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Original Research

Validity and Reproducibility of a Semiquantitative Food Frequency Questionnaire and Food Picture Book in Nigeria

Galya Bigman [1], Sally N Adebamowo [1,2,3], Nutrition Epidemiology Research of Nigeria (NERON) Group[1], Clement A Adebamowo [1,2,3,*]

[1] *Department of Research, Center for Bioethics and Research, Ibadan, Nigeria;* [2] *Department of Epidemiology and Public Health, University of Maryland School of Medicine, Baltimore, MD, United States;* [3] *Greenebaum Comprehensive Cancer Center, University of Maryland School of Medicine, Baltimore, MD, United States*

A B S T R A C T

Background: Increasing noncommunicable diseases in Nigeria are partly related to dietary factors. However, the lack of validated nutrition assessment tools hinders the conduct of nutritional epidemiology research in this population.
Objectives: To develop a Food Frequency Questionnaire (FFQ) and Food Picture Book (FPB) for Nigerian adults, and to assess its reproducibility and validity compared with 24-h dietary recalls (24DRs) during different seasons in the year.
Methods: We compiled 202 foods for the FFQ through focus groups and consultations with local dietitians. We created an FPB with standardized food portion images to enhance the accuracy of reports of dietary intakes. We administered the FFQs to 205 purposively selected adults in Ibadan, Nigeria at ~6 monthly intervals between November 2018 and October 2020. We evaluated the FFQ's reproducibility and validity compared with 24DR across the dry and rainy seasons by examining the consumption of common food and mixed dishes. We computed the Spearman's correlation coefficients (SCC), intraclass correlation coefficients (ICC), and Wilcoxon signed-rank tests, and generated Bland and Altman plots.
Results: Overall, we studied 110 women (53.7%) and 95 men (46.3%) with a mean age of 45.0 ± 13.4 y (mean ± SD). The reproducibility tests showed a mean ± SD SCC of 0.39 ± 0.14 and mean ± SD ICC of 0.32 ± 0.12. Higher mean ± SD SCC values were noted for cereal products (0.43 ± 0.09), starchy roots and tubers (0.45 ± 0.17), and soups (0.44 ± 0.20). Conversely, lower mean ± SD SCC values were observed for milk products (0.29 ± 0.02), solid fats (0.29 ± 0.26), and fish (0.22 ± 0.19). Regarding validity tests, the overall mean ± SD SCC was 0.27 ± 0.16 and mean ± SD ICC was 0.26 ± 0.16. We observed seasonal variations in intakes of fruits, cassava flour-based products, and nuts, although most foods did not show significant differences in intakes between seasons.
Conclusions: Our FFQ and FPB demonstrated moderate correlations and seasonal variations in intakes of certain foods, emphasizing the need to account for seasonality in dietary intakes in nutritional studies in Nigeria and similar countries.

Keywords: validation, reproducibility, Semiquantitative Food Frequency Questionnaire, Food Picture Book, Nigeria

Introduction

In recent decades, African countries have experienced a significant increase in the incidence of many noncommunicable diseases (NCDs), notably obesity and its associated comorbidities, such as cardiovascular diseases, diabetes, and cancer [1–5]. This trend is evident in Nigeria, where the prevalence of overweight has risen steadily to 26%–27% and that of obesity has increased to 14%–15% [1–2]. This increase is partly attributed to the "nutrition transition," primarily taking place in urban areas and reflecting broader dietary changes in Africa. This transition involves a shift toward the consumption of energy-dense, high-fat, and high-sugar foods, with particular emphasis on animal-based products and processed foods, often at

Abbreviations: FFQ, Food Frequency Questionnaire; FPB, Food Picture Book; ICC, intraclass correlation coefficients; NCD, noncommunicable disease; SCC, Spearman's correlation coefficient.

* Corresponding author. *E-mail address:* cadebamowo@som.umaryland.edu (C.A. Adebamowo).

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the expense of traditional whole cereals and pulses, which are rich in valuable nutrients [5–10].

Despite these changes, there is a dearth of nutritional epidemiological research in SSA because of the limited availability of validated dietary assessment tools tailored to the unique characteristics of African diets and cuisine. The invaluable tools for conducting nutrition epidemiology studies include different types of Food Frequency Questionnaires (FFQ) [11,12]. The FFQ is designed to capture long-term dietary intakes, gathering information on the frequencies and quantities of food and beverages taken, typically in the preceding year. The strengths of the FFQ method include its ability to assess habitual dietary intake, minimize intra-individual and day-to-day variability, be cost-effective, and capture past dietary patterns. Despite its inherent measurement error, the FFQ tends to perform effectively in large-scale studies [13]. It is necessary to customize FFQs to the dietary intake preferences of the studied population followed by validation by comparing it to other dietary methods, usually 24-h dietary recall (24DR). The data collected using the reproducible and validated FFQ are used to evaluate associations between individuals' foods and nutrients' intakes and risk of various health outcomes [11–14].

Nigeria is the most populous nation in Africa and is projected to become the third most populous country in the world by 2050 [15]. The country boasts remarkable diversity, with over 500 distinct ethnic groups, each contributing to a rich tapestry of cultures and dietary practices. Because of its geographical location in equatorial Africa, Nigeria experiences 2 predominant seasons—the dry and rainy seasons—which significantly affect the availability of locally sourced foods, although staples like rice and wheat are usually imported [9]. Recently, there has been a proliferation of fast-casual dining establishments and takeaway restaurants that have incorporated numerous traditional Nigerian dishes into their menus [9,16,17]. This has led to a trend toward standardization of portion sizes. However, most Nigerians continue to primarily eat at home, where food portion sizes remain nonstandardized [9]. As a result, when conducting dietary intake studies with FFQs in places like Nigeria, it is crucial to employ tools that can capture and standardize portion sizes across all study participants. Indeed, a viable tool for addressing this challenge is the Food Picture Book (FPB), which has been shown in numerous studies to enable participants to use portion size images as an aide memoire in completing FFQs [18–22].

To conduct nutrition epidemiology research in the adult Nigerian population, taking account of local foods, dietary patterns, and lack of widely accepted uniform portion sizes, we developed a semiquantitative FFQ and a complementary FPB featuring typical Nigerian foods and their corresponding standardized portion sizes. We evaluated the seasonal reproducibility and validity of the semiquantitative FFQ and the FPB and hypothesized that they would demonstrate sufficient reproducibility and validity across seasons over a 12-mo interval.

Methods

Development of the semiquantitative FFQ

The development of the semiquantitative FFQ, along with its FPB, was divided into 5 major sections:

1) The creation of a comprehensive food list based on typical Nigerian cuisine involved several steps. First, we conducted a thorough evaluation of published literature, reports, books, and food lists from reputable sources such as the FAO [23], USDA [24], and other relevant references [25]. Subsequently, the compiled food lists underwent a review process conducted by 2 Focus Groups, comprising randomly selected Nigerian adults, CAA and SNA (Nigerian Nutrition Epidemiologists), along with input from 3 dietitians. Through this collaborative effort, we identified a total of 202 food items commonly found in Nigerian cuisine.
2) The food items in the FFQ were categorized based on multiple criteria, including their core constituents (e.g., protein, carbohydrate, and fat), their physical composition (e.g., grains, breakfast cereals, dairy, and nuts), and their cultural use (e.g., swallows, beans and porridges, and starchy roots, and tubers). For example, "cereals and grain products" include items like rice, noodles, spaghetti, and various breakfast cereals, while also encompassing high-fiber options and mixed dishes made predominantly of grains, such as meat pie, bread rolls, and tarts. The category "starchy roots and tubers" encompasses different forms of swallow (traditional pounded yam, semolina, cassava flour, etc.), cooked roots and tubers (boiled yam, fried sweet potatoes, etc.), and various porridge options (yam, plantain, and potato). Fruits comprise a wide range of fresh fruits like bananas, oranges, apples, and tangerines that are consumed depending on seasonal availabilities. Soups include a variety of types, such as vegetable soup, pepper soup, egusi, and stew that are based mostly on leafy vegetables and proteins such as fish, chicken, and beef. The "legumes" category mostly covers products made from beans like gbegiri and adalu. Protein foods consist mainly of meat, poultry, and various fish, including freshwater (tilapia, carp, catfish, crayfish) and some saltwater varieties (sardines, bonga, and mackerel) (Table 1). In Nigeria, milk is consumed mostly as evaporated milk (shelf-stable canned cow milk product where ~60% of the water has been removed from fresh milk) or powdered milk. In addition, the preferred cooking oil is palm oil [9]. "Nuts and Seeds" cover items like walnuts, peanut butter, and cashew nuts. "Beverages" include mostly water, chocolate drinks (e.g., Milo), soda, and tea. "Nigerian snacks" cover various types of chips made from cocoyam, potato, corn, or plantain. "Condiments and Spices" include food additives such as ginger, garlic, and African locust bean/iru. We arranged the food items in each food category according to their frequency of use in descending order, that is from the "most frequently consumed" to the least frequently consumed foods for ease of administration.
3) Evaluation of standardized food portions for the FPB. We defined reference portion sizes based on the commonly used portion sizes in homes, eateries, and at public occasions in Nigeria and on generally available standard household measurement items such as tablespoons, teaspoons, serving spoons, and a 25-cl mug, etc. For accuracy in quantification of foods, we compiled an FPB to

TABLE 1
List of all the food items and their corresponding categories and subcategories listed in the semiquantitative FFQ

Food main categories	Subcategories	Food items in the semiquantitative FFQ
Cereals and grain products	Rice	Rice (white, jollof, fried, Ofada, coconut, brown)
	Wheat	Noodle, spaghetti, macaroni, bread
	Breakfast Cereals	Pap from corn, millet meal (Pap), breakfast cereal (cornflakes, Rice Krispies, etc.), oats, custard, high-fiber cereals like bran
	Corn	Popcorn, corn cob
	Mixed dishes	Meat pie, bread rolls, cake, tarts, scones, muffins, pancakes, flatbread, doughnut, fried dough, buns, puff puff, vegetable pie
Starchy roots and tubers	Roots and tubers (starchy vegetables)	Swallows: traditional pounded yam, pounded yam from flour, semolina, eba, amala, tuwon shinkafa, fufu or akpu, tuwon masara, tuwon dawa, tuwon gero, cassava flour swallow, plantain flour swallow (Lamala), ground rice (rice flour) swallow, and wheat flour swallow Cooked roots and tubers: boiled yam, fried yam (Dundu), plantain (boiling, steaming, or roasting), cocoyam, boiled sweet potato, fried sweet potato, boiled Irish potato, nonchip fried Irish potato, boiled cassava, fried sliced plantain Porridge: porridge (yam, plantain, potato porridge–Irish/sweet potato)
Vegetables	Whole vegetables/salad	Carrot, cucumber, garden egg, salad
Fruits	Whole Fruits	Banana, orange, apple, tangerine, guava, mango, plum, peaches, African pear (IB: Ube), lemon, lime, avocado, apricot, passion fruit, African cherry (YR: Agbalumo), pineapple, grapes, pawpaw, grapes, watermelon, sweet melon, berries, baobab (HA: Kuka fruit), jackfruit (bread fruit)
	Others	Tamarind (HA: Tsamiya), raisins, dates, sugarcane
Soups (leafy vegetables with/without meat/fish/chicken)		Vegetable soup (YR: Efo; HA: Taushe), bles, pepper soup, edi ka ikong, kuka, banga, bitter leaf soup, white soup, cowpea leaves soup, cassava leaves soup, pumpkin leaves soup (Ugwu), water leaves soup, cocoyam leaves soup, stew, egusi with vegetable, ogbono, amaranthus, okro sliced (HA: Kubewa), okro mixed (YR: Ila Asepo)
Legumes and products	Legumes (beans)	Beans alone, porridge beans, beans and corn (Adalu), bean soup (gbegiri), bean cake (YR: Akara), bean pudding (red beans)
Meat and poultry	Poultry	Chicken with or without Skin (boiled/fried/grilled), turkey, guinea fowl
	Meat	Beef (boiled/fried), goat meat (boiled/fried), pork (boiled/fried), lamb/mutton (boiled/fried), liver (boiled/fried), processed cow skin, offal/tripe, bushmeat, suya, bacon, meat minced, canned meats, snail
Fish and products	Fish (fresh/saltwater)	Saltwater (sea)/freshwater (river/lake) (boiled/fried), dried/smoked fish, sardines, shrimp and prawns
Eggs	Eggs	Egg (boiled/ fried)
Milk and products		Evaporated liquid milk, powdered milk, yogurt (plain/ sweetened), ice cream, fresh milk, cream cheese, and other cheese
Fats and oils	Oils	Palm, soy, groundnut
	Solid fats	Margarine, soft margarine, butter, mayonnaise
Nuts and seeds	Nuts and Seeds	Walnut, peanut butter, cashew nut, tiger nut, groundnut (cooked or roasted), Kwulikwuli
Beverages	Water	
	Cocoa base drink	Chocolate drink (Milo, Bournvita) (with/without milk)
	Tea/coffee	Tea or coffee (with/without milk)
	Fruit base drink	Orange or other fruit juices (sweetened/unsweetened), fruit squash
	Sugar-sweetened beverages (SSB)	Soft drinks [e.g., Coca Cola, Fanta (regular/diet)], nonalcoholic sparkling/nonsparkling wine
	Other	Soya drink, Kunu, Zobo

