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Research Article

Optimization of ingredients for the production of noodles made from rice flour, soybean flour, corn and potato starch -I- optimal mixture design

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Abstract

Central composite mixture design was employed in the formulation of composite blends, numerical optimization of the protein, carbohydrate, texture, appearance, taste and overall acceptability score of the instant dried noodles prepared with rice flour (RF), soybean flour (SF), corn starch (CS) and potato starch (PS). Rice flour (X1, 70–85%), soy flour (X2, 5–15%), corn starch (X3, 5–15%) and potato starch (X4, 5–12%) were the independent variables investigated with respect to Six response variables including protein (Y1), carbohydrate (Y2), texture (Y3), appearance (Y4), taste (Y5) and overall acceptability (Y6). In all 20 experiments were conducted by I-optimal mixture design keeping the upper and lower values of ingredients above in range. Instant dried rice-soy noodles were developed. Regression analysis of all the analyzed responses showed $R^2>0.75$, predicted R^2 and adjusted R^2 were in reasonable agreement. With correlation coefficients of -0.912, -0.841, -0.843, -0.844 and -0.829, for carbohydrate content, texture, appearance, taste and overall acceptability respectively, soybean flour demonstrated a negative association with rice soy noodles. Whereas, soybean flour had a significant ($p<0.05$) impact on the crude protein. Additionally, the 3D surface plot revealed that an increase in soybean flour setting resulted in an increase in protein content and a decrease in the values for carbohydrates, textural appearance, and overall acceptability. Numerical optimization was conducted on the basis of research objectives. Protein and carbohydrate content were maximized with the lower and upper values of 10-12 and 65-75 respectively, while texture, appearance and overall acceptability were set in range with the values of 7.5-8.5. Four optimum solutions were selected with blend ratio of 70:13.13:11.75:5.12 (sample A), 73.297:11.664:5.082:9.956 (sample B), 72.995:11.585:5.199:10.222 (sample C) and 72.198:11.283:5.498:11.020 (sample D) for RF:SF:CS:PS with corresponding desirability ratings of 0.904, 0.894, 0.891 and 0.842 which resulted in the predicted value of 12.827 and 78.271% for protein and carbohydrate while texture, appearance, taste and overall acceptability score were 7 (like moderately), 8.5 (like very much), 8.0 (like very much) and 8 (like very much) respectively.

Keywords: Optimization, dried instant noodles, Rice, Soybean, corn, potato, I-optimal mixture design

INTRODUCTION

Noodles are dried thin strands of wheat dough and alkaline solution. They are ready-to-eat, safe and nutritious products that have become popular among all strata of the Nigerian populace. The term “Asian noodles” is used very broadly to describe noodle-like products from Eastern, Southeastern, or Pacific Asian countries that are made from non-wheat flour, rice flour, or other starch materials as the main structural ingredients (Lu & Nip, 2006). Wheat flour

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and water easily form a dough through appropriate mixing and kneading techniques that facilitate sheeting and slitting into strips or strands to produce noodles. This unique ability to form cohesive, elastic and extensible dough is attributed to gluten, the unique protein in wheat (Hoseney, 1990). Noodles made from rice flour or starches from several sources such as maize and potato differ from wheat noodles in many aspects such as nutritive and structural components (Buddenhagen & Persley 1978).

Rice and starch-based noodles are better alternatives to address the increasing demand for noodles and also reduce the increased demand for wheat importation in Nigeria. The characteristics of gluten-free noodles are heavily dependent on the functional properties of the starch as it undergoes one or two heat treatments during processing (Mestres, 1988; Young et al., 1996).

The lowland NERICA 6 is an improved high yielding, flood-tolerant rice variety that is widely adopted by small-scale farmers in Nigeria. The inclusion of this variety in noodle production is expected to contribute to the income of these farmers and food security through value addition.

Soybean is one of the most nutritious legumes with 36.4 % protein. It also contains several essential amino acids and is important fortifying carbohydrate-rich diets in developing countries such as Nigeria. It also contains valuable phytochemicals and has an extraordinary capacity to nourish and prevent diseases. Soya is also known to be a good source of the trace elements copper, zinc, and manganese and can be said to contain all the nutrients needed in food (Ampofo, 2009). Acceptable noodles have been produced using soybean flour and cassava flour incorporation. Combing soybean flour and rice flour is expected to increase the protein content of rice noodles.

Starch is a primary material in the production of noodles. Owing to the absence of gluten compared to wheat flour, the physicochemical, thermal, and rheological properties of s of starch determine the quality of gluten-free noodles. Composite starches are more effective than single starches for the textural improvement of rice noodles (Sun, 2006). Composite starches can increase the tensile property of gluten-free noodles and decrease the percentage of broken noodles and cooking loss significantly (Sun, 2006). Corn starch is usually used to increase the hardness and decrease the adhesiveness of rice noodles. It is attributed to the high amylose content of corn starch (34.4%). Potato starch can also improve the transparency and elasticity of starch noodles. Sun (2006) also reported that the gelatinization temperature of potato starch is lower than that of corn starch but its swelling power is 48 times that of corn starch. Potato starch also has a slower retrogradation rate and is very effective in decreasing the percentage of broken noodles (Hou, 2010).

Optimization experiments have the advantage of predicting desired responses without the need for repeated laboratory experiments at every variation of I the ingredients of a product. I-optimal split-plot designs, minimize the average prediction variation. I-optimal designs aim to reduce the whole design space's average prediction variance (Goos & Jones, 2012). Additionally, compared to their estimation-oriented D-optimal counterparts, the prediction-oriented I-optimal split-plot designs offer more accurate factor impact estimates (Goos and Jones, 2012).

The objective of this study was to establish the optimum levels of rice flour, soybean flour, corn and potato starch for the production of rice soy noodles and determination of ingredients levels on protein, carbohydrate, colour, texture, appearance, taste and overall acceptability of rice soy noodles.

MATERIALS AND METHODS

White rice (Lowland Nerica 6) was purchased from Taraba State, Nigeria, and soybean (Glycine max) was purchased from mile one market, Port Harcourt, River State, Nigeria. Other ingredients needed for the preparation and analysis of rice noodles were purchased from Merck chemical limited, Lagos state, Nigeria

Preparation of rice flour

Local white rice flour was processed using the method described by Eke-Ejiofor and Nwiganale, with slide modification as shown in **Figure 1.** Rice grains were sorted and cleaned, known quantity of the rice was fermented in a known amount of water in a ratio of 1:3 for 16 hours, then crush and dry at 60°C for 4 hours (partial drying) to 24% moisture content, milled and finally dried at 60°C for 12 hours then sieved with a mesh size of 150 microns (Wang et al., 2004).

Preparation of soybean flour

Soybean flour was prepared by the method described by (Adekoyeni et al., 2013). Soybeans was sorted to remove particles and washed in clean tap water. The seeds were boiled for 30mins and drained so as to inactivate the trypsin inhibitors followed by dehulling using a manual method i.e. hand rubbing within two palms, after dehulling, the soybean seeds were dried in a hot air oven at 70°c for 10 hours. After drying the soybean hulls were removed by winnowing, and the dried samples were milled to fine powder and sieved through a standard sieve of 200μm particle size.

