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Comparative Studies on Homemade Bread Produced from Blends of Wheat Flour with Each of Cassava, Maize and Whole Wheat Flour

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Authors' contributions

This work was carried out in collaboration among all authors. Author EOE designed the study, wrote the protocol and wrote the first draft of the manuscript. Author FOO managed the literature searches. Authors ATC and IDA read and approved the final manuscript.

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ABSTRACT

Homemade bread produced from blends of wheat flour with cassava flour (WCF), wheat flour with maize flour (WMF), and wheat flour with whole wheat flour (WWF) at varying proportions were compared. The bread samples were analysed for sensory evaluation, nutritional value and presence of microorganisms. Sensory evaluation assessment was based on bread's appearance, taste, texture and odour. Proximate and mineral analyses were done using laboratory protocols described by AOAC. Pour plate technique was used to estimate the microbial population and isolates were identified using laboratory procedures. WCF, WMF and WWF blends at ratio 9:1 has the highest acceptability. The percentage of crude protein for the three flour-blends ranges from 12.61 to 27.41 %, 0.31 to 0.70 % for crude fibre, 11.91 to 16.91 % for fat, 0.10 to 0.13 % for ash, 22.25 to 24.91 % for moisture content, 32.85 to 52.82 % for carbohydrate, 115 to 121.68 mg/100g for K, 95.61 to 107.45 mg/100g for Ca, 92.50 to 96.50 mg/100g for P, 21.65 to 27.91 mg/100g for Mg, 3.75 to 5.20

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mg/100g for Fe and 527.20 to 552.40 mg/100g for Na. Estimated bacterial population varies from 0.68 × 10^6 to 5.81× 10^7 cfu/g and 1.04× 10^7 to 2.50× 10^8 cfu/g for fungal population. Two *Bacillus* sp. were bacterial isolates recovered from the bread samples while *Mucor* sp., *Aspergillus flavus*, *Aspergillus tamarii, Neurospora* sp., *Penicillium chrysogenum, Fusarium compacticum* and *Rhizopus* sp. were fungi isolated. Bread samples made from each of the composite flour at ratio 9:1 were at their best with WMF blend being the overall best.

Keywords: Bread, wheat flour; maize flour; cassava flour; whole wheat flour; sensory evaluation; proximate analysis; microorganism.

1. INTRODUCTION

Bread is one of the commonest bakery products consumed by human beings. There is no nation of the world where bread is not produced as they are known with different types, shapes and contents [1,2]. Wheat flour appears to be the main ingredient in bread making. The production of bread has currently embraced the utilization of diverse flours from different sources like whole wheat, cassava, maize, potato, breadfruit [3] and soybean. Several composite flours at varying ratios of the mixture have been demonstrated by several authors in bread-making processes [4-8]. The modern composite flour technology also allows the blend of wheat flour with others products of non-cereal and legume sources [6].

Bran, germ and endosperm are three major components of wheat grain. These contain vital nutrients for healthy living. For example, fibre, known to be found in the considerable amount from whole wheat grain is stored in the bran. The concern now lies with the regular wheat flour sold in the market being a processed material devoid of both wheat's bran and germ leaving the flour without the important macronutrients [7]. This brings about a need to fortify wheat flour during bread production to enhance better nutritional value.

Cassava (*Manihot esculenta*) is a crop that its spread has gone beyond Africa due to the native qualities it possesses [9]. Several reports unveiling the huge potentials of cassava have been made based on the exploration of the crop [5]. Cassava has contributed immensely to the diet of the populace. There are several food commodities made from cassava in Nigeria. *Gari, fufu, lafun* (cassava flour) are examples of such among the Yoruba tribe of the country.

Maize (*Zea mays*) is one of the most important food crops in the Tropics [10]. Farmers across the world cultivate maize at a higher rate than other cereals. The continuous and increased cultivation given to this crop is drastically encouraged by the increased amount of nutrients possessed by maize [10]. This, in turn, contributes to the utilization of maize as the whole meal, whole flour and also serves as a food supplement. A good composite is also obtained when maize flour is blended with wheat flour as more nutrients, like fibre and vitamin B, are added up as supplements [11].

Wheat (*Triticum aestivum*) has attracted a global interest due to its usage industrially [12]. It has been employed for brewing and baking purposes including production of starch and animal feeds. The whole wheat meal has also formed part of the diet for individuals across the globe [12]. Jones [13] reported consumers of whole wheat grain to benefit from the protective properties of whole wheat grain against specific cancers, type 2 diabetes and cardiovascular disease.

