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CHEMICAL COMPOSITION, SENSORY AND MICROBIAL ATTRIBUTES OF PORRIDGES PREPARED FROM AFRICAN YAM BEAN (*Sphenostylis stenocarpa*) AND CORN (*Zea mays*) FLOUR BLENDS

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ABSTRACT

Background: The dietary challenges facing type 2 diabetics have necessitated the development of high fiber indigenous diets for the management/control of blood glucose.

Objectives: The study determined the chemical composition, sensory and microbial attributes of porridges prepared from African yam bean (AYB) and corn flour blends.

Methods: AYB seeds roasted at 191^{0}C for 40 min and corn oven-dried at 50^{0}C for 24 h were finely milled, evaluated for proximate composition and dietary fiber profile and formulated into 5 flour samples in the ratios of 100, 70:30, 50:50, 30:70, 100 to supply one-third ($^1/_3$) of the daily dietary fiber requirement (12.7 g) of a reference man (70 kg). The 5 samples (including 3 composites) together with the control (traditional corn flour) provided 6 samples for the study. The samples were made into porridges and evaluated for chemical composition, sensory and microbial attributes using standard procedures. Data generated were analyzed using the IBM Statistical Product for Service Solution statistics version 21. Results were presented as means and standard deviations, Analysis of variance (ANOVA) was used to compare the means and significance was accepted at $p < 0.05$.

Results: The proximate, minerals, vitamins and phytochemical compositions of the porridges were superior to the traditional corn porridge (control). No anti-nutrients were detected in all the porridges. Flavonoids (0.01 to 0.04 mg) and saponins (0.01 to 0.05 mg) were present in the porridges but not in the control. Viable organisms (*Staphylococcus aureus, Bacillus cereus, Micrococcus spp, Enterobacter aerogenes, Pencillum spp. Rhizopus spp.*) that were unnatural microfloral of AYB and corn seeds were detected in the porridges. The microbial loads (1.2 x 10^1 to 2.0 x 10^2 cfu/g) were within the acceptable International Commission on Microbiological Specification of food limits of 10^5 cfu/g. More coliforms and fungal growth were observed in porridges with higher proportions of corn. All porridges rated higher (5.08 - 6.67) on the acceptability scale than the traditional corn porridge (4.00).

Conclusion: The high-fiber AYB-corn porridges had improved nutrient content, safe microbial load and consumer acceptability than the traditional corn porridge, and will add variety to diabetic meals.

Keywords: *Microbial load, chemical/sensory attributes, African yam bean, corn, porridges*

INTRODUCTION

Recently, there is a global upsurge in the incidence of non-communicable diseases (NCDs) [1] of which type 2 diabetes mellitus (T2DM) is among the most common [2]. In Nigeria, a lot of people are facing the challenge of managing this life-long condition due to limited diets of proven positive effect on blood glucose level. Apprehensions about the nutritional status of the diabetics have generated lots of interest in developing therapeutic diets to add variety to available meals because evidence has shown that blood glucose can largely be controlled through dietary management [3]. Indigenous foods of good nutritional qualities abound. Whole corn is among the world's most popular cereal grains, a very good source of fiber, many vitamins (folate, B-complex and ascorbic acids), minerals (magnesium, phosphorus, potassium), and antioxidants (vitamin E, ubiquinone and phytosterol) which increases its shelf-life and cholesterol lowering ability; its high contents of resistant starches is noted among various health benefits including anti-HIV activity due to its content of galanthus nivalis aggulutinin [4]. African Yam Bean (AYB) has high nutritional quality, good gelation property and high water absorption capacity [5, 6] needed in diabetes management but is facing extinction due to nutrition transition. Efforts to salvage this crop and others to ensure food security and introduce variety to the diabetic diet need to be strengthened. Consequently, this study was designed to develop porridges from AYB and corn flour blends to furnish $^1/_3$ dietary fiber requirement (12.7g) of a 70kg man [7].

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MATERIALS AND METHODS

Selection of subjects

Thirty diabetics from the Diabetic out-patient's clinic of the University of Nigeria Teaching Hospital Enugu willing to participate in the study were purposively selected.

