

Macronutrient Composition of Some Starchy Dishes Commonly Eaten at Lunch and Dinner in Togo

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How to cite this paper: Kouassi, K.C., Kodjo, K., Ahado, J., Kalekou, K.S., Fayeu, C.M., Assem, A., Yibor, J.A., Atokou, M.D., Ony, A.R., Bouka, E.C., Aziato, K., Apaloo, K., Hanvi, D.M., Melila, M. and Belo, M. (2026) Macronutrient Composition of Some Starchy Dishes Commonly Eaten at Lunch and Dinner in Togo. *Food and Nutrition Sciences*, 17, 1015-1041.

<https://doi.org/10.4236/fns.2026.1710061>

Received: July 27, 2026

Accepted: October 26, 2026

Published: October 29, 2026

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Abstract

In Togo, starchy foods form the basis of the daily diet, providing the bulk of the population's energy intake. This highlights the need for a thorough nutritional assessment of local meals in order to provide appropriate dietary advice. The aim of this study was to establish the energy, protein, fat, carbohydrate and ash content of meals consumed at lunch and/or dinner for the purposes of dietary advice. This was a descriptive and analytical study conducted from March 2024 to July 2025, covering 125 dishes based on local starchy foods and accompanying sauces. The analyses were carried out at the "Laboratoire Contrôle Qualité des Aliments" of ITRA now known as "Laboratoire Nationale de Sécurité sanitaire et phytosanitaires des Aliments (LaNSA)" Lomé, Togo. in accordance with international testing standards, notably ISO 665:2020 to determine moisture content, AOAC 923.03 to determine ash content, ISO 20483:2013 to determine protein content, and AOAC 960.39 to determine fat content. Carbohydrate content was determined by difference, and energy content was calculated using the Atwater coefficients. The 90 starchy dishes analysed had carbohydrate contents ranging from 1.33 to 49.50 g/100g, fat contents ranging from 0.00 to 19.85 g/100g, protein contents from 1.22 to 14.14 g/100g, and

fibre contents from 0.56 to 9.70 g/100g. The carbohydrate content in the 35 sauces ranged from 0.32 g to 13.72 g-per-100g, with a fat content ranging from 0.1 g to 8.86 g-per-100g, protein from 1.59 g to 18.07 g-per-100g, and fibre from 1.12 g to 4.60 g-per-100g. The total ash content in the 90 dishes ranged from 0.28 g to 3.94 g-per-100g and in the 35 sauces from 1.46 g to 3.08 g-per-100g. The study provided a nutritional profile of starchy dishes consumed in Togo, revealing high energy intakes. These results provide an essential basis for formulating appropriate nutritional recommendations and guiding public health policies towards a balanced diet.

Keywords

Local Starchy Dishes, Macronutrient Content, Energy Intake, Ash Content, Lunch/Dinner, Togo

1. Introduction

Dietary habits play a crucial role in the health and well-being of populations [1]. A healthy and balanced diet provides essential nutrients, supports normal body functions, and helps prevent malnutrition and diet-related non-communicable diseases [2].

However, globally, dietary imbalances are a reality and remain a major cause of non-communicable diseases (NCDs). According to the World Health Organization (WHO), NCDs such as cardiovascular disease, diabetes and certain cancers are responsible for 41 million deaths annually, accounting for 74 percent of global deaths [3]. Poor diet and lack of physical activity are among the main risk factors, exacerbated by the growing consumption of processed foods high in calories, saturated fats, free sugars and salt. In Africa, these nutritional trends are compounded by rapid urbanization and the nutritional transition, increasing the prevalence of NCDs [4].

In Togo, data from the 2021 STEPS survey reveal that 27.4 percent of adults aged between 18 and 69 suffer from high blood pressure, while 4.9 percent have diabetes. Furthermore, 88.9 percent of Togolese people do not consume the five portions of fruit and vegetables per day recommended by the World Health Organization (WHO) [5]. These findings are set against a dietary backdrop in which starchy foods form the basis of the daily diet, consumed in various forms such as rice, maize, millet, root vegetables and plantains. Although these foods provide a large proportion of energy intake, they also contribute to an increase in overweight, pre-diabetes and diabetes, particularly when consumed in excess or as part of an unbalanced diet [6].

Despite the importance of starchy foods in the Togolese diet, data on their nutritional composition after preparation remain limited. Few studies have examined the exact proportions of carbohydrates, fats and proteins in these traditional dishes, which limits an accurate assessment of their nutritional contribution and

their impact on public health. A thorough understanding of these aspects is essential for determining their glycaemic index (GI) and glycaemic load, key tools in the management of metabolic diseases.

The aim of this study was to determine the energy, protein, fat, carbohydrate, and ash profiles of starchy dishes commonly consumed at lunch and dinner in Togo.

2. Material and Methods

2.1. Study Design, Site and Dishes Collection Period

This was a descriptive and analytical study focusing on selected ready-to-eat dishes commonly consumed by the Togolese population. The study was conducted from March 2024 to July 2025 and aimed to determine the glycemic index and glycemic load of these foods. A preliminary dietary survey was conducted among 500 male and female students aged 18 - 35 years at the University of Lomé, which was selected because of the cosmopolitan nature of its student population, comprising individuals from different regions of Togo. To identify commonly consumed foods, an online questionnaire was developed and administered using the KoboCollect platform. The questionnaire was disseminated through the communication groups of faculties and schools. It collected sociodemographic information, food preferences, and food consumption frequency. The foods investigated included maize, rice, sorghum, millet, fonio, wheat, cassava, yam, sweet potato, taro, plantain, cowpea, and Bambara groundnut (voandzou), as well as their accompanying sauces [7] [8]. Foods reported as being consumed at least four times per week were considered frequently consumed. Among these, locally consumed foods considered to make a significant contribution to daily nutritional intake were selected [9]. A total of 90 starchy-based dishes and 35 accompanying sauces were selected.

2.1.1. Culinary Preparation and Sampling

The selected dishes were prepared according to their usual local recipes and culinary practices. The ingredients used in each preparation were weighed before cooking to determine the proportions incorporated into the dishes. Porridges were prepared without added sugar. For sauces containing meat or fish, 100 g of meat or fish were incorporated according to the corresponding recipe. After cooking, the dishes were allowed to cool to room temperature. Portions weighing approximately 220 g on average were collected and weighed into clean containers. Each sample was immediately sealed and identified by the name of the dish. Samples were collected in successive batches, with an average of 12 samples per collection. The dishes studied represented foods commonly consumed at lunch and dinner, including cereal-based doughs, rice, cowpea, tubers, and plantain, together with their accompanying sauces.

2.1.2. Sample Transport and Storage

Following collection, the samples were placed in a cooler and transported to the laboratory for analysis. Upon arrival, each sample was registered and assigned a

unique identification code. The samples were then prepared for the planned nutritional analyses and stored under refrigerated conditions until analysis.

2.1.3. Ethical Considerations

Ethical approval for the study was obtained from the Comité de Bioéthique pour la Recherche en Santé (CBRS) under Opinion No. 005/2024/CBRS dated January 18, 2024. Authorization to conduct the preliminary dietary survey was also obtained from the Presidency of the University of Lomé prior to data collection.

Inclusion criteria: this study included local Togolese dishes based on starchy foods, as well as the various accompanying sauces consumed locally.

Exclusion criteria: non-traditional, imported and industrially processed ready-to-eat dishes were excluded from this study.

2.2. Nutritional Composition of Local Dishes

A comprehensive analysis of the nutritional composition was carried out on 125 starchy dishes and local sauces. The following parameters were measured: water content, ash, fat, protein, total dietary fibre, available carbohydrates and the energy value of the meals consumed at lunch and dinner.

2.2.1. Laboratory Analyses

Non-homogeneous samples were ground using a mill (Retsch GM 300) prior to analysis.

The water content was determined using the ISO 665:2020 method, based on drying at $103^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for four hours in an oven until a practically constant mass was obtained [10]. The water content content was calculated using the following formula:

$$H = \frac{m1 - m2}{m1 - m0} \times 100$$

H: water content (g/100);

m0: mass, in grams, of the empty crucible;

m1: mass, in grams, of the crucible containing the test specimen, before drying;

m2: mass, in grams, of the crucible with the test sample, after drying.

The ash content represents the total inorganic residue remaining after the incineration of a food sample.

The ash content was determined using AOAC method 923.03. This involves incinerating the food samples in a muffle furnace at a temperature of $500^{\circ}\text{C} \pm 50^{\circ}\text{C}$ until a whitish ash is obtained [11]. The ash content was calculated using the formula:

$$\text{Ash content (g/100g)} = \frac{m1}{m0} \times 100$$

m0: mass, in grams, of the test sample;

m1: mass, in grams, of the incineration residue.

The total protein content is determined using the Kjeldahl method in accordance with ISO 20483:2013 [12]. The principle involves the digestion of organic

matter using concentrated sulfuric acid in the presence of a protein catalyst, followed by alkalization of the reaction products. The ammonia released is distilled and collected in a boric acid solution, then titrated with a standard sulfuric acid solution (0.5 N). The conversion factor used for nitrogen to total protein was 6.25. The total protein content is determined using the formula:

$$T_p = \frac{V - V_0}{P} \times T \times \beta \times 0.014 \times 100$$

T_p : Total protein content (g/100 g);

V : Volume of sulphuric acid used for the blank test (ml);

V_0 : Volume of sulphuric acid used for the blank (ml);

T : Concentration of the sulphuric acid solution used for titration (1 N);

P : Test sample (g);

β : Conversion factor for nitrogen to total protein (6.25);

0.014: Conversion factor from the titre of the sulphuric acid solution used (normality) to mass titre.

Lipids were extracted using the Soxhlet method (AOAC 960.39). A test sample of 2 g of meal was placed in an extraction cartridge. The cartridge was sealed with cotton wool and then placed in the Soxhlet apparatus. The entire extraction system was mounted on a pre-tared beaker containing diethyl ether or hexane. The fat was recovered after extraction [13]. The mass of the lipids was obtained by the difference after drying. The lipid content was determined using the formula:

$$Tl = \frac{mf - m0}{me} \times 100$$

Tl : lipid content (g/100g);

mf : mass, in grams, of fat + capsule;

$m0$: empty weight, in grams;

me : mass, in grams, of the test sample.

The available carbohydrate content in the meals was determined by differential calculation using the formula [14]:

$$\begin{aligned} &\text{Available carbohydrates (g/100g PC)} \\ &= 100 - (\text{water content} + \text{lipids} + \text{total proteins} + \text{Ash content} \\ &\quad + \text{total dietary fibre contents}). \end{aligned}$$

The energy value of the various dishes is calculated using the Atwater factors according to the formula [14]:

$$\begin{aligned} \text{Energy} \left(\frac{\text{kcal}}{100\text{g}} \right) &= \text{total protein} \left(\frac{\text{g}}{100\text{g}} \right) \times 4 + \text{total fat} \left(\frac{\text{g}}{100\text{g}} \right) \times 9 \\ &\quad + \text{Available carbohydrates} \left(\frac{\text{g}}{100\text{g}} \right) \times 4 \\ &\quad + \text{total dietary fibre (g/100g)} \times 2. \end{aligned}$$

The total dietary fibre (crude fibre) contents were determined using the Fibretherm system based on the Weende method [15].

