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Nutritional composition and sensory properties of corn (Variety: Popcorn: Sugar baby) extrudates

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Abstract
A fibre-rich nutritious extruded product was made by using corn (Variety: Popcorn: Sugar baby), pigeonpea brokens and rice bran. The process was performed at different temperature levels (110, 120 and 130 °C), feed composition (92:4:4, 94:3:3 and 96:2:2) and feed moisture (15, 17.5 and 20%) and at constant screw speed (350 rpm). Nutritional composition and sensory parameters of the developed extruded product was evaluated. Sensory evaluation was conducted on a nine-point hedonic scale method. Response surface methodology and Box-Behnken experimental design was used to evaluate the significance of independent and interaction effects of the process variables. The independent variables had significant ($p \leq 0.05$) effects on nutritional composition of extrudates. The optimized condition was found to be 130 °C temperature, 20% feed moisture and 92:4:4 feed composition at constant screw speed of 350 rpm. The sensory results indicated that extrudates prepared were mostly accepted by panel. The products developed with optimized parameters contained 9.64% protein, 72.16% carbohydrates, 2.20% fat, 10.53% crude fiber and 1.77% ash content with a desirability of 0.698.

Keywords: Twin-screw extrusion, temperature, feed composition, feed moisture, nutritional composition & sensory evaluation

Introduction
Extrusion technique is a process in food processing technology which combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming. Food extrusion is a form of extrusion used in food processing. It is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. Extrusion cooking is a high-temperature short-time (HTST) process which reduces microbial contamination and inactivates enzymes (Bordoloi and Ganguly, 2014) [3]. Cereal grains lend themselves as good raw material for preparation of ready to eat snack foods and other products on account of high starch content in them. Extensive work has been reported on extrusion of corn (maize), in comparison to that for wheat and rice. Incorporation of by-products from the food industry using extrusion technology in order to improve the nutritional characteristics of ready-to-eat snacks is very well documented. These products significantly improved the total dietary fiber level but they also affected the textural characteristics of the extrudates (Ainsworth *et al.*, 2007; Stojceska *et al.*, 2008; Shruthi *et al.*, 2017) [1, 12, 9].

Corn has become an attractive ingredient in the extrusion industry due to its attractive yellow colour and great expansion characteristic, which is one of the important parameters in the production of a cereal-based extruded snack food in terms of the functional properties of the final product (Tahnoven *et al.*, 1998) [13]. Rice is a popular, nonallergic, gluten free source of carbohydrate, vitamins, and minerals with little fat. With an annual production of over 120 million tonnes of paddy, rice is the largest crop produced and consumed in India. Rice bran can also be used in extrusion cooking to produce nutritional extruded product (Liu *et al.*, 2011) [6]. Due to the high antioxidant activity and abundance in raw materials, polysaccharides extracted from rice bran can be developed as a new dietary supplement and functional food to replace some rare medicinal plants (Zha *et al.*, 2009) [17]. Pigeonpea brokens are also acceptable for incorporation in extruded product (Sobota and Rzedzicki, 2009) [10].

The present study was, therefore, undertaken to determine the possibility of application of agro-waste products such as pigeonpea brokens and rice bran for the production of corn-based snack food products and to determine the effect of extrusion variables on nutritional composition and sensory properties of corn (variety: Popcorn: Sugar baby) extrudates.

Material and Methods

Raw materials

The composite flour was prepared by mixing corn, pigeonpea brokens and rice bran (Table 1) with calculated amount of water and the flour was allowed to equilibrate for 15 min. The blended samples were conditioned to achieve required moisture content by spraying with water and mixed uniformly. The samples were kept in buckets and stored at 4 °C for 12 h (Deshpande and Poshadri, 2011) [5]. The feed material was allowed to stay for 3 h to equilibrate at room temperature prior to extrusion. This pre-conditioning procedure was employed to ensure uniform mixing and proper hydration and to minimize variability in the state of feed material.

Table 1: Preparation of composite flour

Sl. No	Raw material	A	B	C
1	Corn (Popcorn),%	92.00	94.00	96.00
2	Pigeonpea brokens,%	4.00	3.00	2.00
3	Rice bran,%	4.00	3.00	2.00

Extrusion Process

The experiments were performed using a co-rotating twin-screw extruder (Basic Technology Pvt. Ltd., 3711-12, Kolkata, India). The ratio of barrel length to diameter ratio (L/D) was 8:1 and 3 mm diameter die was selected. The barrel zone temperatures were kept constant at 60 °C throughout the experiments. The speed of cutter was fixed at 150 rpm for all experiments. Extrudates were cut with a sharp knife, at the exit end of the die and left to cool at room temperature for about 20 min.

