Effects of Indigenous Porridges Made from African yam bean (*Sphenostylis stenocarpa*), and Corn (*Zea mays*) on the Anthropometric, and Blood Markers of Health in Diabetics

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Abstract

Background: /Objective: *The study investigated the effect of indigenous porridges on the anthropometric, blood pressure, blood glucose, and lipid profile of type 2 diabetics in a health facility.*

Methodology: *Flour produced from African yam bean (Ayb) and corn were formulated into five ratios (Ayb100, AybC70:30, AybC50:50, AybC30:70, C100), made into porridges and fed to 36 diabetic outpatients purposively selected from the University of Nigeria Teaching Hospital in a 2-week feeding trial. The body mass index, blood glucose, blood pressure (BP), and lipid profile of the diabetics were evaluated using standard procedures. Data collected were analyzed with IBM Statistical Product for Service Solution (SPSS) software version 21 using descriptive statistics, T-test, and simple regression.*

Result: *There were 5.6% reductions in underweight, and obesity, 5.6% increase in normal weight, 11.1% increases in normal, and diabetic optimal (<130/<80) BP respectively; 8.3%, and 13.9% decreases in High BP, and pre-hypertension respectively. AybC30:70 porridge showed significant changes in diastolic and systolic pressures. Ayb100, AybC70:30, and C100 porridges improved the diabetics glycemic curves, total cholesterol (TCHO), high-density lipoproteins (HDL), and TCHO/HDL ratio, AybC70:30, and C100 improved, low-density lipoprotein (LDL), while AybC50:50, had better TCHO, HDL, and LDL status, AybC30:70 had significant positive effects on TCHO/HDL ratio. All porridges except C100 had significant ($p < 0.05$) negative coefficients on BMI, blood pressure, pulse rate, triglycerides (TRIG), TCHOL, and LDL respectively.*

Conclusion: *African yam bean Corn porridges could be used in effective diabetes management.*

Keywords: *Diabetes management; African yam bean Corn porridges; anthropometrics, blood markers, health*

Introduction

1.1 Diet-related non-communicable diseases (NCDs) are diseases acquired from lifestyle and genetic factors. Recently, the number of persons with NCDs has increased in all corners of the globe with enormous consequences linked with huge mortality. Type II diabetes mellitus (T2DM) has long been identified as one of the leading NCDs globally [1]. It is associated with hyperglycemia and disordered insulin metabolism due to inadequate or ineffective insulin. As the most common of all diabetes cases and being a chronic disease, it is mainly found in overweight adults greater than forty years of age. Recently T2DM has been found in children and adolescents [2]. The upsurge was attributed to the growing and aging population, urbanization, increasing prevalence of obesity, nutrition transition, and a Westernized lifestyle [3,4]. The gradual development of T2DM in patients makes it dangerous and fatal as most people are unaware of the disease and thus do not seek health care on time. Consequently, many people with complicated diabetes abound, in search of improved health. Food plays a significant role in the nutritional status of people. Other factors like age, sex, behavior, physical activity, disease, socioeconomic, and cultural factors also interact and determine a person’s nutrition status [5]. In diabetes treatment, dietary approach is one of the bases of effective and sustainable management. High dietary fiber foods like whole grains have been shown to reduce the risk of T2DM due to their low potential to raise blood glucose levels [6]. Many African plant foods could effectively lower the blood glucose levels. Diabetics are concerned with healthy eating, and the search for foods with known nutritional and health benefits is uppermost. The food market is also full of oily and processed foods of low nutrient density. This narrows the food choices, encourages monotonous diet, loss of interest in eating, consumption of unhealthy diet, resulting in more people with uncontrolled diabetes and its antecedent complications, excessive stress to family resources, low productivity with poor economic capacity and unhealthy aging. All these, underscore the enormous challenge of limited foods of known nutrition and health benefits and are detrimental to the effective, and sustainable management of T2D.

Availability, accessibility, and price are important determinants of food choices. African yam bean (Ayb) and corn are indigenous tropical grains. Although corn is very much available, Ayb are found to be on the verge of extinction due to poor and non-consumption stemming from the surplus of ready-to-eat westernized foods. Against this backdrop, researchers have started the formulation of new foods from indigenous food crops. Flour blends are now being developed using Ayb and corn to vary diets, encourage consumption, increase production by farmers, and stop the extinction [7]. The consumption of these flour blends will greatly depend on their potential to improve health, as many consumers are nutritionally literate and can make informed choices. It is, therefore, necessary to ascertain the impact of porridges made from the Ayb-corn flour blends on some anthropometric indices (weight, height, body mass index - BMI) and blood parameters like blood pressure, blood glucose, and lipid profile of type 2 diabetic patients.

2.0 Materials and Methods

Study area: The study was carried out in the outpatient clinic of the University of Nigeria Teaching Hospital Ituku Ozalla, Enugu Nigeria. The Hospital is located in Enugu - Port Harcourt expressway, Enugu state. Enugu state has a Latitude and Longitude of 6.5 and 7.5 respectively and a geographical coordinate of 6 32’N 7 30’E. The state has boundaries with Abia state and Imo state to the south, Ebonyi State to the east, Benue state to the northeast, Kogi state to the northwest and Anambra state to the west. It has a population of 3,267,887 people [8]. The hospital caters to patients in the state as well as referrals from within and outside the state, and houses one of the pioneer national accredited Dietetic Units.

Study Design: A clinical-based assessment consisting of a feeding trial to ascertain the efficacy of Ayb-corn porridges in diabetes management was employed.

Study Population: The study population consisted of diabetics attending the University of Nigeria Teaching Hospital Ituku-Ozalla's out-patient clinic.

Population Size: The annual average (2,888) attendance of diabetics at UNTH from 2013 to 2015 (3227, 2668, and 2517) (UNTH Records, 2016) made up the population size for the study.

Sample Size and Sampling Calculation: The sample size was calculated using the formula n = N ⁄1+N (e)². Where n = sample size, N = population size, 1 = constant, e = marginal error (0.05) Source: Yamane, 1967. N = 2888/1 + 2888 (0.5)² = 351. Five (5) percent attrition provided an additional 17.55 to the total for possible dropout. (351 + 17.55 = 368.55 = 369) approximated to 370.

Sampling Technique: A purposive sampling method was used to select 370 out-patients diabetics. Inclusion criteria involved all type 2 adult diabetics with or without hypertension, a BMI of less than or equal to class 1 obesity, on diet therapy or oral hypoglycemic drugs, or both. The exclusion criteria excluded those on insulin therapy, with major organ disease and complications other than hypertension, with diabetes insipidus, with class 2, and 3 Obesity, and on drugs such as corticosteroids, and hormones among others. Only those who consented to be part of the study were selected.

Sub-Sample: Ten percent of the study sample (37 diabetics) which provided a good representation of the study population was purposively selected for the 2-week feeding protocol.

Ethical Clearance and Informed Consent: A request letter including the research proposal were submitted to the UNTH's Ethical Committee for consideration, and the permission to conduct the study was granted with a certificate (UNTH/CSA/329/vol. 5). The subjects were fully informed of the purpose and procedures of the research and their consent was obtained.

Recruitment and Training of Research Assistants: Four research assistants (Dietetic Interns) were recruited from the Department of Dietetics University of Nigeria Teaching Hospital Enugu and re-trained on anthropometric measurements (weight and heights) and how to assist in the feeding protocols.

