76g. The developed model for omapodi in the form of uncoded (actual) process variables as follows:

Y1 (Carbohydrate) = 31.51+0.53A-0.07B-0.48C-5.04A2-8.64B2-6.57C2 +4.27AB+8.55AC+8.55BC

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

y1 (Carbohydrate) = 71.02+2.97a+1.32b+0.56c-0.01a2-0.02b2-4.11c2+0.11ab+0.11ac+0.11bc

The magnitude of P and F value in table 2 indicates that the negative contribution in the linear terms while Bengal gram flour have the positive effect. The quadratic terms have negative effect while interactive terms have the positive effect on carbohydrate. The effect of Bengal gram flour, RLSP and gingelly seed powder has been shown in fig 1a-1c.

The carbohydrate content increased with the increase in Bengal gram flour up to 74g, but increase in Roasted Linseed Powder did not show more effect on increasing the carbohydrate content (Fig-1a). The effects of carbohydrate content increases by the addition of Bengal gram flour but gingelly seed powder have no effect on carbohydrate (Fig-1b). In fig-1c showed a positive increase in the carbohydrate content in roasted linseed powder to 20g while the gingelly seed powder have no much effect on carbohydrate.

Table 4: ANOVA and Coefficient for Carbohydrate content of RLSP incorporated omapodi

Source	Coefficient	Sum square	df	F value	P value
Model	71.02	149.12	9	659.04	0.0001**
A	2.97	120.83	1	4805.89	0.0001**
B	1.32	23.70	1	942.60	0.0001**
C	0.56	4.32	1	171.64	0.0001**
A2	-0.013	2.285	1	0.091	0.769
B2	-0.022	6.729	1	0.27	0.616
C2	-4.108	2.432	1	9.673	0.924
AB	0.11	0.091	1	3.63	0.086
AC	0.11	0.091	1	3.63	0.086
BC	0.11	0.091	1	3.63	0.086
Lack of fit	-	0.25	5	-	-
R2	0.998				
Adj R2	0.997				
Pred R2	0.986				
Adeq prec	90.744				

A-Bengal gram flour
B-Roasted linseed powder
C-Gingelly seed powder
df- Degree of freedom
*-5% level of significant
**-1% level of significant

