Effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix

Udo, D.E.* [1], Omeire, G.C. [1], Mmuosinam, B.C. [1], Obeleagu, S.O[1], Igwe, V.S.[1], Okon, U.B.[2]

[1]*Department of Food Science and Technology, Federal University of Technology Owerri, Imo state, Nigeria.*
[2]*Department of Food Science and Technology, Federal University of Agriculture Abeokuta, Ogun state, Nigeria.*
**Corresponding Author*

***Abstract*: The effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix was studied using a two-factor simple lattice design of response surface methodology (RSM). The cocoyam and water yam flour mix ratios are 100:0, 0:100, 50:50, 75:25, and 25:75. Moisture, protein, ash, crude fiber, fat, carbohydrate, amylose, amylopectin, calcium, magnesium, and phosphorus were all taken into consideration during the optimization process. On crude fiber, fat content, carbohydrate, calcium, and phosphorus, the linear influence of cocoyam and water yam flour was significant (p<0.05). Moisture, protein, ash, crude fiber, fat, amylose, amylopectin, and magnesium all exhibited a significant (p<0.05) effect on the mix's binary regression coefficient. The binary effect of the blend, on the other hand, decreased the moisture content and crude fiber significantly (p<0.05). On two component mix plots, the blends' linear and binary impacts were graphically depicted. The resulting models were validated at a significance level of 0.05. Furthermore, a desirability of 0.493 was chosen for outcome optimization. The optimization criteria were met by the response variables. The optimal values were: 69.84 g cocoyam, 30.15 g water yam, 5.84% moisture, 11.04% protein, 3.69% ash, 2.18% crude fiber, 2.00% fat, 75.34% carbohydrate, 24.77% amylose, 84.24% amylopectin, 9.17% calcium, 4.71% magnesium, and 79.83% phosphorus. The optimized values were further analyzed to ascertain 95% confidence. According to the findings, cocoyam and water yam flour blends with appropriate chemical and mineral composition can be created and used successfully in the food processing industry.**

***Keywords*: Cocoyam, Water yam, Chemical composition, Mineral composition, Simple lattice design**

I. INTRODUCTION

Dry soups are types of soups that are designed for fast and simple preparation. These products have to be reconstituted with hot water or boiled shortly before consumption. In most societies, dry soups are perceived as convenience products due to their ease of transportation and preparation. Dry soup is commonly used by soldiers, especially, when they have to camp in the jungle for a long time. Modern lifestyle has also generated new demand for such products. Most of the middle-class people and schooling youths normally have busy schedules. This has led to the high demand for easy to prepare foods. Dry soup mixes are made by combining dried ingredients with thickening agents in a blender or spray drying a soup slurry. (Singh *et al*., 2003).

The benefits of dried soup powders include resistance to enzymatic and oxidative deterioration, as well as long-term flavor stability at room temperature. Furthermore, they may be reconstituted in a short amount of time, making them ideal for working families, hotels, hospitals, restaurants, and institutions, in addition to military rations. Production of soup mix will reduce cooking time and create convenience in distribution and utilization of cocoyam and water yam flour. Generally, cocoyam and water yam have been underutilized despite their richness in both nutritional and health benefits. This will to some extent enhance the economic value of these agricultural products and in addition help the society to tap into their nutritional and health benefits (Oke, 2010).

Furthermore, significant quantities of tubers are lost due to poor post-harvest handling and storage practices. There is a need to harness the potentials of these underutilized root and tuber crops as cheap and alternative sources of flour to reduce the burden of increasing demand on the well-known sources like potato, maize, and recently, cassava (Mweta *et al*., 2008). Processing of cocoyam and water yam flour at the industrial level for instant soup mix production will create employment opportunities through the whole production and processing chain. Opportunities to promote and encourage the use of cocoyam and water yam can help countries in cocoyam-growing regions improve their food security (Ukpabi *et al*., 2008).

Cocoyam is a tropical tuberous root crop with a starchy texture. The soft version, which is mostly used as a soup thickening, and the yam-like form, which can be boiled quickly and eaten with pepper sauce, are the most common cocoyam varieties. The soft type is mostly used as a thickening in Nigerian soups. The water yam (*Dioscorea alata*) is a tuber with an uneven shape and a dark to black outer skin. The flesh of the tuber is a bright purple or white cream tint. The tuber normally has a high-water content, hence the term 'water yam.' Water yam, winged yam, larger yam, or purple yam are all names for *D. alata*. (Mudita, 2013). It is one of the six economically important yam species, with a high yield, high nutritious content, high multiplication ratio, and greater storability than other yam species, but it has a low commercial quality, owing to its perceived disappointing food quality attributes (Wireko-Manu *et al*., 2011). In the tropics and subtropics, *D. alata* tubers provide a good source of dietary carbohydrates due to their high starch content. (Osagie, 1992).

Despite their nutritional and physiological benefits, water yam tubers are often limited in their usage and consumption due to considerable post-harvest losses caused by their high moisture content, continuous metabolism, and microbial attack, resulting in damage during harvest and storage. (Akinwande *et al*., 2004; Oluwole, 2008). These issues could be handled by transforming perishable tubers into non-perishable items through food processing activities, such as flour, which can be utilized as a thickener in the preparation of instant soup mix. Time is a precious commodity for the working-class people in Nigeria. Hence, the issue of convenience should be incorporated into our food ingredient formulation. There is a growing demand for quality and nutritious soups and much attention has been drawn to the role of the Food Industry in helping consumers to eat healthy, nutritious, and sustainable food products (Buttriss, 2013).

In many homes these days, both the husband and wife work and do not have time to prepare proper meals. As a result, they choose for quick meals that they can pick up at a store and enjoy without spending hours in the kitchen. The bulk of these items are junk foods because of their high sugar, fat, and salt content, as well as their low nutritional value in terms of protein, fiber, vitamin, and mineral content. The consumption of these nutrient-deficient foods has been connected to malnutrition and diseases. This problem could be remedied by making nutrient-dense foods like soup mix easy to prepare. In this study, the effect of cocoyam and water yam flour blends on the chemical and mineral content of dry soup mix is assessed.

II. MATERIALS AND METHODS

2.1 Materials

The National Root Crops Research Institute (NRCRI) Umudike provided fresh cocoyam (*Xanthosoma sagittifolium*) and water yam (*Dioscorea alata*) tubers. A curator from the Department of Crop Science at the Federal University of Technology in Owerri, Imo State, validated the samples. Finlab Nigeria Limited, Owerri, Imo State, provided the analytical grade chemicals used in this study.

