Original Research Article **Home science**

International Journal of Pharma and Bio Sciences **ISSN 0975-6299**

OPTIMIZATION OF ROASTED LINSEED POWDER (RLSP) INCORPORATED CHIDWA LADDU 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. Flax seed is richest source of alpha-linolenic acid, lignans and other nutritional components. The incorporation of flax seed into diet can help to have a superior taste in regularly consumed dishes. The reddish brown flax seed grains have a pleasant flavour and taste resembling nuts and its utilization is simple in different products. Considering the above facts, this study was undertaken 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 Chidwa laddu food using Response Surface Methodology. The optimum condition of rice flakes 138.16g, RLSP 20g, groundnut 28.82g and Bengal gram 20g respectively. Corresponding to these values of process variables, the values of carbohydrate 287.48g, protein 34.39g, omega 3 fatty acid 36.58mg and overall acceptability 8. The overall desirability was 0.51 respectively.

KEYWORDS: **Chidwa laddu, seeds, Designer food, *Linum Usitatissimum***

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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 consumer demand has increased for a product with taste, safety, convenience and nutrition. This nutrition has emerged an added dimension in the chain of food product development [1]. Diet is essential 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 countries for meeting the challenges of hunger and starvation [2]. 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. Flax seed 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 [3]. 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 [4]. 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 Chidwa laddu food using Response Surface Methodology.

MATERIALS AND METHODS

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

The best processing method which yields high omega 3 fatty acid (Linolenic acid) was selected for the development of Chidwa laddu based on the fatty acid profile results obtained from GC-MS analysis [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 and 2.

Table 1
Recipes selected for omega 3 fatty acid enrichment

Type of Food	Products	Main ingredients
Traditional sweet	Chidwa laddu	Rice flakes Roasted linseed powder Groundnut Roasted Bengal gram

Table 2
Omega 3 fatty acid enriched Traditional sweet (Chidwa Laddu)

Ingredient	Weight (g)
Rice flakes	Variable
RLSP	Variable
Groundnut	Variable
Jaggery	Variable
Water	As required

Preparation

Rice flakes and ground nut roasted separately. Remove the skin of groundnut and coarsely grind. Heat the jiggery with little water. Cook to make into thick consistency syrup. Then add roasted rice flakes and groundnut to the syrup and stir continuously. Make into small ball while it is hot.

Optimization of RLSP Incorporated Chidwa laddu

The levels of these variables along with experimental plan consisting of four variables at five levels have been presented in Table-3.

Table 3
Observed values of dependent variables for RLSP incorporated chidwa laddu in different runs of optimization experiments

Variables	Symbols				Coded level			
			-β	–1	0	+1		+ β
Rice flakes	A		125	130	135	140		145
RLSP	B		5	10	15	20		15
Groundnut	C		15	20	25	30		35
Roasted Bengal gram	D		15	20	25	30		35
Design point	Uncoded				Coded			
	A	B	C	D	a	b	c	d
V1	130	10	20	20	-1	-1	-1	-1
V2	140	10	20	20	+1	-1	-1	-1
V3	130	20	20	20	-1	+1	-1	-1
V4	140	20	20	20	+1	+1	-1	-1
V5	130	10	30	20	-1	-1	+1	-1
V6	140	10	30	20	+1	-1	+1	-1
V7	130	20	30	20	-1	+1	+1	-1
V8	140	20	30	20	+1	+1	+1	-1
V9	130	10	20	30	-1	-1	-1	+1
V10	140	10	20	30	+1	-1	-1	+1
V11	130	20	20	30	-1	+1	-1	+1
V12	140	20	20	30	+1	+1	-1	+1
V13	130	10	30	30	-1	-1	+1	+1
V14	140	10	30	30	+1	-1	+1	+1
V15	130	20	30	30	-1	+1	+1	+1
V16	140	20	30	30	+1	+1	+1	+1
V17	125	15	25	25	-β	0	0	0
V18	145	15	25	25	+β	0	0	0
V19	135	5	25	25	0	-β	0	0
V20	135	25	25	25	0	+β	0	0
V21	135	15	15	25	0	0	-β	0
V22	135	15	35	25	0	0	+β	0
V23	135	15	25	15	0	0	0	-β
V24	135	15	25	35	0	0	0	+β
V25	135	15	25	25	0	0	0	0
V26	135	15	25	25	0	0	0	0
V27	135	15	25	25	0	0	0	0
V28	135	15	25	25	0	0	0	0
V29	135	15	25	25	0	0	0	0
V30	135	15	25	25	0		0	0

For the preparation of chidwa laddu (Plate 1), rice flakes, roasted flax seed powder, groundnut and roasted Bengal gram are optimized using central computation rotator design. The variables were standardized to simplify computation and deduce their relative effect of variables on the responses [6].