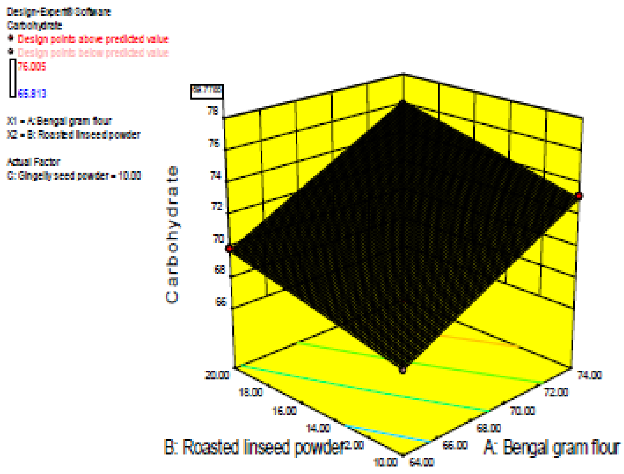

Fig 1a: Effect of Bengal gram flour and RLSP on carbohydrate content of omapodi

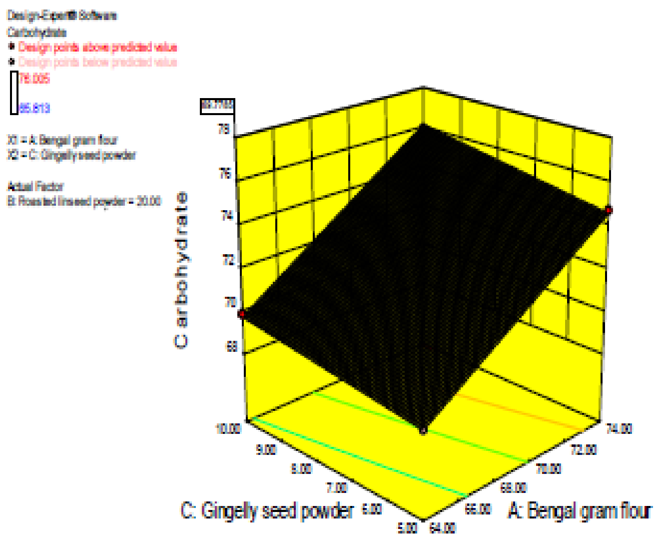

Fig 1b: Effect of Bengal gram flour and gingenlly Seed powder on carbohydrate content of omapodi

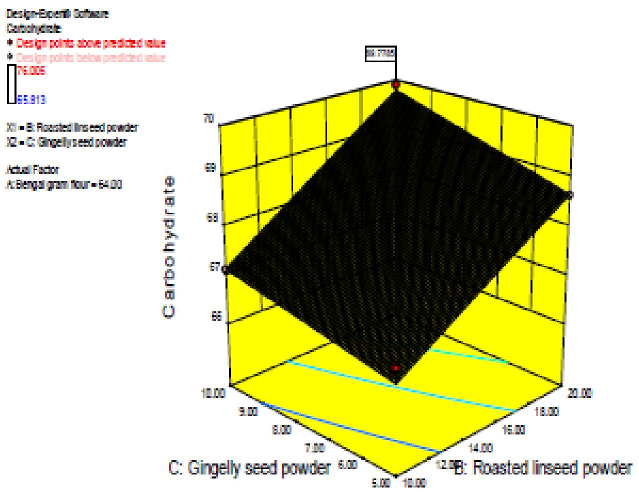

Fig 1c: Effect of RLSP and gingelly seed powder on carbohydrate content of ompodi

b) Protein

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

Table 5: ANOVA and Coefficient for Protein content of RLSP incorporated omapodi

Source	Coefficient	Sum square	df	F value	P value
Model	9.14	316.29	9	3.35	0.037
A	0.78	8.34	1	0.80	0.393
B	0.33	1.45	1	0.14	0.717
C	-0.77	8.18	1	0.78	0.398
A2	3.51	177.26	1	16.89	0.002*
B2	2.27	73.99	1	7.05	0.024
C2	2.67	102.49	1	9.76	0.011
AB	0.00	0.00	1	0.00	1.00
AC	0.00	0.00	1	0.00	1.00
BC	0.00	0.00	1	0.00	1.00
Lack of fit	-	104.96	5	-	-
R2	0.751				
Adj R2	0.527				
Pred R2	-0.886				
Adeq prec	4.904				

A-Bengal gram flour
B-Roasted linseed powder
C-Gingelly seed powder

df- Degree of freedom
*-5% level of significant
**-1% level of significant

The protein content of the developed omapodi was range from 9.27 to 21.87g.

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

Y2 (Protein)=711.99-19.20A-2.65B-6.71C + 0.14A2 + 0.09B2 + 0.43C2 + 2.13AB + 2.84AC-7.54BC

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

y2 (Protein) = 9.14 + 0.78a + 0.33b-0.77c + 3.51a2 + 2.27b2 + 2.67c2 + 0.00ab + 0.00ac + 0.00bc

The magnitude of P and F value in table 3 indicates that the negative contribution in all the process variables. All the quadratic terms have positive effect. The interaction between AB and AC has the positive effect while BC has the negative effect. The effect of Bengal gram flour, RLSP and gingelly seed powder on protein has been shown in fig 2a-2c.

The protein content decrease with the increase in Bengal gram flour up to 74g, but increase in Roasted Linseed Powder decreased with increasing the carbohydrate content (Fig-2a). The effects of protein content decreased with increase by the addition of Bengal gram flour and gingelly seed powder on carbohydrate (Fig-2b). In fig-2c.decrease with increase in the protein content in roasted linseed powder and gingelly seed.

