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CHEMICAL COMPOSITION, FUNCTIONAL AND BAKING PROPERTIES OF WHEAT-PLANTAIN COMPOSITE FLOURS.

Horsfall D. Mepba[1*], Lucy Eboh[2] and S.U. Nwaojigwa[2]

Horsfall Mepba

[1*]Corresponding author email:Mepba12002@yahoo.co.uk
Department of Food Science and Technology, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.

[2]Departemnt of Home Economics, University of Uyo, Akwa Ibom State, Nigeria

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KARI-NARL Complex, Westlands, off Waiyaki Way
P.O. Box 29086-00625 TEL: +254-20-4444030 FAX: +254-20-4444030
Nairobi, KENYA
Email: oniango@iconnect.co.ke OR info@ajfand.net www.ropkenya.org

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ABSTRACT

The feasibility of partially replacing wheat flour with plantain flour in bread and biscuit making were investigated. Matured plantains (*Musa paradisiaca*) were pulped, blanched, dehydrated and pulverized. The wheat flour (WF) was substituted by plantain four at levels of 5, 10, 20 and 30% and 0, 50, 60, 70, 80 90 and 100% for bread and biscuit making, respectively. The protein content of composite breads ranged from 5.6 – 10.2%. No significant difference was observed in the nutrient contents of control (wheat bread) and composite bread at 5% level of plantain addition. Water and oil absorption capacities of composite flours increased with increasing levels of plantain flour in the blend. Emulsion and foam capacities as well as emulsion and foam stabilities decreased at higher (40–100%) levels of dilution with plantain flour. As the plantain flour content of the composite dough increased beyond 5%, alveograph values for dough resistance to extension (R), extensibility (E) and mechanical work of dough deformation (W) decreased. The oven spring and specific loaf volume decreased significantly with increased plantain content of blends. Sensory panel rating (80.2%) of the 10% plantain flour content of composite bread was not significantly different from the score (83.8%) of the 5% level of WF substitution but was significantly different from a score of 88.4% for the control (Wheat-bread) ($P \leq 0.05$). The flow and break strength of wheat-plantain composite biscuits decreased with increasing dilution of wheat with plantain flour. At 50 and 90% plantain flour substitution level the flow and break strengths were 54.2% and 1.90 kg and 50.8% and 1.20 kg, respectively, while the 100% wheat biscuit had a flow and break strength of 69.4% and 3.45 kg respectively. Thus the mean scores for colour, taste and crispness/aroma were generally high for all biscuits samples containing 0–70% plantain flour. Generally the biscuits were highly rated for colour (75.1%), taste (74.9%) and crispness/aroma, 71.6% of the total score for each characteristic on a 9-point hedonic scale. Technically, organoleptically acceptable breads and biscuits were formulated from wheat-plantain composite flours using up to 80:20 (w/w)% and 60:40/w/w) ratios of wheat:plantain flour as maximum acceptable levels of substitution for breads and biscuits, respectively.

Key words: Plantain, composite, dough bread and biscuit.

