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Optimization of Flour Blends for Domestic and Industrial Application

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Authors' contributions

This work was carried out in collaboration between both authors. Authors LAT and AP together designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Both authors managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: To determine the combined effect of brown rice, soybean, yellow corn, and pineapple pomace on physicochemical and proximate quality of their flour blends.
Study Design: Design Expert mixture model
Place and Duration of Study: Indian Institute of Food Processing Technology, Thanjavur, Tamil-Nadu - India. Nov, 2016- May, 2017.
Methodology: Flours were made from brown rice, yellow corn, soybean and pineapple pomaces and blend at 20 different levels with the help of design expert mixture model. The 20 flour blends were analyzed for their physical, functional and proximate values.
Results: Analyzed data from the individual flour samples showed each individual flours had unique characteristics and these impacted positively on the proximate and functional properties of the flour blends based on their levels of incorporation. The flour blends showed improvement in the proximate quality and functional properties at the different levels of the combination.
Conclusion: The final flour products can be recommended for winning food, baking or for extrusion cooking.

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Keywords: Brown rice; soybean; pineapple pomace; flour blends.

1. INTRODUCTION

In an attempt to reduce the risk of chronic diseases associated with food malnutrition, improving and utilization of food blends is an economical option. The combination of agricultural food production has shown to improve nutritional, functional and sensory characteristic of some foods products [1,2]. The ingredients used in food blends are usually foods that contain high levels of one or more essential nutrients and are available at a low cost. In some instances, they are highly nutritious but underutilized. The goal of food blending is to achieve highly nutritious but economical food product. In recent times, nutritious cereals, legumes and fruits are been incorporated into traditional foods, for instance, replacing wheat flour with other flours obtained from local crops for baking, weaning foods and as nutritional therapy [3,4,2,5].

Cereals and grains are the world most consumed crops forming part of every household meal. Rice and corn are staple foods in most countries. Their amylose and amylopetin contents, varying levels of other essential nutrients and their physicochemical qualities allow them to be ideal for food processing. However, brown rice and yellow corn are mostly not preferred because of their high pigmentation which may alter the desired outcome of the food product [6, 7, 8, 9], even though they may have the potential to improve food product development. Legumes, traditionally have been an important part of the diets of many cultures. However, beans have minor dietary role in some developing countries. Beans nutritionally have high protein, low saturated fat, complex carbohydrates and fibre, micronutrients and phytochemicals. Soybean (*Glycine max* L. Merr.) is considered unique because of its isoflavones concentration [10].

The fruit industry generates the significant amount of by-product which can be processed and used to enrich diets [11,12]. Pineapples are mostly eaten raw but are also processed into juice, drinks, jams and jellies. The by-products (after juice extraction) can be processed and used in the food industry as functional foods.

Availability and cost of food have allowed many to choose low nutrient food. There is, therefore, the need to develop alternatives food products to meet the nutritional needs of low-income household, by selecting economical food ingredients which are rich in certain essential nutrients. The objective of this study was to determine the combined effect of brown rice, soybean, yellow corn, and pineapple pomace on physicochemical and proximate quality of their flour blends.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Brown rice flour

Paddy brown rice (Nappillai Samba, a traditional rice variety) was purchased from a local farm at Thanjavur, Tamil Nadu- India. The paddy was de-husked using a Sheller (THU 35B 1999, Japan) and milled using a commercial hammer mill into a 500 µm particle size. Brown rice flour was stored at 4°C until all analyses were performed.

2.1.2 Full fat Soybean flour

Soybean (white variety) was purchased from a local supermarket in Thanjavur, Tamil Nadu- India. The soybean samples were washed and blanched for 30 mins to remove the beany flavour and bitterness from the bean. Blanched soybean samples were put under running water to allow for cooling and dehulling. Dehulled samples were dried in a mechanical dryer (everflow hot air oven, India) at 60°C over night and then milled into 500 µm particle size flour using an industrial hammer mill. Soybean flour was stored at 4°C till all analyses were done.

2.1.3 Pineapple Pomace flour

Ripe pineapples were purchased from a local fruit shop at Thanjavur, Tamil Nadu- India. The pineapples were washed, peel and cut into pieces. Using a Colloids Mill (KWSC, India), the cut pineapples were made into a liquid (smoothly) which was passed through muslin to separate the pineapple juice from the pomace. The pineapple pomace was tinny spread on a tray and dried using a conventional hot air oven dryer (Everflow hot air oven, India) at 40°C over night. The dried pineapple pomace was milled into 500 µm particle size using an industrial hammer mill. Milled pineapple pomace flour was stored at 4°C until all analyse were performed.

