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Optimization of guava grit flour in multigrain mixes to develop a ready to eat extruded snack food using two-component mixture experiments

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ABSTRACT

Deep-fat fried snack food using guava grit flour as an ingredient is scarce in ready-to-eat foods. However, guava grit is an underutilized product. Conversion of guava grit into flour by oven drying method certainly extends its shelf life and can be used in various products to improve the taste and nutritional value. The flour was combined with multigrain powders in various proportions using mixture design experiments (Quadratic model) to develop a deep-fried snack food. The incorporation of guava grit into ready-to-eat expanded product and its effect on physicochemical [Water absorption index (WAI), water solubility index (WSI), bulk density (BD), hardness, expansion ratio), sensory analysis and nutritional quality of snacks were evaluated. The results of the experiments revealed that increase in fibre content in extruded snack food due to the addition of guava grit flour resulted in an increase in WAI, WSI, BD, hardness and expansion ratio.

INTRODUCTION

Vegetables and fruits generate a lot of agro-industrial residues that are wasted every year. This in turn pollutes the atmosphere. Attempts have been made to convert these agro-industrial wastes into value-added products (Melo et al., 2011; Schieber et al., 2001). *Psidium guajava* L. commonly called Guava is one of the most important tropical fruits and a ripened guava contains total solids 8.0–15.3° Brix, pectin 0.62%, total sugars 10.0-15.3%, reducing sugar 2.05-6.08% and acidity 0.08-0.54% (Kaur et al., 2009). Waste generated from guava pomace accounts for about 15% of the total fruit weight during the manufacturing process and guava production in the world is estimated to be about 500,000 metric tons, which generates a huge amount of agro-industrial wastes that is discarded into the environment (Jiménez- Escrig et al., 2001).

By-products wastes from fruits and vegetables are not economical, and are available in huge amounts; characterized by high dietary content which results in high water binding capacity and low in enzyme digestible organic matter (Serena and Knudsen, 2007). Various fruits and vegetable by-products have been used by various researchers such as carrot, orange, asparagus, apple, cherry, artichoke (Grigelmo-Miguel and Martín-Belloso, 1999; Nawirska and Kwaśniewska, 2005). Percentages of by-products generated during guava production accounts for about 25% of total fruit weight which includes three types of by-products during crushing, refining and sieving stages namely; decanter waste (5%), guava siever waste (8%) and refiner waste (12%). Kong and Ismail (2011) reported that these by-products form pink guava and can be used as the potential source of lycopene and beta carotene. Correia et al. (2004) extracted phenolic compounds from guava waste through fermentation. Among the by-products of

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Table 1. Physicochemical characterization of powder produced from the seed obtained from processing guava fruit pulp (*P. guajava* L.).

Parameters (% dry basis)	Results (mean ± SD)
Moisture (g/100g)	6.68 ± 0.00
Ash (g/100g)	1.18 ± 0.02
Total lipids (g/100g)	13.93 ± 0.03
Protein (g/100g)	11.19 ± 0.28
Carbohydrate (g/100g)	3.08
Pectin (g/100g)	0.58 ± 0.01
Fructose (g/100g)	0.29 ± 0.01
Starch (g/100g)	0.17 ± 0.00
Total dietary fiber (g/100g)	63.94 ± 0.10
Total calories (Kcal/100g)	182

guava industry, guava grit is the underutilized product. The waste from the decanter contains the highest amount of guava grit which offers a potential to develop snack products with its incorporation. The chemical composition of guava grit is given in Table 1 (Uchôa-thomaz et al., 2014).

Guava grit is rich in dietary fibre and contains fair amount of protein. From this, it can be concluded that guava grit powder can be utilized in different food formulations. Snack foods in the modern life play a significant role, with the continuous growth of food processing industries, the demand for special type of snack foods is increasing tremendously (Sharma et al., 2016). Wheat flour is one of the best sources of protein materials and vitamins among the cereals, and its ability to provide sap during dough making is the most important technical basis of its use in snacks (Ring et al., 1988).

An Indian traditional deep-fat fried snack food *muruku*, is popular throughout the country due to its versatility and uses as an integral part of the diet. Since snack foods are popular in all age groups and may be consumed during meal time, or in between, deep-fat fried snacks are in increasing demand with growing population and international interest. Consequently, the market of nutritious snack foods is also increasing across the world (Hollingsworth, 1995). Extrusion cooking is versatile, latest and continuous processing technology, gaining much importance in agro-food processing industry, with less energy consumption and final output product at lower cost.

