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Research Article

RESPONSE SURFACE METHODOLOGY (RSM) FOR EVALUATION OF FUNCTIONAL PROPERTIES OF EXTRUDED PRODUCT DEVELOPED FROM BEETROOT LEAVES POWDER (BRLP) ALONG WITH CEREALS AND PULSE POWDER

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ABSTRACT

Beetroot (Beta vulgaris L.) green is more nutritious as compared to the beetroot but many part of India it is not used as food it is only used as animal fodder so that we can utilize beetroot green waste which is nutritionally rich in fiber, protein, and carbohydrate, vitamins and minerals for the products development to overcome the malnutrition problem of developing countries. In this study Response surface methodology (RSM) was used to study the effect of moisture content, chickpea powder and beetroot leaves powder on the functional properties of extradites developed from beetroot leaves powder (BRLP) along with cereals and pulse powder. Moisture content, chickpea powder and beetroot leaves powder had significant effect on lateral expansion, water absorption capacity (WAI), water solubility index (WSI) and sensory evaluation. Result showed that with increase in moisture content and chickpea powder lateral expansion of extrudates increase up to optimum level and finally decrease. Increase in moisture content, chickpea powder and beetroot leaves powder resulted in decrease in lateral expansion of the extradites. Results revealed that optimized extruded products are rich in crude fiber content and total phenolic content (TPC).

KEYWORDS – Beetroot Leaves Powder (BRLP), Chickpea Powder, Extrusion, Moisture Content, Response Surface Methodology (RSM), Total Phenolic Content (TPC)

INTRODUCTION

Extrusion technology is extensively used to develop of new protein, fiber and antioxidant rich products. Extrusion cooking is a relatively modern, high temperature, short-time processing technology which was invented in 1940 to manufacture snack foods. The extrusion technology has gained important place in human food and animal feed industries all over the world, mainly for the processing of cereal grains. Extrusion cooking is a complex process that is different from conventional processing by using high shear rates and high temperatures (150 °C) for few seconds [1].

Beetroot (Beta vulgaris L.) belonging to the Chenopodiaceae family is indigenous to Asia and Europe. Beetroot leaves have more nutritional value than their roots and rich in carbohydrates, protein, fiber, minerals like iron potassium, magnesium, copper, calcium, vitamins like A, B_6, E (Tocopherol), and C (Ascorbic acid) and natural antioxidant like β – carotene and vitamin A (Retinol) [2]. Beetroot leaves are rich source of iron than spinach [3]. Beetroot leaves have remained underutilized due to lack of awareness of nutritional value of leaves [2].

Present study represent the utilization of beetroot leaves powder in extruded product along with rice flour, corn flour and chickpea powder to develop fiber and antioxidant rich cereals based extruded product. Present study also represents the effect of moisture content, chickpea powder and beetroot leaves powder on physical properties of extrudates. Optimization of extrudates carried on the basis of variables like bulk density, lateral expansion, hardness and sensory analysis.

MATERIALS AND METHODS

From the previous study the blanched beetroot leaves dried at 60 °C temperature selected for the development of cereals based extruded products [4]. Selection of blanched beetroot leaves dried at 60 °C temperature is on the basis of chemical analysis of beetroot leaves powder [4].

A. Procurement of Extrudates Ingredients

Extruded product was prepared from the blend of Rice flour, chickpea flour, corn flour, beetroot powder. The raw materials for making the extruded products were procured from Sangrur market (Punjab, India). Rice, chickpea, corn flour were cleaned to remove any foreign material, dirt, stones, grits and were passed through 60 BSS sieve for uniform particle size. Rice flour, chickpea flour and corn flour so produced was stored in air tight plastic bags and kept in room condition for further use.

B. Preliminary Trials to Prepare Blend For Extruded Product

The type and level of ingredient play a major role in the development and quality of extruded product. The various ingredient used for the development of extruded products were rice flour, corn flour, chickpea flour and beetroot leaves powder etc. No literature was available on the formulation of extruded products from beetroot leaves powder. Therefore preliminary experiments for extruded products were prepared by various combinations of chickpea flour; beetroot leaves powder, moisture and premix.