Preparation of flour blends and porridges from African yam bean and corn

Ayb and corn flour were made as described by Henry-Unaeze [7]. Both seeds were sorted individually to remove dirt, washed in tap water, and drained on a colander. Coffee-colored Ayb was roasted for 40minutes on a cooking gas () at 191ºC. The white corn seeds were oven-dried for 24h at 50ºC in a laboratory oven (Uniscope Laboratory Oven (SM9023 Surgifriend Medigals England). Each was milled finely in a Saint Donkey Powder Crusher with 5mm sieve, and measured into five ratios (Ayb100, AybC70:30, AybC50:50, AybC30:70, C100). Each ratio constituting a blend (100g each) was made into porridge using 600ml water, and 4 tablets sweetex. Each blend was mixed with 200ml cold water to a watery consistency, to which 300ml hot water was added with continued stirring. Additional water (100ml) was added while still stirring for 2-3min over a gas burner to desired consistency. Four tablets of sweetex were added to sweeten the porridge.

Methods of Data Collection: Anthropometric measurements, clinical, and biochemical assessment, as well as feeding protocol were used to obtain data for this study.

Anthropometry (Height, Weight, and BMI): The heights of the subjects were measured using a Microtoise height meter. A subject was made to stand erect on the flat platform with arms relaxed by the sides, head held naturally, and footwear removed. The meter rule was placed at the back parallel to the feet and the buttocks. The headpiece was lowered until it touched the crown of the head, and the measurements were taken and recorded to the nearest 0.1cm as described [9]. A CMS weights weighing scale graduated in Kilogram (120kg capacity) was used to take the weights of the subjects. The subjects were made to stand erect, both arms by the sides at the center of the scale with minimal clothing. The scale was read and recorded to the nearest 0.1kg as described [9]. BMI an index of weight for height commonly used to classify overweight and obesity in adults was obtained with the formula: BMI = Weight (Kg)/Height (m^2).

Clinical Assessment: (Blood pressure) The blood pressures of the subjects were determined with an Accoson electronic Sphygmomanometer (Decamet, England). The calibration on the sphygmomanometer ranged between 0 - 300 mmHg. The cuff was wrapped around the subject's left upper arm and connected to the micromachine. Depression of the start button automatically inflated the cuff, after a beep, the audio read out the readings (systolic BP, diastolic BP, pulse rate, and classification according to WHO [10]. Each subject was measured, and the readings were recorded.

Biochemical Assessment: (Determination of fasting blood glucose level, and lipid profile)

Test for fasting blood glucose level: The fasting blood glucose level of the subjects were obtained by the hospital’s laboratory staff using an Evolve glucometer (TysonBio) with a measuring range of 10 – 600mg/dl (0.6 – 33.3mmol/l) after a 24hr overnight fast and standard physical activity. Evolve active glucose test strip was inserted into the glucometer and it was automatically turned on. A cotton wool swap was used to clean the tip of the subject’s thumb and the Evolve lancet was used to puncture the fingertip. A small drop of the subjects' blood was applied on the middle of the strip when a dropping sign was shown on the glucometer, the glucometer measured and displayed the blood glucose level of the subject which was then recorded and categorized according to WHO [11] classification.

Test for Lipid Profile: The subjects’ lipid profile was determined with a Mission Cholesterol monitoring kit (ACON, USA). The 3-1 test device which consisted of a portable meter that analyzes the intensity and color of light reflected from the reagent area of the test device and provides results in 2 minutes was used to quantitatively determine TCHOL, HDL, TRIG and the calculated ratio of CHOL/HDL and LDL in fresh capillary blood from the fingertip. Since LDL and TRIG require a fast, all the tests were performed after a fast for convenience. The hospital’s Laboratory Scientist used an alcohol swap to clean the fingertip of each subject, the safety lancet to prick the fingertip, and a capillary transfer tube/dropper to collect 35µL specimen volume which was applied to the specimen application area. The cholesterol meter reads the test device and displays the concentrations of CHOL, HDL, TRIG, and calculated

LDL and CHOL/HDL values. The specimen was tested within 8 hours of the collection. The results were categorized according to WHO classification [11]

Glycemic Response Watch: The 37 subjects were informed on the diet protocol. They were asked not to eat from 10.00 pm till the next morning throughout the study period. On the first day of the feeding trial, after a 10 – 14h overnight fast the subjects were randomized into six groups (6 persons each). The remaining subject was dropped for uniformity. Their weight, height, blood pressure, fasting blood sugar, and lipid profile were obtained as baseline data to compare with data collected at the end of the feeding period. Each group was fed a different porridge. On administration of the test porridge to each subject, a 2-hour glycemic response watch at an interval of 15 minutes (15, 30, 45, 60, 75, 90, and 120) was observed. The records were filled with the subjects' details (initials, identification number, date, body weight, test meal, and any unusual activities). The subjects remained seated quietly throughout the 2h test. The subjects were offered snacks at the end of the watch.

Two-week feeding trial: Each subject in each group received 14wraps of the study samples with instructions on how to prepare and use the porridge during breakfast daily for 14 days at home. The researcher maintained constant contact with the subjects throughout the study period through home visits and phone calls to monitor compliance. On day 15th, their height, weight, blood glucose, blood pressure, and lipid profile were obtained and recorded.

Data Analysis: The subjects' BMI, blood pressure, blood sugar, and lipid profile were categorized with WHO [10] standards. **BMI**: underweight (<18.5), normal (18.5 – 24.9), overweight (25 – 29.9), obesity (≥30). **Blood pressure**: Normal = 90-119/60-79; pre-hypertension = 120-139/80-89; stage 1 = 140-159/90-99; stage 2 = ≥160/≥100; isolated systolic hypertension = ≥140/<90). Normal blood sugar = < 100mg/dl, pre-diabetes = >100 and <126 mg/dl, diabetes = >126 mg/dl); **TCHOL**: normal < 200 mg/dL (5.17mmol/L), borderline high 200 to 239 mg/dL (5.17 to 6.18mmol/L), high ≥ 240 mg/dL (6.21mmol/L); **LDL cholesterol**: optimal Up to 100mg/dl (2.59mmol), near optimal/above optimal 100 – 129mg/dl (2.59 – 3.34mmol), borderline high 130 – 159 mg/dl (3.37 – 4.12mmol), high 160 –189mg/dl (4.14 – 4.90mmol), very high > 190 mg/dl (4.92mmol); **HDL cholesterol**: level excellent ≥ 60 mg/dL (1.55mmol/L), < 40 mg/dL (1.03mmol/L) are lower than desired; **TRIG**: Normal < 150 mg/dL (1.69mmol/L), borderline high is 150 - 199 mg/dL (1.69 - 2.25mmol/L), high 200 - 499 mg/dL (2.25 to 5.63mmol/L) and very high is ≥ 500 mg/dL (5.65mmol/L).

Statistical Analysis: Data generated were analyzed using Statistical Product for Service Solution (SPSS) software version 21. 0. Descriptive statistics (frequencies, percentages, means, and standard deviation) were used to present the results, while T-test and simple linear regression were used to compare the differences and determine the effects respectively.

RESULTS

There were more (72.2%) females than males (27.8%), within the age range of 44 to 73 years, weight range of 43.7 to 97kg, and height range of 1.55 to 1.75m (table 1). Fifty percent were overweight, 22.2% were obese and normal respectively and 5.56% were underweight.