(*continued on next page*)

TABLE 1 (*continued*)

Food main categories	Subcategories	Food items in the semiquantitative FFQ
Alcoholic drinks		Beer, hard liquor, red wine, white wine, fortified wines, palm wine
Sugars, syrups and sweets	Added sugars	Sugar, artificial sweetener, chocolate bar, sweets/candy, honey, jam, marmalade
Snacks	Snacks	Cocoyam chips, potato or corn chips, plantain chips, potato chips, cassava powder (Garri)
Condiments and spices	Stimulants	Kola nut (YR: Obi), bitter kola (YR: Orogbo)
	Additives	Ginger, garlic, African Locust Bean (YR: Iru)
	Additive	Ginger, Garlic, iru, African locust bean,

Abbreviations: FFQ, Food Frequency Questionnaire; HA, Hausa/Fulani; IB, Igbo; YR, Yoruba.

complement the FFQ and standardize the responses of participants. Responses of portion sizes can be given as fractions of the standard portion size of each food item as seen in the FPB. We used common and easily recognized items like a tin of popularly used evaporated milk, 33- and 50-cl bottles of soda, and cutlery as aids to enable participants estimate the actual sizes of food items in the pictures (Figure 1). We standardized portion sizes by assigning the same size to similar food categories (e.g., rice, jollof rice, and fried rice), and for swallows. The images in the FPB showed different views (90-degree angle, 45-degree angle, and aerial views) of 1–3 portions of foods (e.g., rice, beans, spaghetti, swallows, soups, beef, yam porridge, fish, Moi Moi, plantain, date, and pineapple). The smallest portion in the photographs was used as the standard reference (Figure 1). Commonly sold sizes of fresh fruits or vegetables were assigned 1 portion size, whereas small to medium-sized fruits and nuts were standardized at half a cup or a handful, in accordance with USDA recommendations. However, exceptions were made for fruits like watermelon and pineapple, for which we adopted the standard portion sizes commonly found in Nigerian fruit markets. Standard portion weights were determined by averaging 2–3 measured weights of commonly used portion sizes, as described in Supplemental Table 1.

4) The assignment of the frequency of usual food intake in the FFQ is detailed in Supplemental Table 2. The frequencies of consumption were reported on a monthly, weekly, and daily basis ranging from "Never or less than once per month" to "6 or more times per day." Participants are asked to choose the option that most accurately represents their typical or average consumption of the specific food item during the past year.
5) The FFQs also include supplementary questions such as participant's preferred type(s) of cooking oil, eating behaviors, intake of vitamins and supplements, frequency of "in-between" meals (often known as snacking), and table salt intake among others. For some of these supplementary questions, the frequency of consumption varied based on

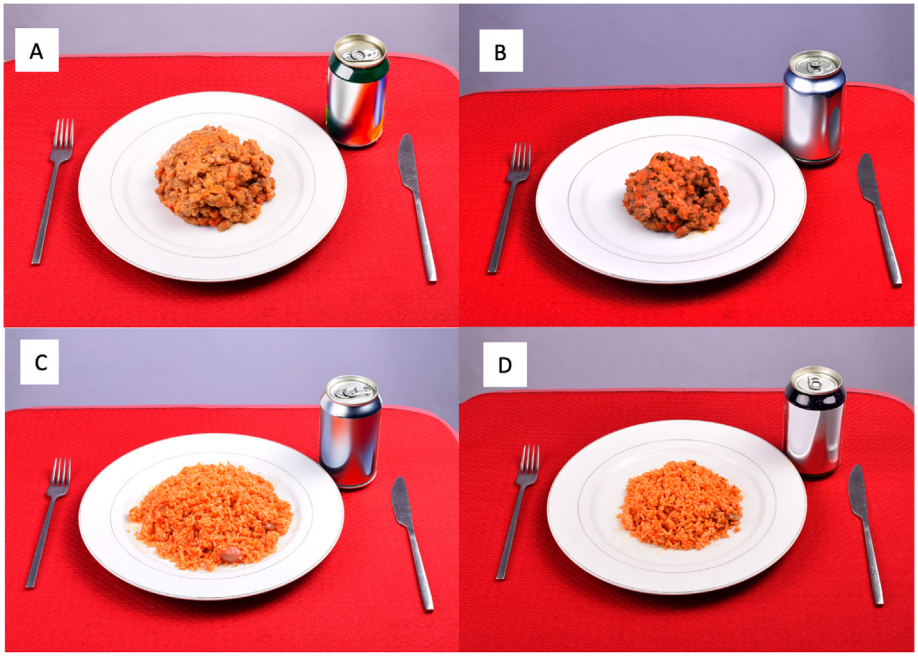

FIGURE 1. Examples from the Food Picture Book of a 45° view of images. Top: (A) 2 portions of beans porridge and (B) 1 portion of beans porridge. Bottom: (C) 2 portions of jollof rice and (D) 1 portion of jollof rice. The soda can serves as a reference for portion sizes.

the item in question, whereas some were in a multiple-response format. Finally, for most categories listed in the FFQ, there was also an open-text option at the end. This allows participants to report intake of additional food item(s) that were not included in the FFQ's predefined list. This feature also allows us to detect any trend in food intakes in Nigeria in the future and to update the FFQ accordingly.

Evaluation of FFQ for completeness of food list

We administered the FFQ to a volunteer group of 50 participants to determine the ease of comprehension of the questions and application of the FPB to support responses. We adjusted questions and changed pictures based on the recommendations of these individuals. These individuals were not enrolled in the study.

Study sample

We used a purposive sampling approach to enlist a total of 220 adult participants aged 18 y and above from the city of Ibadan in the southwestern part of Nigeria. We excluded pregnant or lactating women. The selection criteria were strategically devised to ensure a well-balanced participant group, taking into account factors such as age, sex, profession, and tribes to capture their food consumption patterns. Our goal was to achieve proportional representation across the 3 major Nigerian tribes—Yoruba, Hausa-Fulani, and Igbo—along with a distribution that mirrors the socioeconomic backgrounds and age categories prevalent in the country. The distribution by educational level aligns with that of the Oyo State region where Ibadan, the study site is located [26]. This meticulous approach to participant selection through purposive sampling enhances the study's capacity to capture a broad spectrum of perspectives and characteristics within the specified population. We obtained verbal consent from participants before their enrollment in the study. The study was approved by the Nigerian National Health Research Ethics Committee and the University of Maryland Institutional Review Board.

Dietary intake data

Reproducibility

We used the FFQ to measure participants' food intakes at baseline and every 6 mo for a total of 4 assessments. Baseline and 12-mo measurements were during dry seasons, whereas 6-mo and 18-mo measurements occurred during the rainy seasons. The dry seasons in the southwestern part of Nigeria occur from November to March, whereas the rainy season spans from April to October (Figure 2). We used the FPB to ascertain portion sizes. To evaluate reproducibility, we compared pairs of FFQs within seasons and by year to address seasonal variations (Figure 2).

Validity

For validity, we collected 2 sets of 24DR within a week of obtaining the FFQ data. We also used the FPB to determine portion sizes during the 24DR. We recorded detailed information on the participants' dietary intakes in the preceding 24 h, from waking to bedtime. For analyses of the validity of the FFQ, we averaged the results of 4 sets of 24DRs and compared these with the average of 2 sets of FFQ within each season (Figure 2). All the FFQs and 24DRs evaluations were conducted by the same trained personnel at participants' homes. No data were collected during holidays, festivals, or weekends. All data were doubly entered into the Research Electronic Data Capture (REDCap) database [27,28].

Statistical analysis

The daily food intake in portions was calculated from the FFQ using the following formula: frequency of intake (conversion factor) × total number of portions. The daily intake of food in grams was calculated as follows: frequency of intake (conversion factor) × total number of portions × portion weight. The conversion factors were determined based on the frequency of

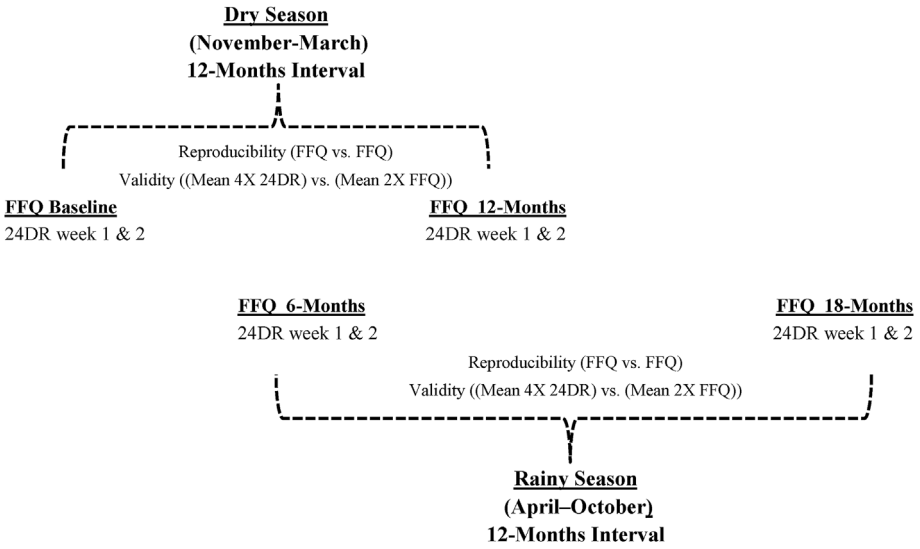

FIGURE 2. Study design for validity and reproducibility across the dry and rainy seasons. This includes 2 (2×) 12-mo intervals to capture seasonality variations. It involves the collection of a Food Frequency Questionnaire (FFQ) and 2 24-h dietary recalls (2× 24 DR), conducted each time at 6-mo intervals 4 times (4×) from November 2018 to October 2020.

intake, as detailed in Supplemental Table 2. The results are presented as mean ± SD and median with IQR for daily intake in both portion sizes and in grams. We used the Shapiro–Wilk test to test for the normality of the distribution of the data and found that the dietary data were not normally distributed. Consequently, we used nonparametric tests for our analyses.

We identified the most frequently reported and consistently mentioned food items in all the FFQs and during the 24DR reports by two-thirds of the study sample. This resulted in a list of 87 food items from the FFQs and 57 food items from the 24DR.

To evaluate the reproducibility of the FFQs across seasons, we computed Spearman's correlation coefficients (SCC) and intraclass correlation coefficients (ICC) for reported food intake (in grams). The FFQs were administered at baseline and 12-mo, as well as at 6-mo and 18-mo, corresponding to dry and rainy seasons, respectively.

We used the Wilcoxon signed-rank test to evaluate relative differences in the intake of food items in grams in the FFQs during the same seasons. To test the validity of the FFQs, we computed the averages of 4 sets of 24DR (2 per season, for 2 y) and compared them with the average of 2 sets of FFQs for each season using SCC, ICC, and Wilcoxon signed-rank tests. Finally, we used Bland–Altman plots to assess agreement between FFQs and between FFQs and 24DRs across the dry and rainy seasons. These plots enable a comparison of the differences between the mean food intake in grams for each season separately. The overall mean difference was used to assess whether 1 assessment had a tendency to overestimate or underestimate food intakes, whereas the limits of agreement (calculated as the mean ± 1.96 times the SD) illustrate the level of agreement between the 2 dietary assessments [29].

Finally, we used Bland–Altman plots to evaluate agreement within FFQs and between FFQs and 24DRs across seasons. These plots analyze differences in dietary assessments, either within the FFQs at a 12-mo interval or between the FFQs and 24DRs, by comparing these differences against the mean food intake in grams for each season separately. The overall mean difference assessed whether 1 method tended to overestimate or underestimate food intakes, whereas the limits of agreement (calculated as the mean ± 1.96 times the SD) illustrated the level of agreement between the 2 dietary assessments [29].

To evaluate seasonal reproducibility, we conducted a Wilcoxon signed-rank test, comparing SCC obtained for the dry season with those from the rainy season.

We checked the values of outliers against the original questionnaire and removed those that could not be resolved. We also excluded data where the time interval between the questionnaires was insufficient to ensure that the data fall into different seasons or years. These exclusions constituted <7% of the total study sample. We used STATA 18.0 (Stata Corp LP) for data analyses and set statistical significance at $P < 0.05$.

