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Nutritional Quality, Glycemic Index and Glycemic Load of Two Similar Traditional Diets Consumed in Northeast, Nigeria

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Abstract

Glycemic index (GI) and glycemic load (GL) have been implicated in the development and progression of chronic non communicable diseases (NCDs) and WHO has recommended dietary approach in its management. This study was conducted to assess the nutritional composition of two varieties of Danwaken; fulawa and dawa which are traditional diets consumed in Bauchi and Gombe states with a view to ascertaining its GI in the management of chronic NCDs. Proximate, amino and fatty acids compositions of the Danwake varieties were analyzed using standard procedures. Eighty volunteers were recruited from Bauchi and Gombe metropolitan areas and feed with 50 g of test and reference foods (white bread) and GI was determined by trapezoid method. Danwaken fulawa had a significantly higher moisture and carbohydrate content ($p<0.05$) and lower protein content compared to Danwaken dawa. Total amino acids and essential amino acids in Danwaken dawa (912, 367 mg/g protein) were higher than Danwaken fulawa (854, 294 mg/g protein) respectively, with higher limiting amino acid score compared with WHO/FAO/UNU requirements except lysine. Both diets had no essential fatty acids with high GI and GL, although Danwaken fulawa had a higher GL value which was significantly different ($p<0.05$).

Keywords: Diet, Non Communicable Diseases, *Danwake*, Amino acid, Fatty acid, Glycemic Index

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INTRODUCTION

The understanding of the relationship between diet and the onset of diseases has resulted in the amplification of numerous studies on the affiliation between diet and health and disease which has led to improved interest on nutrient data (Greenfield and Southgate, 2003). Diets prepared from natural food sources have been shown to contain more nutrients with less refined carbohydrate and fat. Contemporary development and technology have led to the consumption of more refined and processed foods with less nutritional value (Steyn and Damasceno, 2006). This dietary change has been implicated in the increase in the prevalence of chronic non communicable diseases especially diet related diseases such as diabetes mellitus, obesity, hyperlipidemia, cardiovascular diseases and even cancer (WHO, 2003). The Covid-19 pandemic has revealed the extra burden of chronic NCD as it exposed the precarious interplay between infectious disease such as Covid-19 and NCDs and unhealthy diets have been recognized as one of the modifiable behavioral risk factors of chronic NCDs (WHO, 2003). Nutrient deficiencies or suboptimal nutritional status can contribute to the development of diseases and / or health problems (Kiani *et al*., 2022).

The traditional diets consumed by different ethnic groups are almost unique as it differs from one region to another, the method of preparation and the ingredients required for the preparation of these diets are also different in many instances and the typical Nigerian locally consumed diets was traditionally healthy in international comparisons (Petrikova *et al*., 2023). *Danwake* (Nigerian beans dumpling), an age long traditional diet consumed in the northeastern region as well as in other parts of the country is usually prepared from different ingredients although the methods of preparation may be similar. Traditionally, it is prepared from combination of whole grains specifically cereals like wheat, sorghum, millet and legumes such as beans and bambaranut with cassava also being an integral part of the mixture and its traditionally known as *Danwaken dawa*. However, this cultural method of combining different cereals and legumes in the processing of *Danwake* is being neglected as these days most people have adopted the use of only processed wheat flour to prepare *Danwake* and it is locally known as *Danwaken fulawa*. *Danwake* is traditionally served with soup or pepper sauce (a mixture of hot pepper, other spices and seasoning).

