DEVELOPMENT AND OPTIMIZATION OF BISCUITS PRODUCED FROM COMPOSITE FLOURS OF CORN, PEANUT, SWEET POTATO AND SOYA BEAN.

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ABSTRACT

Biscuits are one of the staple baked products consumed in Nigeria by all age grades particularly children. They are produced basically from wheat flour. However, wheat production in Nigeria has been a roller coaster. This study investigated the formulation of biscuit made from blends of roasted corn, peanut, soybean and sweet potatoes. The impact of baking temperature and baking time on biscuit quality were also investigated. Investigations were conducted employing a four-component, two processing parameters, constrained D-optimal mixture-process experimental design with 20 randomized experimental runs. The formulation design constraints were roasted corn flour, peanut, blanched soybean and sweet potato flour. The processing parameters investigated were baking temperature and baking time. The formulated samples were evaluated for the proximate properties, mineral content, sensory qualities, digestibility, bulk density and spread ratio. From the numerical optimization through the desirability function, the formulation that produced biscuit of highest desirability index was 5% of sweet potatoes, 17% of soybeans, 39% of roasted corn, 34% of peanut with baking temperature of 180°C and baking time of 11 min. The proximate properties, mineral content, digestibility, bulk density and spread ratio of this optimal formulation are ; moisture content (11%); crude protein (22); crude fiber (4.5); fat content (12.6); carbohydrate (44); ash content (7.4); energy value (373); potassium (314); calcium (80); iron (3.6); zinc (0.5); digestibility (73); spread ratio (18.7); bulk density (0.6); breaking strength (2) ; colour (5.8); taste (5.3); flavor (4.2); texture (5.2); overall acceptability (4.7). It was deduced the interactions of the mixture component and process variable have significant effect on the sensory quality and the proximate analysis of biscuit from the blends with the level of probability ($p<0.005$).

Keywords: Biscuit, Optimization, Proximate properties, Formulation, D-Optimal Design

1.1 INTRODUCTION

Food deficit is increasing, which affect millions of people especially in developing counties. Food production and processing are encouraged as part of the solution to the mounting problem of food shortage and food wastage due to inadequate storage system. Biscuit are recommended as one of the snack food that can be processed. It is cheap and can be eaten by all age grades, have long shelf live, easy accessible anytime and anywhere. It can be fortified to be highly nutritious. The necessity to optimize local food products help to meets daily supplement needs of the malnourished people in Africa. This need to be propelled in different research activities, to bring about a different high-energy-protein food (Sanni, 1997; Gilbert, et al., 2000; Jideani et al., 2001). Deliberate effort is required to attain high quality, wholesome and safe product in the snacks food business. New product development is one of the most difficult activities in the food industry. Product development strategy has a very important impact on final product quality.It translates the functional needs and expectation of the consumers into specific engineering and quality characteristics. It is responsible for designing new product which meet customer's requirement and expectation and which can be consistently and economically produced by manufacturing. Product quality has been defined as a product ability not merely to meet consumer's expectation but also to exceed them. In product development studies, a simple, but effective strategy of experimentation involves optimizing the formulation via mixture design and optimizing the process with factional design and response surface methodology. Biscuits are amongst the most famous generally expended prepared food item in Nigeria and a standout amongst the most consumed baked food on the earth. It is one of the processed convenience food ever created and widely accepted staple food which requires no extra preparation. Its wide popularity is sequel to it convenience, moderate cost, great nourishing quality, accessibility in various taste and longer shelf life (Kakalibandyopadhyay et al. 2014). Biscuit preparation is a demonstration of transforming a basic ingredient into brilliant delightful nourishment with various aromas and crunchy taste. The basic ingredients are varying proportion of refined wheat flour, vegetable shortening margarine, and sugar, baking powder and seasoning agent (Meena 2013). Biscuits are one of the minimal cost prepared food. They are less expensive than most other snacks, can be eaten anyplace, easy to be access, have variety of tastes, packs and are eaten by all age group consumers, specifically health disorder individuals on account of its moment vitality discharge (Meena, 2013). The nourishing estimation of biscuit can be upgraded by fortification and supplementation with a wide assortment of protein, vitamin and minerals (Sivakamin and Sarojini, 2013). Due to competition in the market and increased interest for healthy characteristic and functional food, efforts are being made to enhance the nutritive estimation of biscuit and usefulness by adjusting their nutritive arrangement.

Biscuits are produced basically from wheat flour. However, wheat production in Nigeria has been a roller coaster. The locally produced wheat is not enough to meet the demand, since wheat are used for other product. Reports indicated that up to 1985, domestic wheat production in Nigeria was about 66,000 metric tonnes. 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 hectare. 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. 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; Sanni 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 (Amman 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.