2.2 Methods

2.2.1 Cocoyam flour production

With minor adjustments, cocoyam flours were made according to the method of Sobowale *et al.* (2017). Fresh cocoyam (*Xanthosoma sagittifolium*) corms (1,486.6g) were separated, cleaned with potable water to remove clinging soil, then manually peeled using a stainless-steel knife. The peeled roots were washed in portable water and sliced into 2 mm thick slices with a mechanical stainless-steel slicer before being spread thinly on drying trays and baked. It was then dried for 12 hours at 65°C before being processed with an electric hand mill (Romer serial II mill, Romer, USA). A 60mm mesh sieve was used to filter the flour. As illustrated in Figure 1, the cocoyam flour was stored in airtight bottles, labeled, and maintained in a cool, dry place for subsequent study.

2.2.2 Water yam flour production

With minor adjustments, water yam flours were made according to the method of Sobowale *et al.* (2017). Water yam (*Dioscorea alata*) tubers (5,221.2g) were separated, cleaned with potable water to remove clinging soil, then manually peeled using a stainless-steel knife. The peeled roots were washed in portable water and sliced into 2 mm thick slices with a mechanical stainless-steel slicer before being spread thinly on drying trays and baked. It was then dried for 12 hours at 65°C before being pulverized with an electric hand mill (Romer serial II mill, Romer, USA). A 60mm-mesh sieve was used to sieve the flour. Figure 2 shows how the water yam flour was stored in airtight bottles, labeled, and maintained in a cool, dry place for subsequent study.

2.3 Chemical Analysis

The blends' proximate (moisture, ash, fiber, fat, and protein) content was determined using AOAC's standard techniques (2015). According to Onwuka (2018), the carbohydrate content of the samples was estimated using the simple difference method.

2.3.1 Moisture Content

Each sample (2g) was weighed at two grams into a dried weighted crucible. In a moisture extraction oven at 105^0C, the samples were cooked for 3 hours. The dried samples were weighed again after cooling in a desiccator. The procedure was repeated until the weight was stable. The difference in weight was calculated as a percentage of the original sample.

$$\% \text{ moisture} = \frac{W_2 - W_2}{W_2 - W_3} \times \frac{100}{1} \quad (1)$$

Where

W_1 = Empty dish weight, W_2 = Empty dish weight Plus un-dried sample weight

W_3 = Dish weight plus dried sample

2.3.2 Ash Content

Each sample (2g) was weighted into crucibles and heated in a moisture extraction oven for 3 hours at 100°C before being moved to a muffle furnace at 550°C until it turned ash/white and free of carbon. The sample was then taken out of the furnace, cooled in a desiccator to room temperature, and reweighed right away. The weight of the leftover ash was then calculated as follows:

$$\text{Percentage ash content} = \frac{Weight\ of\ Ash}{Weight\ of\ original\ sample} \times \frac{100}{1} \quad (2)$$

2.3.3 Crude Protein

Two grams (2g) of each sample were mixed with 10 ml of concentrated H2SO4 in a test tube. The test tube was filled with a selenium catalyst tablet, which was then heated in a fume cupboard. After that, the digest was placed into distilled water to be processed further. A 10 ml portion of the digest was mixed with an equivalent volume of 45 % NaOH solution in a kjeldahl distillation unit. The distillate was collected and placed in a flask with a 4 % boric acid solution and three drops of methyl red indicator. The distillate was collected in 50 ml and titrated against sodium hydroxide. The average of three sets of data was computed. By multiplying the nitrogen concentration by 6.25, the crude protein content was calculated.

$$\text{Percentage Nitrogen} = \frac{(100 \times N \times VF)T}{100 \times V_a} \quad (3)$$

Where

N= Normality of the titrate (0.1N), VF= Total volume of the digest= 100 ml, T= Titer Value

Va= Aliquot Volume distilled

2.3.4 Fat Content

Two grams (2g) of the sample was loosely wrapped in filter paper and placed in a clean round bottom flask that had been cleaned, dried, and weighed with a thimble. The flask contained 120 ml of petroleum ether. After being heated with a heating mantle, the sample was refluxed for 5 hours. After that, the warmth was turned off, and the thimbles with the used samples were kept and weighed afterwards. The difference in weight was estimated as fat mass and expressed as a percentage of the total sample size.

$$\text{Percentage fat} = \frac{W_2 - W_1}{W_3} \times \frac{100}{1} \quad (4)$$

Where

W_1 = weight of the empty extraction flask, W_2 = weight of the flask and oil extracted

W_3 = weight of the sample

2.3.5 Crude Fiber

In 200 ml of 1.25% H_2S0_4, two grams (2g) of the sample and one gram (1g) of asbestos were heated for 30 minutes. The solution was placed in a Buchner funnel, which was held together by muslin fabric and an elastic band. The residue was then filtered before being placed in 200 mL of heated NaOH and cooked for 30 minutes before being transferred to the Buchner funnel and filtered. After being washed twice with alcohol, the substance was rinsed three times with petroleum ether. In the moisture extraction oven, the residue was placed in a clean dry crucible and dried to a constant weight. The crucible was removed from the furnace, let to cool, and weighed. The weight difference (i.e. ignition loss) was calculated and expressed as crude fiber.

$$\text{\% Crude Fibre} = \frac{W_1 - W_2}{W_t} \times \frac{100}{1} \quad (5)$$

Where

W_1 = sample weight before incineration, W_2 = sample weight after incineration

W_t = original sample weight

2.3.6 Carbohydrate

Carbohydrate is calculated as the difference in weight between 100 and the sum of other proximate components. Nitrogen free Extract (NFE) % carbohydrate (NFE) = 100 - (M + P + F1 + A + F2). (6)

Where:

M = Moisture, P = Protein, F_1 = Fat, A = ash, F_2 = Crude fiber

2.4. Amylose and Amylopectin Contents

To eliminate insoluble residues, a 2% flour suspension was filtered, and the pH was adjusted to 6.3 using a phosphate buffer. To disperse the starch molecules, the solution was agitated for 2 hours in a hot water bath. After that, n-Butyl alcohol (20% v/v) was added, and the solution was agitated at 100°C for 1 hour before cooling to ambient temperature over a 24-36-hour period. During cooling, amylose butyl alcohol complex crystals developed and precipitated, which were separated by filtration and dried at 30°C for 48 hours (Song & Jane, 2000).

$$\%\ Amylose\ content = \frac{Dried\ crystals}{Sample\ of\ weight} \times 100 \quad (7)$$

$$\%\ Amylopectin\ content = 100\% - \%\ Amylose\ content \quad (8)$$

2.5 Mineral analysis of flour blends

The AOAC (2015) technique was used to determine the mineral content of flour samples. The levels of calcium and magnesium were tested by titration with ethylenediaminetetraacetic acid (EDTA), while phosphorus was determined using the Vanadomolybdate method in a colorimeter with an absorbance reading of 430nm (Jenway 6051, model PFP7).

