Functional and Sensory Characteristics of Sorghum-Cocoyam-Cassava (SCC) Composite Flour Bread

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Abstract**—** *This study was carried out to evaluate the bread characteristics and sensory attributes of sorghum- cocoyam-cassava flour composite bread using simplex lattice of experimental design of response surface methodology (RSM). The sensory evaluation results from semi-trained panelists were generated into a 3D plot for color, taste, aroma, texture and overall acceptability. Wheat bread was used as control for comparison. The loaf weight of the bread samples ranged from 216.0g by sorghum-cocoyam-cassava bread to 177.5g of wheat bread(control); the loaf specific volume ranged from 251.9cm^3 of wheat to 187.2cm^3 of sorghum bread while loaf specific volume ranged from 1.42cm^3/g to 1.10cm^3/g. The linear mixture components of sorghum-cocoyam, sorghum-cassava, cocoyam-cassava and sorghum-cassava-cocoyam flours were not significant on the attributes. The mean hedonic score values for all tested attributes were different from the bread sample (control) at $p<0.05$. The overall acceptability of the samples showed $p>0.05$ indicating poor acceptance of the composite bread. Generally the samples under study showed dark brown external and internal colour with increased coarseness and firmness. However, a successful use of sorghum, cocoyam and/or cassava with improved processing methods leading to production of indigenous bread would save many less developed countries from importation of wheat.*

Keywords*— *Bread characteristics, sensory evaluation, composite flour, mixture experimental design, Response Surface Methodology (RSM).

I. INTRODUCTION

Bread is the second most consumed non-indigenous food product after rice in Nigeria (Idowu, *et al.,* 1996). Wheat flour is a major component of bread with the proteins glutein and glutenin giving it unique baking properties. Glutein is responsible for the elasticity of the dough by causing it to rise and trap the carbon dioxide generated by yeast during fermentation (Mepba *et al;* 2007). Wheat production in tropical countries vis-à-vis Nigeria is inadequate, hence the heavy reliance on importation thus depleting the lean foreign reserve.

Efforts have been made to promote the use of composite flours using locally grown crops to replace wheat flour in bread making thereby decreasing demand for imported wheat and stimulating production and use of locally grown non-wheat products. Studies on the use of various oilseeds, legumes, and high protein seeds in bread making have been reported (Yue *et al.,* 1991 and Olaoye *et al;* 2006).

According to Mongi *et al;* (2011), 2-10% non-wheat flour can be used without undesirable changes in bread characteristics. Cocoyam, cassava, plantain and other tubers have been reported as alternative sources of major raw materials for bread making (Mepba, *et al* 2007; Udofia *et al;* 2013; Idowu *et al;* 1996). Casier *et al;* (1976) reported the production of good quality bread from pure millet and sorghum flour as well as mixtures of maize and cassava flour. Well structured bread from pure seed sorghum flour was obtained using 3% rye pentosan. The pentosan acted as a binding agent simulating the role of gluten from wheat. Certain bread improvers such as calcium stearate or relatively high percentage of fat and sugar are used to improve the bread characteristics of non-wheat flour (Idowu *et al;* 1996).

Sorghum flour is made from *Sorghum bicolor* and is rich in protein, B Vitamins, dietary fibre and antioxidant. (Tekle, 2009) Sorghum flour would be an excellent substitute for wheat flour in which some consumers are gluten-intolerant. Cocoyam are commonly consumed as energy giving foods. The mainly edible varieties are *Colocasia Esculenta* (taro) and *Xanthosoma Sagittifolium* (tannia). Cocoyam contains minute size starch which enhances digestibility and is ideal for people with digestive problems especially the elderly, invalids, and the diabetics (Idowu *et al.,* 1996). According to Idowu *et al.,* (1996) Cocoyam is nutritionally superior to other roots and tubers in terms of digestibility, crude proteins content, and minerals such as calcium, magnesium, and phosphorus. A major limiting factor in the utilization of cocoyam is the presence of oxalates which cause acridity and irritation when eaten (Bradbury and Holloway, 1988; Bencini, 1991). Proper processing methods however would diminish the acridity. Cassava is a tropical crop with high content of carbohydrate. Though some varieties contain cyanide, improved processing methods are capable of alleviating the cyanide content. Physio-chemical properties of cassava starch are suitable for supplementation of wheat flour in bread making without compromising its sensory attributes (Eduardo *et al;* 2013).

