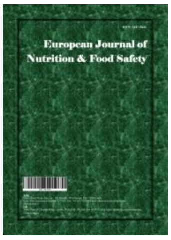

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Characterization of Traditional Foods and Diets in Rural Areas of Bauchi State, Nigeria: Analysis of Nutrient Components

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Objectives: Bauchi is one of the 36 states in Nigeria, the seventh most populous country in the world. This area has the second highest prevalence of thinness among women; with unacceptably high proportions of children 0 – 5 years being stunted. Household dietary intake is believed to be an underlying factor for this nutrition situation. Determination of the nutritional composition of traditional foods is essential in order to evaluate the dietary drivers of undernutrition, and to design interventions to promote sustainable, healthy diets. Yet data on the nutritional composition of traditional foods are lacking. Thus, this study measured the proximate and mineral composition of 31 traditional, composite foods consumed in Bauchi State, Nigeria.
Methods: Proximate analyses and assays for iron (Fe), zinc (Zn), copper (Cu), and calcium (Ca) were conducted according to methods stipulated by AOAC International.
Results: The protein content (9.12%) of *dambun tsakin masara da alaiho* (maize grits and

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spinach) and the Ca, Fe and Cu concentrations (89.64 mg, 6.01 mg and 0.31 mg per 100 g, respectively) of *dambun gero da zogale* (millet and Moringa) were the greatest among granulated dumplings. *Danwake wake da dawa* (cowpea and sorghum) had the greatest protein composition (4.78%) while *danwaken gujiya da masara* (Bambara nut and maize) had the highest Fe, Zn and Cu concentrations (3.97 mg, 1.20 mg and 0.28 mg, respectively) per 100 g of cooked dough balls. *Miyan karago* (powdered peanut cake soup) had the greatest protein concentration (11.40 %) per 100 g of soup. Among cereal paps, puddings and porridges, *Chanchangan dawa* (sorghum, peanut and beans porridge) had the highest protein content (6.43%). Of all foods analyzed, *dambun naman rago* (shredded, fried mutton) and *awara* (spicy, fried tofu) were richest in protein (49.31% and 16.86%) and iron (9.20 and 8.32 mg/100g), respectively.

Conclusion: Traditional foods with good nutrition profiles are available to support adequate nutrition of women and children in rural households in Bauchi State, despite widespread undernutrition.

Keywords: Nutrient composition; mineral concentrations; traditional foods; composite foods; Bauchi.

1. BACKGROUND

Undernutrition and micronutrient inadequacies are endemic public health concerns in developing countries [1]. Over the past three National and Demographic Health Surveys, the North-eastern region of Nigeria has consistently reported the highest prevalence of stunting, wasting and underweight in children, as compared to other regions [2,3,4]. Insufficient macro- and micronutrient intakes are underlying determinants of undernutrition in resource-poor households [5]. Lower mean daily intake of calories is prevalent in adults living in rural areas of Nigeria, as compared to those in urban areas (1691 vs 2061 Kcal for men; 1505 vs 1833 Kcal for women) [6]. Consequently, determination of the nutritional composition of diets fed in the home in this region is of prime importance [7,8].

Traditional foods are defined as foods consumed in a particular region by a specific community, and which have been transmitted between generations over time [9]. These foods contribute to the nutritional quality of diets of indigenous peoples, and have definitive features influenced by the culture and history of people in certain geographical regions [9,10]. Traditional foods are ethnologically acceptable and characterized by unique culinary practices and flavors native to specific societies [11]. They are differentiated by the use of food constituents and/or combinations, or methods of processing that have been passed down along several generations in distinct populations [12]. These may be consumed as single-item foods or composite dishes [13].

Composite foods are usually main dishes commonly eaten at lunch or dinner, often requiring culinary skills, as well as ingredients from a minimum of three out of five major food groups. These food groups include animal flesh and eggs; dairy; vegetables and fruits; starchy staples and legumes; as well as added fats/oils and sweets [14]. These foods are produced from recipes combining raw primary commodities and/or their derivatives [15]. The availability of nutritional information on composite dishes consumed in specific populations is essential for the compilation of food composition databases, determination of nutrient intakes and investigation of the relationships between food and health or disease [16,17].

The double burden of malnutrition (coexistence of obesity and undernutrition), coupled with the ongoing climate emergency, has been categorized as a global syndemic [18]. The syndemic, along with the high prevalence of micronutrient deficiencies, and a recent spike in food insecurity due to the COVID-19 pandemic, constitute a five-pronged crisis affecting the nutritional health and well-being of households in Nigeria [19,20,21]. In northern Nigeria, the impact on dietary intakes and health is aggravated further by violent conflicts, insurgency and desertification [21,22]. Traditional foods have been shown to contribute significantly to food security, as well as energy, protein and micronutrient intakes in Nigeria [23,24].

To date, there is inadequate documentation of the nutrient composition of numerous traditional foods, particularly in Nigeria [9,25,26]. The West African Food Composition Tables [27,28,29] and the Nigerian Food Composition Tables [30] present information on the nutritional value of numerous foods commonly consumed in all regions of Nigeria; but there is insufficient data on traditional foods consumed in North-eastern

Nigeria. A report on the micromineral content of 141 Nigerian foods [31] included only a few of the foods commonly consumed in Northern Nigeria. Limited data on indigenous meals are available for a few states including Jigawa in the north-west [32]; Nasarawa in the north-central [33]; Anambra, Enugu [34], and Abia [35] in the southeast; and Delta in the south-south of Nigeria [34]. In sum, a paucity of data exists on the nutrient profile of numerous foods included in traditional diets in the Bauchi State of North-eastern Nigeria.

