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Sensory and market attributes of wheat-*Musa. spp-soybean* (WPS) flour composite bread

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Abstract *In order to search for local raw materials that could meet the formulation of affordable, nutritious and functional bread that can compete or perform better than the 100% wheat flour, we conducted a study with, composite bread samples baked with blends of wheat, soybeans and plantain flours. The composite flours were formulated using the augmented Simplex Lattice {3,3} design of the response surface methodology (RSM). Fourteen (14) samples from the respective blends were produced using standard method. The bread samples were subjected to sensory evaluation, using the semi-trained panelist of 20 members consisting of 10 male and 10 female, who were familiar with bread quality. The results indicated that the sensory attributes of the 100% wheat (standard) bread, the minimally supplemented bread samples scored higher values of the sensory parameters including shelf stability. Models of the parameters of the bread samples were not significant (p>0.05), but their response surface plots and calculated mathematical models indicated some levels of influence by the components. Optimization analysis of the sensory evaluation and shelf-stability data revealed that 0.590, 0.220, 0.195 proportions of wheat, Musa spp. and soybean flours produced 7.163, 6.835, 6.653, 5.737, 5.301, 8.184, for taste, colour, texture, aroma, acceptability and preference respectively at 100% desireability level. Acceptability and preference of the samples exhibited similar trends with the taste, colour, aroma, and texture. The bread quality parameters were observed to be function of the proportions of the flour components in the samples. The mean mold-free day of the samples was 4.0, the highest hedonic value and shelf-stability were observed in the sample that had high substitution of wheat.*

Key words: *Composite bread, sensory evaluation, bread quality, mixture experimental design*

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1.0 Introduction

Bread is an important snack in the menu of most Nigerians. But as a food item, most formulations of the products have failed to meet the ideal attributes of nutrition, affordability, functionality, taste and shelf-stability of the consumers (Eddy and Ekop, 2005; Eddy *et al*., 2012). According to Eddy *et al.,* (2016) an ideal food is expected to provide adequate nutrition and health needs for the different age-groups which have not been met by most the traditional bread varieties in our markets. Currently, most Nigerians, especially the poor class have few choices to make (if they can afford to buy bread) because varieties of bread formula with different alterations in organoleptic and market attributes are rarely available for consumers of different age-groups. This implies that there is no provision for individual nutritional needs, consequently, consumers are forced to accept what is available due to lack of alternatives (Udofia *et al.,* 2013). According to Kumar *et al.,* (2012), all members of a population need bread to meet specific health. However, hundred (100) percent wheat flour can provide mainly glutein and glutenin (Kolawole, 2018). Also, the hard winter wheat is an alien crop to Nigeria because it is imported at high cost for bread-making. Besides, the quantity imported may not be enough and the quality may not be perfect. Unsuitable agronomic conditions do not support local cultivation of wheat at commercial quantities. Global Agricultural Information Network (through the U.S. Department of Agriculture) reported that Nigeria is currently importing up to 4.4 metric tons of wheat annually at $211.45, amounting to ₦334,936.80 (at exchange rate of ₦380.00 per dollar). It has been predicted that cost of importation and expenditure on wheat will rise in the near future. Several authors have reported that substitution of wheat flour with cassava, cocoyam, and bananas flours could produce good quality bread Kolawole, 2018; Mepba *et al.,* 1990; Mohan *et al.,* 2012; Kumar *et al.,* 2012; Eddy *et al.,* 2016; Udofia *et al.,* 2016). Plantain contains serotonin, the phytochemicals which can expands the arteries, improve blood flow, reduces risk of arterial diseases and strokes (Mepha *et al.,* 1999). Plantain is also rich in dietary fibre, can reduce cholesterol level in the human system and prevent heart disease. Calcium promotes the development of strong bones, muscles, teeth, nails, and prevention of osteoporosis and bone fracture. The quality of carbohydrate in plantain give it preference over other carbohydrate source especially for diabetic patients in Nigeria (Adeleke and Germain, 2000).