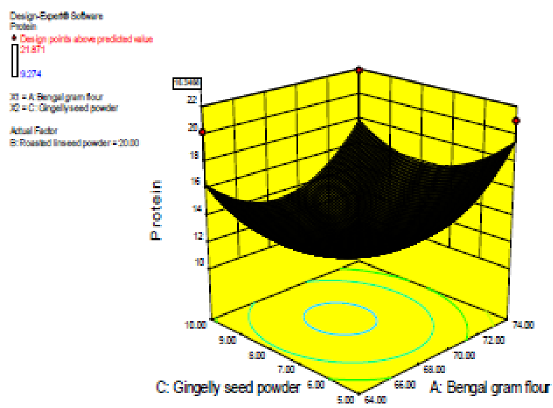

Fig 2a: Effect of Bengal gram flour and RLSP on protein content of omapodi

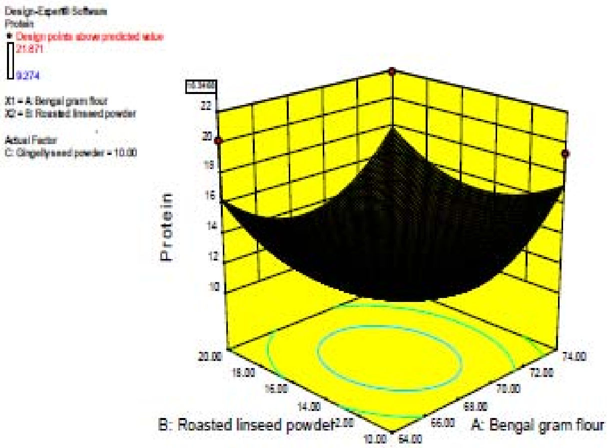

Fig 2b: Effect of Bengal gram flour and gingelly seed powder on protein content of omapodi

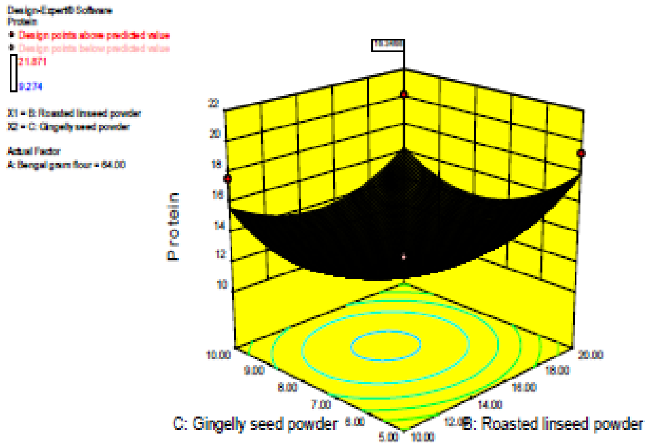

Fig 2c: Effect of RLSP and gingelly seed Powder on protein content of omapodi

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-6.

Table 6: ANOVA and Coefficient for Omega 3 fatty acids content of RLSP incorporated omapodi

Source	Coefficient	Sum square	df	F value	P value
Model	5.88	49.31	9	6.683	0.0001**
A	5.562	4.22	1	5152.73	0.0001**
B	1.90	49.31	1	6.015	0.0001**
C	0.00	0.00	1	0.00	1.000
A2	2.450	8.649	1	10.55	0.0087
B2	6.821	6.705	1	0.82	0.387
C2	6.821	6.705	1	0.82	0.387
AB	0.00	0.00	1	0.00	1.000
AC	0.00	0.00	1	0.00	1.000
BC	0.00	0.00	1	0.00	1.000
Lack of fit	-	8.198	5	-	-
R2	1.000				
Adj R2	1.000				
Pred R2	1.000				
Adeq prec	31568.02				

A-Bengal gram flour
B-Roasted linseed powder
C-Gingelly seed powder

df- Degree of freedom
*-5% level of significant
**-1% level of significant

The omega 3 fatty acid content of the developed omapodi was range from 2.68 to 9.07mg. The developed model for omapodi in the form of uncoded (actual) process variables as follows:

