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# Optimization of Proximate and Minerals Compositions of Sweet Potato, Soybean and Rice Bran Composite Flours for Production of Low Glycemic Index Dough Meal

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## Abstract

Dough meal with low glycemic index was produced from sweet potato, soy bean and rice bran composite flours. Effect of the composite flour samples on the glycemic index, as well as proximate and minerals composition of the dough meal were optimised using optimal mixture design of response surface methodology. The dough meal had considerably high protein and fibre contents. The moisture and ash contents were low. The results indicated that the addition of sweet potato enhances the minerals composition, while soybean and rice bran had highest effect on the protein and fibre contents respectively. The results of the optimisation showed that the dough meal had glycemic index, meaning that the dough meal prepared from sweet potato (65.0-85.0 g/100g), soy bean (10.0-25.0 g/100g) and rice bran (2.5-10.0 g/100g) had acceptable glycemic index. The dough meal with 75.00 g/100g sweet potato flour, 15.00 g/100g soybean meal flour and 10.00 g/100g rice bran flour, however had the lowest glycemic index.

**Keywords:** Dough meal, Fibre, Glycemic index, Optimisation, Protein.

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**Ethical:** This study follows all ethical practices during writing.

## Contents

**Contribution of this paper to the literature**

This study contributes to the existing literature on low glycaemic index foods by utilizing locally, cheaply and widely available raw materials (sweet potato, soybean and rice bran) in the preparation of low glycaemic index foods, rich in protein and dietary fibre. The effects of the raw materials on the chemical composition of the food were optimized using response surface methodology in order statistically arrive at best blends rich in protein, dietary fibre and minerals composition.

## 1. Introduction

The understanding of the impact of foods on actual blood sugar is defined as the glycaemic index. It differs from measurement of the carbohydrate contents in food. In this wise, food are ranked as very low, low, medium or high in glycemic index. It has been observed that foods with very low or low glycemic index are very good for people with cardiovascular diseases (especially type 2 diabetes, metabolic syndrome, stroke and depression).

Sweet potato is a popular low-fat diet and with a low glycemic index (GI), which makes it very healthy for diabetes patients. The most important edible parts are the roots and immature leaves, which are used for human consumption, animal feed and to some extent, for industrial purposes. Sweet potato (*Ipomoea batatas*) is rich protein, carbohydrates, minerals (calcium, iron, and potassium), betacarotenoids, dietary fibre, vitamins (especially C, folate, and B6), very little fat, and sodium [1]. As an excellent source of Vitamin A, it can play an important role in the fight against vitamin A deficiency (VAD).

Rice bran is a by-product of rice processing and rich in nutrients. It has very high fibre content and contain proteins are of high nutritional value [2]. The proteins are also rich in essential amino acids, especially lysine, hence can be used as ingredients in food recipes [3]. It is rich in vitamins including vitamin E, thiamin, niacin and minerals like aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, sodium and zinc [4, 5].

The soybean seeds contain high quality and quantity of protein. Its amino acid composition is approximate to composition of animal proteins, and therefore it is often used as replacement component of meat protein. Lysine, a limiting amino acid in cereal proteins is abundant in soybeans hence the use of soybeans as supplementary and complementary lysine source in cereal-based products.

The application of composite flour has resulted in flours and food products with improved compositional and nutritional qualities [6, 7]. Use of composite flour encourages the utilization of local crops and reduces the expenses on wheat importation. In addition, composite flour has been optimized using response surface methodology in order to evaluate the significant effect of the raw materials on some nutritional and rheological qualities of composite flour [7, 8].

The aim of this research was to investigate the proximate and minerals compositions of dough meal from composite flour comprising of sweet potato flour, rice bran flour, and soymeal flour. The compositions will be optimised using response surface methodology, in order to evaluate the significant effect of the raw materials on the minerals and proximate compositions. The glycemic index of the optimized meal will be evaluated.

## 2. Materials and Methods

### *2.1. Materials*

Sweet potato was obtained from a local market, Akure, Ondo state. Rice bran was purchased from Igbemo –Ekiti, Ekiti State. Soybean meal was obtained at JOF, Owo, Ondo state. All chemicals and reagents used was of analytical grade.

### *2.2. Sweet Potato Flour Preparation*

Sweet potato tubers were sorted, washed, blanched at 80 °C for 5 min, peeled, sliced and dried at 60 °C for 24 h. Thereafter, it was milled using the hammer mill and passed through mesh size of 250 μm to have a fine flour which was then packed in an airtight container for further use.

### *2.3. Soybean Meal Flour Preparation*

The soybean meal was milled and sieved to obtain a fine soybean meal flour according to IITA procedure [9].

### *2.4. Rice Bran Flour Preparation*

The rice bran was destoned, milled and sieved through a 250 μm mesh size to produce a fine rice bran flour [10].

### *2.5. Experimental Design*

The experimental design was carried out using optimal mixture model of response surface methodology (Design Expert 8.0.3.1 software). The responses were proximate properties (protein, carbohydrates, ash, crude fibre, fat and moisture) and mineral (calcium, iron, potassium, magnesium, phosphorus, sodium and zinc) composition, while the variables were the raw materials (sweet potato flour, rice bran flour and soybean meal flour), as presented in Table 1.