Results

There were 205 participants in the study at baseline. This decreased to 187 (91.2%) at 6 mo, 182 (88.8%) at 12 mo, and then increased to 196 (95.6%) at 18 mo. Comparing those who dropped out ($n = 20$, <10% dropout in at least in 2 intervals) with those who remained in the study throughout, there were no significant differences by age ($P = 0.10$), sex ($P = 0.08$), tribe ($P = 0.09$), work ($P = 0.35$), and education ($P = 0.87$) (data are not shown). The onset of COVID-19 led to shutdowns during the fourth group of interviews which occurred during the rainy season. This led to a significantly shorter final phase, resulting in a reduced mean ± SD time interval between the FFQ assessments for rainy seasons (11.8 ± 0.92 mo) compared with the assessments done during the dry seasons (12.9 ± 0.80 mo) ($P < 0.001$).

Table 2 shows the characteristics of the study population based on the baseline FFQ. There were more women than men (53.7% compared with 46.3%). The men were more likely to be under 40 y old (45.3% compared with 28.2%), and women were more likely to be in the 51–60 y age group (30.9%

TABLE 2
Baseline sociodemographic characteristics of the study population: total and by sex ($N = 205$)

	Totals, N (%) $N = 205$	Men, N (%) $n = 95$ (46.3)	Women, N (%) $n = 110$ (53.7)
Sociodemographic characteristics			
Age (y) (mean ± SD)	45.0 ± 13.4	43.0 ± 14.1	46.7 ± 13.1
Age groups (y)			
≤40	74 (36.1)	43 (45.3)	31 (28.2)
41–50	57 (27.8)	27 (28.4)	30 (27.3)
51–60	47 (22.9)	13 (13.7)	34 (30.9)
61≤	27 (13.2)	12 (12.6)	15 (13.6)
Tribe			
Yoruba	70 (34.1)	35 (36.8)	35 (31.8)
Igbo	45 (22.0)	21 (22.1)	24 (21.8)
Hausa/Fulani	79 (38.5)	36 (37.9)	43 (39.1)
Other	11 (5.4)	3 (3.2)	8 (7.3)
Work			
Unemployed	21 (10.2)	14 (14.7)	7 (6.4)
Self-employed	80 (39.0)	16 (16.8)	64 (58.2)
Skilled manual	80 (39.0)	59 (62.1)	21 (19.1)
Professional/executive	24 (11.7)	6 (6.3)	18 (16.4)
Education			
Completed <11 years of school	71 (34.6)	27 (28.4)	44 (40.0)
Completed 12 years of school	73 (35.6)	38 (40.0)	35 (31.8)
Completed postsecondary school or University	61 (29.8)	30 (31.6)	31 (28.2)

TABLE 3
Mean and median values for the daily[1] intake of food portions, as reported in the baseline sample ($N = 205$) using the semiquantitative FFQ[2]

	Mean ± SD	Median (IQR)
Cereals and grain products		
White rice	1.21 ± 0.91	0.86 (0.86–1.57)
Jollof rice	0.60 ± 0.59	0.43 (0.13–0.86)
Fried rice	0.15 ± 0.35	0.00 (0.00–0.13)
Noodle	0.40 ± 0.60	0.13 (0.00–0.86)
Spaghetti	0.36 ± 0.53	0.14 (0.00–0.43)
Bread	2.64 ± 2.24	2.14 (0.86–3.43)
Pap (YR: Akamu, Ogi)/millet	0.68 ± 0.82	0.43 (0.13–0.86)
Corn cob	0.29 ± 0.95	0.07 (0.00–0.29)
Meat pie	0.20 ± 0.34	0.07 (0.00–0.14)
Doudhs	0.33 ± 0.70	0.00 (0.00–0.33)
Starchy roots and tubers		
Pounded yam	0.27 ± 0.38	0.13 (0.00–0.43)
Semolina	0.44 ± 0.46	0.29 (0.07–0.86)
Eba	0.44 ± 0.68	0.13 (0.00–0.86)
Amala	0.67 ± 0.64	0.79 (0.14–0.86)
Tuwon Shinkafa	0.44 ± 0.67	0.00 (0.00–0.86)
Fufu or akpu	0.24 ± 0.40	0.00 (0.00–0.29)
Wheat swallow	0.15 ± 0.29	0.00 (0.00–0.14)
Cassava swallow (YR: Lafun)	0.18 ± 0.46	0.00 (0.00–0.13)
Boiled yam	0.61 ± 0.59	0.43 (0.14–0.86)
Fried yam (Dundu)	0.34 ± 0.76	0.00 (0.00–0.29)
Yam porridge	0.18 ± 0.28	0.07 (0.00–0.29)
Plantain boiled/ roasted	0.25 ± 0.52	0.07 (0.00–0.29)
Sweet potato	0.34 ± 0.72	0.00 (0.00–0.29)
Fried sliced plantain (YR: Dodo)/roasted (Boli)	1.29 ± 1.60	0.71 (0.27–2.14)
Soups (leafy vegetables with/without meat/fish/chicken)		
Stew	1.25 ± 0.72	1.00 (1.00–1.00)
Vegetable soup (YR: Efo; HA: Taushe; Amaranth)	0.47 ± 0.47	0.43 (0.14–0.43)
Egusi soup	0.34 ± 0.47	0.43 (0.07–0.43)
Pepper soup	0.10 ± 0.20	0.00 (0.00–0.07)
Okro sliced (HA: Kubewa)	0.18 ± 0.25	0.07 (0.00–0.43)
Okro mixed (YR: Ila asepo)	0.10 ± 0.18	0.00 (0.00–0.14)
Ogbono soup (YR: Apon)	0.08 ± 0.16	0.00 (0.00–0.07)
Kuka soup (HA: Miyan Kuka)	0.24 ± 0.43	0.00 (0.00–0.43)
Bitter leaf SOUP	0.12 ± 0.20	0.00 (0.00–0.14)
Pumpkin leaves SOUP (IB: Ugwu)	0.13 ± 0.21	0.00 (0.00–0.14)
Water leaves soup (YR: Gbure)	0.07 ± 0.16	0.00 (0.00–0.07)
Whole fruits/vegetables		
Banana	1.51 ± 1.67	1.14 (0.33–2.14)
Orange	1.07 ± 0.99	0.86 (0.29–1.57)
Apple	0.25 ± 0.39	0.13 (0.00–0.43)
Mango	0.36 ± 0.84	0.00 (0.00–0.27)
African Cherry (YR: Agbalumo)	0.38 ± 0.99	0.00 (0.00–0.27)
Pineapple	0.28 ± 0.46	0.13 (0.00–0.43)
Sugarcane	0.24 ± 0.72	0.00 (0.00–0.20)
Pawpaw	0.35 ± 0.71	0.14 (0.00–0.43)
Watermelon	0.55 ± 0.72	0.43 (0.13–0.86)
Carrot	1.12 ± 1.62	0.43 (0.07–1.71)
Garden egg	0.68 ± 1.28	0.00 (0.00–0.86)
Cucumber	0.35 ± 0.55	0.14 (0.00–0.43)
Dates	0.54 ± 1.23	0.00 (0.00–0.57)
Vegetable salad	0.08 ± 0.19	0.00 (0.00–0.07)
Legumes and products		
Bean only	0.49 ± 0.49	0.43 (0.07–0.86)
Bean porridge	0.48 ± 0.50	0.29 (0.07–0.86)
Bean cake (YR: Akara)	1.40 ± 1.52	0.71 (0.20–2.14)
Bean soup (YR: Gbegiri)	0.10 ± 0.18	0.00 (0.00–0.14)
Moi Moi (YR: Moin Moin)	0.41 ± 0.40	0.29 (0.13–0.86)
Meat and poultry		
Chicken	0.23 ± 0.34	0.07 (0.07–0.29)
Turkey	0.07 ± 0.17	0.00 (0.00–0.07)
Goat (boiled/fried)	0.24 ± 0.56	0.07 (0.00–0.29)

(*continued on next page*)

TABLE 3 (*continued*)

	Mean ± SD	Median (IQR)
Beef (boiled/fried)	1.11 ± 1.43	0.86 (0.29–1.14)
Liver (boiled/fried)	0.14 ± 0.30	0.00 (0.00–0.14)
Cow skin	0.56 ± 0.67	0.43 (0.14–0.86)
Offal/tripe (YR: Orisirisi)	0.14 ± 0.30	0.00 (0.00–0.14)
Suya	0.30 ± 0.62	0.00 (0.00–0.43)
Fish and products		
Fish (boiled/fried)	1.12 ± 0.95	0.86 (0.43–1.57)
Dry fish	0.31 ± 0.40	0.14 (0.00–0.43)
Eggs		
Egg (boiled/fried)	0.69 ± 0.64	0.50 (0.14–1.00)
Milks and products		
Evaporated Liquid milk	1.13 ± 1.68	0.43 (0.00–2.00)
Powdered milk	0.54 ± 0.84	0.29 (0.00–0.86)
Solid fats		
Butter	0.11 ± 0.28	0.00 (0.00–0.07)
Margarine	0.08 ± 0.23	0.00 (0.00–0.00)
Condiments, spices, additives		
Garlic	0.27 ± 0.46	0.00 (0.00–0.43)
Ginger	0.34 ± 0.45	0.14 (0.00–0.43)
African locust bean (YR: Iru)	0.76 ± 0.70	0.79 (0.43–1.00)
Beverages (glass 25 cl)		
Water	10.36 ± 6.59	9.00 (6.00–12.00)
Soft drinks	0.55 ± 0.60	0.43 (0.09–0.86)
Chocolate	0.45 ± 0.55	0.43 (0.00–0.57)
Tea	0.55 ± 1.10	0.14 (0.00–0.86)
Coffee	0.10 ± 0.34	0.00 (0.00–0.00)
Fruit juice	0.04 ± 0.14	0.00 (0.00–0.00)
Kunu	0.33 ± 0.83	0.07 (0.00–0.43)
Zobo	0.32 ± 0.83	0.07 (0.00–0.43)
Sugars, syrups, and sweets		
Sugar	0.50 ± 0.80	0.43 (0.00–0.79)
Honey	0.15 ± 0.41	0.00 (0.00–0.13)
Nuts and seeds		
Groundnut	0.43 ± 0.57	0.43 (0.07–0.43)
Walnut	0.38 ± 1.62	0.00 (0.00–0.14)
Tiger Nut (YR:Ofio,HA: Aya, IB:Akiausa)	0.13 ± 0.30	0.00 (0.00–0.14)
Snacks		
Cassava powder (Garri)	0.22 ± 0.33	0.07 (0.00–0.29)
Plantain chips (YR: Igbekere/Ipekere)	0.20 ± 0.34	0.07 (0.00–0.43)

Abbreviations: FFQ, Food Frequency Questionnaire; HA, Hausa/Fulani; IB, Igbo; YR, Yoruba.

[1] The daily intake of food portions was calculated using the conversion factors outlined in Supplemental Table 2.

[2] A total of 87 selected food items were included, as they were consumed at least once a month by more than two-thirds of the participants.

compared with 13.7%). Women were more likely to be self-employed (58.2%), whereas men were more likely to have skilled manual jobs (62.1%). The men tended to have higher levels of education.

Table 3 shows the daily consumption of foods reported in the baseline FFQ. On average, participants consumed ~2 portions of total rice intakes daily, comprising white rice (mean ± SD = 1.21 ± 0.91 portions) and jollof rice (mean ± SD = 0.60 ± 0.59 portions), and 2.64 ± 2.24 (mean ± SD) slices of bread. Participants consumed ~6.66 ± 2.77 (mean ± SD) portions of cereals and grain products daily. "Starchy roots and tubers," including yam and cassava were consumed frequently with mean ± SD daily consumption of amala (0.67 ± 0.64 portions/d), boiled yam (0.61 ± 0.59 portions/d), and eba (0.44 ± 0.68 portions/d). Commonly consumed fruits included bananas (mean ± SD = 1.52 ± 1.67 portions/d), oranges (mean ± SD = 1.07 ± 0.99 portions/d), and carrots (mean ± SD = 1.12 ± 1.62 portions/d). Staple soups, notably stew (mean ± SD = 1.25 ± 0.72 portions/d) and egusi soup (mean ± SD = 0.34 ± 0.47 portions/d) play significant roles in the Nigerian diet. Legumes, including beans (mean ± SD = 0.49 ± 0.49 portions/d) and beans porridge (mean ± SD = 0.48 ± 0.50 portions/d) were also commonly consumed as main meals. Bean cake (akara) (mean ± SD = 1.40 ± 1.52 portions/d) was often enjoyed as a snack. The main sources of protein in the diet included beef, cow skin, fish, and eggs. Milk was primarily consumed in evaporated or powdered form, and palm oil was the preferred cooking oil. Participants also consumed 10.36 ± 6.59 (mean ± SD) glasses of water daily, whereas tea and chocolate drinks (Milo, Bournvita) were the preferred hot beverages.