A= Rice flakes – 135 /5

The relationship between standardized variables value is given as

B= Roasted Flax Seed Powder– 15 /5

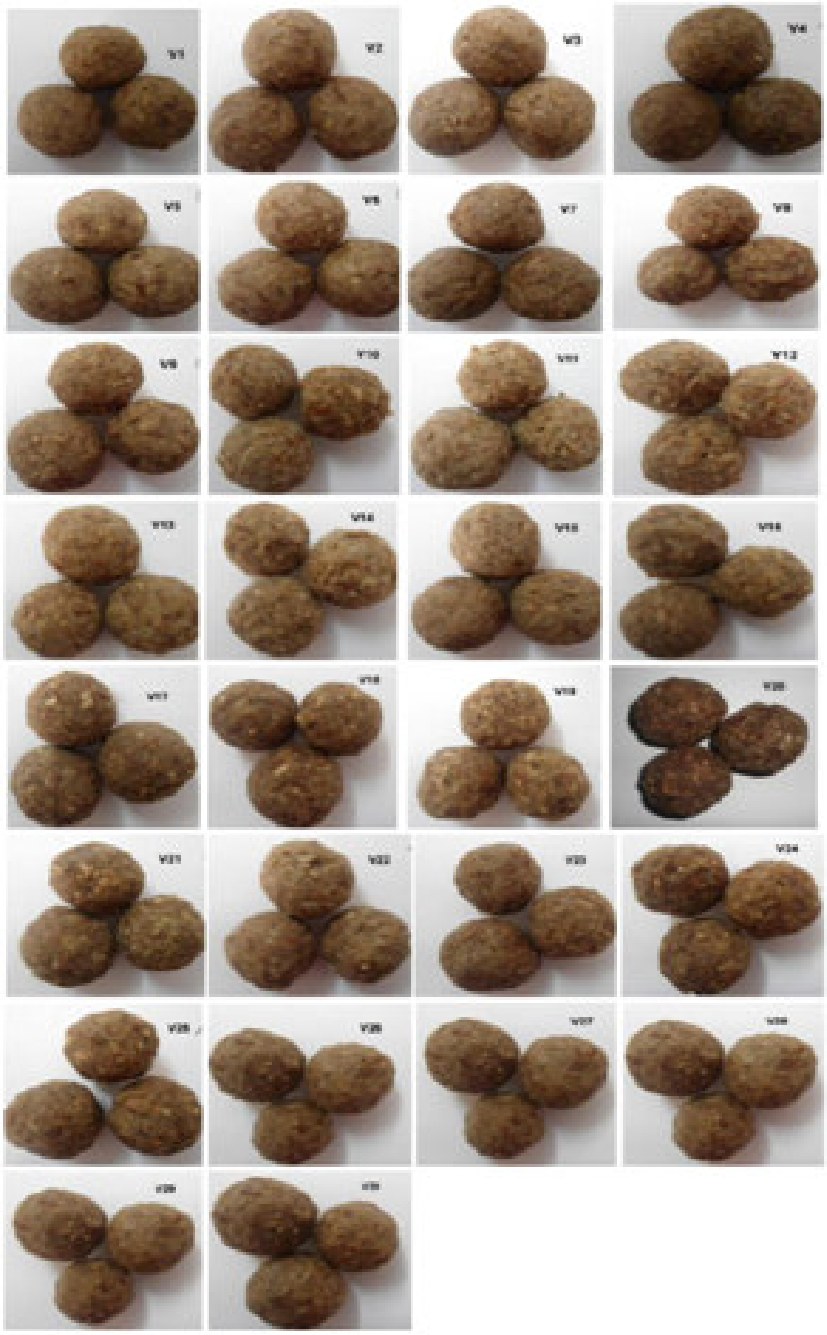
Response surface methodology was applied to the experimental data using a

C= Groundnut-25 /5

D= Roasted Bengal gram- 25 / 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.

Plate 1
Chidwa laddu



RESULTS AND DISCUSSION

Optimization of RLSP Incorporated Traditional Sweet (Laddu)

The laddu prepared with the help of rice flakes (A), RLSP (B), groundnut (A) and Bengal gram (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 Traditional Sweet (Laddu)

The proximate and sensory properties of RLSP incorporated traditional sweet was given in table-4.

Table 4
Proximate and sensory properties of RLSP incorporated traditional sweet (Laddu)

Sl. No	Uncoded value				CHO	Protein	Omega 3 fatty acids	Overall acceptability
	x_1	x_2	x_3	x_4				
1.	130	10	20	20	259.1	21.29	3.8	8
2.	140	10	20	20	276.7	21.95	3.8	8
3.	130	20	20	20	271.8	23.85	3.8	7
4.	140	20	20	20	279.6	65.01	3.8	7
5.	130	10	30	30	212.5	28.5	3.8	8
6.	140	10	30	30	280.28	29.16	3.8	7
7.	130	20	30	30	281.91	30.45	3.8	8
8.	140	20	30	30	281.9	31.75	7.6	8
9.	130	10	20	20	274.9	23.5	3.8	7
10.	140	10	20	20	276.7	24.2	3.8	8
11.	130	20	20	20	271.8	26.1	7.6	8
12.	140	20	20	20	287.7	26.15	7.6	8
13.	130	10	30	30	272.55	30.7	3.8	7
14.	140	10	30	30	280.35	31.31	3.8	7
15.	130	20	30	30	280.3	28.6	7.6	8
16.	140	20	30	30	288	29.2	7.6	8
17.	125	10	25	25	270.9	26.63	5.7	8
18.	145	15	25	25	286.3	28.94	5.7	7
19.	135	5	25	15	277	22.56	1.9	8
20.	135	25	25	25	281	27.83	9.5	7
21.	135	15	15	25	278.2	25.26	5.7	8
22.	135	15	35	25	281.13	28.11	5.7	8
23.	135	15	25	25	272.2	23.01	5.7	9
24.	135	15	25	25	284.12	27.5	5.7	8
25.	135	15	25	25	284.12	27.5	5.7	8
26.	135	15	25	15	284.12	27.5	5.7	8
27.	135	15	25	25	284.12	27.5	5.7	9
28.	135	15	25	25	284.12	27.5	5.7	8
29.	135	15	25	25	284.12	27.5	5.7	8
30.	135	15	25	25	284.12	27.5	5.7	7

