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Optimization Method of Whole Wheat Flour, Soybean Flour, Oyster Meat Powder for Nutrient-Dense Composite Flour

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Authors' contributions

This work was carried out in collaboration among all authors. Authors WTO and SBK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VCW and AAO managed the literature search and analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study the production of Nutrient – Dense Composite Flour from the blends of whole wheat flour, soybean flour (full fat) and oyster meat powder.

Study Design: The study was design using the D-optimal combination design of Response Surface Methodology (RSM).

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Place and Duration of Study: The study was carried out at Department of Food, Nutrition and Home Science, University of Port Harcourt (Processing of raw materials) and the Department of Food Technology, Federal Institute of industrial research Oshodi, Lagos (Analysis of raw materials) between October 2021 and August 2022.

Methodology: The raw materials were each processed to have wholesome flours, and then they were combined according to the matrix generated, which had ranges of 70 – 100%, 0 – 22%, and 0 – 8% for whole wheat flour (WWF), soybean flour (SBF) and oyster meat powder (OMP) respectively.

Results: The design was used to assess the significance (5% probability) of the moisture, fat, and protein content, which ranged from 8.09 to 11.37%, 1.80 to 8.52% and 9.70 to 19.07% respectively; the water absorption (72.00 - 79.10BU), dough stability (9.3 - 17.5BU) and mixing tolerance index (25 - 50BU); and lightness and yellowness, which ranged from 65.48 - 83.2 and 13.77 - 23.58 respectively, of the flour blends. Protein content, water absorption dough stability, and mixing tolerance index were prioritized while moisture content, fat content, and yellowness were minimized for the numerical optimization of the responses. This study highlights the possibilities of utilizing non-conventional raw materials in the production of composite flour with balance nutritional and baking qualities.

Conclusion: The best flour combination was 72.51% whole wheat flour, 19.63% soybean flour, and 7.86% oyster meat powder.

Keywords: Composite flour; D-Optimal design; proximate content; farinograph value; lightness; yellowness; numerical optimization.

1. INTRODUCTION

Globally, the consumption of bread and other baked goods are on the increase but still subjected some factors like economic status of the consumers among others [1-3]. However, the low protein quantity and quality of wheat flour (- an essential component in all baked goods) when compared to protein sources (milk, soybean, pea, and lupin) has been a major concern for producers and consumers alike as it relates to the provision of essential nutrients, especially to the growing and young children [4,5]. Generally, composite flour has been observed to give a balanced nutritional profile, making it healthier than flour made only from any one type of cereal [6].

One of the most significant sources of protein in the world and a good supplier of all essential amino acids is soybean. It is known as "the protein hope of the future" and contains 3 percent lecithin, which is beneficial for brain development. It is also rich in calcium, phosphorus, and vitamins A, B, and D [7]. Additionally, the isoflavones found in soybeans work as powerful cancer-preventive agents to reduce the risk of developing a variety of cancers. Evidence also supports the positive effects of soy isoflavones on the prevention of cardiovascular disease [8].

As a member of the family Ostreidae, Oysters (*Crassostrea gasar*) are aquatic creatures that are one of the most well-known and frequently cultivated marine organisms. They are highly prized seafood and a delicacy everywhere in the world while in some regions of the world this resource is underutilized [9]. In general, shellfish is regarded as a low-fat, low saturated-fat, high poly unsaturated fatty acids (PUFA) (eicosapentaenoic acids, docosahexaenoic acid, and linoleic acid) and high-protein food with higher than usual amounts of stimulating minerals like selenium, zinc, iron, and magnesium, as well as B nutrients. They are excellent sources of zinc, calcium, selenium, and vitamin B-12 [10]. Nowadays, value-addition to seafood products has been highlighted as one of the high priority areas for development within the industry [11], hence its inclusion in composite blends.

The formulation of foods from low lysine staples with addition of other food materials has been proposed as a practical and suitable approach to improving the protein nutritional value (quantity and quality) of foods aimed as popular carrier of nutrition to vulnerable groups like pregnant and nursing mothers, young and school age children so as to reduce the incidence of malnutrition [12].

In general, vegetarians and health-conscious individuals are consuming more meals enriched with proteins from plant sources [13]; however, proteins from these sources are thought to be partially incomplete since they lack some of the important amino acids. The addition of an animal-based protein source (oyster meat powder) is required to correct this alleged protein imbalance. This serves as the conceptual framework for this project, which looks at the possibility of producing a composite blend with balance nutritional and functional qualities.