2.6 Statistical Analysis and Experimental Design

In a study with eight runs/design points, the response surface methodology (RSM) two-factor simplex lattice experimental design was used to develop predictive models and investigate the effect of linear and binary process parameters (cocoyam and water yam) on the chemical and mineral composition of flour blends. Three runs were performed to estimate the internal error within the design, as shown in Table 1. An analysis of variance (ANOVA) was used to compare the chemical and mineral content of flours (cocoyam and water yam). A p-value of 0.05 was considered significant, as shown in Table 2. To produce two-component mix plots and conduct statistical analysis, Design-Expert (Version 12.0.6.2, State-Ease, Inc. Minneapolis, 2015) software was utilized. An analysis of variance (ANOVA) was also performed using this software. Model significance ($p<0.05$), non-significant ($p>0.05$) lack of fit, regression coefficients (R^2), adjusted regression coefficients (R^2adj), and coefficient of variation were all evaluated in this study. A quadratic model was utilized, as described below:

$$y = \sum_{i=1}^{q} \beta_i x_i + \sum_{i \neq j}^{q} \beta_{ij} x_i x_j + \varepsilon_{ij} \quad (9)$$

The major effects are β_i and the binary joint effects between the i[th] and j[th] components are β_{ij}. ε_{ij} is the error involved in estimating the components from the experimental data. Y is the expected response, and q is the number of process parameters (q = 2). The proposed quadratic model equation for each Y response can also be expressed as

$$Y = \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 \quad (10)$$

where Y is the expected response, β's are the parameter estimates for each linear and cross product term in the prediction model, and x_1, x_2, x_1x_2, are the linear terms of cocoyam and water yam flours, respectively. Cornell's recommendations for a significant model (p<0.05), significant (p>0.05) lack of fit, and maximum R^2 were used to select the model (Cornell, 1986). By comparing predicted values to real or experimental values, the model was found to be valid (Vining, Cornell, & Myers, 1993). The response criteria were defined and quantitatively improved (Myers, Montgomery & Anderson-Cook, 2009)

III. RESULTS AND DISCUSSION

Figure 3: A Pareto chart showing the most significant factors in the data

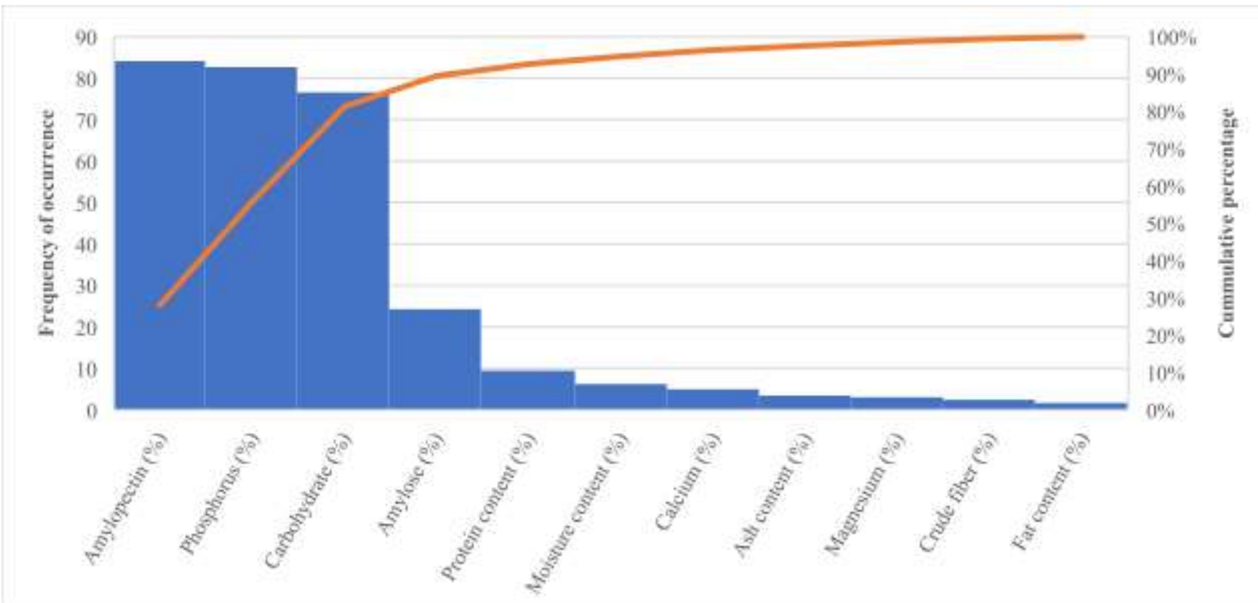


Table 1: Two component simple lattice experimental design for the effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix

Sample	Factor		Response										
	Cocoyam (g)	Wateryam (g)	MC (%)	PC (%)	AC (%)	CF (%)	FC (%)	CHO (%)	Amylose (%)	Amylopectin (%)	Calcium (%)	Magnesium (%)	Phosphorus (%)
1	100	0	6.24	9.50	3.50	2.46	1.68	76.62	24.30	84.18	5.02	3.11	82.74
2	0	100	6.71	10.21	3.20	4.96	1.98	72.94	24.40	83.17	2.51	3.89	62.5
3	50	50	5.59	10.34	3.90	2.60	2.01	75.56	24.87	87.45	5.02	4.56	84.11
4	75	25	5.89	11.01	3.67	1.30	2.11	76.02	24.85	83.09	10.02	5.21	80.21
5	25	75	5.90	9.98	3.91	3.00	2.03	75.18	24.67	89.30	2.51	4.56	81.01
6	100	0	6.30	9.72	3.81	3.10	1.69	75.38	24.50	85.20	6.00	3.99	83.00
7	0	100	6.80	10.56	3.33	5.00	2.01	72.3	24.65	84.19	3.62	4.05	62.99
8	50	50	6.20	11.01	3.81	3.20	2.11	73.67	24.80	88.50	6.52	4.99	74.00

Key: MC – Moisture Content; PC – Protein Content; AC – Ash Content; CF – Crude Fiber; FC – Fat Content; CHO – Carbohydrate.