The sample was brought to the boil in sulfuric acid and then in caustic soda. The resulting residue was dried at 105°C overnight and then ashed at 550°C for 4 hours. The total dietary fiber content is expressed as a percentage of dry matter. The total dietary fiber content is expressed as a percentage of dry matter using the formula:

$$\%CBW = \frac{(S1 - S0) - (M1 - M0 - S0 \times 0.004)}{PE} \times 100$$

%CBW: the total dietary fibre content in g/100 g;

PE: the mass of the test sample, in grams;

S0: the mass, in grams, of the empty sample bag;

S1: the mass, in grams, of the empty sample bag containing the residue;

M0: the mass, in grams, of the empty crucible;

M1: is the mass, in grams, of the crucible containing the ash;

0.004: the correction factor for the ash in the bag.

2.2.2. Laboratory Quality Control

Quality control procedures were implemented throughout the laboratory analyses to ensure the accuracy and reliability of the analytical results. All analyses were carried out in triplicate under the same laboratory conditions, and the reported values correspond to the mean of the three determinations.

For protein determination by the Kjeldahl method, reagent blanks were included to account for potential contributions from the reagents. The distillation step was also verified using a known amount of ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$. This control was performed in triplicate, and an average nitrogen recovery of 95% was considered acceptable.

For lipid determination by Soxhlet extraction, the laboratory quality-control procedure included extraction blanks, duplicate analyses, monitoring of an internal control sample, and control of constant mass of the extraction vessel before weighing the lipid residue. External quality control was also performed through BIPEA interlaboratory comparison when an appropriate test sample was available.

For external quality control, BIPEA interlaboratory comparison results were evaluated by comparing the laboratory results with the assigned values and by monitoring the corresponding z-scores. Internal control results were considered valid when they complied with the established laboratory criteria and the validity and repeatability conditions of the analytical methods.

2.2.3. Data Processing and Analysis

The results obtained were processed using Excel 2016, which was used to calculate the mean values from three trials and the standard deviation for the following measured parameters: moisture content, ash, protein, carbohydrates, lipids and total dietary fiber. Calculations were carried out for each parameter in order to establish comprehensive and comparable nutritional profiles.

3. Results

3.1. Nutritional Composition of Maize Flour Dough

3.1.1. Carbohydrate, Lipid, Protein and Energy Profiles of Maize Flour Dough

The water content of maize flour dough was generally high, ranging from 56.73 g/100g to 85.99 g/100g.

Corn-based doughs exhibited varied nutritional profiles depending on the method of preparation. The fat content remained low, ranging from 0.1 g/100g for akpan to 1.08 g/100g for the fermented maize flour dough. The protein content was higher in some preparations, reaching 4.24 g/100g for Khom maize, whilst crude fibre varied from 0.57 g/100g for akpan to 1.59 g/100g for “Emakoumè”, a fermented dough made from unhusked maize flour. Carbohydrates, the main source of energy in these meals, ranged from 10.81 g/100g to 35.41 g/100g, resulting in a total energy value of between 55.42 kcal and 164.57 kcal (Table 1).

Table 1. Macronutrient composition in g/100g of fresh matter and energy content of maize flour dough.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Ablo from maize	0.53 ± 0.15	3.84 ± 0.33	1.39 ± 0.1	35.41 ± 0.15	164.57
Khom maize	0.30 ± 0.80	4.24 ± 0.02	1.26 ± 0.04	19.97 ± 0.12	102.06
Fermented husked maize flour dough “Emakoumè”	0.45 ± 0.60	2.55 ± 0.90	0.74 ± 0.11	18.98 ± 0.07	91.63
Whole meal maize flour dough “Ewo koumè”	0.52 ± 0.02	3.08 ± 0.02	1.37 ± 0.03	15.41 ± 2.03	87.98
Fermented unhusked maize flour dough “Emakoumè”	1.08 ± 0.13	3.47 ± 0.02	1.59 ± 0.24	16.67 ± 0.07	86.81
Egblin	0.34 ± 0.18	2.46 ± 0.11	0.57 ± 0.15	13.99 ± 0.16	69.99
Akpan	0.10 ± 0.01	2.55 ± 0.01	0.56 ± 0.13	10.81 ± 0.11	55.42

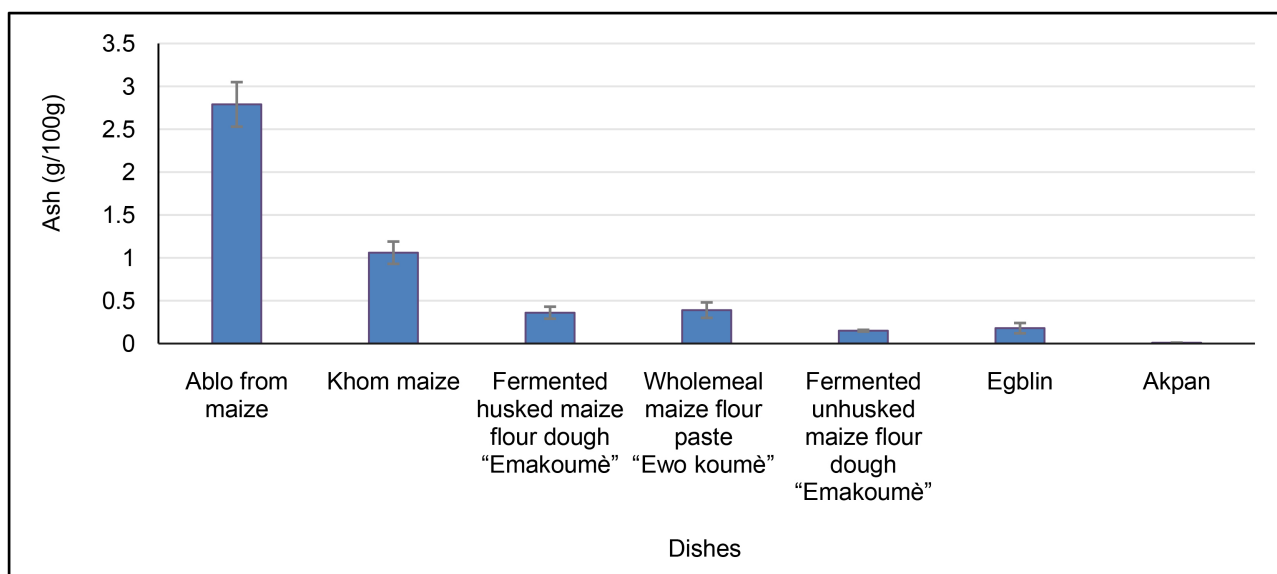


Figure 1. Ash content of maize doughs.

3.1.2. Ash Content of Maize Doughs

Ash contents, ranged from 0.01 for *Akpan* to 2.79 g/100g for maize *ablo* (**Figure 1**).

3.2. Nutritional Composition of Millet, Sorghum, Rice and Maize Flour Dough

3.2.1. Carbohydrate, Lipid, Protein and Energy Profiles of Millet, Sorghum, Rice and Maize Flour Dough

The moisture content ranged from 62.00 g/100g for rice and maize to 72.16 g/100g for the fermented sorghum flour dough *Epomakoumè*. The millet, sorghum, rice and maize pastes analyzed had low fat contents, ranging from 0.00 to 0.46 g/100g, as well as moderate protein (1.59 to 3.78 g/100g) and fibre (0.67 to 1.50 g/100g) contents. Carbohydrate content varied between 18.50 and 33.61 g/100g, resulting in energy values ranging from 86.60 kcal/100g for the *Epokoumè* sorghum dough to 149.36 kcal/100g for the rice and maize *ablo* (**Table 2**).

Table 2. Macronutrient composition (g/100 g fresh matter) and energy content of doughs made from millet, sorghum, rice, and maize.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Ablo made from rice and maize	0.46 ± 0.05	3.78 ± 0.34	0.67 ± 0.04	32.18 ± 0.11	149.36
Ablo made from rice	0.35 ± 0.05	1.59 ± 0.53	0.75 ± 0.03	33.61 ± 0.18	145.50
Millet Khom	0.00 ± 0.01	2.10 ± 0.13	1.43 ± 0.03	28.68 ± 1.13	126.10
Sorghum Khom	0.09 ± 0.05	2.06 ± 0.11	1.37 ± 0.11	25.47 ± 0.95	113.67
Fermented sorghum flour dough “ <i>Epomakoumè</i> ”	0.29 ± 0.98	2.55 ± 0.18	1.50 ± 0.17	22.42 ± 0.11	105.49
Sorghum flour dough “ <i>Epokoumè</i> ”	0.00 ± 0.00	2.80 ± 0.23	0.70 ± 0.21	18.5 ± 1.19	86.60

3.2.2. Ash Content of Millet, Sorghum, Rice and Maize Doughs

Ash contents ranged from 0.85 for “*Ablo*” rice to 1.17 g/100g for *Khom* millet (**Figure 2**).

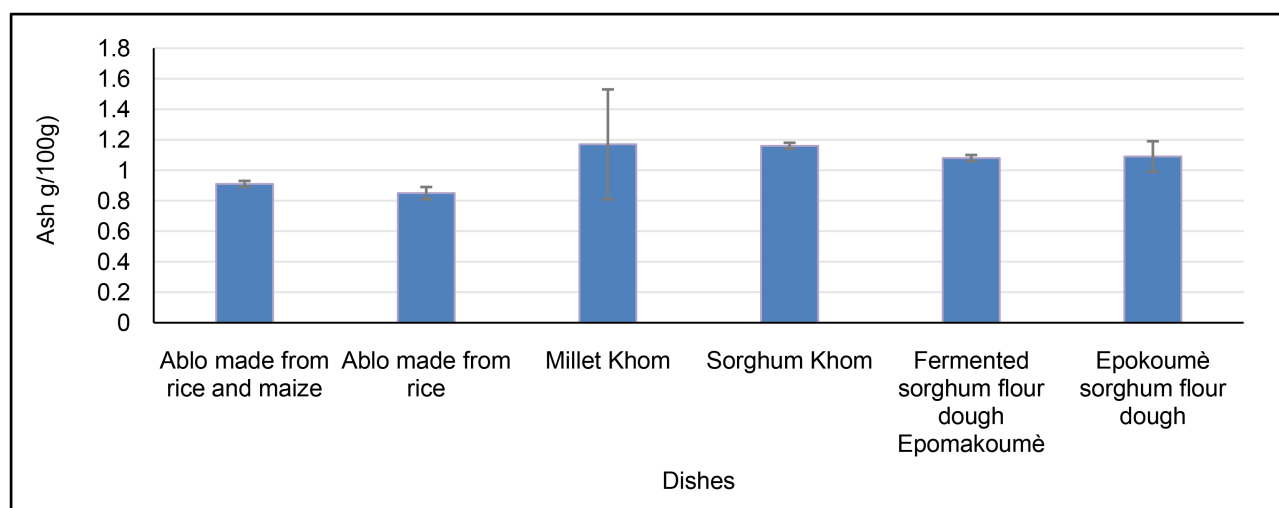


Figure 2. Ash content of millet, sorghum, rice and maize dough.

