Croat. J. Food Sci. Technol. (2020) 12 (1) __ __
"ARTICLES IN PRESS"

Croatian Journal of Food Science and Technology
journal homepage: www.ptfos.unios.hr/cjfst/

Original scientific paper *DOI: 10.17508/CJFST.2020.12.1.05*

The effects of cassava variety, fertilizer type and dosage on physical and sensory characteristics of cassava-wheat composite bread

SEMIU ABOLORE RASAQ[1], TAOFIQ AKINYEMI SHITTU[1], GBEMISOLA JAMIU FADIMU[2]*, ADEBAYO ABASS[3,4], OLAJUMOKE OMONIYI[3]

[1]*Department of Food Science and Technology College of Food Science and Human Ecology, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria*
[2]*Department of Food Science & Nutrition, College of Food and Agricultural Sciences, King Saud University, P.O. Box 2460, Riyadh, Saudi Arabia*
[3]*International Institute of Tropical Agriculture (IITA), P.M.B. 5320, Oyo Road, Ibadan, Nigeria*
[4]*International Institute of Tropical Agriculture (IITA), Plot 25, Light Industrial Area, Coca cola Road, Dar es Salaam, Tanzania*

ARTICLE INFO

Article history:
Received: April 14, 2019
Accepted: November 28, 2019

Keywords:
Composite bread
cassava varieties
fertilizer compounding ratio
fertilizer dosage

ABSTRACT

Substitution of wheat flour with high quality cassava flour (HQCF) in bread making is economically important in Nigeria as wheat is mainly imported. Different treatments are applied to cassava used for HQCF production and the effects of such a treatment on cassava-wheat bread quality is scarce in literature. This study was conducted to study the effects of cassava varieties (TME 419, TMS 30572), fertilizer type ((NPK 15-15-15, 20-10-10, 12-12-17) and dosage (150, 300 kg/ha) on physical and sensory characteristics of cassava-wheat composite bread according to General Linear Model (GLM) analysis. According to the results, the independent variables had varying effects on the composite bread quality. While the main effect of fertilizer type was significant for oven spring and crumb moisture content, the interactive effects of fertilizer type and dosage significantly influenced crumb texture and taste. In spite of the significant differences in certain physical and sensory attributes, the overall acceptability of bread samples did not differ significantly. HQCF from cassava variety TMS 30572 showed the best performance in making composite cassava-wheat bread in terms of physical and sensory properties.

Introduction

Cassava (*Manihot esculenta)* crantz is an important tropical root crop. Its starchy roots are an important source of calories in the tropics, providing energy nourishment for more than 500 million to 1 billion people worldwide (Sornyotha et al., 2010). Nigeria is the leading producer of cassava. In the year 2017, Nigeria produced 59 million metric tons which was about 18% of the total world production (FAOSTAT, 2019). With rising wheat prices on the global market (Adesina, 2011) there is an interest to promote the utilization of local sources of flour for partial substitution of wheat flour in food products. Moreover, the aim is to reduce the dependency on wheat imports and also to increase livelihoods of local farmers.

HQCF is one of the numerous products that are obtained from cassava roots. HQCF is unfermented, white, smooth, and odourless cassava flour with no gluten that has been used as a local inclusion into wheat flour for the use in baking industry (Oti et al., 2010). It is produced from freshly harvested and rapidly processed cassava roots. Optimum utilization of cassava flour in composite bread production could be a catalyst for rural industrial development by raising income levels of farmers, processors and traders as well as ensuring the nutrition and food security status of Nigerians (Plucknett et al., 1998; Balagopalan, 2002). Cassava flour has been reported to contain 0.2% fat, 0.5% fiber, ash 1.7%, starch 85%,

*Corresponding author E-mail: fadimugbemisola@gmail.com

and protein 0.7% (Darkwa and Jetuah, 2003). The starch of cassava is capable of forming strong gel and could be used as a composite flour of good binding property (Oparah et al, 2013). The current status of research in West Africa and in Nigeria is focused on the production of High Quality Cassava Flour (HQCF) for the use in food industry. High quality cassava flour provides the best alternative to flour production for baked products in Nigeria (Nwanekezi, 2013) as cassava is available in almost every part of the country and Nigeria is the largest producer of the root in the world (Oishimaya, 2017). However, the increasing interest in the use of high quality cassava flour in food product development is facing lots of technical challenges, especially the ones that relate to product formulation and product optimization in composite cassava wheat flour application in bakeries.

Bread may be described as a fermented confectionery product made mainly from wheat flour, water, yeast and salt by a series of processes involving mixing, kneading, proofing, shaping and baking (Abdelghafor et al., 2011). Other ingredients, which are optional, include sugar (sucrose), fat, conditioner and preservative. Bread is an important staple food, the consumption of which is becoming steady even in rural areas in Nigeria. Bread is relatively expensive, being made from imported wheat that is not cultivated in the tropics (Olaoye et al., 2006). The use of HQCF for partial substitution of wheat in baking of composite bread has been done successfully in Nigeria (Eleazu et al., 2014) and this has stimulated the local production and processing of non-wheat flours like cassava to be incorporated into wheat. In 2007, Nigerian government directed the wheat millers to incorporate 10% cassava flour in the flour they produce (Nwanekezi, 2013). The inclusion of cassava in bread could help in reducing the costs of bread production since cassava is cheaper and available raw material compared to wheat, which is mostly imported.

A study by Nweke (1996) reported that cassava root has the potential to bridge the food security gap in Africa. Despite the fact that Nigeria is the largest producer of cassava in the world, the yield of cassava produced in the country is still generally low due to poor soil fertility (Nweke, 1996). The poor soil fertility is also accelerated by failure of farmers to apply fertilizers. To increase the yield potential of cassava, the crop had been reported to respond to good soil fertility and adequate fertilizer. Fertilizer application supplies the major soil nutrient such as nitrogen, phosphorus and potassium needed for plant growth. The addition of these soil nutrients will translate to starch synthesis and expressed in variation of starch and flour quality (Gomez et al., 1980).