2. MATERIALS AND METHODS

2.1 Materials

Wholesome raw whole wheat and soybeans were purchased from New Layout open market in Port Harcourt, Rivers State, Nigeria. Raw Oysters in their shells were purchased from Okrika market square in Okrika Island, Rivers State, Nigeria. The grains were kept in air-tight, moisture-proof container after purchase while raw oyster were packed in ziplock bag and stored in refrigeration before usage (within the 24 h).

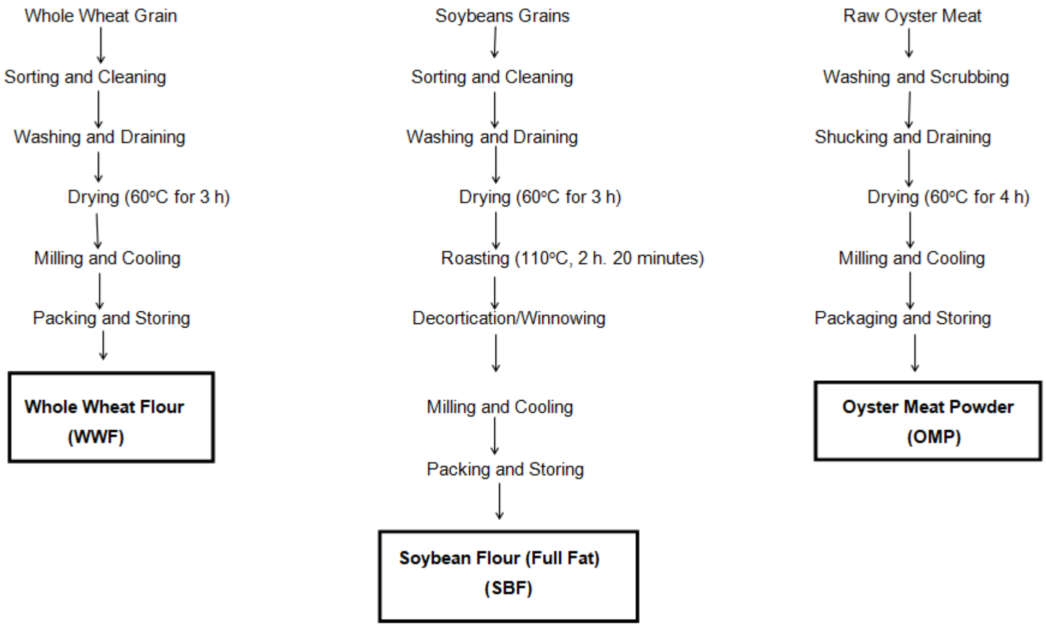
2.2 Methods

2.2.1 Preparation of whole wheat flour, soybeans flour and oyster meat flour

Whole wheat flour was produced from whole wheat grains using a modified method of Ndife *et al,* [14]. The whole wheat grains were sorted (manually) and cleaned of all contaminants (inclusive of spoilt grains) (Flow Chart 1). The grains were then washed, dried, milled using attrition mill and sieved through a 0.25 mm mesh size screen. Whole wheat flour was cooled for six hours and then packed in air and water tight cellophane bag and stored in the refrigerator till usage.

Soybean flour was produced from raw soybean using modified method of Ndife et al. [14]. The soybeans were sorted and cleaned of all contaminants and spoilt seeds. The beans were then washed, oven-dried, roasted, winnowed and milled in an attrition mill. Soybean flour (full fat) was sieved to 0.25 mm particle size, the soya bean flour is then cooled at room temperature for six hours and then packed in air and water tight cellophane bag and stored (Flow Chart 1).

Raw oysters were obtained from the market. Prior to its sales in the market, the Oyster were harvested from the mangrove tree root to which they were attached, they were scrubbed and washed with warm water to remove mud, seawater and all contaminants then rinsed with cold fresh water (Pre-sales/post-harvest activities by the market women). The meat was shucked from the shell with knife and oven-dried at 60°C for 4 h. Dried oyster meat was ground and sieved to 0.25 mm particle size (Flow Chart 1) then packaged and stored.



Flow Chart 1. Production of Whole Wheat Flour (WWF), Soybean Flour (SBF) and Oyster Meat Powder (OMP)

2.3 Experimental Design for Ingredient Optimization

The experimental mixture design and statistical analysis were performed using design expert software version 6.0.8 (stat-ease Inc., Minneapolis, MN, USA). Based on preliminary experiments carried out in the laboratory, the range of the 3 independent variables were - Whole Wheat Flour, (WWF - X_1), Soybean Flour (SBF - X_2) and Oyster Meat Powder (OMP - X_3) were $70 \leq X_1 \leq 100$, $0 \leq X_2 \leq 22$, and $0 \leq X_3 \leq 8$, respectively (Table 1).