C. Preparation of Premix

For the development of extruded products initially premix was prepared from the combination of rice and corn flour in ratio of 80:20, 70:30, 60:40 and 50:50. The products prepared from this blend have been evaluated by sensory analysis on hedonic scale. The maximum overall acceptability was for the extruded product having 60 % rice and 40 % corn flour. Then by using different level of chickpea flour, beetroot leaves powder and moisture content extruded products was prepared. Total 100gm proportion of final blend was adjusted by incorporation of premix flour into chickpea and beetroot leaves powder.

D. Addition of BRLP Powder And Chickpea Powder In The Pre-Mix

During preliminary trial beetroot leaves powder added into the blend of premix flour from 2 %, 5 % 7.5 %, 10 % and 12.5 % level and chickpea powder from 10-30 %. Screw speed and barrel temperature were kept constant throughout the experiment at 270 rpm and 120 °C temperature respectively. The extruded product prepared from the different level of beetroot leaves powder and chickpea proportions have been evaluated by sensory score on hedonic scale. The sensory score for overall acceptability was least for extruded product with 12.5 % beetroot leaves powder and 30 % chickpea powder. The maximum overall acceptability was for the extruded product having 2 % beetroot leaves powder and 20 % chickpea powder.

E. Adjustment of Moisture Content in the Final Blend

During the preparation of extruded products the moisture contents of the blends adjusted to the desired level by the following equation

$$Q = W\left(\frac{M_f - M_i}{100 - M_f}\right)$$

Where,

Q = weight of water added

W= total Weight of the blend

M_f = Final (required) moisture content of the blend

M_i = Initial moisture content of the blend

The whole blend packed in polyethylene a bag which was kept in the refrigerator overnight to allow moisture equilibration. The samples were however brought to room temperature before extrusion process. During preliminary trials the moisture content of the blend was adjusted from 13 % to 20 %. Extruded product having 17 % moisture content got the maximum overall acceptability.

F. Experimental Design

Response surface methodology (RSM) was adopted in the experimental design as it emphasizes the modeling and analysis the problem in which response of interest is influenced by several variables and the objectives is to optimize this response. For the optimization of the formulation the experiments were conducted according to the central composite face centered experimental design with three variables at three levels each. The independent variables selected were proportion of chickpea powder, amount of beetroot powder and moisture content. The low and the high levels of independent variables were 15 % and 25 % for chickpea powder. 2 % and 10 % for beetroot leaves powder and moisture content 15 % and 20 % respectively (Table 1.). The range of pulse powder, beetroot leaves powder and moisture content variables have been selected by conducting the preliminary experiments.

Fig. 1: *Flow sheet for the preparation of extruded products*

Premix(60% Rice + 40% corn flour) Chickpea powder BRLP

↓ ↓ ↓

Composite flour

↓

Adjustment of moisture content

↓

Packaging in polythene bags

↓

Extrusion

↓

Products analysis

The relation between coded form and the actual level of different variables is given in table 1.

Table 1: *Actual values of independent variables at thethree levels of the central composite faced centered design*

Independent Variable	Unit	Symbol	Level in coded form		
			-1	0	1
Chickpea flour	(%)	X_1	15	20	25
BRLP	(%)	X_2	2	6	10
Moisture content	(%)	X_3	15	17.5	20

G. Evaluation of extruded products

a) Lateral expansion

The ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate [5, 6]. Six lengths of extrudate was selected at random during collection of each of the extruded samples, and allowed to cool to room temperature. The extrudates diameter was then measured by vernier caliper, at 10 different positions along the length of each of the six samples. Lateral expansion (LE, %) was then calculated using the mean of the measured diameters:

$$\text{LE} = \frac{\text{Diameter of product} - \text{Diameter of dia holes}}{\text{Diameter of dia hole}} \times 100$$

The experiments planned in coded and uncoded form of variables is given in table 2. The experiments were conducted randomly to minimize the effect of unexplained variability in the observed responses because of external factors.