3.3. Nutritional Composition of Dough Served with Protein-Free Sauces

3.3.1. Lipid, Protein and Energy Profiles of Dough Served with Protein-Free Sauces

Dough served with vegetable-based sauces containing neither meat nor fish had higher moisture contents, ranging from 75.96 g/100g for maize dough served with meat- and fish-free moringa sauce to 82.62 g/100g for maize dough served with meat- and fish-free Adémè sauce. The values were lower for protein (3.49 to 4.64 g/100g) and fat (1.15 to 4.98 g/100g), with fibre contents ranging from 1.86 to 3.67 g/100g. The available carbohydrate content ranged from 2.74 g/100g for the maize dough with Adémè sauce to 14.51 g/100g for the maize dough with okra sauce, while the energy values remained between 78.30 and 93.44 kcal/100g (**Table 3**).

Table 3. Nutritional composition in g/100g of fresh matter and energy content of the doughs + sauces without protein.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Maize dough and Adémè sauce (no meat or fish)	4.98 ± 0.91	4.64 ± 0.42	3.67 ± 0.10	2.74 ± 0.03	81.65
Maize dough and Okra sauce (no meat or fish)	1.15 ± 0.15	3.97 ± 0.11	1.86 ± 0.03	14.51 ± 0.07	88.00
Maize dough and Moringa sauce (no meat or fish)	2.32 ± 0.40	4.56 ± 0.31	2.88 ± 0.4	12.13 ± 0.13	93.44
Sorghum dough and Adémè sauce (no meat or fish)	2.47 ± 0.58	3.49 ± 0.06	2.44 ± 0.58	9.32 ± 0.57	78.30

3.3.2. Ash Content of Dough Served with Protein-Free Sauce

The ash content of dough served with protein-free sauces ranged from 1.35 g/100g in the maize pasta with Adémè sauce (containing no meat or fish) to 2.36 g/100g of fresh weight in the maize dough with okra sauce (containing no meat or fish) (**Figure 3**).

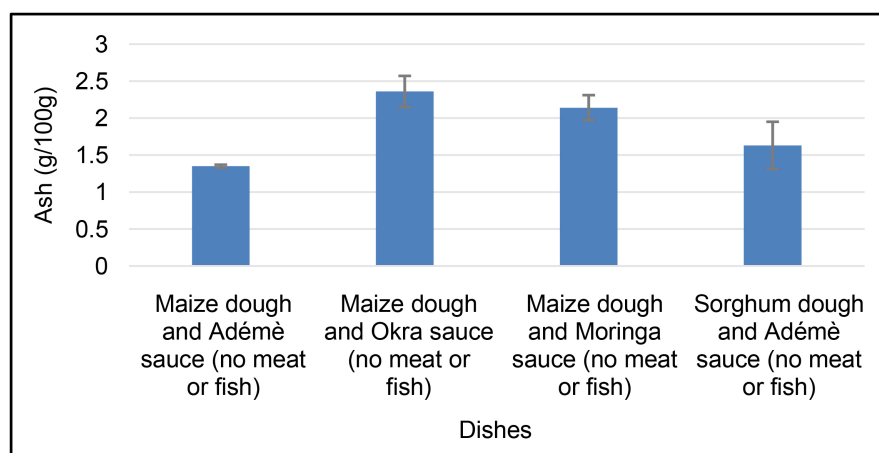


Figure 3. Ash content of doughs + sauces without protein.

3.4. Nutritional Composition of Dough Served with Protein-Containing Sauces

3.4.1. Carbohydrate, Fat, Protein and Energy Profiles of Dough Served with Protein-Containing Sauces

Dough served with sauces containing sources of animal protein (fish, meat or smoked fish) had water contents ranging from 68.10 g/100g for maize Khom served with tomato and fried fish sauce to 82.14 g/100g for maize pasta with baobab leaf sauce and small fish. Protein contents ranged from 4.57 to 8.90 g/100g, with the highest values observed in dishes containing smoked fish or small fish, while fat contents ranged from 1.25 to 7.68 g/100g depending on the type of sauce and method of preparation.

Table 4. Nutritional composition in g/100g of fresh matter and energy content of dough + sauces with animal proteins.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Maize ablo, nougbagba, and fried fish	7.68 ± 0.38	5.35 ± 0.18	1.78 ± 0.21	21.23 ± 0.73	179.02
Maize Khom, tomato sauce with fried fish	5.06 ± 0.17	5.24 ± 0.34	1.47 ± 0.38	17.30 ± 0.34	138.62
Akpan, nougbagba and fried fish	7.38 ± 0.39	5.12 ± 0.07	1.36 ± 0.04	11.29 ± 0.18	134.83
Akpan and aloma sauce with fried fish	3.10 ± 0.2	7.17 ± 0.41	2.20 ± 0.21	12.20 ± 0.03	109.75
Akpan and tomato and meat sauce	4.71 ± 0.11	4.57 ± 0.97	0.78 ± 0.10	8.66 ± 0.13	96.84
Maize dough, Peanut sauce and Smoked fish	5.09 ± 0.62	7.78 ± 0.48	0.57 ± 0.06	6.69 ± 0.23	104.83
Maize dough, Yébesséssé tomato sauce and smoked fish	1.88 ± 0.18	8.90 ± 0.44	1.65 ± 0.20	10.73 ± 0.93	98.78
Maize dough, gboma sauce and smoked fish (akpala)	3.94 ± 0.04	6.10 ± 0.01	4.09 ± 0.03	5.88 ± 0.12	91.58
Maize dough and Gnato sauce (sorrel) with small fish (doèvi)	3.38 ± 0.55	6.03 ± 0.06	5.13 ± 0.06	6.09 ± 0.93	89.13
Maize dough, Essrou sauce (basil) and small fish (doèvi)	1.43 ± 0.04	5.83 ± 0.62	3.65 ± 0.48	9.01 ± 0.23	79.54
Maize dough, Adémè sauce + small fish and smoked fish	3.11 ± 1.00	8.32 ± 0.12	2.49 ± 0.41	5.61 ± 0.05	88.70
Maize dough, Adémè sauce (no meat or fish)	4.98 ± 0.91	4.64 ± 0.42	3.67 ± 0.10	2.74 ± 0.03	81.65
Maize dough and Okra sauce (no meat or fish)	1.15 ± 0.15	3.97 ± 0.11	1.86 ± 0.03	14.51 ± 0.07	88.00
Maize dough, taro leaf sauce and meat	1.33 ± 0.13	8.20 ± 0.38	2.16 ± 0.01	5.90 ± 0.03	78.72
Maize dough, taro leaf sauce with smoked fish	3.03 ± 0.15	8.51 ± 0.11	1.90 ± 0.09	5.53 ± 0.03	87.24
Maize dough, baobab leaf sauce and small fish	1.25 ± 0.10	8.48 ± 0.49	1.76 ± 0.18	4.65 ± 1.31	67.32
Sorghum dough, Adémè sauce with smoked fish	4.37 ± 0.55	8.53 ± 0.5	2.08 ± 0.38	4.42 ± 0.95	95.26
Egblin, tomato sauce with fried fish	3.81 ± 0.35	6.13 ± 0.61	1.34 ± 0.18	14.15 ± 0.07	118.13

Fibre content ranged from 0.57 to 5.13 g/100g, with higher values in leaf-based sauces such as gboma, gnato (sorrel) and essrou (basil) sauces. Available carbohydrates ranged from 4.42 to 21.23 g/100g, whilst energy values ranged from 67.32 kcal/100g for maize dough served with baobab leaf sauce and small fish to 179.02 kcal/100g for maize ablo served with tomato stew, nougbagba and fried fish (**Table 4**).

3.4.2. Ash Content of Dough + Sauces with Animal Proteins

Dough served with sauces containing sources of animal protein (fish, meat or smoked fish) had ash contents ranging from 1.26 g/100g in the maize flour pasta with peanut sauce and smoked fish to 3.22 g/100g in the maize flour dough with *Essrou* (basil) sauce and small fish *doèvi* (**Figure 4**).

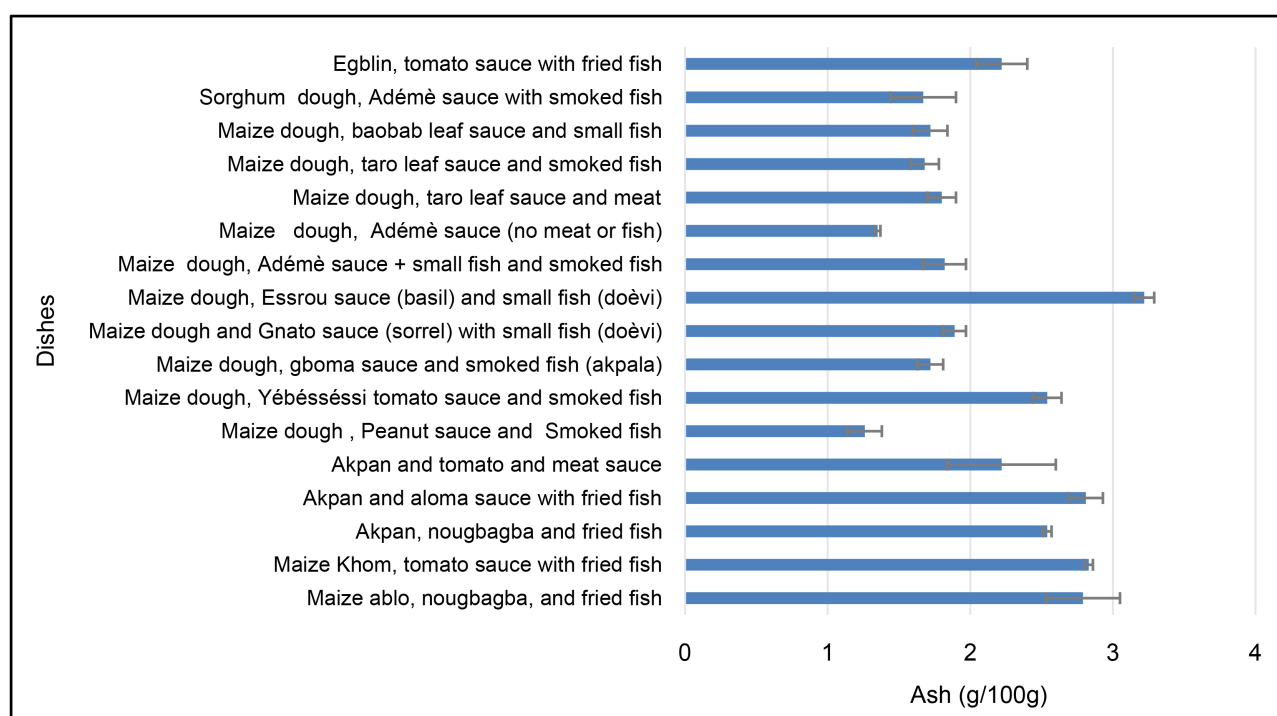


Figure 4. Ash content of dough + sauces with animal proteins.

