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FULL PAPER

# Physicochemical properties of instant noodles produced from blends of sweet potato, soybean and corn flour

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**Abstract**

Studies on substitution of wheat partially with other composite flour and analysis on their different characteristics had been reported; but there was a need to optimize both the formulation and process conditions to give optimum quality while substituting wheat wholly with composite blends of other flours. This study investigated the formulation of instant noodles made from blends of sweet potato, corn, soybean flours; with the quantity of water. The impact of baking temperature, mixing time, frying time and frying temperature on noodles quality were also investigated. Investigations were conducted employing a four-component constrained D-optimal mixture-process experimental design with 39 randomized experimental runs. The formulation design constraints were sweet potato flour ($10\% \leq x_1 \leq 61\%$), soybean flour ($5\% \leq x_2 \leq 20\%$), corn flour ($5\% \leq x_3 \leq 30\%$), and water ($25\% \leq x_4 \leq 37\%$). Other components of the formulation were salt (2.5%), sodium carbonate (0.5%), guar gum (0.5%), and soy lecithin (0.5%). The processing factors investigated were mixing time ($2$ mins $\leq z_1 \leq 10$ mins), frying time ($1$ min $\leq z_2 \leq 3$ mins), and frying temperature ($140°C \leq z_3 \leq 160°C$). The D-optimal mixture-process design was used to evaluate the effect of changes in mixture compositions and the three processing factors on the main proximate qualities of the formulated instant noodles. The effects were established through analysis of variance at 5% level of significance. The formulated samples were evaluated for the proximate properties. From the numerical optimization through the desirability function, the formulation that produced noodles of highest desirability index of 0.723 was: 23.305% of sweet potato flour, 28.529% of soya bean flour, 18.021% of corn flour, 26.145% water, 2.749 mins mixing time, 1.35 mins frying time, and 140°C frying temperature, The proximate composition of this optimal formulation were: 13.17% moisture content, 6.616% ash content, 22.862% crude protein, and 37.707% energy value, 16.001% crude fat, and 4.643% crude fibre.

## 1. Introduction

Noodles are an important food throughout the world, especially in Asian countries such as China, Korea, Malaysia, Philippines and Thailand. Almost 40% of wheat products in Asian countries are consumed in the form of noodles (Gary, 2010; Ojure and Quadri, 2012). There are many types of noodles, but the "instant" types continue to show increasing popularity globally as these products offer ease in preparation while being economical and tasty (Akanbi *et al.,* 2011). However, their significant sales volume is not reflected in the amount of research work been carried out (Akanbi *et al.,* 2011).

In developing countries, there has been a high increase in the consumption of noodles owing to changes in lifestyle and urbanization (Ando, 2010). Nigeria today has up to fifteen brands of noodles including, but not limited to, the following: (a) Golden penny produced by Flour Mills Nigeria Plc (b) Mimee Noodles by May and Baker. (c) Honeywell Noodles by Honey Well Super Fine Food Limited. (d) Dangote Noodles by Dangote Groups. (e) Chef Me by Engels Foods. The nutritional profiles of some of these different noodles brand are shown in Table 1.

Noodles are produced basically from wheat flour. However, wheat production in Nigeria has been a roller coaster. Reports indicated that up to 1985, domestic wheat production in Nigeria was about 66,000 tons (Olugbemi, 1991). In 1988/89 crop production season about 600,000 tons of wheat was produced from a total of 214,000 hectares with an average yield of 2 tons per

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Table 1. Nutritional profiles of some noodle's brand in Nigeria.

| Noodle's Brand | Nutritional Composition (%) | | | | | |
|---|---|---|---|---|---|---|
| | MC | Ash | Fat | CP | CF | CHO |
| Dangote | 5.60 | 5.50 | 15.80 | 0.167 | 9.25 | 63.68 |
| Indomie | 3.65 | 1.80 | 13.64 | 0.176 | 1.00 | 79.71 |
| Honey-well | 6.60 | 1.50 | 18.44 | 0.211 | 3.00 | 70.30 |
| Golden penny | 5.15 | 1.11 | 18.69 | 0.185 | 5.85 | 69.02 |