X1 – Rice flakes X2 –Roasted linseed powder X3 –Groundnut X4 –Bengal gram
The carbohydrate content of the laddu ranges from 212.5 to 288g, protein 21.29 to 65.01g, omega 3 fatty acids 1.9 to 9.5mg and overall acceptability may range from 7 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 68% of carbohydrate (R2>0.68), 61% of protein (R2>0.61), 84% of omega 3 fatty acids (R2>0.84), and 52% of overall acceptability (R2>0.0.52) of the developed RLSP incorporated laddu.

a) Carbohydrate

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 Carbohydrate content of RLSP incorporated laddu

Source	Coefficient	Sum square	df	F value	P value
Model	284.12	3700.52	14	2.31	0.059
A	6.55	1029.27	1	8.99	0.009
B	4.91	579.48	1	5.06	0.039
C	-0.61	8.94	1	0.078	0.784
D	4.68	525.94	1	4.59	0.049
A^2	-2.27	141.56	1	1.24	0.284
B^2	-2.17	129.37	1	1.13	0.305
C^2	-2.01	110.32	1	0.96	0.342
D^2	-2.38	155.60	1	1.36	0.262
AB	-3.97	252.73	1	2.21	0.158
AC	2.51	100.85	1	0.88	0.363
AD	-3.75	224.78	1	1.96	0.182
BC	3.93	247.51	1	2.16	0.162
BD	-3.96	250.67	1	2.19	0.159
CD	2.54	103.58	1	0.90	0.357
Lack of fit	-	1717.86	10	-	-
R2	0.683				
Adj R2	0.387				
Pred R2	-0.826				
Adeq prec	6.769				

A– Rice flakes, df- Degree of freedom, B –Roasted linseed powder , *-5% level of significant ,C –Groundnut ,**-1% level of significant, D –Bengal gram

The carbohydrate content of the developed laddu was range from 212.5 to 288g. The developed model for laddu in the form of uncoded (actual) process variables as follows:

$$Y1\ (Carbohydrate) = -2138+29.467A+29.467B+25.075C-14.572D-0.091A^2 -0.087B^2- 0.080C^2 -0.095D^2 - 0.159AB+0.100AC-0.149AD+0.157BC+0.157BD-0.158CD.$$

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

$$y1\ (Carbohydrate) = 284.12+6.55a+4.91b-0.61c+4.68d-2.27a -2.17b -2.01c -2.38d -3.97ab+2.51ac-3.75ad+3.93bc-3.96bd+2.54cd.$$

The magnitude of P and F value in table 33 indicates that the positive contribution in the rice flakes, RLSP and groundnut while Bengal gram has the negative effect. All the quadratic terms have negative effect on carbohydrate. The interactions of AB and CD have the negative effect while AC, AD, BC and BD have the positive effect on carbohydrate. The effect of rice flakes, RLSP, groundnut and Bengal gram has been shown in fig 1a-1f. The carbohydrate content increased with the increase in rice flakes and roasted linseed powder of the developed product laddu (Fig-1a). The effect of carbohydrate content increased rapidly by the addition of rice flakes, but both the groundnut showed a slight negative effect on carbohydrate content of the product (Fig-1b). In fig-1c showed a positive increase in the carbohydrate content of the product by rice flakes and bengal gram. The carbohydrate increased in Roasted Linseed Powder and groundnut show mild increase in the carbohydrate (Fig-1d). In fig-1e showed an increased with the increase in carbohydrate of the product by both roasted linseed powder and roasted bengal gram. The carbohydrate content increase effect of groundnut and the roasted bengal gram decreased slightly in the developed laddu (Fig-1f).