3.5. Nutritional Composition of Rice Dishes

3.5.1. Lipid, Protein and Energy Profiles of Rice Dishes

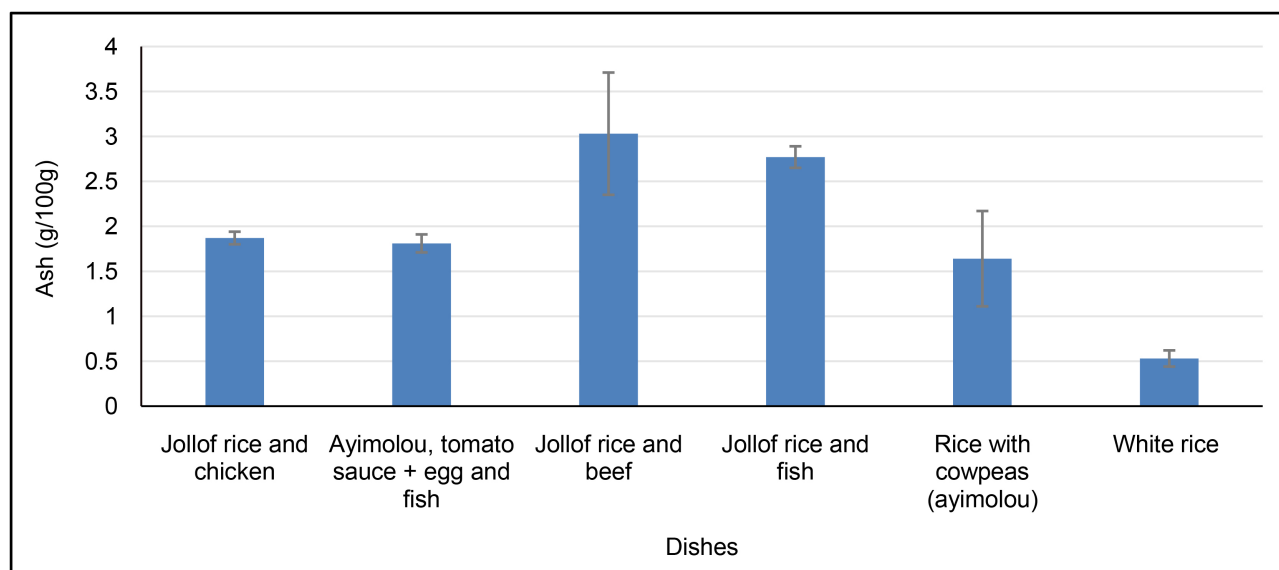
The various rice dishes had a range of nutritional profiles. The water content averaged between 51.36 and 67.31 g/100g. Fat was present in varying amounts, reaching a maximum of 14.17 g/100g in the *Ayimolou* with tomato sauce, egg and fish. The protein content was also high in the jollof rice with beef, at 11.21 g/100g. Crude fibre ranged from 0.67 g/100g in white rice to 2.77 g/100g in jollof rice with beef, while available carbohydrates ranged from 5.13 g/100g for *Ayimolou* served with tomato sauce, egg and fish, to 29.39 g/100g for white rice. In terms of energy, the rice dishes were high in calories, with a maximum of 231.25 kcal in the jollof rice with chicken (**Table 5**).

Table 5. Composition in g/100g of fresh weight and energy content of rice-based dishes.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
<i>Jollof rice</i> and chicken	9.33 ± 0.14	9.59 ± 0.67	1.24 ± 0.03	26.61 ± 1.04	231.25
<i>Ayimolou</i> , tomato sauce + egg and fish	14.17 ± 1.60	9.66 ± 0.35	1.92 ± 0.24	5.13 ± 0.09	190.48
<i>Jollof rice</i> and beef	2.11 ± 0.37	11.21 ± 0.04	2.77 ± 0.73	26.38 ± 0.11	174.88
<i>Jollof rice</i> and fish	5.68 ± 0.79	8.74 ± 0.06	1.94 ± 0.75	20.38 ± 0.12	171.522
Rice with cowpeas (<i>ayimolou</i>)	1.39 ± 0.33	5.05 ± 0.15	0.97 ± 0.04	26.67 ± 0.03	141.34
White rice	0.30 ± 0.04	2.55 ± 0.04	0.67 ± 0.07	29.39 ± 0.07	131.60

3.5.2. Ash Content of Rice Dishes

The ash content ranged from 0.53 g/100g in white rice to 1.87 g/100g in rice with fat and beef (Figure 5).

**Figure 5.** Ash content of rice dishes.

3.6. Nutritional Composition of Wheat-Based Dishes

3.6.1. Lipid, Protein and Energy Profiles of Wheat-Based Dishes

The water content of wheat-based dishes ranged from 58.89 g/100g for couscous with fish sauce to 71.88 g/100g for spaghetti with beef and vegetables.

The nutritional composition varied depending on the presence of sauces, vegetables or animal protein sources. Simple dishes such as boiled spaghetti and plain couscous had high levels of available carbohydrates, at 29.19 g/100g and 30.60 g/100g, respectively, with energy values of 136.66 kcal/100g and 145.38 kcal/100g. Fat content remained low in these simple dishes, ranging from 0.25 to 0.71 g/100g, while protein content remained moderate, ranging from 3.38 to 3.60 g/100g.

The addition of rich sauces, fish, meat or vegetables significantly altered the

nutritional profile of the dishes. Protein content reached up to 10.89 g/100g for Jollof spaghetti and beef, whilst fat content varied from 3.32 to 4.88 g/100g in the enriched dishes. Fibre content was higher in dishes containing vegetables, with a maximum value of 5.82 g/100g observed for jollof couscous, vegetables and fish. In contrast, carbohydrate content decreased in dishes served with sauces and animal proteins, ranging from 11.52 to 23.12 g/100g. The energy values of the enriched dishes ranged from 111.15 to 175.88 kcal/100g, with couscous with fat, fish and vegetables having the highest energy content (**Table 6**).

Table 6. Composition in g/100g of fresh matter and energy content of wheat-based dishes.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Boiled pasta (spaghetti)	0.25 ± 0.05	3.38 ± 0.51	2.46 ± 0.10	29.19 ± 0.19	136.66
Jollof spaghetti, fish and vegetables	4.88 ± 0.9	9.93 ± 0.7	3.32 ± 0.11	11.52 ± 0.12	136.37
Jollof spaghetti and beef	3.32 ± 0.7	10.89 ± 1.3	3.25 ± 0.13	14.03 ± 0.11	136.03
Jollof spaghetti, beef, vegetables	3.40 ± 0.51	5.40 ± 0.09	5.36 ± 0.12	12.00 ± 0.1	111.15
Jollof couscous and fish	4.52 ± 0.45	10.08 ± 0.06	1.97 ± 0.2	22.72 ± 0.04	175.88
White couscous	0.71 ± 0.19	3.60 ± 0.28	1.09 ± 0.16	30.60 ± 0.09	145.38
White couscous with a light sauce, without meat or fish	1.18 ± 0.13	3.82 ± 0.15	1.19 ± 0.42	21.61 ± 0.11	114.7
Jollof couscous vegetables and fish	3.73 ± 0.3	4.40 ± 0.4	5.82 ± 0.15	23.12 ± 0.11	155.24

3.6.2. Ash Content of Wheat-Based Dishes

The ash content ranged from 0.28 g/100g in white couscous to 3.24 g/100g in couscous with fats, vegetables and fish (**Figure 6**).

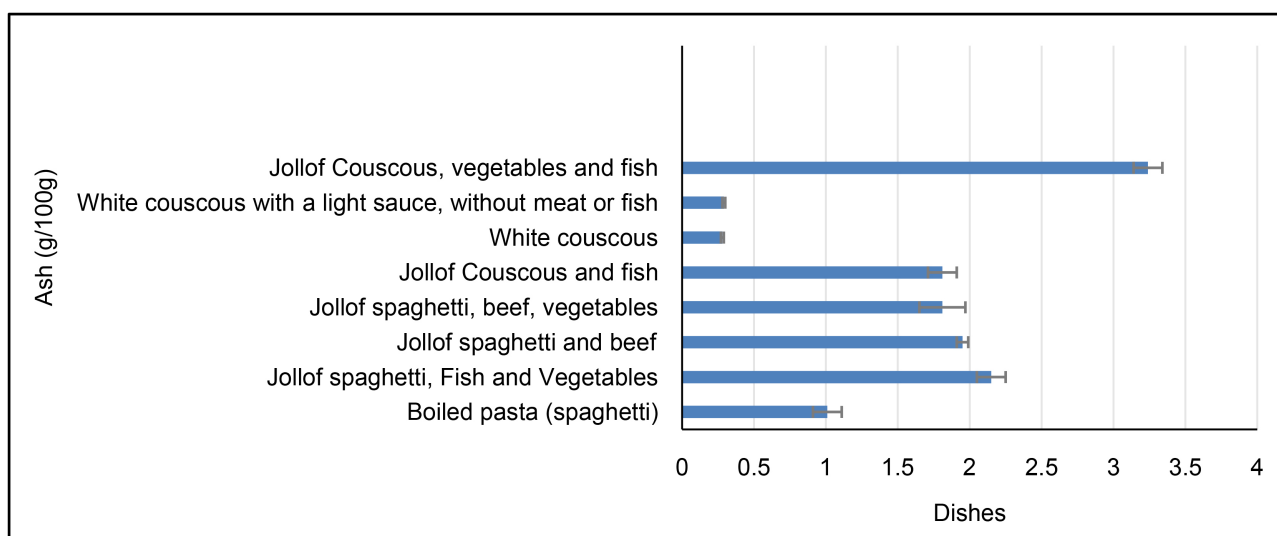


Figure 6. Ash content of wheat-based dishes.

3.7. Nutritional Composition of Fonio-Based Dishes

3.7.1. Lipid, Protein and Energy Profiles of Fonio-Based Dishes

The Fonio-based dishes analysed had moisture contents ranging from 48.91 g/100g in Fonio with fat and “*akpala*” fish’ (100g) to 59.83 g/100g in steamed fonio. Steamed fonio had the highest available carbohydrate content (38.02 g/100g) with a fibre content of 3.59 g/100g and a protein content of 4.44 g/100g. The addition of accompaniments such as fish or beans altered the nutritional profile of the dishes. Fonio with oil and “*akpala*” fish had the highest protein content (8.04 g/100g) and an energy value of 198.591 kcal, whilst fonio with fat and beans had the highest fat content (5.95 g/100g). Carbohydrate content was lower in the fortified dishes, ranging from 24.37 to 38.02 g/100g, whilst the energy values remained moderately high, ranging from 157.92 to 194.35 kcal/100g (**Table 7**).

Table 7. Composition in g/100g of fresh matter and energy content of fonio-based dishes.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Steamed <i>fonio</i>	1.93 ± 0.04	4.44 ± 0.3	3.59 ± 0.51	38.02 ± 0.11	194.35
<i>Fonio</i> with oil, <i>Akpala</i> fish	3.21 ± 0.11	8.04 ± 0.38	3.36 ± 0.54	22.53 ± 0.45	157.92
<i>Fonio</i> with oil and beans	5.95 ± 0.28	5.97 ± 0.07	2.53 ± 0.42	24.37 ± 0.7	179.95

3.7.2. Ash Content of Dishes Made from Fonio

The Ash content ranged from 2.19 g/100g for steamed fonio to 3.94 g/100g for fonio cooked in fat with fish (**Figure 7**).

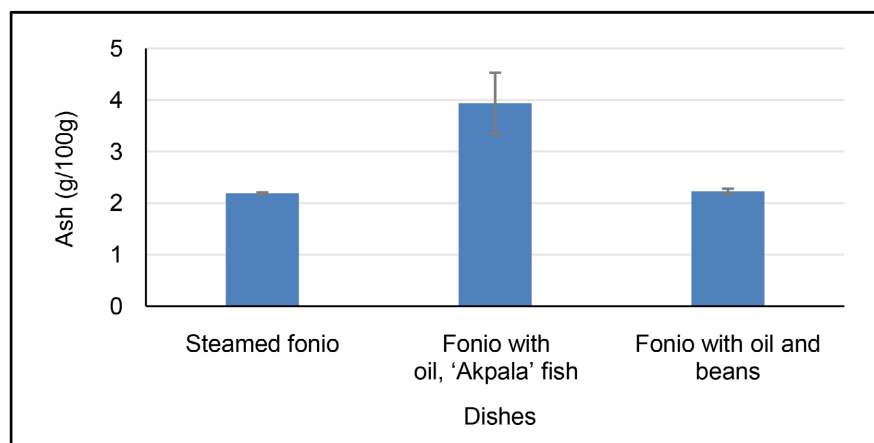


Figure 7. Ash content of dishes made with *fonio*.

