

# Comparative Study of the Macronutrient Content of Selected Traditional Meals Consumed in Abéché (Chad)

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**Abstract** This study aims to assess the nutritional quality of traditional meals commonly consumed in Abéché, Chad, by analysing their macronutrient composition. In a context of double nutritional burden, a survey of 200 households helped identify the most representative dishes. Standardized samples were analysed using AOAC methods. Results show that sauces made with meat and leafy vegetables (moringa, spinach) are the richest in protein, reaching up to 6.78%, while staple foods like millet, rice, and cassava are low in protein but high in complex carbohydrates. Some sauces, such as those made with moringa or okra and meat, also contain moderate levels of lipids. Water content varies significantly between meals, affecting their energy density. The study reveals nutritional imbalances in some food combinations and suggests optimal pairings to improve overall intake, especially for vulnerable groups. These findings can support nutrition education programs and policies promoting balanced, locally sourced, and culturally appropriate diets.

**Keywords:** Nutrition, Traditional meals, Macronutrients, Food security

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## 1. Introduction

Diet is one of the major determinants of human health. In developing countries, particularly in sub-Saharan Africa, it plays an essential role not only in the prevention of chronic diseases, but also in the fight against malnutrition in all its forms. Chad, a Sahelian country facing multiple food security challenges, has a double nutritional burden: the persistence of undernutrition among children and pregnant women on the one hand, and the progressive emergence of dietary imbalances and metabolic diseases, particularly in urban areas, on the other [1,2]. In this context, the study of the nutritional composition of traditionally consumed meals is of paramount importance [3,4,5]. While local foods are generally perceived as healthy due to their cultural roots and non-industrial nature, their true nutritional value often remains unknown or poorly documented.

However, a better understanding of the nutritional quality of these dishes could serve as a basis for guiding dietary recommendations, raising public awareness of healthy food choices, and improving public nutrition policies. The city of Abéché, the capital of Ouaddaï province, offers an emblematic example of urban eating habits in eastern Chad. Located in a semi-arid zone, Abéché boasts a dietary diversity influenced by local

traditions, environmental constraints, and changing lifestyles. According to the results of dietary surveys conducted in this city, the most commonly consumed meals consist of cereal balls (millet, corn, rice) accompanied by sauces based on okra (*Hibiscus esculentus*), sorrel (*Hibiscus sabdariffa*), moringa (*Moringa oleifera*), kawal (*Senna tora*) or dried meat (charmoute). These dishes are often prepared using traditional cooking techniques, but little information exists on their actual macronutrient intake. In light of this, a key question arises: are the most commonly consumed traditional meals in Abéché truly nutritionally balanced, particularly in terms of proteins, carbohydrates and lipids? This question is all the more relevant given that malnutrition, in its acute or chronic forms, remains a concern in the region, despite relative food availability in urban centers.

Based on this question, this study is based on biochemical analyses carried out in the laboratory on several traditional dishes from Abéché in order to determine their average nutritional composition. The research hypothesis postulated is that traditional meals from Abéché have a contrasting nutritional quality, some offering a good balance between macronutrients, while others are unbalanced, either too rich in carbohydrates, or poor in proteins or essential lipids. The general objective of this study is therefore to analyze the nutritional quality of the main traditional meals consumed in the city of Abéché.

More specifically, it will involve: determine the protein, carbohydrate, lipid and moisture content of each dish analyzed; Compare the relative nutritional value of meals to identify the most balanced or the most deficient; Propose ways to improve local eating habits, based on the objective data obtained.

This research is part of a public health and nutritional education perspective. It aims to contribute to a better promotion of traditional dishes by taking into account not only their accessibility or cultural acceptability, but also their nutritional value. By providing a local scientific basis, it offers health and development stakeholders concrete elements to construct nutritional messages adapted to the realities of Abéché.

## 2. Material and Methods

This study is descriptive and analytical in nature. It aims to determine the nutritional composition of several traditional meals frequently consumed in the town of Abéché, located in the Ouaddaï province, in eastern Chad. The methodological approach adopted is based on rigorous collection of food samples, their laboratory analysis according to recognized standards, and an inter-meal comparison based on essential macronutrients.

The first step was to identify the most commonly consumed dishes by households in Abéché. To this end, a dietary survey was conducted among 200 households spread across several neighborhoods of the city, covering all seven districts. The survey, conducted between September and October 2022, used a semi-structured questionnaire administered face-to-face. Respondents were selected using simple random probability sampling, taking into account informed consent. The data collected included meal frequency, cooking processes, ingredients used, cooking energy source, and household socioeconomic profiles. The dishes most frequently cited by households were selected for nutritional analysis.