Bauchi is the most populous of six states in the northeastern region of Nigeria, with over 4.6 million inhabitants [36]. Among women of reproductive age in Nigeria, the state has the third highest prevalence of thinness (23.9% vs 12% nationwide), as defined by body mass index below 18.5. Additionally, over two-thirds (68.6%) of women in Bauchi State are anemic, as compared to 58% nationally [3,4] and these rates are greater than national levels (75.7% vs 68%). Similarly, the proportions of children affected by stunting, underweight and wasting (54.7%, 31.9% and 8.5%) are higher than the national rates of 37%, 22% and 7%, respectively [4]. Furthermore, undernutrition may be exacerbated by endemic infectious diseases. Bauchi State has been identified as one of the hotspots for acute respiratory diseases, as well as acute diarrheal diseases[37,38]. Household dietary intake may be an underlying factor for the grim nutritional situation of women and children in this state. Therefore, it is necessary to identify the nutritional composition of traditional foods in Bauchi State, as a basis for estimation of dietary intake [9] in order to evaluate the dietary drivers of malnutrition and design interventions to promote sustainable, healthy diets [11,39]. This study focused on the proximate and selected mineral contents of 31 traditional, composite foods consumed in Bauchi State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Location

This study was conducted in the target Local Government Areas (LGAs) of Oxfam LINE Project, including Gamawa and Shira in Bauchi North, Darazo and Ningi in Bauchi Central, and Alkaleri and Tafawa Balewa in Bauchi South senatorial districts of Bauchi State, in northeastern Nigeria36. Bauchi State is located between latitudes 9° 3' and 12° 3' north of the equator and between longitude 8° 50' and 11° east of the Greenwich meridian. It spans through two distinctive vegetation zones, which are the Sudan and Sahel savannahs. It has 20 Local Government Areas (LGAs) occupying a total land area of 49, 119 km [2] (representing about 5.3% of Nigeria's total land mass), with a World Bank estimated population of 6,237,295 (RAAMP 2019). Bauchi State has a total of 55 ethnic groups, with diverse food consumption patterns [40].

2.2 Food Selection

A list of traditional foods was generated from six focus group discussions (1 per LGA), each having eight female participants of child-bearing age. Also, twelve key informant interviews (2 per LGA) were conducted with village chiefs and community leaders. The discussions and interviews were facilitated by trained personnel, conducted in the Hausa language, tape recorded, transcribed and translated into English and analyzed. The focus groups and key informants were asked to list foods consumed in their communities, with brief descriptions of the forms in which these foods are consumed. A total of 51 unique food items were listed in the six LGAs. These foods were also evaluated for frequency of consumption in comparison with a 72-item food frequency questionnaire (data not published), administered to one mother and one father in each of 718 households in the study area. Single-food items, as well as foods not frequently consumed were eliminated, resulting in a final list of 31 traditional, composite dishes selected for the study.

2.3 Food Sample Preparation

Focus group participants were consulted on a separate day, for generation of recipes for the composite dishes. Recipes for foods consumed in each LGA were determined by consensus of participants in the respective groups, and documented by the research team. Each focus group picked a central location for cooking, and identified two experienced women volunteers to be responsible for all food preparation activities. On a different day, food ingredients were purchased, prepared and cooked by the designated women. To ensure that the consensus recipes were followed, all focus group participants and researchers were present for cooking in the respective locations. The location from which food samples were collected are found in Supplementary Table 1.

2.4 Sample Collection

100 g samples of each food item 'as consumed' were collected and transported in an unbroken cold chain to the laboratory for analysis. Composite foods consumed in six major forms were analyzed: *danwake* (dumplings); *dambu* (granulated dumplings); *gwate, tuwo and kunnun* (porridges, paps and puddings); *miya* (soups); *shekara* (chips from wild roots); *awara, nono and dambun nama* (plant and animal protein foods).

2.5 Chemical Analyses

2.5.1 Proximate analysis

Each of the collected food samples was analyzed in triplicate. The moisture, crude protein, fat, crude fiber and ash were determined according to standard methods of analysis as stipulated by AOAC [41]: moisture was determined using a hot air oven (AOAC 925.40); protein by micro Kjeldahl method (AOAC, 950.48), fat by Soxhlet extraction, using diethyl ether (AOAC, 948.22); crude fiber by acid-base refluxing and ashing procedure (AOAC, 935.53); and ash content via a muffle furnace (AOAC, 950.49). Carbohydrate was estimated by difference.

Mineral analysis

Levels of calcium, iron, zinc and copper were analyzed at the Department of Human Nutrition and Department of Agronomy, University of Ibadan, Ibadan, Oyo State. Dried food samples were processed for mineral content, according to the method of AOAC (AOAC 2005), as modified by Akinyele and Shokunbi [42]. Briefly, 1 g of each dried sample was weighed into a porcelain crucible and dry-ashed in the Uniscope muffle furnace (model SM 9080, Surgifriend Medicals, England) by a stepwise increase of temperature up to 500°C within 1 h and then allowing it to ash at this temperature for the next 12 h. The residue was dissolved in about 10 mL of 1 M nitric acid (Sigma–Aldrich, Buchs, Switzerland), filtered into a 50 mL volumetric flask using Whatman filter paper and made up to mark with 1 M nitric acid. A Buck Scientific Atomic Absorption Spectrophotometer (210 VGP model, East Norwalk, Connecticut, USA) operating with an air/acetylene flame was used for determination of the mineral concentration of the foods.