Collection and preparation of the flours and composites

Coffee brown African yam bean (*Sphenostylis stenocarpa*) and white corn (*Zea mays*) seeds were purchased from Ndioro, a local market in Abia State, Nigeria. The AYB seeds were sorted to remove dirt, stones and other extraneous materials, washed with clean tap water, drained on a colander and roasted in a large saucepan over a gas burner at 191^{0}C (medium mark temperature calibrated the by manufacturer) for 40 minutes The roasted whole seeds were milled into flour using Saint Donkey Powder Crusher (Leshan Dongchuan) with 5mm sieve and packaged in an air-tight labeled high density polyethene bags. Corn seeds were also sorted to remove extraneous materials, washed with tap water, drained on a colander and oven-dried for 24 hours in a Uniscope Laboratory Oven - SM9023 (Surgifriend Medigals England) to a constant weight at 50^{o}C. The dried whole corn was milled into fine flour using Saint Donkey Powder Crusher. AYB and corn flours were evaluated for proximate composition, and dietary fiber profile using standard procedures [8, 9, 10]. The values obtained were used to calculate the quantity required to provide 12.7 g dietary fiber for each sample in the ratios of 100:0, 70:30, 50:50, 30:70, 0:100 and coded as: $S_{100,}$ $S_{70}Z_{30,}$ S_{50} $Z_{50,}$ $S_{30}Z_{70,}$ and Z_{100} respectively to provide five (5) samples; Samples S_{100} (100% AYB) and Z_{100} (100% corn) were milled whole different from the contemporary usage. Fermented corn flour, finely milled and sifted with muslin cloth of aperture sieve size 2mm (as it is used traditionally) coded as Zc_{100} was used as the control. Each sample was mixed thoroughly in a Kenwood food processor at full speed for 5 min and placed in air-tight Ziploc bag, packed inside high density poly ethylene bags and stored in a deep freezer (-10^{o}C) ready for use.

Preparation of the porridges

Each of the six flour samples including the control measured in quantities 52.87g (S_{100} 100%AYB), 70.85g ($S_{70}Z_{30}$ - 70% AYB:30% corn), 82.84g (S_{50} Z_{50} - 50% AYB:50% corn), 94.81g ($S_{30}Z_{70}$ - 30% AYB:70% corn), 112.79g (Z_{100} – 100% corn), and 104.18 (Zc_{100} traditional corn flour) that will contribute 1/3 of the daily dietary fiber intake as constituted from their chemical composition were mixed with 200ml cold water to get a watery slurry, additional 300 ml of boiling hot water was added to the mixture while stirring. The mixture was placed on gas burner at 191^{0}C and another 100 ml of the boiling water added while still stirring for 60s. Sweeteners (Canderel 4 tablets) were added to sweeten each of the porridge samples.

Chemical analysis

The proximate compositions were determined using standard procedures [8], total carbohydrate was obtained by difference and energy values were calculated using the Atwater factors. Minerals (calcium, iron, magnesium, potassium and sodium), vitamins (beta carotene, thiamin, riboflavin, niacin and vitamin C), and phytochemicals (phenol, flavonoids and saponins) were determined by AOAC [8]. Anti-nutrients (phytic acid, total tannins, and trypsin inhibitor) were determined using standard methods [11, 12].

Microbial load assessment of the porridges

International Commission on Microbiological Specifications for Foods [13] standard method was used to determine the microbial loads of the porridges. Ten grams of each porridge were soaked in 90ml of sterile distilled water to obtain a one in ten serial dilutions of the aqueous samples to the third stage (10^3). Pour plate method [14] was used to mix 0.1 ml of the third stage diluents and 25 ml of cooled molten sterile nutrient agar. Mackonkey and Oxytetracycline Glucose Yeast Extract (OGYE) were also mixed with 0.1 ml of the third stage diluents respectively and the media incubated at 37 ^{0}C overnight (3-5days for yeast and mold). Plate Count Agar (Oxoid CM463) was used for the enumeration of aerobic colony counts (ACC), Mackonkey agar (Oxoid CM7) for the enterobacteriaceae count (EC) and OGYE for the yeast and mold. The colony forming units were determined using an electronic colony counter (Gallenkamp colony counter, UK). The colony forming unit per gram (cfu g^{-1}) was calculated by multiplying the count by the dilution factor. Pure cultures were used to identify pathogenic bacteria, coliforms, yeast and mold.

Evaluation of sensory attributes of the porridges

Sensory evaluation of the porridges in terms of consistency, flavor, taste, color and general acceptability was performed as described [15] with 36 untrained panelists (out-patient diabetics) who consented to the study. The porridges were rated on a 7-point hedonic scale where 7 represented the highest score – liked extremely and 1 the lowest score – extremely disliked. The mean scores for sensory attributes were recorded.

Statistical analysis

Data generated were analyzed using the IBM SPSS Statistics version 21. Results were presented as means and standard deviations, Analysis of variance (ANOVA) was used to compare the means, Duncan's multiple range test was used to separate means and levels of significance was accepted at $p < 0.05$.

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RESULTS

The energy content of the porridges (Table 1) ranged from 46.34 - 239.07kcals. Sample S_{100} (100% AYB) had higher energy value (54.02kcal) than sample Z_{100} (100% Corn). The moisture content of the porridges increased from 40.25% in S_{100} (100% AYB) to 88.51% in Z_{100} (100% Corn). The protein ranged from 2.67% in S_{100} (100% AYB) to 6.84% in Z_{100} (100% Corn), higher than 0.77% in the control Zc_{100} (100% fermented corn porridge). The carbohydrate value of the porridges ranged from 56.67% in S_{100} (100% AYB) to 3.53% in Z_{100} (100% Corn).