Table 2: Regression equation coefficients for the effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix

Coefficient	Responses										
	MC (%)	PC (%)	AC (%)	CF (%)	FC (%)	CHO (%)	Amylose (%)	Amylopectin (%)	Calcium (%)	Magnesium (%)	Phosphorus (%)
Linear											
x_1 (p-value)	6.28 (0.0929)	9.60 (0.1546)	3.65 (0.0668)	2.63* (0.0090)	1.71* (0.0226)	76.30* (0.0115)	24.42 (0.5775)	84.62 (0.5500)	5.57* (0.0102)	3.67 (0.6083)	85.17* (0.0182)
x_2 (p-value)	6.71 (0.0929)	10.38 (0.1546)	3.26 (0.0668)	4.96* (0.0090)	1.97* (0.0226)	73.11* (0.0115)	24.49 (0.5775)	83.61 (0.5500)	3.13* (0.0102)	3.90 (0.6083)	67.46* (0.0182)
Binary											
x_1x_2 (p-value)	-2.71* (0.0119)	2.69* (0.0379)	1.63* (0.0144)	-5.48* (0.0341)	0.98* (0.0142)	-	1.51* (0.0129)	13.85* (0.0051)	7.28 (0.0609)	4.63* (0.0217)	-
R^2	0.7934	0.8567	0.8781	0.8360	0.8285	0.6828	0.7457	0.9412	0.9258	0.6898	0.6327
Adj R^2	0.7107	0.7492	0.7867	0.7705	0.7600	0.6299	0.6440	0.8972	0.8702	0.5657	0.5715
LOF	0.6897	0.9728	0.8074	0.1002	0.0614	0.5235	0.5474	0.2904	0.3418	0.3523	0.1958
CV (%)	3.5	2.71	3.42	18.67	4.31	1.26	0.51	0.91	17.25	10.35	7.66

Key: LOT-Lack of Fit; * Significant at the 5% level ($p < 0.05$). NS - Not Significant; CV- Coefficient of Variation; x_1- cocoyam flour; x_2- water yam flour; MC – Moisture Content; PC – Protein Content; AC – Ash Content; CF – Crude Fiber; FC – Fat Content; CHO – Carbohydrate

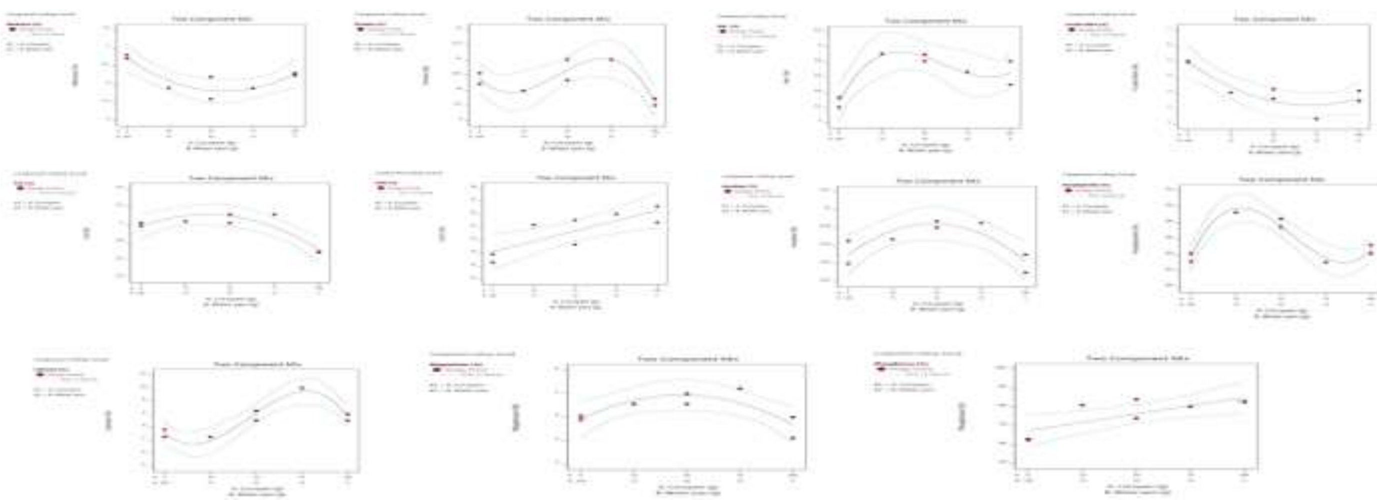


Figure 4: Plot of two-component mix (cocoyam and water yam) flour against response