MC = Moisture Content; Ash = Ash Content; Fat = Crude Fat; CP = Crude Protein; CF = Crude Fibre; and CHO = Carbohydrate

hectare (Olugbemi, 1991). In 2011 the production was 165,000 metric tonnes which drastically dropped to 60,000 metric tonnes in 2016. (Olugbemi, 1991). Since wheat cannot perform well under tropical climate, the country had over the years been dependent on wheat imports mostly from the United States. This wheat importation had detrimental effects on the Nigerian economy involving huge expenditure of foreign exchange (Olaoye *et al.,* 2006). In order to reduce the impact of wheat importation on the economy, the Federal Government released a policy mandating the flour mills to partially or wholly substitute wheat flour (Ammar *et al.,* 2009). This resulted in the adoption of alternative solutions by the baking industries to stay in business. One of the solutions developed was the mixing of flour from other sources with wheat flour (Shittu *et al.,* 2007; Lateef *et al.,* 2007; Orunkoyi, 2009; Abdelghafor *et al.,* 2011).

Studies on the mixing of flour from other sources with wheat flour has been conducted by many researchers, among which are; wheat/colocasia/sweet potato/water chestnut flours (Baljeet *et al.,* 2014), wheat/taro flour (Ammar *et al.,* 2009) wheat/sweet potato flour (Taneya *et al.,* 2014), wheat/soy/cassava flour and wheat/cassava/carrot flour (Adegunwa *et al.,* 2012), yellow peas/lentils/chickpeas (Zhao *et al.,* 2005) and 15% banana flour (Ovando-Martinez *et al.,* 2009). Several other studies on substitution of wheat partially with other composite flour and the analysis on their different characteristics have been conducted. Khetarpaul and Goyal (2007) reported that protein content and quality was improved in noodles by incorporation of soy, sorghum, corn, and rice at 10% level without significantly affecting overall acceptability of the product. Chen *et al.* (2011) reported that that 5–10% wheat bran can be satisfactorily incorporated to prepare fiber-rich dry white Chinese noodles. They also reported that substitution of 10% oat flour in noodle formulation gave satisfactory results in terms of overall acceptability of the product. However, there have been limited research on the formulation and process optimization of noodles, especially regarding substituting the wheat flour totally with other composite flour. There is a need to optimize the formulation, with full substitution of wheat, and processing condition that will give noodles of optimum quality. This was the aim of this research. Instant noodles formulation from composite blends of sweet potatoes, corn and soybean flour was optimized using a D-optimal mixture-process design methodology. The quality of instant noodles is directly linked to the basic material used in the formulation. By varying the ratio of ingredients, and at the same time monitoring the processing parameters, the final product characteristics were determined.

## 2. Materials and methods

### *2.1 Materials*

The major ingredients which include soybean, yellow corn, sweet potato and salt were obtained from Mile 12 Market in Lagos. Other ingredients were obtained from a food chemical market in Lagos. The reagents used were distilled water, petroleum ether, boric acid, hydrogen tetraoxosulpate VI, sodium hydroxide, hydrochloric acid, bromescresol green and methyl red indicator, n-hexane, and selenium tablet. The equipment and apparatus used in the study include Master chef deep fryer (PRODUCT CODE: 3854942 BRAND: Master Chef), manual kneader (Royalty line hand mixer - 200W Royalty Line RL-HM250T.3 MSY), steaming machine (Binatone Rice Cooker - RCSG 2804), and noodles maker (Stainless steel fresh OxGord Pasta Maker Machine).

### *2.2 Preparation of soybean, sweet potato, and corn flours*

Soybean flour was produced according to the methods of Oluwamukomi *et al.* (2011). Soybeans were cleaned, sorted, washed and boiled in water at 100°C for 30 mins. It was dehulled manually, oven dried at 70°C for 15 hrs and milled in a disc attrition mill to obtain the flour followed by sieving using a muslin cloth. The resultant fine flour was stored in air tight polyethylene bags at room temperature for further use.

Sweet potato flour was produced according to the methods of Julianti *et al.* (2017). Sweet potato tubers were washed, peeled and cut into thin slices, spread in a tray and was oven dried at 60°C for 10 hrs after which it was milled into flour. The floursaw were screened through an 80-mesh sieve, and then stored in polyethylene bags.