2.1.4 Yellow Corn flour

Commercial yellow corn flour was bought from a local supermarket at Thanjavur, Tamil Nadu-India and stored at 4°C until all analyse were performed.

2.2 Methodology

2.2.1 Formulation of the flour blends from the individual flour samples

Using the Stat-Ease, (Design-Expert 10, 2016, Minneapolis, MN, USA) software, 20 different blends were generated with the D-Optimal mixture model. The maximum and minimum limits used for the blends of the individual flour samples are represented in Table 1. The individual runs for the flour blends are represented in Table 2.

2.2.2 Determination of proximate composition of the flour samples

The method described by AOAC [13], was used to determine the moisture content Crude protein, crude fat, total ash, crude fibre and total carbohydrate of content of the flour samples.

2.2.3 Physicochemical and function properties of the flour blends

2.2.3.1 Physicochemical properties

The method of Friedrich [14] was used to determine the colour and pH values the flour samples.

Table 1. Composition limits of individual flour samples

Individual flour samples	Limits (%)	
	Maximum	Minimum
Yellow corn	60	40
Brown rice	40	20
Full fat soybean	30	20
Pineapple pomace	10	0

Table 2. Blends for the optimization of the four individual flour samples

Samples code (run)	Yellow corn flour	Brown rice flour	Full fat soybean flour	Pineapple pomace powder
1	60	20	20	0
2	48	28	24	0
3	48	29	20	3
4	51	20	23	6
5	44	24	28	4
6	49	20	30	1
7	41	34	25	0
8	40	25	25	10
9	40	30	30	0
10	40	30	24	6
11	46	34	20	0
12	40	20	30	10
13	51	20	23	6
14	60	20	20	0
15	48	28	24	0
16	44	26	20	10
17	41	35	20	4
18	48	28	21	3
19	40	31	24	6
20	40	40	20	0

The figures were based on 100 g calculation. 1 % salt (for taste) was added to each sample

2.2.3.2 Functional analyses of the flour samples

Bulk density: The bulk density of the flour samples were determined by the method as described by Narayana and Narasinga [15].

Swelling and solubility index: The swelling power and solubility determinations were carried out based on method described by Leach et al. [16].

Water absorption capacity (WAC): WAC of the flour samples was determined using the method described by Adebowale et al. [17].

2.3 Statistical Analyses

Stat-Ease, (Design-Expert 10, 2016, Minneapolis, MN, USA) linear mixture model software was used to generate the optimization runs for the experiment and data analysis of the flour blends. Statgraphic centurion version 17.1 was used for the data analyses and mean separation of the individual flour.

3. RESULTS AND DISCUSSION

The result for the physicochemical, functional and proximate analyses for the four individual flour samples used for the different flour blend compositions are presented in Tables 3, 4 & 7 respectively. The result shown in the Tables 3, 4 & 7 are means values and standard deviations with their mean separation. Results for effect of the individual flour on the physicochemical, functional and proximate analyses of the flour blends compositions are shown in Tables 5, 6 & 8.

3.1 Determination the Physicochemical and Functional Properties of the Four Individual Flour Samples

The analyzed data of the physicochemical and functional properties of the four individual flours are presented in Tables 3 & 4. Values in Tables 3 & 4 are mean values and standard deviation with their mean separation.

The pH value of the four individual flours ranged from 7.04±0.06 to 4.45±0.034. The Pineapple pomace flour had the acidic pH value while the Brown rice powder had a neutral pH value. The mean separation showed that there were significant differences in the pH means of the individual flour samples. Colour values represented in L (lightness), *a** (red or green) *b** (yellow or blue) values. The L value of the hunter lab scale ranged from 88.74±0.01 (Full fat soybean) to 66.59±2.75 (Pineapple pomace). The *a** and *b** mean values ranged from 6.32±0.05 (Brown rice) to 0.63±0.01 (Full fat soybean) and 33.64±0.05 (Yellow corn) to 9.39±0.02 (Brown rice) respectively.