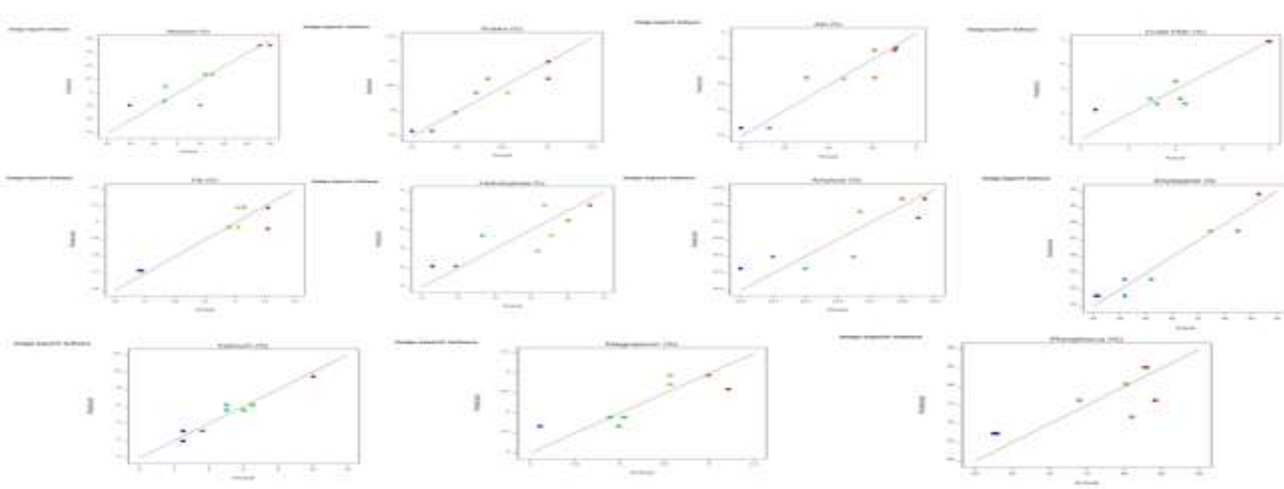


Figure 5: Plot of predicted values against the actual values of response

3.1 Chemical composition of cocoyam and water yam flour blends

The moisture level of cocoyam and water yam flour mixes was shown in Table 1. The percentages varied from 5.59 to 6.80%. The ingredients of the cocoyam and water yam flour caused the moisture content to vary. The kind, variety, and storage conditions all influence the moisture content of food products (Eshun, 2012). Figure 4 shows that the blend ratio of cocoyam and water yam flours (100:0, 0:100, 50:50, 75:25, 25:75) significantly ($p<0.05$) created low moisture content at a binary coefficient of - 2.71 (Table 2). This is consistent with Gharvidel and Dewood (2014) findings. Low moisture level indicates that the product has been stored for a long time. Furthermore, a low coefficient of variation (3.5%) value indicated a high level of precision and a high level of experiment dependability. The R^2 (0.7934) and non-significant ($p>0.05$) lack of fit indicated the model's adequacy. The model explained 71.07% of the data variance (Table 2). Plotting the predicted values versus the actual values confirmed the model (Figure 5). As a result, a strong link was discovered. As can be seen in Table 3, the model was statistically significant ($p<0.05$).

The percentage of protein in the samples ranged from 9.50 to 11.01% (Table 1). Geographical disparities can be related to the differences in values. Nitrogen-rich soils have an impact on protein levels (Brown, 1991). Protein content increased significantly ($p<0.05$) in the two-component mix ratio of cocoyam and water yam flour (100:0, 0:100, 50:50, 75:25, 25:75). (Figure 4). As shown in Table 2, the binary coefficient of the blends was 2.69, indicating this. Because of the high protein content of the blends, they may be useful in food formulation systems. Tissue restoration and lean body deposition both require protein. Furthermore, a low coefficient of variation(2.71%) indicated that the experiment had a high degree of precision and reliability. The model's adequacy was proved by the R^2(0.8567) and non-significant ($p>0.05$) lack of fit. The model explained 74.92 percent of the data variance (Table 2). The predicted and actual protein content values were significantly ($p<0.05$) linked, as shown in Figure 5. This validated the model's accuracy. The model was significant ($p<0.05$) according to Table 3.

The ash content ranged from 3.33 to 3.91%, according to Table 1. The differences were most likely attributable to changes in cultivars, processing procedures, and heat treatment (Mbaey-Nwaoha & Uchendu, 2015). A food's mineral content is determined by the quantity of ash it contains. Figure 4 shows that increasing the blend ratio of cocoyam and water yam flour (100:0, 0:100, 50:50, 75:25, 25:75) significantly ($p<0.05$) increased the ash content at a binary coefficient of 1.63. (Table 2). The increase in ash indicates that the product has a high mineral content. The experiment was more exact and dependable due to the low coefficient of variation (3.42%). The model's adequacy was demonstrated by the R^2(0.7867) and non-significant ($p>0.05$) lack of fit. The model was able to account for 78.67% of the variance data (Table 2). Plotting the predicted values versus the actual values confirmed the model. There was a good correlation found (figure 5). As observed in Table 3, the model was significant ($p<0.05$).

The crude fiber content of the sample ranged from 1.30 to 5.00% (Table 1). The settings in which cocoyam and water yam were grown may have influenced the disparities. Figure 4 shows a two-component mix ratio (100:0, 0:100, 50:50, 75:25, 25:75) plot of cocoyam and water yam flours with significant ($p<0.05$) increases in mix ratio (100:0, 0:100) at linear coefficients of 2.63 and 4.96. (Table 2) The two-component mix ratio (50:50, 75:25, 25:75) of cocoyam and water yam flour significantly ($p<0.05$) lowered the crude fiber at a binary coefficient of -5.48 (Table 2, Figure 4). The high crude fiber content of cocoyam and water yam flour could be due to the dried radicles' remnants (Abebe *et al*., 2018). The blends' low crude fiber content will aid in the relief of diarrhea. The model's adequacy was proved by its R^2(0.8360) and non-significant ($p>0.05$) lack of fit. The model explained 77.05% of the data variance (Table 2). The model was confirmed by a satisfactory correlation in the plot of predicted against real crude fiber values (Figure 4). The model was significant ($p<0.05$) according to Table 3.

The fat level ranged from 1.68 to 2.11%, according to Table 1. Location and varietal differences could be to blame for the variances (Moss, Gore & Murray, 1987). At the linear coefficient of cocoyam (1.71), water yam (1.97), and binary coefficient of the mix (0.98), there was a significant ($p<0.05$) increase in fat content (Table 2). The plot of cocoyam and water yam flour in two-component mix ratios (100:0, 0:100, 50:50, 75:25, 25:75) revealed this even more (Figure 4). High-fat diets considerably increase the amount of energy required by people (Aiyesanmi & Oguntokun, 1996). High fat flours can also be used as flavor enhancers and to improve the palatability of dishes in which they are used. This suggests that this product would be high-energy foods suitable for athletes, military personnel, and others who require a lot of energy to function. Furthermore, a low coefficient of variation (4.31%) demonstrated a high degree of precision and a significant amount of the experiment's reliability. The R^2(0.8285) and non-significant ($p>0.05$) lack of fit confirmed the model's adequacy. The model explained 61.40% of the data variation (Table 2). The plot of anticipated against actual values revealed a strong association (Figure 5). This demonstrated the model's validity. As seen in Table 3, the model was significant ($p<0.05$).