2.6 Statistical Analysis

The mean proximate and mineral composition of the foods are reported in mg per 100 g edible portion on a fresh weight basis. Data were processed using the statistical package for social sciences (SPSS) version 22.0. The estimated mean concentrations per food group were compared using one-way analysis of variance (ANOVA). Pairwise comparison was further done using least significant difference (LSD) to establish pairs that have significant differences at $p < 0.05$.

3. RESULTS

The traditional dishes were prepared primarily with ingredients from three major food groups: starchy staples and legumes, vegetables, and fats/oils. A variety of cooking methods were identified. These include traditional pot-steaming for *dambu* (granulated dumplings); boiling and discarding of cook water for *danwake* (cooked dough balls); stewing for *miya* (soups); cooking in varying quantities of boiling water for *gwate, dahuwar, kunnu* and *shekara* (porridges, puddings, paps and wild roots) and deep frying for *dambun naman rago and awara* (shredded, fried mutton and spicy, fried soy curds). The list of main ingredients used in preparing the foods, as well as descriptions of the foods and cooking methods can be found in Supplementary Table 2.

The proximate composition of the traditional, composite foods is presented in Table 1. Moisture content of the foods ranged widely from 17.21 ± 0.03% in *dambun naman rago* (shredded and fried mutton), to 90.39 ± 0.02% in *kunnun Tsamiya* (millet and tamarind pap). Of five types of *dambu* (granulated dumplings), *dambun tsakin masara da alaiho* (maize grits and spinach dumplings) had the highest protein content (9.12 ± 0.06%). *Dambun gero da zogale* (millet and Moringa dumplings) had the greatest energy (240.03 Kcal/100 g), fat (9.05 ± 0.02%), fiber (2.05 ± 0.01%) and ash (3.35 ±0.01%) concentrations. Conversely, *dambun tsakin dawa* (sorghum grits dumplings) had the lowest amounts of energy (130.11 Kcal/100 g), protein (4.25 ± 0.04%), fat (1.67 ± 0.01%), carbohydrate (24.79 ± 0.02%), fiber (0.93 ± 0.01%) and ash (1.36 ± 0.01%). Per 100 g of *danwake* (cooked dough balls/dumplings), *danwake wake da dawa* (cooked dough balls made from cowpea and sorghum) was highest in energy (140.31 Kcal/100 g), protein (4.78 ± 0.02%), fat (4.38 ± 0.01%), fibre (1.86 ± 0.01%) and ash (1.95 ± 0.01%). This is in contrast to *danwake dawa da alabo* (cooked dough balls from sorghum and cassava flour) that had the lowest levels of these nutrients.

Table 1. Proximate composition of traditional, composite foods consumed in rural areas of Bauchi State