Table 1 Biodata of Individual Subjects used in Feeding Trial (n=36)

S/N	Age (years)	Sex	Weight (kg)	Height (m)	BMI (kg/m^2)
1	60	F	43.7	1.56	18.0
2	57	F	64.0	1.62	24.4
3	71	F	68.0	1.55	28.3
4	52	M	97.0	1.75	31.7
5	55	F	43.9	1.55	18.3
6	42	M	64.4	1.63	24.2
7	52	M	68.4	1.56	28.1
8	69	F	60.0	1.64	22.3
9	44	F	71.5	1.56	29.4
10	63	F	70.5	1.60	27.5
11	49	F	92.0	1.63	34.6
12	68	M	60.1	1.63	22.6
13	58	F	71.4	1.56	29.3
14	60	M	90.3	1.64	33.6
15	48	F	90.0	1.66	32.7
16	71	M	64.0	1.69	22.4
17	54	F	60.0	1.57	24.3
18	56	F	61.0	1.56	25.1
19	46	M	91.0	1.68	32.2
20	50	F	64.5	1.68	22.9
21	58	F	60.2	1.58	24.1
22	53	F	64.0	1.61	25.0
23	52	M	80.0	1.72	27.0
24	55	F	70.0	1.58	28.0
25	59	M	80.4	1.74	26.6
26	52	F	70.3	1.59	27.8
27	65	F	80.3	1.72	27.1
28	50	F	70.2	1.57	28.5
29	71	F	71.0	1.61	27.4
30	68	F	71.4	1.68	25.3
31	58	F	88.0	1.61	33.9
32	63	F	71.2	1.60	27.8
33	48	F	71.3	1.69	25.0
34	66	M	85.2	1.64	31.7
35	64	F	82.5	1.70	28.5
36	73	F	83.4	1.65	30.63

Few (5.6%) subjects were Underweight, 22.2% were of normal weight, 50% were overweight, and 22.2% were in grade 1 obesity before the trial (table 2). At the end of the trial, 2.8%, 27.8%, 50%, and 19.4% of the subjects remained underweight, normal weight, overweight, and in grade 1 obesity respectively.

Table 2 Weight Classification of Subjects Before and After the Feeding Trial

Weight Category	Before Male Freq. (%)	Before Female Freq. (%)	Before Total Freq. (%)	After Male Freq. (%)	After Female Freq. (%)	After Total Freq. (%)
Underweight	-	2(5.6)	2(5.6)	-	1(2.8)	1(2.8)
Normal weight	3(8.3)	5(13.9)	8(22.2)	3(8.3)	7(19.4)	10(27.8)
Overweight	3(8.3)	15(41.7)	18(50)	3(8.3)	15(41.7)	18(50.0)
Class 1 obesity	4(11.1)	4(11.1)	8(22.2)	4(11.1)	3(8.3)	7(19.4)
Total	**10(27.7)**	**26(72.3)**	**36(100.0)**	**10(27.7)**	**26(72.3)**	**36(100.0)**

The group of subjects that consumed porridges Ayb100, AybC70:30, and C100 observed 0.43kg, 0.06kg, and 0.43kg reductions in mean weights respectively (table 3 below); while samples AybC50:50, AybC30:70, Cc100 showed 0.87kg, 0.89kg, and 0.51kg increases in mean weights. All subjects' heights remained the same during the feeding trial. Subjects that ate AybC70:30, and C100 porridges observed 0.10, and 0.35 reductions in mean BMI while AybC50: 50, AybC30: 70 and Cc100 observed 0.35, 0.22, and 0.33 increases in the BMI. All these changes were not significant (p= 0.05)

Twenty-five percent, 38.9%, and 36.1% of the subjects were pre-hypertensive (table 4), hypertensive, and within the diabetic goal at the beginning of the feeding trial. As much as 11.1% achieved normal and diabetic goal blood pressure, with 13.9% and 8.3% reductions in prehypertension and hypertension respectively.

Table 4 Classification of Subjects according to Blood Pressure Before and After the Feeding trial

Class of BP	Before Male Freq. (%)	Before Female Freq. (%)	Before Total Freq. (%)	After Male Freq. (%)	After Female Freq. (%)	After Total Freq. (%)
Normal	-	-	-	1(2.8)	3(8.3)	4(11.1)
Prehypertension	6(16.7)	3(8.3)	9(25.0)	2(5.6)	2(5.6)	4(11.1)
Hypertension	4(11.1)	10(27.8)	14(38.9)	6(16.7)	5(13.8)	11(30.6)
Diabetic Goal	3(8.3)	10(27.8)	13(36.1)	4(11.1)	13(36.1)	17(47.2)
Total	13(36.1)	23(63.9)	36(100.0)	13(36.1)	23(100.0)	36(100.0)

BP = blood pressure; Diabetic Goal = <130/<80mmHg

The systolic pressure of groups fed Ayb100 remained the same throughout the study period (table 5 below). Groups fed AybC50:50, and Cc100 observed 2.57mmHg, and 1.38 mmHg increases in systolic pressure, while AybC70:30, AybC30:70 and C100 observed 4.42mmHg, 40.45mmHg, and 7mmHg reductions in systolic pressure. AybC100, AybC70:30, AybC50:50, and C100 had 1.57mmHg, 1.14mmHg, 1.72mmHg, 2.85mmHg reductions in diastolic pressure, while AybC30:70 and Cc100 had significant increases of 19.85mmHg and 18.99mmHg in diastolic pressure ($p < 0.05$). Ayb100, AybC50:50, and Cc100 had 6.57, 0.57, and 2.7 increases in pulse rate, AybC70:30 maintained the same pulse rate, while AybC30:70 and C100 observed 9.86, and 0.28 reductions in pulse rate after the trial.

The mean fasting blood sugar for the groups at the beginning and end of the feeding trial ranged from 143.0 mg/dl in AybC70:30 to 192.6mg/dl in AybC50:50 and 105.50 mg/dl in Ayb100 to 151.00mg/dl in AybC50:50 (table 6). There was significant ($P < 0.05$) decreases in the fasting blood glucose level of groups fed Ayb100 (152.20 – 105.50mg/dl), AybC70:30 (143.00 – 106.90mg/dl), and C100 (167.30- 111.00mg/dl) after the trial.

Table 6 Fasting Blood Sugar Level of the Subjects Before and After the Feeding Trial

Samples	Mean	Mean Difference	Std Deviation	t-test statistics (p-value)	Decision
Ayb100 Before	152.20	46.71	52.44	2.757 **(0.033)**	Sig
Ayb100 After	105.50		17.54		
AybC70:30 Before	143.00	36.10	23.83	3.767 **(0.009)**	Sig
AybC70:30 After	106.90		12.76		
AybC50:50 Before	192.60	41.60	47.36	1.778 (0.126)	Not sig
AybC50:50 After	151.00		60.89		
AybC30:70 Before	156.60	14.50	44.41	0.491 (0.641)	Not sig
AybC30:70 After	142.10		62.21		
C100 Before	167.30	56.20	52.11	2.576 **(0.042)**	Sig
C100 After	111.00		16.47		
Cc100 Before	155.50	9.00	12.20	0.568 (0.740)	Not sig
Cc100 After	146.00		17.06		

Footnote: If the p-value is less than $\alpha = 0.05$ is significant (sig) difference; Ayb100 = whole African yam bean flour; AybC70:30 = whole African yam bean70% +Corn30% flour blend; AybC50:50 = whole African yam bean50% +Corn50% flour blend; AybC30:70 = whole African yam bean30% +Corn70% flour blend; C100 = whole corn flour 100%; Cc100 = fermented whole corn flour.