Many previous works were devoted to the determination of the effect of cassava genotype and the level of wheat flour substitution with cassava flour on their bread making quality (Adeyemi and Idowu, 1990; Defloor et al., 1993) and fewer studies considered the effect of nitrogen treatment on chemical composition and quality of food product from such roots (Shittu et al., 2008; Mensah, 2013). However, Shittu et al. (2008) showed that the quality of flour from cassava varieties was affected by NPK fertilizer application and this author reported only one fertilizer type and compound dosage ratio of 15/15/15 at 150kg/Ha. Also, Iwe et al. (2017) reported various effects of cassava varieties and improvers on physical and sensory properties of cassava-wheat composite bread. The information on the cassava varieties, fertilizer types and their dosage is not available in literature. This present study was therefore conducted to study the effects of fertilizer type, dosage and cassava varieties on the physical and sensory properties of the composite bread using General Linear Model (GLM) analysis.

Materials and methods

Materials

Two varieties of cassava grown with three different fertilizer protocols were obtained from the research site of the International Institute of Tropical Agriculture (IITA) experimental station in Ikenne, Ogun State, Nigeria. The varieties were: TME 419 and TMS 30572. The cassava varieties were harvested 12 months after the planting. Immediately after the harvest, the cassava roots were transported to processing laboratory to prevent fermentation. Other materials used include: golden penny prime (white) flour (Nigerian Eagle Flour Mills, Ibadan, Nigeria), granulated sugar (Golden Penny sugar company limited Lagos, Nigeria), Royal STK baking yeast (STK industries, China), Edlen dough conditioner (EDC) (Edlen International Inc., Nigeria), Simas margarine (PT Intiboga Sejahtera, Jakarta, Indonesia) and salt (Dangote Nigeria Plc., Lagos), which was obtained from Kuto market, Abeokuta, Ogun State, Nigeria. All chemicals used were of analytical grade and procured from Sigma Aldrich Co. (St Louis, MO, USA).

Preparation of High Quality Cassava Flour (HQCF)

Freshly harvested cassava roots from two varieties and different fertilizer treatments were processed into HQCF using the method of Adekunle et al. (2012). within 24 h from the time of harvest to drying in order to produce good quality flour that conforms to the set standard. The cassava tubers were peeled, thoroughly washed and grated into a mash with a grater. The mash was then dewatered by manual pressing in clean woven sacks, the lumps were pulverized, and the mash solar dried on a raised platform in a solar house (direct natural convection solar drier). The dried mash was then milled into flour using the disc attrition milling machine. The resulting flour was sieved with a 0.25 mm sieve to obtain very fine high quality cassava flour. The flour was packaged in a polythene bag and stored at 4 °C for analysis.

Experimental design to produce cassava-wheat composite flour

A 2×3×2 factorial design involving two cassava varieties (TMS 30572, TMS 419), three compounding fertilizer ratio (NPK 15-15-15, 20-10-10, 12-12-17) at two dosage levels of fertilizer (150 kg/ha, 300 kg/ha) was designed using General Linear Model (GLM) analysis. The 12 experimental runs and two control samples (unfertilized TMS 30572 and TMS 419) that were generated are presented in Table 1.

Preparation of cassava-wheat composite flour

Wheat flour was mixed with the different HQCF samples at the ratio of 80:20 to prepare the 20% composite flour. The choice of this ratio was based on the findings of Eleazu et al. (2014), who reported that 20% substitution of wheat flour with HQCF yielded bread with general acceptability similar to wheat bread. Control composite flour was also prepared using unfertilized cassava varieties at the ratio of 80:20. The composite flour formulation as indicated was used in the production of composite bread.

Baking procedure

Bread loaves were baked with the ingredients listed in Table 2, the proportions expressed as the percentage of flour used. Twenty percent of the hard wheat flour was substituted by cassava flour. This was achieved by mixing 200 g of HQCF with 800 g of wheat flour. The proportions of the remaining ingredients were not changed. All flour samples were baked in triplicate. Fig. 1 shows the flow chart for bread production. The ingredients were mixed and kneaded using an electric dough mixer (Spiral Mixer, Boso machinery, Zhejiang, China) for 15 min, the dough was then divided into 300 g division each and moulded into a baking pan that has been greased and proofed for 2 h in a proofing cabinet (at 34 °C and 78-80% RH). The loaves were then baked in an electric oven (Boso Machinery, Zhejiang China) at 190 °C for 25 min.

Composite dough rheological studies (Farinograph)

The Farinograph analysis was conducted for fourteen samples of the composite flour using the Brabender Farinograph (Brabender GmbH & Co. KG, Duisburg, Germany). The Farinograph parameters, water absorption capacity, peak time, mixing tolerance index and dough stability, were determined and the results are presented in Table 2.