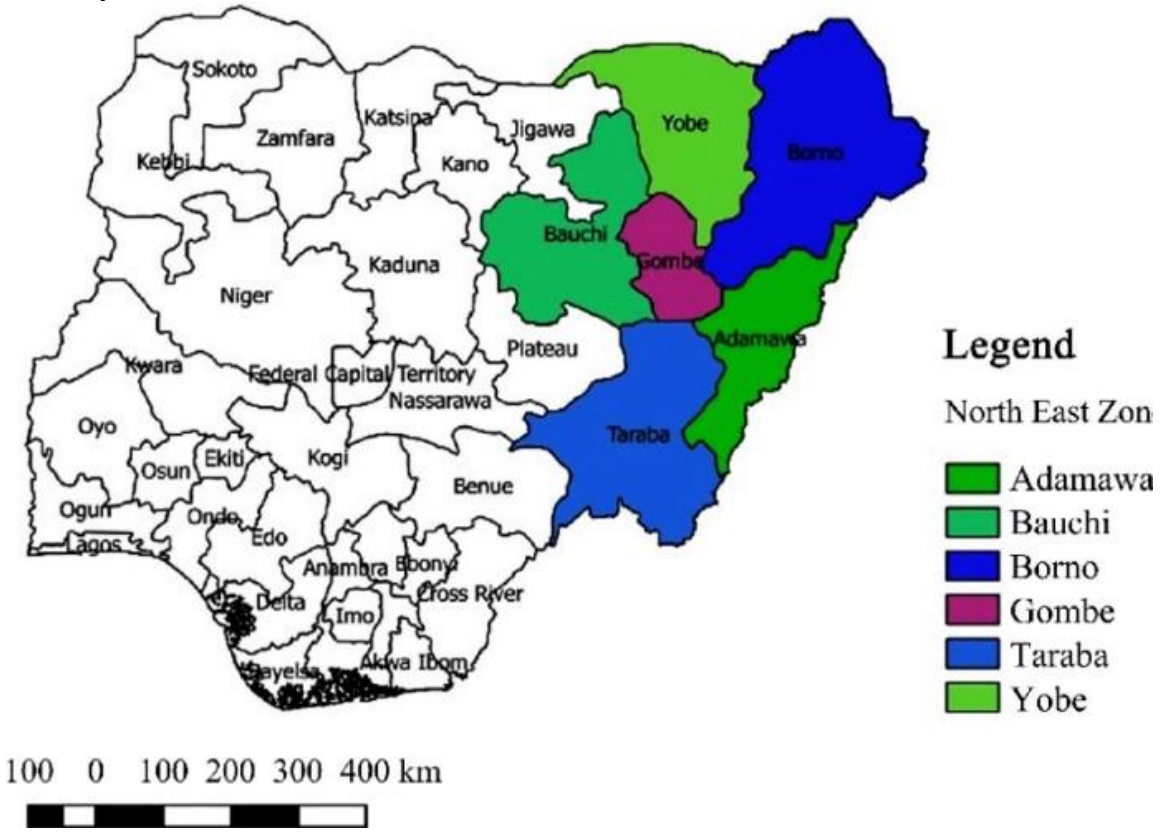
The concept of glycemic index (GI) was introduced based on the influence of different carbohydrate foods on postprandial glycemic response compared to a standard food which may be glucose or white bread (Jenkins *et al.,* 1981). The GI model gives a specific value for carbohydrate rich diets ranging from 0-100 whereby foods with values ranging from 0-55 are considered low GI foods; those with 56-69 are considered medium GI foods and those with 70 and above are considered higher GI foods (Augustin *et al.,* 2015). The quality and the amount of the carbohydrate present in the diet directly influence its digestibility and can provoke conspicuous variation in the postprandial blood glucose. (Liu *et al.,* 2000). As a result, GL is a product of the quality of the carbohydrate which is the GI and the quantity of the same diet consumed (ie GI X available carbohydrate / 100). The experimental utility of GI and GL has been an issue of concern with regards to its relevance in the management of certain diet related diseases due to some limitations with the experimental procedures. However, it has been recognized that the usefulness of GI and GL as a standard indices to comprehend the effect of diets on most chronic non communicable disease cannot be overemphasized (Barclays *et al*., 2008; Ludwig, 2002).. GI and GL have been strongly implicated in increasing the risk of chronic non-communicable diseases such as cardiovascular diseases and even death (Jenkins *et al*., 2021). Research has shown that there is a very strong correlation between the type of food consumed, GI and GL and the development of certain chronic NCDs (Augustin, 2013; Barclays *et al.,* 2008). This study would provide useful nutrition data on these diets which will

aid health care professionals in providing and educating patients on healthy dietary habits. Dietary nutrition is considered an important lifestyle factor contributing to the development of many chronic disease conditions and the presence of one medical condition usually contributes to the development of another resulting in several complications and more burden (Gropper, 2023).

MATERIALS AND METHODS

Study Area

The Northeast area region of Nigeria constitutes six states (Bauchi, Gombe, Borno, Yobe, Adamawa, Taraba) and the study area includes Bauchi (Latitude 10^0 19′ 02″ North and Longitude 09^0 50′ $42^{0'}$ East) and Gombe (10^0 13′ and $10^0$20 North and longitude $11^0$02′ and $11^0$18′ East) states which are part of the six states that makes the Northeast. Bauchi and Gombe states have immense similarities in their traditional and cultural practices including the local food they consume.



Chemicals and Equipment

All solvents and other chemicals used were of High Performance Liquid Chromatography (HPLC) grade. Amino acid analyzer : (Applied Biosystems PTH Amino Acid Analyzer), Gas chromatography (Agilent 6890 series, Agilent technologies, Palo Alto USA) coupled with N-5973 mass spectrometer and a capillary column of HP-5MS with methylphenylsiloxane static phase was used for fatty acid profiling..

Sample Preparation

Ingredients for preparation of the diets were purchased from the local markets in Bauchi and Gombe States northeast region Nigeria and were prepared based on local traditional methods. Prepared samples were mixed with the sauce and groundnut oil, oven dried and ground to

powder prior to amino acid and fatty acid analysis while diets for GI analysis were prepared using same ingredients and method.

Preparation of *Danwaken fulawa* with Pepper Sauce and Oil

Ingredients: Processed wheat flour (100%) (345 g), powdered baobab leaf (11.1 g), potash solution (potash (10.8 g) dissolved in water in 1000 gcm^3), groundnut oil (100 cm^3) and Water (6000 cm^3).