Table 1: Energy and proximate compositions of the porridges *

Sample Quantity (g)	Energy (Kcal)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude Crude Fiber (%)	Carbohydrate (%)
S_{100} (52.87)	$239.07^{a}\pm0.13$	$40.25^{f}\pm0.00$	$2.67^{e}\pm0.10$	$0.19^{e}\pm0.04$	$0.22^{f}\pm0.01$	$0.14^{c}\pm0.01$	$56.67^{a}\pm0.03$
$S_{70}Z_{30}$ (70.85)	$180.49^{b}\pm0.01$	$54.91^{e}\pm0.01$	$3.92^{d}\pm0.08$	$0.29^{d}\pm0.07$	$0.33^{e}\pm0.01$	$0.16^{b}\pm0.08$	$40.55^{b}\pm0.06$
$S_{50}Z_{50}$ (82.84)	$142.60^{c}\pm0.09$	$64.40^{d}\pm0.03$	$4.76^{c}\pm0.04$	$0.36^{c}\pm0.10$	$0.40^{c}\pm0.01$	$0.17^{b}\pm0.00$	$30.08^{c}\pm0.00$
$S_{30}Z_{70}$ (94.81)	$103.32^{d}\pm0.08$	$74.25^{c}\pm0.05$	$5.58^{b}\pm0.02$	$0.44^{b}\pm0.02$	$0.47^{b}\pm0.01$	$0.18^{b}\pm0.06$	$19.31^{d}\pm0.03$
Z_{100} (112.79)	$46.34^{f}\pm0.06$	$88.51^{a}\pm0.01$	$6.84^{a}\pm0.07$	$0.54^{a}\pm0.08$	$0.58^{a}\pm0.03$	$0.20^{a}\pm0.01$	$3.53^{f}\pm0.02$
Zc_{100} (104.18)	$54.03^{e}\pm0.03$	$86.32^{b}\pm0.06$	$0.77^{f}\pm0.00$	$0.15^{f}\pm0.00$	$0.36^{d}\pm0.05$	$0.08^{d}\pm0.03$	$12.40^{e}\pm0.00$

Values are mean, ±SD of triplicate determinations; Means with similar superscript in the same column are not significantly ($P < 0.05$) different; S_{100} = 100% *Sphenostylis stenocarpa;* $S_{70}Z_{30}$= 70% *Sphenostylis stenocarpa* : 30% *Zea may*; $S_{50}Z_{50}$ = 50% *Sphenostylis stenocarpa :* 50% *Zea mays*$_{50}$; $S_{30}Z_{70}$ = 30% *Sphenostylis stenocarpa* : 70% *Zea mays*$_{70}$;, Z_{100} =100% *Zea mays; the control* Zc_{100} =100% *fermented refined Zea mays*.

The mineral and vitamin compositions of the porridges prepared (Table 2) from the blends shows that the calcium content of the porridges ranged from 43.99 mg in S_{100} (100% AYB) to 83.59 mg in Z_{100} (100% Corn). Sample S_{100} (100% AYB) had the lowest iron and magnesium values of 0.32 mg and 4.34 mg, respectively. Z_{100} (100% Corn) had more (64.40 mg) sodium than S_{100} (100% AYB) 24.01 mg. The potassium range was from 11.17 mg in S_{100} (100% AYB) to 36.92 mg in Z_{100} (100% Corn). The beta carotene value of the porridges ranged from 4.0 µg in S_{100} (100% AYB) to 6.07 µg in Z_{100} (100% Corn). These values were higher than 1.06 µg in the control Zc_{100} (100% fermented corn porridge). The range of thiamin in the test porridges was from 0.16 mg in S_{100} (100% AYB) to 0.24 mg in Z_{100} (100% Corn). Fermented corn porridge (Zc_{100}) had the lowest thiamin content. Riboflavin was not detected in the all the test porridges while niacin ranged from 0.32 mg in Z_{100} (100% Corn) to 0.5 mg in S_{100} (100% AYB). Fermented corn porridge (Zc_{100}) had much lower niacin content. The vitamin C value was lowest (1.10 mg) in Zc_{100} (100% fermented corn) and highest in Z_{100} (100% Corn).