Alkaline formulation

Alkaline was prepared following the method described by Hou (2010), with modification. The alkaline ingredient contained 3.6g potassium carbonate, 2.3g sodium carbonate

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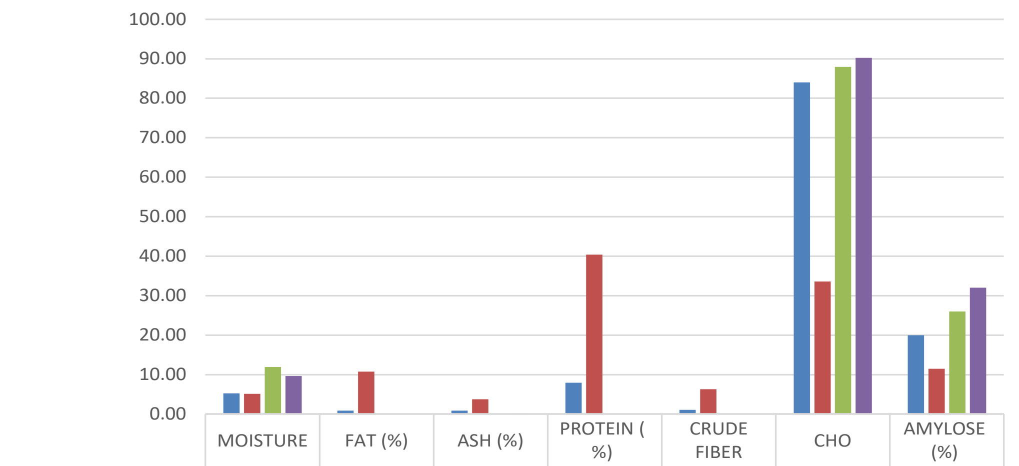

	MOISTURE	FAT (%)	ASH (%)	PROTEIN (%)	CRUDE FIBER	CHO	AMYLOSE (%)
RICE FLOUR	5.24	0.87	0.86	7.94	1.05	84.05	20.00
SOY BEAN FLOUR	5.14	10.79	3.78	40.41	6.32	33.57	11.50
POTATO STARCH	11.92	0.00	0.17	0.00	0.00	87.92	26.00
CORN STARCH	9.63	0.00	0.14	0.00	0.00	90.23	32.00

Figure 1. Proximate composition /amylose content of rice flour soybean flour potato and corn starches.

(2.3), 0.00015g riboflavin, 3.57g polyrinsan, 2.86g gaur gum, 3.0g iodized salt and 1 liter of treated water.

Experimental design

Optimal Custom Mixture Design (Design-Expert version 13.0.5.0 Stat-ease, Inc, 2021) was used to design the research. the design generated 20 runs by mixing four (4) components at two (2) levels which were rice flour X1 (70-85%), soybean flour X2 (5-15%), corn starch X3 (5-15%) and potato starch X4 (5-12%) with five (5) replicate points. **Table 1** shows the formulated mixture runs generated from the design.

Where: $\sum X i = X1 + X2 + X3 + X4 = 100$ (1)

Production of gluten free noodles

Rice -soy noodle was produced according to the method described by Sun (2006). 100g of composite flour blend was transferred into the mixer followed by the addition of 28 ml alkaline solution and 50 ml warm water (75°C), with continuous mixing, with steady mixing to form a dough. Strand formation was carried out through the help of an extruder with 1.5 mm aperture diameter, produced strand was steam at a temperature of 100^0C for 15 min, followed by another second of extruding to give a fine and smooth strand surface to control the thickness. Steamed rice noodles were dried at 70^0C for two hours. The dried gluten-free noodles were allowed to cool followed by packaging.

Proximate composition and amylose content

The methods described by AOAC (2012) were used to determine protein, fiber, fat, moisture and ash contents of rice, soybeans, potato and corn starches. carbohydrate was determined by difference.The amylose content of these samples was also determined by (AOAC 2012) methods. The proximate composition of the rice-soy noodle samples was determined by (AOAC 2012) methods while their carbohydrate contents were determined by difference. The determinations were carried out in triplicates.

Sensory evaluation of rice-soy noodles

Twenty (20) semi-trained panelists who are familiar with noodles were randomly selected from students and staff of the Department of Food Science and Technology Rivers State University, Nigeria to evaluate the products. Evaluation of all the samples took place in a sensory booth. Panelists were instructed to evaluate appearance, texture, taste and overall acceptability of the noodles. A 9-Point hedonic scale was used with 1=dislike extremely, 5=neither like nor dislike and 9=like extremely (Ocheme et al., 2018). Samples were identified with 3-digit code numbers and presented in a random sequence to the panellists. Glass of water was provided for the panelists to rinse their palate after each sample and expectoration bowls with lids were provided for assessors in the event they did not wish to swallow the samples. To prevent interfering with other panelists, the panelists were advised to remain silent throughout the evaluation. They were also asked to comment freely on samples on the form given to them.

Statistical analysis

Statistical analysis of variance (ANOVA), correlation coefficient determination and fit regression analysis

Table 1. Formulation of composite flour blends (%) for rice -soy noodle production.

Run	X_1 (Rice flour)	X_2 (Soybean flour)	X_3 (Corn starch)	X_4 (Potato starch)
1	77.04	5.96	5.00	12.00
2	75.50	9.51	9.99	5.00
3	81.22	5.33	8.45	5.00
4	77.47	5.00	9.15	8.38
5	70.00	12.19	6.50	11.31
6	70.00	9.20	13.16	7.64
7	85.00	5.00	5.00	5.00
8	75.00	5.00	15.00	5.00
9	74.77	8.82	7.12	9.29
10	70.00	12.19	6.50	11.31
11	75.50	9.51	9.99	5.00
12	77.47	5.00	9.15	8.38
13	80.13	9.87	5.00	5.00
14	75.51	12.59	5.00	6.90
15	70.00	15.00	10.00	5.00
16	71.07	8.04	8.89	12.00
17	70.00	9.20	13.16	7.64
18	75.51	12.59	5.00	6.90
19	73.50	5.93	11.88	8.70
20	70.00	5.00	13.00	12.00

were carried out on the data generated from protein, carbohydrate, texture, appearance and overall acceptability of rice soy noodles using statistical software (Design-Expert version 13.0.5.0 Stat-ease, Inc, 2021). Mean separation and one sample T-test were carried out using Minitab software version 20.0.

Numerical optimization

Optimization of formulation Numerical values of independent variables and simultaneous optimization of the multiple responses were carried out by choosing the desired goals for each variable and response by using Design Expert software. Among the ingredients rice flour, soybean flour, corn starch and potato starch (Hoseney, 1990) were kept in the range so as to obtain formulation of blend ratio which produces gluten-free noodles with good nutritional and functional qualities. The pre-determined goal for protein and carbohydrate was maximized while texture, appearance and overall acceptability were set in range (Singh et al., 1989).