Statistical Design

Box-Behnken design of Response surface methodology was employed for optimization of process parameters (Montgomery 2001) [7]. The experiments were designed using Design Expert Software, Version 7.7.0 (State-Ease, Minneapolis, MN). The same software was used for statistical analysis of experimental data. The detail of experimental design is shown in Table 2.

Table 2: Experimental design as per Box-Behnken for coded and un-coded variable levels

Run	Coded levels			Uncoded levels		
	X_1	X_2	X_3	X_1 Temperature (°C)	X_2 Feed moisture (%)	X_3 Feed composition (%)
1	0	-1	1	120	15.0	96:2:2
2	0	0	0	120	17.5	94:3:3
3	0	1	1	120	20.0	96:2:2
4	0	0	0	120	17.5	94:3:3
5	0	-1	-1	120	15.0	92:4:4
6	-1	-1	0	110	15.0	94:3:3
7	1	1	0	130	20.0	94:3:3
8	0	0	0	120	17.5	94:3:3
9	0	0	0	120	17.5	94:3:3
10	-1	0	-1	110	17.5	92:4:4
11	1	0	-1	130	17.5	92:4:4
12	-1	1	0	110	20.0	94:3:3
13	-1	0	1	110	17.5	96:2:2
14	0	0	0	120	17.5	94:3:3
15	0	1	-1	120	20.0	92:4:4
16	1	-1	0	130	15.0	94:3:3
17	0	0	0	120	17.5	94:3:3
18	1	0	1	130	17.5	96:2:2

Nutritional Analysis

The nutritional composition of the developed corn based extruded product samples were determined using standard AOAC 2005 [2] methods. The extrudates were analysed for crude protein (Kjeldahl method, AOAC 2005, 960.52A) [2], crude fat (Soxhlet extraction method, AOAC 2005, 920.85) [2], crude fiber (acid and alkali hydrolysis, AOAC 2005, 920.86) [2], carbohydrate (AOAC 2005, 996.11) [2] and ash content (muffle furnace method, AOAC 2005, 923.03) [2].

Sensory Evaluation

Sensory evaluation of the developed nutri-rich extruded product was conducted using a panel of 13 judges. The members of consumer test panel awarded grades for different quality aspects of fibre-rich, agro-based extruded product like general colour, flavour, taste, hardness, swallowness, stickiness and overall acceptability (Yagci *et al*., 2008) [16].

Results and Discussion

Protein content (%)

Protein content of corn based (Popcorn: Sugar baby) extrudates varied from 9.19 to 10.06 per cent. The average protein content of extrudates was 9.67 per cent. It is observed that the minimum protein content (9.19%) was observed for treatment $T_3M_2F_3$ i.e., 130 °C temperature, 17.5 per cent feed moisture and 96:2:2 feed composition whereas, maximum protein content (10.06%) was observed for treatment $T_1M_2F_1$ i.e., 110 °C temperature, 17.5 per cent feed moisture and 92:4:4 feed composition as given in Table 3. The feed moisture had significant effect on the protein content of the extrudates. As the feed moisture increased the retention of protein content in the extrudate was increased whereas with the increase in temperature protein content in the extrudate was decreased. It might be due to denaturation of protein at higher temperature. Similar results were obtained by Stojceska *et al*. (2009) [11] for cauliflower by-products incorporated cereals based ready-to-eat expanded snacks. Increased pigeonpea and rice bran content in the mixture and decreased corn content results in increased protein content of the extrudate. As whole legume flour contains more proteins than cereal starch (Tharanathan and Mahadevamma, 2003) [14], levels of crude protein increased as a function of increasing rate of pigeonpea and rice bran fortification.

The experimental results of protein content were analyzed by regression model which shows that model ‘F’ value of 53.38 was significant ($p < 0.0001$) whereas, lack-of-fit ‘F’ value of

454.46 was significant ($p < 0.0001$). The lack of best fit model was also expressed by the coefficient of determination R^2, which was 0.9836, indicating that 98.36 per cent of the variability of the response could be explained by the model. The adjusted R^2 value was 0.9652 and adequate precision 25.459. Considering all the above criteria, the model was selected for representing the variation of protein value and for further analysis.