Y3 (Omega 3 fatty acid) = 0.15-2.39A + 0.38B-.64C + 9.79A2 + 2.73B2 + 1.09C2 + 4.13AB + 7.37AC + 8.63BC

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

y3(Omega3fattyacid)= 5.88 + 5.56a + 1.90b + 0.00c + 2.45a2 + 6.82b2 + 6.82c2 + 0.00ab + 0.00ac + 0.00bc

The magnitude of P and F value in table 4 indicates that the linear terms have negative effect on Bengal gram flour and gingelly seed powder while RLSP have the positive effect. The quadratic and interactive terms have positive effect on omeg 3 fatty acid. The effect of Bengal gram flour, RLSP and gingelly seed powder on omega 3 fatty acid has been shown in fig 3a-3c.

The omega 3 fatty acid content increase in roasted linseed powder up to the maximum, but there are no differences in the Bengal gram flour on omega 3 fatty acid content (Fig-3a). The effects of omega 3 fatty acid content increase by the addition of Bengal gram flour and gingelly seed powder (Fig-3b). In fig-3c increase in the omega 3 fatty acid content in roasted linseed powder and gingelly seed.

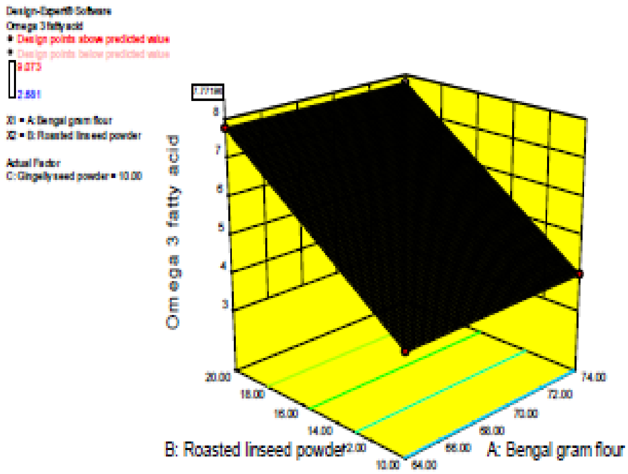

Fig 3a: Effect of Bengal gram flour and RLSP On omega 3 fatty acid content of omapodi

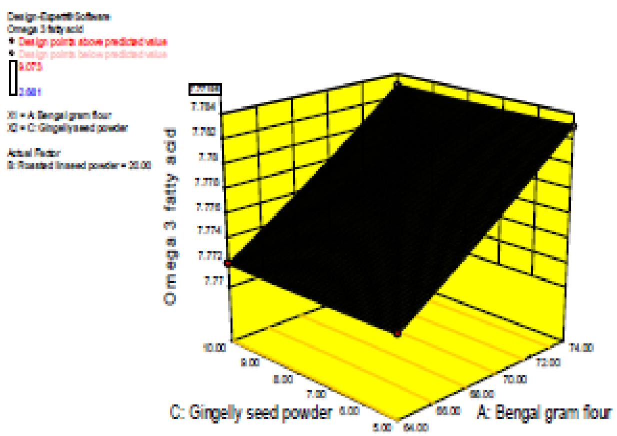

Fig 3b: Effect of Bengal gram flour and gingelly seed powder on omega 3 Fatty acid content of omapodi

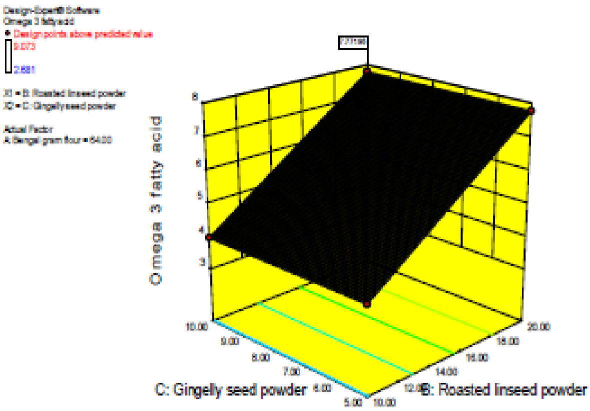

Fig 3c: Effect of RLSP and gingelly seed powder on omega 3 fatty acid content of omapodi