Mixture design is an effective tool to optimize the variables with a minimum number of experiments. An experimental design of simplex-centroid design for mixtures was studied for the effect of sensory quality of the product. A mixture of designs was used to accelerate exploration of alternative blends (Dutcosky et al., 2006).

Ready-to-eat extruded snack food product was based on rice flour, wheat flour, Bengal gram and their combinations were developed widely but the incorporation of guava grit flour which is a by-product from the decanter generated waste has opened a new area for incorporation and development of value added products as well as adding economical cost to the food processing industry. Thus, the present investigation was aimed to study the incorporation and utilization of guava grit flour (by-product) into a ready-to-eat extruded snack food and to optimize the total color difference (ΔE), lateral expansion ratio and overall acceptability using two component mixture experiments.

MATERIALS AND METHODS

The multigrain flour was purchased from already available brands in the local market of katpadi (Chittoor).

Experimental design

The optimal design for mixtures was used to accommodate custom models and constrained regions. This type of mixture designs is used to determine by selection criterion chosen during the build (Table 2). Quadratic design model for custom mixtures was used to study the effect of mixture components on the total color difference (ΔE), lateral expansion ratio and overall acceptability of the product. The two mixture components were multigrain flours and guava grit flour. Several trails were taken to standardize and select the multigrain flour mixes. Lower and high level of the component mixtures were chosen according to several preliminary studies on the acceptability of the product. Mixture component of multigrain flours of high (97.5) and low (92.5) whereas for guava grit flour high (7.5) and low (2.5) of the corresponding ready-to-eat extruded snack product. The response variables were total color difference (ΔE), lateral expansion ratio and overall acceptability were taken to optimize the product characteristics.

Preparation of dry guava grit powder

Guava grit was collected after juice extraction processes, a tray dryer (Armfield – UOP8-A, UK) was used to dry guava grit between 20 to 150°C with high accuracy and to regulate the process. Dryer consisted of a damper to circulate the air, temperature probe, electric fan and heating unit control. The guava grit, which was very high in moisture content, was spread over the trays for drying and the temperature of the dryer was set to 65°C according to the previous study for drying carrot pomace by Kumar et al. (2011). The drying of guava grit was performed until the required moisture content was obtained in the sample. Grinding was done with a roller

Table 2. Optimal experimental design for two mixture components and their responses for ready-to-eat extruded snack food.

Run	Component 1	Component 2	Response 1	Response 2	Response 3
	A: Multigrain flours (%)	**B: Guava grit flour (%)**	**Total colour Difference (ΔE)**	**Lateral expansion (%)**	**OAA**
1	96.25	3.75	8.84	81.23	8
2	94.16	5.83	12.86	85.67	7.5
3	95.83	4.16	10.38	83.21	7.5
4	92.50	7.50	17.02	90.54	7.5
5	97.50	2.50	6.82	78.00	8
6	92.50	7.50	17.02	90.54	7.5
7	95.00	5.00	11.33	84.75	8.5
8	93.75	6.25	14.25	87.35	7.5
9	95.00	5.00	11.33	84.75	8.5
10	92.50	7.50	17.02	90.54	7.5
11	95.00	5.00	11.33	84.75	8.5
12	97.50	2.50	6.82	78.00	8
13	97.50	2.50	6.82	78.00	8

Table 3. Preliminary trails to standardize multigrain mixes with different proportions of guava grit flour.

Sample-A		Sample-B		Sample-C	
Flour ratio (Rice : Wheat : Bengal gram) 2:1:1	**Guava grit flour (%)**	**Flour ratio (Rice : Wheat : Bengal gram) 2:1:2**	**Guava grit flour (%)**	**Flour ratio (Rice : Wheat : Bengal gram) 2:2:2**	**Guava grit flour (%)**
A1	0.0	B1	0.0	C1	0.0
A2	2.5	B2	2.5	C2	2.5
A3	5.0	B3	5.0	C3	5.0
A4	7.5	B4	7.5	C4	7.5
A5	10.0	B5	10.0	C5	10.0
A6	12.5	B6	12.5	C6	12.5
A7	15.0	B7	15.0	C7	15.0

attached grinder. The material was ground and passed through a sieve of 2 mm screen size. The guava grit powder was packed in sealed high density polyethylene (HDPE) bags and this flour was used in snack food.