The advent of bread making has presented it as a product that can only be released industrially, just like biscuits, textile materials, drugs, etc. The impression of most people for accessing bread for consumption has been to purchase it from a retail outlet or directly from the factory. The process involves the production of bread reveals that it can be easily made at home within 90 minutes just the way we prepare other food items in our kitchen. This work thereby seeks to present a simple step by step procedure for making bread at home with the aim of producing it with blends of wheat flour with each of cassava, maize and whole wheat flour at different proportions with further emphases on the sensory evaluation, nutritional value and microflora.

2. MATERIALS AND METHODS

2.1 Materials

The point of purchase for wheat flour, cassava tuber, maize grain, wheat grain with all ingredients for the bread production, sugar, yeast, salt, margarine and flavour was at a local market in Esa-oke, Osun State, Nigeria.

2.2 Flour Making

2.2.1 Cassava flour

The procedure demonstrated by Zvinavashe et al. [14] was employed. The skin of the cassava tubers was peeled off exposing the white part which was thoroughly washed in clean water. The tubers were then sliced manually into small pieces by a knife, soaked in lime water and spread out on a dirt-free platform to sundry. The dried cassava chips were milled into flour and sieved to get fine flour.

2.2.2 Maize flour

The procedure demonstrated by Houssou and Ayemor [15] was adopted. The maize grains were sorted to get rid of every particle. The sorted maize grains were sprinkled with water and left for 10 minutes before they were dehulled and milled into flour which was sieved to get fine flour.

2.2.3 Whole wheat flour

The procedure demonstrated by Ngozi [7] was adopted. Wheat grains were sorted, by removing all foreign materials, and washed with clean water. After sun drying for about 24 hours, the wheat grains were milled into fine flour. Sieving was avoided to retain the wheat wholesomeness.

2.3 Formulation of Flour Blends

The three flours were separately blended with wheat flour. Wheat/cassava flour (WCF) blend was made at ratios 5:5 and 9:1. The same was repeated for both wheat/maize flour (WMF), and wheat/whole wheat flour (WWF) blends.

2.4 Bread Production

The production of the bread followed the procedures described by AACC [16] involving weighing, mixing, kneading, proofing, fermentation and baking. The proportion of the ingredients used for making the bread was 500 g flour, 20 g yeast, 30 g margarine, 30 g sugar, 2.5g salt and 250 ml water. Individual flour blend was mixed according to their ratios (adding up to 500g). The dough was prepared by proper mixing of the ingredients using a kitchen aid stand mixer for about 5 mins. The dough after thoroughly kneaded was transferred into a bowl previously greased with margarine. Proofing was achieved by covering the dough-contained bowl with a clean towel for 45 mins at room temperature. The proofed dough was cut with a knife, moulded into a desired shaped and placed into clean baking pans previously greased with margarine. The loaf was made to fully rise through the fermentation process and finally baked in an oven at 150ºC for 15 mins (after the oven had been heated up). The baked bread was allowed to cool and kept inside a polyethene bag.

2.5 Sensory Evaluation

A nine-point hedonic scale of 9 (extremely unpleasant) to 1 (extremely nice) was used by 20 panelists to assess the acceptance level of the bread samples based on their appearance, taste, texture and odour being the key sensory properties of excellent quality bread [17].

2.6 Nutritional Analysis

Proximate composition determined to include protein, fibre, fat, ash, moisture and carbohydrate contents while the minerals analysed were K, Ca, P, Mg, Fe and Na. All were carried out according to the laboratory protocols described by AOAC [18].

2.7 Microbiological Analysis

One gram of the bread sample was introduced into 9 ml of sterile distilled water, homogenised and serially diluted in further sterile distilled water till the 7^{th} dilution [19]. Pour plate technique was used to estimate the microbial population by using nutrient agar (NA) at 35ºC, and potato dextrose agar (PDA) at 27ºC as culture media. Viable count of the colonies was taken. The colony forming unit was determined.

2.8 Isolation and Characterization of Bacteria

Discrete colonies were picked at random from NA plates and subcultured until pure cultures were obtained. The isolates were tested for Gram's reaction, endospore detection, coagulase, catalase, indole, sugar fermentation and starch hydrolysis [20].

2.9 Isolation and Characterization of Fungi

Discrete colonies were picked at random from PDA plates and subcultured until pure cultures were obtained. The cultural characteristics considered were the colony growth pattern, mycelial and spore colour and growth rate. The fungal hyphae were stained with lactophenol blue and view microscopically [20].