The use of substitutes for wheat flour in bread making if feasible would lower the dependency of developing nations on imported wheat. The major objective of this study therefore was to examine the effect of selected experimental variables (levels of sorghum, Cocoyam, cassava flour) using response surface analysis (RSA) on the physical characteristics of bread (bread volume, loaf volume, organoleptic) of the composite flour bread.

The overall aim was to produce an acceptable indigenous bread like the Pita bread of Arabia and Syria, Roti Bread of Asia, (wheat, millet, cocoyam), Rye bread of Europe (Rye/Wheat); Ezekiel bread, Rye/Wheat. Krisa bread of Sudan (Sorghum), Chapatti bread of India (Sorghum), Tortilla bread of Central and South America (Sorghum). (Asiedu, 1989).

II. MATERIALS AND METHODS

American hard red winter wheat flour was obtained from Niger Mills, Calabar. Sorghum (*Sorghum bicolor*) was purchased from Ikot Ekpene main market. Samples of cocoyam (*Xanthosoma*) and cassava variety TMS (4) 1428 were collected from Root Crop Research Institute Umudike, baking ingredients, reagents and chemicals were sourced from reputable shops in Ikot Ekpene, Nigeria.

2.1 Preparation of sorghum flour

The cleaned sorghum seeds were ground in attrition mill. The ground sorghum was sifted using a sieve DIN 4188 (0.12M) aperture, then stored in plastic container for use.

2.2 Preparation of cocoyam flour

Fresh crowns of cocoyam were washed with water, peeled using stainless steel knife, rewashed and sliced into 0.5 cm thickness. The slices were washed to remove the mucilage, put into 0.5% potassium bisulphide solution for 5-10 minutes to check browning. The slices were drained and dried to a constant weight in a hot air oven at 105^0c for 24 hours before milling into flour using a grinder fitted with a 500µ mesh sieve. The flour obtained was packed in sealed plastic container to check moisture absorption.

2.3 Preparation of cassava flour

The preparation of cassava flour was carried out according to the method adopted by Udofia *et al;* (2013). The cassava tuber was peeled about, 10 hours post harvest, washed, sliced thinly with a shredder (Qlink, China) removing the fibre part. The shredded cassava was washed with ample water and allowed to drain. It was dried in hot air oven (Therm Gross Kucken, le Chef, Sweden) at about 60^oC until moisture content was reduced to about 13%. The cassava flakes were ground through a corn meal grinder to pass through a sieve of 500 cm mesh. The flour was packed in plastic container to deter water absorption.

2.4 Experimental design

The mixture experimental design was used to study the effect that the proportions of the different ingredients in the composite flour have on the food product properties of interest (Hu, 2000). A mixture experiment is one in which the food quality indices (responses) are assumed to depend only on the selective proportions of the ingredient. Response in a mixture experiment is a function of properties and not amounts of the mixture components. On a food formulation study, the mixture experimental design models the relationship between the component proportion (variables) and the food quality indices (responses) shown on the response surface. A full second degree polynomial equation was used to describe the relationship between the variables and responses after fitting the experimental data in the regression model. The experimental design assumes equation (1)

$$Y_i = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \beta_{23} X_2 X_3 + \beta_3 X_1 X_J^2 \qquad (1)$$

Where Y_i is any response, β represents coefficient to be fitted via regression analysis, X_1, X_1, X_2, $X_1 J^2$ are the linear, interaction and quadratic effect of the components respectively. A simplex lattice design of the mixture experimental design was adopted.