Preparation of sample

For development of guava grit flour based highly nutritional ready-to-eat extruded snack product, several preliminary trails were developed prior to optimization of guava grit flour with variation in multigrain mixes in different proportions (Table 3). Multigrain mixes in different proportions with varying quantity of guava grit flour from 2.5 to 15% were evaluated based on the sensory score. From these trails, samples selected for optimal design for mixtures C2 to C4 were acceptable and rated best by all panelists.

In order to prepare the snack food, raw samples were mixed in different proportions with varying quantity of guava grit flour ranging from 2.5 to 15%, 2% salt was added to each of the sample proportions to enhance the taste and nutritional quality. 45 to 55% water was added followed by mixing and relaxation period of 20 min, the dough was then passed through an extruder of 1 mm and fried in refined palm oil (Acid value – 0.2 and PV- 2.91 meq/kg of oil) at a temperature of 160 to 170°C for 2-3 min. Frying was carried out in a batch fryer with a capacity of 2 L and about 120 g of sample was deep fat fried. The fried snack food was packed in zip lock HDPE bags and stored for further analysis (Figure 1).

Hand operated mini extruder

Extrusion trails were performed using a hand operated

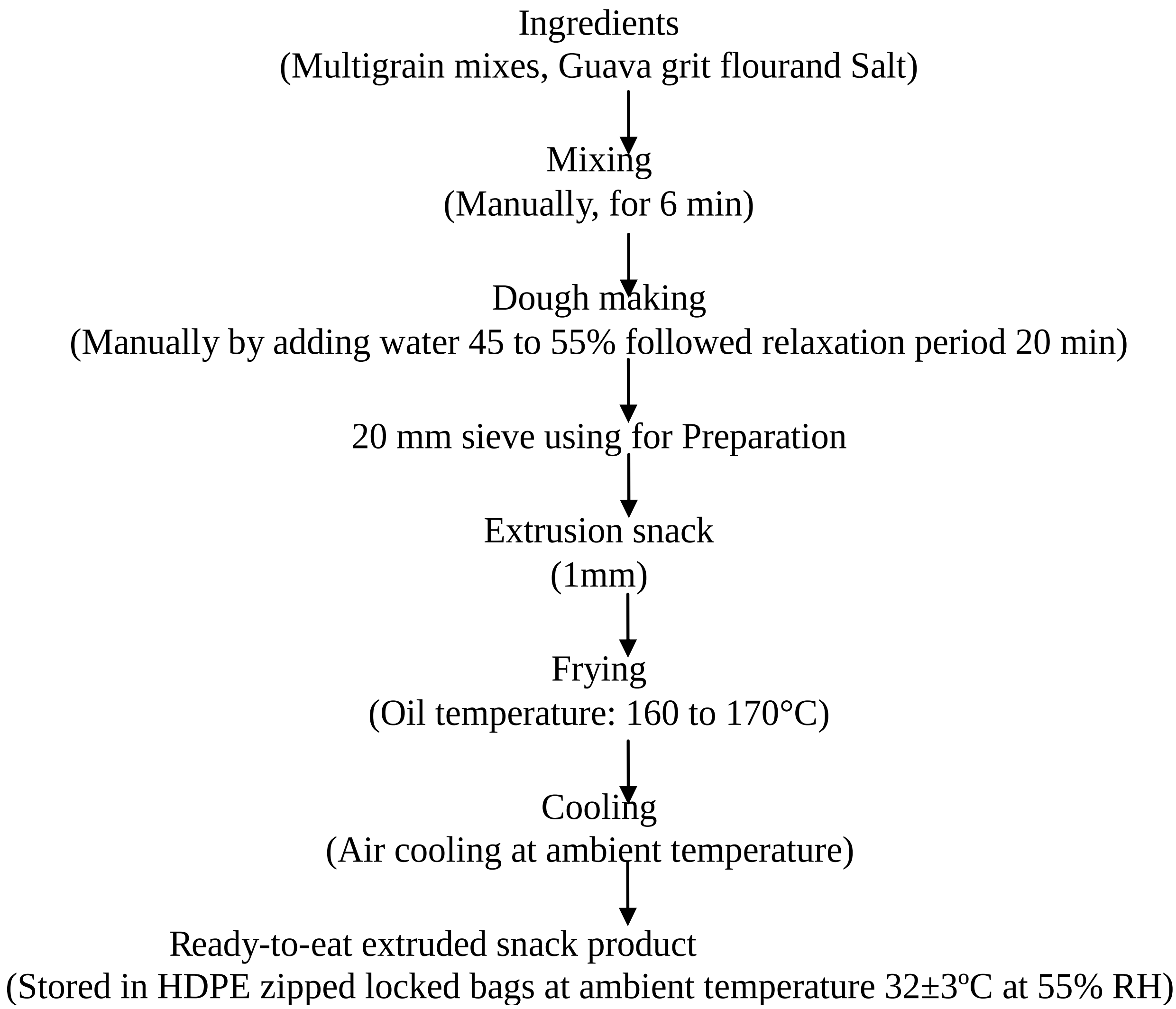

Figure 1. Process flow chart for preparation of ready-to-eat extruded snack product.

mini extruder fabricated by Nazeer industries, Chittoor, Andhra Pradesh. Screw threads were used to tighten 1 mm die plate which was recommended by the manufacturer for ready-to-eat extruded snack product. Samples were then poured into feed hollow cylinder. The product was collected at the die end and packed in zipped lock packs and kept for proper storage. In order to remove extra moisture or to stabilize the moisture in the product, all samples were kept at 60°C for 12 h in an incubator.

Determination of product quality responses for ready-to-eat snack product

Proximate composition

Moisture (Memmert/UF 55) and fat (Soxhlet Apparatus) of snack foods was determined according to the procedure of AOAC (2012). The pH value of the products was determined using digital pH meter (Analab µPHCal100). Peroxide value (PV) and free fatty acid (FFA, as Oleic Acid) was analyzed by AOAC (2012).

Texture measurement for ready-to-eat extruded snack