3. RESULTS

The panelist rating for sensory evaluations (as presented in Table 1) revealed the appearance of the bread samples to range from 5.50 (whole maize) to 8.05 (whole wheat); taste, 5.10 (whole maize) to 7.90 (wheat/maize at ratio 9:1); texture, 5.30 (whole cassava) to 8.00 (whole wheat); and odour, 5.60 (whole cassava) to 7.85 (whole wheat).

The result of the proximate analysis (Figs. 1 - 4) showed whole wheat bread sample to contain 20.43% crude protein (CP), 0.52% crude fibre (CF), 11.32% fat, 0.11% ash, 23.55% moisture content (MC) and 43.49% carbohydrate (CBH). Whole cassava has 23.15% CP, 0.70% CF, 12.40% fat, 0.12% ash, 23.45% MC and 40.18% CBH. Whole maize has 19.78% CP, 0.47% CF, 12.75% fat, 0.11% ash, 22.65% MC and 44.24% CBH. Whole white wheat has 12.61% CP, 0.31% CF, 11.91% fat, 0.10% ash, 22.25% MC and 58.82% CBH. Bread samples made from flour blends have CP ranging from 21.47% (WMF at ratio 5:5) to 27.41% (WCF at ratio 9:1), CF 0.44% (WMF at ratio 5:5) to 0.53% (WWF at ratio 9:1), fat 12.62% (WWF at ratio 5:5) to 16.90% (WMF at ratio 5:5), ash 21.47% (WWF at ratio 9:1) to 0.13% (WCF at ratio 9:1), MC 23.95% (WMF at ratio 5:5) to 24.91% (WCF at ratio 9:1) and CBH 32.85% (WCF at ratio 9:1) to 40.04% (WWF at ratio 5:5).

The result of the mineral content analysis (in mg/100g unit value) (Figs. 5 - 8) showed whole wheat bread sample to contain 116.96 K, 95.61 Ca, 92.75 P, 22.93 Mg, 4.40 Fe and 527.20 Na. Whole cassava has 117.85 K, 98.50 Ca, 94.10 P, 23.78 Mg, 3.80 Fe and 536.50 Na. Whole maize has 115.50 K, 96.86 Ca, 92.50 P, 21.65 Mg, 5.20 Fe and 538.90 Na. Whole white wheat has 120.50 K, 100.45 Ca, 96.50 P, 25.78 Mg, 4.36 Fe and 540.85 Na. Bread samples made from flour blends have K ranging from 118.75 (WMF at ratio 5:5) to 121.651(WCF at ratio 9:1), Ca 97.81(WWF at ratio 5:5) to 107.45 (WMF at ratio 9:1), P 93.78 (WMF at ratio 5:5) to 98.85 (WCF at ratio 9:1), Mg 22.95 (WMF at ratio 5:5) to 27.91(WCF at ratio 9:1), Fe 3.75% (WMF at ratio 5:5) to 4.53 (WWF at ratio 9:1) and Na 533.50 (WWF at ratio 5:5) to 552.40% (WCF at ratio 9:1).

Bacterial population estimated from NA plate for WWF was 8 × 10^6 cfu/g and 1.32 ×10^7 cfu/g; WMF, 2.10 × 10^7 cfu/g and 2.10 × 10^7; WCF, 5.48 × 10^7 and 1.32 × 10^7 all at ratio 5:5 and 9:1 respectively (Table 2). Estimated fungal population for WWF was 2.10 × 10^7 cfu/g and 1.22 ×10^7 cfu/g; WMF, 1.54 × 10^7 cfu/g and 1.40 × 10^7; WCF, 2.15 × 10^8 and 1.22 × 10^7 all at ratio 5:5 and 9:1 respectively (Table 2).

Two species of *Bacillus* were bacterial isolates recovered from all bread samples while seven fungal species were recovered which include *Mucor* sp., *Aspergillus flavus, Rhizopus* sp., *Aspergillus tamarii, Neurospora* sp., *Penicillium chrysogenum* and *Fusarium compaticum* (Table 3).