Table 4 shows the results of the FFQ reproducibility by seasons. The mean ± SD SCC was 0.39 ± 0.14, whereas the mean ± SD ICC was 0.32 ± 0.12. When examining mean correlations by food groups, higher mean ± SD SCC were obtained for cereal products (0.43 ± 0.09), starchy roots and tubers (0.45 ± 0.17), and soups (0.44 ± 0.20). Conversely, lower mean ± SD SCC values were observed for milk products (0.29 ± 0.02), solid fats (0.29 ± 0.26), and fish (0.22 ± 0.19). There were differences between rainy and dry seasons using both tests. For example, in the dry season, mean ± SD SCC was 0.38 ± 0.14, which was significantly lower than that of the rainy season's 0.40 ± 0.15 (P = 0.02). The mean ± SD for ICC of the dry season was 0.34 ±

TABLE 4
Mean daily intake by seasonal and the reproducibility results of the semiquantitative FFQ[1,2] ($N = 205$)

	Dry season					Rainy season				
	Mean ± SD (g/d)		Reproducibility tests			Mean ± SD (g/d)		Reproducibility tests		
	FFQ Baseline	FFQ12 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ 6 mo	FFQ18 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC [3]
	$N = 205$	$N = 182$	z	ρ	r	$N = 187$	$N = 196$	z	ρ	r
Cereals and grain products				0.39 ± 0.11[4]	0.28 ± 0.16[4]				0.43 ± 0.09[4]	0.28 ± 0.12[4]
White rice	205.9 ± 152.1	160.2 ± 102.4	2.98[6]	0.28[6]	0.09 (0.06, 0.31)	194.1 ± 129.8	170.2 ± 121.6	2.58[5]	0.29[6]	0.23 (0.17, 0.42)
Jollof rice	101.3 ± 98.7	75.7 ± 77.0	2.31[5]	0.41[6]	0.24 (0.21, 0.44)	83.7 ± 93.8	75.5 ± 77.0	1.50	0.42[6]	0.18 (0.12, 0.37)
Fried rice	24.8 ± 59.3	20.5 ± 41.2	−1.05	0.26[6]	0.06 (0.03, 0.29)	19.4 ± 48.6	14.5 ± 35.6	1.39	0.32[6]	0.46 (0.40, 0.60)
Noodle	68.1 ± 102.8	53.3 ± 76.2	1.65	0.55[6]	0.43 (0.39, 0.59)	52.0 ± 73.8	65.5 ± 97.2	−0.84	0.59[6]	0.40 (0.34, 0.56)
Spaghetti	67.5 ± 101.1	59.1 ± 72.3	0.05	0.51[6]	0.30 (0.26, 0.49)	53.1 ± 68.6	62.9 ± 70.1	−1.57	0.49[6]	0.39 (0.32, 0.55)
Bread	148.0 ± 125.5	119.9 ± 92.2	2.63[5]	0.53[6]	0.45 (0.40, 0.60)	139.5 ± 106.8	137.3 ± 101.1	0.73	0.47[6]	0.39 (0.33, 0.55)
Pap (YR: Akamu, Ogi)/ millet meal	280.1 ± 335.6	220.8 ± 227.4	1.51	0.36[6]	0.47 (0.42, 0.62)	246.1 ± 265.9	268.4 ± 288.3	−1.08	0.36[6]	0.20 (0.14, 0.39)
Corn cob	57.1 ± 190.0	51.6 ± 114.9	−0.18	0.27[6]	0.07 (0.04, 0.30)	100.0 ± 138.5	94.5 ± 106.7	−0.47	0.46[6]	0.24 (0.17, 0.42)
Meat pie	21.2 ± 36.7	17.1 ± 27.3	−0.37	0.39[6]	0.35 (0.31, 0.53)	20.9 ± 47.5	18.6 ± 28.7	0.80	0.47[6]	0.15 (0.09, 0.35)
Doudhs	5.4 ± 11.4	6.9 ± 12.1	−2.61[5]	0.36[6]	0.38 (0.34, 0.55)	7.2 ± 13.3	6.1 ± 11.5	0.68	0.40[6]	0.12 (0.07, 0.33)
Starchy roots and tubers				0.41 ± 0.15[4]	0.38 ± 0.15[4]				0.45 ± 0.17[4]	0.31 ± 0.20[4]
Traditional pounded yam	43.9 ± 62.2	44.4 ± 69.5	−0.52	0.45[6]	0.46 (0.41, 0.61)	37.0 ± 60.2	41.8 ± 81.6	−0.52	0.43[6]	0.26 (0.19, 0.44)
Semolina	74.3 ± 76.4	78.3 ± 71.1	−0.89	0.43[6]	0.41 (0.36, 0.57)	62.1 ± 65.1	83.7 ± 79.2	−3.65[6]	0.41[6]	0.38 (0.31, 0.53)
Eba	70.5 ± 110.0	53.2 ± 80.2	1.79	0.55[6]	0.29 (0.24, 0.48)	60.2 ± 88.1	66.2 ± 86.9	−0.21	0.68[6]	0.62 (0.57, 0.73)
Amala	111.4 ± 107.7	96.5 ± 75.8	0.59	0.41[6]	0.30 (0.26, 0.49)	107.0 ± 119.5	114.8 ± 89.3	−1.79	0.45[6]	0.26 (0.19, 0.44)
Tuwon Shinkafa	74.4 ± 111.7	63.5 ± 100.9	0.48	0.83[6]	0.56 (0.51, 0.68)	49.3 ± 97.1	62.1 ± 94.4	−2.16[5]	0.82[6]	0.46 (0.40, 0.60)
Fufu or akpu	40.7 ± 67.6	47.5 ± 68.3	−1.43	0.46[6]	0.46 (0.41, 0.60)	42.7 ± 78.0	38.6 ± 58.8	0.44	0.54[6]	0.40 (0.33, 0.54)
Wheat flour swallow	25.6 ± 48.8	33.7 ± 54.4	−1.97	0.29[6]	0.27 (0.23, 0.46)	30.5 ± 59.3	29.9 ± 51.3	−0.12	0.36[6]	0.26 (0.20, 0.44)

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TABLE 4 (*continued*)

	Dry season					Rainy season				
	Mean ± SD (g/d)		Reproducibility tests			Mean ± SD (g/d)		Reproducibility tests		
	FFQ Baseline	FFQ12 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ 6 mo	FFQ18 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC [3]
	$N = 205$	$N = 182$	z	ρ	r	$N = 187$	$N = 196$	z	ρ	r
Cassava flour swallow (YR: Lafun)	30.5 ± 76.1	34.5 ± 74.4	−0.68	0.43[6]	0.44 (0.40, 0.60)	37.6 ± 77.4	35.7 ± 81.7	1.24	0.59[6]	0.76 (0.71, 0.82)
Boiled yam	85.0 ± 81.9	95.3 ± 105.6	−1.08	0.42[6]	0.53 (0.49, 0.67)	84.5 ± 79.8	76.0 ± 78.5	1.17	0.30[6]	0.14 (0.07, 0.33)
Fried yam (Dundu)	47.4 ± 105.7	38.4 ± 69.7	−1.15	0.39[6]	0.32 (0.28, 0.50)	31.7 ± 77.6	38.0 ± 64.6	−2.25[5]	0.55[6]	0.31 (0.25, 0.48)
Yam porridge	73.3 ± 116.3	98.1 ± 153.1	−1.52	0.28[6]	0.08 (0.06, 0.32)	62.1 ± 112.5	79.3 ± 144.2	−1.10	0.32[6]	0.09 (0.02, 0.29)
Plantain boiled/steamed/ roasted	16.1 ± 34.2	14.5 ± 33.7	−0.57	0.19[5]	0.60 (0.56, 0.71)	9.3 ± 17.7	10.0 ± 17.0	−1.61	0.26[6]	0.12 (0.06, 0.32)
Sweet potato (boiled/fried)	37.8 ± 79.6	44.7 ± 68.8	−3.53[6]	0.29[6]	0.41 (0.35, 0.56)	49.3 ± 83.7	44.6 ± 69.8	1.06	0.29[6]	0.20 (0.13, 0.38)
Fried sliced plantain (YR: Dodo)	95.4 ± 118.0	43.6 ± 59.0	4.90[6]	0.27[6]	0.15 (0.11, 0.36)	47.1 ± 72.2	30.0 ± 41.7	2.45[5]	0.34[6]	0.13 (0.07, 0.33)
Soups (leafy vegetables with/without meat/fish/chicken)				0.44 ± 0.19[4]	0.34 ± 0.16[4]				0.44 ± 0.20[4]	0.32 ± 0.16[4]
Stew	150.3 ± 86.5	148.6 ± 116.3	1.93	0.12	0.11 (0.08, 0.33)	170.2 ± 136.2	158.2 ± 144.2	2.07[5]	0.14	0.30 (0.23, 0.47)
Vegetable soup (YR:Efo; HA: Taushe)	82.7 ± 84.3	87.5 ± 66.9	−1.34	0.34[6]	0.50 (0.46, 0.64)	99.7 ± 119.9	111.1 ± 79.9	−2.41[5]	0.23[6]	0.09 (0.03, 0.29)
Egusi soup +vegetables	60.5 ± 82.8	54.3 ± 59.5	0.16	0.48[6]	0.26 (0.22, 0.45)	61.0 ± 115.2	60.4 ± 57.4	−2.16[5]	0.31[6]	0.07 (0.01, 0.28)
Pepper Soup	11.8 ± 24.4	16.6 ± 26.3	−3.95[6]	0.49[6]	0.33 (0.29, 0.52)	14.2 ± 26.3	15.4 ± 26.4	0.21	0.55[6]	0.31 (0.25, 0.48)
Okro (sliced)	24.5 ± 34.9	33.9 ± 41.4	−3.98[6]	0.34[6]	0.33 (0.28, 0.50)	26.7 ± 44.4	34.2 ± 42.5	−2.08[5]	0.32[6]	0.45 (0.38, 0.59)
Okro Mixed	11.6 ± 22.2	23.6 ± 39.7	−3.82[6]	0.21[5]	0.33 (0.29, 0.50)	22.1 ± 39.0	22.0 ± 37.4	0.17	0.43[6]	0.57 (0.51, 0.68)
Ogbono (YR: Apon)	9.8 ± 19.2	14.0 ± 31.3	−1.41	0.59[6]	0.52 (0.48, 0.65)	12.8 ± 32.4	15.3 ± 32.8	−2.79[5]	0.59[6]	0.40 (0.34, 0.55)
Kuka (HA: Miyan Kuka)	28.8 ± 51.3	26.4 ± 43.7	−1.27	0.85[6]	0.61 (0.57, 0.72)	24.7 ± 48.9	29.5 ± 50.1	−1.39	0.86[6]	0.53 (0.47, 0.65)
Bitter leaf soup	20.9 ± 36.0	25.7 ± 44.5	−1.58	0.48[6]	0.37 (0.32, 0.54)	27.6 ± 42.1	26.4 ± 42.8	0.82	0.39[6]	0.23 (0.17, 0.42)
Pumpkin leaves soup (IB: Ugwu)	23.6 ± 37.9	39.7 ± 61.6	−4.26[6]	0.50[6]	0.28 (0.23, 0.47)	40.1 ± 59.4	44.6 ± 59.8	−0.63	0.50[6]	0.34 (0.28, 0.51)
Water leaves soup (YR: Gbure)	13.2 ± 27.9	36.4 ± 63.7	−4.09[6]	0.42[6]	0.12 (0.09, 0.35)	34.8 ± 59.0	41.6 ± 61.1	−1.59	0.49[6]	0.25 (0.18, 0.43)
Whole fruits/vegetables				0.36 ± 0.13[4]	0.32 ± 0.17[4]				0.38 ± 0.15[4]	0.26 ± 0.15[4]
Banana			1.70	0.31[6]				0.59	0.27[6]	

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TABLE 4 (*continued*)