The hardness of the samples was measured from the force deformation curves by using an Instron Universal testing machine (Instron model 4502 with a 1 KN load cell) fitted with a Kramer Shear cell. The crosshead speed of the blades was 180 mm/min with a compression limit of 50 mm. The test was carried out at room temperature (25°C).

Estimation of color values

The color of deep fried ready-to-eat extruded snack was determined in terms of L*, a* and b* values using Konica Minolta CR-400 Chroma Meter. The L* measures lightness of the product color from zero for black to 100 for perfect white. Redness/greenness when a* value is positive/negative, yellowness/blueness when b* value is positive/negative. The colorimeter was calibrated with standard black and white calibration types and displayed values were matched with the values reported in the operating manuals. Total color change (ΔE), Chroma (c) and Hue angle ($\propto^0$) is used to describe the change in color during the deep fat frying.

$$Total\ colour\ change\ (\Delta E) = \sqrt{(L_0 - L_t)^2 + (a_0 - a_t)^2 + (b_0 - b_t)^2}$$

Where, L_0,a_0,b_0 are the Initial color measurement for control sample without guava grit flour and L_t, a_t, b_t are the color measurement of guava grit flour incorporated sample proportions.

$$Chroma\ (c) = (a_t^2 + b_t^2)^{0.5}$$

$$Hue\ Angle\ (\propto^0) = Tan^{-1}(\frac{b_t}{a_t})$$

Longitudinal/lateral expansion ratio

Longitudinal/lateral expansion ratio was determined according to the method proposed by Fan et al. (1996). Averages of 10 measurements were taken for the diameter of the hand operated mini extruder and measured using Vernier caliper.

Bulk density

Bulk density was determined according to the method stated by Stojceska et al. (2008).

$$BD = \frac{(4 \times mass\ of\ extrudates, g)}{\tau \times (diameter\ of\ extrudates, cm)^2 \times lenth\ of\ extrudates, cm} \times 100$$

Water absorption index (WAI) and water solubility index (WSI) for ready-to-eat extruded snack product

Water absorption index and water solubility index were determined according to the method suggested by Kaur et al. (2011). Sample was finely ground, 20 ml of distilled water was added and kept at room temperature for 30 min with intermediate shaking for every 5 min. The sample was centrifuged at 3000 rpm for 15 min. After centrifugation, the supernatant was discarded. The ratio of the weight of the wet sediment to that of dried sedimente gives the WAI, whereas WSI can be calculated by evaporating the supernatant at 105°C till constant weight is achieved. WSI was calculated according to the method of Anderson et al. (1969).

