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UTILIZATION OF BEETROOT (*BETA VULGARIS* L.) LEAVES POWDER IN CEREALS BASED EXTRUDED PRODUCT.

Subhash B. Kakade[1], B.S Hathan[2], Neeha VS[3]
[1, 2,3] Department of Food Engineering and Technology, (SLIET), Longowal - 148106, Punjab, India

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Abstract - *Beetroot green is more nutritious as compared to the beetroot but in many part of India it is not used as food it is only used as animal fodder. To overcome the malnutrition problem of developing countries we can utilize beetroot green waste for products development as it is nutritionally rich in fiber, protein, carbohydrate, vitamins and minerals. In this study, beetroot leaves powder was used to develop extruded product. Response surface methodology (RSM) was used to investigate the effect of extrusion variables like moisture content, chickpea powder and beetroot leaves powder content on the physical and functional properties of extrudates. The results indicate that the moisture content, chickpea powder and beetroot leaves powder had significant effect on variables like bulk density, lateral expansion, hardness and overall acceptability of extrudate prepared from cereals, chickpea and beetroot leaves powder. Result also showed that with increase in moisture and chickpea powder content lateral expansion of extrudates increase upto optimum level and finally decrease. Increase in moisture content, chickpea and beetroot leaves powder resulted in increase in bulk density and hardness of the extrudates. The study concluded that optimized extruded product is 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)

1. Introduction

Extrusion technology is extensively used to develope 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 (Athar et al., 2006).

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) (Biondo et al., 2014). Beetroot leaves are rich source of iron than spinach (Joshi and Mathur, 2010). Beetroot leaves have remained underutilized due to lack of awareness of nutritional value of leaves (Biondo et al., 2014).

Rice is (*oryza sativa* L.) staple diet for more than half of the world population and is consumed principally in Asia. Rice is a cereal foodstuff which is an important part of the diet of many people worldwide. Rice flour is nutritionally rich containing 366 calories energy, 1gm Fat, 6 gm protein, 80gm, 2 gm dietary fiber per 100gm of flour (www.elook.org).

Corn (*Zea mays* L.) based food products are easily found, especially in the area with corn as staple foodstuff. Most people like specific and unique taste of corn, therefore, many snack foods are made from corn, either wet or dry products. Corn is one of the nutritionally rich cereals containing 355 calories energy with 9.08% protein, 3.88% fat, 0.03% ash, 76.80% carbohydrate (Santosa et al., 2005). Tahnoven et al., (1998) reported that corn has become an attractive ingredient in the extrusion industry due to its attractive yellow color and great expansion characteristic. Expansion is an important parameter in the production of a cereal based extruded snack food in terms of the functional properties of the final product.

Chickpea (*Cicer arietinum* L.) is legume, grown in tropical and subtropical areas, that presents high potential as a functional ingredient for the food industry. Chickpea is mainly consumed in the form of dhal or flour obtained from primary processing. Saleh and Tarek (2006) reported that Chickpea is valued for its nutritive seeds with high protein content 25.3 - 28.9 % after dehulling. The chickpeas contain moderately low fat (6.48%), high available carbohydrate (50%) and crude fiber contents of 3.82% (dry basis). Pulse powder is a product of milling process which has a high protein content (22%) similar to dhal and easily available at relatively lower cost as compared to dhal.

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.

2. Materials and method

From the previous study the blanched beetroot leaves dried at 60 °C temperature selected for the development of cereals based extruded products (Kakade and Hathan, 2014). Blanched beetroot leaves dried at 60 °C temperature is selected on the basis of chemical analysis of beetroot leaves powder (Kakade and Hathan, 2014).

2.1 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). 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.

2.2 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.

2.3 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.

2.4 Addition of BRLP 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.

2.5 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.

2.6 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.