The glycemic response curves shows that Ayb100, AybC70:30, Ayb50:50, AybC30:70, and C100 normalized with188.86mg/dl, 202.14mg/dl, 193.43mg/dl,156mg/dl and 176.57mg/dl respectively at 120minutes in the beginning of the trial; with peaks at 244.86mg/dl, 232mg/dl, 242.86mg/dl, 209.14mg/dl, and 227,71mg/dl respectively(Fig 1). At the end of the feeding trial, Ayb100, AybC70:30, Ayb50:50, AybC30:70, and C100 normalized at 161.57mg/dl, 139.86mg/dl, 209.86mg/dl 171.86mg/dl and 141.29mg/dl with peaks at 60mins with 198mg/dl, 208.71mg/dl, 255.43mg/dl, 233mg/dl, and 212.14mg/dl (Fig 2). At baseline, Cc100's blood glucose response normalized with 196.9mg/dl at 120minutes with a peak of 234.4mg/dl at 75mins. At the end, it normalized with 220.23mg/dl at 120min with a peak of 253.80mg/dl at 90mins.

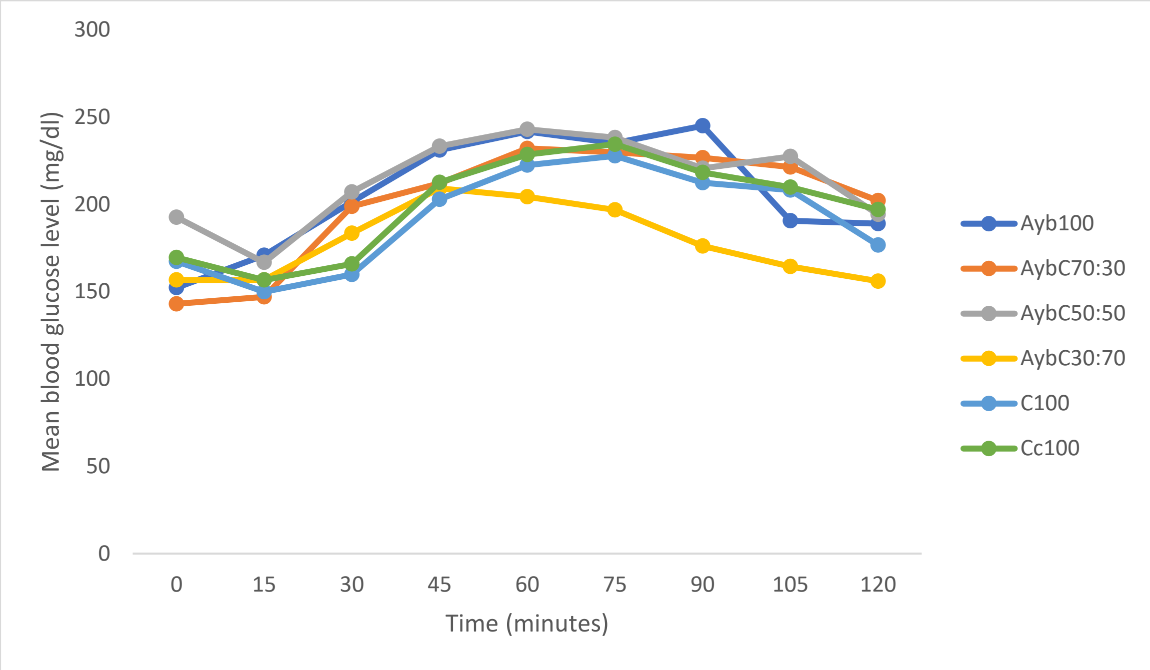

Fig 1 Glycemic Response Curve of Porridges Made from African Yam Bean and Corn Flour Blends Before the Feeding Trial.

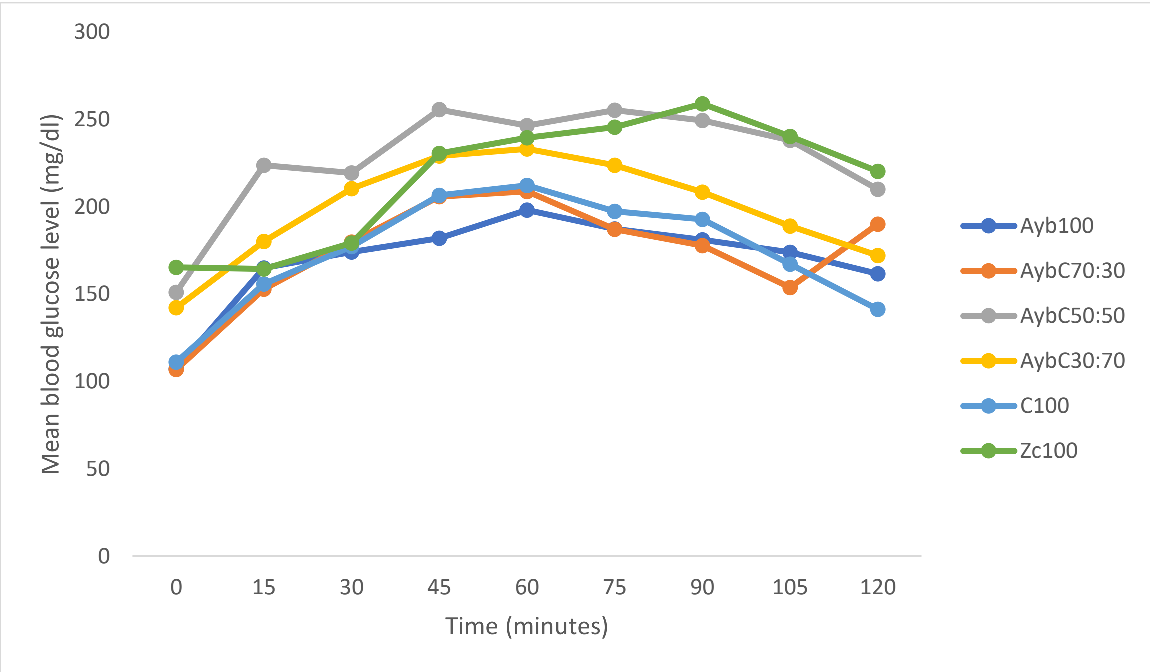

Fig 2 Glycemic Response Curve of Porridges Made from African Yam Bean and Corn Flour Blends After the Feeding Trial.

TCHOL ranged from 177.30mg/dl in AybC30:70 to 216.00mg/dl in Cc100 at baseline, at the end of the feeding trial, the level ranged from 139.10mg/dl in AybC30:70 to 210.00mg/dl in Cc100 (Table 7 below).. The HDL values of the subjects ranged from 39.00mg/dl in AybC30:70

to 54.00mg/dl in C100 at the base baseline, at the end, the range was from 40.00mg/dl in AybC30:70 to 56.42mg/dl in C100. The TG ranged from 52.70mg/dl in C100 to 85.71mg/dl in Cc100 at baseline, while at the end the range was from 50.14mg/dl in AybC70:30 to 95.85mg/dl in AybC30:70. No significant changes were observed in the TRIG levels of all the groups fed the test porridges after the feeding trial. The LDL range for groups was 97.85mg/dl in AybC30:70 to 132.10mg/dl in AybC70:20. At the end of the feeding trial, the mean LDL ranged from 85.00mg/dl in AybC30:70 to 127.00mg/dl in C100. The range of TCHOL/HDL at baseline was from 4.21 in C100 to 4.96 in AybC70:30, at the end, the ratio ranged from 3.31 in C100 to 4.67 in Cc100.