$$WAI\ (g.g^{-1}) = \frac{Weight\ gain\ extrudate\ in\ gel\ form}{Dry\ weight\ of\ extrudate}$$

$$WSI\ (\%) = \frac{Weight\ of\ dry\ solid\ in\ supernatent}{Dry\ weight\ of\ extrudate} \times 100$$

Sensory evaluation

Sensory analysis was conducted to evaluate the flavor acceptability ready-to-eat extruded snack food with the help of 25 panelists (15 trained, 10 semi trained) using 9-point hedonic scale (1 indicates disliked extremely to 9-liked extremely) according to the method described by Amerine et al. (2013). Food analysts working in the food testing laboratory, JNTUK, Kakinada and quality personnel from the nearby food industries were included in the trained panelists. Students pursuing Masters in Food Processing Technology were also included as semi trained panelists. The sensory analysis was conducted in individual booths under constant light source of 500 lux. Sensory attributes like color, taste, flavor, appearance and overall acceptability (OAA). All average scores were computed from 25 panelists for different attributes.

Data analysis

Method of mixture design was adapted to model the experimental data using software Design Expert version 10 (Stat-ease Inc, USA, Free trail). This enabled the researchers to get design constraints, point predictions, summary of the fit for optimization of process variables. Significant means was used to fit the experimental data using Scheffe canonic equation,

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_{3+} \beta_{23} X_2 X_3 + \beta_{123} \beta X_1 X_2 X_3,$$

Where Y indicates the response, $\beta_1, \beta_2, \beta_3, \beta_{12}, \beta_{13}, \beta_{23}, \beta_{123}$ indicates regression parameters and X_1, X_2, X_3 indicates the proportion of guava grit in multigrain mixes.

Mathematical modeling is useful for obtaining the

Table 4. Method of mixture design to fit analysis of variance for the experimental data.

Regression	Sum of squares		
	Total color difference (ΔE)	Lateral expansion	Overall acceptability
p-value (probability >F)	< 0.0001 (Significant)	< 0.0001 (Significant)	0.02 (Significant)
R- squared	0.99	0.99	0.72
Adjusted R-squared	0.99	0.99	0.58
Predicted R-squared	0.99	0.99	-0.19
Adequate precision	91.50	68.43	5.99
C. V. (%)	1.98	0.39	3.40
Standard deviation	0.23	0.33	0.27
Lack of fit	0.53 nonsignificant	0.99 nonsignificant	0.58 nonsignificant

Table 5. Coefficient estimates for coded factors fitted model.

Parameters	Coefficient estimate for coded factors		
	Total color difference (ΔE)	Lateral expansion	Overall acceptability
A-Multigrain flours	6.85	77.97	8.01
B-Guava grit flour	17.00	90.53	7.50
AB	-2.03	1.34	2.42
AB(A-B)	--	5.01	0.38
$AB(A-B)^2$	--	--	-14.59

optimized process values and desirability, this helps in maximizing the desirability function.

RESULTS AND DISCUSSION

Table 2 shows the experimental combinations for various responses for the coded variables. The ANOVA for quadratic mixture model and regression for comparing the factor coefficients are given in Tables 4 and 5. The ANOVA for quadratic mixture model of *F*-value for the total color difference, lateral expansion, and overall acceptability are 160.23, 782.85 and 5.22 respectively, which imply that the model is significant. Adequate precision measures signal to noise ratio and should be greater than 4 is desirable. All the coded factors showed high adequate precision (Table 4).

Various functional and physical properties have been studied in ready-to-eat extruded snack product. Stojceska et al. (2008) studied ready-to-eat snacks by incorporating the cauliflower by-products and found that increase in dietary fibre, color, bulk density, WAI and protein content by 5-20% incorporation of by-products. A wide variation in all the responses was observed for mixture design in coded experimental conditions, that is, total color difference (ΔE) 6.82 to 17.02, lateral expansion 78 to 90.54% and overall acceptability 7.5 to 8.5. The quadratic model was used to analyze using two component mixture designs with and without interaction responses and R^2 values were calculated. ANOVA technique was used to find the adequacy of all models. F-values quadratic model for lack of fit of all responses was found non-significant ($p \leq 0.05$) Figure 2.