Table 3. Physical analyses of the four individual flours samples

Sample (Flour)	pH values	Colour values		
		L	*a**	*b**
Full fat Soybean	$6.80±0.01^{c}$	$88.74±0.01^{d}$	$0.63±0.01^{a}$	$13.54±0.20^{b}$
Brown Rice	$7.043±0.06^{d}$	$75.40±0.09^{b}$	$6.32±0.05^{d}$	$9.39±0.02^{a}$
Yellow Corn	$6.54±0.01^{b}$	$84.15±0.35^{c}$	$5.39±0.21^{c}$	$33.64±0.38^{d}$
Pineapple Pomace	$4.35±0.034^{a}$	$66.59±2.75^{a}$	$4.69±0.45^{b}$	$20.71±0.38^{c}$

Mean values in the same columns with different superscripts are statistically different from each other (P=0.05)

Table 4. Functional properties of the four individual flours samples

Sample (Flour)	Bulk density (%)	Water absorption capacity (%)	Solubility (%)	Swelling power (%)
Full fat soybean	$88.0±0.85^{c}$	$24.0±0^{b}$	$11.57±0.97^{b}$	$54.0±0.40^{a}$
Brown rice	$86.40±1.38^{bc}$	$14.0±2.0^{a}$	$8.18±0.05^{a}$	$80.9±0.06^{b}$
Yellow corn	$83.7±0.78^{b}$	$14.10±0.36^{a}$	$8.25±0.39^{a}$	$78.8±0.38^{b}$
Pineapple Pomace	$45.63±0.24^{a}$	$47.0±1.41^{c}$	$26.36±0.61^{c}$	$85.8±0.20^{b}$

Mean values in the same columns with different superscripts are statistically different from each other (P=0.05)

The means value for pH and colour values showed significant differences among the four individual flour samples. A study by Selani et al. [18] obtained pH and colour values low than this studies pH values however the study obtained lower acidic values for pineapple juice. These studies together with this showed pineapple pomace is acidic. The colour values of corns showed a light yellowish colour, a similar colour value pattern was also observed by Singh et al. [19]. The colour values observed for brown rice in this study showed high *a** and *b** but low L values which imply that the colour of the brown rice was red and darker. A similar colour value were observed by Zhangian et al. [20] in red rice. The pH value for brown rice was neutral.

The percentage bulk density ranged from 88.0±0.85% (Full fat soybean) to 45.63±0.24 % (Pineapple pomace). The mean separation shows a significant difference between the pineapple pomace flour and the other flour samples. The lower the bulk density value, the higher the amount of flour particles that can stay together thereby increases the energy content derivable from such diets [21].

The WAC of the four individual flour samples ranged from 47.0±1.41% (Pineapple Pomace) to 14.0±2.0% (Brown rice). There were no significant differences between brown rice and yellow corn flour, however, there was the significant difference between the full fat soybean and the pineapple pomace flour. The WAC is the ability of a flour product to hold water. Pineapple pomace flour recorded a high WAC which may be as a result its cellulose nature. The percentage fiber can affect the WAC of a product.

The mean values for the percentage solubility ranged from 26.36± 0.61%(Pineapple pomace) to 8.18± 0.05% (Brown rice). Again the mean separation showed no significant differences between brown rice flour and yellow corn among all the four individual flour, however, there was significant difference in the mean values for full fat soybean and pineapple pomace flour. The percentage swelling power showed no significant difference for brown rice and yellow corn flour among the four individual flours however there were differences in the mean for full fat soybean and pineapple pomace flour. The mean value ranged between 85.8±0.02% (Pineapple pomace) to 54.0±0.40% (Full fat soybean). Swelling Power and Solubility index are inversely related. Solubility index increases with decreasing swelling power. Swelling power is the ability of starch to imbibe water whilst solubility is a measure of the dextrinization of starches [22]. From the mean separation it was realized that the mean values for Brown rice and Yellow corn did not show any significant difference among the four individual flour samples. Their functional properties were statistically not different.

3.2 Effect of Different Composition Ratio of the Four Individual Flour on the Physicochemical and Functional Properties of the Flour Blend

The analyzed data of the physicochemical and functional properties of the effect of the different composition of the individual flour on the flour blends are presented in Tables 5 & 6. Values in Tables 5 & 6 are central point values of the four different individual flour samples generated after statistical analyses of the flour blends.