This study was conducted to develop and optimize the formulation and some production processes of biscuit from blends of corn, peanut, sweet potatoes and soya bean. The nutritive, physiochemical, and sensory properties of the formulated biscuits were also estimated.

2.0 Material and Method

2.1 Materials: The materials used were roasted corn flour, defatted peanut meal, blanched soybean, sweet potato extract/gel. The reagents used were distilled water, petroleum ether, boric acid, hydrogen tetraoxosulpatevi, sodium hydroxide, hydrochloric acid, bromescresol green and methyl red indicator, N-hexane, Selenium tablet, anhydrous copper sulphate mixture. The equipment and apparatus used in the study include dryer, deep fryer, manual kneader, chopping board, steaming machine, grater, milling machine, mixer bowl, petri-dishes, electronic weighing balance, desiccators, crucibles, bunsen-burner, fume cupboard, thimbles, soxhlet apparatus, filter paper, beaker, kjeidal apparatus, pipette, condenser, oven, weighing balance, spatula, petri dish, soxhlet apparatus, thimble, complete digestion block set, burette, pipette, pipette filler, cornical flask, makahmps apparatus.

2.2 Methods

The formulation was designed based on the mixture design experimental concept. The constraints for the mixture component of the design are: 20%≤x1 (Roasted corn flour) ≤70%, 10% ≤x2(Defatted peanut meal) ≤30%, 10% ≤x3(Blanched soybean)≤30%, 5% ≤x4(Sweet potatoes)≤20%,Other minor component (constants) used in the formulation are: Sugar 1%, Baking powder 0.8%, Baking fat 0.2%, Water 5%, Total 7%.

Table 2.1 Process Parameter and their Levels are:

Factors	Process variables	Low (-1).	High (+1)
Z1.	Baking Temperature.	120.	180
Z2.	Baking Time.	10.	25

2.3 Mixture-Process Variable Design

Investigations were conducted employing a four-component, two processing parameters, constrained D-optimal mixture-process experimental design with 20 randomized experimental runs. The formulation design constraints were roasted corn flour defatted peanut meal blanched soybean , and sweet potato flour. The processing parameters investigated were baking temperature and baking time. The formulated samples were evaluated for the proximate properties, mineral content, sensory qualities, digestibility, bulk density and spread ratio The table below shows the variation of between the process component and the materials component.

Table 2.2 Mixture-Process Variable Design

S/N	Roasted Corn Flour %	Defatted Peanut Meal, %	Blanched Soybean Flour %	Sweet Potato Extract/Gel, %	Baking Temperature, Degree Centigrade	Baking Time, minutes
1	35	10	30	20	135	13.75
2	50	30	10	5	180	10
3	35	10	30	20	120	25
4	20	25	30	20	180	25
5	39	33	10	13	180	25
6	70	10	10	5	165	21.25
7	50	10	30	5	180	25
8	37.5	27.5	10	20	120	10
9	45	10	20	20	180	25

10	55	10	10	20	180	25
11	50	30	10	5	120	25
12	20	40	30	5	180	10
13	20	40	30	5	120	25
14	55	10	10	20	120	10
15	20	50	10	15	150	17.5
16	50	10	30	5	120	10
17	50	30	10	5	180	10
18	20	32.5	30	12.5	120	10
19	20	40	30	5	120	25
20	20	25	30	20	180	25
21	20	45	10	20	180	10
22	20	50	15	10	180	25
23	20	32.5	30	12.5	120	10
24	20	45	10	20	180	10
25	35	10	30	20	180	10
26	30	50	10	5	120	10
27	30	50	10	5	180	25
28	35	25	30	5	180	10
29	20	45	10	20	120	25
30	47	20	19.5	8.5	150	17.5
31	70	10	10	5	135	13.75
32	70	10	10	5	180	10
33	70	10	10	5	120	25
34	20	50	20	5	120	10

2.4 Proximate Composition

Determination of proximate composition of the biscuit was carried out using standard method. Moisture Content, Crude Protein, Fat Content, Carbohydrate, Crude Fiber, Ash Content, was estimated using approved method (AOAC, 2005).

2.5 Mineral Analysis

The mineral analyses for Iron, calcium, copper, and zinc was determined by atomic-absorption spectrophotometer. Potassium was determined by flame photometry was performed in according to AOAC 2005.

2.6 Physical Properties

Breaking strength and spread ratio as describe by Agu and Ndidiamaka,(2014) was carried out. Bulk density as described by Onwuka, (2005) was carried out.