FRENCH

La possibilité de remplacer partiellement la farrine de blé par la farine de plantain dans la fabrication du pain et du biscuit a été étuduée. less plantains mûrs (*Musa paradisiaca*) etaient reduits en pâte, deshyhatés et pulverize la farine de plantain dans une propotion de 5, 10, 20 et 30% et 0, 50, 60, 70, 80, 90 et 100% dans la fabrication, du pain et du biscuit respectvement. La composition chimique, les proprietés fonctionelles du mé lange de farine, les propriété cheologiques de la pâte, la cuisson et les caracteristiques sensasuelles du pain et du biscuit on été évaluées â, la contenance en protein du pain a été classée de 5.6 â 10.2% aucune difference significative n'a été observée dans la contenu nourissant de contrôle (farine de pain) et dans le compose du pain au niveau de l' adition du plantain â 5%. Les capacities d'absorbtion d' eau et d'huile du compose des farines ont augmenté avec niveau d'accroissement de la farinede plantain dans le mélange. L'emulsion et les capacities de mousse, egalement l'mersion et la stabilité de mousse on diminué au plus haut (40 â 100%) niveau de dilution avec la farine de plantain pendant que la contenance de la farine de plantain du composé de la pâte â augmenté au dela de 5%. Les valeurs de l'alveographe pour la résistance de la pâte a l'extension (R), extensibilité (E) et le travail mécanique de la formation de la pâte a diminué. La fournaise net leipecifique du pain a diminué cosidérablement avec l'augmentation de la farine de plantain dans le mélange. L'estimation sensorielle de la liste (80.2%) du 10% de la contenance de la farine de plantain du composé de pain n'etait pas de maniére significante différente des points (83.8%) du 5% deniveau de substitute de la farine de blé 'wheat flur mais é tait différente de 88.4% de point pour le contrôle du pain de blé (wheat bread). L'eécoulement et la force de cassation du composé de biscuit a la farine de plantain regressent avec l'augmentation du blé â la farine de plantain. A un niveau de substitution de 50 et 90% de la farine de plantain, l'écoulement et la force de cassation étaient respectivement du 54% et 1.9kg et 50.8% et 1.20kg tandis que les 100% de biscuit a la farine avait un écoulement et une force de cassation respectivement de 64.4% et 3.45kg, la mogeune en ce qui concerne les points etait généralement haute pour tous les échantillons de biscuit. Contenant 0-70% de farine de plantain. Les biscuits acceptable étaient products jusqu' â un pourcentage de 80% de dilution. Les biscuits étaient généralement class's â la hausse pour leur coulenur (75.1%) leur goût (74.9%) et craquant/arôme, 71,6% du point tatal pour chaque caractére sur la balance de 9 points. (9-point hedonic scale). Les pains et les biscuits techniquement et organoleptiquement acceptables sont été formulas de la farine composée du blé/plantain utilisant la proportion du blé environ de 80:20 (w/w) et 60:40 (w/w) pourcent: le niveau maximum de farine de plantain acceptable comme une substitution aux pains et biscuits.

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INTRODUCTION

Plantains (*Musa paradisiaca*), AAB group [1] is an important staple food in Central and West Africa, which along with bananas provides 60 million people with 25% of their calories [2]. According to FAO [3], over 2.11 million metric tons of plantains are produced in Nigeria annually. However, about 35-60% post harvest losses had been reported and attributed to lack of storage facilities and inappropriate technologies for food processing [4]. When processed into flour it is used traditionally for preparation of gruel which is made by mixing the flour with appropriate quantities of boiling water to form a thick paste. The use of plantain flour for production of baked goods if feasible would help to lessen our total dependence on imported wheat. It is important to study the quality of the plantain flour to determine its suitability for use as composite flour. The flour quality can be assessed by physical and chemical analysis as well as by baking tests. Many workers have studied the physical and baking properties of other starchy staples like cassava, cocoyam and taro. Idowu *et al.* [5] studied the use of cocoyam flour as composite with wheat flour in bread and biscuit production. They found that up to 10% and 80% substitution with cocoyam flour produced acceptable breads and biscuit, respectively.

Akubor [6] has shown that plantain flour has a good potential for use as a functional agent in bakery products on account of its high water absorption capacity, but evaluation of the functionality of flour in test baking has not been demonstrated. Experience gained in the use of composite flours has clearly demonstrated that for reasons of both product technology and consumer acceptance, wheat is an essential component in many of these flours. The percentage of wheat flour required to achieve a certain effect in composite flours depends heavily on the quality and quantity of wheat gluten and the nature of the product involved. At present the cost of bread and biscuits is very high in Nigeria and thus gives impetus for further research into the use of composite flour for baking. This investigation evaluated the nutritional functional and baking properties of wheat-plantain composite flours.

MATERIALS AND METHODS

Materials

Five kilogrammes (5kg) of "False Horn" matured green plantain (*Musa paradisiaca*) were procured from International Institute of Tropical Agriculture, (IITA), Onne, near Port Harcourt, Rivers State. The wheat flour used was white extract of milled grain imports from USA by the Nigerian Flour Mills. Both hard and soft wheat flours were provided for bread and biscuit formulations respectively. All other baking ingredients were supplied by the Nigerian Flour Mills Plc, Port Harcourt and the baking process was done at their factory.