Table 2:. Ontral composite face centered experimental design for preparation of extruded product

Run	Coded Levels			Uncoded Levels			
Std. No	X_1	X_2	X_3	Premix proportion (gm)	x_1 Chickpea powder (%)	x_2 Beetroot leaves powder (%)	x_3 Moisture content (%)
1	-1	-1	-1	83	15	2	15
2	1	-1	-1	73	25	2	15
3	-1	1	-1	75	15	10	15
4	1	1	-1	65	25	10	15
5	-1	-1	1	83	15	2	20
6	1	-1	1	73	25	2	20
7	-1	1	1	75	15	10	20
8	1	1	1	65	25	10	20
9	-1	0	0	79	15	6	17.5
10	1	0	0	69	25	6	17.5
11	0	-1	0	78	20	2	17.5
12	0	1	0	70	20	10	17.5
13	0	0	-1	74	20	6	15
14	0	0	1	74	20	6	20
15	0	0	0	74	20	6	17.5
16	0	0	0	74	20	6	17.5
17	0	0	0	74	20	6	17.5
18	0	0	0	74	20	6	17.5
19	0	0	0	74	20	6	17.5
20	0	0	0	74	20	6	17.5

b) Water absorption index and water solubility index

Water absorption index (WAI) and water solubility index (WSI) were determined as described in [7]. The process was quite same as the method of calculating sedimentation volume. The extrudates were ground and made almost powder form. Then these were suspended in water and mixed well by stirring at room temperature for at least 30 minutes. The mixture is then put for centrifugation at 3000 rpm for at least 15 minutes. A supernatant was formed having some solids while some residues were also formed. The supernatant was collected very carefully and transferred to a dish of known weight. The residue was taken and weighed. WAI was calculated as the ratio of weight of residue to that of the extrudate taken. The formula for WAI is as follows:

WSI was calculated as percentage. For WSI calculation, the supernatant collected in the known dish was put for evaporation of water. The dry matter was weighted. WSI was calculated as follows:

c) Sensory analysis

Sensory analysis was conducted on all the samples with beetroot powder levels from 2-10%. 20 panelist were asked to assess the expanded snacks for flavor acceptability, and to mark on a Hedonic Rating Test (1 – Dislike extremely, 5 – Neither like nor dislike and 9 – Like extremely) in accordance with their opinion.

H) Chemical analysis of extrudated products

Moisture, ash, and crude protein, crude fiber contents were determined in accordance with AOAC – (Association of Official Analytical Chemists) method [8]. Fat content was determined by method of AOAC [9]. Total carbohydrate (%) was calculated by deducting the sum of the values for moisture, crude protein, crude fat, crude fiber and ash from 100 [10].

I) Total Phenolic Content

The total phenolic content was determined using the Folin-Ciocalteau method. 200 µL of the extract was combined with 1.9 mL of 10-fold diluted Folin-Ciocalteau reagent and 1.9 mL of 60 g/L sodium bicarbonate solution was added. The absorbance was measured at 725 nm after sitting for 2 h at room temperature (Cary 50 Bio UV-Visible Spectrophotometer). Double distilled water was used as the blank, and the gallic acid standards were prepared using methanol. All determinations were carried out in triplicate and the total phenolic content was expressed as mg of gallic acid equivalents (GAE)/g dry matter of leaves [11, 12].

RESULTS AND DISCUSSION

The response surface and contour plots were generated for different interaction of the two variables, while holding the value of third variable as constant at the centre value. Such three dimensional surface could give accurate geometrical representation and provide useful information about the behavior of the system within experimental design. The detail analysis of the response for the above parameter is described below (Table 3.).

A) Diagnostic Checking Of Fitted Model And Surface Plots For Various Responses

a) Extrudate lateral expansion

Expansion is the most important physical property of the snack food. Starch, the main component of cereals plays major role in expansion process [13]. The measured expansion of premix flour, chickpea powder and beetroot leaves powder extrudates varied between 130 % and 275 %. Considering all the data given in table.4 following model was selected for representing the variation of lateral expansion and for further analysis.