TABLE 1
EXPERIMENTAL LAYOUT OF AUGMENTED SIMPLEX LATTICE DESIGN OF SORGHUM-COCOYAM-CASSAVA FLOUR COMPOSITE BREAD

Randomized runs	Sorghum flour (A)	Cocoyam flour (B)	Cassava flour (C)
1	0.33	0.33	0.33
2	0.00	0.50	0.55
3	0.00	0.00	1.00
4	0.17	0.17	0.67
5	1.00	0.00	0.00
6	0.50	0.50	0.00
7	0.00	1.00	0.00
8	0.00	0.00	1.00
9	0.00	1.00	0.00
10	1.00	0.00	0.00
11	0.00	0.50	0.00
12	0.17	0.67	0.17
13	0.50	0.00	0.50
14	0.67	0.17	0.17

Note: Each run produced a sample of the respective mixture

2.5 Preparation of composite flour

Component flour was prepared by intimate mixture of proportion of the three component flours-sorghum, cocoyam, cassava, according to Table 1 (Hugo, 2002). Blends of the mixture were the pure sorghum (A), cocoyam (B) and cassava (C) while the binary mixtures were sorghum and cocoyam (AB) sorghum and cassava (AC) Cocoyam and Cassava (BC); the overall centroid was ABC- sorghum, Cocoyam Cassava flour. One hundred (100%) wheat flour was used as a control. The flour were packed in plastic containers and stored until needed.

2.6 Preparation of dough and baking

The composite flour dough was prepared and baked according to the method specified by Eduardo *et al;* (2013) the whole wheat bread and the composite breads were made by mixing the flour with graded levels of ingredients as follows:

Four (4)g salt, 9g margarine, 5g sugar, 3g yeast in 500 ml water followed by stirring using a Kenwood mixer (Model A 907D) for 5 minutes to obtain a dough. The dough was allowed to ferment in a bowl covered with clean muslin cloth for 55min at room temperature (28^{o}C). Later the dough was punched and scaled to 40 g dough pieces. The dough pieces were proofed in a cabinet for 90 min at 35^{o}C 80% relative humidity and baked at 210^{o}C for 8 min in a hot air oven (Therma Gross Kuchen Le Chef, Sweden). The bread samples were allowed to attain room temperature (28^{o}C$\pm$10^{o}C) before assessing for the bread characteristics (loaf weight, volume) and sensory attributes, crust and crumb color, taste, Texture and general acceptability.

III. EVALUATION OF BREAD CHARACTERISTICS

Bread characteristics were evaluated by measuring the loaf weight, loaf volume and specific loaf volume.

3.1 Loaf weight

Loaf weight was measured 30 minutes after the loaves were removed from the oven using a weighing balance (Iwe, 2002).

3.2 Loaf volume

Loaf volume was measured using the rapeseed displacement method as modified by Giami, *et al.*, (2004). A box of fixed dimensions (23.00x14.30x17.010cm) of internal volume 5660.37cm^3 was put in a tray, half filled with millet seeds, shaken vigorously four times, then slightly overfilled so that overspill fell into the tray. The box was shaken again twice, and then a straight edge was used to press across the top of the box once to give a level surface. The seeds were decanted from the box into a receptacle and weighed. The procedure was repeated three times and the mean value for seed weight was noted (Cg). A weighed loaf was placed in the box and weighed seeds (3500g) were used to fill the box and leveled off as before. The overspill was weighed and from the weight obtained the weight of seeds around the loaf and volume of seed displaced by the loaf were calculated using equation (2) (AACC, 2000).

Seed displaced by leaf (L) = Cg + overspill weight- 3500g

$$\text{Volume of bread} = \frac{\text{L x 5660.37}}{\text{C}}\ \text{cm}^3 \quad (2)$$

Cg = Mean seed value

3.3 Specific loaf volume

Specific loaf volume was determined by dividing the load volume by its corresponding loaf weight (cm^{3}g) as described by Araki *et al*, (2009)

$$\text{Specific volume} = \frac{\text{Volume (cm}^3\text{)}}{\text{Weight (g)}} \quad (3)$$

3.4 Sensory evaluation

Sensory evaluation based on the sensory attributes were conducted using the 9 points hedonic scale method (where 1 = dislike extremely and 9= like extremely) as described by Larmond (1997). A total of 10 semi trained panelists' aged 20 years old and above were involved in the evaluation for crust and crumb colour, aroma, taste, texture and overall acceptability. Among these panelists 5 were males and 5 were females. The bread samples were sliced into pieces of uniform thickness (2 cm) and it was served to the panelists at about 11:15am with distilled water for rinsing the mouth after every sample taste in randomized order. The panelists were instructed to rate the attributes indicating their degree of liking or disliking by putting a number as provided in the hedonic scale according to the preference. The panelists were made to work under controlled condition to avoid biased results. The data after ratings were converted to numerical scores and analyzed using Analysis of Variance (ANOVA) at $p < 0.05$.

