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EFFECT OF BLEND RATIO ON THERMO-PHYSICAL AND SENSORY CHARACTERISTICS OF COMPOSITE WHEAT, CASSAVA AND SOY BREAD

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ABSTRACT
Thermo-physical properties of bread made from wheat, cassava and soybean blends were investigated. During investigation, the organoleptic acceptance of the composite wheat, cassava and soy bread was determined. All the blend ratios were exposed to equal heating rate during baking at set temperature of 230°C. The wheat flour was substituted by composite cassava and soy at levels of 0, 10, 20, 30, 40, and 50%. The formulated products were organoletically tested using a nine point hedonic scale. Statistical package for social sciences (SPSS) software version 16 was used to run analysis of variance (ANOVA) to conduct sensory evaluation. Results show that increase in the level of cassava and soy flours substitute resulted in decrease in loaf volume and height. The results were compared with literature data. Acceptability of the bread products estimated on a 9-point hedonic scale gave score results as follows: A=7.86, B=7.31, C=6.93, D=6.42, E=6.15 and F=5.69, respectively for A= Wheat (100%); B= Wheat : Cassava + Soybean (90%/10%); C= Wheat: Cassava + Soybean (80%/20%); D= Wheat: Cassava + Soybean (70%/30%); E= Wheat: Cassava + Soybean (60%/40%); F = Wheat: Cassava + Soybean (50%/50%).This indicates the feasibility of producing acceptable and nutritious loaves from wheat/cassava/soy composite flour up to 50% cassava and soy composite substitution level.

Keywords: thermo-physical properties, cassava-soybean composite, wheat, bread, blend ratio.

1. INTRODUCTION

The use of composite flours for commercial bread baking purposes and consumption are increasingly gaining much attention in Nigeria [1]. Recently, bread consumption increased continuously in many of the developing countries. Many reasons are adduced for this trend, including a steadily growing population, an overall increase in income, changes in eating and work habits. This meant that a larger proportion of the family income could be spent on food [2].

Although, no other crop can achieve the absolute baking properties of wheat, composite flours have become the subject of numerous studies, for the developing countries. The use of composite flours has the following advantages, namely: savings of hard currency, promotion of high-yielding native plant species, a better supply of protein for human nutrition and a simple production technology [3,4]. Also, the formulation of composite flour with local staple crop results in value-added product. Thus, there is a need for studies on proper utilization of composite flours, including cassava and soybeans. This became a necessity because of over reliance on imported wheat [5]. Nigeria, moreover, grows staple crops other than wheat such as cassava, yam or sweet potatoes and cereals that can be used for bakery foods. It would therefore be economically advantageous if imported wheat could be reduced and the demand for baked foods such as bread could be met by the use of domestically grown products other than wheat.

Numerous studies have documented different substitutes used for partial substitution of wheat in bread making involving use of sorghum [6], corn [7], maize-soybeans [8], malted and fermented sorghum [9] and only cassava [10]. All the authors agreed to the fact that there are prospects for wheat substitution and the potential local market for the by-products. For cassava substitute, the content of hydrogen cyanide is source of health concerns [11]. However, Nigeria is the largest producer of cassava in the world [12] and

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therefore, will gain economy of scale advantage in using cassava more than other crop substitutes for wheat substitution in bread making. The advantage far outweighs the cost element involved in hydrogen cyanide improver or elimination. Also, partial replacement of wheat flour with cassava flour increases the cultivation of cassava in Nigeria as well as contributes to lowering cost of bakery products [13].

But, the science and mechanism of composite cassava flour integration into wheat flour is still at its primary investigative stage. There are problems with the art as faced by bakery industry. Viewed from the perspective of thermal science, we acknowledge the need to understand the impact of thermodynamic variables, mainly extensive and intensive components, on the state of dough constituents. A change in the thermodynamic variables can produce an effect on the quantity and quality of baked products. As a contribution towards promotion of sustainable substitutability of wheat with local flour in bread making, the effect of levels of composite cassava-soy integration on thermal and sensory characteristics of baked bread is investigated. A further motivation is that cassava flour is rich in carbohydrate and its production does not require complicated technology [14].