A D-optimal design consisting of 14 experimental runs including 4 replications was chosen to evaluate the combined effect of the 3 independent variables (Table 2). The dependent variables – Moisture Content (Y_1), Fat Content (Y_2), Protein Content (Y_3), Water Absorption (Y_4), Dough Stability (Y_5), Mixing Tolerance Index (Y_6), Lightness (Y_7) and Yellowness (Y_8) were selected as responses for representing the main parameters of flour. These parameters were chosen because of their pertinent qualities in determining the functionality of the flour.

The significance of all the terms were judged statistically at probability (p) at 0.05; while the interaction effects of ingredients on the mixture were determined using a 3-Dimension contour plots.

The numerical optimization was performed by setting goal for each of the responses and the desirability was predicted based on the pre-set goals.

2.4 Analyses

2.4.1 Proximate analysis of samples

The Moisture content of flours was analyzed according to AACC.44–15.02 [15] while the protein content analysis was determined according to kjeldahl technique [16].

$$\% \text{ Protein} = \frac{(A - B) \times N \times 1.4007 \times F}{\text{Weight of Sample (g)}}$$

Where:
A = volume (ml) of alkali back-titration of blank;
B = volume (ml) of alkali back-titration of sample;
N = normality of alkali; F = Factor of (6.25)

The fat composition was of the samples were determined according to method Thiex et al. [17].

Table 1. Parameters studied in physical optimization of Whole Wheat-Soybean-Oyster Meat Composite Flour

Code	Parameter	Low level	High level
WWF	Whole Wheat Flour	70	100
SBF	Soybean Flour	0	22
OMP	Oyster Meat Powder	0	8

Table 2. Percentage Composition of Whole Wheat-Soybean-Oyster Meat Composite Flour

Exp Run	Sample code	X_1 (WWF)	X_2 (SBF)	X_3 (OMP)
1*	WWC1	78.00	22.00	0.00
2*	WWC 2	70.00	22.00	8.00
3	WWC 3	85.00	11.00	4.00
4	WWC 4	79.50	16.50	4.00
5	WWC 5	78.00	22.00	0.00
6	WWC 6	89.00	11.00	0.00
7	WWC 7	81.00	11.00	8.00
8*	WWC 8	100.00	0.00	0.00
9	WWC 9	70.00	22.00	8.00
10*	WWC10	92.00	0.00	8.00
11	WWC 11	92.00	0.00	8.00
12	WWC 12	100.00	0.00	0.00
13	WWC 13	92.50	5.50	2.00
14	WWC 14	74.00	22.00	4.00

Duplicated runs

2.4.2 Farinograph determination

The dough rheological properties of the blended flour samples were analyzed according to AACC [18] empirical rheological methods using Farinograph (Brabander Farinograph ® E OHG, 2002, Germany) of constant dough weight method at 30 ± 0.2°C using a 300 g mixing bowl, operating at 63 rpm. Each flour sample in the range of 284.5–300 g on a 14% moisture basis was weighed and placed into the corresponding Farinograph mixing bowl. Water from a burette was added to the flour and mixed to form dough.

As the dough was mixed, the farinogram consistence (BU) versus time (min.) was recorded for 20 min. Farinograph values: Water absorption (WA, percentage of water required to yield dough consistency of 500 BU), dough stability time and mixing tolerance index of the samples were determined.

2.4.3 Color properties of samples

Color characteristics, L* (lightness/darkness) and b* (yellowness/blueness), of flour samples were determined with the aid of a colorimeter (ColorFlex, HunterLab, USA). The colorimeter was calibrated with a standard black and white (L* = 93.71, a* = – 0.84 and b* = 1.83) plate before use [19].

3. RESULTS AND DISCUSSION

Results for the samples' moisture, fat, and protein contents ranged from 8.09 to 11.37%, 1.80 to 8.52% and 9.7 to 19.07% respectively, while the ranges for the other measured parameters for the flour samples are water absorption - 72.0 to 79.1 (BU), dough stability - 9.3 to 17.5 (BU), mixing tolerance index - 26 to 50 (BU), lightness - 65.48 to 83.20 and yellowness -13.77 to 23.58.

3.1 Moisture, Fat and Protein Content of the Samples

Fig. 1 (1–3) illustrate how the samples' moisture, fat, and protein contents changed as a result of effect of ingredient combinations. Moisture contents a measure the effect of how water content affects the microbial contamination and a gauge of its water activity. For example, if the moisture content of food increases, the microbial growth that results in food deterioration is accelerated [20]. All the flour samples had moisture contents that were within the permitted range of 12%, which is the level of moisture that has been deemed safe for use in flour and food powders [21]. The samples would likely be shelf stable based on this.