For BMI, the regression coefficient of porridge Ayb100 -2.843 (0.086) was found to be statistically significant and negative with R^2 of 29.4% at 10% alpha level (Table 8), porridge AybC50:50, was also negative -0.575(0.734) but not statistically significant with R^2 of 5.9%. For FBS, porridges Ayb100, AybC70:30, and C100 had negative coefficients that were not statistically significant while AybC50:50 had a positive statistically significant coefficient of 34.607(0.056) with R^2 of 32.6% at a 10% alpha level. For systolic blood pressure, porridge AybC50:50 had a negative statistically significant coefficient -17.50(0.011) with R^2 of 42.5%, and Ayb100 -8.214(0.250) with R^2 of 20.0% although negative was not significant, while C100 had a positive statistically significant coefficient of 18.214(0.008) with R^2 of 44.3% at a p-value of 5%. For diastolic blood pressure, porridges Ayb100 and AybC50:50 had negative coefficient {-2.893(0.234); -5.214(0.028)} with the latter statistically significant at 5% alpha level, while AybC30:70 had positive coefficient 4.071(0.091) with R^2 of 29.0% at 10% alpha level. For pulse pressure, porridges AybC50:50, AybC30:70, and C100 had negative coefficients {-6.107(0.097); -2.714(0.468); -0.750(0.842)} with R^2 of 28.5%, 12.7% and 3.5% respectively. AybC50:50 was statistically significant at a 10% alpha level. For TCHOL, AybC70:30 and AybC30:70 had negative coefficients {-4.679(0.756); -6.286(0.012)}and R^2 of 5.4% and 42.2% respectively. The former was statistically significant at a 5% alpha level. For HDL, Ayb100, AybC50:50, and C100 had positive coefficients {2.607(0.677); 6.893(0.267); 7.786(0.209)} that were not statistically significant with R^2 of 7.3%, 19.3% and 21.8% respectively. For TRIG, Ayb100, AybC70:30 and C100 had negative coefficients {-12.929(0.377); -25.964(0.071); -6.321(0.667)}, while AybC30:70 had positive coefficient {30.643(0.031). Only AybC70:30, and AybC30:70 was statistically significant at 10 and 5% alpha levels respectively. For LDL, only AybC30:70 and C100 had negative coefficients {-23.429(0.042); -7.000(0.555) with the former being statistically significant at 5% alpha level. The remaining porridges had positive but insignificant coefficients. For TCHOL/HDL, Ayb100 and C100 had negative coefficients {0.107(0.837); 0.446(0.388)} that were statistically insignificant.

Discussion

The Biodata of individual subjects, anthropometric indices, and clinical and biochemical parameters of the subjects were indicators of their nutrition and health status. Fewer men participation in the study as was documented Otitiola, Wilna, & Egal [12]. Participation of few men in hospital studies had been attributed to the more healthcare-seeking attitudes and longevity of women than men [13]. The common age range of 40-60 years confirmed the occurrence of type 2 diabetes in middle age. The reduced percentage of those above 60 years may indicate the contribution of diabetes to mortality. The proportions (83.3%)

that weighed 60kg and above showed that underweight was not a problem in the study subjects. Most (88.9%) subjects were of average height, while 72.2% were either overweight or obese. This is a call for urgent action on weight management programs for diabetic patients.

There was an increase in the number that maintained normal weight and a decrease in the number of underweight and obese (Table 2). This could be attributed to the consumption of the test diets. The lower effect of the test porridge on subjects' weights may be due to the shortness of the test period (2 weeks). The weight effect was more in women than men, indicating the inclination of women to adhere to dietary management than men. Bédard, Lamarche, Corneau, Dodin, & Lemieux, observed no gender differences in imparts of Mediterranean diets [14].

Similarly, slight reductions in weight of all the groups were observed (Table 3). This may be attributed to the short period of study. A longer duration may present a significant difference in the weights of the subjects. The mean height range of the subjects was the same throughout the feeding period as expected since they were adults with a mean age of 51 years who had attained their maximum growth in height. Growth in height stops once one attains the adult stage [15]. Subjects fed Ayb100, AybC50:50, and AybC30:70 had slight increases in BMI (0.11, 0.35, 0.22) respectively while Ayb70:30 and C100 had slight decreases in mean BMI (0.10, 0.35) respectively. The mean BMI ranges of this study subjects were higher than the mean BMI (26.4kgm^2) reported [16], lower than females BMI (29.5-31.2kg/m^2) and higher than male (24.2-27.2kg/m^2) in [12]. Maintaining a good BMI is important as overweight and obese are major risk factors for morbidity and mortality [17].

All subjects in this trial were either pre-hypertensive (25.0%), hypertensive (38.9%), or maintaining a diabetic goal (36.1%) of <130/<80mmHg (Table 3.4). This prevalence was worrisome although less than 59.1% reported [12], and higher than 29.1% [18]. Evidence revealed that hypertension is disproportionately higher in diabetics [19], frequently co-exist with diabetes [20], and the two diseases appear to aggravate each other [21]. The very few (4) subjects (11.1%) that slipped to normal blood pressure may be because of the test porridges consumed during the feeding trial. Several health benefits including reduced risk of heart disease, and T2DM have been accorded to whole-grain foods [6]. It is documented that whole-grain cereals protect the body against age-related diseases such as diabetes, cardiovascular diseases, and some cancers [22] and partial substitution of carbohydrates with either protein (1/2 from plant sources) or unsaturated fats (monounsaturated) improves blood pressure, LDL, HDL, and TG levels and reduced risk of CHD [23]. The 11.1% increase in the of subjects that achieved diabetic goal blood pressure and 8.3% reduction of hypertensive cases during the feeding trial was encouraging and called for intensive diet modification.

The systolic blood pressure (SBP) range of this study subjects at the end of the feeding trial (Table 3.5) was not significantly different from that at the beginning of the trials except for porridge AybC30:70. The mean SBP range (126.43 – 155.00mmhg) of subjects at the baseline was lower than that (93-173mmHg) reported [15]. Only subjects fed porridge AybC30:70 had significant differences in their diastolic blood pressure. The diastolic blood pressure (DBP) range (80.14 - 109.14mHg) was like the range of 63 – 110mmHg [10]. The pulse pressure range of all the subjects was not affected by the porridges fed. A mean blood pressure of 143/87mmHg has been reported [12]. The mean SBP range of the study subjects fed the test porridges at the end of the trial was appreciably high (100.71-148.00mmHg). SBP is a major risk factor for cardiovascular disease (CVD) [24]. The mean DBP range of the subjects at the end of the feeding trial (80.14 – 109.14mmHg) followed a similar trend with

SBP. Evidence revealed that the pattern of BP changes with age as SBP rises continuously throughout life in contrast to DBP, which rises until approximately age 50, levels off over the next decade, and remains the same or falls later in life [25]. The BP range in this feeding trial patients were higher than BP values (130–139/85–89 mmHg) associated with a more than twofold increase in relative risk from CVD [26]. The level of hypertension in the study subjects, calls for urgent interventions. Consistent hypertension in adults has been attributed to age-related poor vascular compliance of the large arteries which stiffens and contributes to widened pulse pressure as well [27]. It has also been associated with high overweight and obesity among the subjects. Age and obesity are risk factors in the development of hypertension [28]. Consistent hypertension was linked to obesity in the subjects [12]. Hypertension has also been listed as a risk factor for CVD [26]. The higher the BP, the greater the chance of heart attacks, HF, stroke, and kidney diseases; BP increases impressively to hypertensive levels with age [24]. Prevalence of hypertension was associated with aging affecting more than half of older people. The age-related rise in SBP is primarily responsible for an increase in both the incidence and prevalence of hypertension [25]. For every 20mmHg systolic or 10 mmHg diastolic increase in BP, there is a doubling of mortality from both IHD and stroke [24]. This magnitude of odds reiterates the need for early screening, diagnosis, treatment, and control of hypertension in all diabetic patients. The observed excess body weight by this study respondents may increase their risk of hypertension. The pulse pressure range of the subjects at the end of the feeding trial (74.00-84.14mmHg) was not encouraging as pulse pressure ≥ 60-63mmHg has been associated with greater mortality although some researchers explained that a wide pulse pressure may be an indication of a survivor effect or due to structural changes in large blood vessels that contributes to isolated systolic hypertension and reduced arterial compliance and increased stiffness [29].