Food name in Hausa	Food name in English	Energy (Kcal)	Water (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	CHO (g/100 g)	Fiber (g/100 g)	Ash (g/100 g)
Dambu	**Granulated dumplings**							
Dambun tsakin masara da alaiho	Maize grits and spinach dumplings	189.6	54.11 ± 0.01	9.12 ± 0.06	3.28 ± 0.02	30.95 ± 0.03	1.94 ± 0.01	2.54 ± 0.02
Dambun gero da zogale	Millet and Moringa dumplings	240.03	47.91 ± 0.03	8.53± 0.07	9.05 ± 0.02	31.16 ± 0.06	2.05 ± 0.01	3.35 ± 0.01
Dambun masara da wake	Maize and cowpea dumplings	213.36	53.88 ± 0.03	8.79 ± 0.06	7.48 ± 0.01	27.82 ± 0.06	1.36 ± 0.01	2.04 ± 0.01
Dambun gujiya	Bambara nut dumplings	226.1	50.86 ± 0.015	6.71 ± 0.06	7.35 ± 0.015	33.32 ± 0.06	1.15 ± 0.01	1.76 ± 0.01
Dambun Tsakin Dawa	Sorghum grits dumplings	130.11	67.93 ± 0.04	4.25 ± 0.04	1.67 ± 0.01	24.79 ± 0.02	0.93 ± 0.01	1.36 ± 0.01
	Food group mean ± SD	200.22 [a]	59.94 ± 7.12 [a]	7.48 ± 1.88[b]	5.76 ± 2.90[b]	29.61 ± 3.08[a]	1.49 ± 0.45[a]	2.21 ± 0.71[a]
Danwake	**Cooked dough balls/dumplings**							
Danwaken gujiya da masara	Cooked dough balls from Bambara nut and maize	123.0	69.76 ± 0.04	4.32 ± 0.03	1.67 ± 0.03	22.60 ± 0.06	0.63 ± 0.01	1.64 ± 0.00
Danwake wake da dawa	Cooked dough balls from cowpea and sorghum	140.31	68.47 ± 0.01	4.78 ± 0.02	4.38 ± 0.01	20.42 ± 0.02	1.86 ± 0.01	1.95 ± 0.01
Danwake dawa da alabo	Cooked dough balls from sorghum and cassava flour	116.72	70. 49 ± 0.02	2.14 ± 0.03	0.24 ± 0.01	26.48 ± 0.06	0.50 ± 0.01	0.65 ± 0.01
	Food group mean ± SD	125.56[b]	69.57 ± 0.88[b]	3.75 ± 1.21[b]	2.10 ± 1.82[c]	23.17 ± 2.66[b]	1.00 ± 0.65[b]	1.41 ± 0.59[b]
Miya	**Soups**							
Miyan gyada	Groundnut soup	140.31	73.92 ± 0.03	7.47 ± 0.04	9.95 ± 0.02	5.96 ± 0.04	1.97 ± 0.02	2.7 ± 0.01
Miyan waken soya	Soybean soup	106.28	79.69 ± 0.02	5.99 ± 0.01	6.44 ± 0.01	6.09 ± 0.01	1.84 ± 0.00	1.79 ± 0.01
Miyan karago	Powdered peanut cake soup	157.8	68.61 ± 0.02	11.40 ± 0.03	9.55 ± 0.01	6.52 ± 0.04	2.31 ± 0.01	3.91 ± 0.01
Miyan tsamiya	Tamarind flower soup	156.64	71.71 ± 0.02	6.41 ± 0.03	11.81 ± 0.01	6.21 ± 0.03	1.82 ± 0.01	3.86 ± 0.00
Miyan kuka	Baobab Leaf soup	68.5	85.30 ± 0.03	2.66 ± 0.02	4.30 ± 0.1	4.80 ± 0.01	0.91 ± 0.01	2.95 ± 0.01
Miyan alaiho	Spinach soup	67.36	85.19 ± 0.03	3.08 ± 0.02	3.80 ± 0.01	5.2 ± 0.03	1.29 ± 0.01	2.73 ± 0.01
Miyan Yakuwa	Sorrel leaves soup	62.08	85.68 ± 0.03	3.23 ± 0.01	3.08 ± 0.00	5.34 ± 0.03	0.89 ± 0.00	2.67 ± 0.01
Miyan Ridi	Sesame seed soup	137.9	76. 35 ± 0.02	4.17 ± 0.03	11.26 ± 0.01	4.94 ± 0.4	1.81 ± 0.02	3.28 ± 0.01
Miyan kubewa	Okra soup	68.8	85.01 ±0.03	1.90 ± 0.02	4.68 ± 0.01	4.78 ± 0.02	1.23 ± 0.01	3.63 ± 0.01
	Food group mean ± SD	107.62[b]	79.05 ± 6.38[c]	5.14 ± 2.89[b]	7.21 ± 3.30[b]	5.54 ± 0.64[d]	1.56 ± 0.48[a]	3.06 ± 0.66[a]
Gwate	**Porridges, puddings, paps**							
Chanchangan Dawa	Guinea corn and beans porridge	186.2	59.40 ± 0.03	6.43 ± 0.04	5.61 ± 0.01	27.48 ± 0.07	1.25 + 0.01	1.08 + 0.00
Dahuwar Kuliya	Spicy rice and groundnut pudding	104.0	75.13 ± 0.01	2.77 ± 0.03	1.46± 0.01	19.95± 0.02	0.21±0.01	0.70± 0.01

Danmalele	Guinea corn pap with palm oil and spices	88.66	81.14 ± 0.06	1.22 ± 0.01	3.79 ± 0.01	12.54 ± 0.01	0.32 ± 0.01	1.32 ± 0.01
Dahowan gero	Millet pudding	116.96	71.21 ± 0.02	4.57 ± 0.03	1.84 ± 0.01	20.54 ± 0.05	0.41 ± 0.01	1.83 ± 0.01
Gwaten Dawa	Guinea corn porridge	70.5	83.31 ± 0.02	2.36 ± 0.02	1.79 ± 0.01	11.26 ± 0.02	1.28 ± 0.01	1.28 ± 0.01
Kunnun Tsamiya	Millet and Tamarind Pap	38.5	90.39 ± 0.02	0.97 ± 0.01	0.15 ± 0.00	8.33 ± 0.02	0.1 ± 0.00	0.16 ± 0.00
Tuwon Dawa	Guinea corn stiff pudding	87.22	77.69 ± 0.03	2.23 ± 0.02	0.25 ± 0.01	19.50 + 0.02	0.09 ± 0.01	0.32 ± 0.00
Gwaten Kanzo Masara	Porridge made from burnt crust of maize stiff pudding	84.68	79.10 ± 0 .02	3.40 ± 0.01	3.35 ± 0.12	12.70 ± 0.02	0.56 ± 0.01	1.45 ± 0.01
Kunnun Gyada	Millet and groundnut pap	91.99	79.55 ± 0.01	2.65 ± 0.01	2.31 ± 0.0	15.16 ± 0.01	0.81 ± 0.01	0.33 ± 0.00
Tuwon gero	Millet stiff pudding)	114.34	71.57 ± 0.02	3.25 ± 0.01	0.54 ± 0.01	24.1 ± 0.02	0.66 ± 0.01	0.54 ± 0.01
	Food group mean ± SD	99.54[b]	76.85 ± 8.03[bc]	2.98 ± 1.54[b]	2.11 ± 1.67[c]	17.16 ± 5.91[c]	0.57 ± 0.42[c]	0.90 ± 0.55[b]
	Plant and animal protein foods							
Dambun naman rago	Shredded and fried mutton	384.68	17.21 ± 0.03	49. 31 ± 0.03	16.26 ± 0.02	7.61± 0.01	2.39 ± 0.01	7.21 ± 0.01
Yamri/fura da nono	Dumplings served with fermented and skimmed cow's milk	105.0	75.37 ± 0.02	4.19 ± 0.04	2.04 ± 0.01	17.56 ± 0.07	0.56 ± 0.01	0.83 ± 0.01
Awara	Spicy, fried soy cheese/Soy curds/Tofu	221.92	68.81 ± 0.02	16.86 ± 0.04	11.35 ± 0.01	1.82 ± 0.05	0.71 ± 0.01	1.15 ± 0.01
	Food group mean ± SD	221.97[a]	53.80 ± 27.5[a]	26.79 ± 25.0[a]	9.89 ± 6.25[a]	6.46 ± 8.36[d]	1.22 ± 0.88[ab]	3.07 ± 3.11[a]
	Boiled wild roots							
Shekara	Boiled Burdock chips	213.36	67.54 ± 0.01	4.48 ± 0.01	4.82 ± 0.01	21.06 ± 0.01	1.03 ± 0.01	2.09 ± 0.01
	Food group mean ± SD	145.58[a]	67.54 ± 0.01[bc]	4.48 ± 0.01[b]	4.82 ± 0.01[b]	21.06 ± 0.01[bc]	1.03 ± 0.01[abc]	2.09 ± 0.01[ab]