Table 3. Experimental Design and Mean Value of Quality Characteristic of Whole Wheat – Soybean-Oyster Meat Composite Flour

Runs	Variables			Responses							
	WWF (X_1)	SBF (X_2)	OMP (X_3)	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
WWC_1	78.0	22.0	0.0	9.01	7.13	15.50	75.0	15.6	42	69.80	22.67
WWC_2	70.0	22.0	8.0	8.10	8.52	19.04	79.0	17.5	49	65.48	23.38
WWC_3	85.0	11.0	4.0	9.93	5.40	14.35	73.3	13.9	38	75.00	18.73
WWC_4	79.5	16.5	4.0	8.23	6.75	15.60	74.2	14.0	41	71.02	20.61
WWC_5	78.0	22.0	0.0	8.89	7.15	15.48	74.8	15.5	42	69.84	22.00
WWC_6	89.0	11.0	0.0	9.41	4.35	13.88	73.0	12.0	34	76.52	17.21
WWC_7	81.0	11.0	8.0	9.01	6.11	16.22	74.0	13.1	39	72.05	18.00
WWC_8	100.0	0.0	0.0	11.23	1.88	9.70	72.0	9.5	26	83.00	13.87
WWC_9	70.0	22.0	8.0	8.09	8.19	19.07	79.1	17.3	50	65.53	23.58
WWC_{10}	92.0	0.0	8.0	8.77	3.46	13.40	72.8	10.2	30	78.05	14.66
WWC_{11}	92.0	0.0	8.0	8.72	3.48	13.58	72.6	10.3	30	78.16	14.38
WWC_{12}	100.0	0.0	0.0	11.37	1.80	9.72	72.2	9.3	26	83.20	13.77
WWC_{13}	92.5	5.5	2.0	9.57	3.80	12.38	73.1	10.0	31	78.53	16.91
WWC_{14}	74.0	22.0	4.0	8.23	7.85	17.28	76.5	16.2	44	66.60	21.13

Where: (X_1) = Whole Wheat Flour, (X_2) = Soybean Flour, (X_3) Oyster Meat Powder
(Y_1) = Moisture Content, (Y_2) = Fat Content, (Y_3) = Protein Content, (Y_4) = Water Absorption Capacity,
(Y_5) = Dough Stability, (Y_6) = Mixing Tolerance Index, (Y_7) = Lightness,
(Y_8) = Yellowness

Comparing the composite samples to whole wheat flour, the percentages of fat and protein rose. Iwe et al. [22] found a similar pattern, stating that the amount of substitution was accompanied by an increase in protein content. The rise in protein and fat content was anticipated since whole wheat flour lacks the protein and fat that soybean and oyster meat powder do, which results in the synergistic effects of protein and fat complementation [23]. The increase in the percentage protein and fat content served as the foundation for the blend formulation since it was anticipated that the finished product would have a higher protein and fat content.

The effect of soybean flour on the moisture content of the flour blends was highest and the result of the ANOVA revealed that the model (cubic) terms were all significant ($p \le 0.05$). The final predictive equation model which has the R^2 of 0.999 is as shown in Eqn. 1.

$$\text{Moisture Content} = +11.30*A + 17.14*B - 1551.58*C - 23.37*A*B + 2662.17*A*C + 2692.23*B*C - 2345.89*A*B*C + 22.57*A*B*(A-B) - 1165.78*A*C*(A-C) - 1284.21*B*C*(B-C) \quad \ldots\ldots\ldots \quad (1)$$

The ANOVA results showed that all of the models (cubic) were significant ($p \le 0.05$) with the exception of the interaction AC, which showed that soybeans flour had the greatest impact on the samples' fat content.

Eqn. 2 depicts the prediction equation model, which has an R^2 of 0.998.

$$\text{Fat Content} = +1.82*A + 8.89*B + 0.44*C + 0.46*A*B + 10.49*A*C + 8.88*B*C \quad \ldots\ldots \quad (2)$$

The protein content of the samples is most affected by oyster flesh powder. According to the ANOVA results, the only significant ($p \le 0.05$) model (cubic) terms were the linear mixture and the interaction AB (A-B).