The percentage of carbohydrates in the sample ranged from 72.3 to 76.62% (Table 1). The difference could be ascribed to the constituents of cocoyam and water yam, as well as the processing method. These figures show that cocoyam and water yam, which are grown in Nigeria, are carbohydrate-rich foods that provide a lot of energy. Figure 4 shows that blending cocoyam and water yam flours (100:0, 0:100) significantly ($p<0.05$) increased carbohydrate content at linear coefficients of 76.30% and 73.11%, respectively (Table 2). Cocoyam had the highest carbohydrate content, implying that it was the most carbohydrate-dense. The blends' high carbohydrate content suggested they may be used to treat protein-energy malnutrition since there is enough carbohydrate to get energy from to spare protein, allowing it to be used for its core purpose of body construction and tissue repair rather than as a source of energy (Butt & Batool, 2001). Furthermore, the low coefficient of variation (1.26%) indicated that the experiment had a high degree of precision and reliability. The model was acceptable, as evidenced by the R^2 (0.6828) and non-significant (p>0.05) lack of fit. The model had a p<0.05 significance level according to Table 3.

3.2 Amylose and Amylopectin contents of cocoyam and water yam flour blends

Amylose levels ranged from 24.30 to 24.80% in Table 1. Amylopectin levels varied from 83.09 to 89.30%. Differences in amylose content could be linked to genetic differences in plant species, botanical origin, physiological state, and environmental growing factors (Hoover *et al*., 2010). Significant changes in starch characteristics and functionality result from differences in amylose and amylopectin levels (Thomas & Atwell, 1999). Figure 4 showed that the mixes ratio of cocoyam and water yam flour (100:0, 0:100, 50:50, 75:25, 25:75) significantly (p<0.05) increased amylose and amylopectin at binary coefficients of 1.51% and 13.85%, respectively (Table 2). The amount of amylose and amylopectin in flours has been shown to affect its culinary and industrial applications, as well as their utilitarian properties (Irondi *et al*., 2017). High amylose levels can boost resistant starch production (Hallström *et al.*, 2011). The higher the amylose level, the more likely starch is to retrograde and form a gel (Shimelis *et al*., 2006). According to Shanita *et al*. (2011), the glycemic index is affected by the ratio of amylose to amylopectin concentrations in flours, with lower amylose and higher amylopectin concentrations resulting in a higher glycemic index. A low coefficient of variation implied a high level of precision and a high degree of experiment reliability. The R^2 and non-significant (p>0.05) lack of fit confirmed the model's adequacy, as seen in Table 2. The expected and actual contents of amylose and amylopectin showed a favorable connection (Figure 5). As can be seen in Table 3, the model was statistically significant (p<0.05).

3.2 Mineral contents of cocoyam and water yam flour blends

Calcium was found in concentrations ranging from 2.51 to 10.02%, magnesium was found in concentrations ranging from 3.11 to 5.21%, and phosphorus was found in concentrations ranging from 62.50 to 84.11% (Table 1). The difference in mineral concentration can be related to cocoyam and water yam constituents. The cocoyam (5.57) and water yam (3.13) flour linear coefficients both indicated a significant (p<0.05) increase in calcium. The binary coefficient of 4.43 resulted in a significant (p<0.05) increase in magnesium., while the cocoyam (85.17) and water yam (67.46) linear coefficients had significantly (p<0.05) higher phosphorus. The plot of the two-component mix ratio of cocoyam and water yam flour emphasized these points even more (Figure 4). The results revealed that cocoyam and water yam flour blends contain helpful mineral components that may be advantageous to consumers. Agoreyo *et al.* (2011) found magnesium and calcium amounts in a cocoyam variety that were similar to those found in the current study. The model was statistically significant (p<0.05) as seen in Table 3.

3.3 Optimization of cocoyam and water yam flour blends

Table 4: Numerical optimization criteria for the effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix

Variable	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
Factors						
Cocoyam	is in range	0	100	1	1	3
Water yam	is in range	0	100	1	1	3
Responses						
Moisture content	minimize	5.59	6.80	1	1	3
Protein content	maximize	9.50	11.01	1	1	3
Ash content	maximize	3.20	3.91	1	1	3
Crude Fiber	maximize	1.30	5.00	1	1	3
Fat content	minimize	1.68	2.11	1	1	3
Carbohydrate	maximize	72.30	76.62	1	1	3
Amylose	minimize	24.30	24.87	1	1	3
Amylopectin	maximize	83.09	89.30	1	1	3
Calcium	maximize	2.51	10.02	1	1	3
Magnesium	maximize	3.11	5.21	1	1	3
Phosphorus	maximize	62.50	84.11	1	1	3

Table 5: Optimization value for the effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix

S/N	Cocoyam	Water yam	MC	PC	AC	CF	FC	CHO	Amylose	Amylopectin	Ca	Mg	P	Desirability	
1	**69.84**	**30.15**	**5.84**	**11.04**	**3.69**	**2.18**	**2.00**	**75.34**	**24.77**	**84.24**	**9.17**	**4.71**	**79.83**	**0.493**	**Selected**
2	95.82	4.17	6.19	10.02	3.62	2.51	1.76	76.17	24.49	83.82	6.99	3.86	84.43	0.492	
3	100.00	0.00	6.28	9.60	3.65	2.63	1.71	76.30	24.42	84.62	5.57	3.67	85.17	0.443	
4	1.65	98.35	6.66	10.29	3.33	4.84	1.98	73.16	24.52	84.41	2.76	3.97	67.75	0.253	
5	0.00	100.00	6.71	10.38	3.26	4.96	1.97	73.11	24.49	83.61	3.13	3.90	67.46	0.229	

Key: MC – Moisture Content; PC – Protein Content; AC – Ash Content; CF – Crude Fiber; FC – Fat Content; CHO – Carbohydrate; Ca – calcium; Mg – Magnesium; P – Phosphorus

Table 6: Further analyses to confirm 95% confidence of the selected optimum value