The second order response model for lateral expansion value found after analysis for the regression was as follows

$$LE=247.49-8.47X1-12.67X2-26.23X3-55.47X12-20.97X22+4.03X32+0.84X1*X2-5.96X1*X3-0.34X2*X3 \quad (1)$$

From Fig.2 we can observe the surface plot of lateral expansion ratio as a function of moisture content and chickpea powder at central value of beetroot leaves powder (6%). There was decrease in expansion with the increase in moisture content which may be attributed due to the reduction of elasticity of dough through plasticization of melt as observed by [14, 15], similar result reported by [16] that moisture levels have a significant effect on the expansion ratio of extrudates. High level of moisture reduced the expansion of extrudates. During the study it was observed that by increasing moisture level up to 20 % result in a decrease of expansion ratio. Same kinds of observations were also reported by [17].

The lateral expansion ratio increases with increase in chickpea powder. After reaching maximum level there was decrease lateral expansion with increase in chickpea powder of the extrudate. This may be due to the high protein and dietary fiber contents in chickpea compared to rice and corn [18]. Proteins influence expansion through their ability to affect water distribution in the matrix and through their macromolecular structure and confirmation, which affects the extensional properties of the extruded melts [19].

Fig.3 shows the surface plot of lateral expansion ratio as a function of chickpea powder and beetroot leaves powder at central value of moisture content (17.50%). Initially the lateral expansion increase with increasing beetroot leaves powder and finally decreases this effect may be due to the high fiber content of beetroot leaves powder, which competes for the free water found in the matrix, lowering its expansion capabilities. Similar finding of lowering expansion ratio of extruded biscuits by incorporation of extruded orange pulp containing higher fiber was reported by [20]. lateral expansion decreased with increase in chickpea powder due to the high protein content of chickpea powder [18].

Table 3: *Effect of process variables on response*

Coded variables				Responses			
Sr.No.	X_1	X_2	X_3	Lateral expansion (%)	WAI (g/g)	WSI (%)	Overall Acceptability
1	-1	-1	-1	210	6.9	5.53	7.3
2	1	-1	-1	215	5.92	5.8	7.32
3	-1	1	-1	198	5.388	8	6.98
4	1	1	-1	185	5.75	8.01	6.94
5	-1	-1	1	180.2	7.5	5.64	6.7
6	1	-1	1	140	5.86	5.2	7.01
7	-1	1	1	145.5	7.244	6	5.7
8	1	1	1	130	5.91	3.45	5.7
9	-1	0	0	201	6.91	6.15	7.4
10	1	0	0	180	6.976	5.99	7.4
11	0	-1	0	245	6.42	8.45	7.62
12	0	1	0	205	6.09	8.71	6.9
13	0	0	-1	275	6.61	8.6	7.945
14	0	0	1	225	7.676	7.32	7.1
15	0	0	0	240	7.12	8.4	7.8
16	0	0	0	230	6.98	7.98	7.76
17	0	0	0	240	6.58	8.34	7.78
18	0	0	0	255.5	7.099	7.68	7.8
19	0	0	0	260.5	6.56	7.56	7.77
20	0	0	0	265	6.89	7.9	7.81

Table.4: *Regression equation coefficients of estimates for objective responses*

Coefficients	LE (%)	WAI (g/g)	WSI (%)	OA
Model	247.48*	6.91*	8.07*	7.77*
X_1	-8.47*	-0.35*	-0.28*	0.02*
X_2	-12.67*	-0.22*	0.35*	-0.37*
X_3	-26.23*	0.36*	-0.83*	-0.42*
X_1^2	-55.46*	-0.03	-2.16*	-0.35*
X_2^2	-20.96*	-0.72*	0.34*	-0.49*
X_3^2	4.03	0.16	-0.27	-0.22*
X_1*X_2	0.83	0.20	-0.29	-0.04*
X_1*X_3	-5.96	-0.29*	-0.40*	0.04*
X_2*X_3	-0.33	0.18	-0.75*	-0.20*
R^2	0.95	0.87	0.96	0.99
Adjusted R^2	0.92	0.76	0.92	0.99
Lack of fit	NS	NS	NS	NS