For the corn flour, the traditional method of production was employed. The samples of corn were dehusked, shelled, dried and milled. The milled sample was sieved to obtain fine sample of corn flour.

*2.3 Experimental design*

A four-component constrained D-optimal mixture-process experimental design, with 39 randomized experimental runs, was employed. The formulation design constraints were sweet potato flour (10% ≤ $x_1$ ≤ 61%), soybean flour (5% ≤ $x_2$ ≤ 20%) corn flour (5% ≤ $x_3$ ≤ 30%) and water (25% ≤ $x_4$ ≤ 37%). Other components of the formulation were salt (2.5%), sodium carbonate (0.5%), guar gum (0.5%), and soy lecithin (0.5%). The processing factors investigated were mixing time (2 mins ≤ $z_1$ ≤ 10 mins), frying time (1 min ≤ $z_2$ ≤ 3 mins), and frying temperature (140°C ≤ $z_3$ ≤ 160°C). The design matrix for the D-Optimal mixture-process design is presented in Table 2.

The composite blends were mixed together with salt (2.5%), sodium carbonate (0.5%) while the other ingredients (guar gum (0.5%) and soy lecithin (0.5%)) were mixed with water and added to the composite blend over a period of time. The resultant dough had a moist bread crumb consistency which was then turned into a dough sheet. The formulation of the composite blend, with the other constant components, as well as the variation of the processing parameters were based on the D-Optimal mixture-process design.

## 3. Experimental results

The proximate analyses of the noodles produced were carried out using the method described by the Association of Analytical Chemist (AOAC, 2000). The mean proximate composition of the formulated instant noodles from composite flour blends, based on the D-Optimal mixture-process design is presented in Table 3.

*3.1 Statistical analysis of experimental results*

The experimental results were analyzed and appropriate Scheffe canonical models were fitted to the mean proximate property data. The statistical significance of the terms in the Scheffe canonical regression models were examined by ANOVA for each response, and the adequacy of the models were evaluated by coefficient of determination, F-value, and model p-values at the 0.05 level of significance. The models were subjected to lack-of-fit and adequacy tests and only the model parameters that were found to be statistically significant were retained in the final fitted Scheffe canonical models. The fitted models for all the proximate properties were used to generate 3-D response surfaces as well as their contour plots using the DESIGN EXPERT 11.0 statistical software.

Table 4 shows the analysis of variance (ANOVA) of the final reduced models, p-values of significant terms, F-values, $R^2$, adjusted $R^2$, and Predicted $R^2$ of the noodle. The overlay contour and the overlay contour mix-process plots showing the desired area of all the ten responses containing optimum formulations are presented in Figures 1 and 2.

## 4. Results and discussion

The moisture content model (F-value of 10.39) implies the model is not significant. The Lack of Fit F-value of 0.0025 implies the Lack of Fit is not significant relative to the pure error. There is a 96.83% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit is good, we want the model to fit. The adequacy precision value 12.78 indicates an adequate signal (Raymond *et al.*, 2009; Mark and Patrick, 2017).

The crude protein model F-value of 2.00 implies the model is not significant. The Lack of Fit F-value of 0.09 implies the Lack of Fit is not significant relative to the pure error. There is a 99.25% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit is good, we want the model to fit. The adequacy precision value 6.772 indicates an adequate signal (Raymond *et al.,* 2009; Mark and Patrick, 2017).

The crude fibre model F-value of 1.19 implies the model is not significant relative to the noise. There is a 34.40% chance that an F-value this large could occur due to noise. The Lack of Fit F-value of 3.89 implies the Lack of Fit is not significant relative to the pure error. There is a 38.26% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit is good, we want the model to fit. The adequacy precision value 5.120 indicates an adequate signal. This model can be used to navigate the design space.

The negative Predicted $R^2$ implies that the overall mean may be a better predictor of the crude fibre than the current model (Raymond *et al.,* 2009; Mark and Patrick, 2017).