The mean values of the flour blend had a pH range of 5.93 to 6.88. The Analyses of variance (ANOVA) table for the mean values of the flour blends showed significant effect of the combination ratio on the pH value. The Lack of Fit (LOF) value was non-significant. The model can be used as a good predictor for pH. A decrease or increase of their ratio can affect the pH values. The final equation generated for pH determination was:

$$Y = 6.71{*}A + 6.73{*}B + 7.02{*}C + 5.31{*}D,\ R^2 \text{ value} = 0.9449$$

Table 5. Effect of different composition ratio on the physical properties of the flour blends at central point of the mixture model

Response	Yellow corn (A)	Brown rice (B)	Full fat soybean(C)	Pineapple pomace (D)	ANOVA p-value	Lack of fit (LOF)	R^2
pH	6.71	6.73	7.02	5.31	S	N/S	0.9449
Colour L*	81.05	79.57	81.51	78.90	S	N/S	0.8683
Colour a*	5.00	4.82	4.46	4.32	S	N/S	0.7575
Colour b*	24.73	18.39	21.00	21.44	S	N/S	0.9335

Mean values are coefficient values from the linear mixture model at the central point. N/S- not significant, S- significant where P=0.05

Table 6. Effect of different composition ratio on the functional properties of flour blends at central point of the mixture model

Response	Yellow corn (A)	Brown rice (B)	Full fat soybean(C)	Pineapple pomace (D)	ANOVA p-value	Lack of fit(LOF)	R^2
WAC	15.27	12.57	18.68	20.90	S	N/S	0.7899
Bulk density	85.10	86.01	87.29	80.75	N/S	N/S	0.1453
Swelling power	7.54	7.90	7.94	9.42	N/S	N/S	0.0820
Solubility	9.77	8.73	10.29	9.05	N/S	N/S	0.0838

Mean values are coefficient values from the linear mixture model at the central point. N/S- not significant, S-significant where P=0.05

The mean L colour values for the flour blend samples ranged from 79.30 to 81.27. The final equation value generated after the analyses was:

$Y= 81.05*A + 79.57*B +7.02*C + 78.9*D$, R^2 value = 0.8683.

The ANOVA table showed a significant p-value for the linear mixture model but non-significant LOF, therefore the model could adequately be used as predictive model. Mean values for colour a* values ranged between 4.39 and 5.03. Statistical analyses of the *a** colour value showed a final equation values:

$Y= 5.00*A +4.82*B +4.46*C +4.32*D$, R^2 value =0.7575.

The linear mixture model was significant with a non significant LOF. The model for the analysis of the *a** colour values is therefore a good predictor. The Linear mixture model showed a significant linear mixture value for *b** colour values with a non significant LOF. The model for the mixture components is therefore a good predictor. The final equation for the linear mixture components were:

$Y= 24.73*A +18.39*B + 21.00*C + 21.44*D$. R^2=0.9335

The *b** colour values for the flour blend ranged from 18.91 to 24.82. The four individual flour samples showed a significant effect on each of the colour values. The values obtained shows that the colour of the final flour blends were affected by the composition ratio. An increase or decrease in one or two individual flour can affect the final colour of the blend. Studies have shown that addition of flours of different colour values affected the overall colour of the final product [23,24].

The mean values for the bulk density of the flour blend ranged from 80.41 to 90.90%. The ANOVA table showed a non significant p-value and LOF effect of the individual flour on the blendes with a R^2 value of 0.1453. The overall mean would be a good predictor of the model. The final equation of the model was:

$Y= 85.10*A + 86.01*B + 87.29* C +80.75*D$, R^2 = 0.1453.

The statistical analyses indicate that the individual flour did not influence the bulk density even though there were significant differences in the individual flour. This could be that at the central point of the mixture model used the minimum or the maximum amount of full fat soybean and pineapple pomace flour cannot influence the bulk density of the final flour blend.

WAC had it mean values ranging from 12- 19%. There was a significant p-value for the WAC with a non significant LOF. The model could be adequately used as a predictive model. The final equation was:

$Y= 15.27*A +12.57*B + 18.68*C + 20.90*D$, R^2 = 0.7899.

The individual flour can greatly affect the WAC of the flour. At the central point of the mixture, there is significant effect of the four flour samples on the flour blends. The data could be interpreted that increase in the flours with high WAC could also increase the final WAC of the flour blend.

The mean values for the solubility of the flour blends ranged from 6.71-10.95%. The values showed a non significant p-value and LOF effect of the individual flour samples. The model is therefore fit to be used for predictions for the effect of the individual flour compositions on the solubility of the flour blends regardless of the low R^2 value. The final equation for the model was:

$Y= 9.77*A +8.73*B +10.29*C +9.05*D$, R^2= 0.0838.