Table 1. Farinograph data for the cassava-wheat composite flour

Variety (HQCF)	Fertilizer-type (NPK)	Dosage (kg/ha)	WAC (%)	PT (min)	MTI (BU)	DS (min)
TMS 30572	15-15-15	150	64.05 ± 0.23^{f}	4.06 ± 0.02^{c}	70.02 ± 0.34^{e}	4.29 ± 0.20^{e}
TMS 30572	15-15-15	300	63.75 ± 1.56^{cd}	4.76 ± 0.03^{f}	55.02 ± 0.84^{c}	3.67 ± 0.21^{c}
TMS 30572	20-10-10	150	63.85 ± 0.79^{de}	4.03 ± 0.24^{c}	75.07 ± 0.63^{f}	4.83 ± 0.06^{f}
TMS 30572	20-10-10	300	63.15 ± 0.56^{a}	3.73 ± 0.56^{b}	59.00 ± 0.20^{d}	3.94 ± 0.05^{d}
TMS 30572	12-12-17	150	63.65 ± 1.56^{c}	5.23 ± 0.01^{g}	84.50 ± 0.51^{h}	3.57 ± 0.31^{bc}
TMS 30572	12-12-17	300	64.45 ± 0.76^{g}	4.77 ± 0.23^{f}	70.10 ± 0.85^{e}	5.97 ± 0.62^{h}
TMS 30572	NF	-	64.10 ± 0.75^{f}	4.27 ± 0.25^{d}	50.06 ± 0.09^{b}	4.12 ± 0.08^{e}
TME 419	15-15-15	150	63.75 ± 2.48^{cd}	4.11 ± 0.12^{c}	85.26 ± 0.03^{h}	3.46 ± 0.21^{b}
TME 419	15-15-15	300	63.65 ± 2.36^{c}	3.48 ± 0.32^{a}	80.50 ± 0.12^{g}	5.05 ± 0.18^{g}
TME 419	20-10-10	150	63.45 ± 0.56^{b}	4.52 ± 0.21^{e}	95.30 ± 0.02^{i}	6.83 ± 0.07^{i}
TME 419	20-10-10	300	63.95 ± 1.89^{ef}	4.24 ± 0.41^{d}	40.02 ± 0.63^{a}	2.28 ± 0.57^{a}
TME 419	12-12-17	150	63.85 ± 0.69^{de}	4.77 ± 0.51^{f}	80.48 ± 0.06^{g}	4.99 ± 0.04^{fg}
TME 419	12-12-17	300	63.85 ± 0.42^{de}	4.52 ± 0.21^{e}	85.06 ± 0.07^{h}	3.54 ± 0.06^{bc}
TME 419	NF	-	63.75 ± 0.18^{cd}	4.25 ± 0.51^{d}	85.45 ± 0.31^{h}	4.83 ± 0.21^{f}

PT- Peak time, MTI- Mixing tolerance index, DST- Dough stability, WAC- Water absorption; Values are means of triplicate determination. Mean values with different superscripts within the same column are significantly different ($p<0.05$). F1- NPK 15-15-15, F2- NPK 20-10-10, F3- NPK 12-12-17; NF- No fertilizer (Control sample); V2- TMS 30572, V1- TME 419; R1-Dosage150kg/ha, R2-Dosage300kg/ha

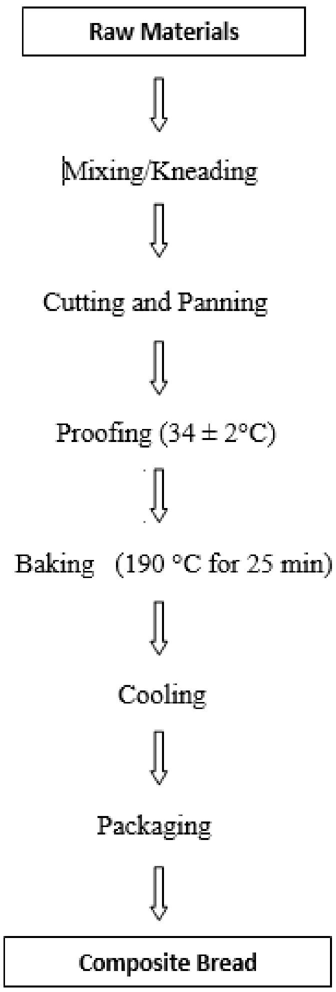

Fig 1. Flow chart for composite bread production

Table 2. Dough recipe and formulation used for bread production

Ingredients	Amount (%)
Wheat flour	80
Cassava flour	20
Water	50-55
Margarine	4
Sugar	12
Salt	1.5
Dried yeast	1
EDC	0.3

All other percentages are based on composite flour weight

Physical analysis of cassava-wheat composite bread

Loaf weight and volume

The weight of the loaves was determined immediately after cooling with the aid of a weighing balance with accuracy of 3 decimal point (Ignition Manufacturing Pty, Germany), while the loaf volume was determined after the baking process using the volume displacement method in which millet seed was used instead of rapeseed. A medium sized graduated cylindrical container was filled to the brim with millet seeds. The millets were then poured into a container and the initial volume was recorded. The bread sample, which has been sufficiently cooled, was placed in the container. The millet seed whose volume has been earlier noted was poured into the container with the bread in the middle of the container. The millet grains were then removed gently from the container without allowing any grain to fall off. The volume of the millet seed was taken and this volume was then subtracted from the initial millet volume to give the loaf volume (Shittu et al., 2008).

Specific volume

The specific volume of the loaves was measured as described by Shittu *et al* (2008) using the Equation (1) below:

$$\text{Specific volume } (cm^3/g) = \frac{\text{Loaf volume}}{\text{Loaf weight}} \quad (1)$$

Density

Density of the loaves was calculated according to the method of Shittu et al. (2008) using the Equation (2) below:

$$\text{Density } (g/cm^3) \quad (2)$$

Oven spring

Oven spring was determined by recording the height of the fermented dough and height of the baked bread samples. Oven spring was obtained as the difference in the dough height and baked bread height (Shittu et al., 2008).

Crumb moisture content

The crumb moisture content was determined using the method of Shittu et al. (2007). One gram of bread sample was obtained from five different portions of a slice and weighed into a previously weighed petri dish. The Petri dish and the samples were transferred into the oven set at 105 °C to dry to constant weight for 4 h. The samples were cooled in a desiccator and weighed using analytical balance.

Sensory evaluation of cassava-wheat composite bread

The sensory evaluation of the cassava-wheat composite bread was carried out according to Land and Sheperd (1988) with slight modification using 30-man sensory panel consisting of students from the Food Science and Technology Department, Federal University of Agriculture, Abeokuta. The quality attributes of bread samples were evaluated and the attributes rated include general appearance, colour, texture, flavour and overall acceptability. The ratings were presented on a nine-point hedonic scale ranging from like extremely (9 point) to dislike extremely (1 point).

Statistical Analysis

Data obtained were subjected to Analysis of Variance (ANOVA) using SPSS version 21.0 and the differences between significant mean values were evaluated at p<0.05 probability level using Duncan's Multiple Range Test. Generalized linear model was used to determine the effect of individual variables on the properties of the HQCF and cassava-wheat composite bread.