Sample Preparation

Plantain heads were cut into separate bunches which were subsequently defingered. The fingers were washed, peeled, cut into thin slices of 2 cm thick and blanched in 1.25% $NaHS0_3$ solution at 80°C for 5 min [7]. Blanched plantain slices sere drained and dehydrated in a Thelco air-recirculating oven at 60°C for 24 hours. Dried plantain slices were milled into flour in a Retch Muhle 2880 Hammer mill. Flour obtained were sifted through a 250 μm aperture sieve and packed in a two-ply medium density (0.926 – 0.949 g/cc) polythene bag.

Bread and biscuit making

Composite flour samples containing wheat and plantain flours were formulated at 0, 5, 10, 20 and 30% (w/w) level of wheat flour substitutions for bread making and for biscuits at 0, 50, 60, 70, 80, 90 and 100% (w/w) levels.

Proximate Composition

Proximate analyses of the samples were carried out using official AOAC methods [8] for moisture (14.004), crude fat (14.081), crude fiber (7.0006), ash (14.006) and crude protein (47.021). A nitrogen to protein conversion factor of 6.25 was used. Carbohydrate was calculated by difference.

Functional Properties

Water and oil absorption capacity:

Water and oil absorption properties of the composite flour were determined following methods of Sathe *et al.* [9]. Briefly, flour sample (2 g) was mixed with 20 ml distilled water for water absorption and 20 ml of oil for oil absorption in a Moulinex blender (Model dePC 3, France) at high speed for 30 (s). Samples were then allowed to stand at 30°C for 30 min then centrifriged at 10,000rpm for 30 min. The volume of supernatant in a graduated cylinder was noted. Density of water was taken to be 1g/ml and that of oil was determined to be 0.93 g/ml. Means of triplicate determinations were reported.

Foaming capacity and stability were studied according to the methods described by Desphande *et al.* [10]. For stability, the flour sample (0.5g) was blended for 30 min in distilled water (40 ml) at top seed in a Moulinex blender. The whipped mixture was transferred into a 100 ml graduated cylinder. The blender was rinsed with 10 ml distilled water which was then gently added to the graduated cylinder. Foam volume in the cylinder were recorded per sample after 30 min standing. Triplicate measurements were made for each sample and mean values recorded.

Emulsion capacity and stability

A flour sample (2g) and distilled water (100ml) were blended for 30 (s) in a Moulinex blender (Model depC 3, France) at high speed (ca.100rpm). After complete dispersion, peanut oil was added from a burette in streams of about 5 ml. Blending continued until there was separation into two layers. Emulsification determinations were carried out at 30°C and expressed as grams of oil emulsified by 1g flour.

Emulsion stability was studied following the methods described by Okezie and Bello [11]. Briefly, sample (4 g) was dispersed in distilled water (100 ml), then 100 ml of peanut oil was added at the rate of 12.5 ml per (s) while blending. Each sample was blended in a Moulinex blender at high speed for additional 60 sec. and transferred into a 250 ml graduated cylinder volumetric changes in foam, oil and aqueous layers were recorded after 3 hr. Triplicate measurements were made and average results taken.

Bulk Density

Bulk densities of samples were determined by weighing the sample (50 g) into 100 ml graduated cylinder, tapping cylinders ten times against the palm of the hand and expressing the final volumes as g/cc.

Rheological Determinations

Rheological properties of dough from the blends were determined using an alveograph (Chopin, Model MA 82, France) using standard recommended alveograph procedures [12, 13]. Flour blends (250g) was kneaded with water (500ml) containing 25% NaCl in the alveograph mixer. A mixing time of 8 min. at 29°C and 20 min rest period were the condition used. From alveograms obtained, the following rheological parameters of dough were calculated;

(i) the height of curve, R (mm) which measured the pressure applied during inflation and indicated the resistance of dough to deformation.

(ii) the length of the curve, L (mm), which measured the extensibility of the dough.

(iii) mechanical work for deformation, W, (10^{-4} joules/g) which measured the overall strength of gluten height/length rate of the curve.

(iv) height/length ratio of curve, R/L.