Figure 1a
Effect of rice flakes and RLSP On Carbohydrate content of laddu

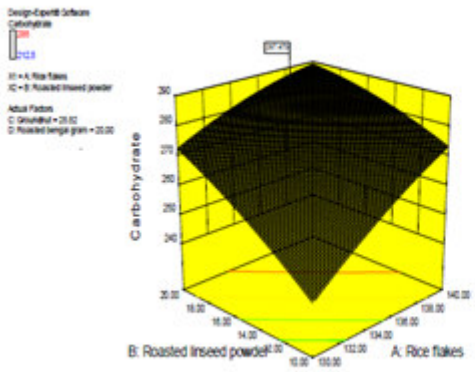


Figure 1b
Effect of rice flakes and groundnut nCarbohydrate content of laddu

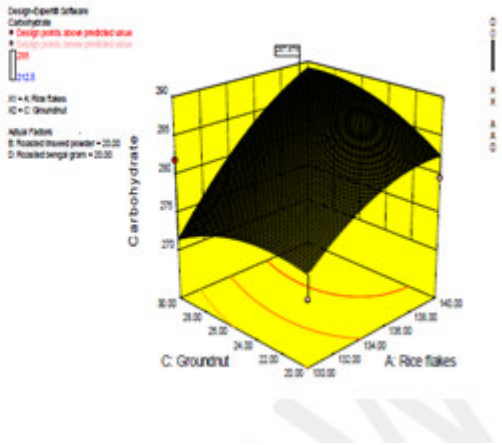


Figure 1c
Effect of rice flaskes and roasted Bengal gram on carbohydrate content of laddu

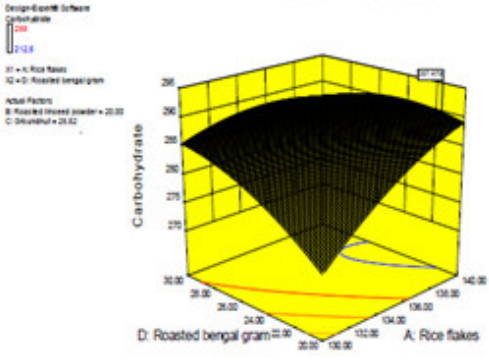


Figure 1d
Effect of RLSP and groundnut on carbohydrate content of laddu

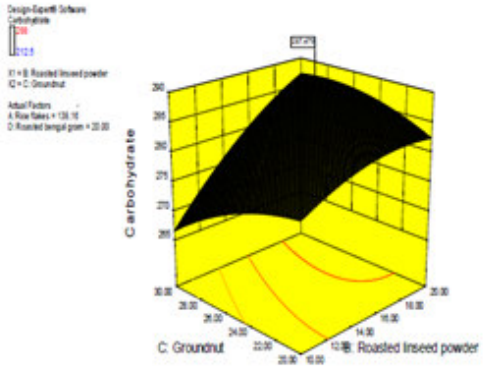


Figure 1e
Effect of RLSP and roasted Bengal Gram on carbohydrate content of Laddu

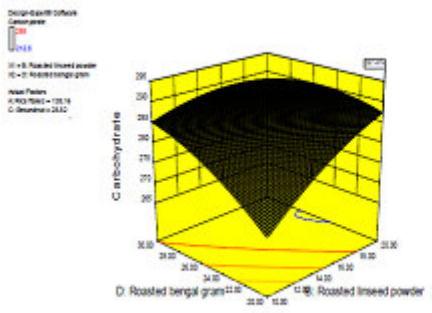
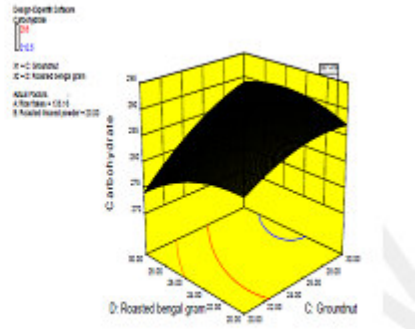


Figure 1f
Effect of groundnut and roasted Bengal gram on carbohydrate content of laddu



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 Potein content of RLSP incorporated laddu

Source	Coefficient	Sum square	df	F value	P value
Model	27.50	987.05	14	1.68	0.165
A	2.10	105.55	1	2.51	0.134
B	2.54	155.09	1	3.69	0.074
C	0.55	7.36	1	0.18	0.681
D	-0.97	22.41	1	0.53	0.476
A^2	0.61	10.31	1	0.25	0.627
B^2	-0.034	0.033	1	7.76	0.978
C^2	0.34	3.13	1	0.07	0.788
D^2	-0.019	0.010	1	2.48	0.988
AB	2.53	102.26	1	2.44	0.139
AC	-2.46	97.17	1	2.31	0.149
AD	-2.61	109.15	1	2.60	0.128
BC	-3.12	155.44	1	3.70	0.073
BD	-3.11	154.94	1	3.69	0.074
CD	2.01	64.52	1	1.54	0.234
Lack of fit	-	629.88	10	-	-
R2	0.610				
Adj R2	0.247				
Pred R2	-1.244				
Adeq prec	6.959				

A– Rice flakes, df- Degree of freedom, B –Roasted linseed powder,*-5% level of significant,C –Groundnut,**-1% level of significant, D –Bengal gram

The protein content of the developed laddu was range from 21.29 to 65.01g.The developed model for laddu in the form of uncoded (actual) process variables as follows:

$$Y2\ (Protein) = -103.88-2.64A-6.87B+12.60C+13.81D+0.02A^2 -1.38B^2 +0.01C^2 -7.79D^2- 0.10AB-0.09AC-0.10AD-0.12BC+0.12BD+0.08CD.$$