The ash content model F-value of 1.04 implies the model is not significant. The Lack of Fit F-value of 0.674 implies the Lack of Fit is not significant relative to the pure error. There is a 45.37% chance that an F-value this large could occur due to noise. Non-significant lack of fit is good. The adequacy precision value 5.301 indicates an adequate signal. This model can be used to navigate the design space (Raymond *et al.,* 2009; Mark and Patrick, 2017). Figure 1 presents the overlay contour plot.

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Table 2. Design matrix for D-optimal mixture – process design

| Run | $x_1$ (%) | $x_2$ (%) | $x_3$ (%) | $x_4$ (%) | $z_1$ (mins) | $z_2$ (mins) | $z_3$ (°C) | $c_1$ (%) | $c_2$ (%) | $c_3$ (%) | $c_4$ (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 46 | 20 | 5 | 25 | 10 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 2 | 21 | 20 | 30 | 25 | 10 | 1 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 3 | 22 | 20 | 17 | 37 | 10 | 1 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 4 | 49 | 5 | 5 | 37 | 10 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 5 | 36.5 | 5 | 17.5 | 37 | 2 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 6 | 41.5 | 12.5 | 5 | 37 | 2 | 3 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 7 | 33.5 | 20 | 17.5 | 37 | 2 | 1 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 8 | 10 | 19 | 30 | 37 | 2 | 2 | 150 | 2.5 | 0.5 | 0.5 | 0.5 |
| 9 | 21 | 20 | 30 | 25 | 10 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 10 | 42.7 | 15 | 13.3 | 25 | 6 | 2 | 150 | 2.5 | 0.5 | 0.5 | 0.5 |
| 11 | 61 | 5 | 5 | 25 | 2 | 1 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 12 | 36 | 5 | 30 | 25 | 10 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 13 | 49 | 5 | 5 | 37 | 10 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 14 | 21 | 20 | 30 | 25 | 2 | 1 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 15 | 61 | 5 | 5 | 25 | 10 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 16 | 28.5 | 12.5 | 30 | 25 | 2 | 3 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 17 | 55 | 5 | 5 | 31 | 2 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 18 | 15.5 | 20 | 30 | 30.5 | 2 | 3 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 19 | 46 | 20 | 5 | 25 | 2 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 20 | 53.5 | 12.5 | 5 | 25 | 2 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 21 | 21 | 30 | 30 | 25 | 2 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 22 | 46 | 20 | 5 | 25 | 10 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 23 | 25.4 | 13.8 | 19.8 | 37 | 10 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 24 | 10 | 19 | 30 | 37 | 10 | 3 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 25 | 10 | 19 | 30 | 37 | 6 | 3 | 150 | 2.5 | 0.5 | 0.5 | 0.5 |
| 26 | 23.3 | 9.7 | 30 | 33 | 2 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 27 | 48.5 | 5 | 17.5 | 25 | 2 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 28 | 24 | 5 | 30 | 37 | 10 | 3 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 29 | 34 | 20 | 5 | 37 | 2 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 30 | 34 | 20 | 5 | 37 | 10 | 3 | 160 | 2.5 | 0.5 | 0.5 | 0.5 |
| 31 | 22 | 20 | 17 | 37 | 2 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 32 | 21 | 20 | 30 | 25 | 2 | 1 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |
| 33 | 36 | 5 | 30 | 25 | 2 | 3 | 140 | 2.5 | 0.5 | 0.5 | 0.5 |