$Y=\beta_0+\beta_1x_1+\beta_2x_2+\beta_3x_3+\beta_{11}x_1^2+\beta_{22}x_2^2+\beta_{33}x_3^2+\beta_{12}x_1.x_2+\beta_{13}x_1.x_3++\beta_{23}x_2.x_3$, ($X_1$ - Chickpea power, X_2 - Beetroot leaves powder, X_3 - Moisture content, *Significant at 5% level ($p < 0.05$), NS - non significant)

Fig.2: *Response surface plot for the variation of lateral expansion of extrudate as a function of moisture content and chickpea powder.*

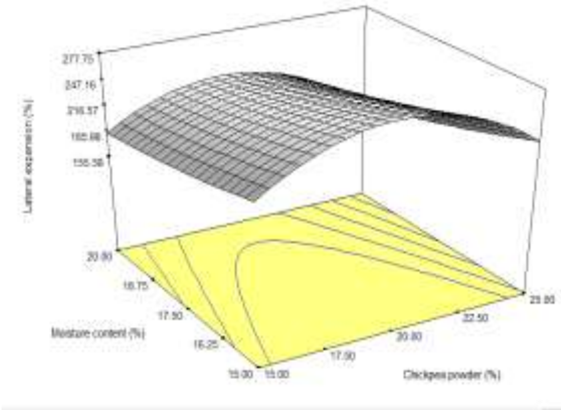
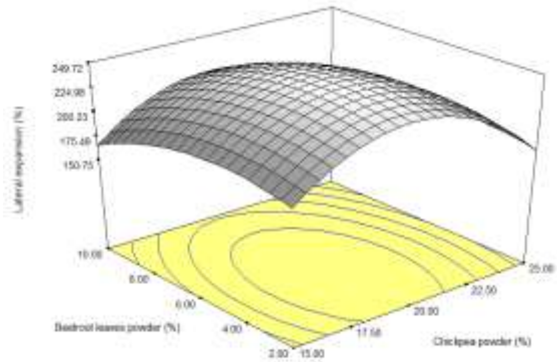


Fig.3 *Response surface plot for the variation of lateral expansion of extrudate as a function of beetroot leaves powder and chickpea powder*



b) Extrudate WAI (Water absorption index) (g/g)

WAI measures the amount of water absorbed by starch that can be used as an index of gelatinization [21]. The WAI ranged from 5.388 to 7.67 g/g for premix, chickpea powder and beetroot leaves powder extrudate. Table.4 shows the coefficient of the model of WAI.

The second order response model for water absorption index value found after analysis for the regression was as follows

$$WAI = 6.91 - 0.35X_1 - 0.22X_2 + 0.36X_3 - 0.034X_1^2 - 0.72X_2^2 + 0.17X_3^2 + 0.21X_1*X_2 - 0.29X_1*X_3 + 0.18X_2*X_3 \quad (2)$$

Where X_1, X_2 and X_3 are the coded values chickpea powder (%), beetroot leaves powder (%) and moisture content (%) respectively. From the Fig.4 the effect of chickpea and moisture content on the WAI at central value of beetroot leaves powder (6%). The WAI measures the volume occupied by the starch after swelling in excess water, which maintains the integrity of starch in aqueous dispersion [22]. Gelatinization, the conversion of raw starch to a cooked and digestible material by the application of water and heat, is one of the important effects that extrusion has on the starch component of foods. Water is absorbed and bound to the starch molecule with a resulting change in the starch granule structure. The maximum gelatinization occurs at high moisture and low temperature or vice versa reported by [23]. WAI of extrudate decreases with increase in the chickpea powder and increases with increase in moisture content, after reaching maximum level the water absorption index decrease which may be attributed to the reduction of elasticity of dough through plasticization of melt at higher moisture content [15]. WAI of extrudate increased with increase in moisture content. Water absorption generally attributed to dispersion of starch in excess of water and the dispersion is increased by degree of starch damage to the gelatinization and extrusion induced fragmentation, that is, molecular weight reduction of amylose and amylopectin molecules [24]. WAI decreased with increase in chickpea powder because of low starch gelatinization.