3.8. Nutritional Composition of Dishes Made from Cowpeas and Voandzou

3.8.1. Lipid, Protein and Energy Profiles of Cowpeas and Voandzou Dishes

The cowpeas and voandzou dishes, served without accompaniments, had a water content ranging from 61.20 g/100g for Kpédji gaou to 79.84 g/100g for Alélé.

Boiled voandzou had the highest protein (8.24 g/100g) and fibre (6.96 g/100g) contents, whilst *Kpédji gaou* had the highest available carbohydrate content (27.13 g/100g) with an energy value of 145.92 kcal/100g. In contrast, dishes such as:

Timbani and *Alélé* had lower carbohydrate and energy contents, with energy values below 90 kcal/100g (Table 8).

Table 8. Composition in g/100g of fresh matter and energy content of dishes made with cowpeas and voandzou.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Boiled voandzou	1.53 ± 0.04	8.24 ± 0.08	6.96 ± 0.01	18.89 ± 0.05	136.21
Boiled cowpeas	0.53 ± 0.06	7.32 ± 0.01	3.65 ± 0.07	17.12 ± 1.31	109.83
<i>Timbani</i>	2.58 ± 0.20	6.81 ± 0.01	1.95 ± 0.07	8.61 ± 0.18	88.73
<i>Alélé</i>	3.46 ± 1.10	6.58 ± 0.36	1.36 ± 0.13	6.95 ± 0.03	87.98
<i>Kpédji gaou</i>	0.26 ± 0.05	7.73 ± 0.49	2.07 ± 0.8	27.13 ± 0.01	145.92

3.8.2. Ash Content Profile of the Cowpea and Voandzou Dishes

The Ash content ranged from 1.1 g/100g for boiled cowpea to 2.1 g/100g for boiled voandzou (Figure 8).

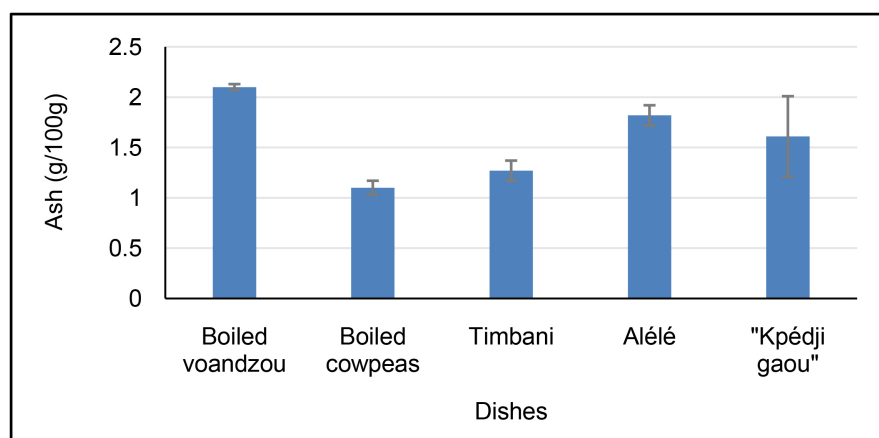


Figure 8. Ash content of cowpea and voandzou dishes.

3.9. Nutritional Composition of Cowpea and Voandzou Dishes with Accompaniments

3.9.1. Lipid, Protein and Energy Profiles of Cowpea and Voandzou Dishes with Side Dishes

The cowpea and voandzou dishes with accompaniments had a lower water content, ranging from 46.07 g/100g for boiled voandzou + oil + gari to 73.93 g/100g for *Alélé* + red oil. Dishes made from cowpea and voandzou served with oil or gari had high fat contents and significant energy values. Fat contents ranged from 5.78 g/100g for *Alélé* + red oil to 19.85 g/100g for *Kpédji gaou* with chilli powder and oil, with energy values reaching 292.69 kcal/100g.

Protein contents ranged from 5.22 to 9.76 g/100g, whilst available carbohydrates varied from 11.34 to 26.46 g/100g. *Timbani* and oil had the highest protein content (9.76 g/100g), whilst boiled cowpea, oil, gari had a high energy density due to its high fat and carbohydrate content (**Table 9**).

Table 9. Composition (g/100 g fresh matter) and energy content of cowpea- and voandzou-based dishes with accompaniments.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Boiled voandzou + oil + <i>gari</i>	10.52 ± 0.15	5.22 ± 0.43	3.35 ± 0.33	33.54 ± 0.19	256.43
Cowpeas dough (<i>Djongoli</i>)	10.87 ± 0.80	5.97 ± 0.40	1.78 ± 0.03	16.80 ± 0.18	192.48
Boiled cowpeas, oil, gari	15.64 ± 0.23	5.90 ± 1.70	2.67 ± 0.05	26.46 ± 0.23	275.48
<i>Timbani</i> and oil	13.82 ± 0.01	9.76 ± 0.40	1.69 ± 0.03	11.78 ± 0.76	213.91
<i>Alélé</i> and red oil	5.78 ± 0.21	6.89 ± 0.01	1.24 ± 0.36	11.34 ± 0.04	127.47
<i>Kpédji gaou</i> and chilli powder and oil	19.85 ± 0.5	6.95 ± 0.29	3.92 ± 0.03	19.09 ± 0.1	292.69

3.9.2. Ash Content Profile of Cowpea and Voandzou Dishes with Accompaniments

The Ash content, shown in **Figure 9**, ranged from 1.41 g/100g for boiled cowpea, oil and *gari* to 2.61 g/100g for bean paste *Djongoli*.

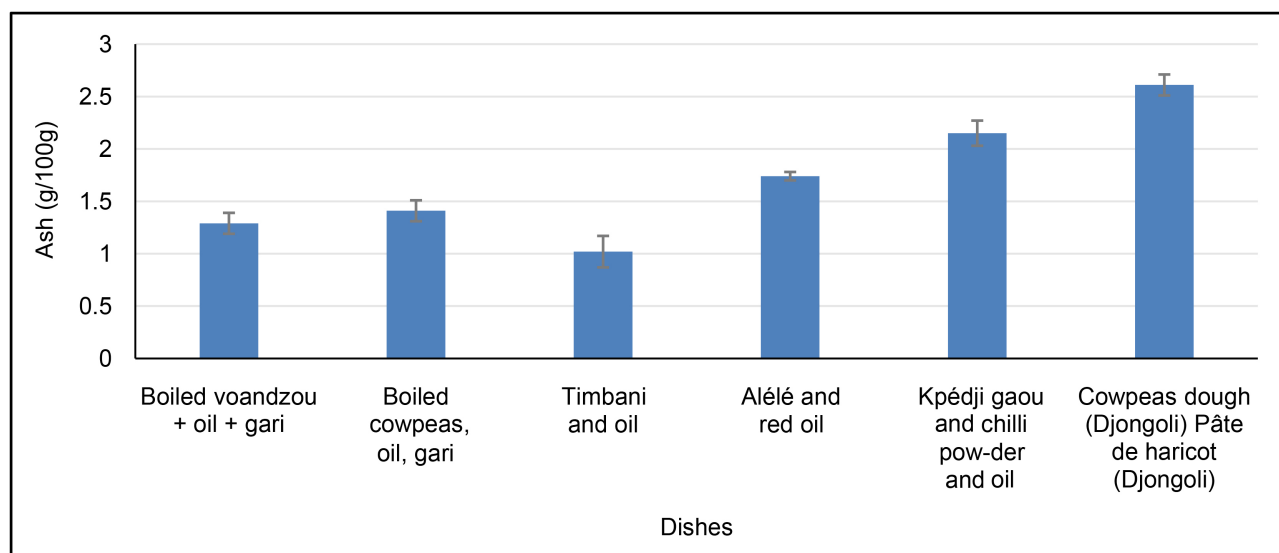


Figure 9. Ash content of beans and voandzou dishes with side dishes.

3.10. Nutritional Composition of Dishes Based on Tubers and Plantains

3.10.1. Lipid, Protein and Energy Profiles of Dishes Based on Tubers and Plantains

Meals based on tubers and plantains contained a water content ranging from 55.88 g/100g in boiled taro to 63.28 g/100g in boiled yam. Dishes made from tubers and

plantains without sauce had low fat contents, generally below 1 g/100g, and moderate levels of available carbohydrates ranging from 22.06 to 36.94 g/100g. Boiled taro had the highest energy value (169.21 kcal/100g) and the highest carbohydrate content, whilst yam *foufou* had the lowest energy value (100.77 kcal/100g).

Protein content was low across all dishes, ranging from 1.23 to 2.56 g/100g. Boiled yam stood out for its high fibre content (9.70 g/100g), compared with the other dishes, whose fibre contents generally remained below 3 g/100g (**Table 10**).

Table 10. Composition in g/100g of fresh matter and energy content of dishes made with tubers and plantains, without sauce.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Boiled taro	0.65 ± 0.12	2.39 ± 0.32	3.03 ± 0.09	36.94 ± 0.03	169.21
Boiled yam	0.00 ± 0.00	2.36 ± 0.11	9.70 ± 0.22	23.64 ± 0.09	123.38
Boiled cassava	0.00 ± 0.00	2.52 ± 0.05	1.98 ± 0.04	30.66 ± 0.07	136.68
Cassava <i>foufou</i>	0.05 ± 0.02	1.23 ± 0.11	1.75 ± 0.07	28.20 ± 0.24	121.73
Boiled plantain	0.79 ± 0.01	2.05 ± 0.04	1.92 ± 0.10	25.59 ± 0.03	114.85
Boiled orange-fleshed sweet potato	0.51 ± 0.02	1.73 ± 0.02	1.38 ± 0.08	25.53 ± 0.17	116.40
Boiled white-fleshed sweet potato	0.00 ± 0.00	2.52 ± 0.03	1.29 ± 0.27	24.98 ± 0.08	114.41
Banana <i>foufou</i>	0.00 ± 0.00	2.12 ± 0.51	1.20 ± 0.41	25.28 ± 0.10	112.00
Yam <i>foufou</i>	0.00 ± 0.00	2.56 ± 0.09	1.15 ± 0.04	22.06 ± 0.09	100.77

3.10.2. Ash Content of Dishes Made from Tubers and Plantains

The Ash content ranged from 0.48 g/100g in yam *foufou* to 1.2 g/100g in boiled plantain (**Figure 10**).