On the other hand, soybean is another important food crop of the tropic (Mepba *et al.,* 1999). It is rich in calcium, dietary fiber, low in saturated fatty acid, cholesterol-free genistein and daidzein flavones which may prevent high cholesterol levels and heart diseases as well as reduction of cancer risk (Tim and Tam, 2001). According to Eddy *et al*., (2016), incorporation of the nutritional flours in composite bread samples could drive nutrients and phytochemicals into the consumers than when consumed singly. Mohan *et al.,* (2012) also stated that replacement of wheat flour by the plantain and soybean flour could reduce the cost of importation of wheat and wheat flour.

Response surface methodology is a statistical technique for systematic determination of quality effects of multiple components in a composite system (Anderson and Whitcomb, 2002). According to Bondari (1999), the quality of composite products depends on the proportions of its individual components indicating that response surface analysis is a significant tool for product optimization. The design has received favourable recommendation in the development of new food product and food product development in the chemical, pharmaceutical and biochemical industries.

Despite growing demand for wheat and the high cost of importation and purchase, little is done on ways of harnessing local raw materials as alternatives to forestall cost and dependency on imported wheat and flour. Therefore, the present study is designed to optimized some sensory and market attributes of composite bread produced from soyabean and plantain flours using the mixture experimental design of the response surface model.

2.0 Material and methodology

2.1 Materials

Wheat flour was bought from the Niger Mills, Calabar, Nigeria. Bunches of unripe plantain *(Musa spp.)* fingers were bought from a local farm. Soybean was bought from Ikot Ekpene Main Market while baking materials were bought from Nteps' Baking Shop, No. 1 Umuahia Road, all in Ikot Ekpene, Nigeria.

2.2 Preparation of plantain flour

Musa spp. flour was prepared according to the method reported by Mepha *et al.,* (1990). The samples were washed, peeled and cut into thin slices of about 2 cm thick and blanched in 1.25% $NaHSO_3$ solution at about 70 °C for 5 minutes. The blanched plantain slices were drained and dehydrated in a Thelco air-recirculating oven at 65 °C for 24 hours. Dried plantain slices were milled into flour in a Retch Muhle 2880 Hammer mill to pass through 250 μm aperture sieve before they were packed in a two-ply medium density of 0.926-0.949 g/cc polythene bag.

2.3 Preparation of soybean flour

Soybean seed stock was sorted of extraneous materials, washed and soaked in hot water maintained at 75 ºC for 2 hours. The hot water was drained off the seed stock and washed with distilled water. It was then soaked in cold distilled water for 24 hours, followed by decocting and sun-drying before re-drying at about 60 ºC in an oven to reduce the moisture content below 12%. The dried soybean seed was milled into flour using the Retch Muhle 2880 Hammer mill, to pass through 250 µm aperture sieve. The produced flour sample was packed in a two-ply medium density, 0.926-0.949 g/cc, polythene bag.

2.3 Determination of mold-free day

Mold-free day of the composite bread samples were determined according to the method reported by Iglesias and Chirife, (1976) and Igathinathane *et al.,* (2005). The bread samples were stored in transparent disposable plastic plates at room temperature. The samples were observed daily for the first appearance of mycelium of mold. The date was taken as the mold-free day, minus one day for the period the mycelium could not be observed with an unaided eye.

2.4 Experimental design

2.4.1 Response surface methodology (RSM)

The formulation of the composite flours was carried out according the Simplex Lattice design method reported by Box and Behnken, (1960) (Table 1) assuming equations 1 and 2. The mixture experimental design was consistent with equation 2 and the contents recorded in Table 1.

$$\sum_{j=1}^{n} xj = 1 = 100\% \quad (1a)$$

$$X_j = 1.0 - \sum_{i=1}^{j-1} xj - \sum_{i=j+1}^{n} xj \quad (1b)$$

2.5 Formulation of the composite flours

Composite flours were formulated according to the method adopted by Dagas and Membre, (2013). In this design, 0, 1/3, 2/3, and 1 proportions of wheat flour (A), *Musa spp.* flour, (B) and soybean flour, (C) designated as {3, 3} proportions were combined to produce different composites flours (Table 2, equations 1 and 2). The design determines the blends of the components and the proportions that produce more desirable products (Dagas and Membre, 2013). The responses may be assessed by the 2nd polynomial fit to the equation (Meyers and Anderson, 2009).

$$Y_n = \beta_1 A + \beta_2 B + \beta_3 C + \beta_{12} AB + \beta_{13} AC + \beta_{23} BC + \beta_{123} ABC \quad (2)$$

where Y_n = a response, β_n = weight of a component(s), A, B, C = pure blends, AB, AC, and BC = binary blends and ABC = tertiary blends. The small model of the design was used resulting in 14 experimental runs i.e. 14 composite bread samples (Table 2).