It was found that addition of a higher quantity of wheat flour resulted in sticky dough. Rice flour, Bengal gram flour and guava grit powder (GGP) were added to provide good textural properties and nutritional quality of snack food. GGP blended samples required 5 to 10% more water than control sample to make dough, mainly due to higher WAI of GGP and may contain more hydrophilic carbohydrates to give rise in water absorption capacity but lowered the frying time and temperature of GGP blended samples as compared to control samples. Frying time and temperature followed the decreasing trend as the level of GGP increased. It might be due to low bulk density (0.22-0.28 $g.cm^{-3}$) of GGP, which spend up frying rate and consequently decreased frying temperature by 10±2°C in comparison to control sample.

Chemical properties and textural properties of ready-to-eat extruded snack product

The moisture contents of all the samples are given in

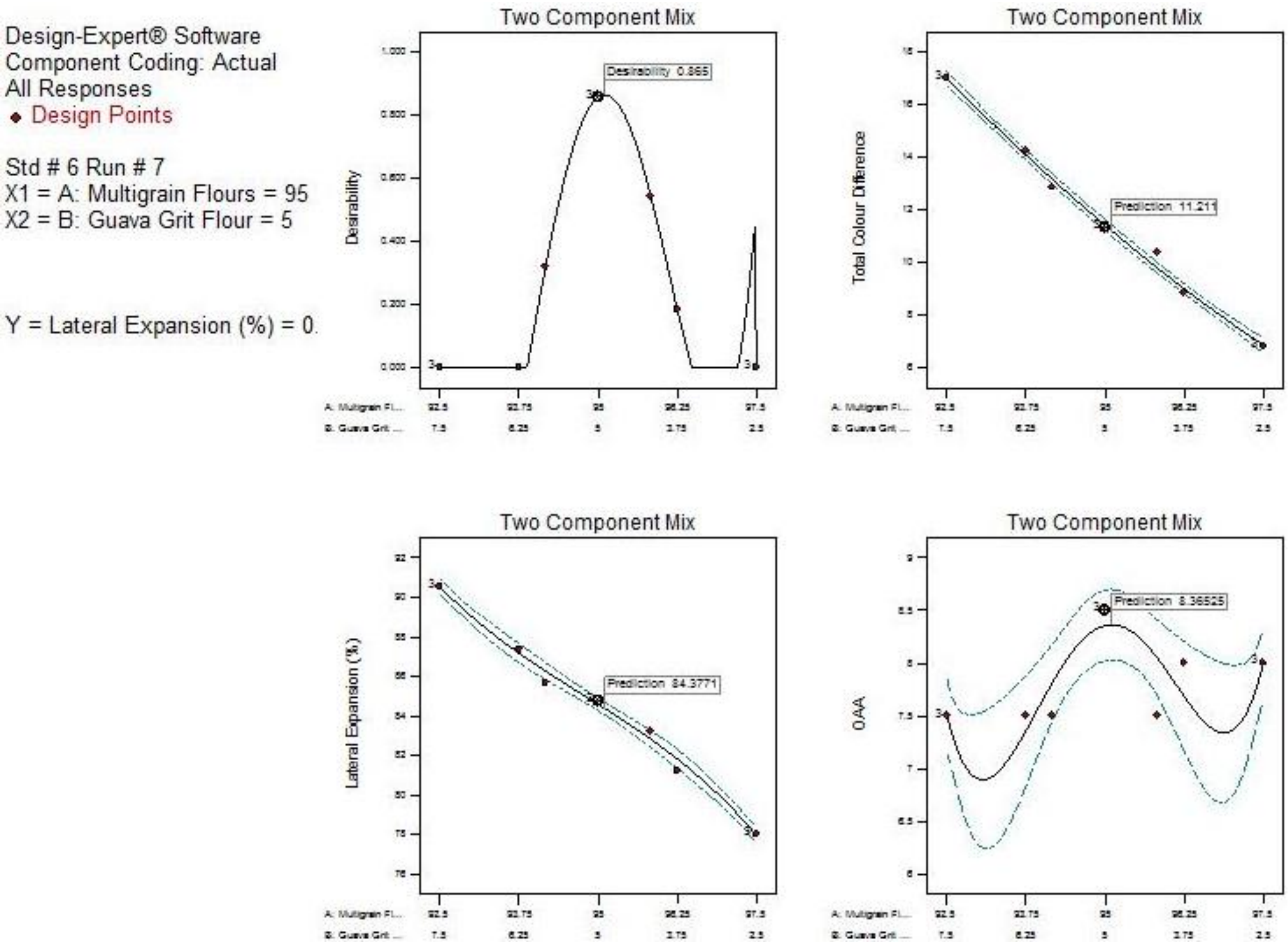

Figure 2. Effect of desirability, total color difference, lateral expansion and overall acceptability using two component mixture design for ready-to-eat extruded snack product.