Swelling Power of the flour blends had means ranged between 7.36-12.94 g/g. The ANOVA showed a non significant p-value and significant LOF value effect of the individual flour on the flour blends. The model cannot be used as a suitable model for predictions. The final equation obtained was:

*Y= 7.54*A + 7.90*B +7.94*C +9.42*D,* R^2 *value =0.0820.*

The solubility and swelling power are inversely related. In this study it could be seen that the p-value of LOF values at central point of the design model are inversely related. The mixture model can be used to predict the influence of solubility of the mixture but not the swelling power.

3.3 Proximate Analyses of the Four Individual Flour and Flour Blend Samples

The results of the four individual flour samples are represented in Table 7 below. The table contains mean values and standard deviation of the four individual flour samples with mean separation for crude protein, total carbohydrate, total crude fat, total ash, total fibre and moisture content. Result of the analyzed data for the flour blends is represented in Table 8 below. Values in Table 8 represent are coefficient value from the linear mixture model at the central point.

The highest crude protein was 25.10±0.15% recorded for full fat soybean flour whilst the lowest was 2.97±0.1% recorded for pineapple pomace flour. There were significant differences in the mean values. The values for the total carbohydrate ranged from 75.04±0.18% (Brown rice) to 2.15±0.17% (Pineapple pomace). The mean values showed significant difference between the four different flour samples. The highest total crude fat content was 32.60±0.75% (total crude fat) and the lowest was 2.54±0.13% (Pineapple Pomace). Statistically, there were significant changes in the mean values of the four different flour samples. Total Ash content value had the highest of 3.99±0.07% (Full fat soybean) and the lowest of 1.18±0.01% (Brown rice). The mean separation showed ash content of brown rice and yellow corn are statistically the same likewise full fat soybean

Table 7. Proximate analyses of the individual flour samples

Proximate analyses (%)	Sample codes (Individual flour)			
	Full fat soybean	Brown rice	Yellow corn	Pineapple pomace
Crude Protein	$25.10±0.15^{d}$	$7.59±0.34^{c}$	$6.67±0.07^{b}$	$2.97±0.1^{a}$
Total Carbohydrate	$26.10±0.033^{b}$	$75.04±0.18^{d}$	$72.78±0.29^{c}$	$2.15±0.17^{a}$
Total crude fat	$32.60±0.75^{d}$	$9.74±0.19^{b}$	$12.04±0.64^{c}$	$2.54±0.13^{a}$
Total Ash	$3.99±0.07^{b}$	$1.18±0.01^{a}$	$1.31±0.33^{a}$	$3.49±0.40^{b}$
Total Fibre content	$5.29±0.34^{b}$	$0.19±0.14^{a}$	$0.50±0.021^{a}$	$83.27±0.04^{c}$
Moisture	$6.91±0.35^{b}$	$6.25±0.21^{ab}$	$6.70±0.19^{b}$	$5.57±0.27^{a}$

Mean values in the same rows with different superscripts are statistically different from each other (P=0.05).

Table 8. Effect of different composition ratio on the proximate analyses of the flour blends at central point of the mixture model

Response	Yellow corn(A)	Brown rice (B)	Full fat soybean(C)	Pineapple pomace (D)	ANOVA P-value	Lack Of fit (LOF)	R^2
Protein	9.06	9.48	12.14	8.52	N/S	N/S	0.3005
Total carbohydrate	69.38	67.23	48.30	67.36	S	N/S	0.6057
Total crude fat	11.35	13.47	29.06	10.16	S	N/S	0.0022
Total ash	2.56	2.27	3.13	2.60	N/S	N/S	0.2881
Total crude fibre	1.08	1.15	1.91	4.27	S	N/S	0.1448
Moisture	6.56	6.47	5.45	7.09	N/S	N/S	0.1448

Mean values are coefficient values from the linear mixture model at the central point. N/S- not significant, S-significant where P=0.05 and pineapple pomace flour. The total crude fibre content of the four flour samples had the highest mean value of 83.27±0.04% (Pineapple pomace) and the lowest of 0.19±0.14% (Brown rice). The means separation showed that there was no significant difference in the mean values for brown rice and yellow corn however, full fat soybean and pineapple pomace flours were statistically different. The highest value recorded for the moisture content of the four different flour samples was 6.91±0.35% (Full fat soybean) and the lowest was 5.57±0.27% (Pineapple pomace). There was not much difference between the four flour samples as mean separation shown overlaps in the values. Soybean flour is believed to have high protein and fat content with low carbohydrate content. The ash content was high which may suggest high mineral content of the soybean flour. The crude fibre was also high. A study by Anuchita and Nattawat [25] reported that yellow soybean has high protein, crude fat, total ash and total fibre content but low in moisture and carbohydrate levels. Rice and corn are believed to have high carbohydrate levels and low in protein and fat. The total ash and fibre content of brown rice flour was low as some researches mentioned that unpolished rice has high fibre and ash content [26,27,28]. Corn recorded low fibre content value but appreciable levels of total fat and ash, a similar trend was observed by Zhangian et al. [20]. Pineapple was added to the blend because of it's high fibre content. The processing of the pineapple pomace flour allowed for the concentration of the cellulose. Therefore it's not surprising that the pineapple pomace flour has very high fibre and ash content coupled with low protein, carbohydrate, moisture and fat content. This was confirmed by Amoakoah et al. [29]. The low moisture content allows for its shelf stability.