Table 1: Experimental layout of the augmented Simplex Lattice {3,3} design, and proportions of the components in the bread sample

Components	Unit	Lower proportion	Upper proportion
A	-	0	1
B	-	0	1
C	-	0	1

2.6 Bread making

Composite dough samples were formulated according to the method reported by Mepha *et al.,* (1990) with slight modifications to suit the design (Tables 1 and 2). 1 g of salt, 30 g butter, 20 g yeast (constant) and 10 g of sugar (constant) were introduced in turn into 100 ml water followed by stirring, using a Kenwood mixer (Model A 907D) for 10 minutes. The dough samples were allowed to ferment in a bowl covered with wet clear muslin cloth for about 25 minutes (at 27±1.0 °C). The fermented products were punched and scaled to 100 g dough pieces. The dough pieces were proofed in a proofing cabinet for 95 minutes at about 30 °C for 30 minutes and baked in a hot air oven at 180 ºC. The samples were cooled to room temperature before presented for sensory evaluation.

2.7 Evaluation of bread characteristics

2.7.1 Sensory Evaluation Procedures

Sensory evaluation on the composite bread samples was done according to the method of Udofia *et al*., (2013) and Eddy *et al*., (2016). A nine 9-point hedonic scale of dislike extremely =1 and like extremely = 9 was deployed to measure degree of preference of samples. Twenty (20) semi-trained panelists who had been familiar with the theory of sensory evaluation and are routine consumers of breads were engaged for the test. The selection covers 15-55 years age group consisting of 10 male and 10 female. The sensory evaluation was done for taste, colour, texture, aroma, preference and overall acceptability. The bread samples were sliced into pieces of uniform thickness of about 2 cm and randomly presented in clean, odourless, identical, coded and disposable plastic plates to the panelists in the morning hours (between 10 a.m. and 12.30 p.m). Nestle portable bottled water was provided to each of the panelists for mouth rinsing and to prevent carry over sensory taste effect among the bread samples. The panelists were instructed to rate the attributes indicating their degree of like or dislike on the evaluation script.

3.0 Result and Discussions

Table 2 presents proportions of the component flours in the composite bread samples, values of sensory perception and shelf-life of the samples. The table shows that responses to the sensory attributes of the samples varied according to the proportions of replacement of wheat flour with plantain and soybean flours in the composite bread samples. From the table, it can be seen that the panelists were able to detect the differences between the normal wheat flour bread and the composite bread samples at low replacement levels. This observation was similar to the trend reported by Eddy *et al.,* (2016) and Udofia *et al.,* (2013) respectively on sensory evaluation of composite flour bread. Equations 3 to 9 are the fitted models in the experimental space, they describe the behavior of each term in the models. Figs, 1 to 7 present graphical variation of the parameters according to changing proportions of the component flours in the composite bread samples. Table 2 (b) shows the mean mold-free day of the composite bread samples. The table shows that pure flour bread samples exhibited lower shelf life than the binary and centroid blend composites. The observation can be attributed to the presence of phytochemicals in plantain and soybean Sim and Tan, 2001). Some phytochemicals in the component flours could provide antimicrobial activity that can inhibit the development, growth and multiplication of mold and bacteria and hence, the shelf life of the bread (especially in the blends samples with less proportion of wheat flour).

Table 2: Assignment of proportions, sensory responses, and shelf life of the composite bread samples baked with flours of A, B and C.