Protein content (%) = $9.73 - 0.30x_1 - 6.250E\text{-}004x_2 - 0.100x_3 + 0.057x_1x_2 - 0.027x_1x_3 - 5.937E\text{-}004x_2x_3 - 0.076x_1^2 - 0.049x_2^2 + 8.183E\text{-}004x_3^2$

Where, x_1, x_2 and x_3 are the coded values of temperature (°C), feed moisture (%) and feed composition (%), respectively.

Carbohydrate (%)

Carbohydrate content of corn based (Popcorn: Sugar baby) extrudates ranged between 70.75 and 73.00 per cent. The mean carbohydrate content of extrudates was 71.63 per cent. It is observed that the minimum carbohydrate content (70.75%) was observed for treatment $T_3M_3F_2$ i.e.,130 °C temperature, 20 per cent feed moisture and 94:3:3 feed composition whereas, maximum carbohydrate content (73.00%) was observed for treatment $T_1M_2F_1$ i.e., 110 °C temperature, 17.5 per cent feed moisture and 92:4:4 feed composition as seen in Table 3. The total carbohydrate content of the extruded product increased as there is decrease in the temperature. This may be because the higher temperature causes degradation of starch. The feed moisture also had significant effect on the total carbohydrate content. The total carbohydrate increased as there is decrease in feed moisture. At higher feed moisture more gelatinization of starch takes place. Similar findings have been reported by Camire and King (1991) [4] for corn meal based extruded snacks. Increased pigeonpea and rice bran content in the mixture and decreased corn content results in decreased carbohydrate content of the extrudate.

The coefficients of the regression model fitted to experimental results of carbohydrate content shows that the model 'F' value of 22.95 was found significant at 0.01 per cent level. The lack of fit 'F' value of 13.51 was also significant ($p < 0.05$).

Table 3: Nutritional composition of corn based (Popcorn: Sugar baby) extruded product

Treatments	Protein (%)	Carbohydrates (%)	Crude fiber (%)	Fat (%)	Ash (%)
$T_2M_1F_3$	9.63	71.10	10.76	2.17	1.95
$T_2M_2F_2$	9.72	71.26	10.78	2.17	2.04
$T_2M_3F_3$	9.62	70.98	10.76	2.13	1.95
$T_2M_2F_2$	9.72	71.36	10.78	2.17	2.06
$T_2M_1F_1$	9.74	72.36	11.33	2.37	2.15
$T_1M_1F_2$	9.95	72.98	11.49	2.51	2.30
$T_3M_3F_2$	9.37	70.75	10.62	2.12	1.54
$T_2M_2F_2$	9.73	71.38	10.87	2.16	2.03
$T_2M_2F_2$	9.73	71.39	10.80	2.17	2.04
$T_1M_2F_1$	10.06	73.00	11.54	3.04	2.24
$T_3M_2F_1$	9.52	70.78	10.69	1.98	1.74
$T_1M_3F_2$	9.84	72.69	11.40	2.46	2.24
$T_1M_2F_3$	9.83	72.64	10.99	2.45	2.20
$T_2M_2F_2$	9.73	71.46	10.89	2.15	2.05
$T_2M_3F_1$	9.73	71.95	11.02	2.34	2.09
$T_3M_1F_2$	9.25	70.88	10.43	2.02	1.16
$T_2M_2F_2$	9.73	71.53	10.94	2.24	2.04
$T_3M_2F_3$	9.19	70.97	10.36	2.21	1.43
Mean	9.67	71.63	10.91	2.27	1.96
Std. Dev.	0.042	0.22	0.11	0.082	0.049
C.V. (%)	0.43	0.30	0.98	3.62	2.49
Adj. R^2	0.9652	0.9207	0.9068	0.8856	0.9740
R^2	0.9836	0.9627	0.9561	0.9462	0.9878
Adeq. precision	25.46	16.67	16.22	15.62	29.09
'F' value	53.38	22.95	19.37	15.63	71.89
Lack of fit	454.46	13.51	5.35	14.93	56.37
$p < 0.01$	S	S	S	S	S

T : Temperature, °C (T_1-110 °C, T_2-120 °C, T_3-130 °C);
M : Feed moisture (w.b.), % (M_1-15%, M_2-17.5%, M_3-20%);
F : Feed composition,% (F_1-92:4:4, F_2-94:3:3, F_3-96:2:2)