In this study, the specific objective is to determine the effect of blend ratio on thermo-physical and sensory characteristics of composite wheat, cassava and soy bread. Also, acceptability of the bread products is estimated, organoleptically. Information obtained from this study is significant and helpful to bakery industries for decision making. To ensure affordable cost of baked items and food security, composite flour became of great need and interest to research scholars, to meet up with the global food requirements.

2. MATERIALS AND METHODS.

2.1 Materials

Wheat flour, sugar, salt, fat, yeast and bread improver were obtained from Ogige main market, Nsukka. The cassava (*Manihot palmata*) and soybean (*Glycine max L merrriel*) were processed into floor as shown in Figures 1 and 2. According to Adeyemi and Balogh [15], the main device for grating fresh cassava is a locally fabricated mechanical grater, made of a flat galvanized sheet punctured with holes of 0.75 cm diameter and fixed round a drum- like plank. This is connected through a belt to a 7 horse power driving motor. The washed cassava roots was held by hand and grated over the rotating drum with extreme care that fingers and palm are not bruised [16].The dewatered lumps were pulverized with hands and sifted on a local raffia made sieve of mesh (0.3 cm x 0.3 cm) mounted on a rectangular wooden frame 40cm^2 to remove the fibres. The sifted cassava meal obtained was allowed to dry using a flash dryer. The dried meal was milled and sieved with a fine mesh (200 µm). The cassava flour was obtained after sieving and later packaged until ready for use. The processing of soybean flour followed the methods of [17].

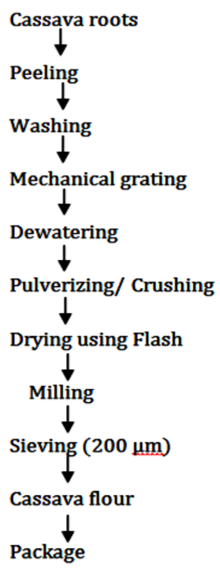

Figure 1: Flow chart for the production of Cassava flour.

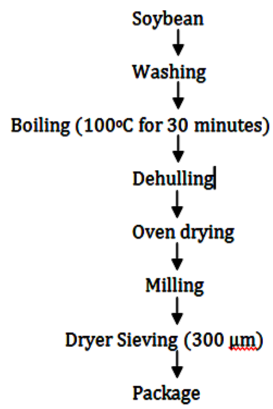

Figure 2: Flow chart for the production of Soybean.

2.2 Methods

The preparation of the composite followed the steps in Figure 3. Dough proofing occurred for 45 to 50 minutes, proofed loaves were baked in oven preheated to set condition of 230°C and baking spanned for 45 to 50 minutes.

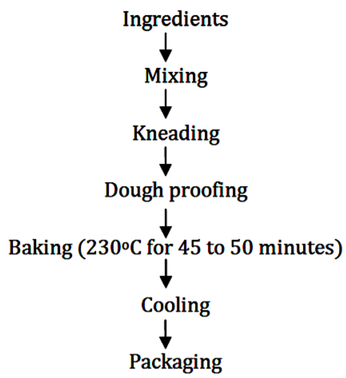

Figure 3: Flow chart for bread production.

Mix blends were varied to check the possibility of accommodating more quantity of indigenous crops which would greatly lower cost of production and in turn lower cost of baked foods. This is contrary to the approach of [1] that varied baking temperature range from 190 to 240°C and baking time from 20 to 40 minutes. In this work, baking temperature was kept constant at 230°C. The time was allowed to run until a desirable crust colour was observed through a show-glass on the oven for each sample of the experimented mix blends. The optimality of temperature used was to be ascertained through consumer perception.

As an improvement on the quality of composite flour experimented upon, soybean flour was added in the composite flour used for this experiment at varied mix ratios to increase the protein content of loaf, thereby, improving the nutritional value of loaves baked. This differed from the work done by [1] that used composite flour of cassava and wheat alone at 10 %/90% ratio.

Cassava flour was mixed with soybean flour at (70%/30%) composite cassava-soy mix, and then, the composite flour was mixed with wheat flour at various blends to form dough as shown in Table 1. The dough was formulated with ingredients in proportions shown in table 2 and further kneaded, moulded and transferred into greased pans for proofing. The proofed dough was transferred into the oven to bake at 230°C and removed after baking. Method outlined in Figure 3 was followed to achieve the desired baked products.

Table 1. Mix formulation used in experiment.