IV. RESULTS AND DISCUSSION

Bread samples were produced from composite flour of Sorghum-Cocoyam-Cassava. Table 2 shows characterization of the composite bread samples (i.e. loaf weight, loaf volume and load specific volume). The 3-dimensional plot of mean loaf weight, loaf volume and specific loaf volume with respect to the component flours are shown in Fig. 1, 2 and 3 respectively

TABLE 2
CHARACTERISTICS OF BREAD SAMPLES OF SORGHUM-COCOYAM-CASSAVA COMPOSITE FLOURS

Samples	Wt. of loaf (g)	Vol. of loaf (cm^3)	Specific vol. of loaf (cm^3/g)
100% wheat flower bread (control)	177.5	251.9	1.42
A	195.2	197.29	1.11
B	189.1	213.3	1.20
C	183.2	220.4	1.24
AB	191.0	201.2	1.10
AC	182.4	232.0	1.30
BC	182.4	232.0	1.30
ABC	216.0	231.0	1.16

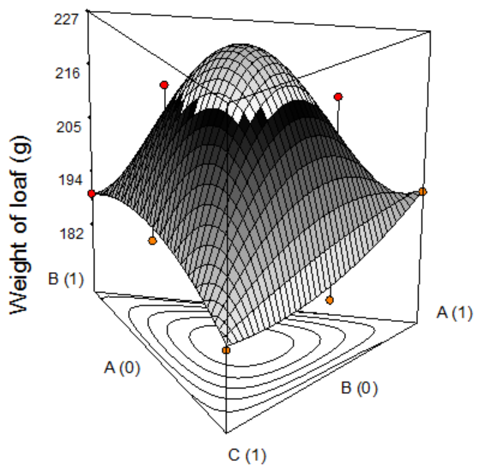

FIGURE 1: Response surface plot of mean weight of composite bread loaves against A, B and C component flours

MWL = 195.76A +189.54B +184.11C -17.01AB -18.41AC +27.48BC +1039.46ABC (4)

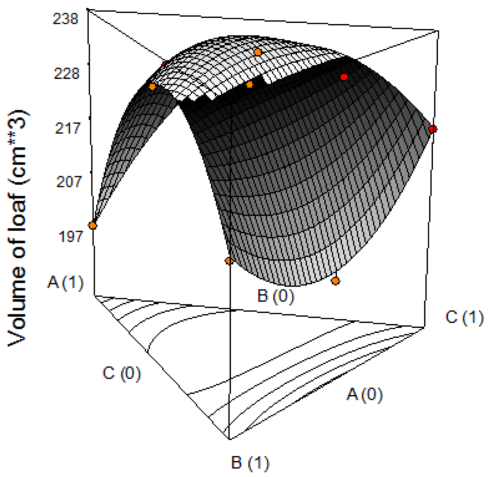

FIGURE 2: Response surface plot of mean vol. of composite bread loaves against A, B and C component flours

Mean volume of composite loaves = 197.24A +213.95B +220.68C+108.00AB +93.99AC -56.99BC + 257.70ABC ..(5)

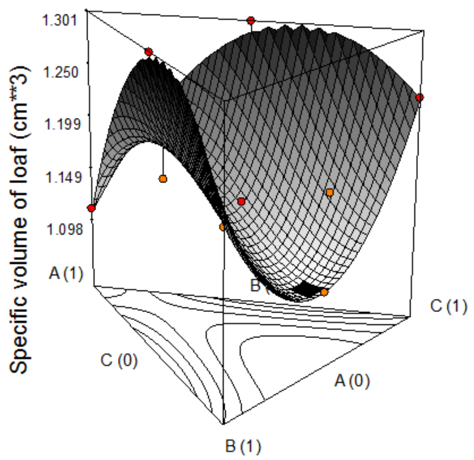

FIGURE 3: Response surface plot of mean specific volume of composite bread loaves against A, B and C component flours