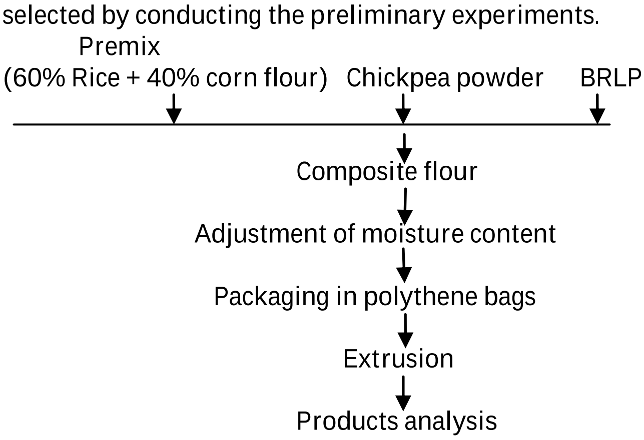

Fig1. Flow sheet for the preparation of extruded products

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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 the three levels of the central composite faced centered design.

Independent Variable	Unit	Symbol	Level in coded form		
			-1	0	1
Chickpea flour	(%)	X1	15	20	25
BRLP	(%)	X2	2	6	10
Moisture content	(%)	X3	15	17.5	20

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. Central composite face centered experimental design for preparation of extruded product

Run	Coded Levels			Premix proportion (gm)	Uncoded Levels		
Std. No	X_1	X_2	X_3		X_1 CP	X_2 BRLP	X_3 MC
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

(CP – Chickpea powder, BRLP – Beetroot leaves powder, MC – Moisture content)

2.7 Evaluation of extruded products

2.7.1 Lateral expansion

The ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate (Fan, 1996; Ainsworth, 2006). 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:

$$LE = \frac{(Diameter\ of\ product - Diameter\ of\ dia\ hole)}{Diameter\ of\ dia\ hole} \times 100$$

2.7.2 Bulk density

Bulk density is the ratio of weight of the sample to it's volume. The unit of bulk density is g/cm³ (CGS method). Bulk density was calculated as follows (Stojceska et al., 2008).

$$BD = 4\ m / \pi\ d^2\ L$$

Where, m = sample mass (g)
D = diameter of sample (cm)
L = Length of sample (cm)

2.7.3 Hardness

Mechanical properties of the extrudate were determined by a crushing method using a TA-XT2 texture-analyze equipped with a 50 kg load cell. An extrudate 40 mm long was compressed with a probe SMS–P/75–75mm diameter at a crosshead speed 5mm/s to 2mm/s of 90% of diameter of the extrudate. The compression generates a curve with the force over distance. The highest first peak value was recorded as this value indicated the first rupture of snack at one point and this value of force was taken as a measurement for hardness (Stojceska et al., 2008).

Table 3. Settings of Texture Analyzer

Probe type	SMS P/75
Test mode	Compression
Pre-test speed	5mm/s
Test speed	2mm/s
Post test speed	10mm/s
Target mode	Distance (5mm)
Trigger force	5N

2.7.4 Sensory analysis

Sensory analysis was conducted on all the samples with beetroot powder levels from 2-10%. 20 panelists were asked to assess the expanded snacks for flavor acceptability, and to mark on a Hedonic Rating Test in accordance with their opinion.

2.8 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 (AOAC 2000). Fat content was determined by method of AOAC (AOAC, 1995). Total carbohydrate (%) was calculated by deducting the sum of the values for moisture, crude protein, crude fat, crude fiber and ash from 100 (Raghuramulu et al., 1983).

2.9 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 [Kwee and Niemeyer, 2011; Cameron and Hosseinian, 2013].

3. 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 4. Effect of process variables on response

Coded Variables				Responses			
Sr. No.	X_1	X_2	X_3	BD (g/cm³)	LE (%)	Hardness (N)	OA
1	-1	-1	-1	0.153	210	13.043	7.3
2	1	-1	-1	0.131	215	8.623	7.32
3	-1	1	-1	0.125	198	10.532	6.98
4	1	1	-1	0.114	185	12.545	6.94
5	-1	-1	1	0.125	180.2	12.548	6.7
6	1	-1	1	0.191	140	18.701	7.01
7	-1	1	1	0.171	145.5	21.254	5.7
8	1	1	1	0.222	130	25.287	5.7
9	-1	0	0	0.147	201	18.382	7.4
10	1	0	0	0.162	180	19.524	7.4
11	0	-1	0	0.153	245	11.524	7.62
12	0	1	0	0.163	205	17.258	6.9
13	0	0	-1	0.112	275	6.186	7.94
14	0	0	1	0.151	225	13.845	7.1
15	0	0	0	0.141	240	13.523	7.8
16	0	0	0	0.142	230	12.571	7.76
17	0	0	0	0.145	240	12.354	7.78
18	0	0	0	0.143	255.5	11.865	7.8
19	0	0	0	0.146	260.5	12.548	7.77
20	0	0	0	0.147	265	12.33	7.81