Food group mean values having different superscript alphabetical letter (on the same column) are significantly different from each other at $p < 0.05$

Table 2. Mineral composition of traditional, composite foods consumed in rural areas of Bauchi State

	Food name in Hausa	Food name in English	Ca (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)	Cu (mg/100 g)
	Dambun	**Granulated dumplings**				
1.	*Dambun tsakin masara da alaiho*	Maize grits and Spinach Dumplings	73.38±0.08	4.48±0.05	1.11±0.02	0.26± 0.01
2.	*Dambun gero da zogale*	Millet and Moringa dumplings	89.64±0.38	6.01±0.06	1.57±0.05	0.31±0.02
3.	*Dambun masara da wake*	Maize and beans dumplings	34.48±0.09	2.51±0.05	1.46±0.01	0.30±0.00
4.	*Dambun gujiya*	Bambara Nut Dumplings	12.86 ± 0.02	1.58± 0.02	1.76 ± 0.00	0.19±0.03
5.	*Dambun Tsakin Dawa*	Guinea corn grits dumplings	76.23±0.23	3.74±0.04	0.88±0.00	0.19±0.01
		Food group mean ± SD	57.32 ± 30.39[ab]	3.66 ± 1.62[b]	1.35 ± 0.34[b]	0.25 ± 0.06[a]
	Danwake	**Cooked dough balls/dumplings**				
6.	*Danwaken gujiya da masara*	Bambara Nut and Maize cooked dough ball	9.26±0.02	3.97±0.05	1.20±0.00	0.28±0.00
7.	*Danwaken wake da dawa*	Cooked dough balls/dumplings made from cowpea and sorghum	13.75±0.04	2.10±0.06	0.98±0.00	0.198±0.00
8.	*Danwaken dawa da alabo*	Cooked dough balls made from sorghum and cassava flour)	9.78±0.20	3.22±0.04	0.75±0.00	0.15±0.00
		Food group mean ± SD	10.9 ± 2.21[ab]	3.06 ± 0.80[bc]	0.98 ± 0.20[b]	0.21 ± 0.06[ab]
	Miya	**Soups**				
9.	*Miyan gyada*	Groundnut soup	5.95±0.06	2.32±0.05	0.89±0.01	0.17±0.00
10.	*Miyan waken soya*	Soybean soup	33.55±0.07	3.09±0.01	0.94±0.03	0.21±0.00
11.	*Miyan karago*	Groundnut cake powder soup	5.181±0.05	5.49±0.04	1.30±0.00	0.33±0.00
12.	*Miyan Tsamiya*	Tamarind flower soup	379.39± 0.31	2.41±0.07	1.19±0.00	0.10±0.00
13.	*Miyan kuka*	Baobab Leaf soup	45.00±1.06	3.78±0.02	0.45±0.00	0.082±0.00
14.	*Miyan alaiho*	Spinach soup	32.18±0.11	2.90±0.04	0.49±0.00	0.16±0.00
15.	*Miyan yakuwa*	Sorrel leaves soup	22.88±0.11	3.02±0.01	0.42±0.00	0.11±0.00
16.	*Miyan ridi*	Sesame seed soup	40.14±0.25	5.98±0.01	1.13±0.00	0.18±0.00
17.	*Miyan kubewa*	Okra soup	22.55 ± 0.21	3.83±0.01	0.44±0.00	0.084±0.00
		Food group mean ± SD	65.26 ± 115.07[a]	3.65 ± 1.26[b]	0.81 ± 0.35[b]	0.16 ± 0.08[b]
		Porridges, puddings, paps				
18.	*Chanchangan dawa*	Guinea corn and beans porridge	6.55±0.04	1.81±0.043	1.06±0.01	0.20±0.00
19.	*Dahuwar kuliya*	Spicy rice and groundnut pudding	3.72±0.04	0.66±0.01	0.71±0.01	0.12±0.00
20.	*Guinea corn pap with palm oil and spices*	Danmalele	2.32±0.01	1.92±0.03	0.38±0.00	0.070±0.00
21.	*Dahowan gero*	Millet pudding	6.38±0.04	0.69±0.02	0.84±0.00	0.13±0.00
22.	*Gwaten dawa*	Guinea corn porridge	25.88±0.06	2.03±0.03	0.52±0.00	0.07±0.00
23.	*Kunnun Tsamiya*	Millet and Tamarind Pap	1.85±0.00	0.79±0.01	0.29±0.00	0.03±0.00
24.	*Tuwon dawa*	Guinea corn stiff pudding	0.840±0.02	3.28±0.01	0.62±0.00	0.13±0.00