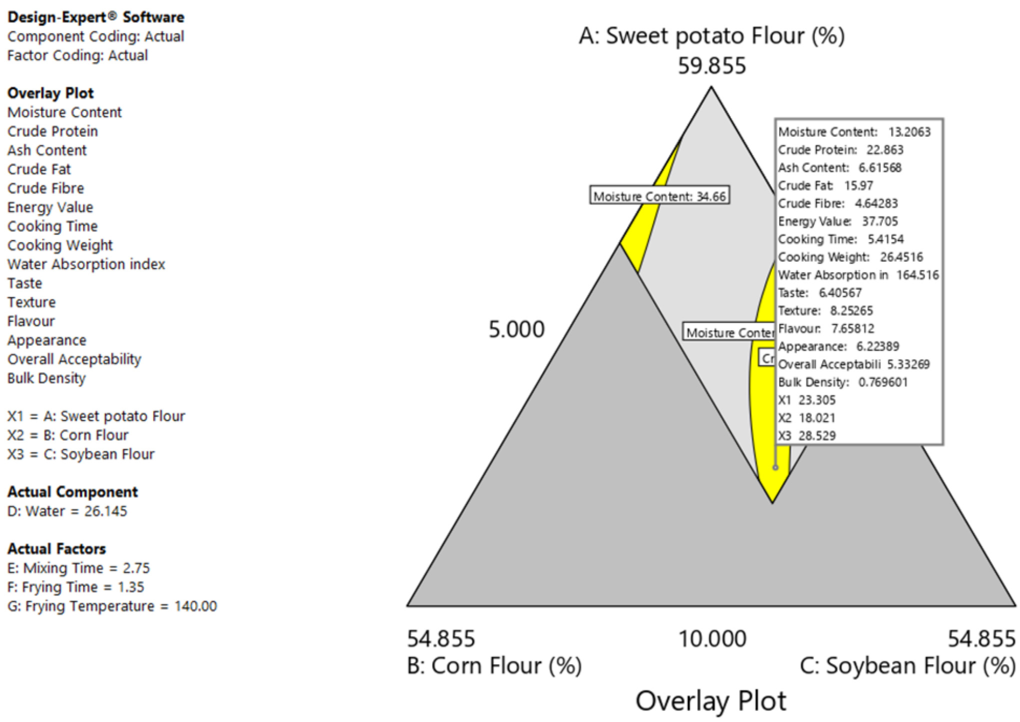


Figure 1. The overlay contour plot

Table 3. Mean of proximate composition of formulated composite instant noodles

| Run | Moisture Content (%) | Crude Protein (g/100 g) | Crude Fibre (g/100 g) | Ash (g/100 g) | Crude Fat (g/100 g) | Energy Value (g/100 g) |
|---|---|---|---|---|---|---|
| 1 | 3.74 | 17.48 | 3.41 | 6.28 | 33.00 | 36.09 |
| 2 | 7.12 | 26.32 | 4.34 | 9.28 | 28.11 | 24.83 |
| 3 | 24.28 | 15.11 | 5.00 | 7.41 | 21.62 | 26.58 |
| 4 | 10.00 | 14.70 | 6.43 | 8.50 | 26.50 | 33.87 |
| 5 | 20.33 | 14.00 | 6.38 | 8.32 | 18.00 | 32.97 |
| 6 | 34.66 | 10.50 | 4.41 | 8.42 | 20.72 | 21.29 |
| 7 | 2.81 | 19.25 | 3.94 | 13.00 | 22.50 | 38.50 |
| 8 | 8.11 | 20.11 | 2.57 | 8.46 | 26.32 | 34.45 |
| 9 | 3.14 | 19.88 | 7.26 | 5.50 | 29.00 | 35.22 |
| 10 | 7.11 | 18.18 | 8.00 | 6.42 | 25.22 | 35.07 |
| 11 | 13.75 | 16.48 | 4.50 | 11.50 | 23.50 | 30.27 |
| 12 | 10.95 | 19.18 | 7.91 | 7.32 | 24.00 | 30.64 |
| 13 | 4.89 | 25.55 | 5.32 | 5.42 | 24.00 | 34.82 |
| 14 | 10.49 | 21.00 | 4.32 | 9.50 | 20.50 | 34.19 |
| 15 | 8.24 | 15.75 | 7.24 | 8.91 | 25.11 | 34.75 |
| 16 | 10.48 | 17.28 | 3.94 | 9.24 | 20.14 | 38.92 |
| 17 | 9.84 | 17.81 | 6.32 | 7.28 | 22.11 | 36.64 |
| 18 | 24.51 | 15.32 | 4.06 | 6.32 | 20.11 | 29.68 |
| 19 | 6.38 | 27.28 | 3.18 | 6.32 | 26.22 | 30.62 |
| 20 | 5.11 | 21.00 | 6.00 | 6.00 | 21.32 | 40.57 |
| 21 | 7.41 | 26.11 | 2.88 | 8.11 | 30.48 | 25.01 |
| 22 | 7.00 | 21.35 | 6.33 | 11.28 | 23.11 | 30.93 |
| 23 | 7.38 | 29.40 | 4.48 | 6.62 | 26.32 | 25.80 |
| 24 | 12.11 | 24.50 | 4.11 | 7.24 | 20.16 | 31.88 |
| 25 | 9.22 | 20.63 | 4.94 | 9.85 | 23.18 | 32.18 |
| 26 | 6.38 | 22.75 | 7.33 | 7.33 | 22.50 | 33.71 |
| 27 | 10.11 | 18.55 | 3.21 | 8.32 | 19.32 | 40.49 |
| 28 | 12.69 | 17.50 | 4.18 | 9.50 | 16.00 | 40.13 |
| 29 | 8.24 | 25.63 | 4.32 | 8.41 | 27.22 | 26.18 |
| 30 | 34.04 | 20.63 | 7.81 | 8.18 | 27.32 | 2.02 |
| 31 | 6.38 | 22.28 | 5.11 | 7.43 | 28.63 | 30.17 |
| 32 | 9.24 | 23.80 | 3.38 | 7.11 | 19.42 | 37.05 |
| 33 | 6.11 | 23.48 | 7.24 | 8.11 | 25.11 | 29.95 |
| 34 | 6.33 | 20.11 | 6.81 | 6.33 | 27.32 | 33.10 |
| 35 | 11.11 | 14.00 | 4.00 | 5.33 | 22.11 | 43.45 |
| 36 | 7.48 | 20.11 | 4.11 | 4.11 | 27.32 | 36.86 |
| 37 | 8.23 | 19.11 | 5.32 | 10.11 | 24.63 | 32.60 |
| 38 | 8.11 | 18.18 | 7.55 | 6.42 | 25.22 | 34.52 |
| 39 | 31.42 | 16.38 | 4.04 | 8.33 | 22.33 | 17.50 |