(BD – Bulk density, LE – Lateral expansion, OA – Overall acceptability)

3.1 Diagnostic Checking of Fitted Model and Surface Plots for Various Responses on experiment

3.1.1 Extrudate bulk density

Bulk density is a major physical property of the extrudate. The bulk density, which considers expansion in all direction, ranged from 0.112 to 0.222 g/cm³ for the (premix flour and chickpea powder, beetroot leaves powder) extrudates. Table.5 shows the coefficient of the model and other statistical attributes of bulk density. Considering coefficient estimate data the following model was selected for representing the variation of bulk density and for further analysis.

Table.5 Regression equation coefficients of estimates for objective responses

Coefficients	BD	LE	Hardness	OA
Model	0.144*	247.487*	12.965*	7.773*
Linear terms				
X_1	0.010*	-8.470*	0.892*	0.029*
X_2	0.004*	-12.670*	2.244*	-0.373*
X_3	0.023*	-26.230*	4.071*	-0.428*
Quadratic terms				
X_1^2	0.010*	-55.468*	5.338*	-0.351*
X_2^2	0.013*	-20.968*	0.776	-0.491*
X_3^2	-0.013*	4.032	-3.600*	-0.229*
Interaction terms				
X_1*X_2	0.000	0.837	0.539	-0.046*
X_1*X_3	0.019*	-5.963	1.574*	0.041*
X_2*X_3	0.015*	-0.338	1.735*	-0.201*
R^2	0.9875	0.9599	0.9597	0.9979
Adjusted R^2	0.9763	0.9237	0.9244	0.9960
Lack of fit	NS	NS	NS	NS

$Y=\beta_0+\beta_1 x_1+\beta_2 x_2+\beta_3 x_3+\beta_{11} x_1^2+\beta_{22} x_2^2+\beta_{33} x_3^2+\beta_{12} x_1.x_2+\beta_{13} x_1.x_3++\beta_{23} x_2.x_3$, ($X_1$ - Chickpea power, X_2 - Beetroot leaves powder, X_3 - Moisture content, *Significant at 5% level ($p < 0.05$), NS-non significant, BD – Bulk density, LE – lateral expansion, OA- Overall acceptability).

The second order response model for bulk density value found after analysis for the regression was as follows

Bulk density =

$0.14+0.0099X_1+0.0042X_2+0.022X_3+0.00977X_1^2+0.013X_2^2-0.013X_3^2-0.0005X_1*X_2+0.019X_1*X_3+0.015X_2*X_3$ (1)

From the Fig.2 the surface plot of bulk density as a function of moisture content and beetroot leaves powder at central value of chickpea powder. Feed moisture has been found to be the main factor affecting extrudate density and expansion. The bulk density initially decreased with moisture content, which may be due to proper gelatinization and higher expansion, whereas further increase in bulk density may be because of reduction in elasticity of dough and lower expansion reported by Ding et al., (2005) and Ding et al., (2006). With increase in beetroot leaves powder bulk density of extrudate initially decreases but further bulk density increases.

From the Fig.3 the surface plot of bulk density as a function of moisture content and chickpea powder at central value of beetroot leaves powder (6%) show that with increase in moisture content, bulk density of extrudates increase it was due to reduction of elasticity of dough. Increase in chickpea powder bulk density of extrudate initially decreases but further bulk density increases. High protein and dietary fiber contents of chickpea powder compared to rice and corn resulted in decrease of lateral expansion and increase in bulk density of extrudate (Shirani and Ganesharanee, 2009).