	Dry season					Rainy season				
	Mean ± SD (g/d)		Reproducibility tests			Mean ± SD (g/d)		Reproducibility tests		
	FFQ Baseline	FFQ12 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ 6 mo	FFQ18 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC [3]
	$N = 205$	$N = 182$	z	ρ	r	$N = 187$	$N = 196$	z	ρ	r
	113.0 ± 124.7	88.2 ± 94.0			0.12 (0.09, 0.34)	81.7 ± 103.4	73.8 ± 86.2			0.37 (0.30, 0.53)
Orange	182.1 ± 168.8	148.6 ± 182.9	2.22[5]	0.29[6]	0.26 (0.22, 0.45)	135.4 ± 144.2	110.3 ± 108.8	1.34	0.22[6]	0.19 (0.13, 0.38)
Apple	35.8 ± 55.3	25.1 ± 38.1	1.79	0.30[6]	0.28 (0.24, 0.47)	27.1 ± 62.4	22.6 ± 38.3	0.93	0.41[6]	0.20 (0.14, 0.39)
Mango	52.1 ± 123.3	36.7 ± 112.0	1.64	0.18[5]	0.12 (0.09, 0.34)	36.7 ± 90.5	27.0 ± 58.0	0.91	0.33[6]	0.17 (0.11, 0.37)
African cherry (YR: Agbalumo)	43.4 ± 114.3	62.0 ± 126.9	−3.26[6]	0.35[6]	0.15 (0.12, 0.37)	33.6 ± 77.0	23.2 ± 54.8	0.29	0.21[5]	0.00 (0.00, 0.18)
Pineapple	78.4 ± 127.4	58.8 ± 83.5	0.18	0.40[6]	0.31 (0.27, 0.49)	79.8 ± 112.6	60.6 ± 105.8	1.53	0.38[6]	0.29 (0.22, 0.46)
Sugarcane	47.0 ± 139.5	26.5 ± 45.6	−0.03	0.48[6]	0.76 (0.73, 0.83)	27.6 ± 54.4	21.2 ± 43.3	2.09[5]	0.56[6]	0.46 (0.39, 0.69)
Pawpaw	48.3 ± 98.5	32.8 ± 49.7	1.49	0.20[5]	0.28 (0.24, 0.47)	23.2 ± 58.8	19.5 ± 36.0	−0.69	0.28[6]	0.20 (0.13, 0.39)
Watermelon	179.5 ± 236.2	142.5 ± 139.9	1.21	0.23[6]	0.40 (0.36, 0.57)	143.7 ± 192.5	162.0 ± 156.7	−2.12[5]	0.35[6]	0.25 (0.18, 0.43)
Carrot	111.2 ± 160.0	113.3 ± 117.9	−1.76	0.32[6]	0.35 (0.31, 0.52)	69.6 ± 113.6	73.1 ± 82.7	−1.66	0.24[6]	0.08 (0.03, 0.29)
Garden egg	157.2 ± 294.4	106.8 ± 197.3	1.52	0.48[6]	0.25 (0.20, 0.44)	172.4 ± 269.6	162.2 ± 216.3	−0.12	0.43[6]	0.44 (0.38, 0.58)
Cucumber	113.3 ± 177.0	89.3 ± 110.0	0.60	0.49[6]	0.49 (0.44, 0.63)	79.6 ± 98.4	81.1 ± 104.6	−0.22	0.55[6]	0.49 (0.43, 0.63)
Dates	20.2 ± 46.0	17.5 ± 36.0	−0.54	0.63[6]	0.25 (0.22, 0.45)	14.0 ± 29.9	17.2 ± 42.3	0.13	0.72[6]	0.34 (0.27, 0.50)
Vegetable salad	13.7 ± 30.7	16.2 ± 30.4	−3.48[6]	0.33[6]	0.50 (0.46, 0.64)	14.1 ± 28.5	13.2 ± 24.1	0.02	0.30[6]	0.10 (0.04, 0.30)
Legumes and products				0.31± 0.06[4]	0.26 ± 0.09[4]				0.34 ± 0.12[4]	0.33 ± 0.10[4]
Bean only	134.9 ± 135.7	112.5 ± 132.9	2.17[5]	0.24[6]	0.10 (0.07, 0.32)	134.0 ± 168.7	104.5 ± 131.4	1.83	0.24[6]	0.45 (0.38, 0.59)
Bean porridge	130.9 ± 137.2	143.4 ± 122.2	−1.57	0.28[6]	0.32 (0.28, 0.50)	164.3 ± 183.3	144.1 ± 137.7	1.37	0.35[6]	0.38 (0.31, 0.53)
Bean cake (YR: Akara)	64.3 ± 69.9	47.2 ± 47.3	1.68	0.30[6]	0.27 (0.22, 0.46)	58.3 ± 55.8	46.4 ± 49.5	2.08[5]	0.33[6]	0.26 (0.19, 0.43)
Bean soup (YR: Gbegiri)	11.6 ± 21.5	24.1 ± 32.8	−4.11[6]	0.41[6]	0.28 (0.24, 0.47)	20.5 ± 31.2	17.2 ± 30.8	0.82	0.53[6]	0.35 (0.28, 0.51)
Moi Moi (YR: Moin Moin)	50.7 ± 50.3	63.3 ± 47.5	−2.38[5]	0.32[6]	0.32 (0.27, 0.50)	56.0 ± 48.7	59.4 ± 50.3	, 0.66	0.25[6]	0.20 (0.13, 0.38)

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TABLE 4 (*continued*)

	Dry season					Rainy season				
	Mean ± SD (g/d)		Reproducibility tests			Mean ± SD (g/d)		Reproducibility tests		
	FFQ Baseline	FFQ12 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ 6 mo	FFQ18 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC [3]
	N = 205	*N* = 182	*z*	*ρ*	*r*	*N* = 187	*N* = 196	*z*	*ρ*	*r*
Meat and poultry				0.33 ± 0.12[4]	0.31 ± 0.11[4]				0.36 ± 0.15[4]	0.22 ± 0.12[4]
Chicken (±skin)	52.8 ± 79.1	50.6 ± 101.7	−0.64	0.32[6]	0.26 (0.22, 0.45)	48.4 ± 93.0	43.8 ± 84.5	1.15	0.33[6]	0.20 (0.13, 0.39)
Turkey	15.4 ± 38.9	14.2 ± 32.8	−1.23	0.38[6]	0.26 (0.22, 0.45)	17.6 ± 72.5	8.1 ± 24.1	3.31[6]	0.15	0.00 (0.00, 0.21)
Goat (boiled/fried)	14.6 ± 34.7	11.5 ± 22.6	0.09	0.32[6]	0.32 (0.27, 0.50)	15.3 ± 35.8	14.1 ± 29.0	0.71	0.47[6]	0.30 (0.24, 0.47)
Beef (boiled/fried)	68.9 ± 88.4	64.2 ± 67.7	−0.84	0.32[6]	0.42 (0.37, 0.58)	75.7 ± 82.8	67.4 ± 85.9	1.58	0.52[6]	0.32 (0.25, 0.49)
Liver (Boiled/Fried)	8.4 ± 18.8	8.5 ± 16.4	−1.16	0.17[5]	0.17 (0.14, 0.38)	6.0 ± 14.3	6.8 ± 14.4	−0.61	0.19[5]	0.10 (0.04, 0.31)
Cow skin (YR: Ponmo, Bokoto)	34.5 ± 41.4	39.9 ± 50.5	−2.38[5]	0.27[6]	0.31 (0.27, 0.49)	38.7 ± 42.0	31.3 ± 24.5	1.58	0.41[6]	0.26 (0.19, 0.44)
Offal/Tripe (YR: Orisirisi)	8.9 ± 18.3	10.4 ± 18.3	−0.85	0.29	0.22 (0.18, 0.43)	14.8 ± 35.0	11.4 ± 21.7	1.42	0.25[6]	0.25 (0.19, 0.43)
Suya	20.8 ± 43.3	16.0 ± 27.9	−0.72	0.60[6]	0.51 (0.47, 0.65)	15.6 ± 29.3	15.0 ± 27.1	−0.25	0.57[6]	0.34 (0.27, 0.50)
Fish and products				0.26 ± 0.03[4]	0.36 ± 0.05[4]				0.22 ± 0.01[4]	0.22 ± 0.19[4]
Fish (boiled/fried)	79.4 ± 67.3	83.2 ± 89.1	−0.76	0.24[6]	0.32 (0.27, 0.50)	66.0 ± 48.8	66.4 ± 72.4	1.80	0.21[5]	0.09 (0.02, 0.29)
Dry fish	18.1 ± 23.5	20.4 ± 24.9	−1.06	0.29[6]	0.40 (0.36, 0.56)	17.3 ± 23.9	21.8 ± 27.1	−1.78	0.22[5]	0.35 (0.29, 0.52)
Eggs										
Egg (boiled/fried)	36.7 ± 34.0	38.2 ± 32.6	−0.87	0.46[6]	0.41 (0.36, 0.57)	40.6 ± 40.5	40.5 ± 32.9	−0.67	0.54[6]	0.38 (0.30, 0.53)
Milks and products				0.31 ± 0.01[4]	0.24 ± 0.02[4]				0.29 ± 0.02[4]	0.15 ± 0.13[4]
Evaporated liquid milk	13.6 ± 20.1	14.0 ± 18.3	−0.02	0.31[6]	0.25 (0.21, 0.45)	15.7 ± 19.1	14.3 ± 17.3	0.28	0.28[6]	0.24 (0.17, 0.42)
Powdered milk	6.5 ± 10.1	4.9 ± 6.4	1.95	0.30[6]	0.23 (0.18, 0.43)	5.7 ± 7.3	5.2 ± 5.4	−0.10	0.31[6]	0.06 (0.00, 0.27)
Solid fats				0.29 ± 0.07[4]	0.32 ± 0.14[4]				0.29 ± 0.26[4]	0.29 ± 0.07[4]
Butter	2.5 ± 6.2	1.3 ± 4.4	1.92	0.35[6]	0.41 (0.37, 0.58)	1.3 ± 5.3	1.1 ± 3.4	0.47	0.10	0.24 (0.17, 0.42)
Margarine	1.8 ± 5.1	3.0 ± 6.3	−2.75[6]	0.24[6]	0.22 (0.18, 0.43)	4.2 ± 7.8	3.1 ± 6.0	2.06[5]	0.47[6]	0.34 (0.27, 0.50)
Condiments, spices, and additives				0.40 ± 0.20[4]					0.36 ± 0.10[4]	

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TABLE 4 (*continued*)

	Dry season					Rainy season				
	Mean ± SD (g/d)		Reproducibility tests			Mean ± SD (g/d)		Reproducibility tests		
	FFQ Baseline	FFQ12 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ 6 mo	FFQ18 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC [3]
	N = 205	*N* = 182	*z*	*ρ*	*r*	*N* = 187	*N* = 196	*z*	*ρ*	*r*
					0.33 ± 0.18[4]					0.26 ± 0.06[4]
Garlic	0.7 ± 1.2	0.8 ± 1.3	−0.56	0.53[6]	0.38 (0.34, 0.56)	0.6 ± 1.3	0.7 ± 1.1	−2.64[5]	0.39[6]	0.20 (0.13, 0.39)
Ginger	11.3 ± 15.2	11.7 ± 16.9	−0.46	0.50[6]	0.48 (0.44, 0.63)	10.3 ± 20.4	11.4 ± 17.4	−2.00	0.44[6]	0.31 (0.24, 0.48)
African locust bean (YR: Iru)	9.8 ± 9.0	11.8 ± 9.4	−2.76[6]	0.17[5]	0.13 (0.09, 0.35)	10.8 ± 7.5	10.5 ± 9.9	1.17	0.26[6]	0.26 (0.20, 0.44)
Beverages (glass 25 cl)				0.41 ± 0.17[4]	0.44 ± 0.25[4]				0.43 ± 0.14[4]	0.40 ± 0.13[4]
Water	2590 ± 1649	2576 ± 1626	1.05	0.13	0.07 (0.06, 0.31)	2756 ± 1643	2614 ± 1503	0.88	0.20[5]	0.18 (0.12, 0.37)
Soft drinks	136.3 ± 150.9	152.5 ± 151.8	−1.95	0.54[6]	0.41 (0.36, 0.57)	150.5 ± 177.4	123.6 ± 137.6	0.97	0.48[6]	0.42 (0.35, 0.57)
Chocolate	113.3 ± 138.1	106.6 ± 127.1	0.97	0.34[6]	0.29 (0.25, 0.48)	114.7 ± 124.5	113.0 ± 126.1	0.86	0.45[6]	0.35 (0.28, 0.50)
Tea	138.6 ± 275.8	103.4 ± 134.6	−0.26	0.67[6]	0.46 (0.42, 0.61)	93.3 ± 127.3	112.8 ± 140.8	, 1.27	0.66[6]	0.55 (0.49, 0.67)
Coffee	24.3 ± 84.6	22.7 ± 70.2	−0.72	0.32[6]	0.44 (0.39, 0.59)	21.4 ± 51.4	12.3 ± 51.9	2.15[5]	0.35[6]	0.47 (0.40, 0.60)
Fruit juice	9.0 ± 34.2	18.4 ± 46.8	−4.07[6]	0.29[6]	0.26 (0.22, 0.46)	14.7 ± 41.9	15.1 ± 37.7	0.13	0.35[6]	0.58 (0.52, 0.69)
Kunu	82.1 ± 207.6	72.7 ± 105.8	−1.44	0.53[6]	0.80 (0.77, 0.85)	58.5 ± 107.8	48.4 ± 74.9	1.17	0.55[6]	0.35 (0.28, 0.51)
Zobo	81.0 ± 206.9	48.0 ± 76.4	1.44	0.45[6]	0.77 (0.74, 0.84)	48.5 ± 92.7	41.2 ± 63.1	1.65	0.39[6]	0.33 (0.26, 0.50)
Sugars, syrups, and sweets				0.37 ± 0.17[4]	0.51 ± 0.38[4]				0.41 ± 0.14[4]	0.31 ± 0.14[4]
Sugar	6.0 ± 9.7	4.8 ± 5.7	0.21	0.56[6]	0.51 (0.47, 0.65)	5.9 ± 6.3	5.3 ± 6.8	1.85	0.51[6]	0.39 (0.32, 0.54)
Honey	1.2 ± 3.2	1.3 ± 2.8	−1.24	0.19[5]	0.51 (0.47, 0.65)	1.8 ± 3.7	1.6 ± 3.1	0.98	0.32[6]	0.24 (0.17, 0.42)
Nuts and seeds				0.31 ± 0.09[4]	0.24 ± 0.26[4]				0.40 ± 0.17[4]	0.22 ± 0.30[4]
Groundnut (cooked/ roasted)	21.7 ± 28.6	18.1 ± 20.0	1.20	0.31[6]	0.52 (0.48, 0.66)	22.8 ± 41.6	19.2 ± 21.3	1.00	0.27[5]	0.01 (0.00, 0.23)
Walnut	21.4 ± 90.0	8.8 ± 24.9	1.85	0.23[5]	0.03 (0.01, 0.26)	9.4 ± 22.8	10.1 ± 23.0	0.46	0.35[6]	0.08 (0.03, 0.29)
Tiger nut (YR:Ofio, HA:Aya,IB: Akiausa)	10.0 ± 22.0	12.9 ± 24.3	−2.58[6]	0.40[6]	0.15 (0.12, 0.37)	12.6 ± 31.3	11.9 ± 33.6	0.84	0.60[6]	0.56 (0.50, 0.67)