Procedure: Processed wheat flour and powdered baobab leaf were mixed together thoroughly, before being mixed with potash solution until it became soft sticky dough (*Danwake* dough). Dough was molded with fingertips into a round/ball shape and was gently dropped into the boiling water and allowed to boil at moderate temperature for 10 minutes after which the lumps of *Danwake* came to the surface of the water as soon as it was heated up. This was stirred for another 5 minutes after which it (*Danwake*) was separated/sieved from the hot water and placed in cold water.

Preparation of Pepper Sauce

Ingredients: Dried red chilli pepper (32.3 g), salt (9.0 g), maggi (27.9 g), clove (8 g), and groundnut cake (22 g), dried ginger (8.2 g).

Procedure: All the ingredients were mixed together in a mortar and pounded to powdered form which is served with groundnut oil as the sauce for consuming the prepared *Danwake.*

Preparation of *Danwaken Dawa*
Mixed Flour Preparation: Cassava (30%), Beans (20%) and Sorghum (50%). Cassava (229.83 g), Beans (267.7 g) and Guinea corn (265.36 g). They were mixed and grounded into powdered form.

Preparation of *Danwake:*

Ingredients: Mixed (white sweet cassava, white black eyed peas and yellow sorghum) flour (435.74 g), powdered Baobab leaf (15 g), Potash solution (potash (12 g) dissolved in water (1000 cm^3), Groundnut oil (100 cm^3), and Water (6000 cm^3).

Procedure: Mixed flour and powdered baobab leaf were mixed and 1000 cm^3 potash solution was added bit by bit till it became soft sticky dough (*Danwake* dough). Same procedure above used for preparation of *Danwaken fulawa* was then used for *Danwaken dawa* and same sauce as well as groundnut oil was used.

Figure 2: Danwaken Fulawa (Nigeiran beans dumpling made from only procesed wheat flour)

Figure 3: Danwaken Dawa (Nigeiran beans dumpling made from sorghum, cassava and beans)

Amino Acid Analysis

Nitrogen Determination

The procedure reported by AOAC (2006) was employed to determine the Nitrogen content of the two varieties of *Danwake.* Defatted sample (0.15 g) was digested in Kjedhal digestion flask using concentrated sulphuric acid (10 cm^3) and catalyst mixture (0.5 g) containing sodium sulphate (Na_2SO_4), copper sulphate ($CuSO_4$) and selenium oxide (SeO_2) in the ratio 10:5:1. The

digested sample was mixed with 15 cm^3 of 45% NaOH and distilled using Markham distillation apparatus and titrated with standardized 0.01N hydrochloric acid.

$$\% \textbf{ Nitrogen} = \frac{(\boldsymbol{a} - \boldsymbol{b}) * \mathbf{0.01} * \mathbf{14} * \boldsymbol{V} * \mathbf{100}}{\boldsymbol{W} * \boldsymbol{C}}$$

a= titre value of digested sample
b= titre value of blank sample
v= volume after dilution (100 cm^3)
W= weight of dried sample (mg)
C= aliquot of the sample used (10 cm^3)
14= Nitrogen constant in mg

Hydrolysis of the Sample

Defatted sample was weighed into glass ampoule, followed by addition of 7 cm^3 of 6N HCl and Nitrogen was passed into the ampoule. Sealed glass ampoule was placed in an oven preset at 105 ^oC ± 5 ^oC for 22 hours. Ampoule was cooled, filtered and filtrate was evaporated to dryness using rotary evaporator. The residue was dissolved with 5 cm^3 acetate buffer (pH 2.0) and stored in the freezer. Sodium hydroxide (4.2M) was used for hydrolysis instead of HCl (6N) for hydrolysis tryptophan (Maria *et al*., 2004). Sixty microlitre (60 µL) of hydrolysate was dispensed into the analyzed and the concentration of each of the amino acids was determined. The Applied Biosystems PTH Amino acid analyzer was used to determine amino acid profile