RESULTS AND DISCUSSION

Proximate composition of rice flour, soybean flour potato and corn flours

Potato starch had the highest mean moisture content of 11.92 % **(Figure 1).** Rice and soybean flours had similar moisture contents of 5.24 and 5.14%, respectively. Porter & Jones (2003) reported moisture content of 5.20% for soy flour. Soybean protein content of 40.41% was significantly ($p < 0.05$) higher than those of all the other ingredients. Protein was not detected in the potato and maize starches. This could either be due to the complete absence of protein or they were present in amounts lower than the limits of detection of the procedure used. Carbohydrate is the most abundant nutrient in rice flour, potato and maize starches. The values obtained in this study **(Figure 1)** are similar to those reported by with carbohydrate content ranging from 76.55 to 82.48% in new rice for African flour. The amylose content of rice flour **(Figure 1)**, the main ingredient in the formulated rice soy noodles, was less than the 27% minimum recommended for production of noodles with acceptable texture. However, inclusion of corn and potato starches with 26 and 30% amylose compensated for the shortfall (Young et al., 1996).

Protein and carbohydrate contents of rice- soy noodles

Table 2 shows the mean values of protein, carbohydrate, texture, appearance and overall acceptability of rice soy noodles. Experimental runs had a significant ($p<0.05$) effect on the crude protein and carbohydrate contents, texture, appearance and overall acceptability of the noodles. Crude protein content ranged from 9.51 to 14.46 %. Sample 4 had the lowest protein content with 5% soy flour addition while sample 15 had the highest protein content with 15% soy flour addition. The increase was attributed to the level of substitution of other ingredients with soybean flour. Soybeans were considered in the formulation because of their high protein content and quality amino acid profile and their content of minerals, such as calcium and iron (Plahar et al., 2003). Adding rice flour and corn starch also decreases

Table 2. Means of protein, carbohydrate, texture, appearance, taste and overall acceptability of gluten-free noodles.

Runs	Factors				Responses					
	A	B	C	D	Protein (%)	CHO (%)	Texture	Appearance	Taste	Overall Acceptability
1	77.04	5.96	5.00	12.00	$10.29^{h} \pm 0.00$	$81.12^{h} \pm 0.00$	$5.60^{e} \pm 0.97$	$6.60^{d} \pm 0.97$	$7.50^{abcd} \pm 1.58$	$6.57^{e} \pm 1.15$
2	75.50	9.51	9.99	5.00	$10.43^{g} \pm 0.03$	$81.74^{e} \pm 0.01$	NE	NE	NE	NE
3	81.22	5.33	8.45	5.00	$9.55^{m} \pm 0.01$	$82.92^{b} \pm 0.03$	$7.50^{bcd} \pm 0.71$	$7.90^{abc} \pm 0.88$	$7.30^{bcd} \pm 1.10$	$7.83^{abcd} \pm 0.43$
4	77.47	5.00	9.15	8.38	$9.51^{m} \pm 0.01$	$83.20^{a} \pm 0.01$	$8.70^{ab} \pm 0.87$	$8.60^{a} \pm 0.52$	$8.10^{abc} \pm 0.74$	$8.37^{ab} \pm 0.22$
5	70.00	12.19	6.50	11.31	$13.11^{c} \pm 0.03$	$77.36^{o} \pm 0.01$	NE	NE	NE	NE
6	70.00	9.20	13.16	7.64	$10.21^{i} \pm 0.00$	$81.00^{i} \pm 0.03$	$6.90^{d} \pm 1.37$	$7.10^{bcd} \pm 0.74$	$6.70^{d} \pm 0.68$	$7.13^{de} \pm 0.59$
7	85.00	5.00	5.00	5.00	$9.98^{k} \pm 0.01$	$82.74^{c} \pm 0.01$	$7.70^{abcd} \pm 1.25$	$7.10^{bcd} \pm 1.10$	$7.10^{cd} \pm 1.20$	$7.35^{cde} \pm 0.75$
8	75.00	5.00	15.00	5.00	$10.13^{j} \pm 0.03$	$82.14^{d} \pm 0.00$	$7.60^{abcd} \pm 0.52$	$8.20^{ab} \pm 1.23$	$8.80^{a} \pm 0.42$	$8.08^{abc} \pm 0.73$
9	74.77	8.82	7.12	9.29	$10.32^{h} \pm 0.03$	$81.30^{g} \pm 0.00$	$7.90^{abcd} \pm 0.74$	$8.50^{a} \pm 0.71$	$7.50^{abcd} \pm 0.85$	$8.13^{abc} \pm 0.54$
10	70.00	12.19	6.50	11.31	$13.15^{c} \pm 0.02$	$77.50^{n} \pm 0.01$	NE	NE	NE	NE
11	75.50	9.51	9.99	5.00	$10.48^{fg} \pm 0.01$	$80.73^{k} \pm 0.00$	NE	NE	NE	NE
12	77.47	5.00	9.15	8.38	$10.10^{j} \pm 0.00$	$81.70^{e} \pm 0.01$	$8.50^{abc} \pm 0.53$	$8.80^{a} \pm 0.42$	$8.50^{ab} \pm 0.53$	$8.62^{a} \pm 0.14$
13	80.13	9.87	5.00	5.00	$10.76^{d} \pm 0.01$	$79.77^{m} \pm 0.00$	NE	NE	NE	NE
14	75.51	12.59	5.00	6.90	$13.43^{b} \pm 0.02$	$77.02^{p} \pm 0.01$	NE	NE	NE	NE
15	70.00	15.00	10.00	5.00	$14.46^{a} \pm 0.02$	$73.55^{r} \pm 0.01$	NE	NE	NE	NE
16	71.07	8.04	8.89	12.00	$10.21^{f} \pm 0.01$	$80.42^{l} \pm 0.03$	$7.40^{cd} \pm 0.52$	$7.70^{abcd} \pm 0.48$	$7.70^{abcd} \pm 0.48$	$7.63^{bcd} \pm 0.31$
17	70.00	9.20	13.16	7.64	$10.43^{e} \pm 0.01$	$79.80^{m} \pm 0.01$	$6.90^{d} \pm 0.74$	$6.80^{cd} \pm 0.42$	$8.10^{abc} \pm 0.99$	$7.35^{cde} \pm 0.40$
18	75.51	12.59	5.00	6.90	$13.22^{b} \pm 0.00$	$76.93^{q} \pm 0.01$	NE	NE	NE	NE
19	73.50	5.93	11.88	8.70	$10.15^{i} \pm 0.00$	$80.90^{j} \pm 0.00$	$8.80^{a} \pm 0.42$	$8.80^{a} \pm 0.42$	$8.30^{abc} \pm 0.48$	$8.35^{ab} \pm 0.15$
20	70.00	5.00	13.00	12.00	$9.78^{l} \pm 0.03$	$81.62^{f} \pm 0.01$	$8.10^{abcd} \pm 0.88$	$8.50^{a} \pm 0.97$	$8.60^{ab} \pm 0.69$	$8.45^{ab} \pm 0.64$

Values are means ± Standard Deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($P<0.05$)

Key: X_1 =A= Rice Flour (Nerica 6);

X_2 = B = Soybean Flour;

X_3 = C = Corn Starch;

X_4 = D = Potato Starch;

NE= Not Evaluated

the protein content of rice soy noodles. Okpalanman & Chukwu, (2020) also reported that increasing the quantity of cassava flour in the blend decreases the protein content and that increase in both soybean and wheat flour in the blend increased the protein content of the biscuit. Protein content in rice soy noodles was similar to those quoted by Nagao (1996) for alkaline noodle flours (10.5–12%). Crosbie et al., (1999) recorded protein contents ranging between 10 and 12.2% in 21 experimental noodle samples, while the commercial Top Raman noodle contained 11% protein. Baik & Lee (2003); Wang et al. (2004) reported that the protein values were between 10.5-16.4 and 10.1-19.3% respectively for cooked white salted noodles.