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

$$y2\ (Protein) = 27.50+2.10a+2.54b+0.55c-0.97d+0.61a^2 -0.03b^2 +0.34c^2 -0.02d^2 +2.53ab- 2.46ac-2.61ad-3.12bc-3.11bd+2.01cd.$$

The magnitude of P and F value in table 34 indicates that the linear terms of rice flakes and RLSP has negative contribution while groundnut and Bengal gram has the positive effect. The quadratic terms of rice flakes and groundnut have positive effect, but RLSP and Bengal gram have the negative effect. The interactions of all the variables have the negative effect but BD and CD have the positive effect on protein content. The effect of rice flakes, RLSP, groundnut and Bengal gram on protein has been shown in fig 2a-2f. The protein content mild increase in the rice flakes and roasted linseed powder (Fig-2a). The effect of protein increased rapidly by the addition of rice flakes but the groundnut does not have any effect on the developed product laddu (Fig-2b). In fig-2c showed a positive increase in the rice flakes and the roasted Bengal gram have no effect on protein. The protein increased in Roasted Linseed Powder and groundnut did not show any positive effect on increasing the protein (Fig-2d). In fig-2e showed an increased with the increase in protein content of the product by roasted linseed powder and the roasted

bengal gram have only mild effect. The overall protein was shows either positive or a negative effect by the addition of roasted Bengal gram and groundnut in the developed product (Fig-2f).

Figure 2a
Effect of rice flakes and RLSP On Protein content of laddu

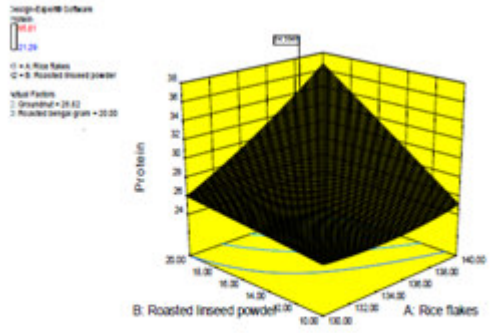


Figure 2b
Effect of rice flakes and groundnut on Protein content of laddu

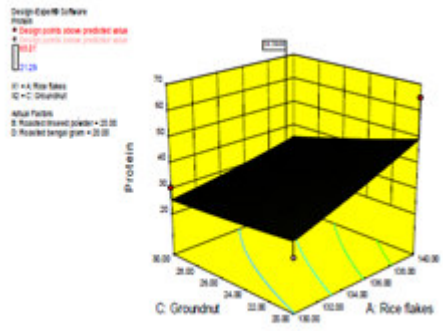


Figure 2c
Effect of rice flaskes and roasted on Protein content of laddu

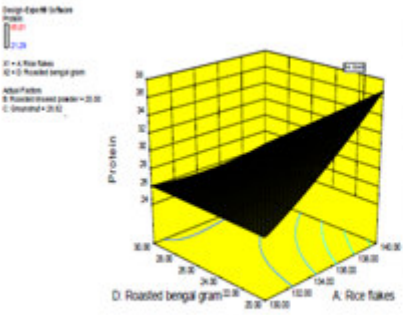


Figure 2d
Effect of RLSP and groundnut onBengal gram Protein content of laddu

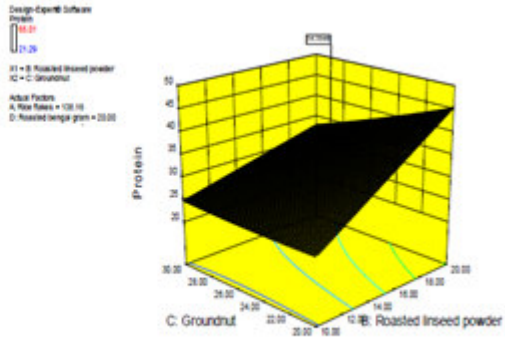


Figure 2e
Effect of RLSP and roasted Bengal Gram on Protein content of Laddu

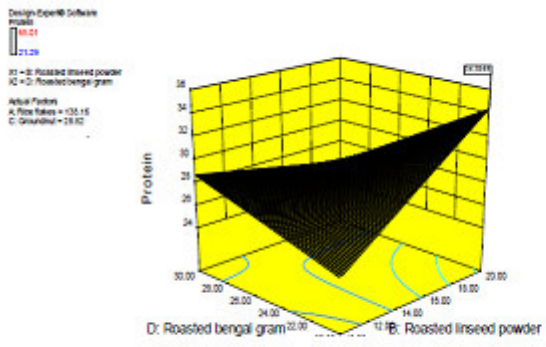
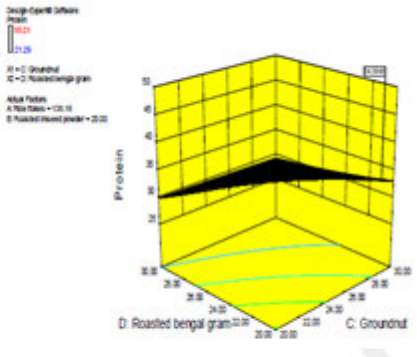


Figure 2f
Effect of groundnut and roasted Bengal gram on Protein content of laddu



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-4.