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TABLE 4 (*continued*)

	Dry season					Rainy season				
	Mean ± SD (g/d)		Reproducibility tests			Mean ± SD (g/d)		Reproducibility tests		
	FFQ Baseline	FFQ12 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ 6 mo	FFQ18 mo	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]
	$N = 205$	$N = 182$	z	ρ	r	$N = 187$	$N = 196$	z	ρ	r
Snacks				0.42 ± 0.15[4]	0.46 ± 0.12[4]				0.40 ± 0.26[4]	0.40 ± 0.15[4]
Cassava powder (Garri) + Water	13.1 ± 20.0	13.8 ± 25.3	−0.03	0.52[6]	0.54 (0.50, 0.67)	16.2 ± 28.3	13.9 ± 22.1	0.56	0.58[6]	0.51 (0.44, 0.63)
Plantain chips (YR: Igbekere/Ipekere)	2.8 ± 4.7	2.5 ± 3.9	−0.27	0.32[6]	0.38 (0.34, 0.55)	2.3 ± 3.3	2.5 ± 4.0	0.17	0.21[5]	0.30 (0.24, 0.47)

Abbreviations: FFQ, Food Frequency Questionnaire; HA, Hausa/Fulani; IB, Igbo; YR, Yoruba.

[1] A total of 87 selected food items were identified, which were consumed at least once a month by more than two-thirds of the participants.

[2] Mean ± SD were reported despite nonnormality because of large sample size and provide insight into central tendency and data spread.

[3] Intraclass correlation coefficient (ICC) values are presented as r (95% confidence interval).

[4] Intraclass correlation coefficient (ICC) values are presented as mean ± SD, representing average correlations by food group.

[5] P value < 0.05.

[6] P value < 0.001.

0.16 which was significantly higher than the mean ± SD ICC of 0.29 ± 0.15 for the rainy season ($P = 0.02$). Approximately 60% of the food items exhibited higher mean ± SD SCC during the rainy season compared with the dry season. This includes fruits (e.g., apple, mango, watermelon), cassava flour-based products (e.g., eba, lafun), nuts (e.g., walnut, tiger nut), fried yam, okro, bean soup, goat, beef, corn cob, chocolate, and honey. Their combined mean ± SD SCC during the rainy season was 0.47 ± 0.10 compared with 0.32 ± 0.10 during the dry season. Conversely, during the dry season, boiled yam, vegetable and egusi soups, cherry, turkey, and plantain chips showed higher combined mean ± SD SCC of 0.40 ± 0.07 compared with mean ± SD SCC of 0.24 ± 0.09 during the rainy season. Across all 87 food items, the Wilcoxon signed-rank tests showed no significant difference in agreement on the intakes of the most food items reported with the FFQs by season (data not shown).

The Bland–Altman analysis showed strong agreement between the FFQs across all 87 food items for both seasons, with <10% of participants outside the limits of agreement. However, certain food items, such as offal, vegetable salad, and wheat swallow, exhibited significant disagreement, with 10.1%–12.2% of participants exceeding the limits of agreement for these foods. The Bland–Altman plots for some selected food items are shown in Figure 3.

Table 5 shows the results of the FFQ validation studies by season. The overall mean ± SD SCC for the validation of FFQ using 24DR was 0.27 ± 0.16 and mean ± SD ICC was 0.26 ± 0.16. A Wilcoxon signed-rank test comparing mean ± SD SCC from the validation studies across seasons showed no significant differences between the dry (mean ± SD = 0.26 ± 0.17) and rainy seasons (mean ± SD = 0.27 ± 0.16) ($P = 0.45$). Similar findings were observed with the ICC tests ($P = 0.42$). When assessing the differences between FFQ and 24DR for food intakes in grams, the majority of food items (>98%) exhibited a significantly higher intake in the FFQ compared with the 24DR, except for bread in both seasons, and white rice, stew, and Tuwon Shinkafa in the dry season. Nonetheless, the Bland–Altman plots revealed good agreement between FFQ and 24DR across both seasons, as <10% of participants fell outside the limits of agreement except for bean soups and Tuwon Shinkafa during the dry season only (data not presented).

Discussion

In this study, we developed a semiquantitative FFQ containing 202 dietary items, covering a wide range of foods, beverages, and condiments from the Nigerian diet. We also created a complementary FPB with images of common foods and portion size options. This FFQ and FPB were designed to be used together to assess the food intakes of adult Nigerians. We tested the reproducibility of the FFQ and its validity compared with 24DR over a 2-y period and the 2 main seasons—dry and rainy—in Nigeria. The FFQ and FPB showed moderate to strong correlations, especially with food groups like cereal products, starchy roots, tubers, beverages, and typical soups. However, correlations were weaker in milk products, solid fats, and fish. The Bland–Altman plots also confirmed good agreement between FFQs and 24DR across both seasons.

The reproducibility of the FFQ measured using SCC was 0.39 ± 0.14, and it was 0.32 ± 0.12 when measured using ICC. The validity of the FFQ compared with 24DR was 0.27 ± 0.16 using

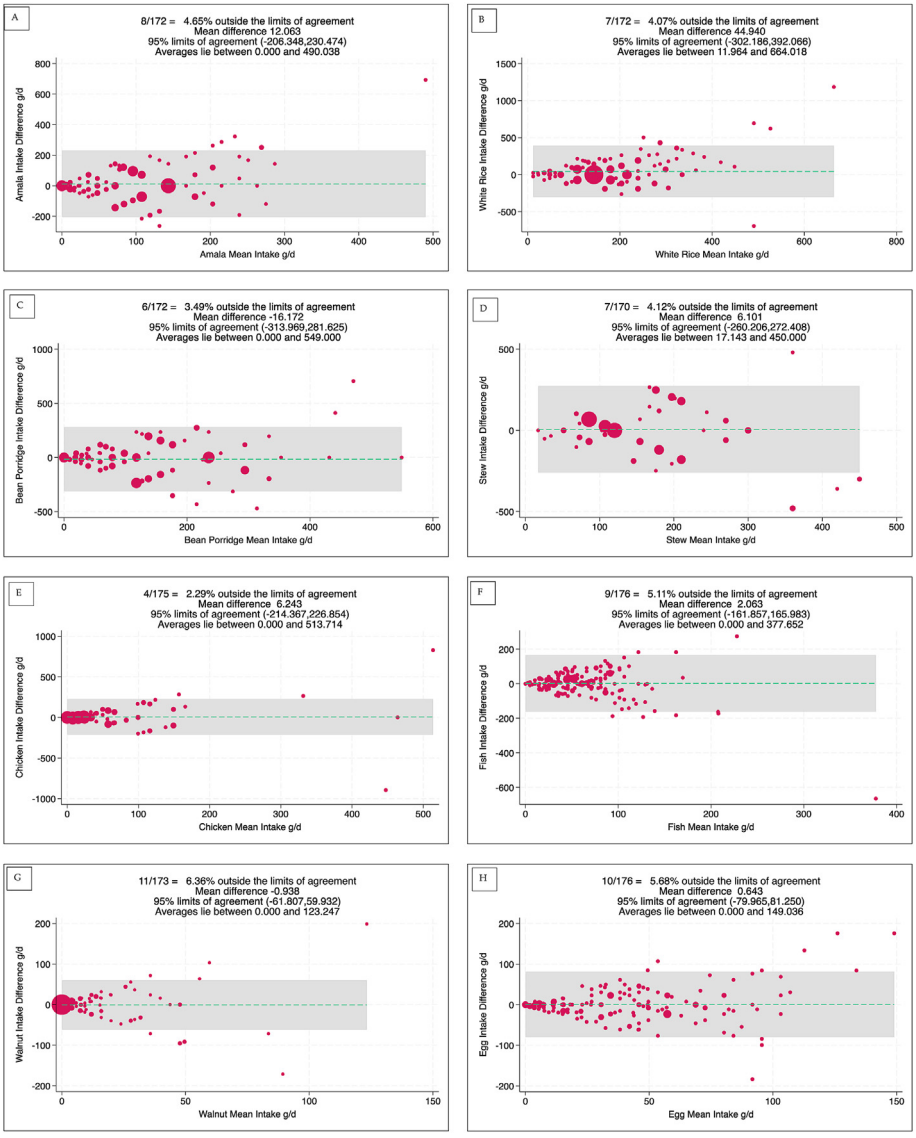

FIGURE 3. Examples of Bland–Altman plots illustrating agreement between FFQs at baseline and 12 mo (dry season) for (A) amala, (B) white rice, (C) bean porridge, and (D) stew, as well as between FFQs at 6 mo and 18 mo (rainy season) for (E) chicken, (F) fish, (G) walnuts, and (H) eggs.

SCC and 0.26 ± 0.16 using ICC. We observed moderate reproducibility correlation coefficients (0.43–0.45) for eggs, cereals and grain products, starchy roots and tubers, and soups. Conversely, we observed low reproducibility correlation coefficients for milk products, solid fats, and fish, (0.22–0.29). Our FFQ's performance is comparable with that of similar studies analyzing food intakes in various populations [30–35]. Examples include studies in Spain (with a 12-mo interval and 2 FFQs, n = 82), Iran (with a 14-mo interval and 2 FFQs, n = 132), and Japan (with 3-mo intervals and 4 FFQs, n = 288). In other studies, the correlation coefficients for the reproducibility of specific food groups ranged from 0.4 to 0.7 [11,12,36,37]. We observed seasonal variations in the reproducibility of some food items like fruits, cassava flour-based products, and nuts, whereas most foods exhibited no significant differences in the reproducibility of the FFQ between seasons. This finding underscores the importance of accounting for seasonal variations when FFQs are used for assessments of intakes of some food items in Nigeria and similar regions.

Most of the previous development, reproducibility, and validation of FFQs studies were done in the United States, Europe, or Asia, and only 6 out of the 123 FFQs in a recent meta-analysis were from Africa [36]. Most of the existing FFQs do not apply to populations in low- and middle-income countries because of differences in food choices and preferences. Out of the 54 countries in Africa, only Mali and Nigeria in the West [38,39]; Tanzania, Kenya, and Ethiopia in the East [40–43]; and Botswana in the South [44] have reproducible and validated FFQs. However, these other African FFQs did not consistently incorporate tools such as detailed images of various foods and dishes with comparisons to common items for standardization of portion sizes [38–42]. This would significantly impact the accuracy of reporting portion sizes. Additionally, the studies of African FFQ typically spanned only 1–3 mo, which is not sufficient duration to account for seasonal variations in food availabilities and its impact on reporting dietary intakes [38–44].