Table 2: Mineral and vitamin composition of the porridges

Mineral and vitamin	Sample (quantity in grams)					
	S_{100} (52.87)	**$S_{70}Z_{30}$ (70.85)**	**$S_{50}Z_{50}$ (82.84)**	**$S_{30}Z_{70}$ (94.81)**	**Z_{100} (112.79)**	**Zc_{100} (104.18)**
Mineral						
Ca (mg)	$43.99^{f}\pm0.01$	$55.88^{d}\pm0.00$	$63.81^{c}\pm0.03$	$71.73^{b}\pm0.06$	$83.59^{a}\pm0.01$	$53.73^{e}\pm0.02$
Fe (mg)	$0.32^{f}\pm0.03$	$0.59^{e}\pm0.06$	$0.75^{d}\pm0.08$	$0.93^{c}\pm0.02$	$1.18^{b}\pm0.00$	$1.25^{a}\pm0.01$
Mg (mg)	$4.34^{f}\pm1.05$	$6.52^{e}\pm1.12$	$7.97^{d}\pm0.04$	$9.42^{c}\pm0.14$	$11.60^{b}\pm0.09$	$12.51^{a}\pm0.12$
Na(mg)	$24.01^{e}\pm0.00$	$36.13^{d}\pm0.09$	$44.21^{c}\pm0.06$	$52.28^{b}\pm0.15$	$64.40^{a}\pm0.19$	$19.61^{f}\pm0.01$
K (mg)	$11.17^{f}\pm0.03$	$18.89^{d}\pm0.06$	$24.04^{c}\pm0.09$	$29.19^{b}\pm0.00$	$36.92^{a}\pm0.11$	$14.60^{e}\pm0.01$
Vitamin						
β-carotene (µg)	$4.01^{e}\pm0.01$	$4.62^{d}\pm0.05$	$5.03^{c}\pm0.00$	$5.45^{b}\pm0.01$	$6.07^{a}\pm0.10$	$1.06^{f}\pm0.00$
B_1(mg)	$0.16^{e}\pm0.12$	$0.18^{d}\pm0.17$	$0.20^{c}\pm0.01$	$0.22^{b}\pm0.01$	$0.24^{a}\pm0.10$	$0.06^{f}\pm0.00$
B_2 (mg)	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$
B_3 (mg)	$0.50^{a}\pm0.01$	$0.44^{b}\pm0.06$	$0.41^{c}\pm0.01$	$0.37^{d}\pm0.02$	$0.32^{e}\pm0.05$	$0.01^{f}\pm0.06$
C (mg)	$3.60^{e}\pm0.01$	$3.66^{d}\pm0.10$	$3.72^{c}\pm0.13$	$3.75^{b}\pm0.15$	$3.82^{a}\pm0.06$	$1.10^{f}\pm0.01$

Values are mean, ±SD of triplicate determinations; Means with similar superscript in the same column are not significantly ($P < 0.05$) different; S_{100} = 100% *Sphenostylis stenocarpa;* $S_{70}Z_{30}$= 70% *Sphenostylis stenocarpa* :/30% *Zea may*; $S_{50}Z_{50}$ = 50% *Sphenostylis stenocarpa* :/50% *Zea mays*$_{50}$; $S_{30}Z_{70}$ = 30% *Sphenostylis stenocarpa* :70% *Zea mays*; Z_{100} = 100% *Zea mays; the control* Zc_{100} =100% *fermented refined Zea mays*.

Table 3 presents the phytochemical and anti-nutrient compositions of the porridges. The phenol, phytate, tannin and trypsin inhibitor in the test porridges were reduced and not detected. The values of flavonoids and saponins ranged from 0.01mg in $S_{30}Z_{70}$ (30% corn: 70% AYB) to 0.04 mg in S_{100} (100% AYB) and 0.01mg in 30% corn: $S_{30}Z_{70}$ 70% AYB) to 0.05 mg in S_{100} (100% AYB) respectively.

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Table: 3 Phytochemical and anti-nutrient compositions of the porridge samples.

Sample	Phenol (mg)	Flavonoid (mg)	Saponin (mg)	Phytate (mg)	Tannin (mg)	Trypsin inhibitor (TIU/mg)
S_{100} (52.87)	ND	$0.04^{a}\pm0.02$	$0.05^{a}\pm0.01$	ND	ND	ND
$S_{70}Z_{30}$ (70.85)	ND	$0.03^{ab}\pm0.01$	$0.04^{a}\pm0.02$	ND	ND	ND
$S_{50}Z_{50}$ (82.84)	ND	$0.02^{ab}\pm0.01$	$0.02^{b}\pm0.01$	ND	ND	ND
$S_{30}Z_{70}$ (94.81)	ND	$0.01^{ab}\pm0.01$	$0.01^{b}\pm0.00$	ND	ND	ND
Z_{100} (112.79)	ND	ND	ND	ND	ND	ND
Zc_{100} (104.18)	ND	ND	ND	ND	ND	ND

Values are mean ±SD of triplicate determinations; Means with similar superscript in the same column are not significantly ($P < 0.05$) different; S_{100} = 100% *Sphenostylis stenocarpa;* $S_{70}Z_{30}$= 70% *Sphenostylis stenocarpa:* 30%*Zea may*; $S_{50}Z_{50}$ = 50% *Sphenostylis stenocarpa* : 50% *Zea mays*; $S_{30}Z_{70}$ = 30% *Sphenostylis stenocarpa* : 70% /*Zea mays*;, Z_{100} =100% *Zea mays; the control* Zc_{100} =100% *fermented refined Zea mays*.