Results and discussion

Effect of cassava varieties, fertilizer type and dosage on the rheological indices of cassava-wheat composite flour

Farinograph curve is an important tool in bread making for measuring dough and gluten properties of flour. Curves on Farinograph reflect three processes: water absorption, dough development and dough breakdown. Generally, the results of Farinograph analysis are used as parameters in formulation to estimate the amount of water required to make dough, evaluate the effects of ingredients on mixing properties, flour blending requirements and to check flour consistency during production (Migliori & Sebastiano, 2013). The results of Farinograph analysis for cassava-wheat composite flour as affected by cassava varieties, fertilizer type and dosage are presented in Fig. 2, while the rheological indices of the dough samples are presented in Table 1. It can be observed from the table that cassava varieties, fertilizer type and dosage had significant (p<0.05) effect the rheological indices of the composite dough. The water absorption capacity (WAC) of the composite dough ranged from 63.15 to 64.45 %. As the table shows, composite dough from wheat and HQCF from TMS 30572 with NPK 12-12-17 at 300 kg/ha had the highest WAC, while the lowest value was recorded from TMS 30572 with NPK 20-10-10 at 300 kg/ha. Farinograph peak time (PT) of the composite cassava-wheat dough which indicates when dough has reached its maximum viscosity before gluten strands begin to break down ranged from 3.48 to 4.77 min. Minimum peak time was recorded in sample TMS 419 with NPK 15-15-15 at 300 kg/ha, while TMS 30572 with NPK 12-12-17 at 300 kg/ha had the highest peak time. The mixing tolerance index (MTI) which is an indication of degree of softening during mixing varied significantly (p<0.05) from 40.02 to 95.30 BU, with TMS 419 with NPK 20-10-10 at 150 kg/ha having the highest value and TMS 30572 without fertilizer had the lowest MTI value. Dough stability time (DST) which measures the dough strength ranged from 2.28 to 6.83 min. While TMS 419 with NPK 20-10-10 at 300 kg/ha had the lowest DST, maximum DST was recorded in TMS 419 with NPK 20-10-10 at 150 kg/ha. The result obtained in this study indicates that the fertilizer dosage had varying effects on the peak time, mixing tolerance index and the dough stability time of flour samples. In addition, the Farinograph indices of the composite flours revealed that higher fertilizer dosage reduced the water absorption capacity, peak time, mixing tolerance index (MTI) and dough stability time of the composite flours. The dough development time for the different composite flour samples differs significantly (p<0.05). The mixing tolerance index used by bakers to determine the extent of softening of dough experienced over the mixing period differ significantly between the cassava varieties, fertilizer type and dosage used. This implies that varietal influence and fertilizer treatments play a vital role in the behavioral pattern of HQCF in composite dough formation.

Effect of cassava varieties, fertilizer type and dosage on physical parameters of cassava-wheat composite bread

Influence of cassava variety, fertilizer type and dosage on the physical parameters of cassava-wheat composite bread are presented in Table 3. The physical parameters studied in this present were significantly (p<0.05) affected by cassava varieties and fertilizer treatments. The loaf weight, loaf volume and the specific volume for the composite bread samples values ranged from 263.15 to 277.70 g, 885.20 to 1025.01 cm^3 and 3.12 to 3.81 cm^3/g, respectively, with maximum loaf weight recorded in TMS 30572 with NPK 12-12-17 at 150 kg/ha, maximum loaf volume in TME 419 at NPK 15-15-15 at 300 kg/ha, while TMS 30572 without fertilizer treatment had the highest specific volume.