2.7 Sensory Evaluation

Sensory evaluation as describe by Iwe (2002) was used. Coded sample biscuit was presented to a 10 man semi trained panelists to evaluate the biscuit. The following attributes were estimated: appearance, flavor, texture, taste and overall acceptability of the product using a 9-point hedonic scale ranging from 1(like extremely) to 9(dislike extremely). The means were calculated and the data was subjected to analysis.

3.0 Result and Discussion

3.1 Presentation of Result

Experimental results obtained during the experimental procedures are shown in table 1.

3.2 Discussion of Result

Factor model equations used to optimize all response were all significant except for: crude fiber; ash content; potassium; calcium; bulk density which were not significant. Model significant indicate that the probabilities that the factors are not modeling noise (error) is low, while not significant means that the probability that the factors are modeling noise is high at confident level of 95% ($P < 0.05$). These non significant occurrences may be due to the errors (noises) that occur during measurements of these responses. For the mixture components model equation used for optimizing the responses, all of them were significant except for: crude fiber; ash content; potassium; calcium; zinc; bulk density, which was not significant. The reasons for these non significant results are the same as that explained for factor model. Two responses, moisture content and spread ratio did not display mixture model equation on its analysis of variance. This was because the mixture components have no effect on these two responses. Rather only the factors affect these two responses. The lack of fit for all responses during the analysis of variance were not significant except for: spread ratio; breaking strength; colour; taste; flavor; texture, which were significant. Non significant lack of fit shows that the probability that the chosen model equation fit the response is high. While significant lack of fit shows that the probability that the chosen model equation fit the response is low. So we always want the lack of fit to be not significant. The significant fit occurs due to physical errors by both measuring equipments and man during measuring of these responses. Before optimization, parameters to be optimized were constrained to achieve the set goals of optimization. For the mixture components, the roasted corn flour was set at maximize because of its availability and low cost. The same goes for defatted peanut meal and blanched soybean flour. The sweet potato extract/ Gel was set at minimize because it is expensive to prepare. For the factors components temperature was set at maximize because high temperature produces high texture quality in the biscuit, while time is set at minimize to save time of production which in turn save cost of production. For responses, moisture content was minimized to give the biscuit a crunchy texture. Crude protein and fiber were set in range to see which protein and fiber values give a better biscuit within the experimental range.