Fig.5 shows the surface plot of WAI as a function of beetroot leaves powder and chickpea powder at central value of moisture content (17.5%) shows at any level of beetroot leaves powder, first there is increase in the WAI with increasing beetroot leaves powder it could be due to the high water absorption capacity of beetroot leaves powder and after reaches its maximum level WAI decrease with increase in beetroot leaves powder. WAI of extrudate decreases with increase in the chickpea powder this is due to the lower starch gelatinization with increase in protein content [19].

Fig.4: *Response surface plot for the variation of WAI of extrudate as a function of moisture content and chickpea powder*

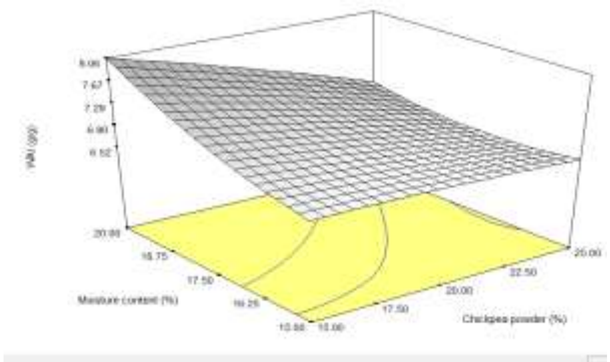
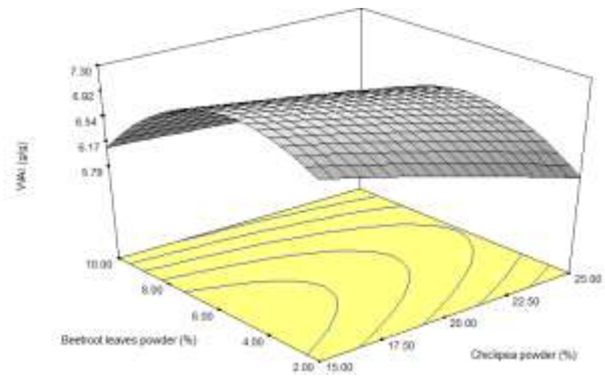


Fig.5: *Response surface plot for the variation of WAI of extrudate as a function of beetroot leaves powder and chickpea powder.*



c) Extrudate water solubility index (WSI).

WSI used as an indicator of degradation of molecular components. It measures the amount of soluble polysaccharide released from the starch component after extrusion [14]. The WSI ranged from 3.45 % to 8.71 % for the extruded product prepared from premix flour, chickpea powder and beetroot leaves powder .Tables 4.shows the coefficient of the model of WSI. The second order response model for water absorption index value found after analysis for the regression was as follows

$$WSI=8.08-0.29X_1+0.36X_2-0.83X_3-2.16X_1^2+0.35X_2^2-0.27X_3^2-0.30X_1*X_2-0.41X_1*X_3-0.76X_2*X_3 \quad (3)$$

Where, X_1, X_2 and X_3 are the coded values of chickpea powder (%), beetroot leaves powder (%) and moisture content (%) respectively.

From the Fig.6 the surface plot of WSI as a function of beetroot leaves powder and moisture content at central value of chickpea powder (20%). There is increase in the WSI of extrudate with increase in beetroot leaves powder and moisture content. Beetroot leaves powder is high in fiber content which disrupts continuous structure of the melt in extruder, impeding elastic deformation during extrusion so, the highest WSI values may be due to disintegration of starch granules and low molecular compounds from extrudate melt during extrusion which might have an increase in soluble material. Similar result reported by [19] during study on utilization of pineapple pomace in extruded product. With increase in moisture content WSI increase because moisture helps in gelatinization of starch.