Table 1. Sensory evaluation of bread

Bread sample	Appearance	Taste	Texture	Odour
WCF	5.85	5.25	5.30	5.60
W_5C_5F	6.55	6.50	5.20	5.12
W_9C_1F	6.50	7.05	6.60	7.05
WMF	5.50	5.10	5.97	6.75
W_5M_5F	7.30	7.60	7.15	7.75
W_9M_1F	7.60	7.90	7.15	7.40
WWF	8.05	7.85	8.00	7.85
W_5W_5F	5.60	6.40	6.00	6.30
W_9W_1F	7.30	6.70	7.25	6.10
OWF	7.80	7.20	7.00	6.35

WCF- whole cassava bread; W_5C_5F- 50% wheat /50% cassava bread; W_9C_1F- 90% wheat/10% cassava bread; WMF- whole maize bread; W_5M_5F- 50% wheat/50% maize bread; W_9M_1F- 90% wheat/10% maize bread; WWF- whole wheat bread; W_5W_5F- 50% wheat/50% whole wheat bread; W_9W_1F- 90% wheat/10% whole wheat bread; OWF- ordinary white wheat bread

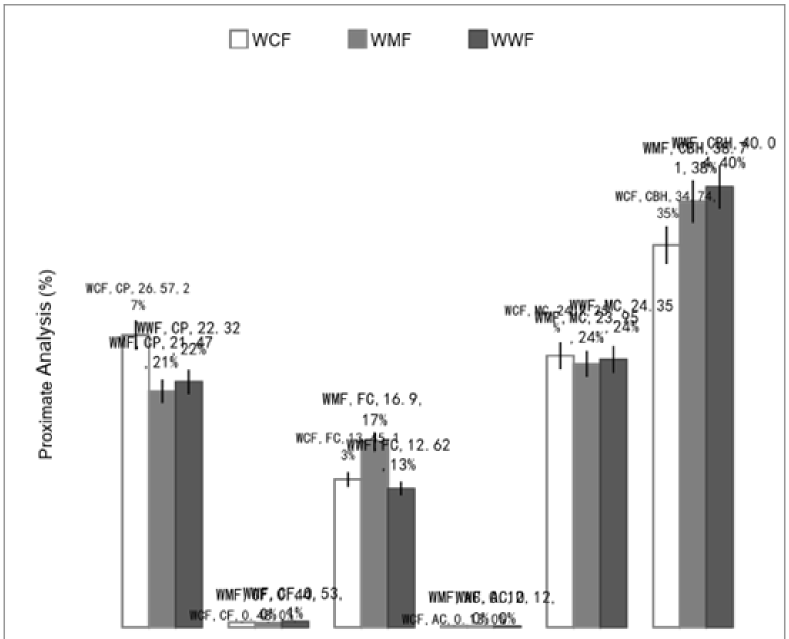

Fig. 1. Proximate analysis of bread from 100% individual flour

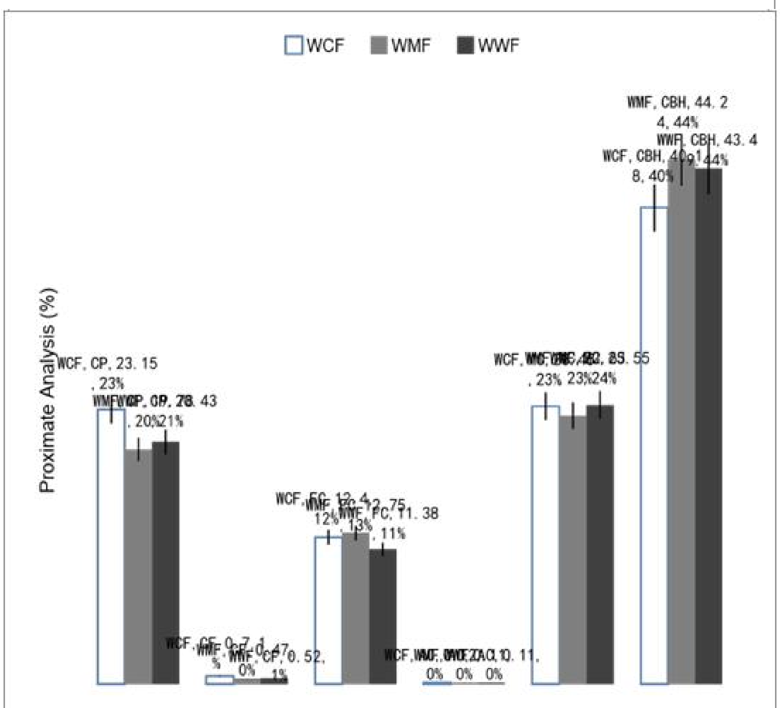

Fig. 2. Proximate analysis of bread from flour blends at ratio 5:5

WCF- wheat/cassava bread; WMF- wheat/maize bread; WWF- wheat/whole wheat bread; CP- crude protein; CF- crude fibre; FC- fat content; AC- ash content; MC- moiture content; CBH- carbohydrate