Run	A	B	B	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	MFD (days) (b)
1	0.67	0.17	0.17	3.90	7.87	2.00	2.00	2.00	2.00	4.0
2	0.50	0.50	0.00	7.30	4.00	2.80	2.00	3.96	4.00	5.0
3	0.17	0.67	0.17	2.00	2.00	2.90	2.08	3.00	2.00	3.0
4	0.50	0.00	0.50	3.00	6.00	4.54	4.00	5.00	6.89	3.0
5	1.00	0.00	0.00	9.00	8.50	9.23	9.00	8.69	8.00	5.0
6	0.00	1.00	0.00	6.00	7.80	6.89	6.00	7.00	8.90	3.0
7	0.00	0.00	1.00	5.00	6.00	3.90	3.00	2.56	2.00	2.0
8	0.00	1.00	1.00	2.30	3.00	2.00	2.33	3.00	2.00	2.0
9	0.50	0.00	0.50	2.00	5.00	2.00	2.20	2.00	4.55	4.0
10	1.00	0.00	0.00	8.60	9.00	8.56	8.50	8.98	8.24	5.0
11	0.17	0.67	1.67	6.00	7.00	6.56	6.00	7.00	7.98	2.0
12	0.00	1.00	0.00	5.99	8.02	7.00	6.33	6.00	5.00	3.0
13	0.00	0.00	1.00	6.45	5.03	5.00	5.34	7.00	6.75	6.0
14	0.33	0.33	0.33	7.99	8,76	8.09	8.12	8.24	8.00	5.0

*****Run = randomized order of baking, A - C = components of the bread samples, Y = a response, MFD = mold-free days in days, Y_1 = taste, Y_2 = colour, Y_3 =texture, Y_4 = aroma, Y_5 = preference, Y_6 = acceptability. MFD = shelf stability (mold-free day).***

3.1 Colour

The brown colour of bakery products is due to Maillard reaction and caramelization of sugars (Purlis, 2017). Colour is responsible for initial acceptance of foods. Flavour and aroma compounds, formation of toxic products acrylamide, and decrease of nutritional value of proteins are also products of the phenomenon. Development of browning in bakery products is a simultaneous function of heat and mass transfer process that occurs mostly in a non-ideal system that operates under non-ideal conditions (Eddy *et al.,* 2016; Purlis, 2017).

The bread consuming population assumes that brownness indicates iron content, Consequently, the deeper the colour the more they desire to accept and consume such breads. This also explain why the crust of any bread sample is expected to be light to deep brown, depending on the preference and baking practice employed (Purlis, 2017). In this study, composite bread samples showed shades of crumb brownness comparable with the pure blend bread samples (runs 1 and 10), (Table 2). The other samples displayed different colours which seems to vary with the colour of the component flours. Generally, appreciation of colour of the bread samples was observed to decreased with the level of substitution of the wheat flour with the component flours. The model of colour was significant ($p<0.05$; R^2 = 0.7579) with mean hedonic scale of 5.57 of 9.

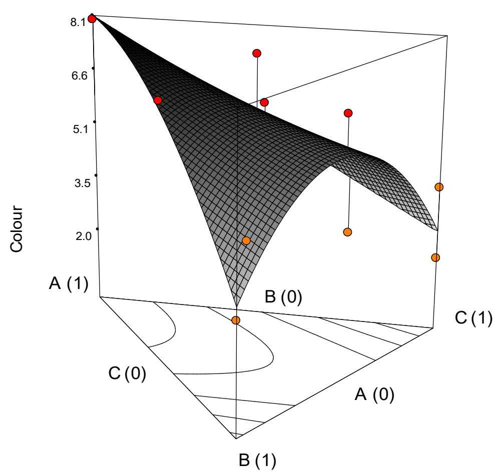

Fig. 1: Response surfaace plot of colour of composite bread samples using flous A, B, and C

Colour of the composite bread were not significant ($p>0.05$), but Fig. 1 and equation 3 shows influence of the components on the model of the parameter. The figure shows that the mean colour of the samples decreased with the degree of replacement of wheat flour with soybeans and plantain flour. The colour of the 100% wheat bread showed 8.1 mean hedonic score on colour while acceptable colour score gave an upper range score of up to 3.5.