The Carbohydrate content for the 20 runs ranged from 73.55 to 83.20%. The carbohydrate content was influenced by the combined effect of rice flour, corn and potato starch. The carbohydrate content decreased significantly ($p<0.05$) with an increase in soybean flour substitution, 83.20% with 5% soybean flour addition in sample 4 and 73.55 % carbohydrate with 15% soybean flour addition in sample 15.

Mean scores for texture, appearance, taste and overall acceptability of rice- soy noodle

Texture depicts the chewiness, firmness and/or softness, springiness, elasticity, and other bite characteristics of instant rice soy noodles. Texture score ranged from 5.6 to 8.8 which indicated neither like nor dislike to like very much. Development of paste during instant noodles preparation was observed in samples 2, 5, 10,11,13,14,15 and 18, this was due to the high soybean flour percentage of above 9.51%, Rice soy noodles texture score increased with the increase in the addition of corn and potato starch this was due to their high amylose content of 32 and 26% respectively Soybean negatively impacted the texture of rice soy noodles with a correlation coefficient of -0.841 **(Table 7)** Wu & Corke (2005) also reported that due to the protein structure, related to the potential for crosslink formation, can affect noodle texture. According to Hou (2021) in improving the processing and texture of noodles, starch or vital gluten is added.

Appearance plays a major role in determining consumer acceptance of food products. The highest appearance score of 8.80 (like very much) of rice soy noodles was observed in sample 19 which was due to the low content of soybean flour. Soybean flour also exhibited and negative correlation coefficient of -0.843 (**Table 7**) which indicated that an increase in rice-soy noodles resulted in a reduction in the appearance score. The reduction of the degree of likeness of appearance is due to the Maillard reaction that occurred during the drying of rice soy noodles thereby leading to browning. This study reveals that an increase in rice flour, corn and potato starch resulted in a significant (p<0.05) increase in the degree of likeness of the appearance of the rice soy noodles. Sharma & Chanhan (2000) reported a decrease in the appearance score of composite flour baked products as substitution increased. Similarly, Emeka et al., (2020) also reported a reduction in appearance (darker and brownish colour) score with an increase in the addition of soybean flour and cassava flour in the production of biscuits. The main senses stimulated by oral processing of food are taste (Pereira & Van der Bilt, 2016). Sample 8 had the highest taste score of 8.80 indicating "*like very much*" and the lowest taste score of 6.70 was observed in sample 6 indicating "*like slightly*". The low score rating observed in sample 6 may be due to the increased addition of soybean flour. Some panelists observed beany taste in the sample. Oknalanma et al., (2020), also reported limiting sensory attributes of a beany taste in biscuits with the addition of soybean flour. This report agrees perfectly with Sabanis & Tzia (2009) and Mohammed, Ahmed & Senge (2003). The overall acceptability score of rice soy noodles ranged from 6.57 (like slightly) to 8.63 (like very much). Sample 12 had the highest overall acceptability, which is attributed to the increase in the composite combination of rice flour, corn and potato starch. Nevertheless, soybean flour exhibited a negative correlation of -0.829 **(Table 7)** with the overall acceptability. Savita, et al., (2018) also reported that the overall acceptability of multigrain gluten-enriched instant noodles reduced with an increase in soy flour. Collins and Pangloli (1997) also reported that the sensory acceptability of sweet potato and soy flour incorporated noodles decreased with increased levels of soy flour.

Fitting the model

Protein content of rice-soy noodles

The ANOVA for protein indicated a quadratic model with a p-value of 0.0001 it also indicates that there was an interactive effect of soybean flour on the protein content of the noodles in **Table 3**, this shows the individual effect

Table 3. ANOVA results of responses as linear, quadratic, special cubic and interaction terms on each response.

Source	Protein		CHO		Texture		Appearance		Taste		Overall Acceptability	
	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
Model	112.43	< 0.0001	26.81	< 0.0001	3387.34	< 0.0001	1440.11	< 0.0001	96.09	< 0.0001	187.47	< 0.0001
(1) Linear Mixture	188.48	< 0.0001	70.8	< 0.0001	11370.04	< 0.0001	4923.45	< 0.0001	312.57	< 0.0001	576.65	< 0.0001
AB	90.83	< 0.0001	21.55	0.0009	126.02	< 0.0001	132.04	< 0.0001	1.56	0.2524	10.86	0.0132
AC	-	-	1.88	0.2001	43.52	0.0006	73.97	0.0001	0.4384	0.5291	16.42	0.0049
AD	-	-	0.0254	0.8766	399.38	< 0.0001	224.06	< 0.0001	5.43	0.0527	48.37	0.0002
BC	89.76	< 0.0001	18.11	0.0017	422.82	< 0.0001	298.54	< 0.0001	35.67	0.0006	29.3	0.001
BD	31.27	< 0.0001	7.67	0.0198	124.88	< 0.0001	95.82	< 0.0001	0.0798	0.7858	10.05	0.0157
CD	-	-	0.2893	0.6024	19.79	0.0043	20.63	0.0039	1.49	0.2612	-	-
ABC	-	-	-	-	661.32	< 0.0001	447.37	< 0.0001	46.89	0.0002	52.08	0.0002
ABD	-	-	-	-	2713.52	< 0.0001	1362.25	< 0.0001	75.4	< 0.0001	179.8	< 0.0001
ACD	-	-	-	-	611	< 0.0001	231.38	< 0.0001	4.73	0.0661	43.09	0.0003
BCD	-	-	-	-	126.43	< 0.0001	114.47	< 0.0001	-	-	8.75	0.0212
Lack of Fit	1.72	0.2842	0.9736	0.5114	2.49	0.1751	0.7808	0.4174	0.7718	0.5104	0.8062	0.4972
Fit Statistics												
Std. Dev	0.2536		0.6838		0.071		0.1119		0.4452		0.3239	
Mean	10.99		80.17		4.98		5.13		5.11		5.04	
C.V. %	2.31		0.8529		1.42		2.18		8.71		6.42	
R^2	0.9811		0.9602		0.999		0.997		0.994		0.9969	
Adjusted R^2	0.9724		0.9244		0.999		0.999		0.984		0.9916	
Predicted R^2	0.924		0.757		0.913		0.916		0.826		0.9295	
Adeq Precision	31.4735		19.2907		133.3235		84.2113		21.965		30.6279	

Significant at p<0.05

(A, B, C and D) and interactive effect AB, BC and BD terms were significant (p≤0.05) while AC, AD and CD were not significant to the model. The coefficient estimate of protein for the components are: A (+9.84), B (+23.10), C (+11.21), D (+9.66), BC (-19.21), and BD (-10.94), while the multiple regression equation for describing the relationship between protein and ingredients (coded form) after neglecting the non-significant terms is given below (Eq. 4)

$$Y1\ (protein) = 9.84A + 23.101B + 11.21C + 9.661D - 14.59AB - 19.21BC - 10.94BD \quad (2)$$

$$R^2 = 98.11$$

The lack of fit for % crude protein was not significant (p≤0.05) with a p-value of 0.2842 which indicate that the model accommodated more observations by less than the variation between replicates, fit statistic standard deviation, C.V %, R2, adjusted R2, predicted R2 and adeq precision were 0.2536, 10.99, 2.31, 0.9811, 0.9724, 0.9240 and 31.4735 respectively. The Model F-value of 112.43 implies the model is significant. The interactive effect of AB, BC and BD was significant with a p-value less than 0.0500, this is because the main effect B had a high amount of protein of about 36.405% (**Figure 1**).