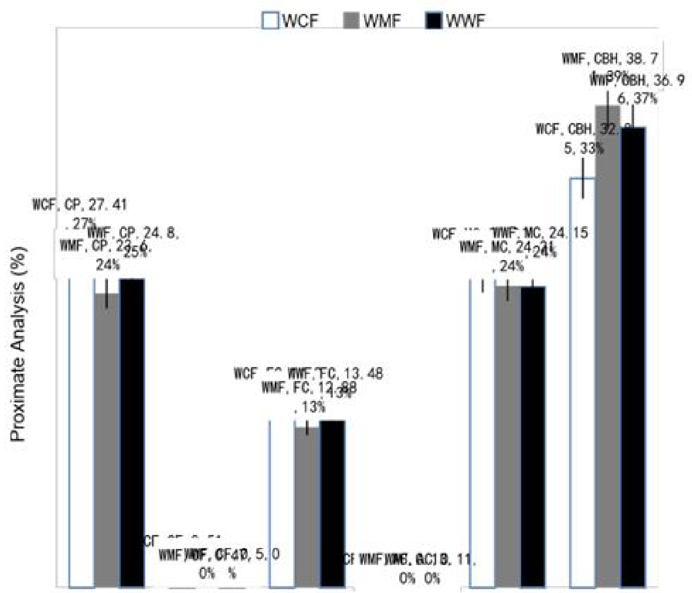

Fig. 3. Proximate analysis of bread from flour blends at ratio 9:1

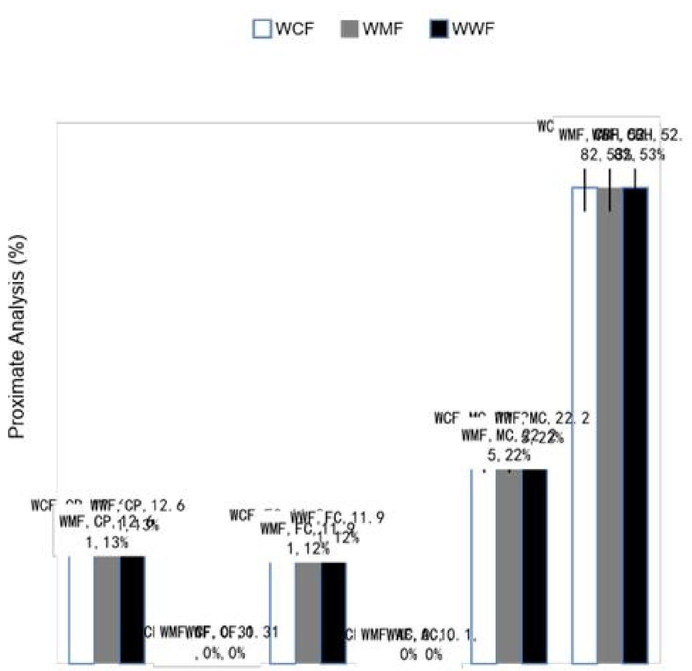

Fig. 4. Proximate analysis of Bread from white flour (control)

WCF- wheat/cassava bread; WMF- wheat/maize bread; WWF- wheat/whole wheat bread; CP- crude protein; CF- crude fibre; FC- fat content; AC- ash content; MC- moiture content; CBH- carbohydrate