The coefficient of determination R^2 values of 0.9627 shows that the model was best fitted to experimental results, indicating that 96.27 per cent of the variations of the response could be described by the model. The adjusted R^2 value was 0.9207 and adequate precision 16.669, which is greater than 4 and hence this model may be used to navigate the design space. The model was determined by considering all the above criteria for representing the variation of carbohydrate content of the extruded product. The quadratic model for carbohydrate content in terms of coded levels of the variables was as follows;

Carbohydrate (%) = $71.39 - 1.00x_1 - 0.12x_2 - 0.35x_3 + 0.040x_1x_2 + 0.032x_1x_3 + 0.072x_2x_3 + 0.33x_1^2 + 0.098x_2^2 + 0.11x_3^2$

Where, x_1, x_2 and x_3 are the coded values of temperature (°C), feed moisture (%) and feed composition (%), respectively.

Crude fiber (%)

Crude fiber content of corn based (Popcorn: Sugar baby) extrudate varied from 10.36 and 11.54 per cent. The treatment $T_3M_2F_3$ i.e., 130 °C temperature, 17.5 per cent feed moisture and 96:2:2 feed composition showed minimum crude fiber content (10.36%) whereas, the treatment $T_1M_2F_1$ i.e., 110 °C temperature, 17.5 per cent feed moisture and 92:4:4 feed composition showed maximum crude fiber content (11.54%). The average value of crude fiber content for all treatments was 10.91 per cent as given in Table 3. The feed moisture had significant effect on the crude fiber content of the extrudates. As the feed moisture increased, the retention of the crude fiber content in the extrudate increased. There was significant decrease in crude fiber content of the extrudate upon increase in temperature. The addition of more amounts of pigeonpea brokens and rice bran results in increased crude fiber content of the corn based extrudate.

The significant ($p< 0.05$) model 'F' value of 19.37 was observed in regression model fitted to experimental results of crude fiber content. The lack of fit 'F' value of 5.35 was not significant ($p> 0.05$). The coefficient of determination R^2 used to determine best fit model was 0.9561, indicating that 95.61 per cent of the variation of the experimental response could be explained by the model. The adjusted R^2 value was 0.9068 and adequate precision 16.224, which is greater than 4. Considering all the above criteria, the model was selected for representing the variation of crude fiber content and for further analysis. The quadratic model for crude fiber in terms of coded levels of the variables is as follows;

$$\text{Crude fiber (\%)} = 10.85 - 0.43x_1 - 9.043\text{E-}003x_2 - 0.21x_3 + 0.11x_1x_2 + 0.058x_1x_3 + 0.076x_2x_3 + 0.017x_1^2 + 0.087x_2^2 + 0.032x_3^2$$

Where, x_1, x_2 and x_3 are the coded values of temperature (°C), feed moisture (%) and feed composition (%), respectively.

Fat content (%)

Fat content of corn based (Popcorn: Sugar baby) extrudate varied from 1.98 to 3.04 per cent. The treatment $T_3M_2F_1$ i.e.,130 °C temperature, 17.5 per cent feed moisture and 92:4:4 feed composition showed minimum fat content (1.98%) whereas, the treatment $T_1M_2F_1$ i.e., 110 °C temperature, 17.5 per cent feed moisture and 92:4:4 showed maximum fat content (3.04%). The average value of fat content for all treatments was 2.27 as given in Table 3. The feed moisture had significant effect on the fat content of the extrudates. As the feed moisture increased the retention of the fat content in the extrudate is increased. Similar results were reported by Vasanthan *et al*. (2002) [15] for barley flour based expanded snacks. The fat content in the extrudates decreases as the temperature increases. This is because the burning of fat takes place during the extrusion process and high temperature burns the fat available in product. Fat content of the corn based extrudate increased with increase in the amount of pigeonpea and rice bran content in the feed material.