Overall Acceptability

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 overall acceptability of RLSP incorporated omapodi

Source	Coefficient	Sum square	df	F value	P value
Model	8.33	2.79	9	1.55	0.253
A	-0.12	0.21	1	1.03	0.334
B	0.00	0.00	1	0.00	1.000
C	-0.12	0.21	1	1.03	0.334
A2	0.094	0.13	1	0.64	0.444
B2	-0.083	0.09	1	0.49	0.499
C2	0.094	0.13	1	0.64	0.444
AB	-0.50	2.00	1	9.96	0.010
A	0.00	0.00	1	0.00	1.00
BC	0.00	0.00	1	0.00	1.00
Lack of fit	-	0.67	5	0.51	0.764
R2	0.5817				
Adj R2	0.2052				
Pred R2	-0.4663				
Adeq prec	4.711				

A-Bengal gram flour
B-Roasted linseed powder
C-Gingelly seed powder

df- Degree of freedom
*-5% level of significant
**-1% level of signifi

The overall acceptability of the developed omapodi was range from 8 to 9 respectively.

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

Y4 (Overall acceptability) = 7.719-0.244A + 1.479B-0.275C + 3.764A2-3.307B2 + 0.015C2-0.020AB + 3.360AC + 7.913BC

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

y4(Overallacceptability)=8.33-0.12a+0.00b-0.12c+0.09a2-3.31b2+0.01c2+0.02ab+3.36ac+7.91bc

The magnitude of P and F value in table 5 indicates that the linear terms of Bengal gram flour and gingelly seed powder have the negative effect while the quadratic terms have the positive effect. The interactions of AB have the negative effect but AC and BC have the positive effect on overall acceptability. The effect of Bengal gram flour, RLSP and gingelly seed powder on overall acceptability has been shown in fig 4a-4c.

The overall acceptability increase and then decreased in roasted linseed powder compared to the Bengal gram flour maximum (Fig-4a). The effects of omega 3 fatty acid content increase by the addition of gingelly seed powder while Bengal gram flour gets decreased (Fig-4b). In fig-4c increase in the overall acceptability content in roasted linseed powder and gingelly seed.