Fig.7 shows the surface plot of WSI as a function of moisture content and chickpea powder at central value of beetroot leaves powder (6%). Water solubility index increased further with increase in chickpea powder because chickpea powder content soluble amino acid and starch. [25], also reported the water solubility index of the extrudates increased when Bengal gram flour incorporation increased from 10% to 20% in the composite mix samples. With increase in moisture content WSI increase initially upto optimum level then decreases because moisture helps in gelatinization of starch.

Fig.6: *Response surface plot for the variation of WSI of extrudate as a function of moisture content and beetroot leaves powder*

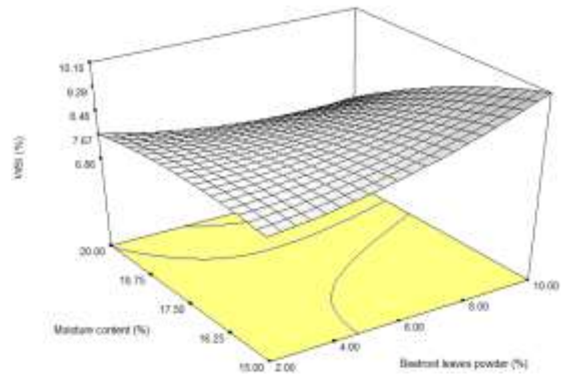
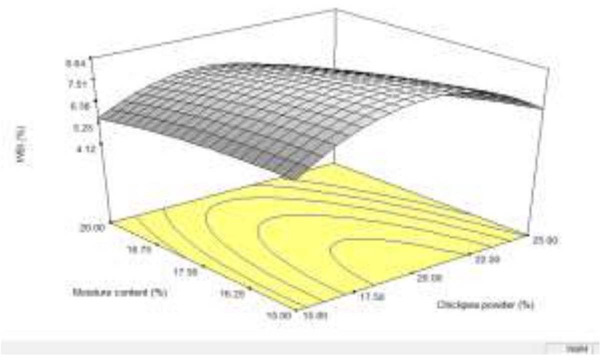


Fig.7: *Response surface plot for the variation of WSI of extrudate as a function of moisture content and chickpea powder.*



d) Extrudate Overall Acceptability

Sensory evaluation indicates the acceptability of the product. Hedonic scale is used to find the different aspect of sensory evaluation. The overall acceptability of the product ranges from 5.7 to 7.95 in the extrudates prepared from (premix flour, chickpea powder, beetroot leaves powder). Considering the data from table.4 following equation occurred.

$$\text{Overall acceptability} = 7.77+0.029X_1-0.37X_2-0.43X_3-0.35X_1^2-0.49X_2^2-0.23X_3^2-0.046X1*X_2+0.041X_1*X_3-0.20X_2*X_3 \quad (4)$$

From the Fig.8 the surface plot of overall acceptability as a function of chickpea powder and beetroot leaves powder at central value of moisture content (17.5 %) shows that at any level of beetroot leaves powder, The overall acceptability value increased slightly with increase in beetroot leaves powder and chickpea powder, and later however overall acceptability value decreased with increase in beetroot leaves powder and chickpea powder.

From the Fig.9 the surface plot of overall acceptability as a function of moisture content and chickpea powder at central value of beetroot leaves powder (6%) shows that at any level of moisture content, The overall acceptability value decrease with increase in moisture content. The overall acceptability increases with increases in chickpea powder and later decreases and it may be due to lower expansion of extrudates.

Fig.8: *Response surface plot for the variation of overall acceptability of extrudate as a function of beetroot leaves powder and chickpea powder*.