Colour = 8.09A+3.33B+2.76 C+4.84AB +1.12AC+12.55BC-18.41+ABC (3)

3.2 Taste

Taste is a the most significant sensory attribute of food after colour (Eddy *et al.,* 2016). Taste is generated as a consequence of mastication of food. In this, the model of taste was significant ($p<<0.05$, R^2 = 0.8853) at mean hedonic score of 5.21. The parameter on the binary and centroid blend composites were not significant ($p>0.05$), From Fig. 1 and equation 3 it is evident that there are some contributions from the components of the flour to the model representing taste. A wide variation in the mean score of the hedonic scale on taste was observed according to the substitution level of the component flours in the samples. This may be attributed to composition of the panel and strangeness of the samples (Udofia *et al*., 2013). Eddy *et al.,* 2016) attributed the trend to the fact that sensitivity of the parameter varies significantly in different population groups, furthermore, taste acceptability is related to cultural, traditional and genetic factors. The samples obtained from the study (except for the control) were new products and needed time for consumers' familiarity and acceptability preference to be fully established.

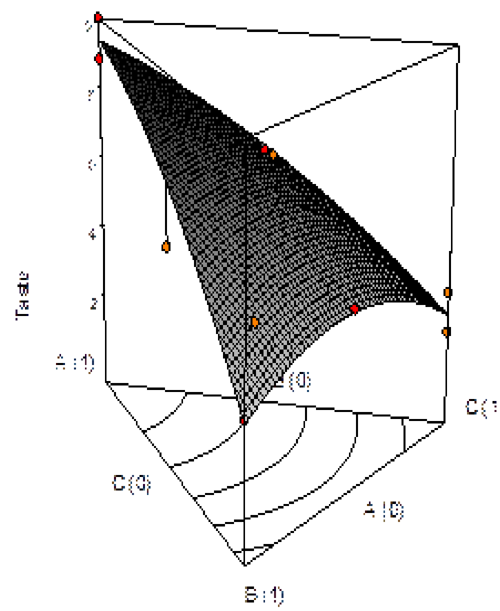

Fig. 2: Response surfaace plot of taste of composite bread samples using flous A, B, and C

Taste = *8.48A+2.91B+2.46C+2.78AB +1.68AC+4.22BC+14.14ABC* (4)

3.3 Texture

Texture of the composite bread samples were rated on the 9-hedonic scale of dislike extremely (1) and like extremely (9). In the study, the mean texture hedonic score ranged between 2 to 8. The 100% wheat flour bread exhibited the highest score of 8, the scores decreased according to the rate of substitution of the wheat flour with the components in the binary and ternary blend composite bread samples. The model of the parameter was significant ($p<0.05$; $R^2 = 0.8138$), the linear mixture and the binary AB effects were also significant ($p<0.05$) in the model. Texture of all-wheat flour bread is promoted by the rising effect of glutein and glutenin proteins in the wheat flour. Replacement of wheat flour with non-wheat flour dilutes the proteins in the wheat flour blends, producing less crumbs colour, air spaces and rising capacity of the samples (Udofia *et al.,* 2013).

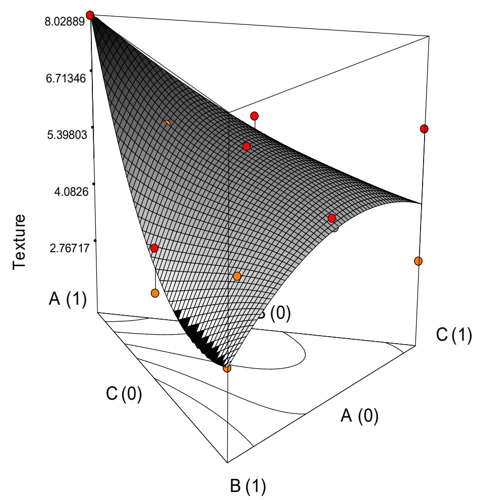

Fig. 3: Response surfaace plot of texture of composite bread samples component flours A, B, and C

Texture = 8.03A+3.03B+4.34C -7.88AB - 1.81AC+4.19BC+22.73ABC (5)