The mean values for Protein content of the flour blends ranged from 8.32 to 11.46%. The ANOVA table showed a non significant p-value and LOF. The model could therefore be a good predictor. The final equation was:

$$Y=9.06*A +9.48*B +12.14*C +8.52*D,\ R^2 = 0.3005$$

Even though the protein content was high, the ratio of the soybean in the different blends did not show any significant difference. This means that at the central point of this model soybean protein did not have significant influence on the different composition ratio of the blend. Carbohydrate had a mean value ranging from 54.00 to 70.79%. The ANOVA table had a significant p-value with a non significant LOF. The final equation was:

$$Y= 69.38*A +67.23*B + 48.30*C + 67.36*D,\ R2 = 0.6057.$$

The mixture model can be used for carbohydrate predictions. From Table 6, it can easily be observed that the carbohydrate levels increased with increasing levels of yellow corn and brown rice. The individual flour of yellow corn and brown rice had significantly high carbohydrate mean values, it is therefore anticipated that carbohydrate content of the flour blend will be mostly determined by their composition ratios. The total crude fat content of the flour blends ranged from 10.80 -24.03% and the final linear mixture equation were:

$$Y=11.35*A +13.47*B +29.06*C +10.00*D,\ R^2 = 0.5877$$

The p-value was significant with a non significant LOF. The model can therefore be used as a suitable prediction for total crude fat. The percentage fat content of the flour blends was greatly influenced by the amount of soybean in the flour blends. At the central point of the mixture model used, the data showed a less influence of the yellow corn, brown rice and pineapple flour. This trend was observed because the soybean flour used had high percentage fat content of 32.60%. This could be a major reason for the direction of the values obtained. Mean values for total ash content of the flour blends ranged from 2.03 to 3.07%. The analysis of variance gave a non significant p-value and LOF. The model could be used for predictions of the ash content of the flour blends. The final equation was:

$$Y= 2.56*A +2.27*B +3.13*C +2.60*D,\ R^2 = 0.2881$$

The final equation at the central point of this model shows that the soybean and the pineapple flour influenced the total ash content. The final equation shows high full fat soybean and pineapple pomace flour content. The mean values for crude fibre ranged between 1.02 and 3.4%. The p-value was significant while the LOF was not significant. The final equation was:

$$Y= 1.08*A +1.15*B +1.91*C +4.27*D,\ R^2 =0.7762$$

The mixture model can be adequately used as a predictor for determining composite ratio for crude fibre of the flour blends. Even though the mean values for the total ash content of the flour blends were low, the individual flour blends had significant influence on the fibre content. From the final equation it can be observed that pineapple pomace flour had significant effect on the total fibre content. The moisture content of the flour blends ranged from 5.69 to 7.54%. The analyses of variance showed a non significant value for both p-value of the ANOVA and LOF. Final equation was:

$$Y=6.56*A \quad +6.41*B \quad +5.45*C \quad +7.07*D, \quad R^2 =0.1448$$

The model is a good predictor for the moisture content determination of the flour blend. From the data analyses it can be predicted that the low moisture content of the individual flour samples resulted in the low moisture content of the flour blends. Many research studies have revealed that the addition of one or two food ingredient can affect the physicochemical, functional and nutritional quality of the final product [2,24,25,30].

4. CONCLUSION

The different flour ingredients were added to improve the nutritional content of the final product. Underutilized brown rice and yellow corn were rich in carbohydrate while soybean had appreciable levels of protein and fat. Pineapple pomace was also added to increase the fibre content of the final flour blends. Each of the individual flours contributed significantly to the parameters determined. These flours blends can be used in weaning foods or for snack production in extrusion technology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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