Our study and outcomes are comparable with those of studies in different populations assessing food intakes, such as those in Spain

TABLE 5
Validity results of the semiquantitative FFQ[1] against 24DR[2] by season ($N = 205$)

	Dry season						Rainy season					
	Mean ± SD (g/d)			Validity tests			Mean ± SD (g/d)			Validity tests		
	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]
				z	ρ	*r*				*z*	ρ	*r*
Cereals and grain products					0.29 ± 0.09[4]	0.30 ± 0.10[4]					0.30 ± 0.09[4]	0.38 ± 0.08[4]
White rice	182.2 ± 99.9	163.7 ± 121.9	16.7 ± 134.2	1.04	0.33[6]	0.27 (0.18, 0.45)	183.2 ± 95.5	154.9 ± 119.2	24.7 ± 127.9	2.26[5]	0.33[6]	0.30 (0.21, 0.46)
Jollof rice	86.7 ± 69.0	54.7 ± 79.6	29.6 ± 86.3	4.93[6]	0.34[6]	0.32 (0.24, 0.50)	78.7 ± 67.4	47.3 ± 68.9	27.8 ± 78.7	4.56[6]	0.28[6]	0.33 (0.24, 0.50)
Fried rice	22.3 ± 37.2	2.4 ± 13.7	19.0 ± 37.0	7.71[6]	0.17[5]	0.16 (0.08, 0.36)	16.7 ± 36.1	3.0 ± 18.5	12.9 ± 32.7	7.91[6]	0.14	0.35 (0.27, 0.51)
Spaghetti	62.7 ± 72.9	20.4 ± 45.4	43.7 ± 81.1	6.96[6]	0.24[6]	0.16 (0.03, 0.32)	57.6 ± 58.0	32.7 ± 73.8	25.0 ± 77.3	5.67[6]	0.34[6]	0.32 (0.23, 0.48)
Bread	134.7 ± 94.0	115.5 ± 106.7	17.7 ± 112.4	1.98	0.41[6]	0.37 (0.28, 0.53)	138.0 ± 85.4	124.4 ± 106.8	14.1 ± 101.0	1.99	0.43[6]	0.45 (0.37, 0.59)
Pap (YR: Akamu, Ogi)/millet meal	240.0 ± 220.2	89.0 ± 146.8	160.9 ± 212.7	8.40[6]	0.33[6]	0.37 (0.26, 0.51)	261.4 ± 220.6	115.5 ± 163.3	140.8 ± 204.1	7.90[6]	0.34[6]	0.45 (0.36, 0.58)
Meat pie	18.0 ± 23.6	5.9 ± 18.3	13.1 ± 22.1	8.13[6]	0.31[6]	0.46 (0.36, 0.59)	19.8 ± 30.9	4.0 ± 12.3	14.0 ± 23.5	8.35[6]	0.33[6]	0.50 (0.43, 0.63)
Doudhs	5.5 ± 8.4	1.5 ± 5.6	3.9 ± 8.6	7.34[6]	0.17[5]	0.28 (0.19, 0.46)	6.8 ± 9.8	2.3 ± 6.3	4.4 ± 9.6	7.08[6]	0.25[6]	0.31 (0.23, 0.48)
Starchy roots and tubers					0.32 ± 0.20[4]	0.35 ± 0.20[4]					0.31 ± 0.20[4]	0.30 ± 0.17[4]
Traditional Pounded yam	42.9 ± 55.8	7.6 ± 23.5	32.9 ± 49.9	8.28[6]	0.21[6]	0.34 (0.26, 0.51)	39.6 ± 58.8	7.6 ± 29.2	31.3 ± 53.3	9.36[6]	0.27[6]	0.34 (0.26, 0.50)
Eba	61.9 ± 78.9	41.3 ± 77.9	22.2 ± 68.7	4.91[6]	0.60[6]	0.62 (0.55, 0.72)	65.2 ± 79.8	32.5 ± 75.8	33.6 ± 73.5	6.52[6]	0.49[6]	0.55 (0.48, 0.67)
Amala	101.7 ± 74.5	85.6 ± 105.4	17.7 ± 107.3	2.68[5]	0.34[6]	0.29 (0.21, 0.47)	110.0 ± 85.0	85.6 ± 105.3	26.4 ± 112.5	3.45[6]	0.37[6]	0.31 (0.21, 0.47)
Tuwon Shinkafa	68.5 ± 94.2	61.9 ± 99.0	7.2 ± 68.1	1.89	0.81[6]	0.75 (0.70, 0.82)	53.2 ± 81.8	41.8 ± 81.2	6.8 ± 65.7	2.32[5]	0.81[6]	0.68 (0.61, 0.76)

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TABLE 5 (*continued*)

	Dry season						Rainy season					
	Mean ± SD (g/d)			Validity tests			Mean ± SD (g/d)			Validity tests		
	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]
				z	*ρ*	*r*				*z*	*ρ*	*r*
Fufu or akpu	43.6 ± 58.5	22.0 ± 51.1	21.3 ± 57.1	5.97[6]	0.36[6]	0.46 (0.38, 0.60)	41.9 ± 59.2	20.4 ± 56.1	23.1 ± 67.1	6.56[6]	0.35[6]	0.32 (0.23, 0.48)
Wheat flour Swallow	29.7 ± 40.2	3.5 ± 16.5	28.1 ± 40.6	8.45[6]	0.25[6]	0.16 (0.05, 0.34)	30.4 ± 45.4	5.9 ± 25.9	23.8 ± 46.1	7.99[6]	0.31[6]	0.23 (0.14, 0.41)
Cassava flour Swallow (YR: Lafun)	31.5 ± 63.1	7.9 ± 34.4	23.8 ± 58.5	6.97[6]	0.35[6]	0.35 (0.27, 0.52)	39.1 ± 77.5	8.9 ± 35.9	32.2 ± 68.3	7.54[6]	0.35[6]	0.37 (0.27, 0.51)
Boiled yam	85.6 ± 65.7	31.5 ± 57.9	52.3 ± 78.5	7.00[6]	0.20[5]	0.20 (0.12, 0.40)	80.6 ± 60.4	32.0 ± 64.3	48.3 ± 78.6	7.63[6]	0.25[6]	0.21 (0.11, 0.39)
Fried yam (Dundu)	38.7 ± 63.5	13.4 ± 42.4	24.3 ± 56.6	6.59[6]	0.20[5]	0.46 (0.38, 0.60)	35.7 ± 60.5	5.5 ± 31.4	28.7 ± 62.6	8.06[6]	0.18[5]	0.17 (0.08, 0.36)
Yam porridge	88.7 ± 105.8	7.4 ± 33.7	82.3 ± 103.2	9.55[6]	0.16[6]	0.17 (0.08, 0.36)	70.6 ± 97.1	13.4 ± 62.3	56.7 ± 106.4	8.59[6]	0.06	0.16 (0.06, 0.34)
Plantain boiled/ steamed/roasted	14.4 ± 24.1	1.5 ± 5.4	12.5 ± 24.6	9.38[6]	0.18[6]	0.05 (0.00, 0.28)	9.6 ± 13.6	1.2 ± 6.1	8.9 ± 14.5	9.45[6]	0.16[5]	0.07 (0.00, 0.25)
Fried sliced Plantain (YR: Dodo)	66.9 ± 65.5	22.9 ± 45.0	43.2 ± 67.8	7.68[6]	0.20[6]	0.29 (0.20, 0.46)	37.3 ± 43.2	11.3 ± 26.1	25.0 ± 46.1	7.50[6]	0.15	0.17 (0.09, 0.36)
Soups (leafy vegetables with/without meat/fish/chicken)					0.30 ± 0.23[4]	0.23 ± 0.23[4]					0.31 ± 0.20[4]	0.22 ± 0.23[4]
Stew	149.4 ± 78.2	116.9 ± 68.6	29.1 ± 103.5	2.75	0.12	0.02 (0.00, 0.24)	161.7 ± 106.0	119.3 ± 77.4	44.9 ± 126.7	3.57[6]	0.23[6]	0.07 (0.00, 0.27)
Vegetable soup (YR: Efo; HA: Taushe)	81.5 ± 51.1	33.1 ± 58.0	47.5 ± 75.5	7.14[6]	0.09	0.04 (0.00, 0.27)	104.4 ± 76.7	66.6 ± 80.7	41.4 ± 105.7	5.30[6]	0.19[5]	0.10 (0.00, 0.28)
Egusi soup + vegetables	55.8 ± 58.6	42.1 ± 60.8	15.0 ± 72.0	3.62[6]	0.37[6]	0.27 (0.18, 0.45)	62.5 ± 69.7	48.6 ± 72.9	12.3 ± 89.9	2.64[5]	0.36[6]	0.21 (0.12, 0.39)
Ogbono (YR: Apon)	10.7 ± 17.2	2.3 ± 10.0	8.6 ± 13.7	7.70[6]	0.41[6]	0.54 (0.45, 0.66)	14.3 ± 28.3	3.4 ± 12.8	11.1 ± 27.3	7.51[6]	0.27[6]	0.24 (0.15, 0.41)
Kuka (HA: Miyan Kuka)	27.0 ± 41.5	15.0 ± 29.8	13.3 ± 37.3	4.05[6]	0.69[6]	0.47 (0.39, 0.61)	27.0 ± 44.3	12.9 ± 33.4	12.0 ± 32.0	5.27[6]	0.68[6]	0.67 (0.61, 0.76)

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TABLE 5 (*continued*)

	Dry season						Rainy season					
	Mean ± SD (g/d)			Validity tests			Mean ± SD (g/d)			Validity tests		
	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]
				z	ρ	*r*				*z*	ρ	*r*
Bitter leaf soup	22.9 ± 33.7	3.5 ± 18.0	21.4 ± 37.9	8.43[6]	0.14	0.04 (0.00, 0.23)	27.5 ± 34.2	1.3 ± 12.2	26.3 ± 35.7	9.79[6]	0.12	0.05 (0.00, 0.25)
Whole fruits/vegetables					0.15 ± 0.15[4]	0.14 ± 0.16[4]					0.12 ± 0.04[4]	0.08 ± 0.02[4]
Banana	99.7 ± 85.1	8.7 ± 27.8	91.1 ± 89.4	10.22[6]	0.06	0.05 (0.00, 0.25)	78.1 ± 79.3	6.9 ± 23.9	69.9 ± 78.8	10.02[6]	0.05	0.10 (0.02, 0.31)
Orange	161.7 ± 137.3	20.9 ± 57.0	143.0 ± 136.0	9.92[6]	0.14	0.19 (0.09, 0.37)	122.1 ± 95.4	22.5 ± 54.8	98.4 ± 105.9	9.51[6]	0.13	0.08 (0.00, 0.28)
Pineapple	64.9 ± 80.1	5.4 ± 21.9	60.1 ± 83.2	9.20[6]	0.06	0.04 (0.00, 0.25)	71.1 ± 91.0	5.3 ± 27.4	62.2 ± 92.4	9.79[6]	0.14	0.07 (0.00, 0.28)
Sugarcane	31.5 ± 46.6	0.3 ± 3.9	30.6 ± 47.7	8.81[6]	0.08	0.01 (0.00, 0.24)	23.7 ± 41.7	1.4 ± 11.0	21.4 ± 41.4	8.68[6]	0.11	0.09 (0.01, 0.29)
Watermelon	157.7 ± 126.6	35.0 ± 92.3	126.2 ± 122.1	9.77[6]	0.41[6]	0.40 (0.29, 0.54)	148.2 ± 137.1	22.6 ± 67.6	121.9 ± 148.4	10.07[6]	0.16[5]	0.07 (000, 0.27)
Legumes and products					0.18 ± 0.14[4]	0.17 ± 0.12[4]					0.16 ± 0.12[4]	0.20 ± 0.17[4]
Bean only	124.5 ± 102.8	70.4 ± 84.5	55.3 ± 127.2	5.01[6]	0.23[6]	0.10 (0.01, 0.30)	119.1 ± 130.8	68.2 ± 96.9	50.4 ± 142.8	4.69[6]	0.28[6]	0.23 (0.14, 0.41)
Bean porridge	134.9 ± 102.3	66.4 ± 92.6	72.6 ± 122.2	6.86[6]	0.22[6]	0.22 (0.12, 0.40)	158.8 ± 138.0	77.9 ± 114.4	82.7 ± 172.3	6.33[6]	0.13	0.08 (0.00, 0.27)
Bean cake (YR: Akara)	54.3 ± 45.6	10.3 ± 27.6	42.8 ± 47.0	9.35[6]	0.18[5]	0.24 (0.15, 0.42)	52.5 ± 42.0	10.6 ± 29.6	41.2 ± 45.3	9.27[6]	0.06	0.23 (0.13, 0.40)
Bean soup (YR: Gbegiri)	17.8 ± 22.1	5.3 ± 13.8	13.3 ± 22.1	7.42[6]	0.32[6]	0.30 (0.20, 0.46)	18.6 ± 23.8	7.1 ± 23.6	10.8 ± 24.8	7.88[6]	0.30[6]	0.45 (0.37, 0.59)
Moi Moi (YR: Moin Moin)	56.4 ± 37.9	6.3 ± 41.3	52.1 ± 58.3	9.58[6]	−0.06	0.00 (0.00, 0.11)	57.8 ± 37.8	12.1 ± 41.5	45.7 ± 55.4	9.21[6]	0.04	0.02 (0.00, 0.22)
Meat and poultry					0.14 ± 0.11[4]	0.21 ± 0.14[4]					0.20 ± 0.09[4]	0.20 ± 0.15[4]
Chicken (±skin)	49.0 ± 72.6	9.8 ± 33.7	38.1 ± 83.9	7.87[6]	−0.03	0.00 (0.00, 0.17)	45.6 ± 71.7	6.8 ± 29.5	39.1 ± 71.9	9.51[6]	0.13	0.15 (0.05, 0.34)