Mean specific volume of composite loaves = 1.11A +1.20B +1.24C +0.57AB +0.47AC –0.48BC -2.91ABC (6)

The wheat bread had loaf weight of 177.5 g, loaf volume 251.9 cm3, and loaf specific volume of 1.42cm^3/g, sorghum bread had loaf weight of 195.2g, loaf volume 197.2cm^3 and specific loaf volume 1.11cm^3, cocoyam bread had loaf weight of 183.2g, loaf volume 220.4cm^3 and loaf specific volume 1.24cm3/g, cassava bread had loaf weight of 189.1g loaf volume 213.3cm3, and loaf specific volume 1.2cm3/g, while cassava cocoyam bread had loaf weight of 191.0g, loaf volume 0f 201.2cm3 and loaf specific volume of 1.10cm3/g, sorghum cassava bread had loaf weight of 182.4g, loaf volume 2.320cm3 and loaf specific volume 1.3cm3/g, sorghum cassava bread had load weight of 182.4g, loaf volume 2.32cm3 and loaf specific volume 1.30cm^3/g, sorghum cocoyam bread had loaf weight of 179.3g, loaf volume 241.8cm^3 and loaf specific volume 1.36cm^3/g, sorghum cocoyam, cassava bread had loaf weight of 216.0g, loaf volume of 231.0cm^3 and loaf specific volume of 1.16cm^3/g.

Table 3 shows the results of the mean consumer acceptance scores observed from bread sample produced from wheat flour which acted as the control, sorghum flour, cocoyam flour and cassava flour. The table reveals that sorghum cassava composite four bread sample of blend AC was the most acceptable in texture, taste, colour, aroma and overall acceptability.

TABLE 3
OVERALL ACCEPTABILITY OF SCC COMPOSITE BREAD SAMPLES

	LW	LV	SLV	Taste	Colour	Aroma	Texture	Acceptance	Preference
Model	0.989	0.856	0.414	0.038	0.221	0.069	0.127	0.104	0.079
A	196.12	205.18	1.42	6.77	4.15	2.14	4.69	4.56	2.10
B	178.31	213.98	1.24	5.77	4.50	2.05	3.44	4.02	3.40
C	184.00	205.89	1.20	2.78	2.24	6.18	1.74	3.02	2.54
AB	-11.43	65.97	-0.136	NA	-2.30	16.56	-2.54	-3.80	-3.80
AC	-22.42	78.18	-0.056	NA	8.78	-11.58	7.77	2.20	2.21
BC	28.36	-117.42	-0.496	NA	4.36	-1.53	-2.91	6.08	-5.59
ABC	ND	ND	0.0247	NA	-62.69	-58.86	-73.64	0.600	NA
R^2	0.102	0.308	0.961	0.377	0.613	0.884	0.683	0.973	0.655
Mean	185.81	209.98	1.22	5.25	3.31	3.04	2.91	3.91	3.20

Note: A= sorghum flour, B= cocoyam flour, C=cassava flour, NA = not application, LW (g) = weight of loaf, LV (cm**3) = loaf volume, SLV (cm**3)/g = specific loaf volume.

V. DISCUSSION

Bread samples were evaluated for their loaf weight, loaf volume and specific loaf volume. The sorghum-cocoyam-cassava (SCC) bread had the highest loaf weight of 216.0g followed by sorghum bread with loaf weight of 195.2g while the wheat bread had the lowest loaf weight of 177.5g. Wheat bread (control) had highest bread loaf volume of 251.9cm^3 followed by sorghum-cocoyam bread with 241.8cm^3 while sorghum bread had loaf volume of 187.2cm^3. Sorghum-cocoyam-cassava bread had highest loaf weight because of the dense starch content (sorghum 27%, cocoyam 24.5%, cassava 27.5% Asiedu, 1989) and quadratic effects of the components. Loaf volume is influenced by the entrapment of carbon dioxide gas in the dough during fermentation, hence the corresponding loaf volume increase.