**Table-1.** Factor design and their level of mixture.

| Run | Component 1 A: g/100g | Component 2 B: g/100g | Component 3 C: g/100g |
|---|---|---|---|
| 1 | 65.000 | 25.000 | 10.000 |
| 2 | 85.000 | 12.500 | 2.500 |
| 3 | 85.000 | 10.000 | 5.000 |
| 4 | 77.500 | 16.500 | 6.000 |
| 5 | 72.500 | 25.000 | 2.500 |
| 6 | 76.667 | 20.833 | 2.500 |
| 7 | 85.000 | 12.500 | 2.500 |
| 8 | 75.000 | 15.000 | 10.000 |
| 9 | 85.000 | 10.000 | 5.000 |
| 10 | 70.000 | 20.000 | 10.000 |
| 11 | 68.750 | 25.000 | 6.250 |
| 12 | 72.500 | 25.000 | 2.500 |
| 13 | 65.000 | 25.000 | 10.000 |
| 14 | 80.000 | 10.000 | 10.000 |
| 15 | 80.000 | 10.000 | 10.000 |
| 16 | 73.125 | 20.750 | 6.125 |

**Note:** Where, A= Sweet potato flour; B= Soybean meal flour; C= Rice bran flour.

### *2.6. Dough Preparation*

Dough was made from the composite flours in the right proportion Table 1 with hot water in a ratio of 100 g of flour to 25 g of water to form a thick paste and then was placed on a gas cooker at a temperature of 45 °C for about 10 min. A good stirring was done and dough obtained was allowed to cool.

### *2.7. Determination of the Proximate Composition of Dough Meal*

The proximate composition including moisture, ash content, crude protein, crude fat and crude fibre of the dough meal were determined using AOAC methods [11]. The carbohydrate was estimated by difference.

### *2.8. Mineral Analysis of the Dough Meal*

Determination of calcium, magnesium, zinc and iron was by Atomic Absorption Spectrophotometer (AAS), while potassium, phosphorus and sodium was determined by flame photometry method following AOAC procedures [11].

### *2.9. Glycemic Index of the Dough Meal*

The glycemic index was determined by using Wolever method [12]. The glycemic index of the food samples were determined by feeding the samples to rat for a period of 2 h. The bloods of the rats were then used to calculate for the glycemic index level in the food samples.

### *2.10. Statistical Data Analysis*

All analysis was done in triplicate and results presented as the average of triplicate determinations, expressed as mean ± standard deviation (S.D). The data were subjected to the statistical analysis of variance (ANOVA) using SPSS software version 17.0.

## 3. Results and Discussion

### *3.1. Proximate Compositions of Dough Meal*

The result of the proximate composition is presented in Table 2, and the contour plots presented in Figures 1a to 1f. The carbohydrate content had no significant model terms, while the $R^2$ and adjusted $R^2$ values were also low Figure 1a, despite the fact that the values of the carbohydrate contents vary from 57.32 to 62.52%. The values could indicate that although, the dough meal would be a good source of energy, yet, it would not be a high glycemic index food.

The fat content was moderately high (9.09-13.19 g/100g). Soybean supports the fat content of the composite flour as shown in the contour plot Figure 1b. The significant model terms (linear mixture, AB, $A^2BC$) also showed that sample C (rice bran) did not significantly ($p > 0.05$) contribute to the fat content of the composite flour Table 2. The fat content of the composite flour is pointer to the fact that it would be good as flavour retainer, and a carrier of fat-soluble vitamins.

**Table-2.** ANOVA results for proximate composition.

| Parameter | Model (significant level) | R2 | Adj R2 | Lack of fit (P ≤ 0.05) | Significant (P ≤ 0.05) terms |
|---|---|---|---|---|---|
| Carbohydrate | cubic | 0.8253 | 0.5633 | 0.3988 | nil |
| Crude Fat | Special quartic (< 0.0001) | 0.9948 | 0.9889 | < 0.0001 | Linear mixture, AB, $A^2BC$ |
| Crude Protein | Cubic (< 0.0001) | 0.9998 | 0.9995 | 0.4135 | Linear mixture, AB, AC, BC, ABC, AB(A-B), AC (A-C), BC (B-C) |
| Crude Fibre | Special quartic (< 0.0001) | 0.9998 | 0.9995 | 0.0002 | Linear mixture, AC, BC, $ABC^2$ |
| Total Ash | Linear mixture (0.3131) | 0.1636 | 0.0349 | 0.9189 | nil |
| Moisture | Special quartic (0.0003) | 0.9607 | 0.9157 | 0.5897 | Linear mixture, AC, AB, $AB^2C$, $ABC^2$ |

The dough meal showed significant ($p < 0.05$) increase in crude protein content ranging from 8.75-10.87% with increase in soybean meal and rice bran flours. However, dough meal with high sweet potato flour and low soymeal flour had low protein content [13]. The optimisation results Table 2 showed that the protein had high $R^2$ (0.9998) and adjusted $R^2$ (0.9995) values. The model (cubic) and model terms (linear mixture, AB, AC, BC, ABC, AB(A-B), AC (A-C), BC (B-C)) were significant ($p \leq 0.05$) with a non-significant lack of fit. This $R^2$ and adjusted $R^2$ values together with the significant model terms for protein contents indicated that the composite flour prepared in this study had reasonable and acceptable protein contents. High $R^2$ and adjusted $R^2$ values (close to one) indicates statistical models that are fit [10, 14]. The contour plot representing the effect of the raw materials on the protein content is shown in Figure 1c. These results showed that the composite flours making the dough significantly ($p \leq 0.05$) effect the protein content. The areas shaded red in the contour plot are the areas with highest protein content. It could be seen that the areas with high protein content were as a result of the soy bean and potato flours incorporation.