3.4 Aroma

The model for aroma was significant ($p>0.05$; $R^2 = 0.3838$) and showed a mean hedonic score of 5.43. The aroma of composite bread samples was rated on a hedonic scale of 1 to 9 for dislike extremely and like extremely respectively. The mean aroma value ranged from 2 to 8 for highly substituted wheat flour composite bread samples and for the non- and lowly substituted wheat flour composite bread samples. Despite the beany aroma and raw odour of *Musa spp*. and soybean, high substitution of the wheat flour by the composite flour samples did not adversely decrease choice on the aroma. The observation could be attributed to the effect of high temperature on the protein content of soybean and plantain flours, an effect which is desired in traditional roasted soybean and plantain. Similar observation was also reported by Cornel, (2002) on 'eating qualities of muffins prepared with 10% and 20% soy flour. The derived regression equation is expressed in equation 6.

3.6 *Acceptability*

Food acceptability is an extremely complex phenomenon in food preference (Rozin, 2007). It is a function of the consumers' behavior detected by psychology, physiology and economy factors. Most often, food acceptability lacks defined pattern since it is a function of several combination of factors. In this study, the parameter did not trace a defined pattern although Fig. 5 and equation 7 indicated some trend. Table 2 indicated that some would be rejected samples scored favourable hedonic cores. This observation could be attributed to the idiosyncrasy of the consumer, Rozin, (2007) reported similar trend in his study of food choice. Also, sensory scores on the parameter was influenced by the levels of other sensory attributes of the bread samples.

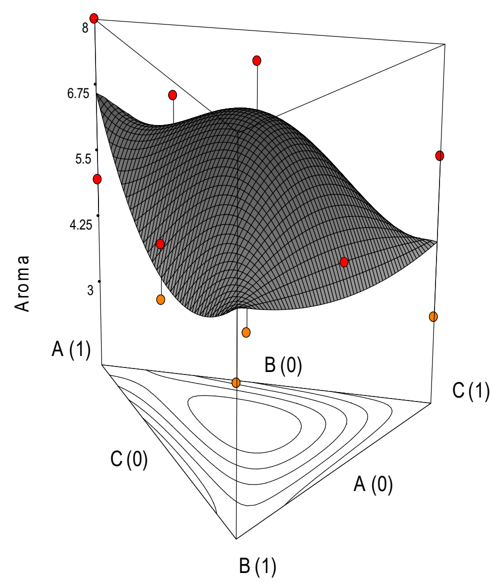

Fig. 4: Response surfaace plot of aroma of composite bread samples components flours A, B, and C

Aroma = 6.64A+5.26B+4.43C-6.19AB-1.54AC-1.82B C+71.57ABC (6)

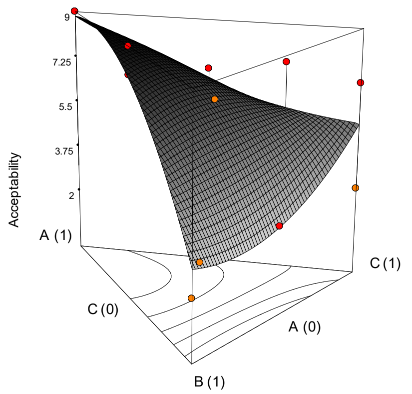

Fig. 5: Response surfaace plot of aceptability of composite bread samples using component flours A, B, and C

Acceptability = 8.84A+3.03B+5.46C +7.72AB-2.22AC-5.07BC+30.24ABC (7)

3.5 Preference

Preference of a new product indicates readiness to buy and use the product in the presence of a close substitutes, it is also a factor of acceptability. In this work, the parameter was rated on the hedonic scale of 1 to 9. The model of preference of the composite bread samples appeared to be significant ($p=0.1261$; $R^2=0.6835$) and the overall mean of 5.50, AC was significant ($p<0.05$). AB appeared to be significant ($p=0.1057$) and ABC, $p=0.1911$. The calculated mean hedonic scale on preference of the composite bread samples ranged from 2 to 9. The all-wheat flour bread samples scored had highest values of 8 and 9 on hedonic scale. The binary and centroid blend composites score between 2 and 7. The result showed that minimal substitution of wheat flour in the composite bread samples did not adversely decrease preference for the bread samples. The contribution of the terms to the model is shown in equation 7Fig. 6 and equation 8.