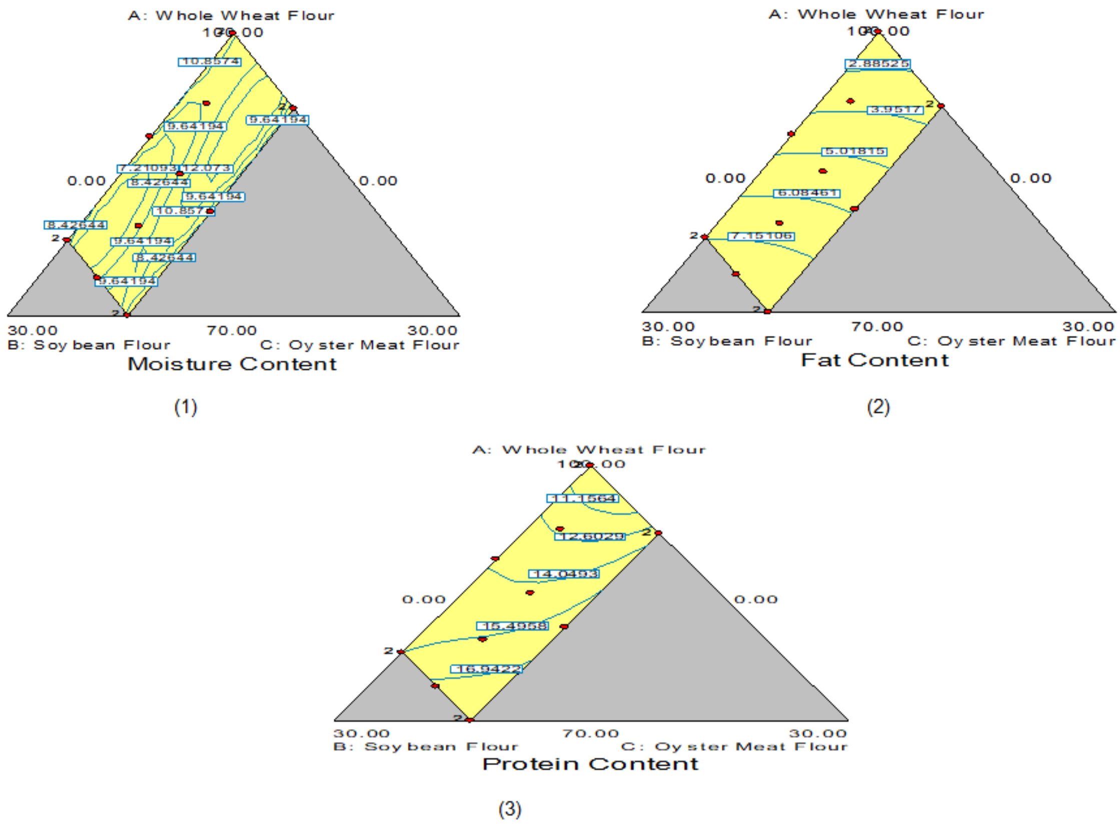


Fig. 1 (1-3). 3D plot showing the varying the effect of levels inclusion of whole wheat flour, soybean flour and oyster meat powder on (1) Moisture Content, (2) Fat Content and (3) Protein content of flour samples

Eqn. 3 illustrates the final prediction equation model, which has an R^2 of 1.0.

Protein Content = + 9.71*A + 18.42*B + 85.63*C + 1.55*A*B - 85.55*A*C - 119.10*B*C + 61.42*A*B*C + 9.97*A*B*(A-B) + 2.90*A*C*(A-C) + 65.79*B*C*(B-C) ……… (3)

3.2 Rheological Properties of the Flour Samples

The farinograph test measures the dough's resilience. It involves assessing how dough behaves when mixed at a certain constant speed with a specified amount of water addition [24]. It is one of the most often used tests for assessing the quality of flour, mostly used to determine how much water is needed to produce a dough and then anticipate the texture of the final result [25].

The effects of the different sample mixes on the rheological characteristics of the samples are depicted in Fig. 2 (1–3). The amount of water needed to reach the center of the peak area of a farinographic curve on the 500 Brabender Unit (BU) line for flour-water dough is known as the water absorption parameter, which is a significant dough parameter [26].

The biggest impact on the flour mixes' ability to absorb water was caused by oyster meat powder (with soybeans flour also contributing). This might be explained by oyster meat powder's greater protein content. The ANOVA's findings showed that only the linear mixtures of AB and AC and the model (cubic) term were significant ($p \le 0.05$).

The final prediction equation model, represented by Eqn. 4, has an R^2 of 0.999.

Water Absorption = + 72.10*A + 80.59*B + 217.61*C - 12.44*A*B - 249.08*A*C - 242.48*B*C + 211.81*A*B*C + 10.90*A*B*(A-B) + 115.14*A*C*(A-C) + 102.32*B*C*(B-C)… (4)

Strong wheat flour's graph often exhibits high water absorption, quick development, and little breakdown. Although weak wheat flours also develop quickly, they break down more quickly and have a lower capacity to absorb water. This can be ascribed to non-wheat flour's chemical makeup having a significant impact on the composite dough's ability to absorb water [27].