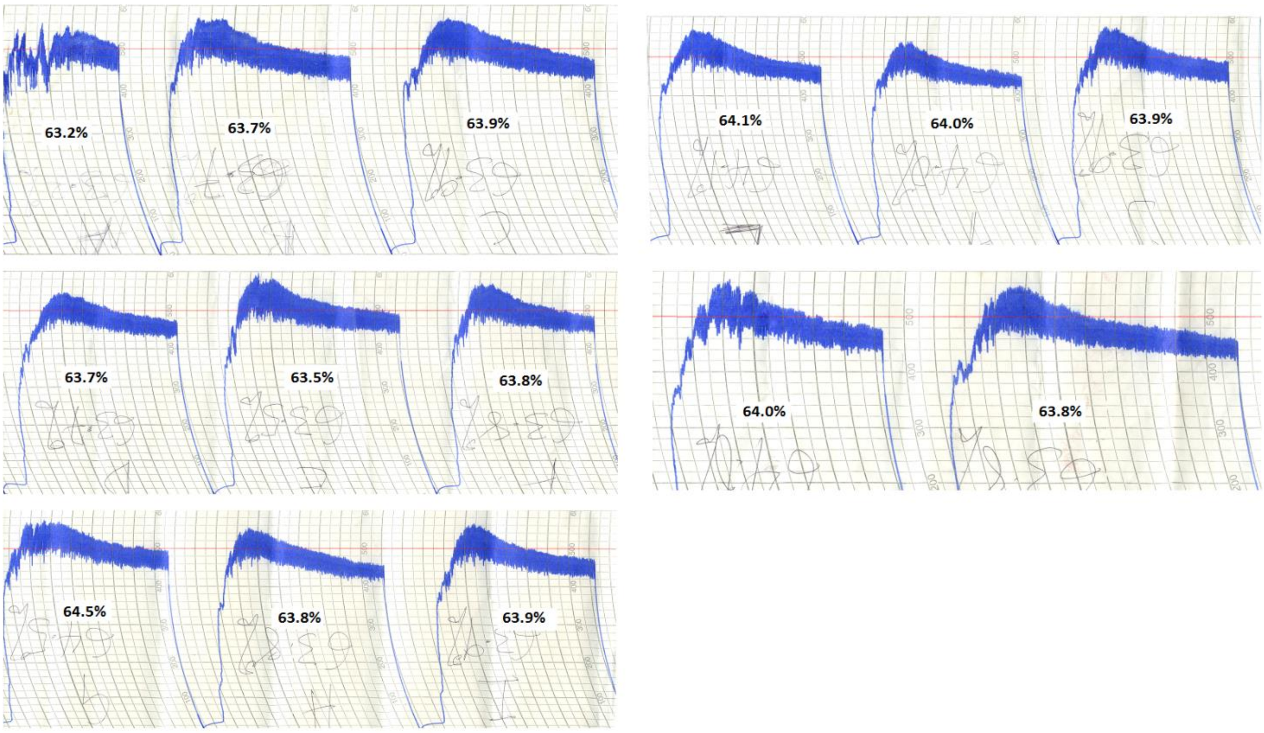

Fig 2. Results of Farinograph analysis of composite flour sample

Table 3. Effect of variety, fertilizer type and dosage on the physical parameters of cassava-wheat composite bread

Variety	Fertilizer type (NPK)	Dosage (kg/ha)	Loaf weight (g)	Loaf volume (cm^3)	Specific volume (cm^3/g)	Oven spring (cm)	Density (g/cm^3)	Crumb moisture (%)
TMS 30572	15-15-15	150	264.55±0.01^{ab}	1025.01±0.21^{h}	3.70±0.23^{de}	0.35±0.00^{ef}	0.26±0.00^{abc}	34.95±0.21^{de}
TMS 30572	15-15-15	300	267.05±0.02^{abc}	945.25±0.02^{d}	3.47±0.36^{abcde}	0.30±0.01^{de}	0.28±0.01^{cde}	34.78±1.26^{cde}
TMS 30572	20-10-10	150	271.95±0.08^{cde}	996.90±0.63^{f}	3.58±0.15^{bcde}	0.13±0.00^{a}	0.27±0.00^{bcd}	32.01±0.59^{a}
TMS 30572	20-10-10	300	275.70±0.23^{de}	890.00±0.25^{a}	3.12±0.23^{a}	0.14±0.00^{a}	0.30±0.01^{de}	32.23±2.59^{a}
TMS 30572	12-12-17	150	277.70±0.12^{e}	885.20±0.30^{a}	3.20±0.15^{ab}	0.26±0.01^{cd}	0.31±0.01^{e}	33.74±2.63^{bc}
TMS 30572	12-12-17	300	272.35±0.02^{cde}	998.25±2.36^{f}	3.61±0.32^{bcde}	0.24±0.02^{bc}	0.27±0.00^{bcd}	34.14±0.89^{cd}
TMS 30572	NF	-	263.15±0.06^{a}	1058.00±1.63^{j}	3.81±0.02^{e}	0.38±0.02^{f}	0.25±0.00^{ab}	34.81±0.75^{cde}
TME 419	15-15-15	150	272.80±0.04^{cde}	998.40±0.99^{f}	3.62±0.21^{bcde}	0.30±0.01^{de}	0.27±0.00^{bcd}	34.58±1.57^{cd}
TME 419	15-15-15	300	270.00±0.14^{bcd}	1012.50±2.47^{g}	3.65±0.50^{cde}	0.25±0.01^{cd}	0.25±0.01^{abc}	35.92±1.61^{e}
TME 419	20-10-10	150	266.50±0.96^{abc}	909.50±0.69^{b}	3.32±0.07^{abcd}	0.18±0.00^{a}	0.28±0.02^{cde}	34.45±2.14^{cd}
TME 419	20-10-10	300	263.90±0.31^{ab}	978.05±0.36^{e}	3.67±0.85^{cde}	0.15±0.00^{a}	0.26±0.01^{bcd}	33.85±0.58^{bcd}
TME 419	12-12-17	150	266.90±0.51^{abc}	1022.10±2.96^{h}	3.49±0.24^{abcde}	0.19±0.00^{ab}	0.23±0.02^{a}	32.27±1.07^{a}
TME 419	12-12-17	300	267.70±0.25^{abc}	933.19±2.36^{c}	3.26±0.02^{abc}	0.27±0.00^{cd}	0.28±0.02^{bcde}	34.03±2.47^{cd}
TME 419	NF	-	271.50±0.09^{cde}	1041.00±1.57^{i}	3.50±0.15^{abcde}	0.31±0.01^{de}	0.26±0.02^{abc}	32.83±0.57^{ab}

PT- Peak time, MTI- Mixing tolerance index, DST- Dough stability, WAC- Water absorption. Values are means of triplicate determination. Mean values with different superscripts within the same column are significantly different ($p<0.05$). F1- NPK 15-15-15, F2- NPK 20-10-10, F3- NPK 12-12-17; NF- No fertilizer (Control sample); V2- TMS 30572, V1- TME 419; R1-Dosage150kg/ha, R2-Dosage300kg/ha

Also, oven spring, density and crumb moisture for the composite bread samples ranged between 0.13 to 0.38 cm, 0.23 to 0.30 g/cm^3 and 32.01 and 35.92 %, respectively. These values are similar to those reported in previous studies (Shittu et al., 2008). From the GLM analysis, the main effect of fertilizer-type significantly ($p<0.05$) affected the oven spring and the crumb moisture of the cassava-wheat composite bread samples, while the 2-way and 3-way interactive effects of the independent factors were not significant on the physical parameters of the cassava-wheat composite bread samples (Table 5a, b and c).

Loaf volume is an important quality parameter of bread and it is mostly affected negatively when wheat flour is replaced with HQCF (Eduardo, Syanberg, & Ahrme, 2014). The decrease in the specific volume of composite bread with increasing proportion of cassava flour has been well reported in literature (Shittu et al., 2007).