The study observed a significant decrease in the fasting blood glucose level of groups fed porridges Ayb100, AybC70:30, and C100 after the feeding trial respectively (Table 3.6). Groups fed porridges AybC50:50, AybC30:70, and Cc100 had slight reductions in fasting blood glucose levels. All the group means were outside the normal range at the beginning of the feeding trial indicating that all subjects were confirmed diabetics. At the end of the feeding trial, only groups Ayb100 (105.5mg/dl) and AybC70:30 (106.9mg/dl) achieved normal blood glucose levels. The blood sugar levels of all groups at the beginning of the feeding trial indicated that all the subjects were having a difficult time controlling their sugar level. The study areas have high carbohydrate foods as the staple diets. High intake of carbohydrates in overweight and obese patients can elevate blood glucose and TG levels [30]. Poor sugar control with mean blood sugar of 7.7+/- 3.4 mmol/L have been reported respectively [31]. The mean sugar range at the end of the trial indicated the ability of the test porridge to reduce the sugar levels of the groups. Porridges C100, Ayb100, and AybC70:30 showed significant effects compared to AybC50:50, AybC30:70, and Cc100 respectively.

The mean blood glucose curves for each group of subjects (Fig 1) had similar trends as their fasting blood sugar (Table 6). Groups fed porridges Ayb100, AybC70:30, and C100 had better curves than samples AybC50:50, AybC30:70, and Cc100 respectively. This could mean that the former porridges had lower GI than the latter, probably due to the constitutions of the test diets made of more whole grain AYB and Corn flour blends. These porridges were more nutrient-dense than traditional corn porridge and as such will contribute to the adequacy of diabetic diets.

All subjects fed test porridges achieved desirable TCHOL except the control subjects Cc100. The decrease in TCHOL of subjects fed porridges Ayb100, AybC70:30, AybC50:50, and C100 were significant and could be attributed to the fiber contents of the porridges. Mean TCHOL 0.111mg/dl or 4.3+/- 0.9mmol/L was reported [31]. Soluble fiber between 2 to 10g per day has been associated with small but significant decreases in total cholesterol [32]. Soluble fiber can lower blood cholesterol, including LDL cholesterol by trapping fat and cholesterol that would otherwise be digested by the body. The decrease in TCHOL of the subjects in this study was impressive and pleasing as high blood cholesterol levels can lead to early heart disease. WHO HDL classification shows that all subjects were within the desirable level of HDL at the beginning and the end of the feeding trial. Significant increases were observed in the HDL status of subjects fed porridges Ayb100, AybC70:30, AybC30:70 AybC50:50, and C100. This is at variance with the report that HDL cholesterol was not significantly influenced by soluble fiber [32]. There was a report of very low HDL levels of 0.0258mg/dl or 1.0+/- 0.2mmol/L [31]. The increase in HDL status of most of the subjects is a plus to their health as HDL cholesterol is protective against atherosclerosis. All subjects had TG levels within the desirable range both before and after the feeding trial, although it was notable that subjects fed porridges AybC70:30, C100, and Cc100 had slight decreases in their TG levels as compared with subjects fed porridges Ayb100, AybC50:50, and AybC30:70 which had increases in their TG levels. These changes were not significant. This aligned with the report that TG cholesterol was not significantly influenced by soluble fiber [32]. The increase in TG level of subjects fed porridges Ayb100, AybC50:50, and AybC30:70 was understandable as diabetes is known to increase triglycerides, decrease HDL, and increase LDL [33]. The lower TG status of subjects was advantageous as very high levels of TG can cause complications like fatty deposits in the liver, and skin, acute pancreatitis [34] as well as an increase in heart attack [35]. Only subjects fed porridge AybC30:70 were within the desirable range of LDL at baseline. After the feeding trial, subjects fed AybC30:70 and C100 remained and achieved desirable LDL levels respectively together with subjects fed porridge AybC70:30. All three groups had significant reductions in the LDL levels. All subjects fed porridge Cc100 were almost at borderline risk. These subjects needed to re-evaluate their diet regime as high LDL can promote atherosclerosis [35]. There is evidence that soluble fiber makes LDL particles less dense and, therefore, less harmful. LDL 0.72mg/dl or 2.8+/-0.8 in subjects has been reported [31]. Abnormally high levels of LDL were largely genetically determined and had been associated with premature development of heart disease [35]. Subjects fed porridges Ayb100, AybC70:30, AybC30:70, and C100 experienced significant improvement in their CHO/HDL ratio. It was documented that AYB can improve lipid profile by causing a significant ($p<0.05$) reduction in the ratios of total cholesterol/HDL-cholesterol, reverse diabetes-associated dyslipidemia, and a reduction in fasting plasma glucose concentration [36]. A high TCHOL to HDL ratio can increase the risk for CHD [37]. This implied that the subjects with low TCHOL/HDL ratio were at reduced risk of CHD.

The coefficient of porridge Ayb100 -2.843 (0.086) was found to be statistically significant but negative (table 8), showing that a unit of BMI was reduced by the intake of 2.843g of the porridge, R^2 of 29.4% indicated that Ayb100 had 29.4% effect on patient's BMI. Similarly, AybC50:50 had negative -0.575(0.734) coefficient with R^2 of 5.9% effect on the BMI of the group fed AybC50:50. This is in line with the *a priori* expectation as increased consumption of dietary fiber will reduce one's BMI. Dietary fiber can reduce BMI [38]. The positive coefficients as observed in the other porridges may be attributed to the shortness of the test period (2 weeks). Porridges Ayb100, AybC70:30, and C100 had negative coefficients {-28.179(0.222); -20.571(0.264); -15.393(0.405)} with R^2 of 20.9%, 19.4%, and 14.5% effect on FBS respectively indicating that these porridges will reduce a unit of FBS at approximately 28.2g, 20.6g and 15.4g intake. This was expected as it had been demonstrated that plant foods (with increased fiber contents) can lower the blood glucose levels of non-diabetics [39]. However, the effect was not statistically significant at either p-value 0.05 or 0.10 respectively. This may be due to the short duration of the feeding trial. The significant positive coefficient of AybC50:50 34.607(0.056) with R^2 of 32.6% on FBS indicated that the porridge can cause a unit rise in FBS at 34.6g intake. This was a surprise and did not conform to expectations which may be because these patients may not have adhered to the dietary regime of confirmed diabetics as recommended during the trial. Porridges Ayb100 and AybC50:50 had negative coefficients with R^2 of 20.0% and 42.5% effect in systolic blood pressure respectively while AybC70:30, AybC30:70, and C100 had positive coefficients with the latter porridge, and were found to be statistically significant at 10% alpha level and R^2 of 44.3% effect on systolic blood pressure. This implied that Ayb100, AybC50:50 and AybC70:30, AybC30:70, C100 will reduce systolic blood pressure at approximately 8.2g and 17.5g and increase it at 6.6g, 0.9g, 18.2g intake respectively. This was expected because although diet can result in significant reductions in blood pressure, other factors like age, overweight, and obesity issues observed in this study may have contributed to the increase in systolic pressure as observed in the latter porridges. Age and obesity have already been listed as risk factors in the development of hypertension [43]. Similarly, Ayb100 and AybC50:50 had negative coefficients and R^2 of 20.6% and 37.2% effect on diastolic blood pressure while AybC30:70 had positive coefficients and R^2 of 29.0% effect on the same parameter. Porridges AybC50:50, AybC30:70, and C100 had negative coefficients and R^2 of 28.5%, 12.7%, and 3.5% effect on pulse pressure. This implied that these porridges would reduce pulse pressure at 6.1g, 2.7g, and 0.8g intake levels. This effect though small was appreciated as it has already been explained that widened pulse pressure could be attributed to structural changes in large blood vessels that contribute to isolated systolic hypertension reduced arterial compliance and increased stiffness [45]. Porridges AybC70:30 and AybC30:70 had negative coefficients with R^2 of 5.4% and 42.2% effect on TCHOL, $S_{30}Z_{70}$ was statistically significant at 5% alpha level. The porridges will reduce TCHOL at 4.6g and 6.3g intake levels; this aligns with the soluble fiber association with small but significant decreases in total cholesterol [57]. Ayb100, AybC50:50, and C100 had positive coefficients and positive effects on HDL while AybC70:30, and AybC30:70 had negative coefficients with R^2 of 5.4% and 35.7% effect on HDL. The latter was statistically significant at a 5% alpha level. HDL is not significantly influenced by soluble fiber [57]. Porridges Ayb100, AybC70:30, and C100 had negative coefficients implying that they will reduce TRIG at 12.9g, 25.9g, and 6.3g intake while AybC50:50, and AybC30:70 will increase TRIG at14.6g and 30.6g intake. Diabetes is known to increase triglycerides [60]. Only AybC30:70, and C100 had negative coefficients, the former had -23.429(0.042), R^2 of 34.6%, and significant at p-values of 0.05 the positive effect of other porridges may be attributed to the shortness of the feeding trial. Porridges Ayb100 and C100 had negative coefficients on TCHOL/HDL while the rest had positive coefficients. All porridges were found to be statistically significant probably due to the short duration of the feeding trial.