Table 4 shows the mean sensory properties scores of the porridges prepared from African Yam bean (*Sphenostylis stenocarpa*) and Corn (*Zea mays*) seed flour. Sample $S_{50}Z_{50}$ (50% AYB: 50% Corn) had the highest mean score (6.19) for color while $S_{30}Z_{70}$ (30% AYB: 70% Corn) had the least score (5.78). There was a general decrease in the mean scores of flavor of porridges made from S_{100} (100% AYB), $S_{70}Z_{30}$ (70% AYB: 30% Corn), $S_{50}Z_{50}$ (50% AYB: 50% Corn), $S_{30}Z_{70}$ (30% AYB: 70% Corn), Z_{100} (100% Corn) and Zc_{100} (100% fermented corn) respectively. Zc_{100} (4.05) had the least flavor value and S_{100} (100% AYB) had the highest flavor (5.83). S_{100} (100% AYB) and $S_{70}Z_{30}$ (70% AYB: 30% Corn) were not significantly ($P < 0.05$) different in terms of flavor, but were different from $S_{50}Z_{50}$ (50% AYB: 50% Corn) and $S_{30}Z_{70}$ (30% AYB: 70% Corn) which on their own were not significantly ($P<0.05$) different from each other. Both the latter and the former pairs were significantly ($P < 0.05$) different from Z_{100} (100% Corn) in terms of flavor. For consistency attribute, 100% fermented corn (Zc_{100}) was more (6.94) acceptable while $S_{30}Z_{70}$ (30% AYB: 70% Corn) had the least score (5.22). Consistency showed no significant ($P<0.05$) differences between porridges made with $S_{50}Z_{50}$ (50% AYB: 50% Corn), $S_{30}Z_{70}$ (30% AYB: 70% Corn) and Z_{100} (100% Corn), but these were significantly ($P<0.05$) different from S_{100} (100% AYB) and $S_{70}Z_{30}$ (70% AYB: 30% Corn) respectively. S_{100} (100% AYB) had the highest mean score for taste (6.72) while Z_{100} (100% Corn) had the least score (4.81). All samples were significantly ($P < 0.05$) different in terms of taste. S_{100} (100% AYB) had the highest score for general acceptability (6.67) and Zc_{100} (100% fermented corn) had the least score (4.00). $S_{50}Z_{50}$ and $S_{30}Z_{70}$ (30% AYB: 70% Corn) were not significantly different at $P < 0.05$ but both were significantly different from S_{100} (100% AYB), $S_{70}Z_{30}$ (70% AYB: 30% Corn) and Z_{100} (100% Corn) respectively for general acceptability.

Table 4: Mean sensory properties scores of the porridges

Sample	Color	Flavor	Consistency	Taste	General acceptability
S_{100}	$6.11^{a}\pm1.14$	$5.83^{a}\pm1.89$	$6.33^{b}\pm1.12$	$6.72^{a}\pm0.45$	$6.67^{a}\pm0.63$
$S_{70}Z_{30}$	$6.12^{a}\pm0.81$	$5.69^{a}\pm1.52$	$5.92^{bc}\pm1.05$	$6.19^{b}\pm0.67$	$6.32^{ab}\pm0.88$
$S_{50}Z_{50}$	$6.19^{a}\pm0.82$	$5.39^{ab}\pm1.44$	$5.44^{c}\pm1.16$	$5.58^{c}\pm1.46$	$6.17^{b}\pm0.88$
$S_{30}Z_{70}$	$5.78^{a}\pm0.90$	$5.09^{ab}\pm1.69$	$5.22^{c}\pm1.71$	$5.31^{cd}\pm1.31$	$5.89^{b}\pm0.85$
Z_{100}	$6.03^{a}\pm0.69$	$4.83^{b}\pm1.80$	$5.28^{c}\pm1.78$	$4.81^{e}\pm1.33$	$5.08^{c}\pm1.50$
Zc_{100}	$6.00^{b}\pm0.19$	$4.05^{c}\pm0.62$	$6.94^{a}\pm1.27$	$5.00^{d}\pm1.36$	$4.00^{d}\pm0.34$

Values are mean ±SD of triplicate determinations; Means with similar superscript in the same column are not significantly ($P < 0.05$) different; S_{100} = 100% *Sphenostylis stenocarpa;* $S_{70}Z_{30}$= 70% *Sphenostylis stenocarpa* $_7$: 30% *Zea may*$_{30}$; $S_{50}Z_{50}$ = 50% *Sphenostylis stenocarpa*: 50% *Zea mays*; $S_{30}Z_{70}$ = 30% *Sphenostylis stenocarpa* : 70% /*Zea mays*;, Z_{100} =100% *Zea mays; the control* Zc_{100} =100% *fermented refined Zea mays*.

The microbial population of the experimental porridges (Table 5) shows that the total viable count (TVC) for the porridges ranged from $1.2 \times 10^{1} \pm 1.02$ in the S_{100} (100% AYB) to$1.5 \times 10^{2} \pm 0.06$ in Zc_{100} (100% fermented corn) and coliform from $3.0 \times 10^{1} \pm 0.20$ in the $S_{30}Z_{70}$ (30% AYB: 70% Corn) to $2.0 \times 10^{2} \pm 0.15$ in the Zc_{100} (100% fermented corn). No visible growth of coliform was observed in the samples S_{100} (100% AYB), $S_{70}Z_{30}$ (70% AYB: 30% Corn) and Z_{100} (100% Corn) while the $S_{50}Z_{50}$ (50% AYB: 50% Corn), the $S_{30}Z_{70}$ (30% AYB: 70% Corn) and Zc_{100} (100% fermented corn) had $7.0 \times 10^{1} \pm 0.08$, $3.0 \times 10^{1} \pm 0.20$

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and 2.0 x $10^2 \pm 0.15$, respectively. Mold and yeast ranged from 1.0 x$10^1 \pm 0.19$ in the Z_{100} (100% Corn) to 2.0 x $10^1 \pm 1.13$ in Zc_{100} (100% fermented corn). No visible growth of mold or yeast was observed in the samples S_{100} (100% AYB), $S_{70}Z_{30}$ (70% AYB: 30% Corn), $S_{50}Z_{50}$ (50% AYB: 50% Corn) and $S_{30}Z_{70}$ (30% AYB: 70% Corn).