Response	Predicted Mean	Predicted Median	Std Dev	SE Pred	95% PI low	Data Mean	95% PI high
Moisture content	5.84	5.84	0.22	0.24	5.20	6.20	6.48
Protein content	11.04	11.04	0.27	0.35	10.05	10.29	12.03
Ash content	3.68	3.68	0.12	0.15	3.24	3.64	4.12
Crude Fiber	2.18	2.18	0.59	0.67	0.45	3.20	3.90
Fat content	1.99	1.99	0.08	0.09	1.75	1.95	2.23
Carbohydrate	75.36	75.36	0.94	1.01	72.87	74.71	77.84
Amylose	24.76	24.76	0.12	0.14	24.39	24.63	25.13
Amylopectin	84.15	84.15	0.78	1.00	81.37	85.63	86.94
Calcium	9.22	9.22	0.88	1.13	6.07	5.15	12.38
Magnesium	4.70	4.70	0.44	0.49	3.42	4.29	5.98
Phosphorus	79.94	79.94	5.84	6.29	64.53	76.32	95.35

Std Dev – Standard Deviation, SE Pred – Standard Error Predicted, PI – Prediction Interval

Individual responses were optimized using the "Design Expert" statistical tool (Version 12.0.5, Stat-Ease, Inc., Minneapolis, USA) in order to identify a combination of factor levels that satisfied the target requirement placed on each response and factor at the same time. There was a goal, a lower limit, a higher limit, a lower weight, an upper weight, and an importance for each component and reaction. When the importance of both the independent and response variables is set to 3, no goals are prioritized above others (Table 4). These objectives were emphasized further more in the numerical optimization ramps perspective (Figure 6). Ramps are a graphic representation of the optimal option. Flat ramps represent uniform desirability (cocoyam and water yam flour), while inclined ramps represent the response's minimum and maximum preferred values. Red and blue dots represent factors and reactions, respectively. The level of desirability achieved after optimization is represented by the height of the dot. Table 5 shows that the cocoyam and water yam flour mix ratio (69.84: 30.15) with a high desirability of 0.493 was chosen. The desirability graph of two component cocoyam and water yam flour blends highlighted the selected optimum value even more. This means that 69.84% of cocoyam flour mixes and 30.15% of water yam flour blends met each response's aim. This proportions will be critical at the industrial level for the creation of instant soup mixes, as well as in other food formulation systems.

Table 6 shows the results of further analysis of selected optimum values to determine 95% confidence. For each response, the predicted mean and data mean was found to be near to each other, as well as within the range of real or experimental values. The standard deviation (SD) of the responses was modest. This showed how closely the individual numbers matched the mean. Furthermore, the responses' estimated standard error was low. A small standard error (SE) suggests that the sample mean more accurately represents the underlying population mean. The standard error is a measure of the mean's consistency. Furthermore, the 95% prediction interval (PI high) suggested that there is a 95% likelihood that a future observation will fall inside the prediction interval based on the sample. The next observation, on the other hand, has a 5% chance of not being contained inside the interval. A prediction interval is a range of values that is likely to contain the value of a single new observation given the settings of the predictors. Prediction intervals account for the variability in any prediction's mean response (Scheffé, 1963). As a result, the ideal blend ratio for making instant soup mix is 69.84% cocoyam flour and 30.15% water yam flour.

IV. CONCLUSION

The effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix was investigated using response surface methods with simplex lattice design. The two independent factors were shown to have a substantial linear or binary influence on all of the response variables based on the two component mix plots. The most significant component ($p<0.05$) in the creation of dry soup mix was discovered to be a cocoyam and water yam combination. RSM can forecast the mix effect of two variables on responses, which is difficult to do with traditional approaches. The food processing companies can employ the cocoyam and water yam flour combination for commercial purposes.

Compliance With Ethical Standards Statement

Declaration of Interest: None

Ethical Statement

Hereby, I consciously assure that for the manuscript “Effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix”, the following is fulfilled:

1. This material is the authors’ own original work, which has not been previously published elsewhere.
2. The paper is not currently being considered for publication elsewhere.
3. The paper reflects the authors’ own research and analysis in a truthful and complete manner.
4. The paper properly credits the meaningful contributions of co-authors and co-researchers.
5. The results are appropriately placed in the context of prior and existing research.
6. All sources used are properly cited

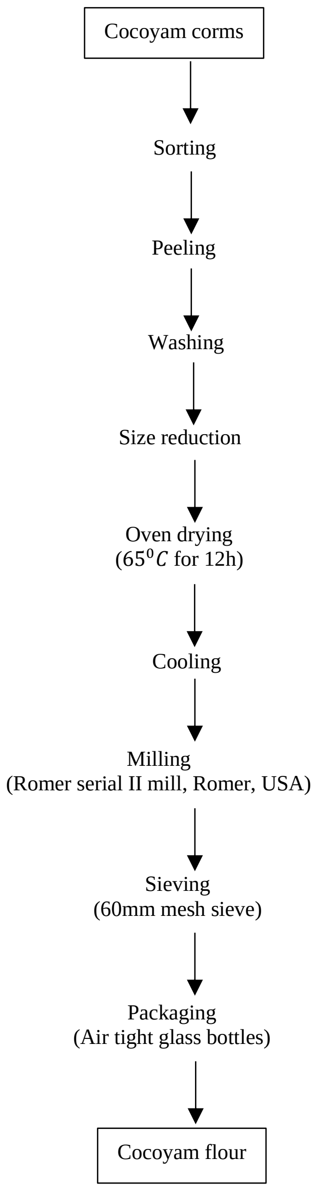
Consent Statement

I hereby declare that we participated in the study and in the development of the manuscript titled "Effect of cocoyam and water yam flour blends on the chemical and mineral composition of dry soup mix". Authors and co-authors have read the final version and give our consent for the article to be published.

Data Availability Statement

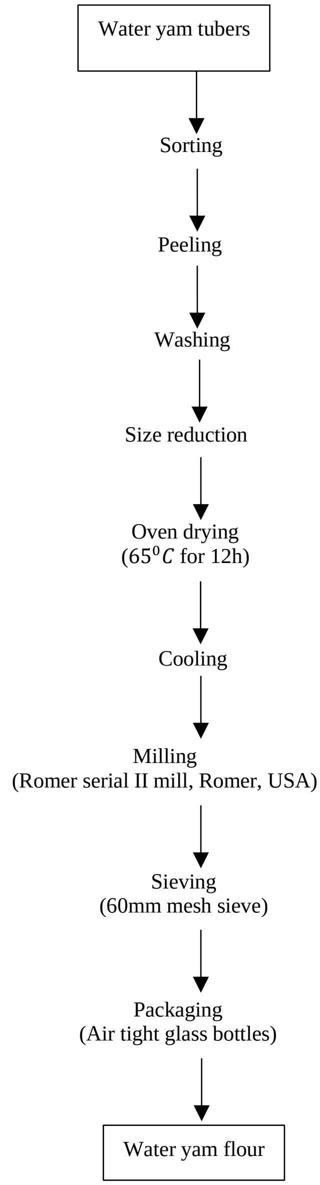
Authors can confirm that all relevant data are within the article.