Table 3.1 Experimental result table

	C1	C2	C3	C4	F5	F6	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
	A	B	C	D	E	F	moisture	protein	fiber	fat	carbohydrate	ash	energy	potassium	calcium	iron	zinc	digestibility	spread ratio	bulk density	breaking strenghr	colour	taste	flavour	texture	overall acceptability
Run	%	%	%	%	deg	min	%																			
1	35	10	30	20	135	13.8	13.3	25.3	5.32	20.5	29.6	6	404	340	79.2	3.24	0.38	76.2	24.5	0.78	0.815	2.5	1.5	1.5	3.8	4
2	50	30	10	5	180	10	10.3	21.3	4.76	10.1	47.5	6.04	366	333	76.3	2.81	0.22	71.9	20	0.77	3.746	6.8	5.8	4.3	4.5	5
3	35	10	30	20	120	25	17.6	26	6	15	30.9	4.5	363	349	75.3	2.72	0.36	76.3	19.6	0.65	0.795	4.5	3	3	3.5	5.5
4	20	25	30	20	180	25	11.3	30.3	3	18.6	30.3	6.5	410	350	80.3	3.33	0.42	76	20	0.67	3.246	6.8	4.5	5.5	4	6
5	39	33	10	13	180	25	10.2	21	4	12	48.3	4.5	385	358	81.6	4.81	0.51	71.3	20	0.65	3.246	2.3	3	2.5	3.8	4
6	70	10	10	5	165	21.3	13.1	16.5	6.31	8.5	52.1	3.5	351	355	82.2	4.32	0.43	71	19	0.61	2.246	6.8	6.3	5.5	6.3	5.5
7	50	10	30	5	180	25	11.1	22.2	4.11	14.3	43.4	5	391	342	80.7	3.92	0.36	76.5	16.5	0.65	3.5	3.8	3.3	2	2.3	3
8	37.5	27.5	10	20	120	10	14.7	14.3	4.5	8	53.1	3.5	341	350	77.3	3.96	0.44	71.5	24.8	0.69	0.5	3	2.8	2	3.8	4.5
9	45	10	20	20	180	25	9.38	16.5	5.5	7.72	54.4	5.5	353	402	74.2	4.61	0.3	74	16.3	0.71	2.74	4.8	3.3	2.3	2.5	5
10	55	10	10	20	180	25	8.7	12.5	5.5	8.5	61.4	3.5	372	393	76.4	4.72	0.3	71.3	16.7	0.69	2.398	2.5	3	2	1.8	4.5
11	50	30	10	5	120	25	12.1	24.1	4.91	14.3	37.2	7.5	373	349	86.3	4	0.33	70.9	24.5	0.68	0.5	8	6	5	5.5	5
12	20	40	30	5	180	10	10.1	28.1	4.32	16.8	33.7	7	398	379	86.3	3.33	0.32	76.5	19.8	0.65	0.746	4.5	6.3	5.3	5.3	4
13	20	40	30	5	120	25	16.2	26.5	3.5	17	31.1	5.5	383	370	84.2	3	0.44	76	24.8	0.67	2.246	4.5	5.3	4.3	4.5	4.5
14	55	10	10	20	120	10	15.2	11.5	2.5	9	59.4	2.5	364	381	79	2.83	0.38	71	20	0.61	0.5	6.5	6.3	5.5	4.8	5
15	20	50	10	15	150	17.5	12.5	17.5	5.5	11	50.5	3	371	382	72.2	2.94	0.32	71.5	16.3	0.68	3.246	4.3	4.3	3.3	4.5	4.5
16	50	10	30	5	120	10	16.6	14.2	6	12.5	46.3	4.38	354	374	70.3	2.63	0.41	75.9	20.4	0.63	0.746	6.8	3.3	2.8	4.8	4
17	50	30	10	5	180	10	11.3	17.1	3.98	10.5	51.3	5.8	368	403	74.7	3.98	0.46	71.3	20	0.68	3.746	6.8	5.8	4.3	4.5	5
18	20	32.5	30	12.5	120	10	16.8	22.8	4	18.1	35.2	3.14	395	400	79.9	3.9	0.52	76.6	20	0.65	0.5	4.8	4.8	4	3	5.5
19	20	40	30	5	120	25	15.4	25.8	5	17.2	33.1	3.61	390	378	83.1	4.11	0.55	76.4	24.8	0.64	2.246	4.5	5.3	4.3	4.5	4.5
20	20	25	30	20	180	25	12.1	20.9	4.22	15	40.3	7.5	380	379	83	3.22	0.57	76.1	20	0.61	3.246	6.8	4.5	5.5	4	6
21	20	45	10	20	180	10	15.2	19.3	4.11	18.6	36.1	6.11	389	360	80.2	2.62	0.48	71.2	19.6	0.62	1.246	4.8	5.5	4.3	4.8	4.5
22	20	50	15	10	180	25	11.7	22.8	3.5	10	47.5	4.5	371	364	84.3	2.99	0.41	72.3	20	0.58	3.246	6.8	6.3	6	7.5	5.5
23	20	32.5	30	12.5	120	10	16.1	24	4.32	16.2	34.7	4.7	380	370	84.1	3	0.36	75.9	19.6	0.75	0.5	5	4.5	4.3	4.3	6.5
24	20	45	10	20	180	10	12.9	25.4	5	14	36.2	6.5	372	363	84.3	3.33	0.4	71	19.6	0.7	1.246	4.8	5.5	4.3	4.8	4.5
25	35	10	30	20	180	10	10.9	23.8	6.11	17.5	34.2	7.5	389	340	79.3	4.16	0.42	76.1	19	0.66	3.246	3.5	4.3	4.5	3.8	6
26	30	50	10	5	120	10	17.5	24.7	5.31	10.1	37.6	4.8	340	360	76.2	4.43	0.39	71.8	24.5	0.61	0.5	5.3	4.5	5	4	5
27	30	50	10	5	180	25	11.6	23.8	6	11	42.1	5.5	363	358	80.4	5.11	0.4	72.1	16.7	0.58	1.246	7.3	5.8	5.3	6	5
28	35	25	30	5	180	10	14.5	25	6.5	12.5	40.1	2	373	354	79.2	5.18	0.52	76.5	19.4	0.61	1.246	4.3	4	4.8	4.3	4
29	20	45	10	20	120	25	16.5	26.2	4.81	16.5	33.5	2.5	387	368	83.3	5	0.57	71.3	20	0.63	0.5	2.3	3	3.5	2.8	5
30	47	20	19.5	8.5	150	17.5	15.1	18.8	4.33	16.1	37.2	8.5	369	261	77.8	4.32	0.48	73.7	16.7	0.66	1.246	2.8	2.8	3.3	3.5	3.5
31	70	10	10	5	135	13.8	13.5	18.2	5.21	13	47.1	3	378	300	78.6	2.91	0.52	71.5	19.6	0.7	1.246	4.5	4	4.5	5.5	4.5
32	70	10	10	5	180	10	12.1	18.6	5.5	14.3	43	6.5	375	320	80.1	4.28	0.57	71.9	16.3	0.64	3.246	6	5.5	5	5.3	4
33	70	10	10	5	120	25	16.7	19	3.61	13	42.3	5.4	362	340	80.1	3.12	0.53	71.1	19.6	0.68	0.746	5.8	4.5	4.5	4.8	4.5
34	20	50	20	5	120	10	16.3	28.9	4	17.6	28.3	4.9	387	342	82.6	3.63	0.55	74.4	20	0.64	0.746	5.3	5	3.8	4.3	5.5