Table 5: Microbial population of the porridges prepared

Samples	TVC	Coliform counts	Mold yeast counts
S_{100}	1.2 x $10^1 \pm 1.02^c$	NG	NG
$S_{70}Z_{30}$	9.7 x $10^1 \pm 0.02^a$	NG	NG
$S_{50}Z_{50}$	9.2 x $10^1 \pm 0.01^a$	7.0 x $10^1 \pm 0.08^a$	NG
$S_{30}Z_{70}$	8.4 x $10^1 \pm 1.10^b$	3.0 x$10^1 \pm 0.20^b$	NG
Z_{100}	1.6 x $10^1 \pm 0.04^c$	NG	1.0 x$10^1 \pm 0.19^b$
Zc_{100}	1.5 x $10^2 \pm 0.06^c$	2.0 x $10^2 \pm 0.15^c$	2.0 x $10^1 \pm 1.13^a$

Values are mean ±SD of triplicate determinations; Means with similar superscript in the same column are not significantly ($P < 0.05$) different; S_{100} = 100% *Sphenostylis stenocarpa;* $S_{70}Z_{30}$= 70% *Sphenostylis stenocarpa* $_7$: 30% *Zea may*$_{30}$; $S_{50}Z_{50}$ = 50% *Sphenostylis stenocarpa*: 50% *Zea mays*; $S_{30}Z_{70}$ = 30% *Sphenostylis stenocarpa* : 70% /*Zea mays*;, Z_{100} =100% *Zea mays; the control* Zc_{100} =100% *fermented refined Zea mays*, NG = no visible growth

The bacterial and fungal profile isolated from the test porridges (Table 6) shows that *Staphylococcus aureus* and bacillus *cereus* were present in all the porridges. The *Micrococcus spp* was found only in the sample S_{100} (100% AYB), *Enterobacter aerogenes* in samples $S_{70}Z_{30}$ (70% AYB: 30% Corn), $S_{50}Z_{50}$(50% AYB: 50% Corn), Z_{100} (100% Corn) and Zc_{100} (100% fermented corn porridge) while *Pencillum spp.* and *Rhizopus spp.* were isolated in Z_{100} (100% Corn) and Zc_{100} (100% fermented corn porridge) respectively.

Table 6: Bacteria and fungi isolated from the porridges

Isolates	S_{100}	$S_{70}Z_{30}$	$S_{50}Z_{50}$	$S_{30}Z_{70}$	Z_{100}	Zc_{100}
Staphylococcus aureus	+	+	+	+	+	+
Bacillus cereus	-	-	-	-	-	+
Micrococcus spp.	+	-	-	-	-	-
Escherichia coli	-	-	-	-	-	-
Enterobacter aerogenes	-	+	+	-	+	+
Aspergillus flavus	-	-	-	-	-	-
Pencillum spp.	-	-	-	-	+	+
Rhizopus spp.	-	-	-	-	+	+

Values are mean ±SD of triplicate determinations; Means with similar superscript in the same column are not significantly ($P < 0.05$) different; S_{100} = 100% *Sphenostylis stenocarpa;* $S_{70}Z_{30}$= *Sphenostylis stenocarpa* $_{70}$/*Zea may*$_{30}$; $S_{50}Z_{50}$ = *Sphenostylis stenocarpa* $_{50}$/*Zea mays*$_{50}$; $S_{30}Z_{70}$ = *Sphenostylis stenocarpa* $_{30}$/*Zea mays*$_{70}$; Z_{100} =100% *Zea mays*; *the control* Zc_{100} =100% *fermented refined Zea mays* + = presence; - = absence.

DISCUSSION

The moisture contents of the porridges increased as the quantities of the flour samples used in making the porridges increased (Table 1). This was expected as water absorption capacity increases with increase in the incorporation of more flour [16]. Samples Z_{100} (100% Corn) and Zc_{100} (100% fermented corn porridge, the control) with weight values of 112.79g and 104.18g respectively had higher moisture contents in line with their weight when compared with the other samples weighing between 52.87 to 94.81g. These high moisture values of Z_{100} (100% Corn) and Zc_{100} (100% fermented corn) porridges also reduced their other proximate values. The test porridges had higher protein contents (2.67 – 6.84%) than the control Zc_{100} (traditional corn porridge) (0.77%). This is in consonance with Aguilera *et al.* [17] report of reduced protein content of legumes due to soaking. The soaking of corn in making of traditional corn porridge must have reduced the protein content as reported above. It could also be because, the porridges were all made from whole AYB and corn seeds milled with their bran and germs known to contain additional proteins, unlike the traditional fermented corn in which these protein sources were removed during sieving. Contrarily, finer legume flour fraction was reported to contained more protein than coarse defatted flour [18]. The porridges S_{100} (100% AYB), $S_{70}Z_{30}$ (70% AYB : 30% CORN), $S_{50}Z_{50}$ (50% AYB :50% CORN), and $S_{30}Z_{70}$ (30% AYB : 70% CORN), that had more quantity of AYB than whole corn (Z_{100}) demonstrated a value addition strategy that produced porridges with increased protein value and dietary fiber that is advocated in the diabetes diet. This is