Composite flours were then used to prepare bread and biscuits using standard recipes (Table 1). For bread-making, a modification of the straight dough method [14] was used. The ingredients, based on a 350 g wheat flour or wheat-plantain composite flour were mixed in a Hobart N-50 mixer fitted to a dough hook for 1 min at No. 1 speed, 1 min at No. 2 speed and the rest of the mixing time at No. 3 speed. Two baking responses namely, dough handling properties and loaf volume (rapeseed method as modified by Giami *et al.* [15] were monitored as function of added water and % plantain flour in the composite while mixing for 6 mins. Following a 90 minute fermentation time, doughs were punched, moulded, scaled to 500 g and proofed for 2 hr, which gave good loaf volumes for wheat flour and optimum volumes for blends. Baking was at 204°C for 30 min. Duplicate loaves were baked for each substitution level. Loaves were allowed to cool on stainless steel wire at room temperature then placed in plastic bags for sensory evaluation on the second day.

For biscuit making, the sheeting method described by Adeyemi and Omolaye [16] was used.

Evaluation of Bread Characteristics

Bread characteristics or baking qualities were evaluated by measuring the loaf volume, specific loaf volume, the oven by spring and the organoleptic characteristics. Loaf volume was measured 50 minutes after loaves were removed from the oven by using the rapeseed displacement method as modified by Giami *et al.* [15]. Briefly, loaf volume was measured by seed displacement using pearled barley in place of rapeseed. A box of fixed dimensions (24.00 x 15.70 x 18.95 cm) of internal volume 7140 cm^3 was put in a tray, half filled with pearled barley, shaken vigorously 4 times, then filled till slightly overfilled, so that overspill fell into the tray. The box was shaken again twice, then a straight edge (or rule) 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 (B g). A weighed loaf was placed in the box and weighed seeds (4500 g) 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 the following equations.

Seeds displaced by loaf (L) = B g + overspill weight – 4500 g.

$$\text{Vol. of loaf (V)} = \frac{L \times 7140}{B}\ cm^3$$

Specific volume of loaf = V/wt (cm^3/g)

Weight of loaf samples were taken and specific loaf volume was obtained by dividing the loaf volume by its corresponding loaf weight. Oven spring was determined from the difference in height of dough before and after baking.

Sensory evaluation was performed 24 hours after baking to evaluate loaf appearance, crust colour, crumb colour, taste/flavour and overall acceptability of the bread sample. The bread samples were sliced into pieces of uniform thickness and served with water. Twenty panel members (familiar with quality attributes of local bread) were randomly selected from students and staff of the Department of Food Science and Technology, to perform the evaluation. Panelists evaluated bread samples on a 9 point hedonic scale quality analysis [17] with 9 = liked extremely, 8 = liked very much, 7 = liked, 6 = liked mildly, 5 = neither liked nor disliked, 4 = disliked mildly, 3 = disliked, 2 = disliked very much and 1 = disliked extremely .

Evaluation of Biscuits

The flow and break strength were determined according to Okaka and Isieh [18] Taste panel evaluation of biscuit samples was similarly conducted using fifteen panel members selected randomly (that are familiar with quality attributes of local biscuits) to access colour, crispness and taste as quality parameters. A 9-point hedonic scale quality analysis as described by Larmond [17] was similarly used as described above.

Statistical Analysis

Analysis for significant differences in the results obtained were performed by using the F-test and the least significant Difference Test (LSD) [19].

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RESULTS

Blanching of plantain slices in hot 1.25% $NaHSO_3$ solution resulted in bleaching of plantain slices with reduced browning of dehydrated products and stability of packaged flour.

The proximate contents of plantain flour, wheat flour and wheat-plantain composite bread are presented in Table 2. The protein contents of wheat and plantain flours were 12.86% and 2.30% respectively. Differences in the nutrient contents of 0 (wheat bread), the control, and 5% level of wheat flour substitution by plantain flour were not significant (P>0.05). The protein contents of the composite breads ranged from 5.6 – 10.2%. Protein contents decreased significantly while carbohydrate contents increased with increasing levels of plantain flour in the composite flours. The crude fibre and ash contents of composite breads differ significantly p≤0.05 at higher levels of dilution of wheat with plantain.

The functional properties of wheat plantain composite flours are presented in Table 3. Both water and oil absorption increased with increasing contents of plantain flour in the blends. Differences in water absorption capacities of flours increased significantly from the 90:10 to 100:0 (w/w)% wheat to plantain flour. Differences in the values for oil absorption from the 100:0 to 50:50 (w/w)% wheat: plantain flour blends were not significant (P>0.05). Similarly, differences in the values for bulk density and emulsion activity were not significant (P>0.05). However, the emulsion activity and stability decreased with increased content of plantain in flour blends. Foam capacity increased from the 100:0 to 80:20 (w/w)% wheat:plantain flour blend. Differences in the values obtained for foam stability were not significant. However, the foam volume on whole plantain flour sample was insignificant and stable.