Figure 1: Modified flow diagram for cocoyam (*Xanthosoma sagittifolium*) flour production



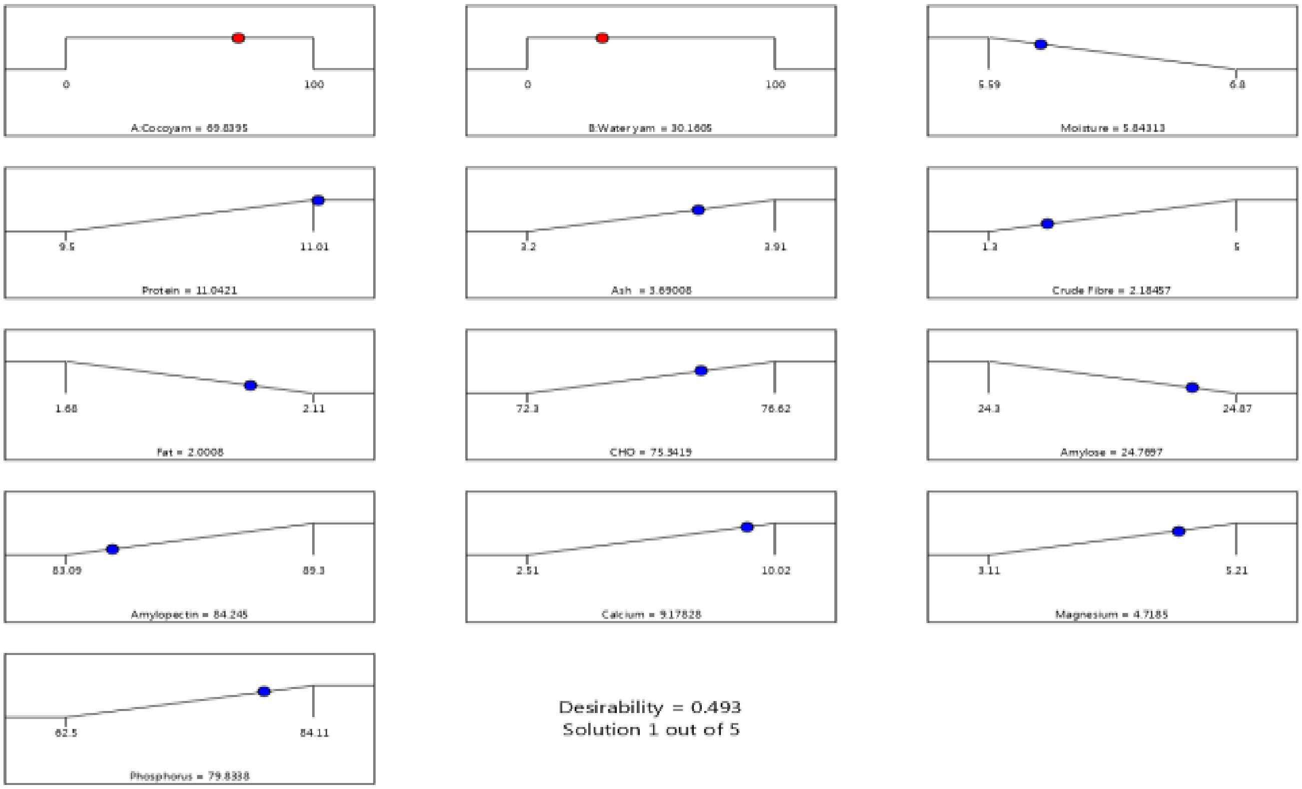
Source: Sobowale *et al.* (2017)

Figure 2: Modified flow diagram for water yam (*Dioscorea alata*) flour production



Source: Sobowale *et al.* (2017)

Figure 6: Numerical optimization ramps view



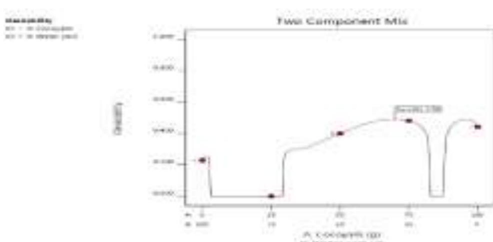


Figure 7: Desirability graph of two component mix of cocoyam and water yam flour blends

Plate 1: Cocoyam (Xanthosoma sagittifolium)

Plate 2: Dry slices of Xanthosoma sagittifolium

Plate 3: Wateryam tubers (D. alata)

Plate 4: Dry slices of water yam

Table 3: Analyses of the significant (p<0.05) model equation for the responses

S/N	Response	Selected Model	P<0.05	Significant (p<0.05) model equation
1	Moisture Content	Quadratic	0.0194	$-2.71x_1x_2$
2	Protein Content	Quadratic	0.0366	$2.69x_1x_2$
3	Ash Content	Quadratic	0.0267	$1.63x_1x_2$
4	Crude Fiber	Quadratic	0.0109	$2.63x_1 + 4.96x_2 - 5.48x_1x_2$
5	Fat Content	Quadratic	0.0122	$1.71x_1 + 1.97x_2 + 0.98x_1x_2$
6	Carbohydrate	Linear	0.0115	$76.30x_1 + 73.11x_2$
7	Amylose	Quadratic	0.0326	$1.51x_1x_2$
8	Amylopectin	Quadratic	0.0063	$13.85x_1x_2$
9	Calcium	Quadratic	0.0101	$5.57x_1 + 3.13x_2$
10	Magnesium	Quadratic	0.0536	$4.63x_1x_2$
11	Phosphorus	Linear	0.0182	$85.17x_1 + 67.46x_2$

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Author Statement

Udo, D.E.: Conceptualization, Writing-Original draft, Writing-Reviewing and Editing, Formal Analysis
Omeire, G.C.: Supervision
Mmuosinam, B.C.: Resources.
Obeleagu, S.O.: Methodology, Validation, Investigation.
Igwe, V.S.: Resources.
Okon, U.B.: Resources.

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