Table 6. Chemical properties, textural analysis of control and blended samples for ready-to-eat extruded snack product.

Constituent	Sample code			
	C1	C2	C3	C4
Moisture content (%)	2.40±0.01	2.00±0.01	1.50±0.01	1.00±0.01
Fat content (%)	35.00±0.02	33.00±0.02	28.00±0.02	24.00±0.02
pH	7.20±0.03	7.30±0.03	7.50±0.03	7.80±0.03
Free fatty acid (%)	0.34±0.02	0.33±0.02	0.30±0.02	0.26±0.02
Peroxide value (PV) meq kg^{-1}	4.32±0.03	4.17±0.03	3.72±0.03	3.26±0.03
Textural analysis (hardness), positive peak force (N)	28.92±0.01	25.56±0.01	16.10±0.01	13.32±0.01

Mean values of determination ± standard deviation for three replicates determinations.

Table 6 and it is ranged between 1 to 2.2%. According to Mazumder et al. (2007), the textural properties of the snack product were acceptable below a moisture content 4%. The textural properties were highly effected above 4% moisture content. Sample with a higher blend of GGP had the lowest value, while control sample (without GGP) had a maximum value of moisture content.

The pH of snack food samples C1 (control), C2 and C3

Table 7. Physical properties of control and blended ready-to-eat extruded snack food product.

Constituent	Sample code			
	C1	C2	C3	C4
Lateral expansion, %	68.0±0.01	76.60±0.01	83.20±0.01	90.50±0.01
WSI, %	4.10±0.03	15.06±0.03	17.92±0.03	34.26±0.03
Bulk density ($g.cm^{-3}$)	0.22±0.05	0.25±0.05	0.26±0.05	0.28±0.05
WAI,($g.g^{-1}$)	5.54±0.02	6.17±0.02	7.92±0.02	6.75±0.02

Mean values of determination ± standard deviation for three replicates determinations.

Table 8. Color evaluation of control and GGP blended incorporated ready-to-eat extruded snack food product.

Sample code	Color Value					
	L^*-Value	a^*-Value	b^*-Value	Chroma(C)	$\propto^0$	ΔE
C1	42.18±0.01	11.11±0.01	36.98±0.01	38.16	73.32	-
C2	38.39±0.01	10.99±0.01	31.38±0.01	33.25	70.73	6.82
C3	34.37±0.01	10.68±0.01	28.78±0.01	30.70	69.68	11.33
C4	29.94±0.01	10.34±0.01	25.18±0.01	27.22	67.71	17.02

Mean values of determination ± standard deviation for three replicates determinations.

were found as 7.4, 7.4 and 7.5 (Table 6). The sample C4, having higher level of GGP, had a highest pH value of 7.6 and might be due to more release of water during frying. This result showed a little difference with the finding of Anandh et al. (2005), where they have reported pH value 6.45 of snack food prepared from buffalo rumen meat and corn flour.

FFA contents of snack food samples were found to vary between 0.26 and 0.34% of oleic acid (Table 6), and are in line with the results of Tiwari et al. (2011). The snack food sample (C4), with higher guava grit powder, showed lowest values of FFA as 0.26% and other GGP blended samples C2 and C3 had FFA values as 0.33 and 30% of oleic acid, respectively. Snack food that had lower moisture content had less degradation products of hydro-peroxide and consequently less in FFA.

Peroxide values of snack food ranged between 4.30 and 3.25 meq per kg fat (Table 6). Tiwari et al. (2011) reported that snack food can be consumed if the peroxide value is less than 5 meq/kg oil. The sample C1 had highest peroxide value as 4.30 meq/kg than the snack food samples. The lowest peroxide value was noted for the sample C4, and might be due to lowest moisture content and antioxidant properties of guava grit powder.

The peak position of the force-deformation curve is at 28.92 N for the control sample, hardness was gradually decreased with the increase in the content of the GGP in the sample (Table 6).