The fat content, carbohydrate and energy values were set to maximize because of its high energy content for children. Ash content, potassium, iron, zinc, digestibility, spread ratio and bulk density, were all set to experimental range, to see which value produce a better biscuit. Calcium was set to maximize to give the children a healthy teeth and bones. Breaking strength was set at maximum to increase the strength of the biscuit for handling purpose. Colour was set at maximize to make the product attractive. Taste, flavor and texture were all set to maximize to give the biscuit an acceptable quality. Overall acceptability was set to maximize to see the best judgment. Then the product was optimized.

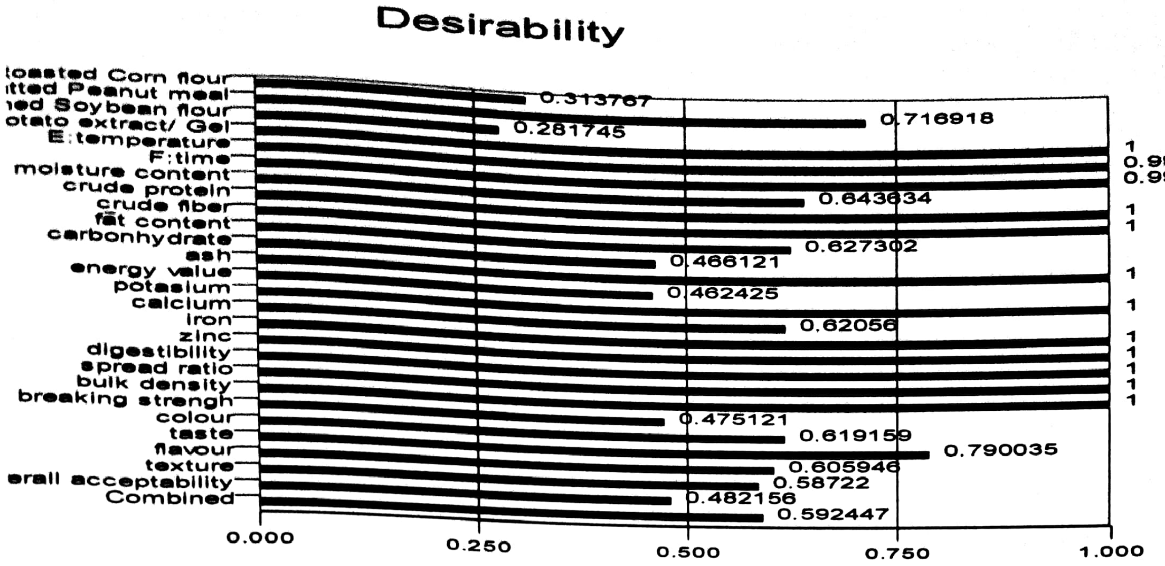
3.2 ANOVA for model equations used for optimization.

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	
Moisture Model	148.3477 7	2	74.17388 3	32.81087 6	2.226E- 08	significant
Lack of Fit	66.07132 7	26	2.541204 9	3.169533 2	0.100882 4	not significant
Protein Model	563.1045 4	15	37.54030 3	3.556733 1	0.006029 9	significant
Linear Mixture	404.3658 2	3	134.7886 1	12.77046 4	0.000103 6	significant
Lack of Fit	116.7998 6	13	8.984604 7	0.613828 3	0.778996 6	not significant
Fiber Model	17.08490 1	13	1.314223 2	1.783265 7	0.118601 6	not significant
Linear Mixture	1.710916 2	3	0.570305 4	0.773845 8	0.522228	not significant
Lack of Fit	12.11886 1	15	0.807924	1.541457 3	0.333120 7	not significant
Fat Model	284.6344 8	15	18.97563 2	2.593834 5	0.02831	significant
Linear Mixture	170.9073 5	3	56.96911 6	7.787274 7	0.001537 9	significant
Lack of Fit	112.4914 7	13	8.653190 3	2.254544 6	0.189527 2	not significant
Carbohydrate Model	2100.439	15	140.0293	5.073018	0.000774	significant