Determination of Fatty Acid profile

The procedure reported by Kitson *et al.* (1996) was employed to determine the fatty acid content of the two varieties of *Danwake.* Prepared food samples (*Danwaken fulawa* and *Danwaken* dawa) were ground into powdered form and the oil content was extracted using soxhlet extraction with petroleum ether as the solvent as described in AOAC (2000a). The extraction of the fatty acids was carried out by the method of Folch *et al.* (1957) by homogenizing the powdered sample (0.5 g) with 20 ml chloroform:methanol mixture in a ratio of 2:1 v/v solution. Ultrasonication was done for about 15 minutes at room temperature. This was allowed to settle for some few more minutes before the homogenate was filtered and NaCl solution was added to the filtrate. The resulting mixture was centrifuged at 3000 rmp for 20 minutes and the upper part (methanol:water) was removed while the lower one was filtered through anhydrous Na_2SO_4. This was followed by the evaporation of the solvent and the fatty acid methyl esters (FAME) which were prepared according to the American Oil Chemists Society (AOCS) (2006) tagged Ce 2-66. A measured quantity of the methylated sample (0.5 µL) was introduced to the GC column (100 m x 0.25 mm, 0.20 µm) and molecules in the analytes were separated as they moved along the length of the column. The injector temperature was 260 ^0C and the injector split ratio was 1:50. The temperature of the detector was 270 ^0C and the carrier gas helium had a constant flow rate of 1.0 mL/min. The FAME standard used for the identification of the fatty acids was a mixture of 37 component containing C4:0 – C22:6. This was used to identify the constituent fatty acids and its related compounds based on the obtained chromatograms analysis by comparing the standards with the evaluated retention indices and the mass spectral data of the peaks with aid of a computer library (Wiley-14 and NIST-14 mass Spectral Library) for all the extracted oils The molecules elute separately from the gas chromatograph owning to the differences in their retention time. The eluted molecules were captured, ionized, accelerated, deflected and detected by the mass spectrometer.

Glycemic Index and Load Analysis

Determination of proximate composition of *Danwaken fulawa* and *Danwaken dawa*.

All the nutritional parameters (moisture, ash, crude fibre, fat and protein) of the proximate composition were determined by the Official Methods of the AOAC (2000b), while the carbohydrate content was determined using the Anthrone method.
Sample (100 mg) was hydrolyzed by keeping it in a boiling water bath for three hours with 5 cm^3 of 2.5 N HCl in a boiling tube. It was cooled to room temperature, neutralized with solid sodium carbonate, made up to 100 cm^3 and centrifuged. Obtained supernatant (1 cm^3) was used for analysis. Standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 cm^3 of the working standard and volume was made up to 1cm^3. Ice-cold anthrone reagent (4 cm^3 of 2.5N) was added after cooling and heated in water bath for eight minutes, they were cooled and absorbance read at 630 nm.
A graph of concentration of the standard on the X-axis *versus* absorbance on the Y-axis was plotted and carbohydrate was calculated as $= \frac{mg\ of\ glucose}{volume\ of\ the\ test\ sample} * 100$

Ethical Consideration
Ethical approval was obtained from the Research and Ethics Committee of Ministry of Health, Bauchi State, Nigeria (MOH/GEN/S/1409/I). All participants gave their consent to freely participate in this study in accordance with the Declaration of Helsinki.

Experimental Design
Eighty (80) human volunteers were consented from around Bauchi and Gombe state metropolitan area. Forty volunteers (23 males and 17 females) were consented from Bauchi State for GI analysis of *Danwaken fulawa*. Forty volunteers (25 males and 15 female) were selected from Gombe state, while forty (30 males and 10 females) selected from the already consented volunteers from both states were used for standard meal and all volunteers were between the ages of 20-40 years. This was achieved by distributing consent forms to all the participants who were selected as volunteers based on the fitness quality and health status as some were diabetic, hypertensive, or having some other ailments for which they are still taking some local or orthodox treatment for.

Inclusion and Exclusion Criteria

Volunteers must be adults (18 yrs above), mentally stable with the ability to provide informed consent to partake in the study, Non diabetic and Non hypertensive, Non alcoholic and non smokers.

Volunteers that are under age (less than 18 yrs), Pregnant, with diagnosed medical condition such as myocardial infarction, hepatitis, and inflammatory or metabolic diseases were exclused from this study.

Test Foods
Eighty volunteers, forty for each diet were fed with 50 g of available carbohydrate of *Danwaken fulawa* (80 g) and *Danwaken dawa* (91 g), after fasting for 10-12 hours. All volunteers reported to the GI testing venue at 7:00 am and anthropometric indices were determined and blood pressure of the volunteers was also measured. fasting blood glucose (FBG) level was determined (0 min) using glucometer (Accu Chek) before the volunteers were served with test

foods with little quantity of water. Blood glucose levels were determined again at 30th, 60th, 90th and 120th minutes and the glucose concentration recorded.

Standard/Reference Food (White Bread).
The standard reference food that was used in this study was white bread (50g) as described by (Wolver *et al.,*1991).

Calculation of Glycemic Index and Load
Glycemic index was calculated from the blood glucose response curve at 0-120 minutes and the GL was evaluated from the GI and the carbohydrate content of the diet mathematically represented as: GI = IAUC of test food/IAUC of standard reference food x 100. GL= GI/100 × Available carbohydrates

Statistical Analysis
For the proximate analysis, determinations were performed in three replicates while for GI determination; forty (40) subjects were used for the study of each diet in each state. Results were presented as mean ± standard error of the mean. Data from the proximate analysis was subjected to analysis of variance (ANOVA), while the data for GI, GL and body mass index (BMI) were subjected to paired samples T-test using SPSS software version 20.0 with P value <0.05 considered significant.