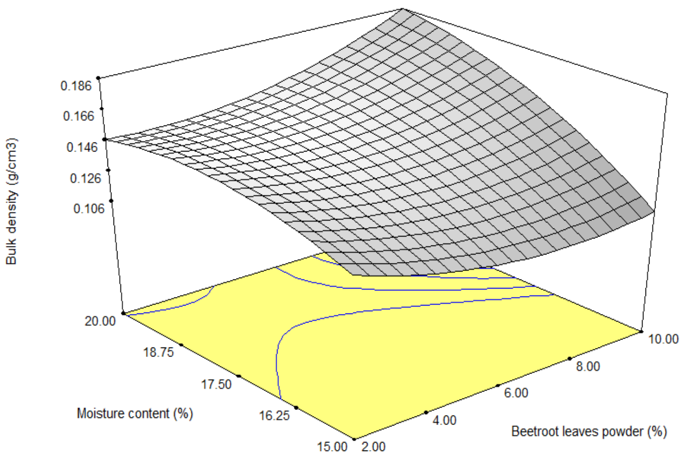

Fig.2 Response surface plot for the variation of bulk density of extrudate as a function of moisture content and beetroot leaves powder.

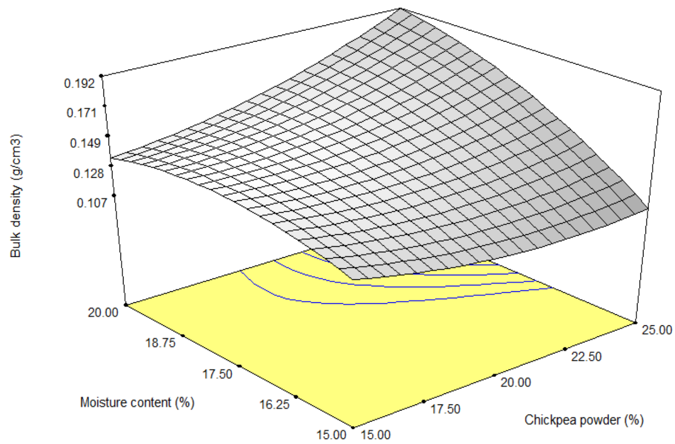

Fig.3 Response surface plot for the variation of bulk density of extrudate as a function of moisture content and chickpea powder.

3.1.2 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 (Kokini et al., 1992). 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.5 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

$LE=247.49-8.47X_1-12.67X_2-26.23X_3-55.47X_1^2-20.97X_2^2+4.03X_3^2+0.84X_1*X_2-5.96X_1*X_3-0.34X_2*X_3$ (2)

From Fig.4 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 Ding et al., (2005) and Ding et al., (2006), similar result reported by Gonzalez et al., (2004) 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 Owusuansah et al., (1984). 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 (Shirani and Ganesharanee, 2009). 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 (Moraru and Kokini, 2003).

Fig.5 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 Larrea et al., (2005) and lateral expansion decreased with increase in chickpea powder due to the high protein content of chickpea powder (Shirani and Ganesharanee, 2009).

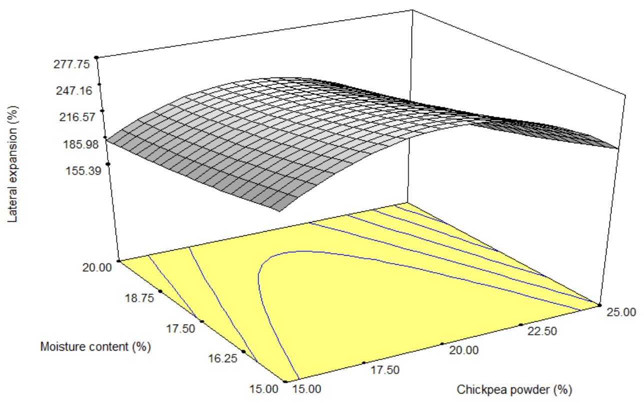

Fig.4 Response surface plot for the variation of lateral expansion of extrudate as a function of moisture content and chickpea powder.

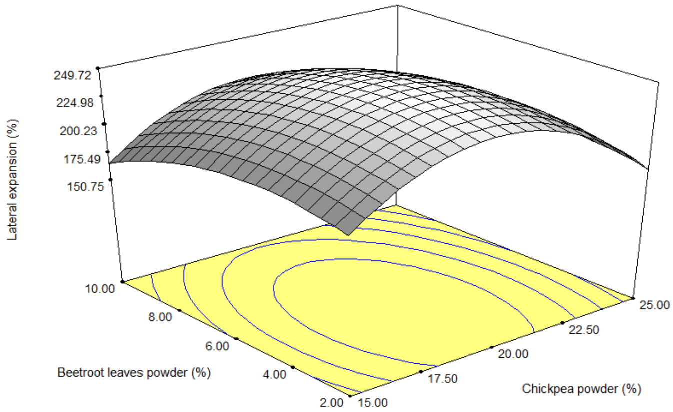

Fig.5 Response surface plot for the variation of lateral expansion of extrudate as a function of beetroot leaves powder and chickpea powder.