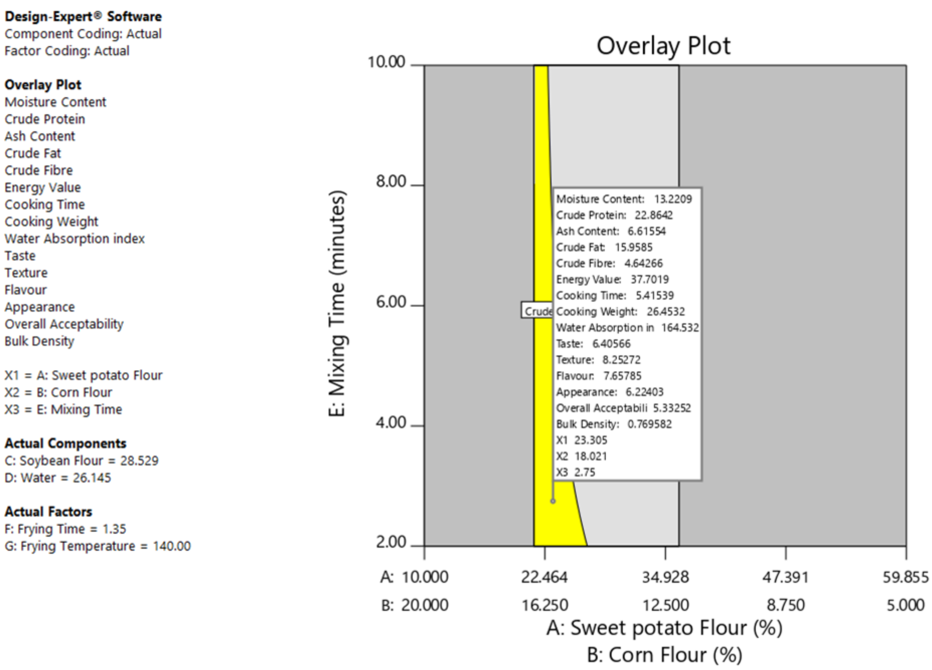

Figure 2. The overlay contour mix-process plot

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Table 4. Summary of the analysis of variance for the responses