RESULTS
Table 1 shows amino acid profile of *Danwaken fulawa* and *dawa*. The total amount of essential amino acids (EAA) was higher in *Danwaken dawa* compared to *Danwaken fulawa* likewise the total amino acid (AA). However both diets were observed to contain all the amino acids with the essential amino acids being identified with asterisk.

Table 1: Amino acid profile of *Danwaken fulawa* and *Danwaken dawa* consumed around Bauchi and Gombe States

Amino acids	*Danwaken fulawa*	*Danwaken dawa*
Leucine*	64.20	88.70
Lysine*	32.30	36.10
Isoleucine*	34.00	39.30
Phenylalanine*	40.80	46.10
Tryptophan*	11.50	15.20
Valine*	43.30	51.40
Methionine*	15.50	23.00
Histidine*	21.70	33.90
Threonine*	31.10	33.80
Proline	70.00	56.80
Arginine	48.20	49.90
Tyrosine	31.00	34.40
Cystine	12.10	20.60
Alanine	36.40	52.30
Glutamic acid	228.60	181.70
Glycine	39.90	35.60
Serine	38.90	40.00
Aspartic acid	55.20	73.20
Total EAA	294.40	367.50
Total NEAA	560.30	544.50
Total AA	854.70	912.00

Table 2 shows the amino acid score of all EAA present in the diets. All the EAAwere found to be present in both diets. However *Danwaken dawa* was seen to have a higher limiting amino acid score than *Danwaken fulawa.* Comparing the scores with the established WHO.FAO/UNU (2007) requirements indicated that *Danwaken dawa* has higher scores for all the EAA except for lysine which was noted to be lower.

Table 2: Comparison of amino acid score of *Danwaken fulawa* and *Danwaken dawa* with WHO/FAO/UNU (2007) for all age groups.

Amino Acid	*Danwaken fulawa*	*Danwaken dawa*	Egg scoring pattern (mg/g)	WHO/FAO/UNU (2007) scoring pattern (mg/g protein requirement) for all age groups					
				0.5yer r	1-2yrs	3-10yrs	11-14yrs	15-18yrs	>18yrs
Leu	75	103	86	66	63	61	60	60	59
Lys	46	52	70	57	52	48	48	47	45
Ile	63	73	54	32	31	31	30	30	30
Phe + Tyr (AAA)	77	87	93	52	46	41	41	40	38
Trp	68	89	17	8.5	7.4	6.6	6.5	6.3	6.0
Valine	66	78	66	43	42	40	40	40	39
Met + Cys (SAA)	48	76	57	28	26	24	23	23	22
His	99	154	22	20	18	16	16	16	15
Thr	84	91	37	31	27	25	25	24	23

AAA: aromatic amino acids, SAA: sulphur amino acids

Tables 3 and 4 present the fatty acids composition of *Danwaken fulawa* and *Danwaken dawa*. *Danwaken dawa* (Table 4) was seen to contain more fatty acids and less of the other lipid related compounds than *Danwaken fulawa* (Table 3) with both diets containing the saturated odd numbered fatty acid (pentadecanoic acid) and unsaturated even numbered fatty acids (11-octadecenoic acid).

Table 3: Fatty acids profile and lipid related compounds of oil extracted from *Danwaken fulawa*

Ret time	% area	Fatty acid	Quality
17.870	9.85	Pentadecanoic acid (pentadecyclic)	73
19.531	11.60	11-octadecenoic acid (vaccenic acid)	94
19.677	1.93	Eicosanoic acid (arachidic acid)	90
Other Lipid Related Compounds of Fatty acids			
11.725	0.45	8-Methyl-9-tetradecen-1-ol acetate	73
12.211	0.44	11-Methyl-12-tetradecen-1-ol acetate	82
13.248	0.65	Ethyl 2,3-dipropylcyclopropanecarboxylate	64
13.865	0.46	Oxalic acid, 6-ethyloct-3-yl isobutyl ester	72
14.516	1.00	Methoxyacetic acid, 4-tetradecyl ester	86
16.845	0.51	Oleyl alcohol, trifluoroacetate	83
17.222	0.34	Oxalic acid, cyclohexylmethyl tridecyl ester	59
17.459	0.37	Oxalic acid, butyl 6-ethyloct-3-yl ester	60
17.655	0.47	Phthalic acid, 5-methylhex-2-yl butyl ester	87
18.005	0.64	Oxalic acid, hexyl tridecyl ester	60
19.099	0.70	Octadecanoic acid, 4-hydroxy-, .gamma.-lactone	85
19.395	141	Fumaric acid, decyl propargyl ester	47
28.343	0.44	Cholest-8-en-3-yl acetate	82

Table 4: Fatty acid profile and lipid related compounds of oil extracted from *Danwaken dawa*