Sample	Wheat(%)	Cassava(%)	Soy(%)
A	100	0	0
B	90	7	3
C	80	14	6
D	70	21	9
E	60	28	12
F	50	35	15

Source: *Experimental set up.*

Table 2: Ingredients used in dough formulation per loaf

Materials	Composition(g)
Flour	285
Water(ml)	180
Sugar	18
Shortening(butter)	8
Yeast	5
VitaminC(improver)	2
Salt(NaCl)	2

Source: *Food Science and Technology Baking Laboratory, University of Nigeria, Nsukka (UNN)*

2.2.1 Determination of thermal and physical properties

The weights of both dough and bread samples were determined using a digital weighing balance (0.01g accuracy, model YP202N). The loaf volumes were determined mathematically by taking measurements of length, width and height of samples. The specific volume of each loaf was then calculated as expressed in equation (1)

$$Specific\ volume = \frac{loaf\ volume}{loaf\ weight}\left(\frac{cm^3}{g}\right) \quad (1)$$

Baking and proofing times were both determined using a stop watch, as the experiment progressed. Baking temperature was kept constant at 230°C, while mix ratio varied for the 6 samples A-F.

Moisture content was determined mathematically as the difference in weight of dough and baked bread. Density was determined mathematically in equation (2)

$$Density(g/cm^3) = \frac{loaf\ weight}{loaf\ volume} \quad (2)$$

The oven was preheated at a temperature of 230°C for 15 minutes to prevent risen dough from falling. The weights of dough and loaf were determined using a digital weighing balance (0.01g accuracy and model YP202N). The difference in weight between dough and loaf gave the moisture content for each sample. Loaf volume in cubic centimeter was obtained mathematically by multiplying the height of loaf with the length and width of baking pan for each sample. Baking time was recorded with the aid of a stop watch; reading was taken for each sample as baking progressed.

2.2.2 Sensory evaluation of bread from blends of wheat/cassava/soybean flours.

The organoleptic evaluation of the bread loaves samples was carried out for consumer acceptance and preference using 20-trained panelist (students of the Department of Food Science and Technology, University of Nigeria, Nsukka. Nigeria). They were to evaluate the sensory properties based on Taste, Aroma, Aftertaste, Mouth feel, Crumb colour, Crust colour, Texture, Appearance and Overall acceptability using a nine point Hedonic scale where 1 represents "extremely dislike" and 9 "extremely like" respectively. During sensory evaluation, panelists rinsed their mouths with water to clear the palate after each sample evaluation. The analysis of variance (ANOVA) was performed to determine the significant level of all sensory attributes measured. The mean ± standard error of mean was determined for all the sensory attributes and separated by least significant difference (LSD) at $P \leq 0.05$, using statistical package for social sciences (SPSS) computer software version 16.0.

3. RESULTS AND DISCUSSION

3.1 Results

Tables 3 and 4 show readings collected during experiments to ascertain the thermophysical properties of bread from wheat, cassava and soy composite blends. Specific volume was observed to decrease as substitution level increasesd.

The object of the research was to understand how changes in extensive and intensive properties affect the varied composite cassava, soybean and wheat bread mix during baking. Secondly, it is important to ascertain the level of acceptance of the bread under these conditions. The analysis of the monitored properties in Tables 3 and 4 showed significant deviations in their values as Figure 4 indicates. Table 5 shows the sensory scores of bread baked from the composites arranged according to blend ratios.

Table 3: Thermal and physical properties of bread from composite flour (wheat/cassava/soybean).

S	DPT time (mins)	BT (mins)	B T (^{0}C)	Oven pre-heat Temp. ^{0}C	Mix w:cs %	Weight of Dough (g)	Weight of Bread (g)	Moisture Content %	Loaf Volume Cm^3	Specific Volume (Cm^3/g)	Density g/Cm^3
A	45.00	45.00	230.00	230.00	100:00	482.80	462.20	20.60	2323	5.03	0.199
B	46.20	47.50	230.00	230.00	90:10	471.40	461.90	09.50	2105	4.56	0.219
C	46.57	47.57	230.00	230.00	80:20	486.10	465.70	20.40	1984	4.26	0.235
D	48.10	48.20	230.00	230.00	70:30	479.20	466.70	12.50	1815	3.89	0.257
E	49.30	48.54	230.00	230.00	60:40	488.90	467.20	21.70	1621	3.47	0.288
F	52.00	49.33	230.00	230.00	50:50	485.60	467.50	18.10	1331	2.85	0.351

S= Sample, DPT= Dough proofing time, BT= Baking time, Baking temperature, 0^oC.