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	
	6		1	9	1	
Linear Mixture	1258.5923	3	419.53076	15.198872	3.545E-05	significant
Lack of Fit	436.72992	13	33.594609	2.7939768	0.1318708	not significant
Ash Model	34.430599	9	3.8256221	1.6670459	0.1525411	not significant
Linear Mixture	1.8628783	3	0.6209594	0.2705881	0.845962	not significant
Lack of Fit	51.468725	19	2.7088803	3.7543037	0.0740911	not significant
Energy Model	2734.661	3	911.55365	4.334487	0.0118635	significant
Linear Mixture	2734.661	3	911.55365	4.334487	0.0118635	significant
Lack of Fit	5593.0654	25	223.72262	1.5622849	0.3287331	not significant
Potassium Model	15353.89	13	1181.0684	2.0986544	0.0659434	not significant
Linear Mixture	3894.8892	3	1298.2964	2.3069582	0.1075336	not significant
Lack of Fit	7892.6495	15	526.17663	0.7823413	0.6760406	not significant
Calcium Model	196.31839	9	21.813154	1.7676125	0.1277634	not significant
Linear Mixture	75.710536	3	25.236845	2.0450488	0.1343342	not significant
Lack of Fit	273.46792	19	14.393049	3.1698352	0.1024916	not significant
Iron Model	12.28803	11	1.1170936	3.18716	0.0099435	significant
Linear Mixture	0.779658	3	0.259886	0.741476	0.538695	significant

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	
	5		2	6	5	
Lack of Fit	5.7473587	17	0.3380799	0.8608676	0.6323628	not significant
Zinc Model	0.1275817	13	0.009814	1.3724095	0.2545254	not significant
Linear Mixture	0.005488	3	0.0018293	0.2558178	0.8562756	not significant
Lack of Fit	0.0809183	15	0.0053946	0.4343438	0.9032791	not significant
Digestibility Model	175.28577	3	58.428589	618.45957	4.717E-27	significant
Linear Mixture	175.28577	3	58.428589	618.45957	4.717E-27	significant
Lack of Fit	2.3042316	25	0.0921693	0.8695214	0.6391872	not significant
Spread ratio Model	69.300708	2	34.650354	7.16004	0.0027772	significant
Lack of Fit	149.94164	26	5.7669863	360.43665	1.375E-06	significant
Bulk density Model	0.0300345	13	0.0023103	1.0439288	0.4522117	not significant
Linear Mixture	0.0063754	3	0.0021251	0.96024	0.4307263	not significant
Lack of Fit	0.0297625	15	0.0019842	0.6841964	0.7401192	not significant
Breaking strength Model	35.731445	11	3.2483132	6.3229665	0.0001256	significant
Linear Mixture	0.4836185	3	0.1612062	0.313794	0.8152128	significant
Lack of Fit	11.302114	17	0.6648302			significant
Colour Model	51.75073	13	3.980826	2.544627	0.029414	significant

Source	Sum of Squares	Df	Mean Square	F Value	p-value Prob > F	
	9		1	5	6	
Linear Mixture	12.736811	3	4.2456037	2.7138789	0.0721275	significant
Lack of Fit	31.268085	15	2.084539	521.13475	6.01E-07	significant
Taste Model	15.893132	3	5.2977107	4.218339	0.0132984	significant
Linear Mixture	15.893132	3	5.2977107	4.218339	0.0132984	significant
Lack of Fit	37.63128	25	1.5052512	167.25013	9.359E-06	significant
Flavor Model	23.649157	9	2.6276841	2.5497885	0.0324568	significant
Linear Mixture	7.7851274	3	2.5950425	2.5181145	0.0821303	not significant
Lack of Fit	24.688196	19	1.2993787	144.37542	1.406E-05	significant
Texture Model	28.965155	11	2.6331959	4.0138815	0.0026911	significant
Linear Mixture	12.489801	3	4.1632671	6.3462276	0.0028966	significant
Lack of Fit	13.587492	17	0.7992642	4.7293741	0.0470387	significant
Overall acceptability Model	11.297373	9	1.2552636	3.6466145	0.0053881	significant
Linear Mixture	2.7842017	3	0.9280672	2.6960898	0.0524816	significant
Lack of Fit	7.761451	19	0.4084974	4.0849742	0.0626869	not significant



It can be deduced from the optimization process that biscuit of 0.5925 desirability index can be obtained from the optimal conditions selected on the basis of the chosen criteria. Desirability is an objective function that ranges from zero (0) outside of the limits to one (1) at the goal of optimization. For any exact solution within the optimized ranges see table 5.Figure 1 shows a typical 3D surface graph to study the desirability of optimization to achieve the set goals of optimizing among the mixture components. Figure 3 shows a typical 3D mix - process graph for determining the desirability of the product by combining both the mixture components and the factors. This graph is used to fine tune the best mixture components and factors that will produce the desired optimization goals.