R- squared value is an indication of the level of response that could be explained by the model (Okpalanma et al., 2020). The Predicted R^2 of 0.8829 is in reasonable agreement with the Adjusted R^2 of 0.9750. The adequate precision test measures the signal to noise ratio. It compares the range of the predicted values at the design points to the average prediction error. A ratio greater than 4 indicates adequate model discrimination and then the model can be used to navigate the design space. The ratio of 31.4735 indicates an adequate signal therefore the model can be used to navigate the design space.

There was a relative increase in protein content with an increase in soybean flour, this was seen in the positive coefficient of 23.19 for soybean flour in the predictive equation. Also, the positive correlation coefficient of 0.898 **(Table 7)** also indicates an increase in protein content or rice soy noodles with an increase in soybean flour. The 3D surface plot (Fig 2a) also shows that an increase in soybean settings resulted in a significant (p<0.05) increase in the overall protein content of the product, while an increase in rice flour and corn starch setting decreases the protein content of rice soy noodles. Emeka et al., (2020) also reported that increasing the quantity of cassava flour in the blend decreases the protein content and that increase in both soybean and wheat flour in the blend increased the protein content of the biscuit. However, soybean flour contributed more to the increase in protein than wheat flour.

Carbohydrate content of –rice soy noodles

The suggested quadratic model on the carbohydrate content is shown in (**Table 4)**. Based on the ANOVA, the interactive effect AB, BC and BD were significant (p≤0.05) while AC, AD and CD were not significant to the model. The lack of fit for % carbohydrate was not significant (p≤0.05) with a p-value of 0.3066. also fit statistic standard deviation, C.V%, R2, adjusted R2, predicted R2 and adeq precision were 0.6838, 80.17, 0.8529, 0.9602, 0.9244, 0.7570 and 19.2907 respectively. The coefficient estimate of carbohydrates for the components are: A (+82.63), B (+62.11), C (+79.86), C (+80.16), AB (-19.40), BC (+25.52), and BD (+22.30), while the multiple regression equation for describing the relationship between carbohydrate and ingredients (coded form) after neglecting the non-significant terms is given below (Eq. 4)

$$Y2\ (CHO) = 82.63A + 62.11B + 79.86C + 80.161D - 19.40AB + 25.52BC + 22.30BD \quad (3)$$

$$R^2 = 96.02$$

The Model F-value of 26.81 implies the model is significant. The interactive effect of AB, BC and BD were all significant with a p-value less than 0.0500, this is because of main effects A, C and D (rice flour, corn and potato starch) had a considerable amount of carbohydrates of about 84.05, 87.92 and 90.23% respectively **(Figure 1).** A similar result was also reported by warda with carbohydrate content ranging from 76.55 to 82.48% in new rice for Africa flour.

The Lack of Fit F-value of 0.97 implies the lack of fit is not significant relative to the pure error. The Predicted R^2 is in

Table 4. Constraints fixed for numerical optimization of independent variables and responses.

Variables	Goal	Lower limit	Upper Limit
Rice Flour (%)	In range	70	85
Soybean flour (%)	In range	5	15
Corn starch (%)	In range	5	15
Potato starch (%)	In range	5	12
Protein (%)	Maximize	10	12
Carbohydrate (%)	Minimized	65	75
Texture	In range	7.5	8.5
Appearance	In range	7.5	8.5
Taste	In range	7.5	8.5
Overall Acceptability	In range	7.5	8.5

reasonable agreement with the Adjusted R^2. Observed adeq Precision is desirable (Chang et al., 2006).

From equation 3, it can be seen that there is a relative increase in soybean flour resulting in a reduction in the carbohydrate content of rice soy noodles, also the negative correlation coefficient was -0.912 **(Table 7)** also agrees with the equation of coded factor. From this study, an increase in soybean addition resulted in a significant (p<0.05) reduction in the carbohydrate content of the gluten-free noodles and also an increase in rice flour and corn starch resulted in an increase in the carbohydrate content of the samples. Okpalanma et al. (2020) also reported that increasing soybean flour significantly decrease the carbohydrate content of biscuit. However, there was a need to control the carbohydrate level in gluten-free noodles as an increase in carbohydrate content can increase the cooking loss in noodles (Fu, 2008). The 3D plot also reveal that increase in the setting of rice flour, corn and potato starch increased the carbohydrate content of rice soy noodle, this is due to the high carbohydrate content of 84.95, 87.95 and 90.23% in rice flour, potato and corn starch respectively **(Figure 1).**

Texture of rice-soy noodles

The suggested special cubic model on the texture of rice soy noodle is shown in **Table 4**. Based on the analysis of variance (ANOVA), all the interactive effect AB, AC, AD, BC, BD, CD, ABC, ABD, ACD and BCD were significant (p≤0.05) to the model.

The lack of fit for texture was not significant (p≤0.05) with a p-value of 0.1751. Also, fit statistic standard deviation, C.V%, R2, adjusted R2, predicted R2 and adeq precision were 0.071, 4.98, 1.42, 0.999, 0.99, 0.913 and 133.3235 respectively. The coefficient estimate of texture for the components are: A (+ 7.69), B (-28.96), C (+5.59), D(+15.42), AB (+23.76), AC (+5.81), AD (-39.74), BC (+83.02), BD (+37.46), CD (8.41), ABC (-180.21), ABD (+251.06), ACD (+125.71), and BCD (-165.64), While the Model for texture is presented as:

Y3 (Texture) =

$$7.69A - 28.96B + 5.59C + 15.42D + 23.76AB + 5.81AC - 39.74AD + 83.02BC + 37.46BD - 8.41CD - 180.21ABC + 251.06ABD + 125.71ACD - 165.64BCD \quad (4)$$

$$R^2 = 99.9$$

The ANOVA for texture indicates the interactive effect of the independent variable. The Model F-value of 3387.34 implies the model is significant. All the interactive effects were significant with a p-value less than 0.0500, this is because all the main effects played a major role in the texture of the gluten-free noodles.

The Lack of Fit F-value of 2.49 implies the Lack of Fit is not significant relative to the pure error. Non-significant lack of fit is required for the model to fit. R- squared value is an indication of the level of response that could be explained by the model (Okpalanma et al., 2020). The result shows that 99.99% of the response could be explained by the model at 0.0001 significant level. The Predicted R^2 of 0.9128 is in reasonable agreement with the Adjusted R^2 of 0.9996; due to the difference is less than 0.2.