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possible when the weight of these samples (52.87 to 94.81g compared to 112.79g shown in table 1) that supplied the improved dietary fiber was considered. The protein content of porridges though less than the daily requirement for adults will add to the protein content of the diets.

The increase in ash across the porridges implied increased mineral components. The ash contents of the porridges in this work were lower than that (1.5 -2.5%) reported for porridges made from malted barley, maize and roasted pea flour [19] probably because of malting shown to increase nutrient contents of foods [20]. The carbohydrate content of the porridges was appreciably lower than 69-71% reported in soy and cowpea enriched maize gruel [21] and 91- 95% in pigeon pea and sorghum enriched gruel [6]. The lower carbohydrate and energy value of samples Z_{100} (100% corn porridge) and the control Zc_{100} (100% fermented refined corn porridge) was due to their higher moisture value which reduced their proximate density when compared with the other porridges. The lower carbohydrate content of the test porridges would be highly appreciated in diabetic diets as the amount of total carbohydrate determines the blood glucose response.

The quantity of the porridges in grams influenced their minerals composition (Table 2). Porridges with smaller quantities had lower mineral contents as the differences in the quantities of the porridges were determined by the amount of test flour required to provide the 1/3 of adult daily dietary fiber recommendation. Oghbaei and Prakash [22] reported reduction in mineral contents of cereals and legumes during milling and emphasized their improved availability due to reduction in anti-nutrient content. The porridges had higher beta-carotene values (4.01 to 6.07µg) than the control (1.06µg). The lower value of vitamin C in the control was expected as vitamin C is easily lost during traditional methods of cooking [23]. This is in consonance with the report of nutrient losses during milling [24]. Processing methods can influence the phytochemical and anti-nutrient composition of food samples [25]. The phenol, phytate, tannin and trypsin inhibitor in the test porridges were reduced entirely and will thus not inhibit the absorption of other essential nutrients from the porridges. Oghbaei and Prakash [22] reported improved bioavailability and absorption of essential nutrients with reduction in phytic acid and polyphenols of diets. Similarly, Onyeike and Omubo [26] reported decreased anti-nutrients of AYB by heat treatment. Soaking and milling completely reduced the phytochemicals and anti-nutrients value of the control (Zc_{100}) sample. Xu and Chang [27] reported reduction in soluble and insoluble dietary fiber, phytic acid, polyphenol and tannin through soaking, dehulling and cooking. The flavonoids and saponin in the porridges could be beneficial because of their antioxidant activity [28].

The mean sensory ratings of the porridges prepared from flour blends (Table 4) showed that S_{50} Z_{50} (50% AYB: 50% Corn porridge) was more acceptable for color and there was a general decrease in the mean scores of flavor of samples S_{100} (100% AYB), $S_{70}Z_{30}$ (70% AYB: 30% Corn), $S_{50}Z_{50}$ (50% AYB: 50% Corn), $S_{30}Z_{70}$ (30% AYB: 70% Corn), Z_{100} (100% Corn) to Z_{c100} (100% fermented corn) porridges. This was understandable as roasting imparted a more acceptable flavor than fermentation. Zc_{100} (traditional fermented corn porridge) was more acceptable for consistency because of its very refined form. The similarity in samples $S_{50}Z_{50}$ (50% AYB: 50% Corn), $S_{30}Z_{70}$ (30% AYB: 70% Corn) and Z_{100} (100% Corn) porridges in terms of consistency was understandable as they contained more of corn which has coarse nature than the AYB. Porridges with more AYB were more acceptable taste-wise. General acceptability followed similar trend. Nout [29] reported that roasting of food imparted significant desirable quality on odour that corresponds to aroma development. Abdoulaye *et al*. [30] also included improvement of sensory qualities as one of the goals of roasting. Color and taste were two organoleptic properties that predicted acceptability of a food. All samples were acceptable to the panelists. This was not surprising as most people will accept a product that they can sensorial appreciate especially once there is indication of good health. The low scores of Zc_{100} (100% fermented corn porridge) in terms of flavor and general acceptability was attributed to the reduced pH, increased titratable acidity during fermentation [31], and the breakdown of complex carbohydrates to organic acids and other simpler substances [32] that imparted flavor and aroma to the gruel. It was also noted that the brown color of AYB flour resulting roasting according to Abdoulaye et al. [30] did not reduce its acceptability.