The crude fibre ranged from 1.96-5.83%, with high $R^2$ and adjusted $R^2$ values Table 2. Rice bran flour was the best source of crude fibre as indicated by the $R^2$ value, adjusted $R^2$ value, and significant model terms Table 2. The contour plot is shown in Figure 1d. Rice bran is rich in soluble fiber like beta-glucan, pectin, gums helpful in reduction of serum cholesterol, certain forms of cancer and constipation [15]. Nutritional and functional properties of rice bran are well suited for baked products like cookies, muffins, breads, crackers, pastries and pancakes [16].

The ash contents too had no significant model terms together with very low $R^2$ and adjusted $R^2$ values Figure 1e and Table 2. Although the total ash contents ranged from 1.49 to 3.00%.

The moisture content decreased significantly ($p \leq 0.05$) as in soybean meal and rice bran flour contents increased. The $R^2$ and adjusted $R^2$ values were 0.9607 and 0.5897 respectively. The drastic reduction in the adjusted $R^2$ value is an indication that the composite flour does not strongly support water content, which indicates that the dough meal would be shelf stable. The contour plot for carbohydrate content is shown in Figure 1f.

### *3.2. Minerals Compositions of Dough Meal*

The optimisation results of the minerals composition, consisting the model, $R^2$ value, adjusted $R^2$ value, lack of fit and significant model terms is presented in Table 3. The contour plot showing the graphical illustration of the effect of the raw materials on the dough meal minerals composition is shown in Figures 2a to 2g. From the optimisation results in Table 2, only potassium (k), Magnesium (Mg) and Calcium (Ca) had considerable $R^2$ and adjusted $R^2$ values meaning that they were enhanced by the raw materials. In addition, the dough meal had considerable effect on iron (Fe) content Figure 2a. From the contour plot in Figure 2a, sweet potato and soy bean flours were the main sources of iron in the dough meal. It has been reported that sweet potato is a reliable source of mineral iron [17].

The dough meal had low sodium content, as it had no significant ($P \leq 0.05$) model term Table 3. The sodium content of the dough meal ranged from 23.62-58.72 mg/kg while the potassium content ranged from 180.77-266.79 mg/kg. The contour plot Figure 2b also showed that the raw materials contributed very little to the dough meal. None of the raw material increased the sodium content. The considerable high potassium content in relation to the considerable low sodium content is an indication that the dough meal would be suitable for better cardiovascular functions. High K/Na ratio is recommended for patients with high blood pressure (K/Na < 1.0). Sweet potato had positive effect on the potassium content Figure 2c. The plot also indicated that sweet potato was the main source of potassium.

**Table-3.** ANOVA results for minerals composition.

| Parameter | Model (significant level) | $R^2$ | Adj $R^2$ | Lack of fit ($P \leq 0.05$) | Significant ($P \leq 0.05$) terms |
|---|---|---|---|---|---|
| Fe | Cubic | 0.8241 | 0.5603 | 0.8907 | nil |
| K | Linear mixture ($p< 0.0001$) | 0.7734 | 0.7385 | < 0.0001 | Linear mixture |
| Mg | Linear mixture ($p< 0.0001$) | 0.8150 | 0.7866 | 0.9625 | Linear mixture |
| Ca | Special quartic ($p< 0.0001$) | 0.9968 | 0.9931 | 0.0028 | Linear mixture |
| P | Linear mixture ($p=0.0579$) | 0.3549 | 0.2557 | 0.9267 | nil |
| Na | Quadratic ($p=0.1890$) | 0.4817 | 0.2225 | 0.1485 | nil |
| Zn | Mean | 0.0000 | 0.0000 | 0.8917 | nil |

The calcium content of the dough meal significantly increased ($p<0.05$) as the level of soybean meal flour increased Figure 2d. The contour plot Figure 2d clearly shown that soybean was the main source of calcium, followed by rice bran flour. The phosphorus content of the dough meal significantly ($p<0.05$) increased as the substitution levels of sweet potato in the dough meal increased Figure 2e. The 3D plot showed revealed that sweet potato was the richest source of calcium among the raw materials, followed by rice bran.

The zinc content ranged from 0.34-2.09 mg/kg. It was observed from the 3D plot Figure 2f that the raw materials were not rich in mineral zinc. Zinc is a micronutrient; hence, the content could be sufficient for daily nutritional needs. Soybean flour was the best source of magnesium followed by rice bran flour Figure 2g. The magnesium contents for the samples varied from 30.58 to 43.44 mg/Kg.

### *3.3. Glycemic Index of the Dough Meal*

The results of the optimisation of the proximate and minerals composition has given pointers to the possibility of the dough meal to have cardiovascular benefits. The $R^2$ and adjusted $R^2$ values for the optimisation carbohydrate composition were 0.5633 and 0.3988 respectively, while it has no significant model terms. This showed that the raw materials may not support sugar (from carbohydrate metabolism) contents in the dough meal. It implies that the dough meal would be useful for consumers against incidences or prevention of diabetic mellitus.

The glycemic index (GI) of the dough meal ranged from 22.66 to 45.37. They can however, be classified as low GI meal. Low GI foods have been shown to release glucose slowly and steadily [18]. They are slowly digested, absorbed and metabolised, leading to a slower rise in blood glucose level.

The sample with 75.00 g/100g sweet potato flour, 15.00 g/100g soybean meal flour and 10.00 g/100g rice bran had the least glycemic index. The profile of glycemic evaluation of the dough meal from composite flour blends of sweet potato, soybean meal and rice bran in their different mixing ratio is shown in Figure 3.