The regression equation in terms of coded factors can be used to make predictions about the texture for given levels of each factor. Here, the levels should be specified in the original units for each factor.

The texture of rice soy noodles was affected by the addition of corn and potato starches. This may be due to the high content of amylose content of 26 and 32 %, respectively (**Figure 1**). Tungtrakul (1998) reported that amylose content greater than 27% is recommended for production of rice noodles. Generally, the best substrate for starch noodles is considered to be starch from legumes like mung beans, which normally have more than 30% amylose content (Hou, 2010). The alkaline salt composition has a significant effect on noodle color, whereas concentration has a significant impact on noodle texture (Hatcher & Anderson 2007). There was an inverse proportionality of soybean flour concentration to the texture of rice soy noodles with a correlation coefficient of -0.841. Wu & Corke (2005) also reported that due to the protein structure, related to the potential for crosslink formation, can affect noodle texture.

Appearance of rice-soy noodles

The suggested special cubic model on the analyzed appearance of gluten-free noodles shown in **Table 3**. All the interactive effect AB, AC, AD, BC, BD, CD, ABC, ABD, ACD and BCD were significant (p≤0.05) to the model.

The lack of fit for texture was not significant (p≤0.05) with a p-value of 0.7808. Also, fit statistic standard deviation, C.V%, R2, adjusted R2, predicted R2 and adeq precision were 0.1119, 5.13, 2.18, 0.997, 0.999, 0.916 and 84.2113 respectively. The coefficient estimate of appearance for the components are: A (+7.09), B (-37.68), C (+4.73), D(+20.03), AB (+38.51), AC (+11.99), AD (-47.12), BC (+110.45), BD (+51.96), CD (-13.96), ABC (-234.96), ABD (+281.66), ACD (+122.49), and BCD (-249.54), While the Model for protein is presented as:

Y5 (Apperance) =

$$7.09A - 37.68B + 4.73C + 20.03D + 38.51AB + 11.99AC - 47.12AD + 110.45BC + 51.96BD - 13.96CD - 234.96ABC + 281.66ABD + 122.49ACD - 249.54BCD \quad (5)$$

$$R^2 = 99.7$$

The ANOVA for appearance noodles' the interactive effect of the independent variable on the appearance of gluten-free noodles. All the interactive effects were significant ($p<0.05$), this is because all the main effects played a major role in the appearance of the noodles.

The Lack of Fit F-value of 0.7808 implies the Lack of Fit is not significant relative to the pure error. Non-significant lack of fit was observed. The Predicted R^2 is in reasonable agreement with the Adjusted R. adequate precision ratio of 84.211 indicates an adequate signal

The equation in terms of actual factors (Eq. 5) can be used to make predictions about the appearance for given levels of each factor.

With coefficient of -37.68 in the regression equation, it is evident from the result that a relative increase in % soybean resulted in a reduction in the degree of likeness of the appearance. Objective colour determination of rice soy noodle colour also indicated that soybean to L* resulted in a negative correlation coefficient of -0.719 **(Table 7)**. The reduction of the degree of likeness of appearance is due to the mallard reaction that occurred during drying of rice soy noodle thereby leading to browning. This study reveals that an increase in rice flour, corn and potato starch resulted in a significant ($p<0.05$) increase in the degree of likeness of appearance of the rice soy noodles

Taste of rice-soy noodles

The suggested special cubic model on the taste of gluten-free noodles is shown in **Table 3.** Based on the analysis of variance (ANOVA), the interactive effect BC, ABC and ABD were significant ($p\leq0.05$) to the model.

Model lack of fit was not significant ($p\leq0.05$) with a p-value of 0.5104. also fit statistic standard deviation, C.V%, R2, adjusted R2, predicted R2 and adeq precision were 0.4452, 5.11, 8.71, 0.994, 0.9836, 0.8256 and 21.9650 respectively. The multiple regression equation for describing the relationship between taste and ingredients (coded form) after neglecting the non-significant terms is given below (Eq. 6)

$$Y5\ (\text{Taste}) = 7.14A - 15.55B + 8.32C + 16.18D + 38.71BC - 123.36ABC + 199.17ABD \qquad (6)$$

$$R^2 = 99.4$$

The Lack of Fit F-value of 0.7718 implies the Lack of Fit is not significant relative to the pure error. The Predicted R^2 of 0.8256 is in reasonable agreement with the Adjusted R^2 of 0.9836. Adeq Precision measures the signal-to-noise ratio. The result showed ratio of 84.211 indicating an adequate signal which implies that the model can be used to navigate the design space.

With a coefficient of -15.65 in equation 6, it is evident from the result that a relative increase in soybean flour resulted in a reduction in taste perception. Negative correlation coefficient of -0.844 **(Table 7)** indicates that an increase in soybean flour resulted in a reduction in the taste of rice soy noodles while increase in rice flour, corn starch and potato starch resulted in an increase in taste score with a correlation coefficient of 0.758, 0.430 and 0.259 respectively. 3D model **(Figure 2e)** also confirms the increase in soybean setting resulted in the reduction of taste score of rice soy noodles. This study reveals that an increase in rice flour, corn and potato starch resulted in a significant ($p<0.05$) increase in the degree of likeness of the appearance of the rice soy noodles (Caulibaly et al., 2006).

Overall acceptability of rice-soy noodles

The suggested special cubic model on the overall acceptability of gluten-free noodles is shown in **Table 4.6.** Based on the ANOVA, all the interactive effect AB, AC, AD, BC, BD, ABC, ABD, ACD and BCD were significant ($p\leq0.05$) to the model while CD (corn starch x potato starch) was insignificant to the model.

The lack of fit for overall acceptability was not significant ($p\leq0.05$) with a p-value of 0.5869. Also fit statistic standard deviation, C.V%, R2, adjusted R2, predicted R2 and adeq precision were 0.3216, 5.04, 6.38, 0.9974, 0.9917, 0.8600 and 29.9742 respectively. The coefficient estimate of overall acceptability for the components are: A (+7.28), B (-32.97), C (+3.68), D(+13.97), AB (+30.54), AC (+13.58), AD (-32.95), BC (+97.60), BD (+48.60), ABC (-225.27), ABD (+257.11), ACD (+81.07), and BCD (-193.55), While the Model for protein is presented as:

Y6 (Overall acceptability) =

$$7.28A - 32.97B + 3.68C + 13.97D + 30.54AB + 13.58AC - 32.95AD +$$

$$97.60BC + 48.60BD - 225.27ABC + 257.11ABD + 81.07ACD - 193.55BCD \qquad (7)$$

$$R^2 = 99.69$$

The ANOVA for overall acceptability indicates the interactive effect of the independent variable on the overall acceptability of gluten-free noodles. The Model F-value of 187.47 in **Table 3** implies the model is significant. It is evident from the result that all the interactive effects were all significant ($p<0.05$) except CD this is because the main effects A (Nerica rice) and B (Soybean flour) played a major role in the overall acceptability of the gluten-free noodles.