3.1.3 Effect of process variables on product Hardness

The textural property of extrudate was determined by measuring the force required to break the extrudate. The higher the value of maximum peak force required in Newton, which means the more force required to breakdown the sample, the higher the hardness of the sample to fracture (Li et al., 2005). Hardness of extrudate prepared from premix flour, chickpea powder and beetroot leaves powder varied between 6.19N and 19.52N. Table.5 shows the coefficient of the model and other statistical attributes of Hardness.

The second order response model for hardness value found after analysis for the regression was as follows.

$$HARDNESS=12.97+0.89X_1+2.24X_2+4.07X_3+5.34X_1^2+0.78X_2^2-3.60X_3^2+0.54X_1*X_2+1.57X_1*X_3+1.74X_2*X_3 \quad (3)$$

It is evident from Fig.6 the surface plot of hardness as a function of moisture content and chickpea powder at central value of beetroot leaves powder (6%). Result shows that an increase in chickpea powder resulted in a decreases in product hardness after reaching 20% there is increase in the hardness this may be due to the high protein content and low starch content of chickpea powder. Hardness of extrudates was found to increase with increased feed moisture content. It might be due to the reduced expansion caused by the increased moisture content (Ding et al., 2005).

It may be observed from Fig.7 the surface plot of hardness as a function of beetroot leaves powder and moisture content at central value of chickpea powder (20%). Hardness increased with the increase in moisture content and beetroot leaves powder. Increase in hardness with increase in beetroot leaves powder. It may be due to high fiber content of beetroot leaves powder caused to reduce expansion ratio.

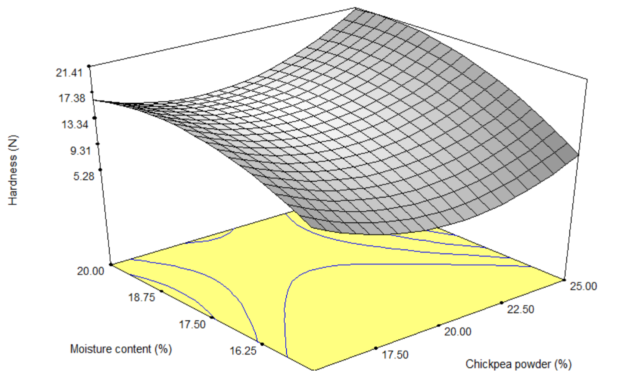

Fig.6 Response surface plot for the variation of hardness of extrudate as a function of moisture content and chickpea powder.

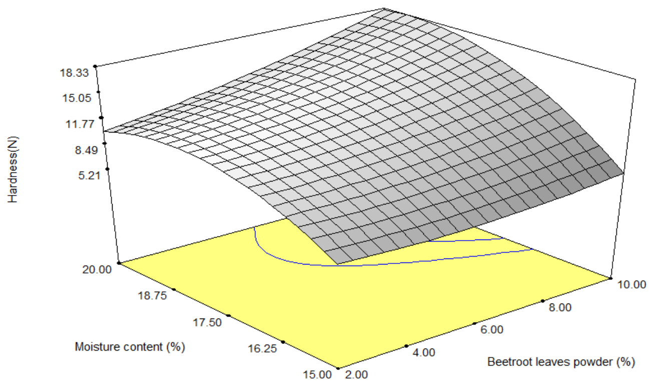

Fig.7 Response surface plot for the variation of hardness of extrudate as a function of moisture content and Beetroot leaves powder.

3.1.4 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.5 following equation occurred.

Overall acceptability = $7.77+0.029X_1-0.37X_2-0.43X_3-0.35X_1^2-0.49X_2^2-0.23X_3^2-0.046X_1*X_2+0.041X_1*X_3-0.20X_2*X_3$ (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.