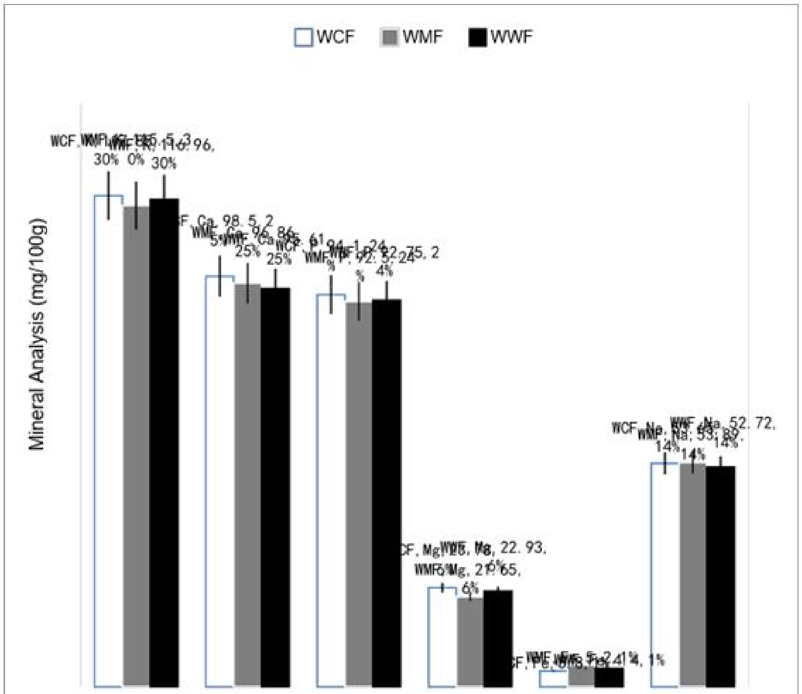

Fig. 5. Mineral analysis of bread from 100% individual flour

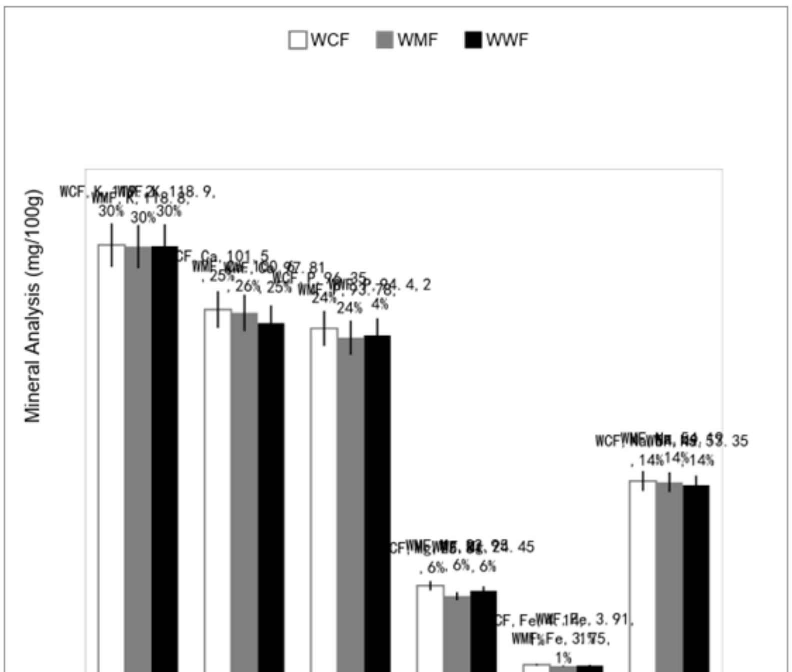

Fig. 6. Mineral analysis of bread from flour blends at ratio 5:5

WCF- wheat/cassava bread; WMF- wheat/maize bread; WWF- wheat/whole wheat bread. The values for Na were presented in a division of 10 ($^x/_{10}$)for better presentation