Wheat glutein causes the dough to leaven whereas there was no rising in the others because of lack of gas entrapment. Some baked goods however rely on carbon dioxide emanating from baking powder added together with air whipped into the mixture for the purpose of leavening the dough (Sivasanker, 2010). Fermented material could produce carbon dioxide to increase dough volume and desirable texture development (Asiedu, 1989).

The models of the results of the variable effect on definite responses shown in a 3-dimensional plot depicted the linear, quadratic interactive effects of the mixture component on the response attributes. The linas shown in Figs. 4, 5, 6, 7 with respect to taste, colour, aroma and texture. The linear mixture component of AB, AC, BC, and ABC were not significant on the attributes. The mean hedonic score values for all tested attributes were different from the bread sample at $p<0.05$. The overall acceptability of the sample showed $p>0.05$ indicating poor acceptance of the composite bread.

Taste had mean hedonic score of 5.25 and F value of 3.33 and was not significant at $p < 0.05$ contributing 33.29% of variation. The goodness of fit (R^2) of 37.738% of the model was not significant ($p>0.05$). The response surface plot for taste showed a straight plane indicating significant effect of the variables. Taste is an important attribute to any food as it affects food acceptability and intake. Sensory attributes of color and texture were not significant ($p>0.05$) with goodness of fit (R^2) in each case was not sufficient description of the models except in case of aroma with goodness of fit of 59.46% and SCC bread samples significant at $p<0.05$. Inspite of the poor statistical characteristic of the model, the 3-D projection showed some contribution to the parameter showing a linear relationship of all components while aroma and overall acceptability showed a curvilinear relationship of the components.

There were associations of the component flours in case of overall acceptability with some components producing similar values of response.

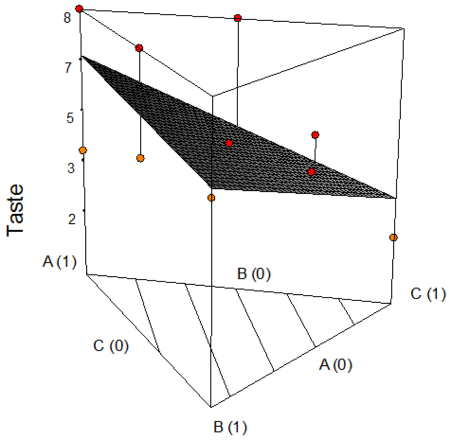

FIGURE 4: Response surface plot for Taste against SCC composite flour bread

Taste = 7.55A + 1.59B + 3.02C (7)

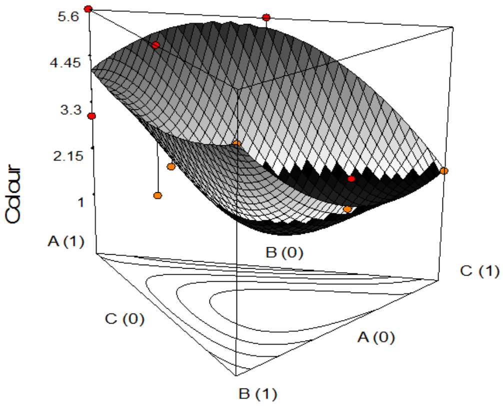

FIGURE 5: Response surface plot of crust colour of composite bread samples against A, B and C components

Colour = 4.15A + 4.50B + 2.24C – 2.30AB + 8.75AC – BC – 62.69 (8)