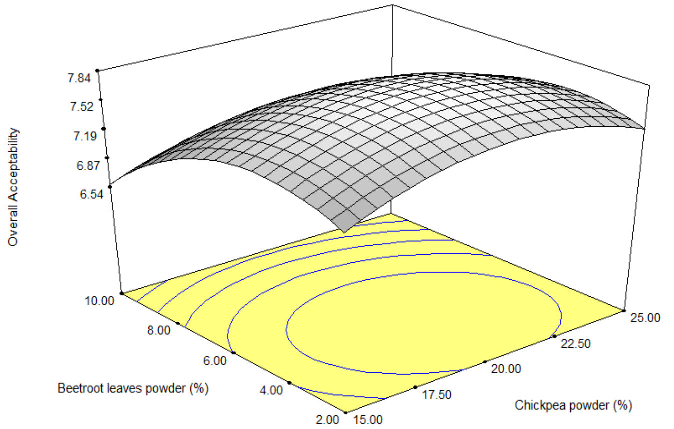

Fig.8 Response surface plot for the variation of overall acceptability of extrudate as a function of beetroot leaves powder and chickpea powder.

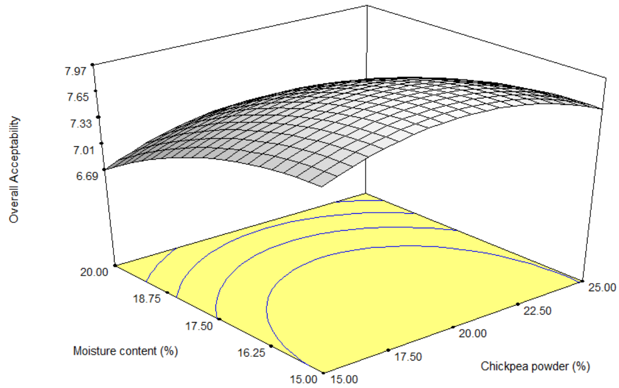

Fig.9 Response surface plot for the variation of overall acceptability of extrudate as a function of moisture content and chickpea powder.

3.2 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, minimum bulk density, in range expansion and in range hardness (Table 6.).

After numerical optimization design expert gives solution containing 16.03 gm chickpea powder, 4.26 gm beetroot leaves powder, 15 % moisture content (Table.7). 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 7.

Table 6. Constraints in the process of optimization

Parameter	Goal	Lower limit	Upper limit
Pulse	Is in range	15	25
Beetroot	Is in range	2	10
Moisture	Is in range	15	20
Bulk density	Minimize	0.112	0.222
Lateral expansion	Is in range	130	275
Hardness	Is in range	6.186	25.29
Overall Acceptability	Maximize	5.7	7.945

Table 7. Predicted and actual values of the responses for optimized product

Process variables (%)	Unco - ded	Response	Predicted value	Actual value
Chickpea powder	16.03	BD	0.12	0.12
BRLP	4.26	LE	246.49	265
Moisture content	15	Hardness	9.31	8.35
		OA	7.73	7.99

(Note: - BRLP - Beetroot leaves powder, BD – Bulk density, LE – Lateral expansion, 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 8. shows the chemical analysis of control and optimized extruded product.

Table 8. 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

4. CONCLUSIONS

In extruded products study the product responses like lateral expansion bulk density were mostly affected by changes in beetroot leaves powder, chickpea powder and moisture content. Increasing in chickpea powder content resulted in maximum expansion, minimum bulk density was observed. Hardness of extrudates increases with increase in BRLP while lateral expansion decrease. 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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BIOGRAPHIES

Name - Subhash B. Kakade
Educational Background – B.Tech. in Food Science and Technology completed from Dr.B.S.K.K.V Dapoli (Maharashtra, India), in the year 2012. M.Tech. in Food Engineering and Technology completed from SLIET University Punjab (India) in 2014.

Name – Dr. B.S Hathan (Associate Professor, FET, SLIET, Longowal, Punjab)
Educational Background – Did B.Sc (Non medical) from Punjabi University , Patiala (Punjab) in 1986; B.Tech., M Tech and Ph. D (Agricultural Engineering) from Punjab Agricultural University, Ludhiana (Punjab).

Name – Neeha VS
Educational Background - B.Tech in Food Processing & Engineering completed from Karunya University, Coimbatore, Tamilnadu in the year 2010. M.Tech. in Food Engineering and Technology completed from SLIET University Punjab (India) in 2014.