Data on the rheological properties of dough samples from wheat/plantain flour and blends are presented in Table 4. The energy of the dough samples decreased with increased levels of substitution with plantain flour. This was further reflected by the decreasing trend in the resistance of the dough to extension. It was also observed that the value for resistance to extension decreased gradually from 110 Extensograph units for whole wheat dough to 52.0 Extensograph unit for 70:30 (w/w)% wheat/plantain dough. Hence the extensibility which indicates the stretchability of the dough was reduced accordingly.

Data on the baking characteristics of wheat and plantain composite bread are given in Table 5. The oven spring and specific volume of plantain composite breads decreased significantly with increasing plantain flour content of the composite flour. Beyond 5% level of wheat flour substitution the oven spring and specific loaf volume were significantly less than the value for control. Further increase up to 30% level of wheat flour substitution produced a poorer loaf.

Presented in Table 6 are the sensory attributes of wheat-plantain composite bread. Taste panel ratings of sensory properties of the bread samples increased significantly (P≤0.05) with increased contents of wheat flour in the composite. For mixtures up to

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30% of plantain flour, the scores for loaf appearance, crust colour, crumb colour, taste/flavour and overall acceptability were significantly ($P \leq 0.05$) lower than the 20, 10, and 5% mixtures. Differences in panel scores for the control bread and the 5% dilution were nonsignificant.

Scores obtained at 30% level of substitution were less acceptable. At 10% level of substitution of plantain flour for wheat flour, acceptable loaves of bread were obtained. However, bread produced with 10% plantain flour in the mixture had total score of 80.2% which was not significantly different from the 5% level of substitution with a total score of 83.8%. However, the control had a total score of 88.4% and significantly different from bread with 10% plantain flour in the mixtures. These scores which represent cumulative sensory panel scores for the breads represent fractions of the total score (100%) for the tested attributes and demonstrate high level of acceptability of the breads up to 10% level of substitution of wheat flour by plantain flour.

Data on the flow and break strength of wheat-plantain composite flour biscuit are presented in Table 7. The flow and break strength of wheat/plantain biscuits were lower than the 100% wheat biscuits but higher than those of 100% plantain biscuits. Thus, the flow and break strength of the fragile plantain biscuits decreased with increasing wheat flour dilution. The 100% wheat biscuit had the highest flow and break strength of 69.4% and 3.45kg respectively.

Presented in Table 8 are data on the sensory evaluation of wheat-plantain composite flour biscuit. The wheat-plantain flour blends of 80% or below produced highly acceptable biscuits. The mean score for colour, taste, crispness/aroma were generally high for all biscuit samples from 0 – 70%. The 80, 90 and 100% plantain biscuits generally had significantly lower average score for the tested attributes when compared with the control and the 50:50 plantain biscuit sample. The biscuit samples were highly rated for colour (75.1%), taste (74.9%) followed by crispness/aroma (71.6%).

DISCUSSION

The slicing of plantain pulp prior to blanching in 1.25% $NaHSO_3$ and dehydration facilitated penetration of $NaHSO_3$ solution into the slices and the rate of heat and mass transfer during dehydration. Mepba *et al.* [7] similarly enhanced the colour and oxidative stability of ripe banana flour by blanching fruit slices in 1.25% $NaHSO_3$ solution. The sodium and potassium salts of sulphite, bisulphite and metabisulphite are antioxidants with strong reducing power which allows these compounds to reduce oxygen tension thus inhibiting growth of microorganisms by inhibiting essential enzymes [20]. The increased carbohydrate and decreased protein contents of composite flours with increasing levels of plantain flour was expected. Plantain is consumed as an energy yielding food comparable with potatoes and is predominantly starchy [21]. Similarly the increased crude fibre and ash contents at downstream dilutions suggest that at higher dilution levels the coarse plantain flour enhanced the fibre and ash contents of the mixtures. The wheat flour was found to have a protein content of 12.86%. According to Zeleney [22] a minimum protein content of 11.0% in wheat flour is necessary for the production of yeast-leavened bread. The importance of the protein level was due to its gluten fraction in that gluten was responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide generated by yeast during fermentation. When gluten coagulated under the influence of heat during baking, it served as the framework of the loaf, which became relatively rigid and did not collapse. Plantain flour contained no gluten and consequently could not be used solely for breadmaking. When used, however, a limit of substitution level with wheat flour was necessarily imposed on the extent to which the flour could be used as a substitute for wheat flour in breadmaking.