Ret time	% Area	Fatty acid	Quality
16.615	0.15	Tetracosanoic acid (lignoceric acid)	69
17.882	16.06	n-pentadecanoic acid	94
19.681	64.30	11-octadecenoic acid (cis vaccenic acid)	95
19.782	4.77	n-octadecanoic acid	91
Other Lipid Related Compounds of Fatty acids			
13.248	0.17	Octadecanoic acid, 9,10-epoxy-, isopropyl ester	71
14.450	0.18	Undecanoic acid, 4,8-dimethyl-10-oxo-, methyl ester	53
15.365	0.38	3,7,11-Trimethyldodecylacetate	69
15.498	0.31	11,13-Dimethyl-12-tetradecen-1-ol acetate	61

The proximate composition (%) (Table 5) shows that both diets *Danwaken fulawa* had more carbohydrate and moisture content than *Danwaken dawa* and the mean differences in both parameters were found to be significant ($p>0.05$). However the mean values for ash, fat, crude fibre and protein content of *Danwaken dawa* were significantly higher ($p>0.05$) than *Danwaken fulawa* except for the protein which showed no significant difference ($p>0.05$). This shows that the carbohydrate content of *Danwaken dawa* was relatively moderate compared to *Danwaken fulawa.*

Table 5: Proximate composition of *Danwaken fulawa* and *Danwaken dawa* diets consumed in Bauchi and Gombe states

Parameter State / Samples	Moisture	Ash	Crude fibre	Crude fat	Crude protein	Carbohydrate	Energy (Kcal)
Bauchi : *danwaken fulawa*	10.9677 ± 0.4554^{a}	3.6736 ± 0.0789^{a}	1.9283 ± 0.0848^{a}	8.0239 ± 0.2150^{a}	10.8100 ± 0.7834^{a}	63.3623 ± 0.5781^{a}	368.9043 ± 1.2777^{a}
Gombe *: danwake dawa*	7.9333 ± 0.1894^{b}	5.5569 ± 0.1550^{b}	4.0333 ± 0.1816^{b}	12.7167 ± 0.9412^{b}	13.2611 ± 0.4060^{a}	54.5195 ± 2.3025^{b}	385.5723 ± 1.4986^{b}

Values are expressed as Mean±SEM, n=3. Values with the different alphabet on the same column are significantly different ($p<0.05$) with respect to each other.

The mean GI and GL values of both diets were observed be high, although there was no significant difference ($p<0.05$) in the mean GI between the two diets. The difference between the mean GL of both diets was significant ($p<0.05$). The BMI of all the volunteers for the GI protocol of both diets were normal and the mean difference was not significant ($p>0.05$).

Table 6: Carbohydrate content and mean glycemic index and load of prepared diets consumed around Bauchi and Gombe States

Food Samples	Weight of food served (g)	GI	GL	BMI (kg/m^2)
Danwaken fulawa **(BAUCHI)**	80	78.32 ± 1.28^{a}	49.63 ± 0.81^{a}	22.44 ± 0.34^{a}
Danwaken dawa **(GOMBE)**	91	76.52 ± 1.41^{a}	41.71 ± 0.77^{b}	21.49 ± 0.30^{a}

Results are Mean±SEM, n (number of volunteers for each diet) = 40 for GI, GL and BMI and values with different alphabetical superscript between rows are significantly different ($p<0.05$).

The blood glucose response is an expression of the symmetry between the availability of glucose and its removal from the blood circulation (Augustin *et al*., 2015). The standard reference food (Figure 1) which is white shows a higher and much sustained postprandial hyperglycemia. There was sharp rise in the blood glucose concentration after consumption of both diets but *Danwaken dawa* showed a slower and slighter rise thirty minutes after the meal. However, the blood glucose response of both diets showed significant decrease compared to the standard food after two hours.