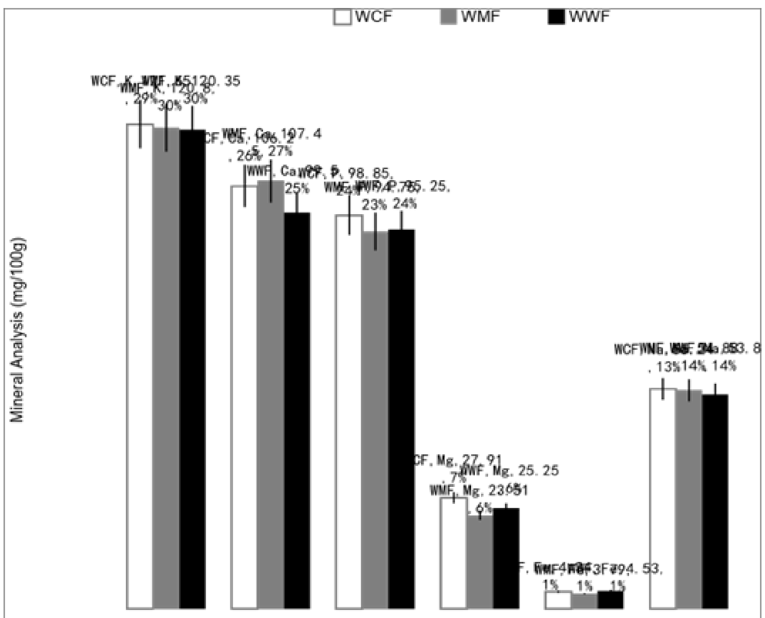

Fig. 7. Mineral analysis of bread from flour blends at ratio 9:1

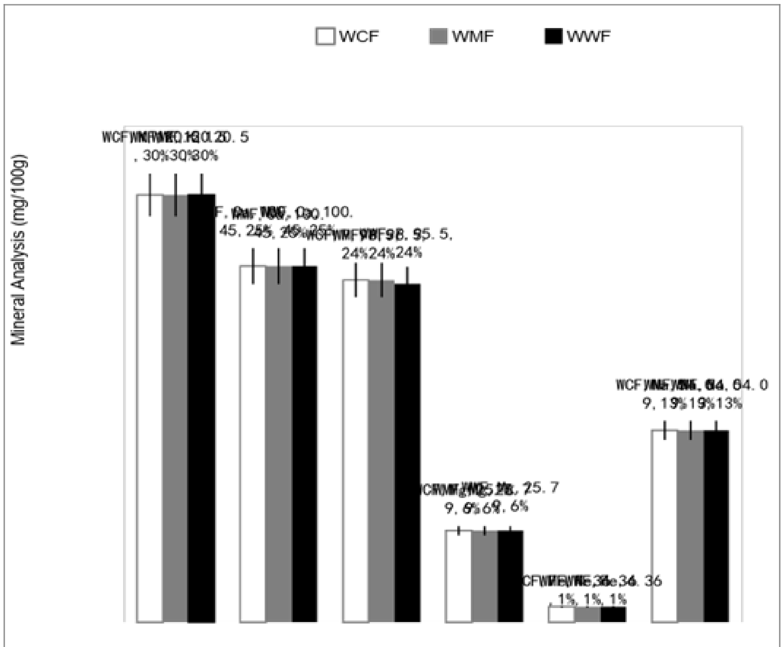

Fig. 8. Mineral analysis of bread from white flour (control)

WCF- wheat/cassava bread; WMF- wheat/maize bread; WWF- wheat/whole wheat bread. The values for Na were presented in a division of 10 ($^{x}/_{10}$)for better presentation

Table 2. Microbial counts on bread samples

Sample	WCF		WMF		WWF	
	NA (cfu/g)	PDA (cfu/g)	NA (cfu/g)	PDA (cfu/g)	NA (cfu/g)	PDA (cfu/g)
A	3.70×10^7	1.04×10^7	1.87×10^8	1.52×10^7	0.68×10^6	1.10×10^7
B	5.48×10^7	2.15×10^8	2.10×10^8	1.54×10^7	8.00×10^6	2.10×10^7
C	1.32×10^7	1.22×10^7	2.10×10^8	1.40×10^7	1.32×10^7	1.22×10^7
D	5.81×10^7	2.50×10^7	5.81×10^7	2.50×10^7	5.81×10^7	2.50×10^7

WCF- wheat/cassava bread; WMF- wheat/maize bread; WWF- wheat/whole wheat bread; A- whole flour; B- flour blend at ratio 5:5; C- flour blend at ratio 9:1; D- 100% white wheat flour

Table 3. Incidence of the bread isolates

Microorganisms	1	2	3	4	5	6	7	8	9	10
Bacillus subtilis	-	-	+	-	-	+	-	-	+	+
B. licheniformis	+	-	-	+	-	+	+	-	-	+
Mucor sp	-	+	+	-	-	+	-	+	+	+
Aspergillus flavus	-	+	+	+	+	+	-	+	+	+
Rhizopus sp	-	+	+	-	-	+	-	+	+	+
Aspergillus tamarii	+	-	+	-	-	+	+	-	+	+
Neurospora sp	-	+	-	+	-	-	-	+	-	+
Penicillium chrysogenum	+	+	-	+	+	-	+	+	-	+
Fusarium compaticum	+	+	-	-	+	-	+	+	-	+

1= whole cassava bread; 2= 50% wheat /50% cassava bread; 3= 90% wheat/10% cassava bread; 4= whole maize bread; 5= 50% wheat/50% maize bread; 6= 90% wheat/10% maize bread; 7= whole wheat bread; 8= 50% wheat/50% whole wheat bread; 9= 90% wheat/10% whole wheat bread; 10= ordinary white wheat bread; + = present; - = absent

4. DISCUSSION

All steps involved in the production of bread are of high relevance to its outcome. Sieving process, for instance, removes particles and impurities. Weighing ensures for proper mixing of the exact quantities of bread ingredients. Mixing makes better dough formation possible for the development of gluten structures and gas retention capacity. Fermentation process results in the availability of CO_2 (that makes the dough to rise) and atmospheric oxygen (useful for dough oxidation and yeast activity). The baking temperature has a “- cidal" effect on the yeast activity and also capable of starch gelatinisation, gluten coagulation and browning reaction [21].