Table 4: Physical properties of bread samples.

Sample	Length (L) of pan (cm)	Width (W) of pan (cm)	Height (H) of Loaf (cm)
A	22	11	9.6
B	22	11	8.7
C	22	11	8.2
D	22	11	7.5
E	22	11	6.7
F	22	11	5.5

Figure 4. Bread from blends of wheat/cassava/soybean flours.

A= Wheat (100%); B= Wheat: Cassava + Soybean (90%/10%); C= Wheat: Cassava + Soybean (80%/20%);D= Wheat: Cassava + Soybean (70%/30%);E= Wheat: Cassava + Soybean (60%/40%); F = Wheat: Cassava + Soybean (50%/50%).

3.2 Discussion

3.2.1 Effect of Blend ratio on characteristics of composite bread

The effect of blend ratio on thermo-physical and sensory characteristics of composite wheat, cassava and soy bread can be deduced from the changes in value of the physical characteristics. For example, Figures 5 and 6 showed changes in specific volume and height of composite cassava, soybean and wheat bread. Bread specific volume decreased significantly with increasing Cassava and soybean flour mix substitution level. The volumes of bread made from composite flours, were lower than those made from pure wheat. The highest bread specific volume was obtained from 100% wheat flour (control) while flour containing 50% Cassava and soybean flour mix, resulted in the lowest bread specific volume for same 500g weight of loaf. This finding was in agreement with that reported work by [18], who found lower volumes associated with composite of sorghum as opposed to 100% wheat. This can be attributed partly to lower levels of gluten network in the dough and consequently less ability of the dough to rise due to the weaker cell wall structure.

Higher loaf weight and volume have positive economic effect on bread at the retail end. Therefore, loaf weight reduction during baking is an undesirable economic quality to bakers, as consumers often get attracted to bread loaf with higher weight and volume believing that it has more substance for the same price. Loaf volume is affected by the quantity and quality of protein in the flour [19] as well as proofing time. Whereas, loaf weight is basically determined by the quantity of dough baked, and the amount of moisture and carbon dioxide diffused out of the loaf during baking [20].

Loaf size

The results of parameters of the bread from composite blends are shown in Table 3. A decrease in loaf volume and specific volume was observed at increased substitution level, as displayed in Figure 4. It must also be mentioned that baking temperature and time affect moisture retention capacity of bread crumb as reported by [21]. Prolonged baking time and very high temperature result in tough crumb texture and undesirable crust colour. The second inference about the observed changes is related to the plastic characteristic of composite dough. The dough when blended with ingredients behaved as plastics [22].By increasing the cassava and soybean composite for the same quantity of ingredient affected the heating rates. From the experimental data obtained (Table 3) and the various plots deduced, it could be established that:

1. Baking time is a function of composition involved and weight (g) of loaf baked, it was observed that loaves with less percentage composite inclusion baked at lesser time compared to those with highest quantity of composite. It was equally observed that loaves of ≤ 500g mix were baked at a time range of 45 to 50 minutes.
2. Baking temperature affects the product quality of bread from both pure wheat and composite flours. High temperature of above 230°C resulted in tough texture and dark crust colour

Table 5: Sensory scores of bread from blends of wheat/cassava/soybean flour.