Ribotta et al. [28] found that using heat-treated full-fat flour, enzyme-active defatted flour, and soy protein isolates in place of wheat flour had the same effect on the water absorption value. The interaction between soybean proteins such globulins and wheat gluten, which was observed to happen in the composite flour, may also be the cause [29]. Authors who used protein-rich flours in a wheat composite blend reported a similar outcome [30,31].

Higher values of dough stability time indicate stronger dough, which could be considered a measure of the strength of the flour [32]. It is the interval of time between the top of the curve's initial intercept of the 500 BU line and its subsequent departure from the 500 BU line, as well as the departure time [33]. The ANOVA results showed that all of the model's (cubic) terms were significant ($p \le 0.05$), with soybean flour having the greatest impact on the dough stability time characteristics of the flour blends. The ultimate prediction equation model, represented by Eqn. 5, has an R^2 of 1.0.

Dough Stability = + 9.40*A + 26.95*B - 2491.98*C - 23.01*A*B + 4289.77*A*C + 4328.41*B*C - 3827.10*A*B*C + 24.34*A*B*(A-B) - 1873.83*A*C*(A-C) - 2019.33*B*C*(B-C) ……… (5)

The findings showed that adding more soybeans lengthened the dough's stability duration. Both Khating et al. [26], who reported a linear rise in dough stability time with increasing sorghum flour incorporation percentage, and Symons and Brennan, [34], who reported an increase in dough stability time with increased inclusion of rice bran, saw a similar outcome. The amount that dough will soften over the course of mixing is measured using the Mixing Tolerance Index (MTI). It is the difference between the peak of the curve and the peak of the curve five minutes later [35].

Soybean flour has the highest effect on the mixing tolerance index of the flour samples; and the ANOVA showed that all the model (cubic) term were significant ($p \le 0.05$) except AB and AB(A-B) terms. The final predictive equation model which has the R^2 of 0.999 is as shown in Eqn. 6.

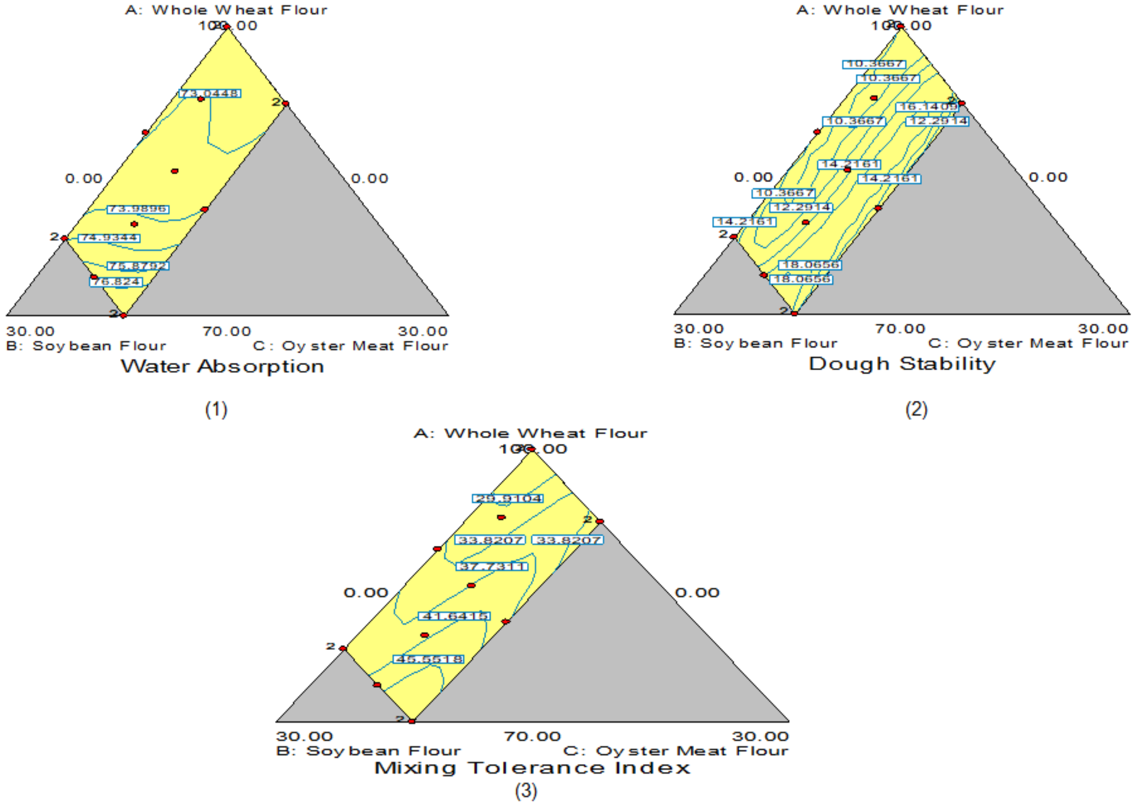


Fig. 2 (1-3). 3D plot showing the effect of varying levels inclusion of whole wheat flour, soybean flour and oyster meat powder on (1) Water Absorption, (2) Dough Stability and (3) Mixing Tolerance Index of flour samples