Table 4
ANOVA and Coefficient for Omega 3 fatty acids content of RLSP incorporated laddu

Source	Coefficient	Sum square	df	F value	P value
Model	5.70	69.07	14	5.59	0.001**
A	0.16	0.60	1	0.68	0.422
B	1.43	48.73	1	55.23	0.0001**
C	0.16	0.60	1	0.68	0.422
D	0.48	5.42	1	6.14	0.026
A^2	-0.12	0.39	1	0.44	0.008
B^2	-0.12	0.39	1	0.44	0.328
C^2	-0.12	0.39	1	0.44	0.518
D^2	-0.12	0.39	1	0.44	0.518
AB	0.24	0.90	1	1.02	0.518
AC	0.24	0.90	1	1.02	0.518
AD	-0.24	0.90	1	1.02	0.328
BC	0.24	0.90	1	1.02	0.328
BD	0.71	8.12	1	9.20	0.328
CD	-0.24	0.90	1	1.02	0.328
Lack of fit	-	13.24	10	-	-
R2	0.839				
Adj R2	0.689				
Pred R2	0.074				
Adeq prec	9.058				

A– Rice flakes, df- Degree of freedom ,B –Roasted linseed powder, *-5% level of significant, C –Groundnut, **-1% level of significant, D –Bengal gram.

The omega 3 fatty acid content of the developed laddu was range from 1.9 to 9.5mg. The developed model for laddu in the form of uncoded (actual) process variables as follows:

$$Y3\ (\text{Omega 3 fatty acid}) = -72.04+1.17A-1.80B-0.92C+1.42D-4.75A^2 - 4.75B^2 - 4.75C^2 - 4.75D^2 +9.50AB+9.50AC-9.50AD+9.50BC+0.03BD-9.50CD.$$

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

$$y3\ (\text{Omega 3 fatty acid}) = 5.70+0.16a+1.43b+0.16c+0.48d-0.12a^2 -0.12b^2 -0.12c^2 - 0.12d^2+0.24ab+0.24ac-0.24ad+0.24bc+0.71bd-0.24cd.$$

The magnitude of P and F value in table 35 indicates that the linear terms of rice flakes and Bengal gram has positive effect while RLSP and groundnut has the positive effect. All the quadratic terms have negative effect on omeg 3 fatty acid. All the interactive terms have the positive effect, but AD and CD has the negative effect on omega 3 fatty acid. The effect of riceflakes, RLSP, groundnut and Bengal gram on protein has been shown in fig 3a-3f. The omega 3 fatty acid increased with the increase in rice flakes and roasted linseed powder of the product (Fig-3a). The effect of omega 3 fatty acid increased rapidly by the addition of rice flakes and groundnut of the product (Fig-3b). In fig-3c showed a positive increase in the omega 3 fatty acid of the product by roasted bengal gram than rice flakes. The omega 3 fatty acid increased in Roasted Linseed Powder and groundnut (Fig- 3d). In fig-3e showed an increased with the increase in omega 3 fatty acid of the roasted linseed powder. The omega 3 fatty acid was showed a positive effect by the addition of roasted bengal gram in laddu (Fig-3f).

Figure 3a
Effect of rice flakes and RLSP On omega 3 fatty acid content of laddu

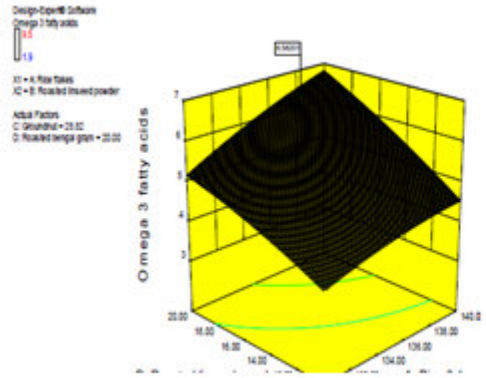


Figure 3b
Effect of rice flakes and groundnut on omega 3 fatty acid content of laddu

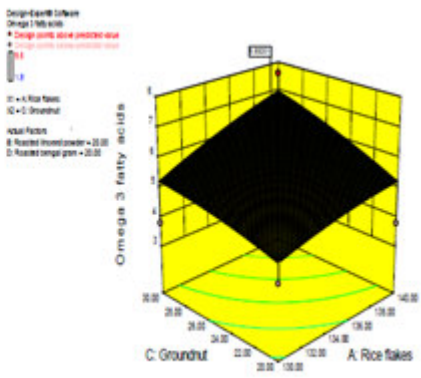


Figure 3c
Effect of rice flaskes and roasted Bengal gram on omega 3 fatty acid content of laddu