25.	*Gwaten kanzo masara*	Porridge made from burnt crust of maize stiff pudding	10.64±0.08	3.12±0.02	0.63±0.00	0.11±0.00
26.	*Kunnun gyada*	Millet and groundnut pap	1.21±0.07	2.28±0.01	0.49±0.00	0.07±0.00
27.	*Tuwon gero*	Millet stiff pudding)	2.31±0.02	2.41±0.03	1.15±0.01	0.12±0.00
		Food group mean ± SD	6.18 ± 7.37[b]	1.90 ± 0.92[c]	0.67 ± 0.27[b]	0.11 ± 0.05[c]
		Plant and animal protein foods				
28.	*Dambun naman rago*	Shredded and fried mutton	138.76±0.3	9.20±0.09	7.54±0.00	0.41±0.00
29.	*YamrifFura da nono*	Dumplings served with cooked, fermented milk	58.06±0.08	1.33±0.06	0.86±0.00	0.09±0.00
30.	*Awara*	Soy cheese/Soy curds/Tofu	52.4±0.06	8.32±0.01	1.72±0.04	0.14±0.00
		Food group mean ± SD	83.09 ± 43.2[a]	6.30 ± 3.87[a]	3.37 ± 3.25[a]	0.21 ± 0.15[ab]
		Boiled wild roots				
31.	*Shekara*	Boiled Burdock chips	6.91±0.02	1.18±0.04	0.46±0.01	0.16±0.01
		Food group mean ± SD	6.91±0.02[ab]	1.18±0.04[bc]	0.46±0.01[b]	0.16±0.01[abc]

Food group mean values having different superscript alphabetical letter (on the same column) are significantly different from each other at $p < 0.05$

Of nine soups, *miyan kubewa* (okra soup) and *miyan karago* (powdered peanut cake soup) had the lowest and highest protein (1.90 ± 0.02% vs 11.40 ± 0.03%). Also, *miyan karago* was highest in fiber (2.31 ± 0.01%) and ash (3.91 ± 0.01%). *Chanchangan dawa* (sorghum, beans and peanut porridge) had the highest energy (186.2 Kcal/100 g), protein (6.43 ± 0.04%) and fat (5.61 ± 0.01%) content of ten cereal puddings, paps and porridges. In contrast, *kunnun Tsamiya* (millet and Tamarind Pap) had the lowest energy (38.5 Kcal/100 g), protein (0.97 ± 0.01%), fat (0.15 ± 0.00%), and ash (0.16 ± 0.00%) of the puddings, paps and porridges. *Dambun naman rago* (shredded, fried, mutton) and *awara* (spicy, fried tofu) were excellent sources of protein (49.31% and 16.86%) and fat (16.26 ± 0.02% and 11.35 ± 0.01%), respectively. The wild root *Shekara* (boiled Burdock chips served with powdered peanut cake), had a higher protein content (4.48 ± 0.01%) than eight of the ten puddings, paps and porridges.

In Table 2, the mineral (Ca, Fe, Zn and Cu) composition of the traditional composite foods is presented. *Dambun gero da zogale* (millet and Moringa dumplings) was richest in Ca (89.64±0.38 mg), Fe (6.01±0.06 mg mg) and Cu (0.31±0.02 mg) per 100 g of *dambu.* Of three types of *danwake*, the highest Ca content (13.75 ± 0.04mg/100 g) was found in *Danwake wake da dawa* (cooked dough balls from cowpea and sorghum), while Fe (3.97 ± 0.05 mg/100 g), Zn (1.20 ± 0.00 mg/100 g) and Cu (0.28 ±0.00 mg/100 g) were highest in *danwaken gujiya da masara* (Bambara nut and maize cooked dough ball). The soups richest in mineral elements were *miyan tsamiya* (Tamarind leaf soup, Ca = 379.39 ± 0.31); *miyan ridi* (Sesame seed soup, Fe = 5.98 ± 0.01 mg/100 g); and *miyan karago* (powdered peanut cake soup, Zn = 1.30 ± 0.00 mg/100 g, Cu = 0.33 ± 0.00 mg/100 g). Among the puddings, paps and porridges, *gwaten dawa* (sorghum porridge) had the highest amount of Ca (25.88 ± 0.06 mg) per 100 g. *Tuwon dawa* (stiff sorghum pudding) and *gwaten kanzo masara* (porridge made from burnt crust of leftover, stiff pudding) were the richest sources of Fe (3.28±0.01 mg/100 g and 3.12 ± 0.02 mg/100 g, respectively); while Zn (0.20 ± 0.00 mg/100 g) was highest in *chanchangan dawa* (sorghum and beans porridge). The three plant and animal protein foods analyzed in this study were rich in Ca, ranging from 52.4 - 138.76 mg/100 g. *Dambun naman rago* (shredded, fried mutton) had the greatest content of iron (9.20 ± 0.09 mg) per 100 g of plant and animal protein food. Nonetheless, *awara* (spicy, fried tofu) was similarly high in iron (8.32 ± 0.01 mg/100 g).