## 4. Conclusions

The dough meal prepared from flour blends of sweet potato, soybean meal and rice bran flour exhibited good and acceptable glycemic index properties. In addition, the dough had high protein and fibre contents. The Na/K ratio of the dough meals were lower than 1; a pointer to antihypertensive capacity. The composite flour with 75.00 g/100g sweet potato flour, 15.00 g/100g soybean meal flour and 10.00 g/100g rice bran, however had the lowest glycemic index.

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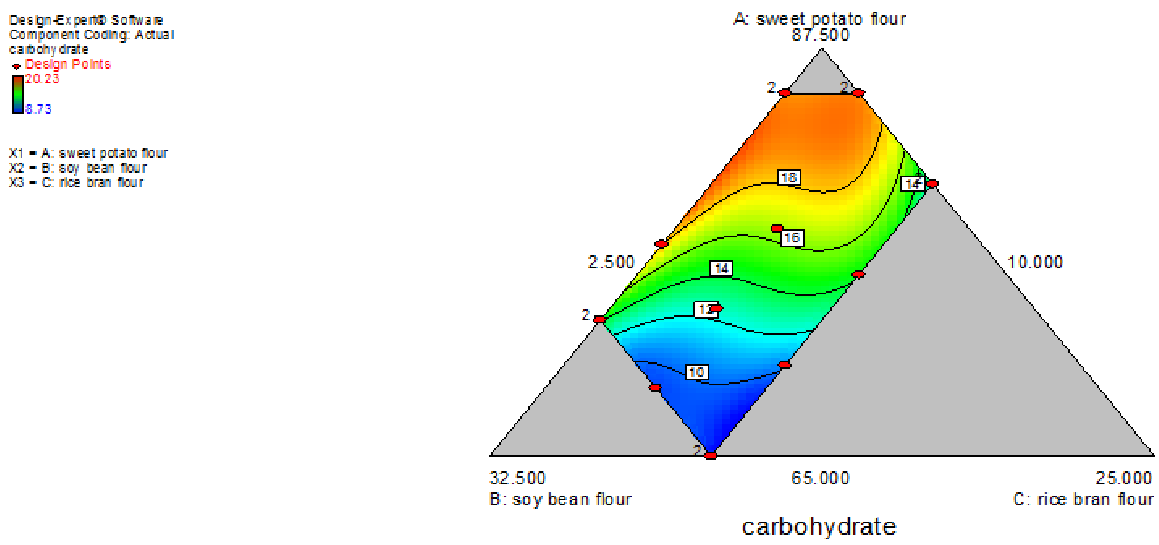