Acceptable lack of fit was observed. The result also showed that the Predicted R^2 is in reasonable agreement with the Adjusted R^2 of 0.9916; because the difference is less than 0.2. Adeq Precision measures the signal-to-noise ratio. This model provides adeq precision of 30.628 which indicates an adequate signal. This model can be used to navigate the

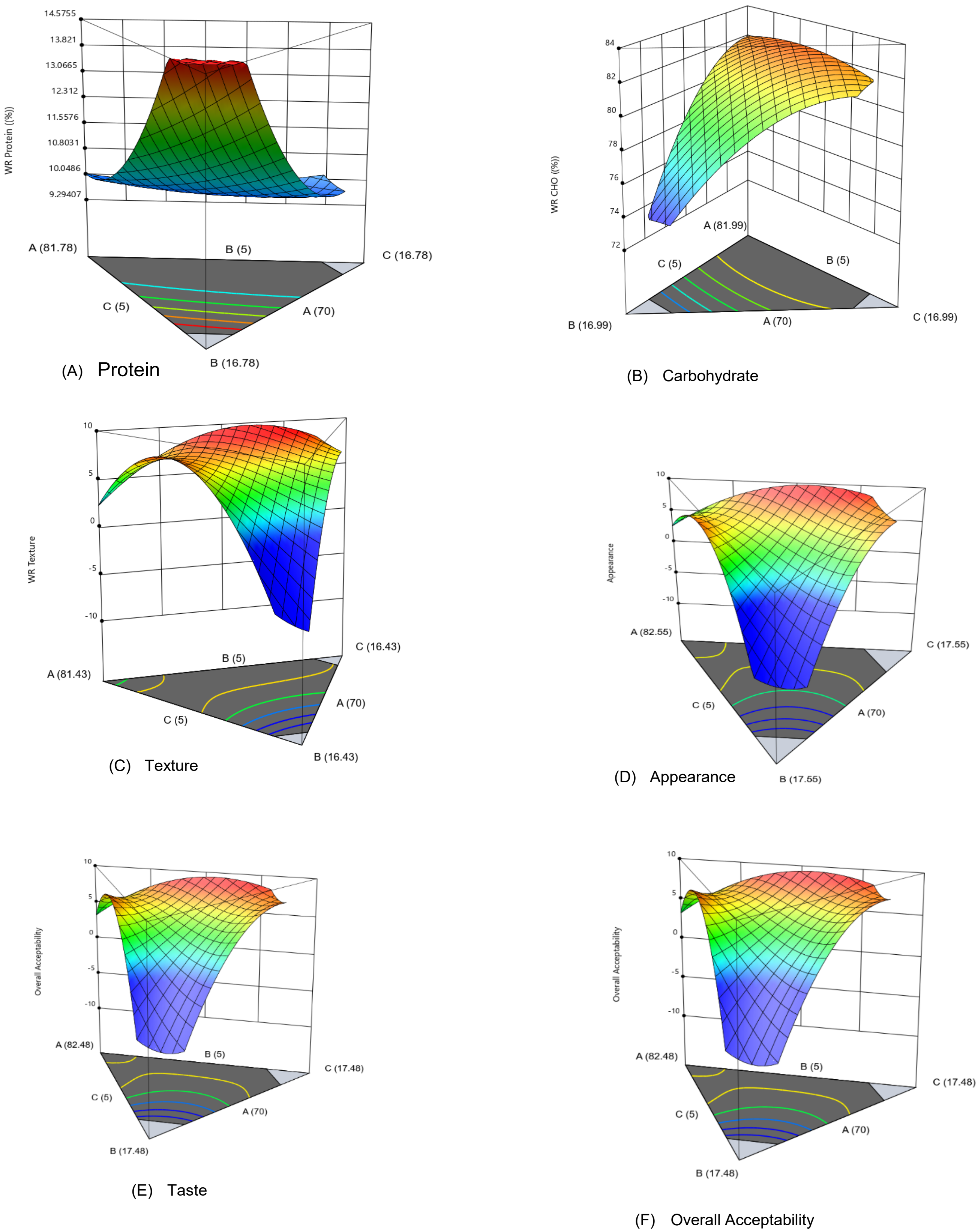

Figure 2. Effect of interaction of rice flour (A), soybean flour (B) and corn starch (C) on the protein, carbohydrate, texture, appearance, taste, and overall acceptability.

Table 5. Numerical optimization of protein, carbohydrate, texture, appearance, taste and overall acceptability of rice soy noodles.

Solutions	Factors				Predicted response value							
Number	Rice Flour	Soybean Flour	Corn Starch	Potato Starch	Protein	CHO	Texture	Appear	Taste	O/A	Desirability	Selected solution
1	70.000	13.133	11.749	5.117	12.542	76.576	7.000	8.500	8.000	8.002	0.904	Selected
2	73.568	11.698	5.000	9.734	12.849	77.809	7.000	8.500	8.000	7.925	0.903	
3	73.297	11.664	5.082	9.956	12.827	77.849	7.000	8.500	8.100	7.905	0.894	Selected
4	73.789	11.650	5.000	9.561	12.790	77.877	7.000	8.466	8.150	7.915	0.893	
5	72.995	11.585	5.199	10.222	12.763	77.943	7.000	8.490	8.000	7.878	0.891	Selected
6	74.122	11.561	5.000	9.318	12.688	77.997	7.000	8.421	8.150	7.904	0.879	
7	72.556	11.440	5.362	10.642	12.650	78.105	7.000	8.491	8.425	7.855	0.873	
8	74.522	11.428	5.000	9.051	12.550	78.168	7.000	8.377	8.144	7.896	0.849	
9	72.198	11.283	5.498	11.020	12.528	78.271	7.000	8.500	8.200	7.846	0.842	Selected
10	74.792	11.324	5.000	8.884	12.448	78.297	7.000	8.352	8.152	7.892	0.832	
11	75.229	9.990	5.910	8.871	11.363	79.777	7.500	8.500	8.102	7.950	0.825	
12	75.669	9.758	5.901	8.672	11.212	79.996	7.500	8.478	8.415	7.960	0.778	
13	71.617	9.635	6.881	11.867	11.198	79.886	7.500	8.500	8.515	7.733	0.774	
14	76.289	9.521	5.764	8.426	11.081	80.195	7.500	8.500	8.154	8.019	0.735	
15	76.955	9.182	5.648	8.214	10.907	80.462	7.500	8.500	8.225	8.074	0.673	
16	76.203	9.228	6.086	8.483	10.889	80.465	7.500	8.367	8.052	7.906	0.667	
17	77.566	8.857	5.513	8.064	10.763	80.689	7.500	8.500	8.152	8.136	0.618	
18	77.954	8.644	5.408	7.994	10.681	80.822	7.500	8.500	8.114	8.183	0.583	
19	78.614	8.256	5.188	7.942	10.556	81.025	7.500	8.500	8.250	8.283	0.527	
20	78.679	8.214	5.163	7.944	10.544	81.045	7.500	8.500	8.015	8.295	0.522	
21	79.049	7.912	5.000	8.039	10.473	81.162	7.500	8.500	8.442	8.383	0.486	
22	79.019	7.495	5.000	8.487	10.383	81.294	7.500	8.474	8.328	8.444	0.438	
23	78.561	7.143	5.093	9.203	10.329	81.342	7.500	8.484	8.500	8.475	0.405	
24	77.594	6.725	5.401	10.280	10.249	81.369	7.500	8.477	8.512	8.361	0.353	
25	74.119	5.000	15.000	5.881	10.218	81.901	8.193	8.500	8.524	8.099	0.330	
26	72.373	5.000	15.000	7.627	10.198	81.480	8.500	8.420	7.980	8.067	0.315	
27	71.523	7.844	8.633	12.000	10.189	81.036	8.044	8.500	7.990	8.082	0.308	
28	75.996	6.092	5.912	12.000	10.115	81.323	7.500	8.500	7.858	8.020	0.240	

design space. Pamplona & Roger GM (2005) the equation in terms of coded factors can be used to make predictions about the response (overall acceptability) for given levels of each factor. Here, the levels should be specified in the original units for each factor.