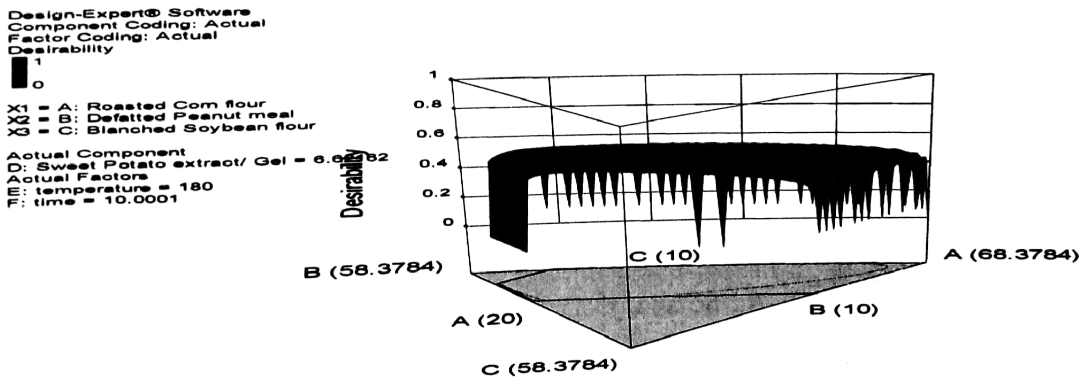


Figure 3.1: Typical 3D surface graph of the desirability of optimization

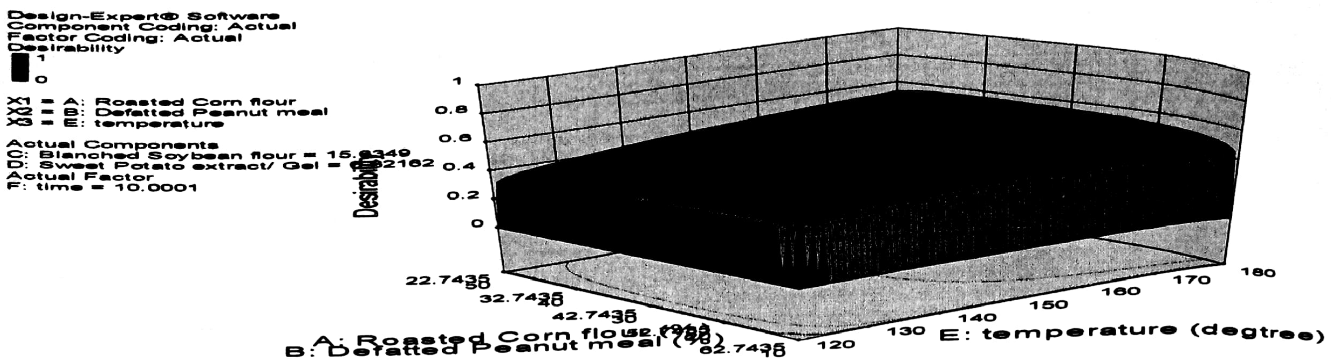


Figure 3.2: Typical 3D mix - process graph for desirability of the optimization

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

From the numerical optimization through the desirability function, the formulation that produced biscuit of highest desirability index was 5% of sweet potatoes, 17% of soybeans, 39% of roasted corn, 34% of peanut with baking temperature of 180°C and baking time of 11 min. The proximate properties, mineral content, digestibility, bulk density and spread ratio of this optimal formulation are moisture content (11%); crude protein (22); crude fiber (4.5); fat content (12.6); carbohydrate (44); ash content (7.4); energy value (373); potassium (314); calcium (80); iron(3.6); zinc (0.5); digestibility (73); spread ratio (18.7); bulk density (0.6); breaking strength (2) ; colour (5.8); taste (5.3); flavor (4.2); texture (5.2); overall acceptability (4.7); The fitted models provide the basis for selecting process parameters for optimal condition in the production of biscuit.