BREAD SAMPLES	TASTE	AFTER TASTE	AROMA	CRUST COLOUR	CRUMB COLOUR	MOUTH FEEL	TEXTURE	APPEARANCE	OVERALL ACCEPTABILITY	AVERAGE ASSESSMENT
	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM
A	7.25 ± 0.22^{a}	7.30 ± 0.27^{a}	7.80 ± 0.25^{a}	8.45 ± 0.14^{a}	8.55 ± 0.17^{a}	7.40 ± 0.27^{a}	7.80 ± 0.20^{a}	8.25 ± 0.23^{a}	7.90 ± 0.23^{a}	7.86 ± 0.15^{a}
B	6.55 ± 0.31^{ab}	6.55 ± 0.30^{b}	7.05 ± 0.35^{b}	8.10 ± 0.24^{a}	8.20 ± 0.20^{ab}	7.15 ± 0.17^{a}	7.40 ± 0.20^{a}	7.35 ± 0.24^{b}	7.45 ± 0.18^{a}	7.31 ± 0.18^{b}
C	6.25 ± 0.31^{b}	6.40 ± 0.30^{b}	6.95 ± 0.28^{bc}	7.75 ± 0.35^{ab}	7.50 ± 0.30^{bc}	6.90 ± 0.22^{ab}	7.05 ± 0.26^{a}	6.85 ± 0.30^{bc}	6.70 ± 0.30^{bc}	6.93 ± 0.23^{bc}
D	5.85 ± 0.24^{bd}	5.55 ± 0.18^{c}	6.70 ± 0.21^{bd}	7.30 ± 0.24^{b}	7.25 ± 0.23^{c}	6.20 ± 0.20^{bc}	6.20 ± 0.22^{b}	6.50 ± 0.22^{cd}	6.20 ± 0.16^{cd}	6.42 ± 0.12^{c}
E	5.25 ± 0.24^{cd}	5.45 ± 0.27^{c}	6.60 ± 0.26^{bd}	7.35 ± 0.29^{b}	7.10 ± 0.32^{c}	6.00 ± 0.32^{cd}	6.00 ± 0.35^{b}	5.85 ± 0.32^{de}	5.80 ± 0.30^{d}	6.15 ± 0.21^{cd}
F	5.35 ± 0.21^{cd}	4.85 ± 0.22^{c}	6.30 ± 0.11^{cd}	7.20 ± 0.29^{b}	6.95 ± 0.26^{c}	5.45 ± 0.34^{d}	5.10 ± 0.39^{c}	5.55 ± 0.34^{e}	4.85 ± 0.33^{e}	5.69 ± 0.21^{d}

Values are means ± SEM (standard errors of mean) of scores determined. Values with different superscripts on the same column are significant at $p<0.05$.

A = Wheat (100%);B = Wheat : Cassava + Soybean (90%/10%);C = Wheat: Cassava + Soybean (80%/20%);D = Wheat: Cassava + Soybean (70%/30%);E = Wheat: Cassava + Soybean (60%/40%);F = Wheat: Cassava + Soybean (50%/50%).

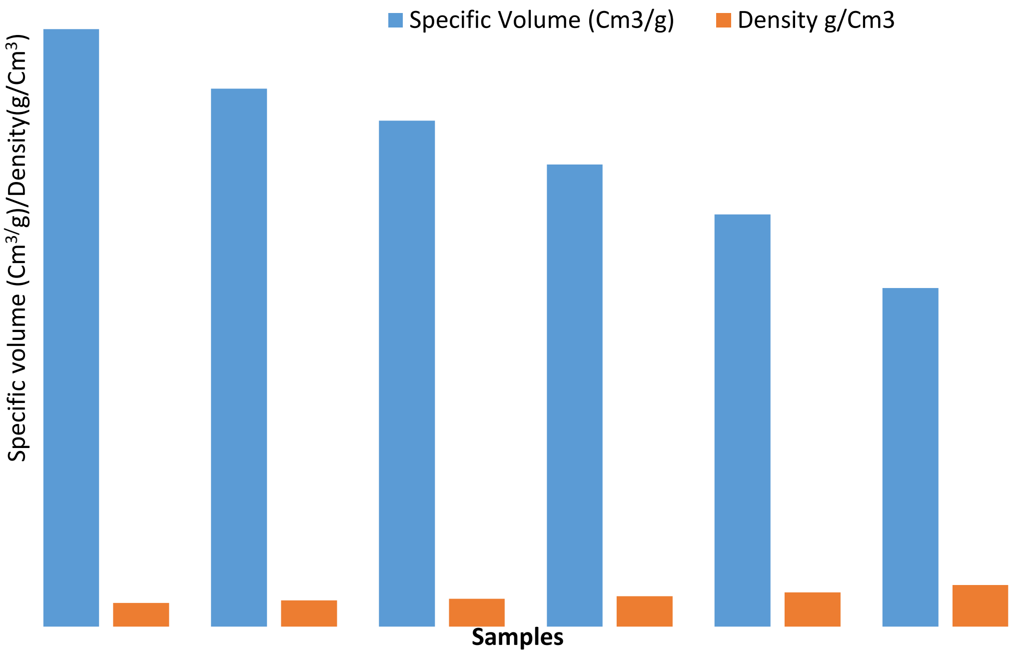

Figure 5. Specific Volume and Density of formulated bread samples from blends of wheat/cassava/soybean.