Physical properties of ready-to-eat extruded snack food product

The effects of dependent variables (lateral or longitudinal expansion indices, bulk density, water absorption index, water solubility index, and overall acceptability) are given in Table 7. Color evaluation for control and GGP was established to fit the experimental data (Table 8).

Lateral or longitudinal expansion indices varied from 68.0±0.01 to 90.5±0.01%. The variation in lateral expansion might be due to change in processing conditions. The expansion mainly occurred due to gelatinization of starch in the presence of moisture and desirable temperature. The lateral expansion decrease with increase in moisture content. The lateral expansion increased with increase in rice starch proportion at all levels of moisture contents, which might be attributed to higher gelatinization due to the presence of higher proportion rice starch in the ingredients. WSI ranged from 4.10±0.03 to 34.26±0.03% which indicates the molecular components degradation and the decrease in WSI means the increase in rice proportion and moisture of the ready-to-eat extruded snack product. Water absorption indices varied from 5.54±0.02 to 6.75±0.02 $g.g^{-1}$. The bulk density of ready-to-eat extruded snack product varied from 0.22±0.05 to 0.28±0.05 $g.cm^{-3}$. The change in bulk density might be mainly because of change in composition and extrusion conditions.

Table 9. Sensory evaluation results of control and GGP blended ready-to-eat extruded snack food product.

Sample code	Color	Flavor	Texture	Taste	Crispness	Overall acceptability
C1	8.1	7.9	7.1	8.5	7.2	7.8
C2	8.2	8.4	7.4	8.7	7.8	8.1
C3	8.3	8.5	7.5	8.8	8.0	8.2
C4	8.0	7.5	7.4	8.2	7.6	7.6

The whiteness or brightness/darkness (L^* value), redness/greenness (a^* value) and yellowness (b^* value) of GGP blend samples (C2, C3 and C4) were different from the control (C1). ‘L^*’, ‘a^*’ and ‘b^*’ values of GGP blend samples decreased as the level of GGP increased. This might be due to addition of pigment (Carotenoids) color after frying, which imparted slightly golden color. For control sample, the value of ‘L^*’, ‘a^*’ and ‘b^*’ was 42.18±0.015, 11.11±0.013 and 36.98±0.013, respectively, while for GGP blend samples the values ranged from 31.38±0.015 to 25.18±0.015, 10.99±0.015 to 10.34±0.016 and 31.38±0.015 to 25.18±0.015, respectively. Similarly, Chroma ‘C’, and hue angle ‘$\propto^{0}$’ of GGP blend samples were also less than the control sample (C1) and recorded decreasing trend as the level of GGP increased. The total color change in sample C4 (higher GGP) was higher than the samples C2 and C3.

Sensory analysis of snack food

Samples in A-group were completely excluded due to their higher hardness, while samples in B-group were acceptable although the taste quality was not satisfactory. More hardness of group-A samples might be due the insufficient quality of Bengal gram flour and wheat to compensate the gel like character of rice flour. On the other hand, the problem was almost negligible in group-C samples with 0 to 7.5% blended of guava powder, due to sufficient quality of Bengal gram, wheat flour and rice flour (Table 3). The other samples in group-C, with 10 to 15% guava grit powder were excluded due to burning flavor after frying. It is also important to note that the overall acceptability (OAA) of these fried snack were 7.8, 8.2 and 8.1, respectively, in fresh condition. The samples with highest GGP blend ratio showed lowest OAA and buying intention by the panelist. This was mainly due to slight dark color imparted by GGP after frying (Table 9).

Conclusion

Two component mixture experiments was effective in optimizing and studying the incorporation of guava grit flour by-product in multigrain mixes for ready-to-eat extruded snack product. The addition of guava grit flour in multigrain mixes by 2.5 to 15% and using the responses in experimental mixture design like total color difference, lateral or longitudinal expansion indices and overall acceptability and thus, made easy to optimize and characterize the ready-to-eat snack product.

The guava grit flour blends could be used to produce good quality snack food with acceptable physicochemical and organoleptic qualities. The quality of snack food based on multigrain flour and guava grit flour was nutritionally better as compared to control sample. The snacks with higher guava grit flour have lower fat content, while the snack food without having maximum fat content. Physicochemical and textural properties of snack foods showed a linear increased/decreased in their values as blends of guava powder increased.

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Disclosure statement

No potential conflict of interest.

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