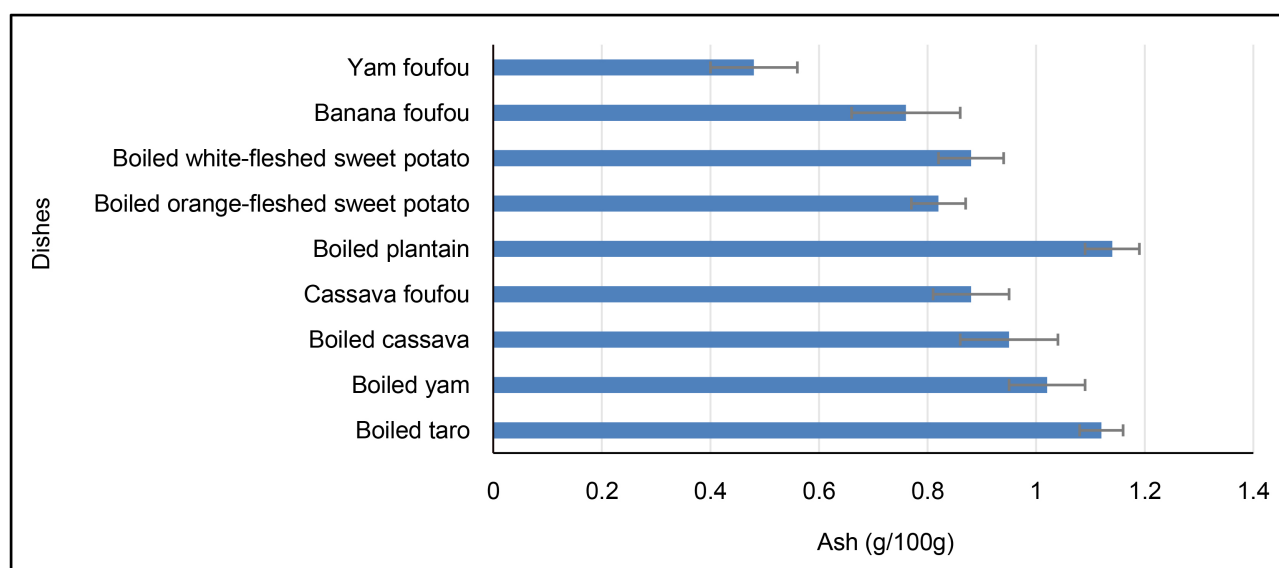


Figure 10. Ash content of tuber- and plantain-based dishes.

3.11. Nutritional Composition of Dishes Made from Tubers and Plantains, Either Fried or with Added Fat

3.11.1. Lipid, Protein and Energy Profiles of Dishes Made from Tubers and Plantains, Either Fried or with Added Fat

The analysed dishes made from tubers and plantains, either fried or with added fat, had a water content ranging from 33.57 g/100g for fried plantain to 59.38 g/100g for taro and tomato stew (*nougbagba*). Fat contents were high, ranging from 2.92 to 8.80 g/100g, and energy content from 191.14 to 293.34 kcal/100g respectively, with fried plantain having the highest energy and carbohydrate values. Fibre content ranged from 0.57 g/100g to 3.90 g/100g (Table 11).

Table 11. Composition in g/100g of fresh matter and energy content of the dishes based on tubers and fried plantains or containing added fats.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Fried plantain	8.80 ± 0.81	2.10 ± 0.61	3.90 ± 0.04	49.50 ± 0.04	293.34
Fried white-fleshed sweet potato	4.68 ± 0.1	2.52 ± 0.03	3.90 ± 0.04	34.15 ± 0.06	196.96
Fried yam	2.92 ± 0.01	2.93 ± 0.91	1.66 ± 0.09	38.49 ± 0.03	195.24
Taro and nougbagba	8.52 ± 0.47	2.46 ± 0.11	0.57 ± 0.15	25.88 ± 0.03	191.14

3.11.2. Ash Content of Dishes Based on Tubers and Plantains, Either Fried or with Added Fat

The Ash content of dishes made from tubers and fried plantains ranged from 1.14 g/100g for fried yams to 2.14 g/100g for fried plantains (Figure 11).

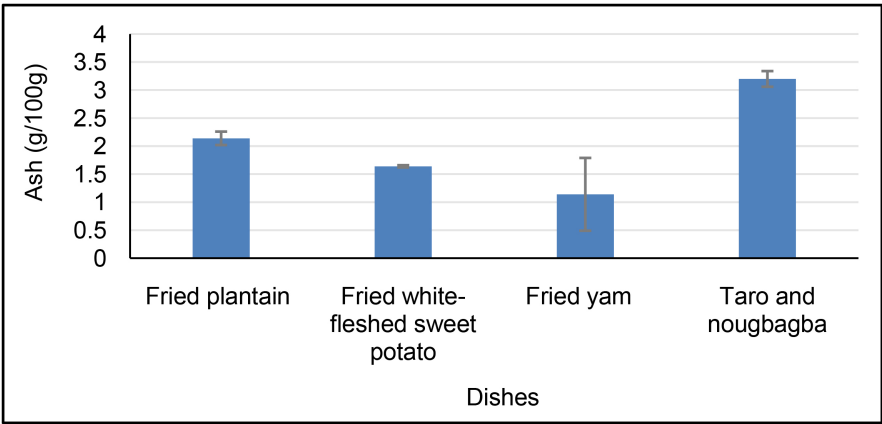


Figure 11. Ash content of dishes made from tubers and fried plantains or with added fat.

3.12. Nutritional Composition of Dishes Made from Tubers and Plantains, with Tomato and Chilli Sauce and Protein

3.12.1. Lipid, Protein and Energy Profiles of Dishes Made from Tubers and Plantains with Tomato and Chilli Sauce and Protein

Dishes made from tubers and plantains with tomato sauce had a water content ranging from 62.22 g/100g for Pinon and chili and chicken to 83.33 g/100g for

yam *foufou* with clear beef sauce. These dishes have relatively high protein contents, ranging from 3.58 to 9.15 g/100g, with the highest values observed for yam with tomato sauce, egg and sardines, as well as *foufou* dishes served with meat or fish. Fat contents remained moderate (1.59 to 5.20 g/100g), whilst energy values ranged from 77.03 to 133.65 kcal/100g.

The available carbohydrates were generally low to moderate in these dishes, particularly in *foufou* served with clear sauces, whilst yam with tomato sauce and fried fish stood out for its high fibre content (8.39 g/100g). Combining tubers with sauces enriched with fish, meat or eggs thus improved the protein and nutritional density of these traditional dishes (**Table 12**).

Table 12. Composition in g/100g of fresh matter and energy content of dishes based on tubers and plantains with tomato/chilli sauce and protein.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Boiled plantain, Tomato and fish sauce	3.76 ± 0.16	8.63 ± 0.32	3.92 ± 0.09	4.64 ± 0.02	94.72
Boiled sweet potato, noughagba fish	3.39 ± 0.37	8.49 ± 0.10	1.34 ± 0.09	16.61 ± 0.23	133.65
Yam, tomato sauce, fried fish	5.20 ± 0.71	6.63 ± 0.16	8.39 ± 0.42	6.95 ± 0.03	117.91
Yam, tomato sauce, egg and sardines	4.07 ± 0.67	9.15 ± 0.43	1.67 ± 0.27	13.44 ± 0.05	130.39
Cassava <i>foufou</i> , light sauce and beef	2.59 ± 0.09	8.99 ± 0.86	1.17 ± 0.14	3.92 ± 0.10	77.25
Cassava <i>foufou</i> , light sauce and smoked fish	1.59 ± 0.10	7.55 ± 0.17	1.92 ± 0.07	10.97 ± 1.13	92.27
Yam and fish stew	1.69 ± 0.07	3.58 ± 0.27	1.55 ± 0.03	19.38 ± 0.04	110.11
Yam <i>foufou</i> , light beef sauce	4.09 ± 0.44	8.49 ± 0.28	0.55 ± 0.01	1.3 ± 0.04	77.03
Yam <i>foufou</i> , tomato sauce and fried fish	3.08 ± 0.10	8.38 ± 0.23	0.75 ± 0.20	11.81 ± 0.04	109.95

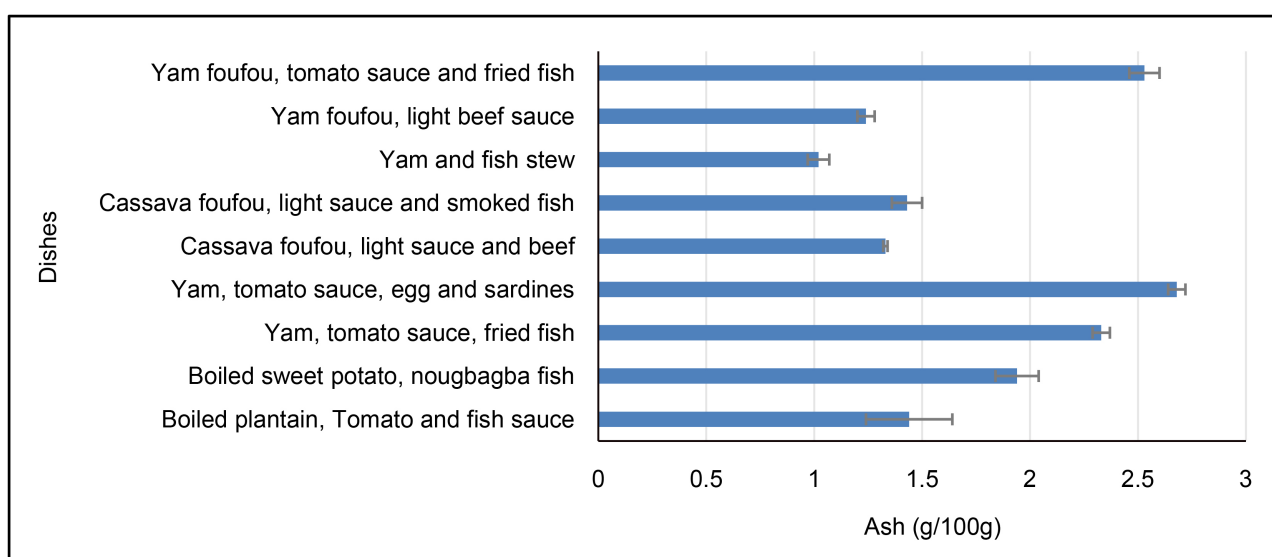


Figure 12. Ash content of dishes based on tubers and plantains with tomato/chilli sauce and protein.

3.12.2. Ash Content of Dishes Based on Tubers and Plantains with Tomato and Chilli Sauce and Protein

The Ash content ranged from 1.02 g/100g for the yam and fish (horse mackerel) stew to 2.53 g/100g for the yam *foufou* with tomato sauce and fried fish (**Figure 12**).

3.13. Nutritional Composition of Dishes Based on Tubers and Plantains with Vegetable/Seed/Chilli Sauce and Animal Proteins

3.13.1. Lipid, Protein and Energy Profiles of Dishes Based on Tubers and Plantains with Vegetable/Seed/Chilli Sauce and Animal Proteins

The dishes analysed contained a water content ranging from 69.16 g/100g for yam with taro leaf sauce and fried fish, to 77.99 g/100g for yam *foufou* with okra sauce and smoked fish. Protein contents ranged from 3.40 to 10.71 g/100g. Cassava *foufou* served with peanut sauce and smoked fish had the highest protein content (10.71 g/100g).

Fat contents ranged from 0.64 to 7.61 g/100g, with the highest values observed in sauces made from peanuts or palm nuts (*dékoudéssi*). Available carbohydrates remained moderate (2.56 to 27.59 g/100g), whilst energy values ranged from 92.90 to 134.16 kcal/100g, reflecting the effect of the addition of sauces and animal proteins on the energy density of the dishes (**Table 13**).