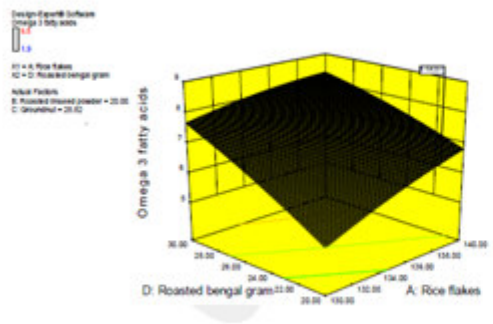


Figure 3d
Effect of RLSP and groundnut on omega 3 fatty acid content of laddu

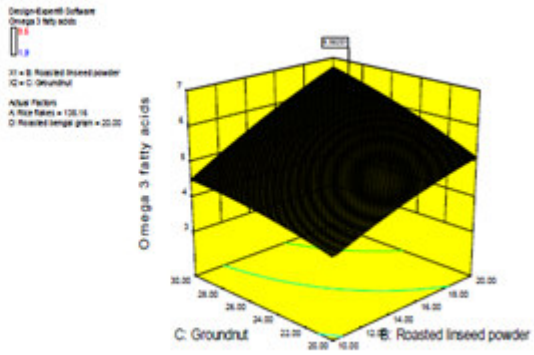


Figure 3e
Effect of RLSP and roasted BengalGram on omega 3 fatty acid content of laddu

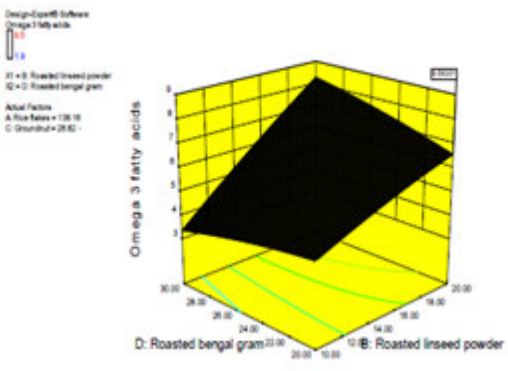
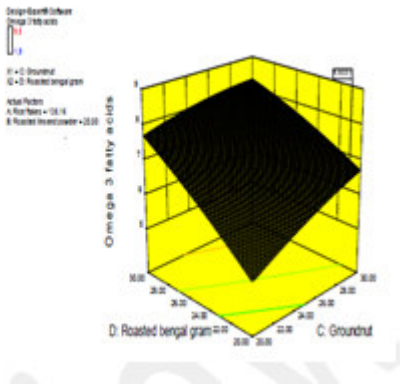


Figure 3f
Effect of groundnut and roasted Bengal gram on omega 3 fatty acid content of Laddu



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-5.

Table 5
ANOVA and Coefficient for overall acceptability of RLSP incorporated laddu

Source	Coefficient	Sum square	df	F value	P value
Model	8.00	4.87	14	1.16	0.389
A	-0.083	0.17	1	0.56	0.468
B	0.00	0.00	1	0.00	1.000
C	0.00	0.00	1	0.00	1.000
D	-0.083	0.17	1	0.56	0.468
A^2	-0.17	0.76	1	2.54	0.132
B^2	-0.17	0.76	1	2.54	0.132
C^2	-0.042	0.05	1	0.16	0.696
D^2	0.083	0.19	1	0.63	0.438
AB	0.00	0.00	1	0.00	1.000
AC	-0.12	0.25	1	0.83	0.376
AD	0.13	0.25	1	0.83	0.376
BC	0.25	1.00	1	3.33	0.088
BD	0.25	1.00	1	3.33	0.088
CD	-0.12	0.25	1	0.83	0.376
Lack of fit	-	2.50	10	0.62	0.754
R2	0.519				
Adj R2	0.071				
Pred R2	-0.845				
Adeq prec	4.088				

A– Rice flakes , df- Degree of freedom, B –Roasted linseed powder , *-5% level of significant , C –Groundnut ,**-1% level of significant D –Bengal gram.

The overall acceptability of the developed laddu was range from 7 to 9 respectively. The developed model for laddu in the form of uncoded (actual) process variables as follows:

$$Y4 \text{ (Overall acceptability)} = -106.92+1.78A-0.30B+0.73C-0.88D-6.67A^2 -6.67B^2 -1.67C^2 +3.33D^2 +4.11AB-5.00AC+5.00AD+0.01BC+0.01BD-5.00CD.$$

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

$$y4 \text{ (Overall acceptability)} = 8.00-0.08a+0.00b+0.00c-0.08d-0.17a^2 -0.17b^2 -0.04c^2 \backslash+0.08d^2 -0.00ab-0.12ac+0.13ad+0.25bc+0.25bd-0.12cd.$$

The magnitude of P and F value in table 36 indicates that the linear terms of rice flakes and groundnut has the positive effect while RLSP and Bengal gram has the negative contribution in the process variable. All the quadratic terms have negative effect while the Bengal gram has the positive effect on overall acceptability. All the interactive terms have the positive effect but AC and CD have the negative effect on overall acceptability. The effect of rice flakes, RLSP, groundnut and Bengal gram on overall acceptability has been shown in fig 4a-4f. The overall acceptability increased with slight increase in roasted linseed powder of the developed product laddu (Fig-4a). In fig-4e showed an slight increased with the increase in overall acceptability of the roasted linseed powder of the developed product. The overall acceptability was showed a positive effect on the addition of roasted linseed powder than groundnut in laddu (Fig-4f).