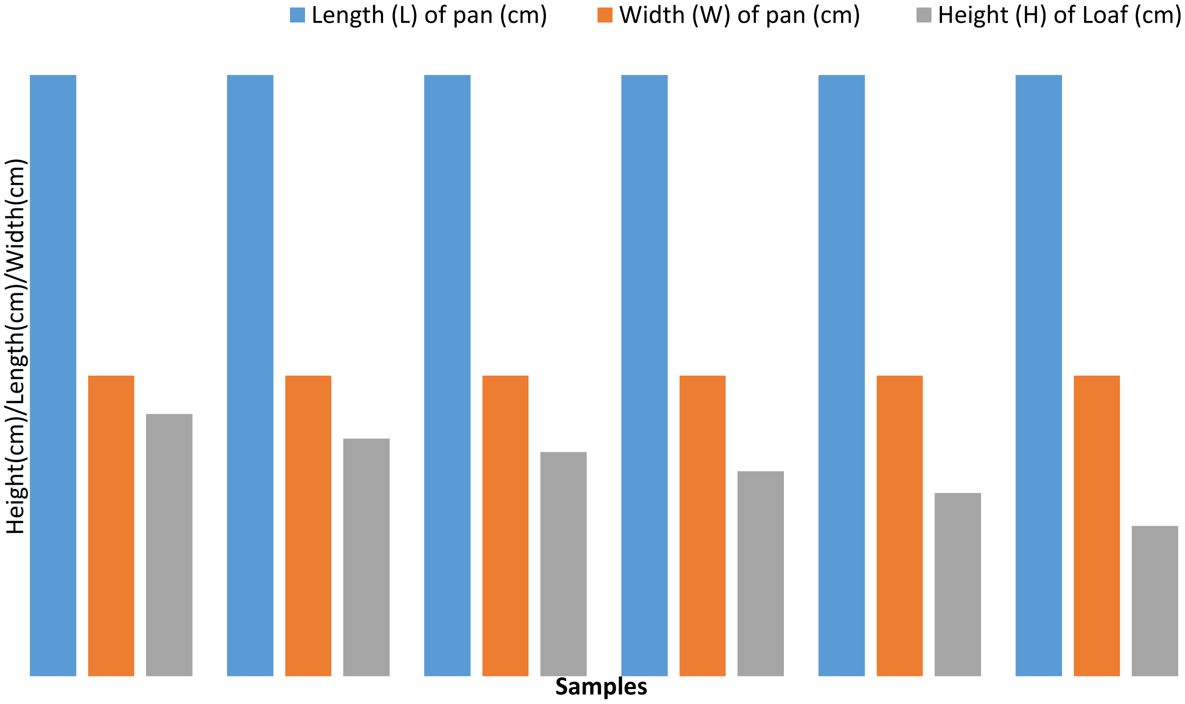

Figure 6. Height (cm) of formulated bread samples from blends of wheat/cassava/soy.

3.2.2 Sensory evaluation of bread samples

The overall assessment of sensory scores of bread samples baked from blends of wheat, cassava and soybean flour as well as the 100% wheat bread are shown in Figure 7. All bread samples on average assessment showed that "B" is significantly different from "A","C" is not significantly different from "B","D" and "E", "E" is not significantly different from "C" & "D" and lastly, "F" is significantly different from all except "E". All bread samples were rated as acceptable by the panel, overall acceptance scores indicated as follows; A=7.86, B=7.31, C=6.93, D=6.42, E=6.15 and F=5.69 in 9 – point hedonic scale. Although, all samples were rated above average, the preference however, decreased as the substitution level of cassava and soybean flour increased. Therefore, results of acceptance score showed that ratio of composite affected the sensory properties of bread.