4. DISCUSSION

The present study provides information on the nutritive composition of traditional, composite foods commonly consumed in rural areas of Bauchi State, Nigeria. The protein, fat, Ca and Zn concentrations varied widely across the different types of foods analyzed. The results have shown that the nutrient content of the foods was influenced by the specific food groups utilized in the preparation of the dishes, as well as preparation methods. The higher protein in *dambun tsakin masara da alaiho,* as compared to other types of *dambu* in this study, may be attributable to the content of *karago (*powdered peanut cake) in this food. Peanut cake is a common, relatively inexpensive snack in northern Nigeria that is rich in protein (25.2 – 46.18%) [43]. When ground into powder, it serves as a versatile food ingredient for seasoning barbequed meats, fried foods, porridges, puddings and salads; as well as a thickening agent for soups and sauces. Badau *et al* have shown that consuming 100 – 300 g of *dambu* formulated with fresh peanuts in the laboratory can meet the average daily requirement for some macronutrients, Ca and Zn [44]. Traditional *dambu* with high proportions of powdered peanut cake can contribute substantially to increasing nutrient intakes of women and children, and reducing undernutrition within the sub-region.

Dambun gero da zogale (millet and Moringa dumplings) had the greatest concentrations of fiber, Ca, Fe and Cu, explainable by the inclusion of Moringa leaves in the recipe. Moringa is a drought-tolerant tree plant that thrives in the semi-arid savanna of northern Nigeria, and is common in many rural households in the region [45,46]. It is rich in essential micronutrients, and reportedly prescribed for anemia in this region [47]. Despite variations in ingredients, mode of preparation and formulations, the protein content of *dambu* in the present study is similar to that reported [48] in Bauchi metropolis; nonetheless protein, iron, zinc and copper in this study were lower than the values for *dambun masara* in Borno State, Nigeria [44]. This discrepancy may have arisen from differing methods of preparation, moisture contents and proportions of cereals and legumes in the mixtures.

Of the three types of *danwake* analyzed, *danwake wake da dawa* (cooked dough balls made from cowpea and sorghum) had the highest composition for most of the parameters. It also contained a combination of two legumes (cowpea and peanuts) and one cereal. The protein (dry matter basis), zinc and iron content of *danwake* in the current study are comparable to *danwake* made from varying mixtures of sorghum, cowpea, wheat and cassava flours in Borno State, Nigeria [49]. The Bambara nut content of *danwaken gujiya da masara* (Bambara nut and maize cooked dough ball) may be responsible for the higher Fe, Zn and Cu content of this food. Bambara nut is an under-utilized, climate-resilient crop, that has adapted to a broad range of adverse ecological conditions, including poor quality soil and drought [50]. It is rich in essential macro- and micronutrients, particularly protein, Fe and Ca [51]. Traditional *danwake* prepared with Bambara nut would contribute substantially to improving micronutrient intakes in the area.

In the current study, *miyan kubewa*, *miyan kuka*, *miyan alaiho*, and *miyan yakuwa* which are the most commonly consumed soups in the study area had the lowest protein content. The protein content (2.67%) of *miyan kubewa* in this research was lower than the value 4.36% observed by Nnam and Nwofor [52]. Conversely, peanut-based soups (*miyan karago* and *miyan gyada)* had the highest protein composition of all the soups. Regular consumption of these soups as accompaniments for starchy staples can help ameliorate nutrient deficiencies in households with limited access to animal source foods [53]. *Miyan kuka* (Baobab leaf soup)*, miyan ridi* (sesame seed soup) and *miyan karago* (powdered peanut cake soup) had the greatest contents of Ca, Fe and Zn, respectively. Baobab leaves, sesame seeds and powdered peanut cake are abundant in mineral elements including Ca, Fe and Zn [54,55,43]. Public enlightenment campaigns could promote the consumption of the more nutrient-dense soups, since most households cultivate these ingredients on their farms.

Chanchangan dawa had the richest macronutrient profile among the porridges, paps and puddings. The utilization of two legumes (beans and cowpea), in addition to cereal, may have contributed to the higher protein content in this food. *Gwaten Kanzo masara* is a réchauffé dish, defined as a warmed-up food prepared with left-overs from a previous meal [56]. *Gwaten kanzo masara* is made from the burnt crust of stiff cereal pudding, whole peanuts and peanut paste. It is an important dish that reduces food waste, as the crust would ordinarily have been discarded as pot waste. This dish also contributes to food security in times of widespread food shortage, as families can get more value out of a single meal, when the crust is re-used. Of ten puddings, paps and porridges evaluated, g*waten kanzo masara* was the third highest source of protein, and second highest in Ca and Fe. Among the puddings, paps and porridges, k*unnun tsamiya* and *danmalele* had the least protein. *Kunnun tsamiya* is used as a weaning food, with the cultural notion of providing nutritional and medicinal benefits [23]. During the focus group discussions in this study, *danmalele* was reported as a food perceived to be good for children, and commonly used for weaning. Nonetheless, the nutritional profile (protein, energy, calcium, zinc and copper) of *danmalele* was quite poor. Traditional weaning foods in West Africa are known to be of low nutritional value and are characterized by low protein, low energy density, and high bulk [57,58]. Maize pap or *koko* has been implicated in the etiology of protein-energy malnutrition in children during the weaning period [59]. Due to the poor nutritional value of this food, *danmalele* may be enriched with inexpensive legume products such as powdered peanut cake or soybean powder for better nutritional outcomes.