Regression model fitted to experimental results of fat which shows significant ($p< 0.05$) model 'F' value of 15.63 and lack-of-fit 'F' value of 14.93. The adjusted R^2 value was 0.8856 and adequate precision 15.620, which is greater than 4 and hence this model may be used to navigate the design space. The best fit model was also expressed by the coefficient of determination R^2, which was 0.9462, indicating that 94.62 per cent of the variability of the response could be explained by the model. Considering all the above criteria, the model was selected for representing the variation of fat content and for further analysis. The fat content of extrudates expressed by quadratic model in terms of coded levels of the variables is as follows;

$$\text{Fat content (\%)} = 2.17 - 0.27x_1 - 2.309\text{E-}003x_2 - 0.16x_3 - 0.037x_1x_2 + 0.091x_1x_3 - 2.197\text{E-}003x_2x_3 + 0.13x_1^2 - 0.030x_2^2 - 0.11x_3^2$$

Where, x_1, x_2 and x_3 are the coded values of temperature (°C), feed moisture (%) and feed composition (%), respectively.

Ash content (%)

Ash content of corn based (Popcorn: Sugar baby) extrudate varied from 1.16 to 2.30 per cent. The treatment $T_3M_1F_2$ i.e., 130 °C temperature, 15 per cent feed moisture and 94:3:3 feed composition showed minimum ash content (1.16%) whereas, the treatment $T_1M_1F_2$ i.e., 110 °C temperature, 15 per cent feed moisture and 94:3:3 feed composition showed maximum ash content (2.30%). The results show that ash content of the extrudate decreased as the temperature increased. The ash content also increases as the feed moisture increases. The feed composition had significant effect on ash content of the extrudate. As the amount of pigeonpea and rice bran increased and corn content decreased in the feed composition, the ash content increased.

The average value of ash content for all treatments was 1.96 per cent. Regression model fitted to experimental results of ash content shows that model 'F' value of 71.89 was significant ($p< 0.0001$) whereas, lack-of-fit 'F' value of 56.37 was not significant ($p> 0.0001$). The coefficient of determination R^2, which is 0.9878, indicates that 98.78 per cent regression model can approximate the response variation. The adjusted R^2 value which shows suitability of experimental results was 0.9740 whereas, adequate precision was 29.085, which is greater than 4 and hence this model may be used to navigate the design space. Considering all the above criteria, the model was selected for representing the variation of ash content value and for further analysis. The quadratic model for ash content in terms of coded levels of the variables is as follows;

$$\text{Ash content (\%)} = 2.04 - 0.39x_1 + 4.721\text{E-}003x_2 - 0.13x_3 + 0.029x_1x_2 - 0.12x_1x_3 + 0.015x_2x_3 - 0.18x_1^2 + 1.109\text{E-}003x_2^2 - 9.971\text{E-}003x^3$$

Where, x_1, x_2 and x_3 are the coded values of temperature (°C), feed moisture (%) and feed composition (%), respectively.

Sensory characteristics of developed corn extrudates

For the corn based extruded product (Popcorn: Sugar baby), the overall acceptability varied from 7.28 to 8.24. The average scores of extruded products for each characteristic are given in Table 4. The treatment $T_3M_2F_1$ i.e.,130 °C temperature, 17.5 per cent feed moisture and 92:4:4 feed composition scored the highest by sensory panel (overall acceptability 8.24) whereas, the treatment $T_1M_1F_2$ i.e.,110 °C temperature, 15 per cent feed moisture and 94:3:3 feed composition scored the lowest by sensory panel (overall acceptability 7.28). The second-best treatment selected by sensory panel was $T_3M_2F_3$ i.e., 130 °C temperature, 17.5 per cent feed moisture and 96:2:2 feed composition with overall acceptability of 8.12. it was observed that the overall acceptability of the extruded product increases as the temperature increases but it decreases as the moisture content decreases. Feed moisture content had significant effect on the overall acceptability of the product.

Regression model fitted to experimental results of overall acceptability showed that model 'F' value of 5.89 was significant (p< 0.0001) whereas, lack-of-fit 'F' value of 10.52 was significant (p> 0.05). The best fit model was also expressed by the coefficient of determination R^2, which was found to be 0.8688, indicating that 86.88 per cent of the variability of the response could be explained by the model. The adjusted R^2 was 0.7212 and adequate precision was 10.060 suggesting that this model can be used for prediction purpose. Considering all the above criteria, the model was selected for representing the variation of overall acceptability and for further analysis. The quadratic model for sensory value (overall acceptability) in terms of coded levels of the variables is as follows;

$$\text{Sensory (Overall acceptability)} = 7.71 + 0.30x_1 - 0.065x_2 + 0.047x_3 + 0.10x_1x_2 - 0.16x_1x_3 + 0.080x_2x_3 + 0.085x_1^2 - 0.11x_2^2 + 0.55x_3^2$$

Where, x_1, x_2 and x_3 are the coded values of temperature (°C), feed moisture (%) and feed composition (%), respectively.