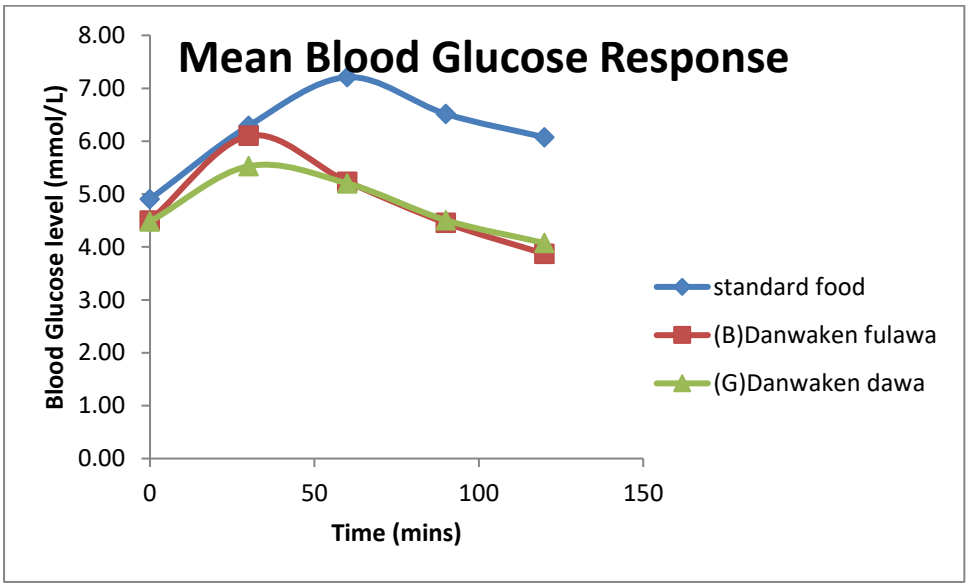


Figure 4: Mean Blood Glucose response curve (B): Bauchi, (G): Gombe

DISCUSSION

Data on food constituent is essential for the estimation of the quality of any diet and the advancement and application of established guidelines on dietary habits, which serves as a beneficial tool for professionals in the field of public health nutrition (Meyer, 2010). The amino acid composition of the two diets (Table 1) indicats that *Danwaken fulawa* mostly consumed in Bauchi contained lower quantity of amino acids when compared with *Danwaken dawa* mostly consumed in Gombe state. The concentrations of EAA and AA present in *Danwaken dawa* (367 and 912 mg/g protein) were higher than *Danwaken fulawa* (294 and 854.72 mg/g protein). The difference may have been from the individual ingredients that were used in the preparation of both diets as the integral ingredient for *Danwaken fulawa* is processed wheat flour while in that of *Danwaken dawa* combination of beans, sorghum and cassava flour formed the key ingredients. With beans, a legume which is known to be moderately rich in protein being part of the preparation mixture for *Danwaken dawa*, the amino acid content is predictably high (Mohammed *et al*., 2019). The concentration of glutamic acid was notably the highest in both diets with *Danwaken fulawa* having a higher concentration (228 mg/g protein) than *Danwaken dawa* (181.70 mg/g protein). The amino acid tryptophan was found to have the lowest concentration of 11.50 mg/g protein and 15.20 mg/g protein for both *Danwaken fulawa* and *Danwaken dawa* respectively. The concentration of the amino acid present in a given protein food matrix is a reflection of the quality of the protein available in that food component (Huang *et al*., 2018). A balanced dietary habit that is rich in protein was found to be beneficial for better cognitive function (Sakurai *et al*., 2023). Evaluation of the amino acid score of both diets (Table 2) revealed that *Danwaken dawa* had a higher score in all the limiting amino acids, although the scores for both diets were found to measure up to the WHO/FAO/UNU (2007)

requirements for all age groups with the exception of lysine. The score for lysine in *Danwaken dawa* met the requirement for all age groups in WHO/FAO/UNU (2007) except for children that are less than one year old, while the score for lysine in *Danwaken fulawa* did not meet the established WHO/FAO/UNU (2007) requirement for ages below 18 years. The amino acid score of similar prepared diet in the northwest region of Nigeria also showed *Danwaken dawa* to have a higher amino acid score compared to established WHO/FAO/UNU (2007) requirements for all age groups (Dangambo *et al.,* 2022).

The regular consumption of dietary fats with high percentage of trans fatty acids (TFA) has been strongly linked with the generation and progression of cardiovascular diseases, insulin resistance and endothelial dysfunction (Mozaffarian *et al.,* 2009). Substitution of saturated fatty acids (SAFA) with unsaturated fatty acids enhances the blood lipid and lipoprotein profile and decreases the risk of cardiovascular diseases. Fatty acid profiling studies can be useful for the investigation of epidemiological and nutritional relation with the aim of assessing the fatty acid status of the population. The fatty acid profile for both diets (Tables 3 and 4) showed that none of the essential fatty acids (EFA) was found to be present, although eicosanoic acid, a product of arachidonic acid which is a semi-essential fatty acid was present in *Danwaken fulawa*. The deficiency of EFA is not common, however regular consumption of diets devoid of EFA appears to play a critical role in the certain diseases such as diabetes mellitus, arthritis, renal hypertension, cardiovascular diseases (CVD) and low immune response to disease threat (Simopoulos, 1999). Also moderate consumption of EFA has been shown to reduce low density lipoprotein (LDL) and total cholesterol in circulation (Froyen *et al*., 2020). The fatty acid profiling of both diets indicated no trace of TFA, which is a good fat nutrition as consumption of TFA has been reported to be a significant contributor to the scourge of diabetes and coronary heart diseases (De Souza *et al.,* 2015). WHO has recommended a consumption limit of less < 1% of TFA of the total fat intake. The Nigerian government, through the National Agency for Food and Drug Administration and Control (NAFDAC) has approved the consumption of fats and oils and specifically TFA content to less 2% of dietary intake of fats and oils in accordance with the WHO advocacy campaign for mandatory standards towards reducing TFA in Nigerian food supply chain (WHO *et al*., 2022). Pentadecanoic acid (C15:0) was present in both prepared diets, although it is a saturated fatty acid, recent researches has demonstrated the broad positive impact it has on health such as being able to stem chronic cardiometabolic, liver and inflammatory diseases as well as possessing anti-inflammatory, immunomodulatory and antifibrotic activities (Venn Watson *et al*., 2020; Venn Watson *et al*., 2022). The other related compounds found in both diets (Tables 3 and 4) are mainly fatty acids esters i.e carboxylic acid esters. We observed that *Danwaken fulawa* (Table 3) contained more fatty acid esters than *Danwaken dawa* (Table 4). These lipid compounds may have been formed upon heat processing (cooking) of the diets as several different compounds can be produced from lipid degradation also their interaction with other compounds (Kerth *et al.,* 2020). Some of the compounds formed may contribute to the pleasant taste of the diets and while others may not have any plausible effect on the flavor of the diets. Oxidation of lipids in foods such as the oxidation of unsaturated fatty acids during food processing may result in the development of several volatile constituents of diets and this however depends on the component compounds of the diets and how they are being processed (Shahidi and Hossain, 2022).