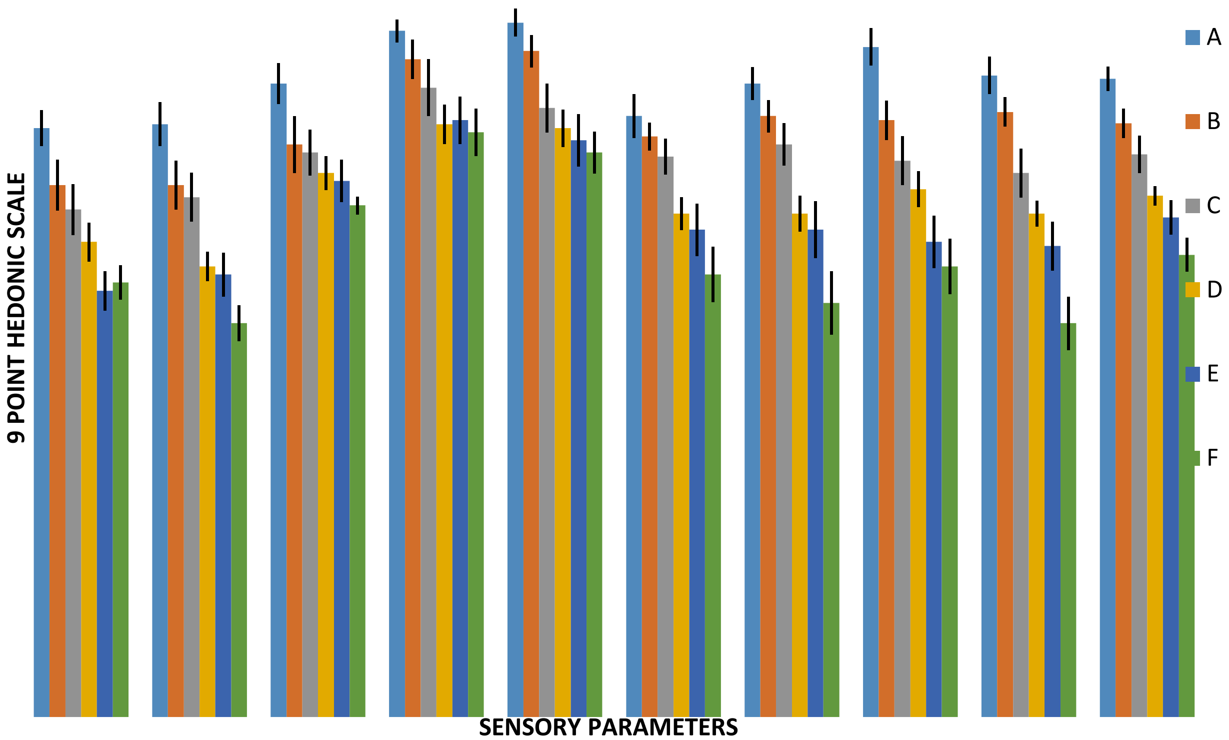

Figure 7. Sensory scores of bread samples from blends of wheat/cassava/soybean.

A = Wheat (100%); B = Wheat : Cassava + Soybean (90%/10%); C = Wheat: Cassava + Soybean (80%/20%); D = Wheat: Cassava + Soybean (70%/30%); E = Wheat: Cassava + Soybean (60%/40%); F = Wheat: Cassava + Soybean (50%/50%);

4. CONCLUSION

The study investigated the effects of blend ratio on thermo-physical and sensory characteristics of composite wheat, cassava and soy bread. Baking and proofing time were both determined using a stop watch, as the experiment progressed. Baking temperature was kept constant at 230°C, while mix ratio varied for the 6 samples A-F. The wheat flour was substituted by composite cassava and soy at levels 0, 10, 20, 30, 40, and 50%. The formulated products were organoletically tested using a nine point hedonic scale. Statistical package for social sciences (SPSS) software version 16 was used to run analysis of variance (ANOVA) to conduct sensory evaluation.

Blend formulation affects kneading (dough preparation) and as well as proofing. It was observed also that in excess of water, and or improper mixing of cassava and soybean flour, dough preparation became almost impossible, as it became sticky to both palms and kneading board.

Results show that increase in the level of cassava and soy flours substitute resulted in decrease in loaf volume and height. The results were compared with literature data. Higher temperature resulted in darker crust colour and tough texture while lower temperature resulted in longer baking time and an unacceptable crust colour and as well more energy and labour cost, which would in turn increase the cost of bread.

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