**Figure-1a.** Contour plot showing the effect of variables on carbohydrate content.

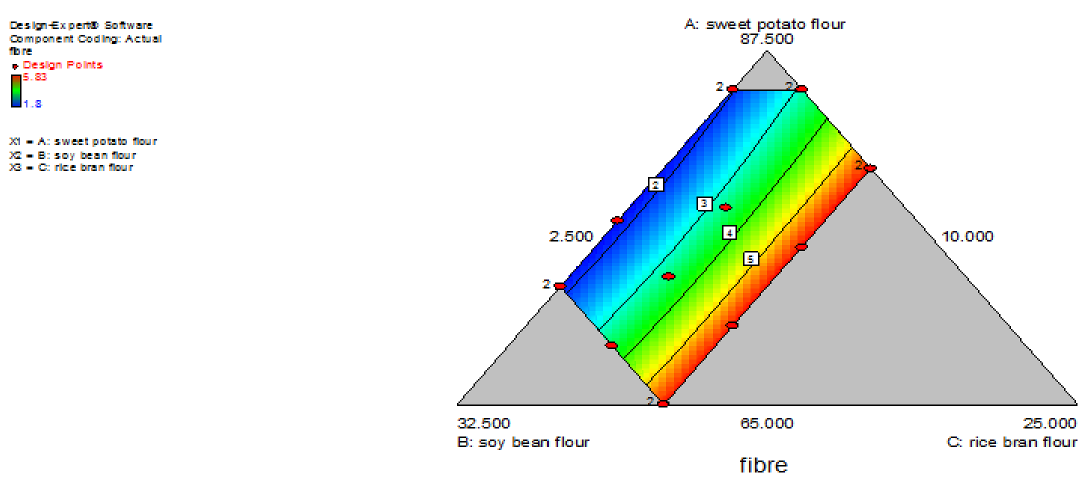


**Figure-1c.** Contour plot showing the effect of variables on protein content.

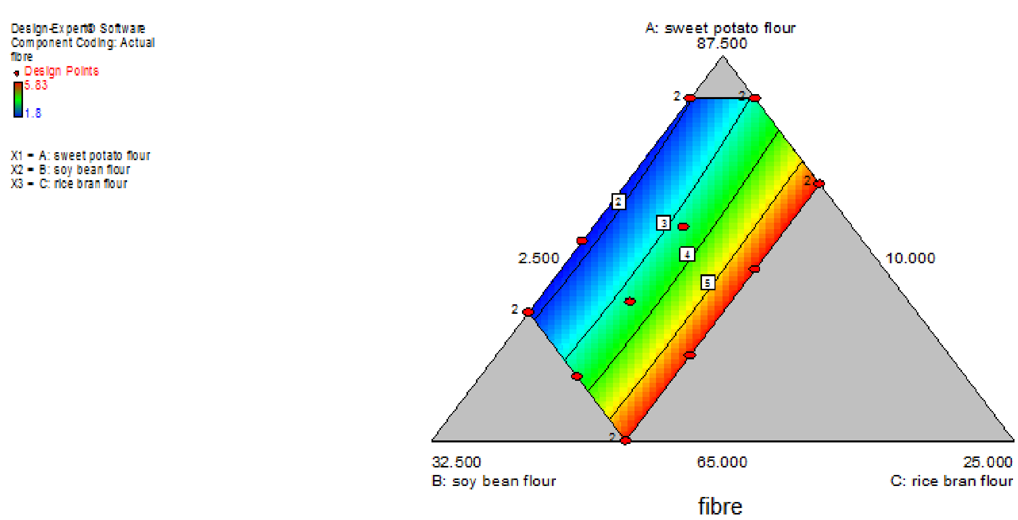


**Figure-1d.** Contour plot showing the effect of variables on fibre content.

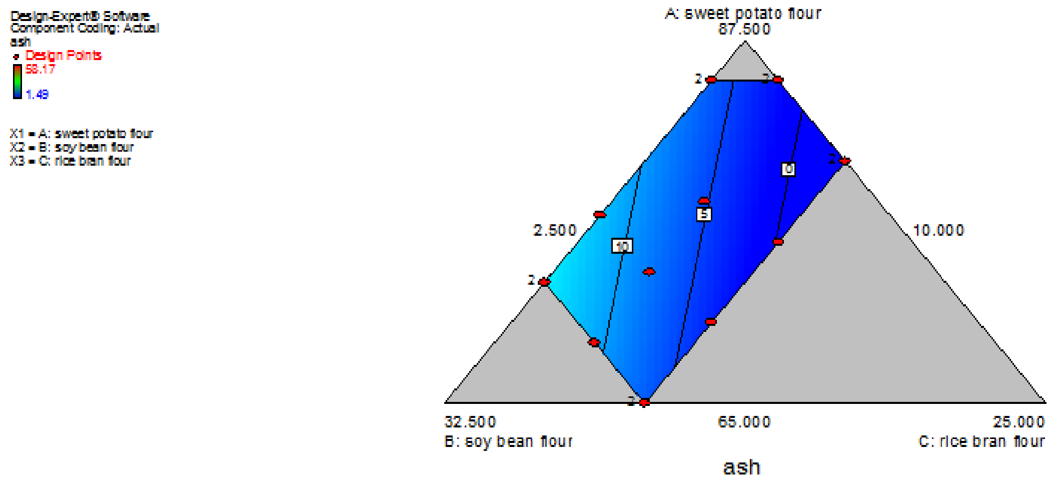