The proximate composition of *Danwaken fulawa* and *Danwaken dawa* (table 5) shows that both diets had low percentage of protein with *Danwaken fulawa* having a lower percentage, however the difference was not significant ($p>0.05$). The ash, fat and crude fibre content of

Danwaken dawa was significantly higher than *Danwaken fulawa* ($p<0.05$). Result from Table 5 also reveal the carbohydrate and moisture content to be high with that of *Danwaken fulawa being* significantly higher ($p<0.05$) than *Danwaken dawa*. The findings from a recent study showed that high carbohydrate diets can modify insulin, triglycerides and high density lipoprotein (HDL) levels and that there is a connection between these parameters and the prevalence of coronary heart disease (Al Bahrani *et al*., 2023).

The results of the GI of both diets (Table 6) showed that both diets had high glycemic index when compared with the GI scale (<55 low GI, 55-70 medium GI, > 70 high GI) Augustin *et al*., 2015), however there was no significant difference ($p>0.05$) in the GI values of both diets. The evaluated GL values of both diets indicate that it had a high GL when compared with the GL scale (< 10 low GL, 11-20 medium GL and >20 high GL). The GL value of *Danwaken dawa* was lower than *Danwaken fulawa* and the difference between the two diets was significant ($p<0.05$). Although *Danwaken fulawa* had a higher carbohydrate, GI and GL values than *Danwaken dawa* and the difference in the carbohydrate content was statistically significant. The integral constituent ingredients that were used for the preparation of both diets were mainly of carbohydrate origin. This may have resulted in the high postprandial glucose level and a high GL value since GL incorporates the GI of the prepared diets and the carbohydrate quantity of calculated amount of the same diet. Substantial decrease in the carbohydrate content of food is an efficient way of improving postprandial blood glucose level in people with type 2 diabetes (Vlachos *et al*., 2020). *Danwake* is one of the most commonly consumed diets in northeastern region in Nigeria, ffrequent consumption of these diets in large quantity may result in severe health implication especially for people who are already suffering from certain chronic NCDs such as diabetes mellitus, obesity, and cardiovascular disease. A recent study reported that recurrent exposure to high glycemic index food has been implicated in the occurrence of breast cancer (Haluska *et al*., 2022). The glucose response (Figure 4) shows a rapid rise in the mean blood glucose level (BGL) observed in *Danwaken fulawa* was seen to be almost equivalent to the standard reference food (white bread) while *Danwaken fulawa* showed a slow rise in mean BGL after the first 30 minutes. There was a decline in the mean BGL for both diets after the next 30 minutes (an hour later) which declined further away from that of white bread and subsequently plunged lower than the initial BGL after 2 hours. The potential of any diet to raise blood glucose concentration articulates the quantity of carbohydrate consumed and the digestibility of the carbohydrate (Jenkins *et al*., 1981). Possible ways of attenuating postprandial hyperglycemia is by reducing the amount of glycaemic carbohydrate in the diet and the consumption of lower GI diets (Pasman *et al*., 2022).

There are little or no published data on similar prepared diets that could be directly compared with our results as there is no comprehensively compiled food composition database (FCDB) or food composition table (FCT) in Nigeria, and the international FCDB and FCT were not seen to contain nutritional data on the selected diets assessed in this study. Hence, the amino and fatty acid profiles and the GI and GL values obtained in this study could be compiled to the Nigeria food composition tables and may also be registered into the international FCDBs.

CONCLUSION

Danwaken dawa is a more nutritionally healthy diet compared to *Danwaken fulawa* as it had relatively lower GI and GL values, a higher amino and fatty acid content, as well as a higher amino acid score than *Danwaken fulawa*. However, we would recommend moderate consumption of both diets since it had high glycemic index values particularly with regards to people with diet related diseases such as diabetes, obesity and cardiovascular disease. Moreover, it can be consumed with vegetables such as cabbage, broccoli, cucumber, spinach

lettuce, onion and tomato or even any other fruit that is affordable and accessible as most fruits are known to contain more fiber and have low GI which may mitigate the GI effect of *Danwake*.

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