Mixing Tolerance Index = + 26.00*A+ 46.96*B - 1819.55*C + 2.03*A*B + 3148.24*A*C + 3279.62*B*C - 2883.96*A*B*C - 2.54*A*B*(A-B) - 1309.57*A*C*(A-C) - 1545.86*B*C*(B-C) …… (6)

In general, it has been demonstrated that the mixing tolerance index has an impact on baking quality and an MTI value of 30 BU. Hard wheat flours are rated very good to excellent if the MTI is 50 B.U or less, whereas a flour with an MTI higher than 50 B.U shows less tolerance and frequently suggests significant difficulties during mechanical handling and dough formulation.

3.3 Colour Indices of the Flour Samples

The acceptance of food products is significantly influenced by colour, an essential organoleptic feature of foods [36]. The results for the brightness and yellowness indices ranged from 65.48 to 83.2 and 13.77 to 23.58 correspondingly.

Fig. 3 (1-2) shows the impact of the various sample blends on the samples' lightness and yellowness indexes. The ANOVA showed that all model (cubic) terms, with the exception of AB and AB (A-B) terms, were significant ($p \leq 0.05$). Eqn. 7's final prediction equation model, which is depicted, has an R^2 of 1.0.

Lightness = + 83.10*A + 63.21*B - 856.67*C + 4.38*A*B + 1556.37*A*C + 1629.06*B*C -1431.02*A*B*C - 4.92*A*B*(A-B) - 643.71*A*C*(A-C) - 777.71*B*C*(B-C) ……… (7)

The ANOVA showed that it is only the model (cubic) term and the linear mixture terms were the only significant ($p \leq 0.05$) terms. The final predictive equation model which has the R^2 of 0.998 is as shown in Eqn. 8.

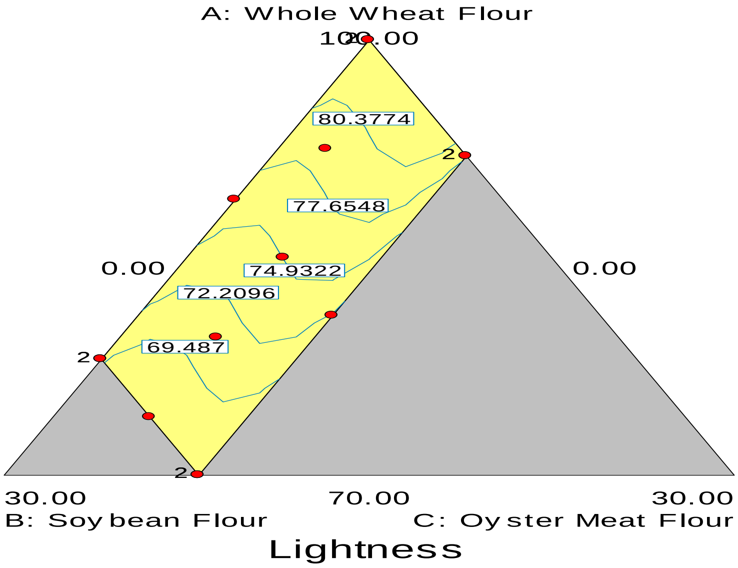
Yellowness = + 13.82*A + 18.81*B + 147.15*C + 13.31*A*B - 287.21*A*C - 168.59*B*C + 193.16*A*B*C - 24.71*A*B*(A-B) + 233.53*A*C*(A-C) + 37.44*B*C*(B-C) ……… (8)

3.4 Optimization of Whole Wheat-Soybean-Oyster Meat Composite Flour

Generally, optimization method is aimed at finding solutions that maximize or minimize the experimental variables in the production processes. It is the method used for arriving at the optimal ingredient combination of processing condition [37].

In order to verify the optimum level of whole wheat flour, soybean flour and oyster meat powder in producing composite flour, numerical optimization was carried out with criteria and goal for the responses set as presented in Table 4.

Whole wheat flour (72.51%), soybean flour (19.63%), and oyster meat powder (7.86%) are the experimental values from the optimized composite. The composite flour has a 0.64 desirability value; this means that the optimum combination will give a product that has characteristics according to the optimization target of 64%.