Fig 4a
Effect of rice flakes and RLSP On overall acceptability of laddu

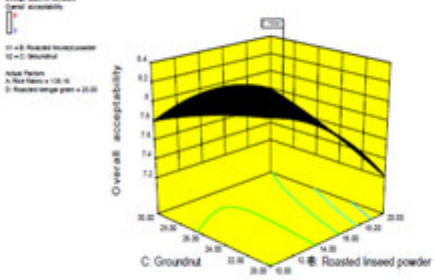


Fig 4b
Effect of rice flakes and groundnut on overall acceptability of laddu

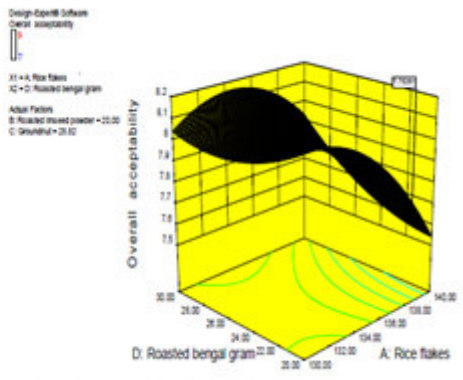


Fig 4c
Effect of rice flaskes and roasted Bengal gram on overall acceptability of laddu

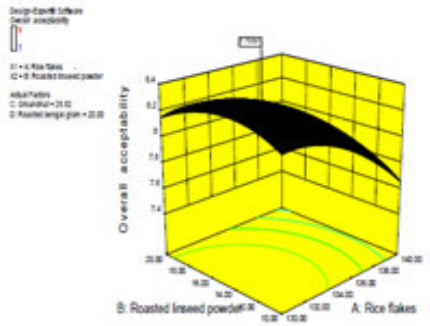


Fig 4d
Effect of RLSP and groundnut on overall acceptability of laddu

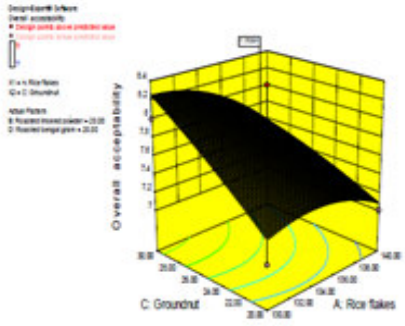


Fig 4e
Effect of RLSP and roasted Bengal Gram on overall acceptability of laddu

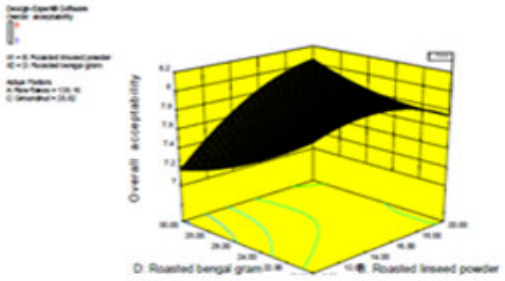
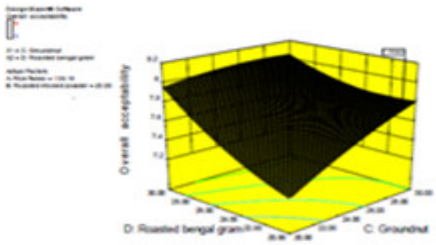


Fig 4f
Effect of groundnut and roasted Bengal gram on overall acceptability of Laddu



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 6
Optimum value of process parameters responses for laddu

Process Parameters	Target	Experimental Design		Importance	Optimum values	Desirability
Broken	In range	130	140	3	138.16	
wheat	In range	10	20	3	20	
RLSP	In range	20	30	3	28.82	
Moong dal	In range	20	30	3	20	
Responses					**Predicted values**	
CHO	Maximum	212.5	288	3	287.48	
Protein	Maximum	21.29	65.0	3	34.39	0.51
Omega 3	Maximum	1.9	9.5	3	36.58	
fatty acid	Maximum	7	9	3	7.75	

In order to optimize the Chidwa laddu , equal importance of 3 was given to all the four parameters and four responses. The optimum condition of rice flakes 138.16g, RLSP 20g, groundnut 28.82g and Bengal gram 20g respectively. Corresponding to these values of process variables, the values of carbohydrate 287.48g, protein 34.39g, omega 3 fatty acid 36.58mg and overall acceptability 8. The overall desirability was 0.51 respectively.

CONCLUSION

Present study concluded that optimized Chidwa laddu is benefit for human health including diabetic patients.

ACKNOWLEDGEMENT

The authors are grateful to Dr. S. Velavan, Director, Harman Institute of Science Education and Research, Thanjavur, Tamil Nadu for his support.

CONFLICT OF INTEREST

None declared.

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