**Figure-1e.** Contour plot showing the effect of variables on ash content.

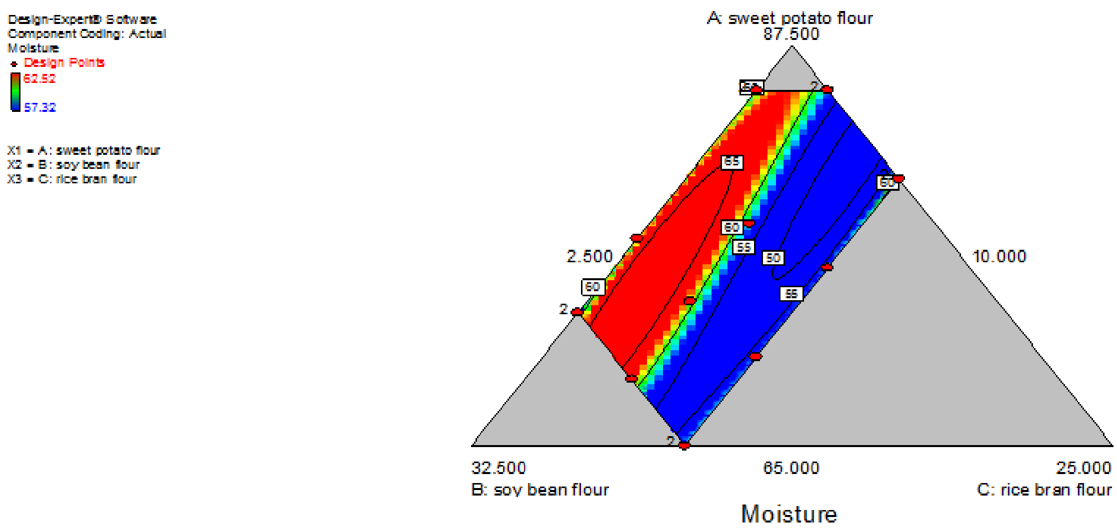


**Figure-1f.** Contour plot showing the effect of variables on carbohydrate.

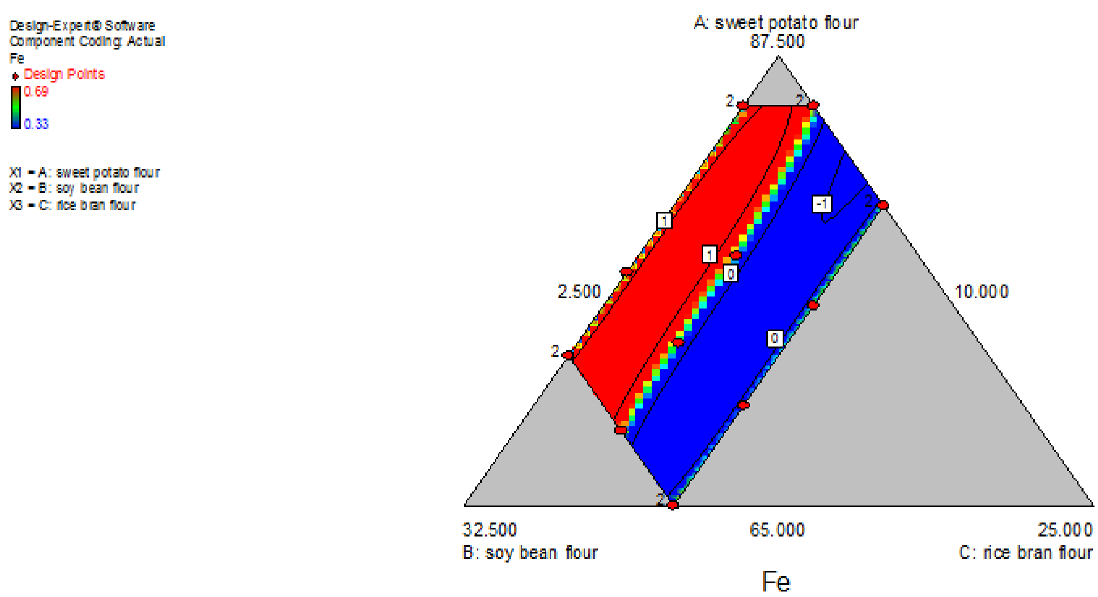


**Figure-2a.** Contour plot showing the influence of variables on iron (Fe).

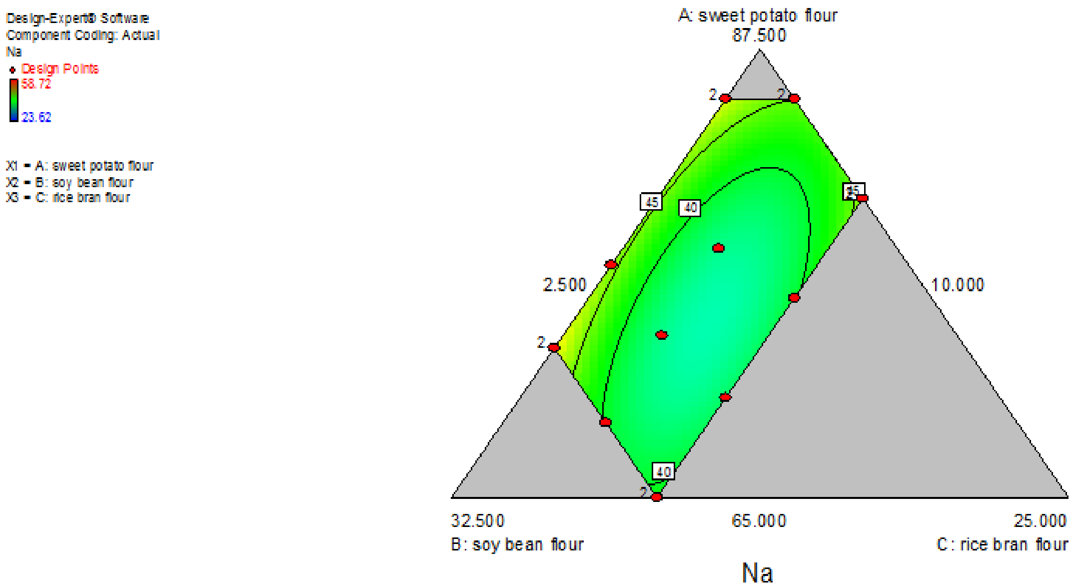