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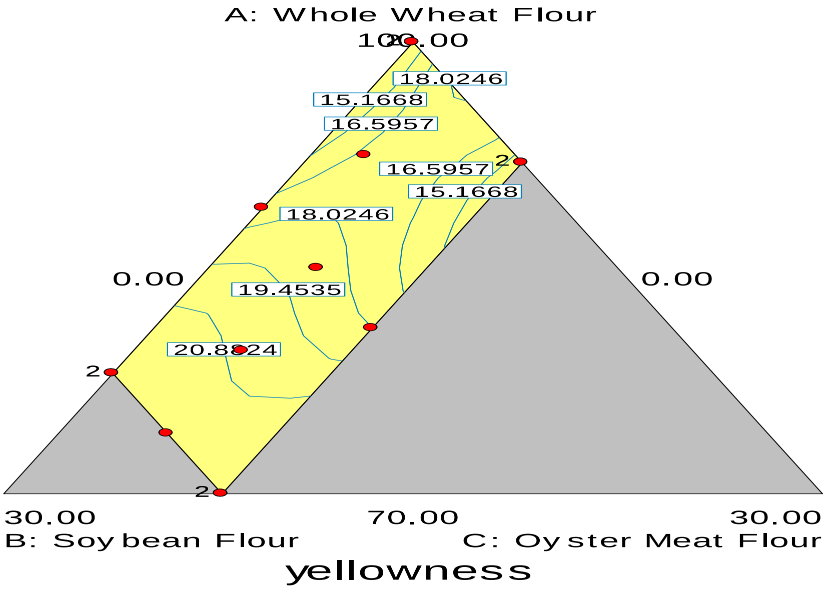

(2)

Fig. 3 (1-2). 3D plot showing the effect of varying levels inclusion of whole wheat flour, soybean flour and oyster meat powder on (1) Lightness and (2) Yellowness of flour samples

Table 4. Criteria and Goals for the Numerical Optimization of Responses for Whole Wheat Composite Flour

Category	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
Whole Wheat Flour	is in range	70	100	1	1	3
SoyBean Flour	is in range	0	22	1	1	3
Oyster Meat Powder	is in range	0	8	1	1	3
Moisture Content	minimum	8.09	11.37	1	1	3
Fat Content	minimum	1.80	8.52	1	1	3
Protein Content	maximize	9.70	19.07	1	1	3
Water Absorption Capacity	maximize	72	79.1	1	1	3
Dough Stability	maximize	9.3	17.5	1	1	3
Mixing Tolerance Index	maximize	26	50	1	1	3
Lightness (L*)	maximize	65.48	83.2	1	1	3
Yellowness (b*)	minimize	13.77	23.58	1	1	3

Table 5. Solution for the Numerical Optimization of Responses for the Production of Whole Wheat Composite Flour

No	WWF	SBF	OMP	MC	FC	PC	WA	MTI	DS	L*	b*	DY	
1	72.50	19.64	7.86	8.09	7.86	18.08	77.21	47.41	16.19	67.41	22.30	0.64	Selected
2	75.08	20.55	4.37	8.45	7.66	16.91	75.83	44.13	16.13	67.91	21.19	0.58	

Where: WWF = Whole Wheat Flour; SBF = SoyBean Flour, OMP = Oyster Meat Powder; MC = Moisture Content; LC = Lipid Content; PC =Protein Content; WA = Water Absorption; MTI = Mixing tolerance index; DS = Dough Stability; Lightness = L; b* = Yellowness; DY = Desirability*

At these values, the maximum protein content, dough stability, water absorption, mixing tolerance index, and yellowness are, respectively, 18.06, 77.20, 16.19, 47.41, and 22.70, while the minimum moisture content and fat content are, respectively, 8.09 and 7.86, with lightness in the range at 67.33.

The optimum level for each of the individual flour (whole wheat flour, soybean flour and oyster meat powder), the predicted values for the responses were obtained in the solution.

4. CONCLUSION

To optimize whole wheat flour, soybean flour, and oyster meat powder composite flour for use in both home and industrial applications with improved nutritional quality, responses surface approach was successfully utilized. The study's flour variable had a significant impact on the flour's quality.

The soybean has the greatest positive impact on the lipid content and yellowness, the whole wheat flour has the greatest positive impact on the moisture content, water absorption, and dough stability of the flour and the oyster meat powder has the greatest positive impact on the protein and mixing tolerance index.

The final results of optimization indicate that the ratio of whole wheat flour to soybean flour to oyster meat powder to optimize the nutritional density of the composite flour is 72.51% whole wheat flour, 19.63% soybean flour, and 7.86% oyster meat powder.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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