Functional Properties of the Flour

Water and oil absorption: Water and oil absorption capacities of our blends increased progressively as the level of plantain flour was increased (Table 3). The results showed that the blends would be useful in bakery products where hydration to improve handling is desired and in ground meat, doughnuts, and pancakes where oil absorption property is of prime importance. The water absorption of wheat flour blends reported in the present study fell within the range reported for other flours. Lin *et al.* [23] reported 130% water absorption for soy flour and 227.3% and 196.1% respectively for two commercial soy protein concentrates namely, Isopro and promo soy. The low bulk density of the blends could be an advantage in the formulation of baby foods where high nutrient density to low bulk is desired. Although the protein and lipid contents of wheat-plantain flour blends were low compared with infant formula from commercial outlets, fortification of wheat-plantain flour with animal protein sources such as powdered milk and ground crayfish as practiced by mothers in rural communities in Nigeria would improve the nutrient contents of these flour blends.

Emulsion Properties

The emulsion properties of the composite flours decreased with increased levels of plantain flours in the blends. Increasing Emulsion Activity (EA), Emulsion stability and fat binding during processing are primary functional properties of protein in such foods as communited meat products, salad dressings, frozen deserts and mayonnaise. All blends showed relatively good capacity for emulsion activity and could then be used for the products listed above. Lin *et al.* [23] reported the emulsion capacities of wheat flour, soy flour, sunflower flour and protein concentrates and isolates from soy and sunflower flours to be in the range of 10.1 to 25.6% with the exception of sunflower (in which 95.1% oil emulsified). In the present study, the Emulsion Capacity (EC) of the wheat plantain flour blends falls within the range of 3.5 – 12.8% and ES 2.4 – 18.6%.

Foam Properties

Data on foaming capacity and stability of wheat-plantain flour blends suggest that the foaming capacity of the blends rose to 26% in the 80:20 blend and dropped abruptly to 2.0% in 0:100 blend. Similarly, Foam Stability (FS) was constant between 66.7 – 67.2% and dropped in the 0:100 wheat/plantain flour blend. The blends depicted high foam stability and may find application in baked and confectionery products. Product foamability is related to the rate of decrease of the surface tension of air/water interface caused by absorption of protein molecules. Graham and Phillips [24] observed that flexible protein molecules such as β (beta) casein, which can rapidly reduce surface tension, gave good foamability, whereas a highly ordered globular protein molecule such as lysozyme, which is relatively difficult to surface denature gave low foamability.

Rheological Determinations

The addition of plantain flour to wheat flour decreased the resistance of dough to extension (R), extensibility of dough (L) and mechanical work of deformation of dough, W (Table 4). There were no significant ($P \leq 0.05$) differences between the alveograph values obtained for these parameters in blends containing 0 and 5% plantain flour. The mechanical work (W), measure of energy for dough deformation decreased from 292 x 10-4 joules/g in wheat flour to 93 x 10-4 joules/g at 30% level of blending with plantain flour. The high W value of wheat flour dough indicated the presence of strong gluten, which appeared to get weakened and destabilized by incorporation of plantain flour. This explains the drastic reductions in W value of composite dough with increased dilutions of wheat flour with plantain flour. A similar decrease in alveograph W value was observed by Misra *et al.* [25] for soy-wheat flour blends. Dough extensibility remained unchanged at 5% level of substitution but decreased with further increase in substitution level. Chauhan *et al.* [27], Okaka and Potter [28] reported reduced extensibilities of dough with increased substitution levels of non-wheat flour protein.

Results in Table 5 show that significant differences in oven spring and specific volume of breads were observed when plantain flour incorporation in blends increased beyond 5%. Reductions in volume and quality as a result of blending wheat flour with more than 5% legume and oilseed flours and protein concentrates have been reported for sunflower [26], quinoa [27] and great northern bean [9].