Assessment done by panellists on sensorial quality of the bread samples showed that whole wheat bread has the highest rating for all parameters considered with all the bread samples. The final appearance of whole cassava and whole maize bread was unattractive, unlike white wheat bread after baking. The size too, due to their poor dough formation, was at a greater reduced level. The appearance of whole cassava and whole maize bread samples resembles "semi-soft" and "hard" biscuits respectively; the reason being that maize and cassava flours lack glutenin and gliadin - the protein that forms gluten when contact is made with water molecules [13]. All bread samples made with flour blends at ratio 9:1 was rated high with wheat/maize bread having the highest rating. This is in line with the findings of Aboaba and Obakpolor [6] and Shittu et al. [22] as they rated composite bread samples made from flour blend containing 10% cassava flour and 90% wheat flour very high.

The percentage of crude protein, crude fibre and fat of bread made with flour blends increased from ratio 5:5 to 9:1, while the reverse is the case with ash, moisture content and carbohydrate. All values of proximate analysis for white wheat bread samples were far lower than that of the flour-blend bread samples except for carbohydrate. The same occurs for bread made with whole flours but more than that of the white wheat bread. The white wheat bread had the highest values for K, Ca, P, Mg, Fe and Na and bread samples from flour blends increased in values from ratio 5:5 to 9:1 in all the minerals analysed. The whole flour (WWF, WCF and WMF) bread samples have the lowest values. This shows that composite bread technology has an increased contributory effect to the bread nutritional value. This new technology, on this note, should be further embraced as bread fortification plays a positive role in its final outcome and this cannot be overlooked.

The microbial count for whole flour (WWF, WCF and WMF) bread samples were at the lowest range while that of white wheat bread was more than the blend-flour. The carbohydrate content could be one of the factors responsible for this. The fungal count for blend-flour bread samples decreased from ratio 5:5 to 9:1 while bacterial count has an undulating pattern. The percentage of the moisture content could have promoted this. Moisture content contributes immensely to the thriving of microorganisms when nutrients such as carbohydrates are available.

All microorganisms recorded in this work were found in white wheat bread samples (Table 3). The same occurred for WWF and WCF both at ratio 5:5 except for the absence of *A. tamarii*. *A. flavus* was found in all except for whole cassava bread and whole wheat bread. *P. chrysogenum* was present in all except for all whole-flour bread at ratio 9:1. *Bacillus subtilis* and *B. licheniformis* have been reported in bread [23] as they are associated with rope spoilage of bread [24]. All fungal species isolated in this work have also been previously reported to be associated with bread samples [24-27]. Species of *Aspergillus, Penicillum, Rhizopus* and *Fusarium* are known for mould spoilage of bread [28].

5. CONCLUSION

Home-based production of bread is easily practicable in our kitchen today. Modern tools like mixing machine and oven have contributed to the possibility of producing bread at home with little or no stress. The most tasking part, the kneading process, has been overcome by mixing machine. Those unable to afford modern mixer and oven can still improvise. Mixing and kneading can be done by hand and roller respectively. Within the time frame of 90 minutes bread is ready. Even with this, many individuals are already accustomed to buying bread from bread sellers. Our mind needs to be re-orientated that bread too is a diet that should not be only consumed at home but can also be made at home. This ensures safety and freshness of our meal. Yes, there are many bread factories that pay great attention to bread hygiene, but several sellers still handle bread with poor hygienic practices. The freshness of bread bought, at times, cannot be confirmed at the sale's point for some might have become ropy and/or mouldy. Home-based production of bread also helps in managing feeding expenses. For high consumption of balanced diet, better fortification of homemade bread is encouraged which is best achieved by baking it with more than one flour at appropriate ratios. Homemade bread can likewise become ropy and/or mouldy if not properly handled. Prompt preservation and care should be given to ensure consumer safety and avoid biodeterioration or microbial spoilage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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