Table 13. Composition in g/100g of fresh matter and energy content of dishes based on tubers and plantains with vegetable/seed/chilli sauce and animal proteins.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Yam + Taro leaf sauce and fried fish	3.62 ± 0.04	9.08 ± 0.47	3.12 ± 0.19	12.29 ± 1.31	124.30
Gari dough (<i>Pinon</i>), chilli and chicken	0.64 ± 0.01	3.40 ± 0.31	2.20 ± 0.03	27.59 ± 0.57	134.16
Cassava <i>foufou</i> with peanut sauce and smoked fish	5.16 ± 0.31	10.71 ± 0.45	1.51 ± 0.14	10.31 ± 0.95	133.54
Yam <i>foufou</i> with okra sauce and smoked fish	2.93 ± 0.52	7.09 ± 0.03	1.77 ± 0.20	8.66 ± 0.24	92.90
Yam <i>foufou</i> + peanut sauce with smoked fish	5.87 ± 0.58	8.32 ± 0.45	1.56 ± 0.10	8.58 ± 0.07	123.53
Yam <i>foufou</i> + vegetable sauce (cabbage, carrot) + smoked fish	2.65 ± 0.15	8.81 ± 0.54	1.81 ± 0.23	10.84 ± 0.57	106.11
Yam <i>foufou</i> + palm nut sauce (<i>dékoudéssi</i>) and smoked fish	7.61 ± 0.64	8.91 ± 0.04	1.95 ± 0.07	2.56 ± 0.03	118.29

3.13.2. Ash Content of Dishes Based on Tubers and Plantains with Vegetable/Seed/Chilli Sauce and Animal Protein

The Ash content of dishes based on tubers and fried plantains ranged from 1.08 g/100g for yam *foufou* with a vegetable sauce (cabbage, carrot) and smoked fish to 3.97 g/100g for Gari dough (*Pinon*), chilli and chicken (**Figure 13**).

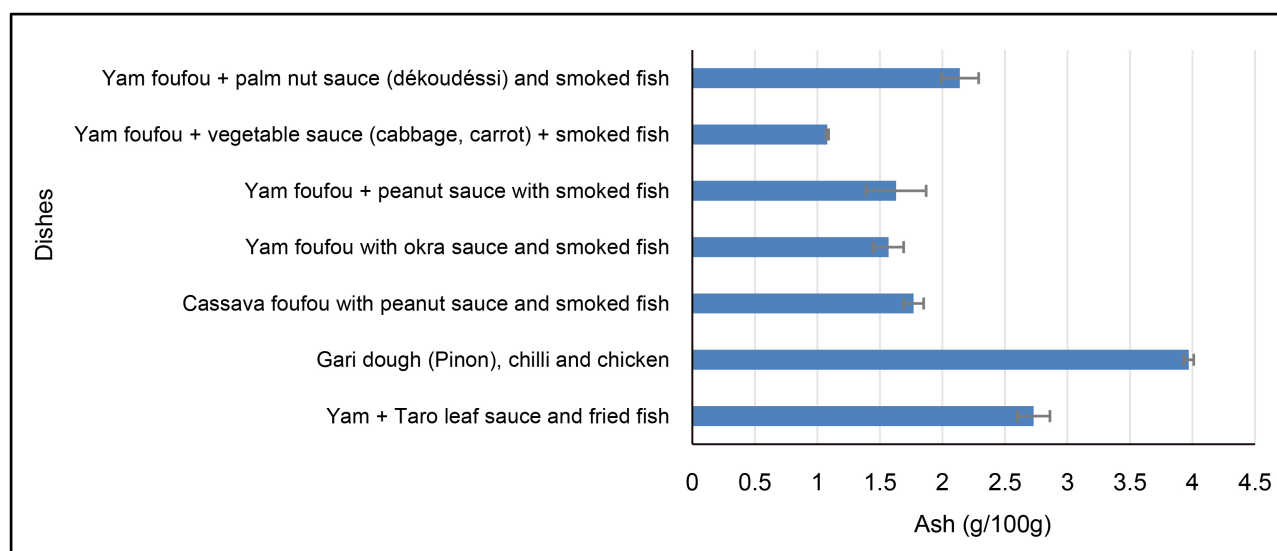


Figure 13. Ash content of dishes based on tubers and plantains with vegetable/seed/chilli sauce and animal protein.

3.14. Nutritional Composition of Sauces Made from Leafy Vegetables

3.14.1. Lipid, Protein and Energy Profile of Leafy Vegetable-Based Sauces

Table 14 summarises the macronutrient and energy composition of leafy vegetable sauces consumed in Togo. Sauces containing fish and fats, such as the *Aloma* and fried fish sauce (152.57 kcal/100g) and the taro leaves and fried fish sauce (145.81 kcal/100g), are the most calorific. Protein content was particularly high in the sorrel sauce (*Gnato*) with small fish (18.07 g/100g), whilst fibre content ranged from 1.15 g/100g (cabbage and carrot sauce with smoked fish) to 1.12 g/100g (baobab leaf sauce). Fat content remained low in sauces such as *moringa* sauce (0.10 g/100g), in contrast to the *gboma* sauce with fried fish, which had a content of 8.86 g/100g.

Table 14. Composition in g/100g of fresh weight and energy content of leafy vegetable sauces.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
<i>Vernonia</i> (<i>Aloma</i>) sauce and fried fish	8.35 ± 0.15	14.14 ± 0.58	3.24 ± 0.03	3.59 ± 1.04	152.57
<i>Vernonia</i> (<i>Aloma</i>) sauce and smoked fish	5.82 ± 0.56	13.56 ± 0.32	3.11 ± 0.05	1.53 ± 0.03	118.93
<i>Vernonia</i> (<i>Aloma</i>) sauce and small doèvi fish	4.79 ± 0.32	13.58 ± 0.03	4.09 ± 0.09	5.22 ± 0.07	126.50
Taro leaf sauce and fried fish	8.73 ± 1.03	8.96 ± 0.03	2.50 ± 0.07	6.60 ± 0.12	145.81
Taro leaf and smoked fish sauce	1.10 ± 0.11	8.38 ± 0.52	1.42 ± 0.58	0.32 ± 0.07	47.54
Taro leaf sauce with beef	2.74 ± 0.05	9.37 ± 0.42	2.09 ± 0.02	0.77 ± 0.04	69.41
Sauce made with corète potagère leaf (<i>Adémè</i>), small fish (<i>doèvi</i>) and smoked fish	8.29 ± 0.10	13.16 ± 0.17	2.11 ± 0.11	1.10 ± 0.18	135.87

Continued

<i>Adémè</i> sauce + beef	1.59 ± 0.11	7.65 ± 0.32	1.51 ± 0.26	0.98 ± 0.13	51.86
<i>Gnato</i> sauce with small fish (<i>doèvi</i>)	2.41 ± 0.09	18.07 ± 0.18	4.60 ± 0.03	3.76 ± 0.45	118.26
<i>Gboma</i> sauce and fried fish	8.86 ± 0.72	10.93 ± 0.6	3.04 ± 0.87	1.22 ± 0.13	134.43
<i>Gboma</i> sauce and smoked fish	3.59 ± 0.17	3.67 ± 0.17	3.46 ± 0.18	13.72 ± 0.51	108.83
<i>Gboma</i> sauce and beef	4.07 ± 0.02	13.64 ± 0.75	3.04 ± 0.87	2.92 ± 0.24	107.07
<i>Essrou</i> leaf sauce and small fish	3.59 ± 0.51	3.67 ± 0.18	3.13 ± 0.85	12.28 ± 0.71	102.45
Sauce with vegetables (cabbage, carrot) and smoked fish	5.69 ± 0.18	8.15 ± 0.17	1.15 ± 0.19	3.92 ± 0.93	101.85
Okra sauce and smoked fish	5.24 ± 0.28	3.97 ± 0.11	1.46 ± 0.17	7.54 ± 0.07	96.16
<i>Gboma</i> sauce and fried fish	5.23 ± 0.13	4.09 ± 0.18	2.42 ± 0.03	5.33 ± 0.23	89.54
Baobab leaf and small fish sauce	0.15 ± 0.05	4.65 ± 0.03	1.12 ± 0.28	9.19 ± 0.11	58.91
<i>Vernonia</i> (<i>Aloma</i>) leaf sauce, meat and fish-free	0.65 ± 0.11	4.43 ± 0.18	2.35 ± 0.38	7.35 ± 0.17	57.63
Sauce with vegetables (cabbage, carrot) and beef	1.44 ± 0.07	2.07 ± 0.05	1.81 ± 0.15	5.62 ± 0.13	47.38
Meat and fish-free okra sauce	1.68 ± 0.01	1.59 ± 0.07	2.46 ± 0.11	4.43 ± 0.08	44.12
<i>Moringa</i> sauce (no meat or fish)	0.1 ± 0.01	2.82 ± 0.03	1.8 ± 0.10	3.36 ± 0.11	29.19
<i>Adémè</i> leaf sauce, containing no meat or fish	0.48 ± 0.16	3.18 ± 0.19	2.4 ± 0.13	1.39 ± 0.15	27.40

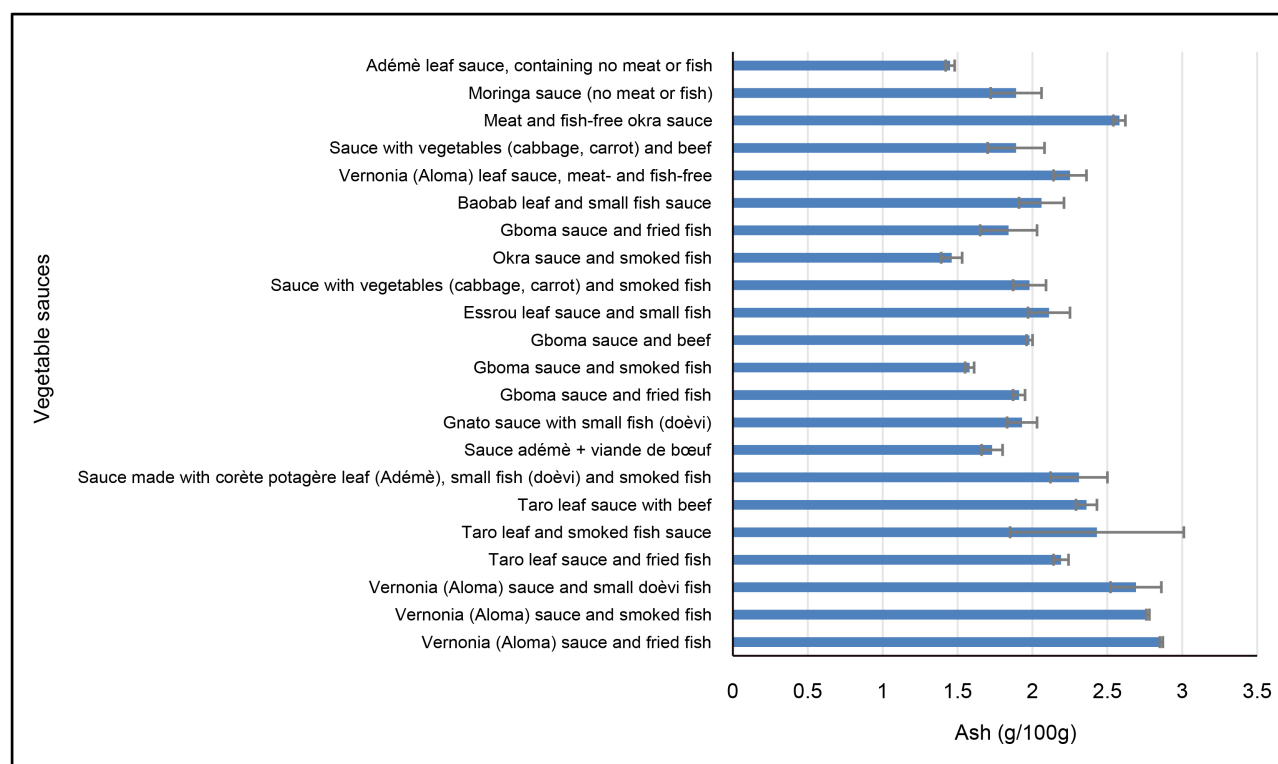


Figure 14. Ash content of leafy vegetable-based sauces.