Flour fortified with wheat flour showed no significant ($p>0.05$) differences with respect to loaf appearance, crust colour, taste/flavour and overall acceptability (Table 6). However, as the level of plantain incorporation increased beyond 5% there was a significant change in the sensory attributes of bread samples. The plantain biscuits made from the 50:50, 60:40 and up to 70:30 (w/w)% wheat:plantain flour blends were fragile and this was reflected in their flow and break strength (Table 7). This fragile nature of plantain biscuits was consistent with the result of Adeyemi and Omolaye [16] regarding cocoyam biscuits made from wheat blended with cocoyam flour. This is attributed to the low gluten content and development [18] in the composite flours. The colour of the plantain biscuits was generally less acceptable at high concentration (Table 8) probably due to maillard reactions and caramelization during baking. Besides, crispness of biscuits was compromised at high levels of plantain flour dilution of the composite, presumably due to the high starch content of plantains.

CONCLUSION

The protein content of wheat/plantain composite breads ranged from 5.6 – 10.2%. Water and oil absorption capacities of the flour blends increased with increasing plantain flour contents while emulsion properties decreased simultaneously. The addition of plantain flour to wheat flour decreased the resistance of dough to extension (R), extensibility of dough (L) and mechanical work of dough deformation (W). Substitution of wheat flour with plantain flour depressed loaf volume, sensory acceptability of breads as well as biscuit flow and break strength. Technically, organoleptically acceptable breads and biscuits were formulated from wheat/plantain composite flours using up to 80:20 (w/w)% and 60:40 (w/w)% ratios of wheat:plantain flour as maximum acceptable levels of substitution for breads and biscuits respectively. However crispness of composite biscuits was compromised at high levels of plantain flour dilution when compared with non-blended wheat flour biscuits

Table 1: Ingredients for making bread and biscuits using wheat or wheat-plantain flour.

	Bread	Biscuit
Component	Composition (%)	Composition (%)
Flour*	100	100
Yeast	2.0	-
Sugar	5.0	50
Salt	1.5	2.0
Fat	3.0	18.0
Ascorbic acid	75ppm	-
Baking powder	-	3.0
Egg	-	25.0
Calcium phosphate	-	0.8
Vanilla/Nutmeg	-	-
Water	54.66	22.0

*Wheat or wheat-plantain composite flour.

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Table 2: Proximate composition of plantain flour, wheat flour and wheat-plantain composite bread

Flour	Components (g/100g flour)					
	Moisture (%)	Protein (%)	Lipid (%)	Crude fibre (%)	Total Ash (%)	Carbohydrate (by difference)
Wheat flour	11.31	12.86	1.40	0.82	0.46	73.15
Plantain flour	11.48	2.30	1.64	3.50	2.36	78.72
Breads % plantain flour in composite bread						
0 (wheat bread)	12.6^{c}	10.2^{c}	1.7^{ab}	0.09^{a}	2.9^{a}	71.7^{a}
5	11.9^{c}	9.1^{c}	1.6^{ab}	1.5^{a}	3.4^{a}	72.5^{a}
10	11.2^{c}	7.7^{b}	1.4^{a}	2.3^{ab}	3.8^{ab}	73.6^{b}
20	9.8^{b}	6.4^{a}	0.9^{a}	3.4^{c}	4.9^{c}	74.6^{c}
30	8.2^{a}	5.6^{a}	0.6^{a}	4.3^{d}	5.8^{d}	75.7^{d}
LSD = 0.94						

a, b, c Means in the same columns not followed by the same superscript are significantly different (P≤0.05).

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Email: oniango@iconnect.co.ke OR info@ajfand.net www.ropkenya.org

Table 3: Functional properties of wheat/plantain composite flours

Property	Wheat/plantain (w/w)						
	100.0	90.10	80.20	70.30	60.40	50.50	0.100
Water absorption capacity (%)	65[a]	76[a]	88[ab]	101[ab]	120[c]	168[d]	284[c]
Oil absorption capacity (%)	110[a]	112[a]	113[a]	114[a]	118[a]	120[a]	130[ab]
Bulk density (g/cm^3)	0.63[a]	0.62[a]	0.60[a]	0.60[a]	0.61[a]	0.60[a]	0.57[a]
Emulsion stability (%)	12.8[a]	14.8[a]	15.6[a]	8.2[a]	6.0[a]	4.5[a]	3.5[a]
Emulsion stability (%)	18.6[ab]	5.2[a]	10.4[a]	8.6[a]	5.1[a]	3.8[a]	2.4[a]
Foam capacity (%)	20.4[ab]	24.8[a]	26.0[b]	18.2[b]	6.4[a]	12.0[a]	2.0[a]
Foam stability (%)	63.2[a]	65.6[a]	67.5[a]	67.2[c]	66.7[d]	67.2[a]	0.0
	LSD	= 15.6					