The microbial analysis shows that all the porridges contained viable organisms that were not part of the natural microfloral of AYB seeds. These included *Lactobacillus jensenii*, *Bacillus coagulans, Acrococcus viridans, Canadidan mycoderm.* Although Agboola [33] opined that the seeds of AYB had high aerobic count attributed to its high protein content. The TVC were more in samples $S_{70}Z_{30}$ (70% AYB: 30% Corn), S_{50} Z_{50} (50% AYB: 50% Corn), and $S_{30}Z_{70}$ (30% AYB: 70% Corn) than the other porridges. This could have been introduced during the processing and reconstitution of the flour blends. The coliforms were more in the porridges with higher quantity of corn than

AYB. This may have been possible during oven drying of the corn with lower temperature for longer time that allowed some persistent microbes to thrive compared to the higher roasting temperature for short period used for drying AYB that formed a higher proportion of the other porridges. The FAO/WHO [34] revealed that roasting reduced micro-organisms and enzyme activity and destroyed insects to improve keeping qualities. It was comforting to note that micro-organisms like *E. coli, Salmonella, L. monocytogenes, Bacillus cereus, Clostridium botulinium and C. perfringens* which were not expected in a food product were not isolated in the porridges. The porridges contained some bacteria (*Staphylococcus aureus, Bacillus cereus, Micrococcus spp, Enterobacter aerogenes)* that ranged from 1.2 x 10^1 to 2.0 x 10^2 cfu/g, and fungi (*Pencillum spp. Rhizopus spp.*) from 1.0 x 10^2 to 2.0 x 10^1 cfu/g; but the values were within the acceptable limits (10^5cfu/g) and recommendation for good manufacturing practice [13]. The lower ash content of this study porridges in relation to other study [18] may have contributed to their low microbial loads. There is evidence that flours with lower ash content have greater reductions in microbial population [35]. *Staphylococcus spp*. were the dominant bacteria isolated from the porridges (Table 6). This might be due to post-processing contamination. *Staphylococcus aureus* is known to be widely distributed on human skin, mouth, nose, hair and hands. The presence of *Bacillus cereus* might be due to the processing materials and storage temperature which favored the growth and proliferation of organisms. Consequently, thorough and proper heating of food before consumption is advocated. The absence of *E. coli* and other opportunistic human pathogens could be attributed to the high temperature involved in making of the porridges.

The fungal profile of the test porridges shows that samples 100% AYB (S_{100}), 70% AYB: 30% Corn ($S_{70}Z_{30}$), 50% AYB: 50% Corn ($S_{50}Z_{50}$), and 30% AYB: 70% Corn ($S_{30}Z_{70}$) were not contaminated with fungi. This indicated the use of good raw materials in processing these porridges. However, viable mold spores were present in the control and could be attributed to handling during milling and drying. Afolabi, Oloyede and Agbaje [36] reported high (5.0 x 10^1 to 5.85 x 10^1 cfu/g) fungal growth due to post-harvest handling. The microbiological load of the porridges was significantly $p < 0.05$ lower (1.2 x 10^1 to 2.0 x 10^2 cfu/g) and less varied (*Staphylococcus aureus, Bacillus cereus, Micrococcus spp, Enterobacter aerogenes, Pencillum spp. Rhizopus spp.*) than those (*Staphylococcus aureus, Bacillus sphaericus, staphylococcus carnosus subsp utilis, staphylococcus saprophyticus subsp bovis, streptococcus australis, Edwardsiella ictaluri, Aspergillus niger, Fusarium spp, Mucor spp, Penicillium spp Aspergiluus flavus and Aspergillus fumigatus)* isolated in the latter study [36]. The loads were equally lower than 1.80 x 10^2 to 4.8 x 10^5 cfu/g TVC, 1.2 x 10^2 to 5.0 x 10^3 cfu/g fungal count; 1.0 x 10^2 to 1.6 x 10^3 cfu/g bacteria count reported in the study of Yusuf, Ojo, Egwujeh and Ebiloma [37] and Madueke, Awe and Jonah [38] respectively. This maybe because the porridges under study were laboratory prepared samples that observe Hazard Analysis and Critical Control Points (HACCP) approach and good manufacturing practices while these other authors worked on ready to eat street foods made by different vendors.

CONCLUSION

This study on chemical composition, sensory and microbial attributes of porridges made from African yam bean and corn seeds flour blends shows that in addition to contributing high fiber compared with traditional corn porridge, the porridges have improved nutrient content, safe microbial load and consumer acceptability, and will add variety not only to diabetic meals but to daily meals for all as well.

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Ethics approval:

Permission for the study was obtained from the University of Nigeria Teaching Hospital's Ethical Committee and ethical clearance certificate (UNTH/CSA/329/vol. 5) was obtained.

Informed Consent:

Thirty diabetics purposively selected from the hospital's out-patient's clinic were fully informed of the purpose and procedures of the research and their personal consents obtained.

Conflict of interest

None

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Author Contribution

The authors articulated the concept and design of the study. H.N. collected, analyzed, interpreted the data, and drafted the manuscript. E.K reviewed the manuscript. Both authors made contributions to improve the manuscript.

Data and material availability

The data and materials for this work are available

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