Conclusion

The feeding trial showed small but significant improvement in weight, BMI, blood glucose management, and lipid profile of study subjects. The subjects' blood pressure was consistently high in appreciable proportions of the subjects at the beginning of the trial with small reductions at the end of the feeding trial. Consumption of the porridges made from African yam bean and corn in varied forms will help to enhance the life of diabetic patients.

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Author Contribution: Henry-Unaeze H.N. and Ngwu E.K. formulated the study concept and design. Henry-Unaeze H.N. collected and compiled the data. Statistician Dr. Biu analyzed the data collected, Henry-Unaeze H.N. developed the manuscript and Ngwu E.K. supervised and reviewed the work. Both authors approved the manuscript.

Data and material availability: Data, and materials used for the study are available from the authors on request.

Table 3 Mean Weight, Height, and BMI of Subjects fed Different Samples Before and After the Feeding Trial.

Samples	Weight		*P value	Height		*P value	BMI		*P value
	Before	After		Before	After		Before	After	
S_{100}	64.20^{a}±17.98	63.77^{a}±18.72	0.97^{ns}	1.60^{a}±.07	1.60^{a}±.07	0.97^{ns}	24.66^{a}±5.17	24.77^{a}±4.93	0.97^{ns}
$S_{70}Z_{30}$	73.69^{a}±12.93	73.63^{a}±12.30	0.99^{ns}	1.61^{a}±.04	1.61^{a}±.03	0.88^{ns}	28.46^{a}±4.82	28.36^{a}±4.48	0.97^{ns}
$S_{50}Z_{50}$	70.10^{a}±14.08	70.97^{a}±14.96	0.91^{ns}	1.63^{a}±.06	1.63^{a}±.07	0.97^{ns}	26.24^{a}±4.34	26.59^{a}±4.54	0.89^{ns}
$S_{30}Z_{70}$	73.54^{a}±6.51	74.43^{a}±7.19	0.81^{ns}	1.65^{a}±.08	1.65^{a}±.08	0.97^{ns}	27.14^{a}±1.15	27.36^{a}±1.40	0.76^{ns}
Z_{100}	77.23^{a}±7.66	76.80^{a}±7.81	0.91^{ns}	1.65^{a}±.04	1.65^{a}±.04	0.76^{ns}	28.51^{a}±3.26	28.16^{a}±3.24	0.84^{ns}
Zc_{100}	72.04^{a}±1.06	72.91^{a}±1.96	0.91^{ns}	1.62^{a}±.06	1.62^{a}±.06	0.97^{ns}	27.45^{a}±4.12	27.78^{a}±4.32	0.87^{ns}

[means] with similar superscript in the same column are not significantly different; *Significant difference exists between means of before and after for each parameter if P value is less than 0.05 (ns = not significantly different; SF = Significantly different); S100 = *Sphenostylis stenocarpa;* S70Z30 = *Sphenostylis stenocarpa* 70/*Zea may*30; S50Z50 = *Sphenostylis stenocarpa* 50/ *Zea mays*50; S30Z70 = *Sphenostylis stenocarpa* 30/*Zea mays*70; Z100 = *Zea mays*100.

Table 5 Blood Pressure and Pulse Rate of Subjects Fed Porridges Made from African Yam Bean (*Sphenostylis stenocarpa*) and Corn (*Zea mays*) Flour Blends Before and After the Feeding Trial.

Samples	Systolic		*P value	Diastolic		*P value	Pulse		*P value
	Before	After		Before	After		Before	After	
S_{100}	133.86^{bc}±8.60	133.86^{a}±10.19	1.00^{ns}	83.71^{ab}±5.50	82.14^{b}±4.85	0.58^{ns}	77.57^{ab}±8.14	84.14^{a}±6.77	1.26^{ns}
$S_{70}Z_{30}$	145.71^{ab}±15.32	141.29^{a}±18.69	0.64^{ns}	86.57^{ab}±4.76	85.43^{b}±6.02	0.70^{ns}	81.29^{ab}±6.55	81.29^{a}±4.61	1.00^{ns}
$S_{50}Z_{50}$	126.43^{c}±10.77	129.00^{a}±14.07	0.71^{ns}	81.86^{b}±2.91	80.14^{b}±6.41	0.53^{ns}	73.43^{b}±6.21	74.00^{a}±7.16	0.88^{ns}
$S_{30}Z_{70}$	141.14^{abc}±14.37	100.71^{b}±24.13	0.02^{sf}	89.29^{a}±4.79	109.14^{a}±23.86	0.05^{sf}	86.57^{a}±12.58	76.71^{a}±2.87	0.06^{ns}
Z_{100}	155.00^{a}±19.72	148.00^{a}±37.83	0.67^{ns}	88.71^{a}±7.18	85.86^{b}±4.95	0.40^{ns}	78.57^{ab}±12.20	78.29^{a}±15.11	0.97^{ns}
Zc_{100}	154.62^{a} ±16.37	156.00^{a}±10.52	0.62^{ns}	89.65^{a} ±10.37	108.64^{a}±11.37	0.07^{sf}	78.6^{ab} ±12.00	81.30^{a} ±0.37	1.00^{ns}

[abc]Means with a similar superscript in the same column are not significantly different; *Significant difference exists between means of before and after for each parameter if the P value is less than 0.05 (ns = not significantly different; SF = Significantly different); S100 = *Sphenostylis*

stenocarpa; S70Z30 = *Sphenostylis stenocarpa* 70/*Zea may*30; S50Z50 = *Sphenostylis stenocarpa* 50/ *Zea mays*50; S30Z70 = *Sphenostylis stenocarpa* 30/*Zea mays*70; Z100 = *Zea mays*100.

Table 7 Lipid profile of subjects' groups fed porridges made from African Yam Bean (*Sphenostylis stenocarpa*) and Corn (*Zea mays*) Flour Blends Before and After the Feeding Trial.