3.6 *Mold-free day*

Mold spoilage is a major problem in bakery industry and baking products, resulting in significant losses (Igathinathane *et al*., 2005); Kunyanga and Imungu, (2010) and Giami *et al.,* 2004). Mold-free day indicates shelf-life stability of baked products. During storage of bread samples, spore germination and mycelium proliferation occur, molds may produce exoenzymes like lipases, proteases, and carbohydrases. The exoenzymes transform the sensorial properties of the food product by inducing off-flavours and discolouration. Toxins are potentially dangerous to health of the consumer. The observed models, Fig. 7 and equation 9 was not significant, ($p>0.05$, $R^2 = 0.2653$), the mean mold-free day for the samples was 3.17 days, indicating that the samples could lose their functionality in 4 days of storage. The shelf-life of carbohydrate products is a factor of formulation, process and environment, control of the factors may extend shelf life (Iganthinathane *et al*., 2005).

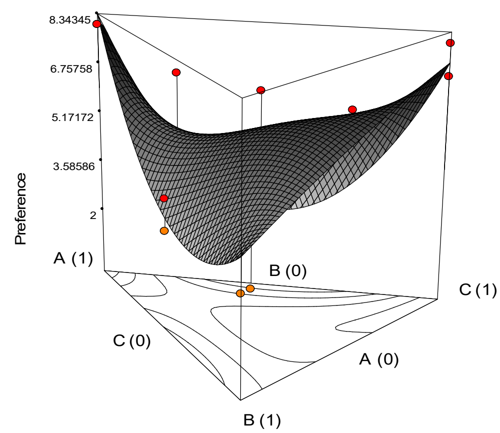

Fig. 6: Response surfaace plot of preference of composite bread samples using of component flours, A, B, and C

Preference = 8.34 A+4.06B+7.42C-11.20AB-21.42AC+0.86BC+76.84ABC (8)

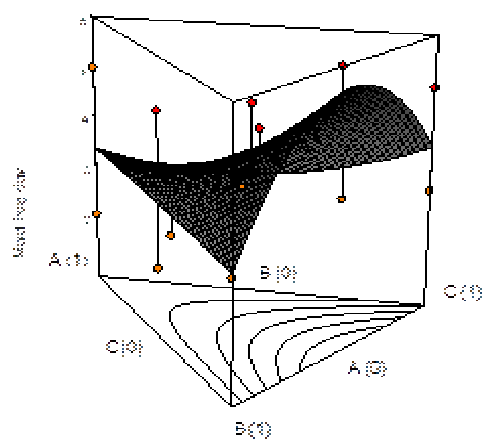

Fig. 7: Response surface plot of mold-free day of composite bread samples of components flours, A, B and C

Mold-free day

=3.36A+3.07B+3.86C+0.86AB-70AC +9.59BC-21.19ABC (9)

Fig. 7 shows that the all-wheat flour bread exhibited lower mold-free day than the composite bread samples following the trend of substitution of the wheat flour by the non-wheat components. This observation could be attributed to the fact that soybean incorporated with wheat flour including other baking ingredients were rich in nutrients to support microbial life. The water activity of the composite bread samples could also play a role. This observation as represented by equation 9, which expresses the contribution of the flour components to the model

4.0 *Conclusion*

The results showed that the sensory attributes of standard bread, followed by the minimally supplemented bread samples showed higher values including shelf stability. Models of the parameters of the bread samples were not significant ($p>0.05$), but their response surface plots and mathematical models showed some levels of contribution to the models. The high displacement of wheat flour breads showed higher shelf life in terms of mold-free days (4 days). Optimization analysis of the sensory and shelf-life data revealed that 0.590, 0.220, 0.195 proportion of wheat flour, *Musa spp*., and soybean flours respectively produced 7.163, 6.835, 6.653, 5.737, 5.301, 8.184, of taste, colour, texture, aroma, acceptability, preference and MFD respectively at 100% desireability level. More work should be done on the health potential of the composite flour bread samples.

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