**Figure-2b.** Contour plot showing the influence of variables on sodium (Na).

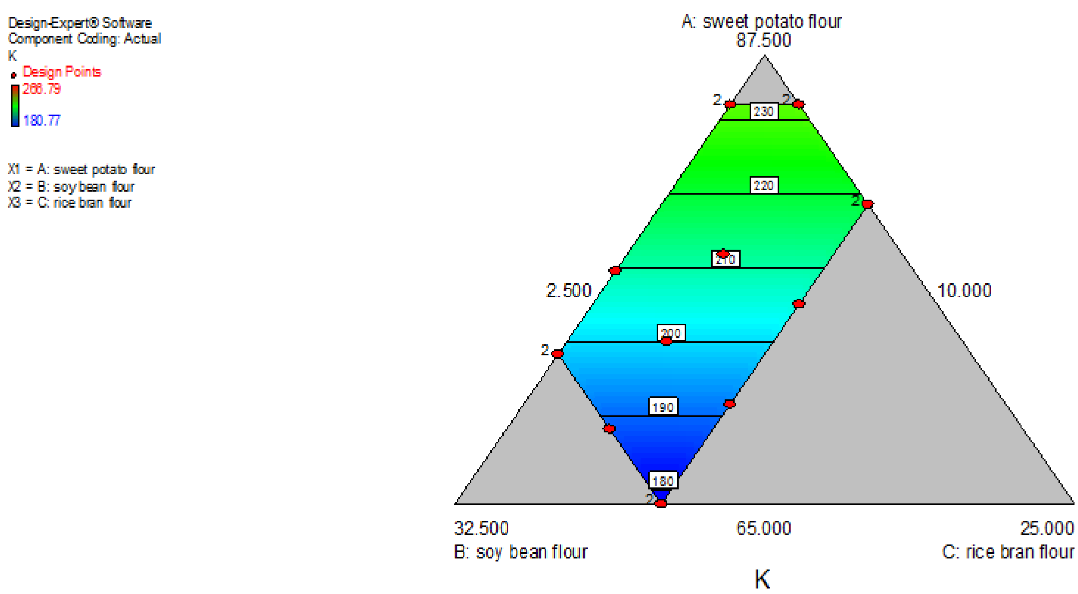


**Figure-2c.** Contour plot showing the influence of variables on potassium (k).

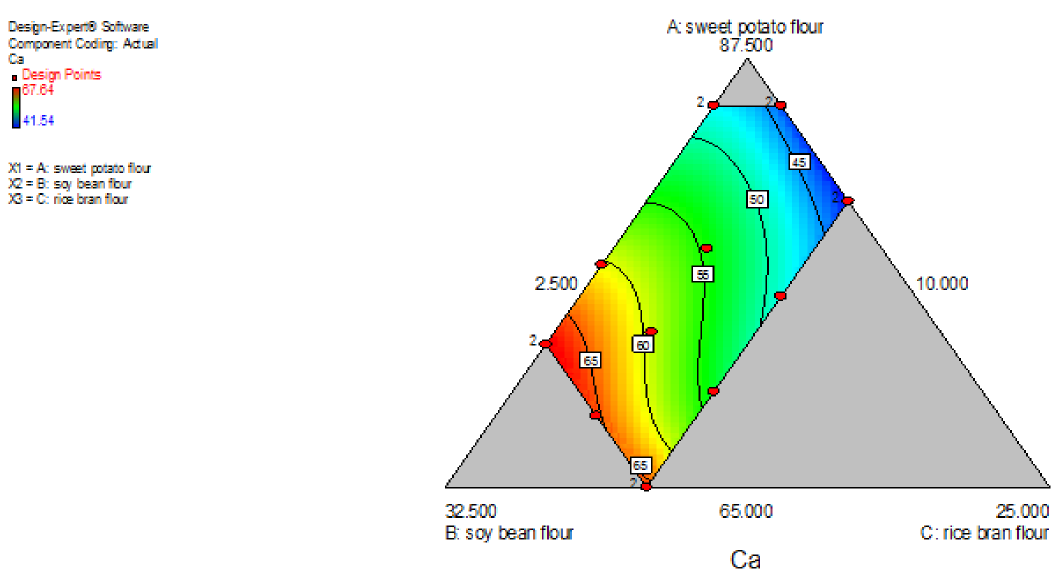


**Figure-2d.** Contour plot showing the influence of variables on calcium (Ca).

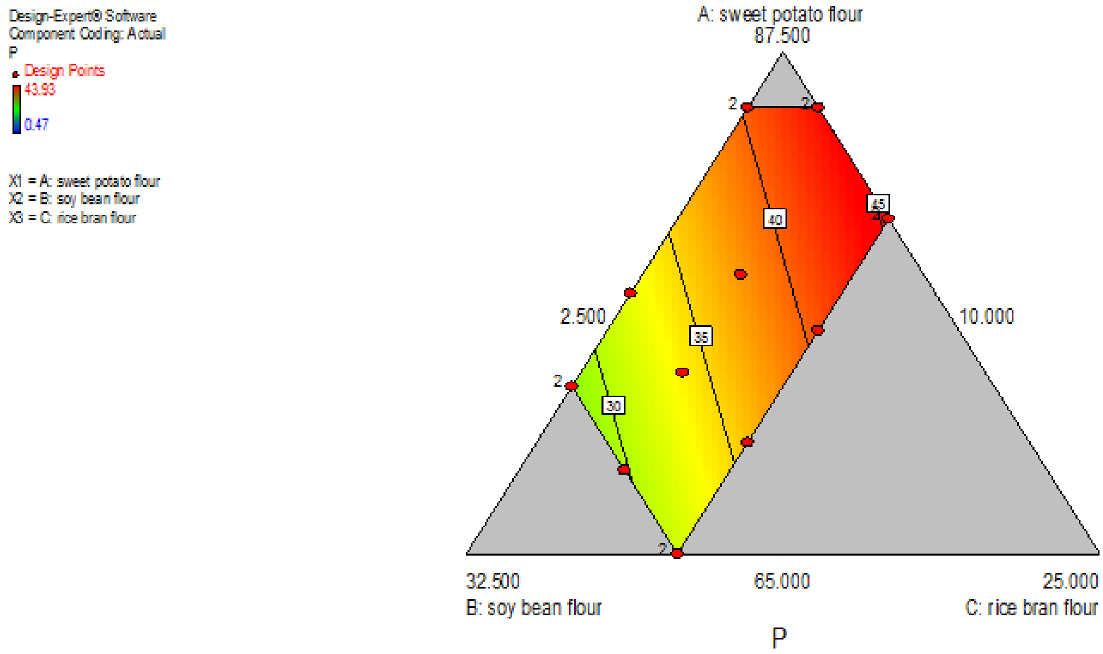