Means of the same row followed by the same superscript are significantly ($P \leq 0.05$) different.

Table 4: Rheological properties of dough sample from wheat/plantain flour blends

Dough samples	Energy of dough (w) ($X10^{-4}$ joules/g)	Resistance to Extensibility Extensograph unit (R)	Extensibility (mm) (L)	Ratio of Resistance/ Extensibility (R/L)
100% wheat flour (control)	292×10^{-4}	110.0	54.0	2.04
95:5%	222×10^{-4}	108.0	53.0	1.67
90:10%	205×10^{-4}	78.0	50.0	1.56
80:20%	144×10^{-4}	65.0	46.0	1.41
70:30%	93×10^{-4}	52.0	43.0	1.21

Values are means of duplicate determinations

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Table 5:Baking characteristics of wheat-plantain composite bread

Type of flour	Level of wheat flour substitution	Oven spring (cm)	Specific volume (cc/g)
Wheat-Plantain	0	2.10[d]	5.3[d]
	5	2.01[d]	5.3[d]
	10	1.70[c]	4.6[c]
	20	1.50[b]	4.4[b]
	30	1.0[a]	4.2[a]
	LSD = 0.01		

abc Means within the same column not followed by same superscripts are significantly ($P \leq 0.05$) different.

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Table 6: Sensory properties of wheat-plantain composite bread

Type of flour	Level of wheat flour substitution	Loaf appearance	Crust colour	Crumb colour	Taste/flavour	Overall acceptability
Wheat-Plantain	0	8.2^{d}	7.6^{d}	7.8^{d}	8.2^{d}	8.0^{d}
	5	8.1^{d}	7.8^{d}	7.5^{d}	8.1^{d}	8.0^{d}
	10	7.2^{c}	6.5^{c}	7.2^{c}	7.0^{c}	7.4^{c}
	20	5.8^{b}	5.2^{b}	6.4^{b}	4.0^{b}	6.0^{b}
	30	4.6^{a}	3.6^{a}	4.0^{a}	3.5^{a}	4.8^{a}
		LSD = 0.01				

abc Means not followed by same superscripts within the columns are significantly ($P \leq 0.05$) different.

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Table 7: Flow and break strength of wheat-plantain composite flour biscuit

Type of flour	Level of wheat flour substitution	Biscuit flow (%)	Biscuit break strength (kg)
Wheat-Plantain	0	69.4^{g}	3.45^{c}
	50	64.2^{f}	1.90^{b}
	60	63.5^{e}	1.85^{ab}
	70	62.4^{d}	1.80^{ab}
	80	58.8^{d}	1.70^{a}
	90	50.8^{b}	1.20^{a}
	100	34.5^{a}	1.10^{a}
	LSD = 0.63		

abc Means in the same column followed by different letters are significantly (P≤0.05) different.

Table 8: Sensory evaluation of wheat-plantain composite flour biscuit

		Mean scores of attributes			
Type of flour	Level of wheat flour substitution	Colour	Taste	Crispiness/Aroma	Average
Wheat-plantain	0	7.6[g]	7.5[g]	7.6[g]	7.6[g]
	50	7.5[f]	7.4[f]	7.3[c]	7.4[f]
	60	7.3[e]	7.1[e]	7.3[e]	7.1[e]
	70	7.0[d]	6.8[d]	7.2[d]	7.0[d]
	80	6.5[c]	6.9[c]	6.4[c]	6.6[c]
	90	6.0[b]	6.2[b]	5.0[b]	5.3[b]
	100	5.4[a]	5.3[a]	4.6[a]	5.1[a]
	LSD = 0.1				

abc Means in the same column followed by different letters are significantly ($P \leq 0.05$) different.

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