In our present study, it is important to note that loaf volume, loaf weight and the specific volume were significantly affected by cassava variety and fertilization. Hence, bread prepared from sample TMS 30572 with NPK 12-12-17 150 kg/ha had the highest loaf volume, while TMS 30572 without treatment had the highest loaf volume and specific volume, respectively. Weight loss during baking is caused by evaporation at the outermost layer (Therd-thai, Zhou, & Adamczak, 2002). The evaporated water consists of free or temporarily bound water molecules and not from the mass of the flour gel. Oven spring, which takes place in the early period of baking, is a measure of dough stability and it is basically dependent on factors such as ingredients, thermal regime and type of flour used in formulation of dough (Sumnu, Datta, Sahin, Ozge, & Rakesh, 2006). The main effect of fertilizer type significantly affected oven spring, while interaction of fertilizer type with either cassava variety or fertilizer dosage did not have any effects on oven spring.

It is important to note that only the main effect of fertilizer type had significant effect on crumb moisture (Table 5a).

Table 4. Sensory acceptability of cassava-wheat composite bread as affected by cassava variety, fertilizer type and dosage

Variety	Fertilizer type (NPK)	Dosage (kg/ha)	Appearance	Taste	Crumb texture	Crust colour	Over Acceptability
TMS 30572	15-15-15	150	7.37±0.02[a]	7.00±0.20[ab]	6.83±0.43[ab]	6.33±0.52[a]	6.33±0.02[a]
TMS 30572	15-15-15	300	6.97±0.57[a]	7.47±0.96[b]	7.37±0.93[b]	7.00±0.64[a]	7.00±0.00[a]
TMS 30572	20-10-10	150	6.80±0.21[a]	7.47±0.51[b]	6.53±0.51[a]	6.53±0.85[a]	6.53±0.23[a]
TMS 30572	20-10-10	300	6.93±0.34[a]	6.70±0.48[ab]	6.57±0.03[a]	6.73±0.76[a]	6.73±0.47[a]
TMS 30572	12-12-17	150	7.30±0.01[a]	6.90±0.20[ab]	7.10±0.43[ab]	6.83±0.32[a]	6.83±0.58[a]
TMS 30572	12-12-17	300	7.00±0.00[a]	7.07±0.95[ab]	6.83±0.83[ab]	6.67±0.05[a]	6.67±0.48[a]
TMS 30572	NF	-	6.87±0.24[a]	7.30±0.17[b]	7.03±0.48[ab]	7.03±0.02[a]	7.03±0.21[a]
TME 419	15-15-15	150	7.03±0.67[a]	6.90±0.21[ab]	6.73±0.31[ab]	6.60±0.14[a]	6.60±0.63[a]
TME 419	15-15-15	300	6.83±0.15[a]	6.87±0.59[ab]	7.00±0.75[ab]	6.87±0.52[a]	6.87±0.24[a]
TME 419	20-10-10	150	6.97±0.97[a]	6.70±0.32[ab]	6.47±0.26[a]	6.70±0.43[a]	6.70±0.52[a]
TME 419	20-10-10	300	6.57±0.32[a]	6.77±0.85[ab]	6.40±0.42[a]	6.97±0.91[a]	6.97±0.97[a]
TME 419	12-12-17	150	7.10±0.21[a]	6.70±0.52[ab]	6.67±0.79[ab]	6.73±0.20[a]	6.73±0.25[a]
TME 419	12-12-17	300	7.03±0.35[a]	6.47±0.26[a]	6.80±0.27[ab]	6.27±0.45[a]	6.27±0.54[a]
TME 419	NF	-	6.67±0.14[a]	6.90±0.94[ab]	6.83±0.61[ab]	6.67±0.94[a]	6.67±0.20[a]

PT- Peak time, MTI- Mixing tolerance index, DST- Dough stability, WAC- Water absorption. Values are means of triplicate determination. Mean values with different superscripts within the same column are significantly different ($p<0.05$). F1- NPK 15-15-15, F2- NPK 20-10-10, F3- NPK 12-12-17; NF- No fertilizer (Control sample); V2- TMS 30572, V1- TME 419; R1-Dosage150kg/ha, R2-Dosage300kg/ha

Table 5a. Summary of Analysis of variance for the main effects of the independent variable on physical parameter of composite bread

Independent variable	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.P
Fertilizer-type	Loaf weight	13.495	2	6.748	.299	.750
	Loaf volume	5595.183	2	2797.591	.899	.449
	Specific volume	.114	2	.057	1.257	.342
	Oven spring	.047	2	.024	16.001	.002
	Density	.000	2	.000	.201	.823
	Crumb Moisture	8.202	2	4.101	4.758	.050
Variety	Loaf weight	38.521	1	38.521	1.708	.233
	Loaf volume	1066.627	1	1066.627	.343	.577
	Specific volume	.009	1	.009	.189	.677
	Oven spring	.001	1	.001	.399	.547
	Density	.001	1	.001	1.522	.257
	Crumb Moisture	.880	1	.880	1.021	.346
Dosage	Loaf weight	1.141	1	1.141	.051	.828
	Loaf volume	531.535	1	531.535	.171	.692
	Specific volume	.001	1	.001	.031	.865
	Oven spring	.000	1	.000	.142	.718
	Density	.000	1	.000	.230	.646
	Crumb Moisture	.725	1	.725	.841	.389

Table 5b. Summary of Analysis of variance for 2-way interactive effects of the independent variable on physical parameters of composite bread

Independent variable	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.P
Fertilizer-type* Dosage	Loaf weight	37.449	3	12.483	1.392	.367
	Loaf volume	2886.780	3	962.260	.178	.906
	Specific volume	.035	3	.012	.145	.928
	Oven spring	.008	3	.003	1.065	.457
	Density	.000	3	.000	.157	.920
	Crumb Moisture	4.181	3	1.394	1.934	.266
Variety * Dosage	Loaf weight	2.521	1	2.521	.281	.624
	Loaf volume	377.946	1	377.946	.070	.805
	Specific volume	.016	1	.016	.201	.677
	Oven spring	.000	1	.000	.109	.758
	Density	5.333E-06	1	5.333E-06	.006	.943
	Crumb Moisture	.350	1	.350	.486	.524
Fertilizer-type* variety	Loaf weight	124.385	3	41.462	4.625	.087
	Loaf volume	1011.223	3	337.074	.062	.977
	Specific volume	.020	3	.007	.082	.966
	Oven spring	.008	3	.003	1.030	.469
	Density	.001	3	.000	.222	.877
	Crumb Moisture	3.104	3	1.035	1.436	.357