4.2Recommendation

The effect of more process variables using other methods of design of experiment should be explored. Further research should be carried out to determine the shelf life of the biscuit using suitable packaging material.

REFERENCE

Abdelghafor, R.F., Mustafa, A.I., Ibrahim, A.M.H., Krishnan, P.G. (2011). Quality of bread from composite flour of sorghum and hard white wheat. Adv. J. Food Sci. technol. 3:9-15.

Adegunwa, M. O., Adebowal, A. A., Solano, E. O. (2012). Effect of thermal processing on the biochemical composition, anti-nutritional factors and functional properties of beniseed (sesamum indicum) flour. Am. J. Biochem. Mol. Biol. 2012;2(3); 175-182

Ammar, M.S., Hegazy, A.E.. Bedeir, S.H. (2009). Using of taro flour as partial substitute of wheat flour in bread making. World journal of dairy and food sciences 4(2): 94-99.

A.O.A.C. (2005). Official method of analysis USA. Association of official analytical chemists.

Agu O.H., NdidiamakaA.O.,(2014) physiochemical, sensory and microbiological assessment of wheat based biscuit improved with benniseed and unripe plantain, 2(5) 464-469

Baljeet, S.Y., Ritika, B.Y., Manisha, K., Bhupendes, K. (2014). Studies on suitability of wheatflour blends with sweet potato, colocasia and water chestnut flour for noodle making. LWT. Food science and Technology 57(1); 352-358.

Gilbert, R.J., De-louvois, J., Donovan, T., Little, C., Nye, K., Riberio, C..D., Richard, J., Robert, D., and Bolton, F.J. (2000). Guideline for the microbiological quality of some ready-to-eat foods sampled at the point of sale. Public health 3: 163-167.

Iwe M.O. (2002). A handbook on method and analysis. Rejoin communication service ltd. Enugu. Pp 71-75.

Jideani, I.A., Osume, B.U. (2001). Comparative studies on the microbiology of three Nigerian fermented beverages-burukutu, pito and nbal. Nigerian food journal vol 19:25-33.

Kakalibandyopadhya, Chaitalichakraborty and Sagarika Bhattacharyya (2014). Fortification of mango peel and kernel powder in cookies formulation. Journal of academia and industrial research (JAIR) Vol 2, pp 661-664.

Meena Mehta (2013). Development of low cost nutritive biscuit with ayurvedic formulation. International journal of ayurvedic and herbal medicine. 3(3) 1182-1190.

Olaoye, O.A., Onilude, A.A., Idowu, O.A. (2006). Quality characteristic of bread produced from composite flour of wheat, plantain and soybeans. Afri. J. of biotechnology vol 5 (11) pp 1102-1106.

Olugbemi, L.B. (1991). Wheat cultivation in Nigeria : problem, progress and prospects. Pp 525-529, D.A. Saunders, ED., wheat for the nontraditional warm areas. Mexico D.F: CIMMYT.

Onwaka, G.I. (2005). Food analysis techniques and instrumentation. Naphtali prints pp 64-75, 133-137.

Orunkoyi, O. (2009). Evaluation of sweet potatoes flour for the production of instant noodles. Unpublished M.SC dissertation 67 pages.

Ovando-msrtinez, M., Sayago-Ayerdi, S., Agama-Acevedo, E., Goni, I., Bello-perez, L. A. 2009. Unripe banana flour as an ingredient to increase the undiegestible carbonhydrates of pasta. Food chemistry 113;121-126

Sanni L,(1997). Quality assurance system in the food industry. Jedidiah publish, Abeokuta pp 17-30.

Sanni, L.O., Babajide, J.M., Ojerinde, M.W. (2007). Effect of chemical pretreatments on the physic-chemical and sensory attributes of sweet potato-garri. An international journal asset series B6(1); 41-49

Shittu, T.A., Raji, A.O., Sanni, L.O. (2007). Bread from composite cassava-wheat flour. Effect of baking time and temperature on some physical properties of bread loaf. FD. Res. Int. 40:280-290

Sivakamisaridevi P.L., Sarojini K.S.(2013). Formulation of value added biscuits using defatted coconut flour. America journal of food technology. 8(3) 207-212

Tanaya, M. L. J., Biswas, M. M. H., Shamsuddin, M.(2014). The studies on the preparation of instant noodles from wheat flour supplementing with sweet potatoes flour. Journal Bangladesh agriculture university 121(1); 135-142

Zhao, Y. H., Manthey, F. A., Chang, S.K.C., Hou , H.J., Yuan, S.H. (2005). Quality characteristics of spaghetti as affected by green and yellow pea, lentil and chicken pea flour. Journal food science 70:371-376