3.14.2. Ash Content of Leafy Vegetable-Based Sauces

Figure 14 showed the ash content of the various leafy vegetable-based sauces. It reveals considerable variability depending on the ingredients used, with values generally ranging from approximately 1.45 to 2.86 g/100g; sauces served with fish and vegetables generally had higher ash contents, reflecting a higher ash content.

3.15. Nutritional Composition of Tomato, Chili, and Seed Sauces

3.15.1. Lipid, Protein and Energy Profiles of Tomato, Chili, and Seed Sauces

Tomato and seed-based sauces exhibited varied nutritional profiles, influenced by the ingredients used. The water content was high, ranging from 60.57 g/100g for the crushed green chilli and sardine sauce to 93.36 g/100g for the clear sauce. The ash content varied from 0.98 to 2.83 g/100g. Sauces high in fat, such as those containing sardines or added oils, had high values, with a maximum of 18.84 g/100g for the crushed green chilli with sardines and oil. Sauces containing fish, meat or eggs had protein levels of up to 14.08 g/100g in the tomato juice and fried fish sauce. The total dietary fibre content ranged from 0.67 to 3.36 g/100g. Carbohydrate concentrations ranged from 2.52 g/100g for the clear sauce without meat or fish to 24.24 g/100g for the tomato and smoked fish sauce. The oil-rich sauces also had the highest energy values, reaching up to 233.9 kcal/100g (Table 15).

Table 15. composition in g/100g of fresh matter and energy content of tomato and seed sauces.

Dishes	Fat	Protein	Fibre	Available carbohydrates	Energy in kcal/100g
Crushed green chilli, sardines and oil	18.84 ± 0.01	5.27 ± 0.07	3.36 ± 0.12	9.13 ± 0.13	233.90
Tomato stew (<i>nougbagba</i>) and beef	9.22 ± 0.83	10.04 ± 0.81	1.39 ± 0.03	13.63 ± 0.07	180.42
Tomato stew (<i>nougbagba</i>) and fish	11.86 ± 0.40	6.80 ± 0.23	2.37 ± 0.03	9.58 ± 1.19	180.21
Tomato sauce and smoked fish	5.51 ± 0.13	5.84 ± 0.98	1.32 ± 0.05	24.24 ± 0.11	172.57
Palm nut sauce (<i>Dékoudéssi</i>) with smoked fish	8.67 ± 0.75	6.80 ± 0.11	3.03 ± 0.09	7.96 ± 0.17	143.09
Tomato stew (<i>nougbagba</i>) with fried fish and a boiled egg	6.22 ± 0.06	7.22 ± 0.19	1.24 ± 0.32	3.95 ± 0.14	125.53
Tomato sauce and fried fish	7.30 ± 0.11	5.73 ± 0.98	1.37 ± 0.11	5.05 ± 0.09	111.57
Chilli paste and chicken	8.07 ± 0.52	6.79 ± 0.11	1.16 ± 0.08	0.22 ± 0.1	103.04
Peanut sauce and smoked fish	4.65 ± 0.11	5.28 ± 0.11	2.38 ± 0.34	5.60 ± 0.11	90.12
Clear sauce and beef	0.49 ± 0.11	0.87 ± 0.17	1.31 ± 0.15	9.53 ± 0.34	48.63
Clear sauce with small fish doèvi and smoked fish	0.64 ± 0.11	7.74 ± 0.11	0.32 ± 0.07	2.63 ± 0.07	47.85
<i>Yébésséssi</i> and smoked fish	0.67 ± 0.11	5.55 ± 0.12	0.95 ± 0.11	2.61 ± 0.11	40.25
Clear sauce without meat or fish	0.20 ± 0.01	1.31 ± 0.05	0.67 ± 0.12	2.52 ± 0.73	18.42

3.15.2. Ash Content of Tomato Sauces, Chilli Sauces and Seed Sauces

The Ash content of the tomato, chilli and seed sauces ranged from 1.63 g/100g for Yébésséssi and smoked fish to 3.08 g/100g for crushed chilli and chicken (Figure 15).

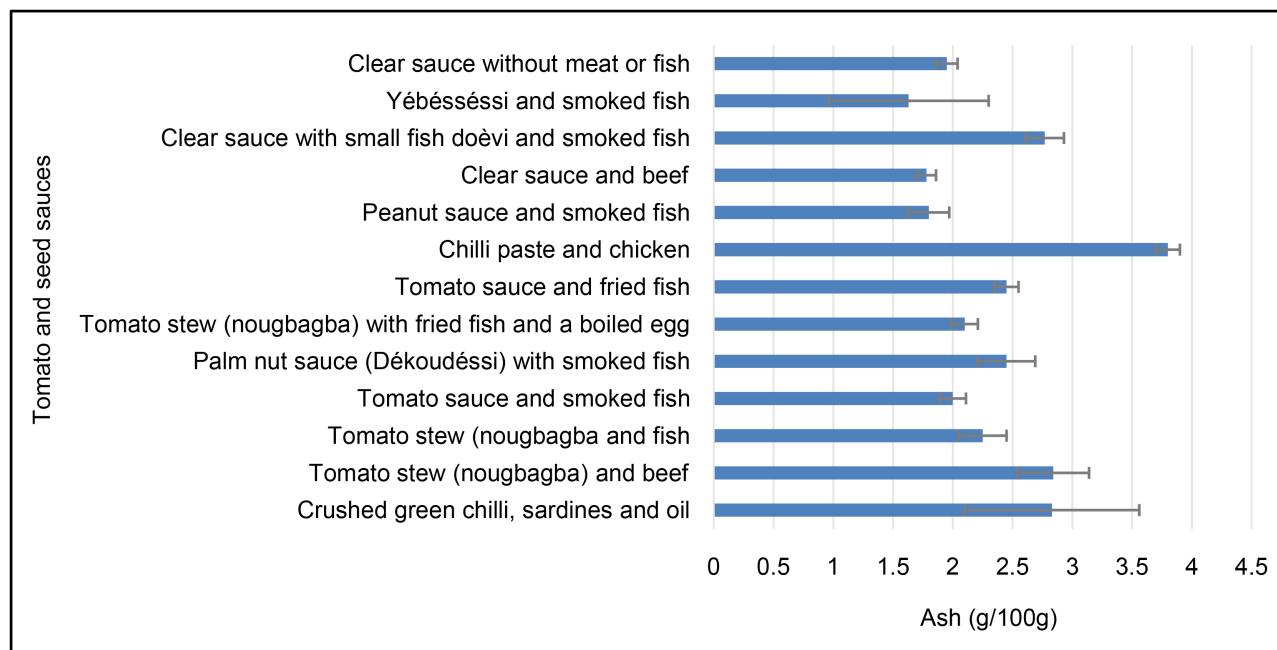


Figure 15. Ash content of selected tomato, seed and chilli sauces and animal proteins.

4. Discussion

The aim of this study was to determine the nutritional composition of starchy dishes commonly consumed for lunch in Togo, with a particular focus on their macronutrient content (carbohydrates, protein, fat, fibre) and their energy value. The foods were selected on the basis of a preliminary survey to identify the dishes most frequently consumed in urban areas, particularly on university campuses. Although this selection covers a wide variety of dishes based on cereals, tubers, pulses, sauces and animal proteins, it does not claim to represent an exhaustive list of lunches consumed throughout the country, particularly in rural areas where dietary practices may differ. The analyses were then carried out in a testing laboratory accredited to ISO 17025:2017, using methods that included ISO and AOAC standards. These protocols are widely used in food composition studies in Africa and internationally.

Meals based on maize, rice, sorghum, wheat and fonio generally had a high water content and variable energy density, depending on the presence of sauces and animal proteins. Simple dishes were mainly rich in carbohydrates (ranging from 10.81 g/100g for “akpan” to 49.50 g/100g for fried plantain). These results confirm the role of cereals as the main sources of energy, in line with FAO recommendations [16] and the principles of balanced nutrition set out by the WHO [17] and the Codex Alimentarius [18]. Research by Adepoju *et al.* (2014) [19] evaluated the

nutritional composition of four traditional complementary foods in Nigeria and reported variations in their protein, lipid, carbohydrate and energy contents.

The addition of sauces significantly altered the composition of the dishes. Sauces containing fish, meat or eggs significantly increased protein and fat content, as well as energy value.

Sauces made from leafy vegetables (gboma, moringa, gnato, taro leaves) contributed to increased fibre and ash content, thereby improving the overall nutritional quality of the meals. The results are consistent with those of Uwagbale E.E. *et al.* (2016) [20], who demonstrated that processing methods and food combinations strongly influence the fibre content of African cereal-based foods.

Furthermore, the work of Slavin (2005) [21] highlights the importance of fibre in regulating satiety, weight control and the prevention of cardiovascular diseases. Several of our vegetable-enriched dishes have higher fibre contents than simple preparations, which represents a nutritional advantage.

Energy values vary considerably depending on the presence of oil, deep-frying and animal proteins. Some dishes have high energy densities, particularly those containing added oils or deep-fried ingredients.

According to WHO recommendations (WHO, 2020) [17], fats should account for 20% - 35% of total energy intake. Dishes very high in oil may exceed this balance when consumed frequently. Conversely, dishes combining starchy foods, vegetables and moderate sources of protein offer a more balanced profile.

Research by Leidy *et al.* (2015) [22] shows that an adequate protein intake at the main meal contributes to satiety and a reduction in subsequent energy intake, which may be relevant in the prevention of overweight.

The ash content, which represents the total inorganic residue remaining after the incineration of a food sample, varies according to the ingredients, with higher values found in dishes containing vegetables and animal products.

Limitations of the Study

Certain limitations must be taken into account when interpreting the results. Furthermore, the study focused primarily on the most frequently consumed dishes identified during the preliminary survey, without covering the full range of national dietary habits.

5. Conclusions

This study provided a nutritional profile of local starchy dishes commonly eaten for lunch and dinner in Togo, highlighting their content of carbohydrates, protein, fat, and energy in relation to health recommendations for adults. These meals are an important source of energy but often lack sufficient nutrients to fully meet nutritional requirements. The results highlight major nutritional challenges, particularly in relation to managing the risks associated with metabolic and cardiovascular diseases.

This study therefore represents an important step towards understanding the

impact of local meals on health and forms part of a broader approach aimed at assessing their glycaemic index and glycaemic load.

Acknowledgements

The authors extend their sincere thanks to the Food and Agriculture Organisation of the United Nations (FAO) for its financial support, which enabled the laboratory analyses to be carried out.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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