Sample/Time	Lipid profile														
	TCHOL			**HDL**			**TRIG**			**LDL**			**TCHOL/HDL**		
	Mean ± SD	**Mean difference**	**t-test statistics**	Mean ± SD	**Mean difference**	**t-test statistics**	Mean ± SD	**Mean difference**	**t-test statistics**	Mean ± SD	**Mean difference**	**t-test statistics**	Mean ± SD	**Mean difference**	**t-test statistics**
S_{100} Before	193.6 ± 12.33	20.0	3.654 **(0.011)**^{s}	46.6 ± 11.49	-5.71	-2.85 **(0.029)**^{s}	52.7 ± 21.57	-7.86	-0.928 (0.389)^{ns}	122.7 ± 17.62	13.07	1.819 (0.119)^{ns}	4.40 ± 1.23	0.81	7.125 **(0.001)**^{s}
After	173.6 ± 23.70			52.3 ± 13.95			60.6 ± 8.34			109.4 ± 15.95			3.59 ± 1.23		
$S_{70}Z_{30}$ Before	202.8 ± 25.10	38.4	4.940 **(0.003)**^{s}	42.57 ± 9.18	-4.00	-2.795 **(0.031)**^{s}	55.42 ± 22.59	5.26	0.694 (0.513)^{ns}	132.1 ± 19.48	22.4	5.108 **(0.002)**^{s}	4.96 ± 1.28	1.26	4.487 **(0.004)**^{s}
After	164.4 ± 26.81			46.57 ± 9.29			50.14 ± 14.74			109.7 ± 22.51			3.70 ± 1.10		
$S_{50}Z_{50}$ Before	197.1 ± 28.84	13.57	3.499 **(0.013)**^{s}	49.14 ± 14.11	-6.57	- 4.265 **(0.005)**^{s}	64.42 ± 14.68	-18.15	-1.302 (0.241)^{ns}	123.2 ± 36.78	6.80	8.000 **(0.001)**^{s}	4.49 ± 2.15	0.31	1.325 (0.475)^{ns}

After	183.5 ± 28.90			55.71 ± 14.85			82.57 ± 42.85			116.4 ± 36.00			4.17 ± 1.97		
$S_{30}Z_{70}$ Before	1.77.3 ± 77.89	38.14	1.603 (0.160)^{ns}	39.00 ± 13.72	-1.00	-0.323 (0.757)^{ns}	84.28 ± 58.01	-11.14	-0.927 (0.390)^{ns}	97.85 ± 36.56	12.85	1.567 (0.168)^{ns}	4.59 ± 0.87	1.00	4.885 (**0.003**)^{s}
After	139.1 ± 38.37			40.00 ± 12.45			95.42 ± 44.41			85.00 ± 30.89			3.59 ± 0.68		
Z_{100} Before	213.2 ± 32.81	33.57	3.310 (**0.016**)^{s}	54.00 ± 19.27	-2.43	-2.887 (**0.028**)^{s}	81.57 ± 52.24	15.71	1.267 (0.252)^{ns}	119.1 ± 24.42	21.00	3.852 (**0.008**)^{s}	4.21 ± 0.91	0.91	3.813 (**0.009**)^{s}
After	180.1 ± 42.99			56.42 ± 17.71			65.85 ± 31.15			98.14 ± 23.65			3.31 ± 0.83		
Z_{c100} Before	216.0 ± 18.30	5.90	1.103 (0.006)^{ns}	45.00 ± 20.19	-0.09	-2.887 (0.002)^{ns}	85.71 ± 32.42	0.13	1.226 (0.205)^{ns}	129.10 ± 21.44	2.10	3.045 (0.005)^{ns}	4.80 ± 0.69	0.13	2.781 (0.007)^{ns}
After	210.1 ± 24.09			45.09 ± 17.16			85.58 ± 31.15			127.00 ± 21.32			4.67 ± 0.53		

Footnote: If the p-value is less than $\alpha = 0.05$ is significant (sig) difference; ***Sphenostylis stenocarpa* =** S_{100}; ***Zea mays*= Z_{100}**; HDL = high-density lipoproteins, TRIG = Triglycerides, LDL = low-density lipoproteins, TCHOL/HDL – total cholesterol/high-density lipoproteins. ns = not significantly different; sf = significantly different; S100 = *Sphenostylis stenocarpa;* S70Z30 = *Sphenostylis stenocarpa* 70/*Zea may*30; S50Z50 = *Sphenostylis stenocarpa* 50/ *Zea mays*50; S30Z70 = *Sphenostylis stenocarpa* 30/*Zea mays*70; Z100 = *Zea mays*100, Zc100 = *Zea mays*100 Control.

Table 8 Simple Linear Regression Results of AYB AND CORN Flour Blends on BMI, FBS, Blood Pressure, Pulse Pressure and Lipid Profile of Patients After the Feeding Trial

Parameters	S_{100} Co-eff (SE)	$S_{70}S_{30}$ Co-eff (SE)	$S_{50}S_{50}$ Co-eff (SE)	$S_{30}Z_{70}$ Co-eff (SE)	Z_{100} Co-eff (SE)
BMI	**-2.843(0.086)***	1.639(0.330)	-0.575(0.734)	0.389(0.818)	1.393(0.410)
R^2	29.4	17.0	5.9	4.0	14.4
FBS	-22.179(0.228)	-20.571(0.264)	**34.607(0.056)***	23.536(0.200)	-15.393(0.405)
R^2 (%)	20.9	19.4	32.6	22.2	14.5
Systolic	-8.214(0.250)	6.607(0.357)	**-17.50(0.011)****	0.893(0.902)	**18.214(0.008)****
R^2 (%)	20.0	16.1	42.5	2.2	44.3
Diastolic	-2.893(0.234)	0.679(0.782)	**-5.214(0.028)****	**4.071(0.091)***	3.357(0.166)
R^2 (%)	20.6	4.8	37.2	29.0	23.9
Pulse	6.571(0.073)	3.000(0.422)	**-6.107(0.097)***	-2.714(0.468)	-0.750(0.842)
R^2 (%)	30.7	14.0	28.5	12.7	3.5
TCHOL	6.750(0.654)	-4.679(0.756)	19.250(0.196)	**-6.286(0.012)****	14.964(0.318)
R^2 (%)	7.8	5.4	22.4	42.2	17.4
HDL	2.607(0.677)	-4.536(0.468)	6.893(0.267)	**-12.750(0.035)****	7.786(0.209)
R^2 (%)	7.3	12.7	19.3	35.7	21.8
TRIG	-12.929(0.377)	**-25.964(0.071)***	14.571(0.319)	**30.643(0.031)****	-6.321(0.667)
R^2 (%)	15.4	30.9	17.3	36.5	7.5
LDL	7.107(0.549)	7.464(0.529)	18.857(0.176)	**-23.429(0.042)****	-7.000(0.555)
R^2 (%)	10.5	11.0	23.4	34.6	10.3
TCHOL/HDL	-0.107(0.837)	0.036(0.945)	0.625(0.224)	0.107(0.837)	-0.446(0.388)
R^2 (%)	3.6	1.2	21.1	3.6	15.1

Footnote: Estimated Coefficients (P-values at ** - 5% and * - 10%); p-values greater than the appropriate critical values (0.05 and 0.10) are not significant, while the bold critical values are significant. Co-eff = coefficient; SE = standard error; BMI = body mass index; FBS = fasting blood glucose; TCHOL = total cholesterol; HDL = high density lipoprotein; TRIG = triglycerides; LDL = low density lipoproteins; TCHOL/HDL = total cholesterol/ high density lipoprotein

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