The protein, fiber and ash contents of mutton-based *dambun naman rago* indicated in the present study are higher than the values indicated for beef-based *dambun nama* by Eke [60]. This may be as a result of the differences in proximate composition between beef and mutton. Furthermore, the protein and ash contents of mutton-based *dambun nama* observed in this study were similar to those reported by Abubakar et al of protein and ash contents of 42.2 – 59.9% and 5.3 – 7.4% respectively, for *dambun nama* produced from non-ruminant animals such as rabbits and chickens [61]. Due to prevailing economic challenges in the study area, large proportions of households cannot afford animal source foods regularly. Yet, during annual religious and cultural festivals, there is usually an abundance of mutton, which is either completely used up or wasted in the absence of affordable food preservation methods. *Dambu*n *nama* generally has a relatively long shelf life [62]. Thus, processing excess mutton into *dambun naman rago* can extend the period when households have access to animal source foods.

In northern Nigeria, a*wara is* usually consumed as a snack, as part of a main dish, or served as a side dish. In this study, *awara* (spicy, fried tofu) was found to be very rich in protein and energy. In developing countries, insufficient protein in the diet predisposes a large percentage of the population to malnutrition [62]. Alternative sources of protein from legumes are essential to meet protein demands in regions where animal protein is either grossly inadequate or relatively expensive. Soybean (*Glycine max*) is a versatile legume that constitutes a staple food to millions of people in West and Central Africa. It is the richest and cheapest source of vegetable protein available [62,63,64,65]. Thus, *awara* can be used as a cheap alternative to animal protein, and consumed along with other foods to improve household nutrient intakes.

Burdock tuber, a wild edible root that looks like sweet potato, is a potential food security crop. The nutrient profile of *shekara* (boiled Burdock chips with powdered peanut cake) observed in this study, denotes a food that can support adequate nutrition during harsh environmental and economic conditions, including the post-COVID-19 era. Nonetheless, *shekara* requires steeping in water for 3-4 days to eliminate bitter-tasting guaianolide constituents for improved palatability [66]. Further studies should be conducted to characterize the chemical composition of Burdock root, and elucidate more efficient means of eliminating the bitter taste. Additionally, *tafasa* used in the preparation of *dambun tsakin dawa* is a wild edible vegetable that can contribute to micronutrient intakes in low-income households. The resilience of these wild edible plants allows them to thrive where other cultivated species would fail [67,68], thus these can act as safety nets in times of food shortage and famine.

Food samples analyzed in this study were comprised mostly of food ingredients from only a few food groups, with a minimal number of animal-source foods. This is a reflection of limited diversity of diets in the study area. This is consistent with the findings that in resource-constrained settings worldwide, monotonous diets of inadequate quality are common, often contributing to diminished micronutrient availability from foods consumed in these households [69,70,71]. Diets in low-income households are composed predominantly of starchy staple foods of plant origin, often processed and/or cooked using methods associated with considerable losses of micro nutrients [72]. One method identified in the current research is boiling in water and discarding of cooking water, utilized in the preparation of *danwake* (cooked dough balls). Despite having similar food ingredients, the notably lower protein, calcium, iron and zinc contents of *danwake* as compared to *dambu*, may be explainable by leaching of nutrients into cooking water,[73] and subsequent loss of these nutrients when cook water is discarded [49,74]. *Danwake* is an important meal in northern Nigeria due to its short cooking time (15-30 minutes) and high satiety value [49]. Thus, further studies are needed to quantify the nutrient losses in preparation of *danwake.* Alternative cooking methods that conserve nutrients should be evaluated for acceptability.

Composite foods including *awara,* those containing combinations of two cereals and one legume, or peanut cake powder, have been demonstrated to have superior nutrient values. Among other factors, limited knowledge of household members on appropriate ways of combining these foods for optimum nutrition may contribute to the prevalence of undernutrition in the study area [75]. The rich nutritional profile, affordability and versatility of peanut cake powder can provide a sustainable means of improving nutrient intakes in low-income households. Conversely, peanut cake powder is abundant in fats, thus, the lipid profile of this food ingredient as well as its long-term effects on health of the study population require further investigation. Furthermore, peanuts are known to be potent allergens. Yet, peanut allergy is reportedly less common in developing countries as compared to developed countries [76]. A novel pathophysiology for the reduced incidence of peanut allergies in low-income countries has been demonstrated [77]. An inverse relationship exists between helminth infestation prevalent in these countries, and peanut allergenic positivity [78,79]. This is presumably due to antigenic cross-reactivity between antibody constituents of peanuts and helminthes [77]. Further research is needed to explore the immunological effects of peanut consumption in Nigeria.

5. CONCLUSION

In conclusion, traditional foods rich in macro- and micronutrients were identified in the study area. Although malnutrition is rife in these locations, this research has shown that some relatively cheap, traditional foods with good nutrition profiles are available and can support adequate nutrition in rural households. Interventions should be designed to improve the knowledge of household members on appropriate ways of combining and utilizing these traditional foods. This will promote sustainable, healthy diets and improve the nutritional status of women and children in rural areas in Bauchi State.

SUPPLEMENTARY METIRIALS

Supplementary metirials available in this link: https://www.journalejnfs.com/index.php/EJNFS/libraryFiles/downloadPublic/10

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by the non-profit Oxfam LINE Project, Bauchi.

CONSENT

Informed consent was obtained from the study participants at the site of recruitment. Parental permission was obtained for young children.

ETHICAL APPROVAL

The study received approval from the Bauchi State Ministry of Health Ethics Review Committee.

DISCLOSURES

Mercy E. Sosanya received funding for the study from Oxfam LINE Project, Bauchi. Ayodele O. Gbemileke was an employee of Oxfam LINE Project during the study. Jeanne H. Freeland-Graves, Funke F. Adeosun, Folake O. Samuel and Olutayo S. Shokunbi have no competing interests to declare.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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