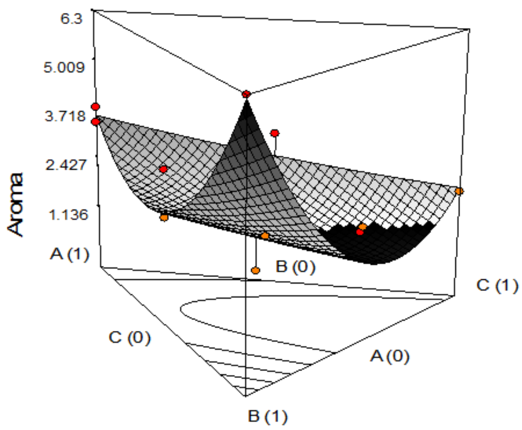

FIGURE 6: Response surface plot for aroma against SCC composite flour bread

Aroma = 2.14A + 2.05B + 6.18C – 16.56AB – 11.58AC – 1.53BC -58.86ABC (9)

Texture

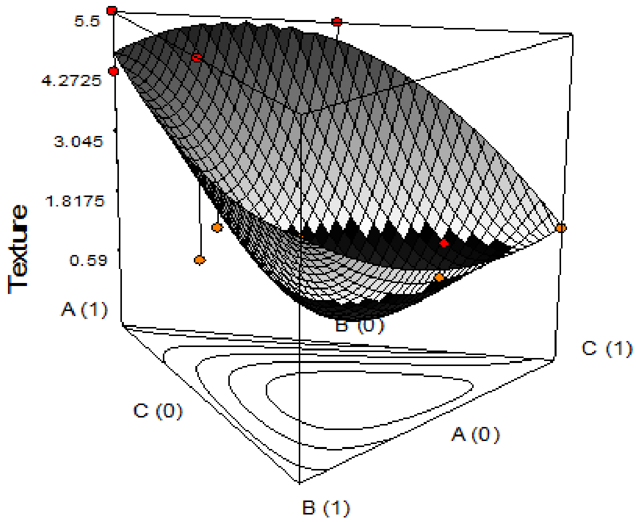

FIGURE 7: Response surface plot for texture against SCC composite flour bread

Texture = 4.69A+3.44B+1.74C–2.54AB–7.77AC-2.53BC-75.64ABC (10)

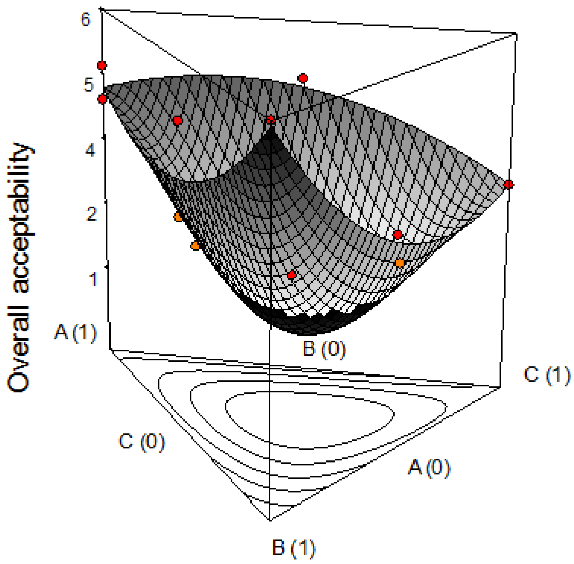

FIGURE 8: Response surface plot for Overall acceptability against SCC composite flour bread

Acceptability = 4.56A + 4.02B + 3.02C – 3.80AB – 2.20AC – 6.08BC – 78.56A^2BC – 213.92AB^2C – 196.48ABC^2 (11)

VI. OPTIMIZATION PROCESS

Optimization analysis of the process revealed that 0.12, 0.08, and 0.80 proportions of sourghum, cocoyam and cassava produced 1.855.14 g, 2.21 cm^3, 1.21 cm^3/g, 3.45, 3.09, 3.85 and 4.86 of loaf weight, loaf volume, loaf specific volume taste, colour, aroma, texture and overall acceptability respectively at 0.547 desirability level.

VII. CONCLUSION

It was observed that all parameters failed to meet the important attributes of pure wheat bread which hindered general acceptability of the bread sample. However sorghum–cassava bread showed much acceptability. Levels of brownness were shown by the weight increase which consumers are familiar with in all wheat flour bread which would easily be accepted. It is envisaged that regular supply, publicity, nutritional and health claims on the products may improve production and acceptability of sorghum- cocoyam- cassava flour bread as an indigenous food product.