**Figure-2e.**Contour plot showing the influence of variables on phosphorus (P).

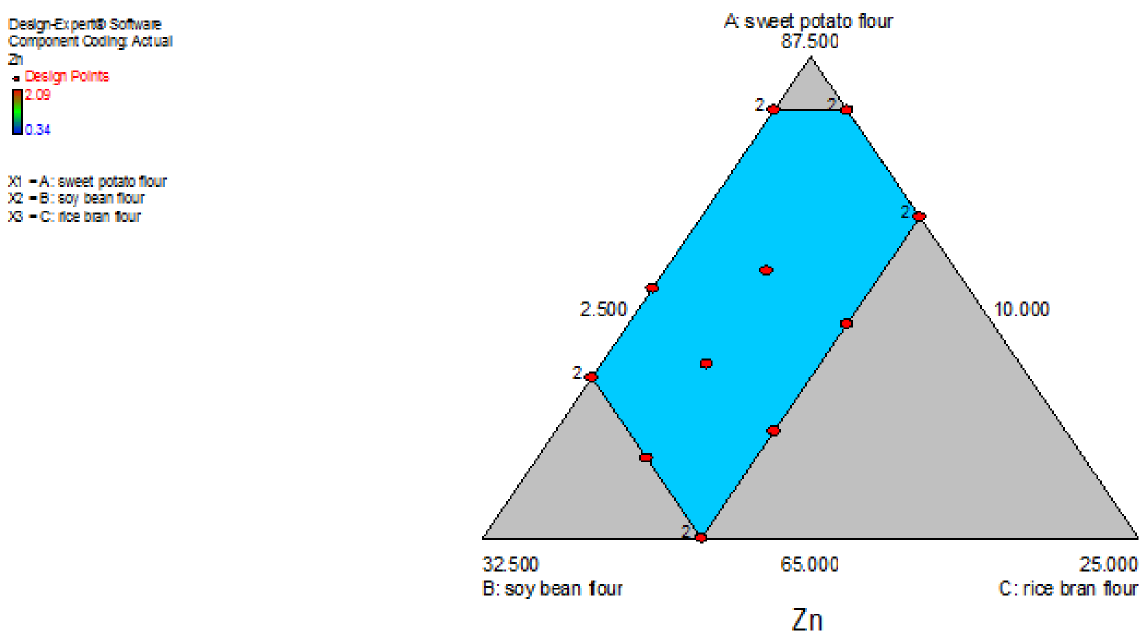


**Figure-2f.** Contour plot showing the influence of variables on Zinc (Zn).

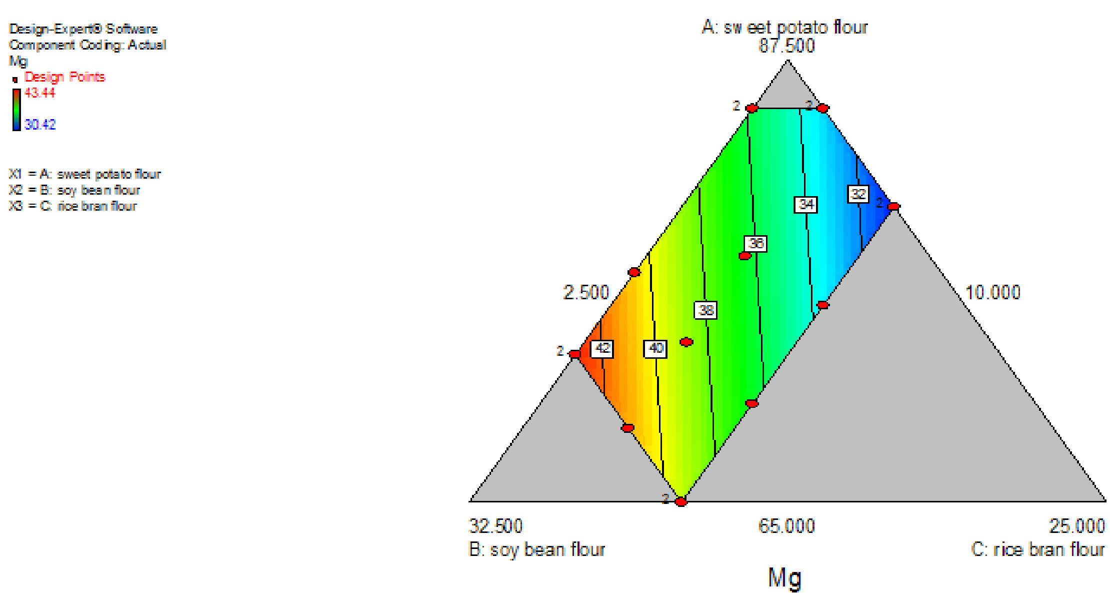


**Figure-2g.** Contour plot showing the influence of variables on magnesium (Mg).

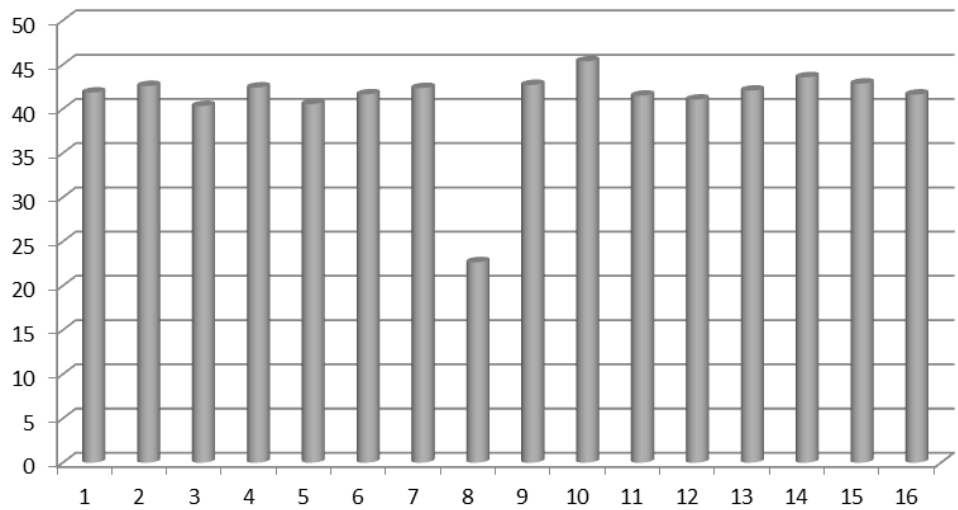


**Figure-3.** The glycemic index of the dough meal.