Optimization of Extrusion Process Variables

A numerical multi-response optimization technique was applied (Park *et al*., 1993) [8] to determine the optimum combination for the production of extru date. The assumptions were made to develop a product which would have maximum score in sensory acceptability so as to get market acceptability. Under these criteria, the uncoded optimum operating conditions for development of corn based (Popcorn: Sugar baby) extrudates were 130 °C of temperature, 20 per cent of feed moisture and 92:4:4 feed composition at constant screw speed of 350 rpm. The responses predicted by the Design-Expert 7.7.0 software for these optimum process conditions were resulted as follows with desirability 0.698.

Table 4: Sensory evaluation of corn based extruded product (Popcorn: Sugar baby)

Treatment	Sensory attributes						
	Colour	Flavour	Taste	Hardness	Swallowness	Sticki ness	Overall acceptability
$T_2M_1F_3$	7.86	7.68	7.58	7.41	7.21	7.20	7.45
$T_2M_2F_2$	7.62	6.79	7.14	7.19	7.24	7.04	7.56
$T_2M_3F_3$	7.56	7.28	7.45	7.60	7.61	7.41	7.59
$T_2M_2F_2$	7.46	7.68	7.26	7.85	7.28	7.44	7.62
$T_2M_1F_1$	7.12	6.92	7.56	7.31	6.92	7.65	7.78
$T_1M_1F_2$	7.14	7.58	7.23	6.87	6.98	7.00	7.28
$T_3M_3F_2$	7.86	7.42	8.02	7.95	7.21	7.90	7.72
$T_2M_2F_2$	7.84	7.63	7.61	7.43	7.30	7.41	7.54
$T_2M_2F_2$	7.71	7.58	7.64	7.71	7.57	7.47	7.68
$T_1M_2F_1$	6.86	7.11	6.79	6.85	6.92	7.01	7.30
$T_3M_2F_1$	7.92	8.10	8.13	7.98	7.84	8.10	8.24
$T_1M_3F_2$	6.98	7.64	7.41	7.51	7.32	7.37	7.46
$T_1M_2F_3$	7.85	7.15	7.31	7.08	7.02	6.58	7.51
$T_2M_2F_2$	7.79	7.83	7.56	7.43	7.71	7.20	7.64
$T_2M_3F_1$	7.64	7.33	7.22	7.58	7.54	7.18	7.34
$T_3M_1F_2$	7.34	7.65	7.28	7.46	7.85	7.13	7.38
$T_2M_2F_2$	7.75	7.79	7.58	7.41	7.21	7.20	7.58
$T_3M_2F_3$	7.85	7.95	8.00	7.95	8.10	7.74	8.12
Average	7.56	7.51	7.49	7.48	7.38	7.34	7.62
S. Em ±	0.079	0.083	0.079	0.080	0.081	0.085	0.540
C.V. (%)	0.045	0.047	0.045	0.045	0.047	0.049	0.380
Std. Dev.	0.337	0.351	0.335	0.340	0.344	0.360	0.029
p< 0.01	S	S	S	S	S	S	S

S – Significant
T : Temperature, °C (T_1-110 °C, T_2-120 °C, T_3-130 °C);
M : Feed moisture, % (M_1-15%, M_2-17.5%, M_3-20%);
F : Feed composition, % (F_1-92:4:4, F_2-94:3:3, F_3-96:2:2)

Conclusion

The fibre rich nutritious ready-to-eat extruded snack product was prepared by using corn (variety: Hema: NAH-1137) pigeonpea brokens and rice bran. The extruded product was evaluated for nutritional composition and sensory parameters. The independent variables such as barrel temperature, feed composition and feed moisture had significant ($p\leq$ 0.05) effects on nutritional composition of extrudates. The optimized condition was found to be 130 °C temperature, 20% feed moisture and 92:4:4 feed composition at constant screw speed of 350 rpm. The sensory results indicated that extrudates prepared were mostly accepted by panel. The products developed with optimized parameters contained 9.64% protein, 72.16% carbohydrates, 2.20% fat, 10.53% crude fiber and 1.77% ash content with a desirability of 0.698. This work has shown the potential of pigeonpea brokens and rice bran in food formulation as well as in the development of acceptable product from agro-industries by-products.

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