Table 5c. Summary of Analysis of variance for 3-way interactive effects of the independent variable on physical parameters of composite bread

Independent variable	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.P
Fertilizer-type* Variety * Dosage	Loaf weight	110.053	3	36.684	2.907	.101
	Loaf volume	3943.043	3	1314.348	.420	.744
	Specific volume	.089	3	.030	.679	.589
	Oven spring	.031	3	.010	3.118	.088
	Density	.001	3	.000	.646	.607
	Crumb Moisture	7.427	3	2.476	2.354	.148

Hence, bread samples from TMS 30572 with NPK in the ratio 20-10-10 at 150 kg/ha, TMS 30572 NPK 20-10-10 at 300 kg/ha and TME 419 NPK 12-12-17 at 150 kg/ha had the lowest crumb moisture, while the highest crumb moisture was reported in fertilized bread from TME 419 with NPK 15-15-15 at 300 kg/ha. Generalized linear model (GLM) indicated that crumb moisture of the composite bread samples was basically affected by the fertilizer-type. This is contrary to the findings of Shittu, Dixon, Awonorin, Sanni, & Mariya-Dixon (2008) who reported that genotypic differences other than fertilizer application affected crumb moisture. Defloor. Leijskens, Bokanga & Delcour (1995) found out that bread had a drier crumb with a finer structure when cassava starch was used instead of cassava flour.

Sensory properties of cassava-wheat composite bread as affected by cassava varieties, fertilizer type and dosage

Table 4 shows the effects of cassava varieties, fertilizer compounding ratio and dosage on the sensory properties of composite bread. Generally, the bread samples were not statistically different from one another, except for the crumb texture and taste. In terms of appearance, bread produced from TMS 30572 with NPK 15-15-15 at 150 kg/ha had the highest mean score of 7.47, closely followed by TMS 30572 with NPK 12-12-17 at 150 kg/ha, while bread baked using TMS 419 with NPK 20-10-10 at 300 kg/ha had the lowest in terms of appearance. The independent variables generally had lesser effects on the appearance of the bread samples and similar result has been reported for cassava-wheat composite flour (Nwosu et al., 2014). Studied variables had a significant effect on the taste of the composite bread. Varietal differences are the main factor that affected the taste of the composite, as cassava-wheat composite bread from cassava variety TMS 30575 had significantly ($p<0.05$) higher mean score than those baked using TMS 419 variety. This is similar to the findings of Eriksson et al. (2014), who reported that cassava varieties affected the taste of cassava-wheat bread.

Softness of feel in bread is an index for determining the texture of bread samples. The texture of good quality bread is expected to be soft and tender. As observed in Table 4, softness of the composite bread samples was significantly affected by cassava varieties, fertilizer type and dosage. Composite bread baked from TMS 419 with NPK 20-10-10 at 300 kg/ha produced bread that was the hardest with mean sensory score of 6.40 followed by TME 419 with NPK 20-10-10 at 150 kg/ha (6.47), while TMS 30572 with NPK 15-15-15 at 300 kg/ha was the most preferred in softness of feel with mean score of 7.37. General acceptability is an overall assessment of the sensory characteristics of samples (Ihekoronye and Ngoddy, 1985). No significant difference was observed among the samples and all the composite bread samples were generally accepted by panelists. However, bread from fertilized root from TMS 30752 had the highest sensory score for appearance and overall acceptability and also for taste, crumb texture and crust colour. The insignificant differences in terms of the sensory acceptability of the composite bread could actually indicate that in spite of fertilizer application and varietal differences, the HQCF from fertilized roots could still give acceptable composite bread loaves with little or no impairment of its commercial value.

Conclusion

Despite the fact that 20% of hard wheat flour was substituted by HQCF, the quality attributes and baking characteristics of the composite flours from different cassava variety grown with different fertilizer compounding ratio at different dosage differed significantly. The rheological indices studied using Farinograph curve also revealed that varietal influence and fertilizer treatments play a vital role in the behavioral pattern of HQCF in composite dough formation, with fertilizer dosage having strong impact on the rheological indices of the composite flours. The greatest effect of fertilizer type was observed on the oven spring and crumb moisture while interaction of fertilizer type and dosage had the greatest effect on the bread crumb texture and taste. The unfertilized bread from TMS 30572 cassava variety had more loaf volume than the fertilized bread from both varieties and unfertilized TMS 419 bread. HQCF from cassava variety TMS 30572 at 20-10-10 compounding ratio and 300 kg/ha showed the best performance in making composite cassava-wheat bread. Contrary to an existing belief that fertilizer application during cassava growing stage negatively affects food product quality, this research has established that fertilizer application during the field cultivation of cassava root does not have any adverse effect on the sensory quality of composite bread produced from such roots. In addition, this study has further established that cassava root variety, fertilizer compounding ratio and fertilizer dosage are important factors that should be considered in composite cassava-wheat bread quality.

References

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 winter wheat. *Adv. J. Food Sci. Technol*. 3, 9-15.

Adekunle, A. A., Fatumbi, A. O., Sanni, L. O. (2012): Commercial utilisation of cassava in Nigeria- an illustrated guide. Ibadan: IITA.

Adesina, A. (2011): Weekly Federal Executive Committee press briefing. http://africa.com (Accessed December 12, 2011).

Adeyemi, I. A., Idowu, M. A. (1990): The evaluation of pre-gelatinised maize flour in the development of Massai, a baked product. *Nigerian Food Journal* 8, 63-73.

Balagopalan, C. (2002): Crop utilization and biotechnology. Central Tuber Crops. Research Institute, Sreekariyan, Trivandrum 695077, Kerala, India.