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REFERENCES

[1] AACC, (2000). Approved methods of American Association of Cereal Chemistry 10th ed AACC International, St. Paul MN.

[2] Araki, E., Ikeda M. T, Ashida, K; Tanaka, K, Yanaka, M and Ida, S. (2009) Effects of rice flour properties on specific loaf volume of one-loaf bread made from rice flour with wheat vital gluten. Journal of Food Science and Technology Research 15 (4): 439-448.

[3] Bencini M. C (1991) Post harvest and processing technologies of African Staple Foods-a technical compendium James P Walton (ed) FAO Agric Services, Bulletin 89, FAO Rome. P 160-270.

[4] Asiedu, J. J. (1989). Processing Tropical Crops: A Technological Approach. Macmillan Education Ltd. London.

[5] Bradbury, J. H and Holloway, W. D. (1988) Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in Pacifics ACIAR.

[6] Casier, J. P. J; de Paepe, G; William, H; Goffings, G, and Neppen, H. (1976) International Association for Cereal Chemistry, Vienna 11-12th May 1976- (Dendy, D.A.V ed) Tropical Products Institute, London.

[7] Dendy, D. A. V. (2013). Review of composite flour technology in the content of Tanzania. National Resources Institute Chatham, UK. pp 1-23.

[8] Eddy. N. O. Udofia, P. G., Eyo D. (2007) Sensory Evaluation of Wheat/Cassava composite bread and effect of label information on acceptance and preference. African J. Biotechnology (20); 2415-2418.

[9] Eduardo, M., Svanbery U, Oliveira, J and Ahrne, L. (2013) Effect of cassava flour characteristics on properties of cassava wheat maize composite bread type. Int'l Journal of Food Sc. 1-10.

[10] Giami, S. Y. Amasisi T and Ekiyor, G (2004) Comparison of bread making properties of composite flour form kernels of roasted and boiled African breadfruit (Treculia Africana decne) Seeds. Journal of Raw Material Research 1:16-25.

[11] Hu, R. (2000) Food Product Design, CRC Press p125

[12] Idowu, M. A., Oni A. and Amusa, B. M. (1996) Bread and biscuit making potential of some Nigerian Cocoyam cultivators. Nig. Journal of Science 14:1-12.

[13] Iwe M. O. (2002) Handbook of Sensory Methods and Analysis. ROJOINT Communications Services Ltd. Enugu, pp 20-72.

[14] Larmond, E. (1997) Laboratory methods for sensory Evaluation of Foods. Food Res. Inst. Department of Agric, Ottawa, Canada.

[15] Mepba, H. D; Eboh, L and Nwaojigwa, S. U. (2007) Chemical Composition, Functional and baking properties of wheat-plantain composite flours. African Journal of Food Agriculture, Nutrition and Development 7(1):1-22.

[16] Mongi, R. J, Ndabi Kunze, B. K, Chove, B. E., Mamoro, P., Ruhembe, C. C. and Ntwenya J. G. (2011). Proximate composition, Bread Characteristics and sensory evaluation of Cocoyam Wheat composite breads. African Journal of Food Agriculture, Nutrition and Development 11 (7): 5586-5599.

[17] Olaoye, D. A., Onilude, A. A. and Idowu, O. A. (2006) Quality Characteristics of Bread produced from composite flour of wheat, plantain and soya beans. African Journal of Biotechnology 5(11):1102-1106.

[18] Sivasankar, B. (2010). Food Processing and Preservation. PHI Learning Private Limited, New Delhi India.

[19] Tekle, A. (2009). The effect of bread proportion and baking condition on the quality of cookie made from taro and wheat flour blend. School of graduate studies. Addis Ababa Univ. http://etd.

[20] Udofia, P. G., Udoudoh P. J. and Eyen NO (2013) Sensory Evaluation of wheat –cassava soybeans composite flour bread by the mixture experimental design. African Journal of Food Sc. 7 (10):368-374.

[21] Yue, P., Hettiarachchy, N. and Dappolonia, B. L. (1999). Native and succinylated sunflower proteins used in bread baking. Journal of Food Science, 56:992-998.