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TABLE 5 (*continued*)

	Dry season						Rainy season					
	Mean ± SD (g/d)			Validity tests			Mean ± SD (g/d)			Validity tests		
	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]
				z	*ρ*	*r*				*z*	*ρ*	*r*
Turkey	14.0 ± 25.7	3.8 ± 18.4	10.7 ± 28.9	6.98[6]	0.16	0.18 (0.09, 0.36)	12.2 ± 38.0	1.4 ± 8.8	10.7 ± 40.3	7.63[6]	0.12	0.00 (0.00, 0.17)
Beef (boiled/fried)	62.0 ± 51.3	14.4 ± 27.4	46.5 ± 50.0	9.76[6]	0.30[6]	0.28 (0.19, 0.46)	71.3 ± 69.5	19.3 ± 33.2	48.8 ± 60.3	9.14[6]	0.36[6]	0.39 (0.30, 0.54)
Cow skin (YR: Ponmo, Bokoto)	34.9 ± 34.0	10.0 ± 18.0	23.8 ± 30.2	8.77[6]	0.19[6]	0.40 (0.32, 0.56)	34.7 ± 27.7	11.5 ± 20.0	23.4 ± 27.4	8.79[6]	0.14	0.36 (0.26, 0.50)
Offal/Trip (YR: Orisirisi)	9.5 ± 13.4	1.7 ± 9.1	8.1 ± 14.2	8.17[6]	0.10	0.24 (0.15, 0.42)	13.3 ± 23.6	1.4 ± 12.3	11.6 ± 24.6	9.43[6]	0.26[6]	0.15 (0.07, 0.35)
Suya	17.1 ± 23.6	0.8 ± 4.6	15.9 ± 23.0	9.00[6]	0.12	0.13 (0.05, 0.34)	14.5 ± 22.7	0.8 ± 7.3	13.1 ± 22.3	9.49[6]	0.17[5]	0.14 (0.06, 0.34)
Fish and products					0.17 ± 0.05[4]	0.21 ± 0.06[4]					0.25 ± 0.01[4]	0.23 ± 0.16[4]
Fish (boiled/fried)	77.9 ± 60.1	51.4 ± 39.8	27.6 ± 66.4	4.86[6]	0.12	0.17 (0.08, 0.36)	65.0 ± 46.0	41.5 ± 32.5	22.5 ± 53.0	5.46[6]	0.24[6]	0.12 (0.04, 0.32)
Dry fish	18.8 ± 18.8	9.1 ± 15.7	8.6 ± 21.3	5.71[6]	0.21[5]	0.26 (0.18, 0.44)	19.6 ± 21.9	12.4 ± 20.4	7.7 ± 24.3	4.86[6]	0.26[6]	0.34 (0.25, 0.50)
Eggs												
Egg (boiled/fried)	37.1 ± 28.2	12.5 ± 18.8	22.8 ± 28.8	8.44[6]	0.34[6]	0.29 (0.22, 0.48)	39.8 ± 30.4	17.2 ± 21.4	21.4 ± 28.2	8.20[6]	0.39[6]	0.43 (0.34, 0.57)
Milks and products					0.29 ± 0.06[4]	0.32 ± 0.01[4]					0.32 ± 0.06[4]	0.36 ± 0.11[4]
Evaporated liquid milk	13.9 ± 15.7	5.0 ± 11.8	9.2 ± 16.3	7.53[6]	0.24[6]	0.31 (0.23, 0.49)	15.0 ± 14.5	5.5 ± 15.5	9.2 ± 15.9	8.35[6]	0.36[6]	0.44 (0.35, 0.58)
Powdered milk	5.6 ± 6.1	3.3 ± 5.6	2.4 ± 6.8	5.06[6]	0.33[6]	0.32 (0.23, 0.49)	5.6 ± 4.9	3.0 ± 5.0	2.6 ± 6.0	5.79[6]	0.28[6]	0.27 (0.18, 0.44)
Condiments, spices, and additives												
African locust bean (YR: Iru)	10.8 ± 6.7	4.4 ± 6.4	6.7 ± 8.9	8.17[6]	0.15	0.08 (0.00, 0.27)	10.9 ± 7.1	7.6 ± 7.5	3.5 ± 9.7	4.56[6]	0.08	0.13 (0.04, 0.31)
Beverages (glass 25 cl)					0.38 ± 0.18[4]	0.36 ± 0.21[4]					0.35 ± 0.22[4]	0.34 ± 0.24[4]

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TABLE 5 (*continued*)

	Dry season						Rainy season					
	Mean ± SD (g/d)			Validity tests			Mean ± SD (g/d)			Validity tests		
	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]	FFQ	24DR	Mean ± SD (FFQ compared with 24DR) differences (g/d)	Wilcoxon's signed-rank test	Spearman correlation	ICC[3]
				z	ρ	*r*				*z*	ρ	*r*
Water	2609 ± 1272	1556 ± 582	1072± 1317	8.59[6]	0.29[6]	0.14 (0.05, 0.33)	2693 ± 1235	1688 ± 629	999 ± 1326	8.98[6]	0.22[5]	0.09 (0.00, 0.29)
Soft drinks	143.0 ± 123.6	49.1 ± 66.3	96.1 ± 113.5	8.66[6]	0.46[6]	0.36 (0.26, 0.52)	137.2 ± 137.3	46.7 ± 65.9	89.2 ± 126.1	8.54[6]	0.40[6]	0.32 (0.23, 0.48)
Chocolate	111.0 ± 107.1	50.3 ± 75.0	60.0 ± 108.2	6.23[6]	0.36[6]	0.33 (0.24, 0.49)	110.5 ± 98.6	68.0 ± 117.3	40.2 ± 113.7	4.70[6]	0.36[6]	0.45 (0.36, 0.59)
Tea	115.9 ± 148.3	86.0 ± 133.9	31.9 ± 131.8	3.92[6]	0.66[6]	0.57 (0.49, 0.68)	101.9 ± 116.2	66.9 ± 107.0	27.3 ± 88.4	5.23[6]	0.65[6]	0.69 (0.63, 0.77)
Coffee	24.2 ± 69.9	7.3 ± 45.2	18.6 ± 51.4	6.56[6]	0.40[6]	0.63 (0.56, 0.73)	17.1 ± 44.8	8.5 ± 33.3	7.7 ± 41.8	4.56[6]	0.47[6]	0.44 (0.36, 0.58)
Fruit juice	12.8 ± 32.3	1.6 ± 10.0	10.6 ± 32.5	5.56[6]	0.10	0.11 (0.04, 0.32)	14.9 ± 35.8	4.8 ± 30.4	11.0 ± 46.1	6.78[6]	0.00	0.04 (0.00, 0.23)
Sugars, syrups, and sweets												
Sugar	5.0 ± 5.6	1.6 ± 2.8	3.3 ± 5.3	7.40[6]	0.41[6]	0.29 (0.20, 0.47)	5.6 ± 5.6	2.1 ± 3.9	3.3 ± 5.1	7.92[6]	0.47[6]	0.44 (0.36, 0.58)
Snacks					0.22 ± 0.01[4]	0.17 ± 0.07[4]					0.24 ± 0.20[4]	0.15±0.21[4]
Cassava powder (Garri) + water	12.8 ± 18.3	4.7 ± 12.1	7.8 ± 19.5	6.19[6]	0.23[6]	0.22 (0.14, 0.41)	15.9 ± 22.8	5.9 ± 14.9	9.6 ± 22.9	6.97[6]	0.38[6]	0.30 (0.21, 0.47)
Plantain chips (YR: Igbekere/ Ipekere)	2.6 ± 3.5	0.1 ± 0.5	2.5 ± 3.4	9.96[6]	0.22[6]	0.12 (0.03, 0.32)	2.4 ± 2.8	0.1 ± 0.7	2.3 ± 2.8	10.30[6]	0.10	0.01 (0.00, 0.21)

Abbreviations: 24HR, 24-h recall (average of 4 different 24HRs within the same season); FFQ, Food Frequency Questionnaire (average of 2 different FFQs within the same season); HA, Hausa/Fulani; IB, Igbo; YR, Yoruba.

[1] A total of 57 selected food items, consumed by more than two-thirds of the participants, were identified based on the 24DR reports.

[2] Mean ± SD of 2 sets of FFQs within each season were reported, providing insight into central tendency and data spread despite nonnormality because of the large sample size.

[3] Intraclass correlation coefficient (ICC) values are presented as *r* (95% confidence interval).

[4] Intraclass correlation coefficient (ICC) values are presented as mean ± SD, representing average correlations by food group.

[5] *P* value < 0.05,

[6] *P* value < 0.001.

(12-mo interval, 2 FFQs, $n = 82$), Iran (14-mo interval, 2 FFQs, $n = 132$), and Japan (3-mo intervals, 4 FFQs, $n = 288$) [30–35].

Recent nutrition epidemiology studies have recognized that diets consist of a blend of both nutrients and foods that cannot be easily separated, hence more focus is being placed on methods that capture foods and food groups intakes and creation of eating patterns such as the Mediterranean diet, Dietary Approaches to Stop Hypertension, and plant-based diet [45–47]. Furthermore, by considering the intake of specific foods and food groups, dietary indices such as the Healthy Eating Index [48] and Global Diet Quality Score [49] can be readily evaluated for associations with health outcomes. These indices assess overall diet quality, which is more likely to be applicable in cases of NCDs rather than intake of specific nutrients or bioactive components. The data collected by our FFQ can be used to reveal dietary intake patterns among Nigerians, and facilitate comparisons with the dietary intakes of other populations using various dietary indices. In addition, it is worth noting that the lack of uniformity in food composition databases poses significant limitations to the conversion of FFQ data to nutrients' data [50]. This limitation is particularly relevant in developing countries where food composition databases may be unavailable, incomplete, infrequently updated, or poorly maintained.

Our study has several strengths. First, we had a large sample size, a long study duration of 2 y covering multiple dry and rainy seasons, and a low dropout rate. We balanced the study sample by sex, age group, and cultural diversity by recruiting participants from the 3 largest tribes in Nigeria. We designed the FFQ thoughtfully so that it is comprehensive, encompassing a wide variety of food items, beverages, and condiments, and effectively capturing the diversity of the Nigerian diet. Furthermore, the FFQ includes an FPB with standardized portion sizes, along with widely recognized objects for comparison with food images, enabling a more precise reporting of dietary intakes.

We acknowledge several limitations in our study. The study participants were recruited from an urban area in southwest Nigeria. Although we ensured diversity among the tribes, it is important to acknowledge that the dietary habits of individuals from tribes not native to the area may have been influenced by the dietary patterns of natives and by food availability. The dietary intakes of residents in urbanized regions of Nigeria may also be substantially different from that of rural residents. Additionally, we assumed that similar recipes were used for the listed dishes, but significant variations may occur during preparation and with ingredient choices, especially since most Nigerians primarily eat meals cooked at home. Although this assumption could introduce some inaccuracies into the assessment of dietary intake among participants, it's expected to have a lesser impact on the reproducibility findings of the FFQ.

In conclusion, our study revealed reproducibility and validity results that are consistent with other nutrition epidemiology studies. Given the limited availability of dietary assessment tools tailored for African populations, our study is a significant contribution to future nutrition epidemiology research in Nigeria. Our validated FFQ and complementary FPB create opportunities for research exploring the associations between various foods and nutrients with NCDs in Nigeria. With the size of its population (approximately half of all West Africans and one-sixth of all Africans are Nigerians), such studies would have significant population-level impacts beyond Nigeria's borders. The FFQ also covers a wide range of food groups that can be used to generate diet quality indices and facilitate international comparisons.

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Author contributions

The authors' responsibilities were as follows – CAA: designed research; SNA, GB, CAA, members of Nutrition Epidemiology Research of Nigeria (NERON): conducted research; GB: analyzed data; GB, CAA: wrote the article; CAA: had primary responsibility for final content; and all authors: read and approved the final manuscript.

Conflict of interest

The authors have no conflict of interest to report.

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Data availability

Data described in the manuscript, codebook, and analytic code will be made available upon request. The FFQ and FPB can be accessed on request by contacting CAA at cadebamowo@som.umaryland.edu and helpmeto@analyze.lifestyle.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cdnut.2024.102135.

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