Darkwa, N. A., Jetuah, F. K. (2003): Survey of plywood and paperboard factories. DFID crop post –harvest programme, final report on project output 2.2.2, project R8268. Forestry research institute of Ghana, Kumasi, Ghana.

Defloor, I., Leijskens, R., Bokanga, M., Delcour, J. A. (1995): Impact of genotype, crop age and planting season on the breadmaking and gelatinization properties of flour produced from cassava (*Manihot esculenta Crantz*). *J. Sci. Food Agri.* 68, 167-174.

Defloor, I., Nys, M., Delcour, J. A. (1993): Wheat starch, cassava starch, and cassava flour impairment of the bread making potential of wheat flour. *Cereal Chem*. 78, 525-530.

Eduardo, M., Svanberg, U., Ahrme, I. (2014): Consumers acceptability of composite cassava-maize-wheat breads using baking improvers. *African J. Food Sci*. 8 (7), 390-401. http://doi.org/10.5897/AJFS2014.1179.

Eleazu, C., Eleazu, K., Aniedu, C., Amajor, J., Ikpeama, A. (2014): Effect of partial replacement of wheat flour with High Quality Cassava Flour on the chemical composition, antioxidant activity, sensory quality and microbial quality of bread. *Prev. Nutri. Food Sci.* 19 (2), 115–123. http://doi.org/10.3746/pnf.2014.19.2.115

Eriksson, E., Koch, K., Tortoe, C., Akonor, P.T., Oduro-Yeboah, C. (2014): Evaluation of the physical and sensory characteristics of bread produced from three varieties of cassava and wheat composite flours. *Food and Public Health*. 4 (5), 214-222.

FAOSTAT, (2019): Food and Agriculture Organisation of the United Nations. Retrieved 23rd March 2019.

Gomez, J. C., Howeler, R. H., Webber, E. J. (1980): Cassava production in low fertility soils. In: Toro MJC, Graham M (eds) Cassava cultural practices. Bowker Publication. Co Ltd, Epping, UK.

Ihekoronye, A.I., Ngoddy, P.O. (1985): Integrated Food Science and Technology for the Tropics. Macmillian press Publisher London. Pp. 10-26, 293-300.

Iwe, M.O., Linus-Chibuezeh, Ngadi, A.M., Asumugha, V.U., Obasi N.E. (2017): Bread from cassava-wheat composite flours: Effect of cassava varieties, flour composite and improvers on the physical and sensory properties of bread loaves. *Imperial J. Interdisciplinary Resear.* 3, 9.

Land, D. G., Sheperd, R. (1988): Scale and Ranking methods in sensory analysis, Piggot JR, *Elsevier Applied Science*, New York. 155-185.

Mensah, A. A. (2013): Comparative evaluation of physicochemical and functional properties of cassava aflour from different fertilizer protocols. PhD Thesis, Kwame Nkrumah University of Science and Technology. (KNUST), Kumasi, Ghana

Migliori, M., Sebastiano, C. (2013): Modelling of dough formation process and structure evolution during farinograph test. *Int. J. Food Sci. Technol.* 48 (1) 121-127. https://doi.org/10.1111/j.1365-2621.2012.03167.x

Nwanekezi, E.C. (2013): Composite flours for baked products and possible challenges-A review. *Nigerian Food Journal* 3 (2), 8–17.

Nweke, F. I. (1996): Cassava: A Cash Crop in Africa. COSCA Working Paper No. 14. Collaborative Study of Cassava in Africa, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Nwosu, J.N., Owuamanam, C.I., Omeire, G.C., Eke, C.C. (2014): Quality parameters of bread produced from substitution of wheat flour with cassava flour using soybean as an improver. *Ame. J. Res. Comm.* 2, (3) 99-118.

Oishimaya, N. (2017): Top cassava producing countries in the world. World Atlas, http://worldatlas.com/articles/top-cassava-producing-countries-in-the-world.html.

Olaoye, O. A., Onilade, A. A., Idowu, O. A. (2006): Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. *Afri. Journal of Biotechnol.* 5 (11), 1102-1106.

Oparah, C. C., Edem, U. B., Anierobi, B. U. (2013): Deep Fat Frying Properties of Malted Sorghum Buns with Cassava and Rice Flour as Binders. *Greener J. Agric. Sci.* 3 (2), 185.

Oti, E., Olapeju, O., Dohou, S., Moutairou, E., Nankagninou, D., Komlaga, G.A., Loueke, G.M. (2010): Processing of cassava into gari and high quality cassava flour in West Africa. Training manual (draft). USAID/CORAF/SONGHAI.

Plucknett, D. L., Philips, T. P., Kagho., R. B. (1998): A global development strategy for cassava: transforming a traditional tropical root. Paper presented at Asian Cassava Stakeholders' consultation on a global cassava development strategy at Bangkok, Thailand, 23-25 November 1998.

Shittu, T. A., Dixon, A., Awonorin, S. O., Sanni, L. O., Maziya-Dixon, B. (2008): Bread from composite cassava-wheat flour: II. Effect of cassava genotype and nitrogen fertilizer on bread quality *Food Resear. Int.* 40, 280–290. http://doi.org/10.1016/j.foodres.2008.03.008

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. *Food Resear. Int.* 40, 280–290. https://doi.org/10.1016/j.foodres.2006.10.012

Sornyotha, S., Kyu, K.L., Ratanakhanokchai, K. (2010): An efficient treatment for detoxification process of cassava starch by plant cell wall-degrading enzymes. *J. Bioscien. Bioengineer.* 109 (1), 9-14.

Sumnu, G., Datta, A. K., Sahin, S., Ozge, K. S., Rakesh, V. (2006): Transport and related properties of bread baked using various heating modes. *J. Food Eng.* 78, 1382-1387. https://doi.org/10.1016/j.jfoodeng.2006.01.010

Therdthai, N., Zhou, W. Adamczak, T. (2002): Optimisation of the temperature profile in bread baking. *J. Food Eng.* 55, 41-48. https://doi.org/10.1016/S0260-8774(01)00240-0