| Response | Source | Sum of Squares | df | Mean Square | F value | Prob>F |
|---|---|---|---|---|---|---|
| Moisture Content ($Y_{mc}$) | Model | 2448.67 | 36 | 68.02 | 10.39 | 0.0915* |
| | Linear Mixture | 345.2 | 3 | 115.07 | 17.58 | 0.0543 |
| | Residual | 13.09 | 2 | | | |
| | Lack of Fit | 0.0324 | 1 | 0.0324 | 0.0025 | 0.9683* |
| | Pure Error | 13.06 | 1 | | | |
| | Cor Total | 2461.76 | 38 | | | |
| | Std. Dev. | 2.558 | | $R^2$ | 0.9946 | |
| | Mean | 11.152 | | Adjusted $R^2$ | 0.8989 | |
| | C.V. % | 22.939 | | Predicted $R^2$ | NA(1) | |
| | | | | Adeq. Precision | 12.7823 | |
| Crude Protein ($Y_{cp}$) | Model | 548.81 | 27 | 20.33 | 2.00 | 0.1127* |
| | Linear Mixture | 56.7 | 3 | 18.90 | 1.86 | 0.1941 |
| | Residual | 111.53 | 11 | 10.14 | | |
| | Lack of Fit | 52.66 | 10 | 5.27 | 0.09 | 0.9925* |
| | Pure Error | 58.86 | 1 | 58.86 | | |
| | Cor Total | 660.34 | 38 | | | |
| | Std. Dev. | 3.18 | | $R^2$ | 0.8311 | |
| | Mean | 19.91 | | Adjusted $R^2$ | 0.4166 | |
| | C.V. % | 15.99 | | Predicted $R^2$ | -186.462 | |
| | | | | Adeq. Precision | 6.7715 | |
| Crude Fibre ($Y_{cf}$) | Model | 41.46 | 15 | 2.76 | 1.19 | 0.3440* |
| | Linear Mixture | 8.2 | 3 | 2.73 | 1.18 | 0.3402 |
| | Residual | 53.4 | 23 | 2.32 | | |
| | Lack of Fit | 52.78 | 22 | 2.4 | 3.89 | 0.3826* |
| | Pure Error | 0.616 | 1 | 0.616 | | |
| | Cor Total | 94.86 | 38 | | | |
| | Std. Dev. | 1.5 | | $R^2$ | 0.4371 | |
| | Mean | 5.17 | | Adjusted $R^2$ | 0.0699 | |
| | C.V. % | 29.47 | | Predicted $R^2$ | -0.499 | |
| | | | | Adeq. Precision | 5.1198 | |
| Ash Content ($Y_{ash}$) | Model | 50.92 | 15 | 3.39 | 1.04 | 0.4537* |
| | Linear Mixture | 2.93 | 3 | 0.98 | 0.30 | 0.8254 |
| | Residual | 75.06 | 23 | 3.26 | | |
| | Lack of Fit | 70.31 | 22 | 3.2 | 0.6738 | 0.7640* |
| | Pure Error | 4.74 | 1 | 4.74 | | |
| | Cor Total | 125.98 | 38 | | | |
| | Std. Dev. | 1.81 | | $R^2$ | 0.4042 | |
| | Mean | 7.89 | | Adjusted $R^2$ | 0.0157 | |
| | C.V. % | 22.91 | | Predicted $R^2$ | -0.5234 | |
| | | | | Adeq. Precision | 5.3006 | |
| Crude Fat ($Y_{fat}$) | Model | 494.02 | 36 | 13.72 | 8.64 | 0.1089* |
| | Linear Mixture | 98.2 | 3 | 32.72 | 20.62 | 0.0466 |
| | Residual | 3.18 | 2 | 1.59 | | |
| | Lack of Fit | 0.506 | 1 | 0.0506 | 0.0162 | 0.9194* |
| | Pure Error | 3.13 | 1 | 3.13 | | |
| | Cor Total | 497.19 | 38 | | | |
| | Std. Dev. | 1.26 | | $R^2$ | 0.9936 | |
| | Mean | 23.99 | | Adjusted $R^2$ | 0.8786 | |
| | C.V. % | 5.25 | | Predicted $R^2$ | NA(1) | |
| | | | | Adeq. Precision | 13.851 | |

Figures **bold** under the Prob>F column indicates significant difference

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Table 4. Summary of the analysis of variance for the responses (Cont.)