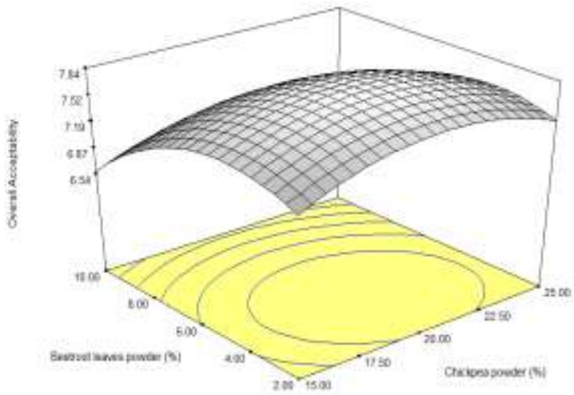
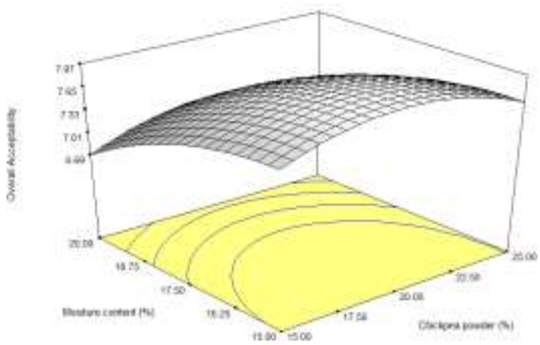


Fig.9: *bResponse surface plot for the variation of overall acceptability of extrudate as a function of moisture content and chickpea powder.*



B) Optimization

The compromised optimum condition for the development of extruded products with premix flour, chickpea powder and Beetroot leaves powder moisture content was determined using the following criteria by Design Expert software Package (Design Expert Software-6). The product should get the maximum score in sensory characteristics so as to get market acceptability, in range lateral expansion, water solubility index and water absorption index (Table 5.).

After numerical optimization design expert gives solution containing 16.03 gm chickpea powder, 4.26 gm beetroot leaves powder, 15 % moisture content(Table 6.). Total 100 gm of blend was prepared by adding 79.71 gm premix flour into chickpea and beetroot leaves powder blend. Predicted and actual value of the response for optimized product is shown in table 6.

Table 5: *Constraints in the process of optimization*

Parameters	Goal	Lower limit	Upper limit
Pulse	Is in range	15	25
Beetroot	Is in range	2	10
Moisture	Is in range	15	20
Lateral expansion	Is in range	130	275
WAI	Is in range	5.38	7.67
WSI	Is in range	3.45	8.71
OA	Maximize	5.7	7.945

Table 6: *Predicted and actual values of the responses for optimized product*

Process variables	Cod – ed	Unco- ded	Resp-onse	Predicte-d value	Actualvalue
CPP (%)	-0.79	16.03	LE	246.49	265
BRLP (%)	-0.44	4.26	WAI	6.85	6.01
M.C (%)	-0.1	15	WSI	6.66	5.98
			OA	7.73	7.95

(Note: - CPP – Chickpea powder, BRLP - Beetroot leaves powder, M.C – Moisture content, LE – Lateral expansion, WAI – water absorption index, OA – Overall acceptability)

It was observed that addition of beetroot leaves powder and chickpea powder resulted in increase in protein, crude fiber and TPC content of optimized extruded product. Table 7. Shows the chemical analysis of control and optimized extruded product.

Table 7: *Proximate analysis of control and optimized extruded products*

Parameter (%)	Control product	Optimized product
Moisture content	3.47	4.74
Carbohydrate	87.05	78.679
Crude protein	5.21	9.01
Crude fat	1.05	1.95
Crude fiber	2.14	3.65
Ash content	1.01	1.98
TPC (mg/gm)	3.93	10.25

CONCLUSIONS

In extruded products study the product responses like lateral expansion, WAI, WSI and overall acceptability were mostly affected by changes in beetroot leaves powder, chickpea powder and moisture content. Increasing in chickpea powder content resulted in maximum expansion and WSI was observed. Hardness of extrudates increases with increase in BRLP while lateral expansion decrease. WAI and WSI increases with increase in beetroot leave powder and chickpea powder. It was also observed that lateral expansion decrease and WSI increases with increase in moisture content. Overall acceptability of extruded products increases with increase in chickpea powder. The optimized conditions of extruded product were chickpea powder content 16.03%, BRLP 4.26% and moisture content 15%. Optimized extruded product contains 3.65% crude fiber and 10.25 mg/gm of TPC content. It show that addition of BRLP increase the fiber and TPC content of product.

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