From the above equation, it is evident from the result that a relative increase in % soybean resulted in a reduction in the appearance of gluten-free noodles appearance, with a negative correlation coefficient of -0.829 **(Table 7)**. The effect of soybean flour on the gluten-free noodle appearance in the special cubic model. This study reveals that an increase in soybean addition resulted in a significant ($p<0.05$) reduction in the appearance of the gluten-free noodles and also an increase in rice flour (Nerica 6, corn starch, and potato starch) resulted in an increase in the appearance of the gluten-free noodles. Savita et al., (2018) also reported that the overall acceptability of multigrain gluten enriched instant noodles reduced with increase in soy flour. Collins & Pangloli (1997) also reported that sensory acceptability of sweet potato and soy flour incorporated noodles decreased with increased level of soy flour. Similar findings were also reported by Singh, Chauhan & Bains (1989) for noodles prepared for the noodles prepared with incorporation of conventional soy flour

Optimized formulations

The protein and carbohydrate content of the gluten-free noodle was optimized by maximizing the value (10-13%) and 65-75% respectively, while the texture, appearance and overall acceptability of the gluten-free noodle were in the range (7-8.5). Stat-ease Inc (2021) the response optimizer of the software generated 28 solutions of the ingredient value with the desirability of 0.24 to 0.904 and their respective protein, carbohydrate, texture, appearance and overall acceptability values as shown in **Table 4**. Suggested solution (1) and three other solution (3, 5 and 9) were selected and coded sample A, B, C and D. this was due to the high desirability.

Design validation

The selected blend obtained through optimization were validated by the development of gluten-free noodle and by analyzing the actual values of the responses in triplicate. The results for all responses were compared by one sample

Table 6. Predicted value and experimental quality attribute of rice soy noodles (One sample T-test).

Rice soy Noodles	Responses	Predicted Value	Experimental Value	p-Value	Residual	Significant
A	% Crude Protein	12.542	12.063	0.077	0.479	**
	% CHO	75.576	75.637	0.738	-0.061	**
	Texture	7	7.75	0.001	-0.75	*
	Appearance	8.5	8.25	0.171	0.25	**
	Taste	8.00	8.300	0.285	0.300	**
	Overall Acceptability	8.142	8.002	0.085	0.14	**
B	% Crude Protein	12.827	12.987	0.107	-0.16	**
	% CHO	77.849	74.693	0.00	3.156	*
	Texture	7	7.25	0.349	-0.25	**
	Appearance	8.5	8.55	0.666	-0.05	**
	Taste	8.10	7.95	0.459		**
	Overall Acceptability	7.905	8.075	0.015	-0.17	*
C	% Crude Protein	12.763	13.77	0.003	-1.007	*
	% CHO	77.943	73.663	0.00	4.28	*
	Texture	7	6.85	0.505	0.15	**
	Appearance	8.49	7.9	0.006	0.59	*
	Taste	8.00	8.00	1.00	0.00	**
	Overall Acceptability	7.878	7.625	0.013	0.253	*
D	% Crude Protein	12.528	10.257	0.00	2.271	*
	% CHO	78.271	77.45	0.00	0.821	*
	Texture	7	7.6	0.00	-0.6	*
	Appearance	8.5	8.35	0.505	0.15	**
	Taste	8.20	8.15	1.00	0.05	**
	Overall Acceptability	7.846	7.975	0.335	-0.129	**

Significant (*); not significant (**)

Table 7. Effect of ingredient ratio on the proximate, sensory attribute and cooking time of rice soy noodles.

Quality attribute	Rice flour	Soybean flour	Corn starch	Potato starch
Protein content	-0.38	0.898	-0.383	-0.003
Carbohydrate content	0.496	-0.912	0.271	-0.032
Texture	0.154	-0.841	0.443	0.225
Appearance	0.135	-0.843	0.444	0.255
Taste	0.758	-0.844	0.471	0.267
Overall Acceptability	0.129	-0.829	0.43	0.259

t-test **(Table 6).** The values of all the responses for samples A, B, C and D had a residual value of <4. Sample A was not significantly different at 5% level of significance for protein, carbohydrate, appearance, taste and overall acceptability, sample B was not significantly different at 5% level of significance for protein, texture, taste and appearance, and sample C was not significantly different at 5% level of significance for texture and taste while sample D was not significantly different at 5% level of significance for appearance, taste and overall acceptability (Catling & Alam 1983).

Validation results showed that experimental values were in good agreement with the predicted response values, thereby confirming the adequacy of the selected model. This is due to the high desirability value 0.842, 0.891, 0.894 and 0.904 for selected solutions. A desirability of 1.00 means the goals were easy to reach and better results may be available (stat-ease, 2021). Savita et al., (2018) also reported high desirability of 0.89 when selecting the optimum solution during optimization. Control of the experiment was also monitored to avoid variation in the experimental result and predicted values **(Table 5).**

CONCLUSION

Gluten-free noodles developed from composite blends of rice flour (X1), soybean flour (X2), corn starch (X3) and potato starch (X4) using I-optimal mixture design were evaluated for their quality and sensory attributes. All the statistically significant terms such as R2, F value and lack of fit show the adequacy of the model. It is also reported that soybean flour had a significant impact on the protein, carbohydrate, appearance, texture, taste and overall acceptability of rice-soy noodles. Current research suggests the effect of corn and potato starch had a significant (P<0.05) effect on the textural attribute of gluten-free noodles. Furthermore, due to their high protein level, these noodles can be used as part of mid-day meals to overcome the problem of protein-energy malnutrition. Suggested solutions with better desirability have provided varied options to choose from by manufacturers that would satisfy targeted consumers. Hence, saving time and cost. Four optimum formulae were selected, for independent variables for rice flour for the selected formula were 70.00%, 73.297%, 72.995% and 72.198% for samples A, B, C and D respectively. Soybean flour predicted optimum levels were 13.133%, 11.664%, 11.585 and 11.283% while corn starch and potato starch were 11.749% and 5.117%, 5.082% and 9.956%, 5.199% and 10.222% and 11.020% and 12.528% for sample A, B, C and D respectively. The Successful utilization of these local commodities for the development of high protein-rich gluten-free noodles will definitely spread new ideas to the food sectors.

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