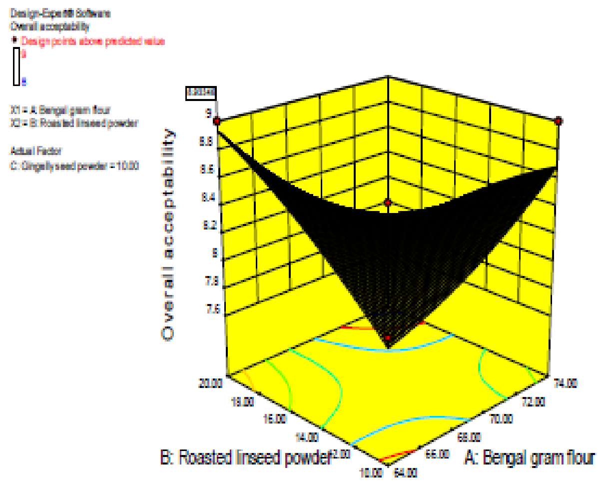

Fig 4a: Effect of Bengal gram flour and RLSP on overall acceptability of omaodi

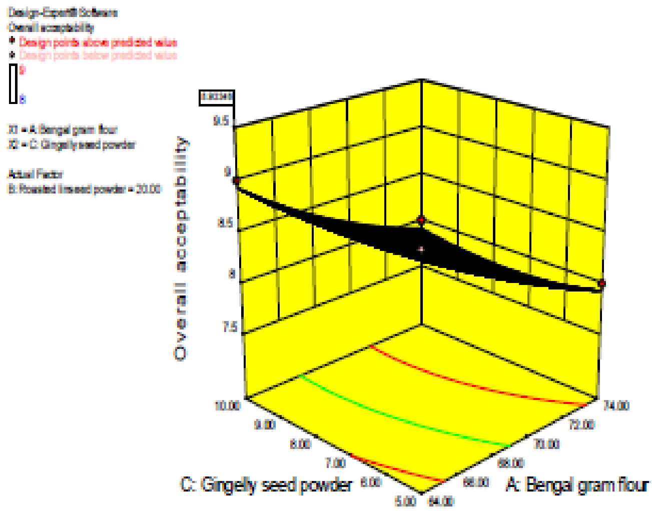

Fig 4b: Effect of Bengal gram flour and gingelly seed powder on overall acceptability of omapodi

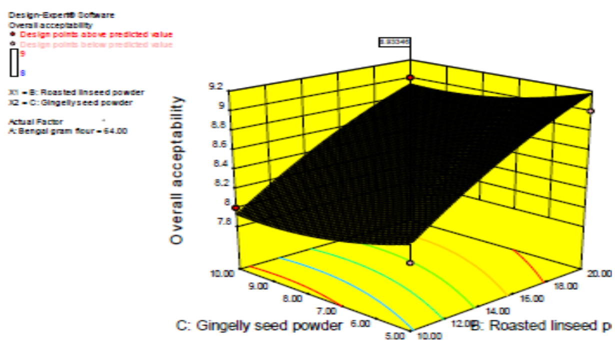

Fig 4c: Effect of RLSP and gingelly seed powder on overall acceptability of compounds

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 8: Optimum value of process parameters responses for omapodi

Process Parameters	Target	Experimental Design	Importance	Optimum values	Desirability
Bengal gram flour	In range	64	74	3	0.63
RLSP	In range	10	20	3	
Gingelly seed powder	In range	5	10	3	
	Responses		**Predicted values**		
Carbohydrate	Maximum	65.18	76	3	
Protein	Maximum	9.27	21.87	3	
Omega 3 fatty acid	Maximum	2.68	9.07	3	
Overall acceptability	Maximum	8	9	3	

In order to optimize the omapodi, equal importance was given to all the three parameters and four responses. The optimum condition of Bengal gram flour 64g, RLSP 20g and gingelly seed powder 10g respectively. Corresponding to these values of process variables, the values of carbohydrate 69.78g, protein 16.35g, omega 3 fatty acid 7.77mg and overall acceptability 9. The overall desirability was 0.63 respectively.

Acknowledgement

We would like to acknowledge Dr. S. Velavan, Director, Harman Institute of Science Education and Research, Thanjavur, Tamil Nadu for preparing this manuscript.

References

1. Apata DF. Biochemical, nutritional and toxicological assessment of some tropical legume seeds. Ph.D Dissert, Deptt. Anim. Sci. Univ. Ibadan, Nigeria. Embryogenesis. *Photosynthetica,* 1990; 19:194-197.
2. Autin A, Ram A. Studies on chapathi making quality of wheat. Indian council of agric. Res. Tech. bull. ICAR, New Delhi, 1971, 31.
3. Basantpure D, Kumbhar BK, Awasthi P. Optimization of level of ingredients and drying air temperature in development of dehydrated carrot halwa using response surface methodology, 2003.
4. Gacula Jr MC, Singh. Statistical methods in food consumer research, New York; Academic Press, Inc., 1994, 214-272.
5. Parameshwari S, Nazni P. Analysis of Bioactive Compounds Inraw (Dried), Autoclaving, Boiling and Roasted Linum Usitatissimumseed Using Gas Chromatography and Mass Spectroscopy. Indian Journal of Applied Research, 2015; 5(8):168- 172.
6. Shahidi F. Nutraceuticals & functional foods: research addresses bioactive components. Food Technol 2002; 56(5):23.