| Response | Source | Sum of Squares | df | Mean Square | F value | Prob>F |
|---|---|---|---|---|---|---|
| Energy Value ($Y_{ev}$) | Model | 2020.6 | 32 | 63.14 | 53.45 | **<0.0001** |
| | Linear Mixture | 343.37 | 3 | 114.45 | 96.88 | <0.0001 |
| | Residual | 7.09 | 6 | 1.18 | | |
| | Lack of Fit | 6.64 | 5 | 1.33 | 2.94 | 0.4148* |
| | Pure Error | 0.4513 | 1 | 0.4513 | | |
| | Cor Total | 2027.69 | 38 | | | |
| | Std. Dev. | 1.09 | | $R^2$ | 0.9965 | |
| | Mean | 31.88 | | Adjusted $R^2$ | 0.9779 | |
| | C.V. % | 3.41 | | Predicted $R^2$ | 0.4644 | |
| | | | | Adeq. Precision | 41.8074 | |

Figures **bold** under the Prob>F column indicates significant difference

The crude fat model F-value of 8.64 implies the model is not significant. There is a 10.89% chance that an F-value this large could occur due to noise. The Lack of Fit F-value of 0.0162 implies the Lack of Fit is not significant relative to the pure error. There is a 91.94% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit is good. The adequacy precision value 13.8510 indicates an adequate signal. This model can be used to navigate the design space (Raymond *et al.,* 2009; Mark and Patrick, 2017).

The energy value model F-value of 53.45 implies the model is significant. There is only a 0.01% chance that an F-value this large could occur due to noise. The model terms with p-values less than 0.0500 indicate model terms are significant. The Lack of Fit F-value of 2.94 implies the Lack of Fit is not significant relative to the pure error. There is a 41.48% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit is good, we want the model to fit. The Predicted $R^2$ of 0.4644 which is not as close to the Adjusted $R^2$ of 0.9779 indicates a possible problem with the model and/or data and the resolution of this could be model reduction, response transformation, outliers, etc. The adequacy precision value 41.807 indicates an adequate signal. This model can be used to navigate the design space (Raymond *et al.,* 2009; Mark and Patrick, 2017).

From the numerical optimization through the desirability function, the formulation that produced instant noodles of highest desirability index of 0.723 are: 23.305% of sweet potato flour, 28.529% of soya bean flour, 18.021% of corn flour, 26.145% water, 2.749 mins mixing time, 1.35 mins frying time, and 140°Cfrying temperature, The proximate composition of this optimal formulation are: 13.17% moisture content, 6.616% ash content, 22.862 crude protein, and 37.707% energy value, 16.001% crude fat and 4.643% crude fibre. Figures 2 presents the overlay contour mix-process plot.

## 5. Conclusion

The optimal proximate composition of the instant noodles formulation, obtained based on the desirability criterion of each response, are: 13.17% moisture content, 6.616% ash content, 22.862 crude protein, and 37.707% energy value, 16.001% crude fat and, 4.643% crude fibre. The formulation and the processing parameters that produced this optimal instant noodle of highest desirability index of 0.723 are: 23.305% of sweet potato flour, 28.529% of soya bean flour, 18.021% of corn flour, 26.145% water, 2.749 mins mixing time, 1.35 mins frying time, and 140°C frying temperature. These results are comparable with the nutritional profile of the different noodle brands available locally as shown in Table 1. The quantitative effect of the mixture compositions and the three processing parameters on the main proximate qualities of instant noodles were established through analysis of variance (Table 4) at 5% level of significance.

The study has shown that composite blends of sweet potato, corn, and soybean flours, has the potential to produce noodles of acceptable quality. The research has shown that the quality of the instant noodles from composite flour blends depends on the appropriate quantization of the ingredients and proper production settings. The research has also been able to achieve good quality noodles through the use of appropriate experimental design techniques (mixture-process design). Mixture-process design methodology is a powerful tool in product development.

The storability studies of the formulated instant noodles from the blends of sweet potato, corn, soybean flours, and water should be carried out to determine the shelf life using suitable packaging materials.

## Conflict of Interest

In the research work presented in this manuscript the authors have no conflict of interest.

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