These include: millet ball with okra sauce (fresh or dried), corn ball (pulped or not) accompanied by sorrel sauce or moringa sauce, rice ball with red sauce made from fresh meat, and penicillaria millet ball with kawal sauce (*Senna tora*) with dried meat called (*charmoute* locally). These dishes were selected due to their frequency of consumption and their representativeness in the urban diet of Abéché. Once the meals were identified, samples were prepared according to local culinary practices, in collaboration with housewives from the city and community health workers. Each dish was cooked under standardized conditions to ensure the reproducibility of the results. Three samples of each type of meal were collected and immediately stored in airtight containers, then transported to the laboratory for analysis.

Nutritional analysis was carried out at the CECOQDA Laboratory in N'Djamena. Analyses focused on the main macronutrients: total carbohydrates, lipids, proteins, and moisture content.

The assay methods used comply with international

standards recommended by the Association of Official Analytical Chemists [6]. The Kjeldahl method was used to determine total protein. This involves measuring the total nitrogen content, multiplied by a standard conversion factor (usually 6.25), to obtain the protein content.

Lipid content was determined by petroleum ether extraction using a Soxhlet apparatus. This method quantifies the total fat present in the sample. Total carbohydrates were estimated indirectly using the difference method, subtracting the sum of the percentages of protein, lipids, moisture, and ash from the total (100%). However, for some specific samples (notably sauces), a potassium permanganate redox method was used for cross-validation.

Water content (moisture) was measured by drying at 105°C until a constant weight was obtained. This method allows the proportion of water contained in foods to be assessed, which is important for the evaluation of energy density and food preservation. For each dish, three replicates were performed to ensure data accuracy. Results were expressed as a percentage (% fresh matter), and means were calculated with their standard deviations. Data were entered and processed using Excel software, then statistically analyzed with SPSS (version 25.0). A one-way analysis of variance (ANOVA) was used to compare the mean macronutrient contents between the different dishes, with a significance threshold set at 5% ( $p < 0.05$ ). In addition, carbohydrate/fat and protein/carbohydrate ratios were calculated to assess the overall nutritional balance of each dish. These reports are useful for guiding dietary recommendations, particularly in the context of preventing protein-energy malnutrition or nutritional imbalances.

Finally, all data collection and analysis procedures complied with current ethical standards. The research protocol was approved by the ethics committee of the Faculty of Human Health Sciences at the University of N'Djamena. Data from the dietary survey were anonymized, and participants' free and informed consent was obtained prior to participation.

## 3. Results

Nutritional analysis of food samples collected in the town of Abéché determined the macronutrient composition of the most commonly consumed local dishes. The results are presented in the following tables, along with the average levels measured for each nutrient (protein, fat, carbohydrate, and moisture).

### 3.1. Protein Content

Meat and leafy greens-based sauces had higher protein contents than the side dishes. The red meat sauce had the highest protein content (6.78%), followed by the spinach sauce (5.47%) and the moringa sauce (5.66%). In contrast, cassava, rice, or millet balls had low protein content, with the lowest observed for the cassava ball (0.85%).

**Table 1. Average protein content of traditional meals (1.6g of sample).**

| Meal                    | Proteins content (%) |
|-------------------------|----------------------|
| moringa Sauce           | 5,66                 |
| Dried okra sauce + fish | 4,35                 |
| Sorrel Sauce            | 4,96                 |
| Kawal Sauce             | 1,90                 |
| Red meat sauce          | 6,78                 |
| Spinach Sauce           | 5,47                 |
| Fresh okra sauce + meat | 3,79                 |
| Corn ball               | 2,64                 |
| Béré-béré ball          | 3,13                 |
| Red millet ball         | 2,90                 |
| Penicillaria ball       | 2,75                 |
| Cassava ball            | 0,85                 |
| Rice ball               | 2,59                 |

### 3.2. Lipids Content

**Table 2. Average fat content of traditional meals (5g sample).**

| Meal                    | Lipids content (%) |
|-------------------------|--------------------|
| moringa Sauce           | 4,65               |
| Dried okra sauce + fish | 1,23               |
| Sorrel Sauce            | 3,45               |
| kawal Sauce             | 1,65               |
| Red meat sauce          | 4,12               |
| Spinach Sauce           | 2,92               |
| Fresh okra sauce + meat | 5,55               |

Fat content is higher in sauces rich in meat or peanuts. Okra sauce with meat has the highest fat content (5.55%), which can be attributed to the presence of fatty meat and sometimes peanut oil in the preparation. Moringa and red sauces with meat follow, with 4.65% and 4.12% fat, respectively. In contrast, dry okra + fish and kawal sauces have the lowest fat content (1.23% and 1.65%).

### 3.3. Carbohydrate and Moisture Content

**Table 3. Average total carbohydrate content (4g of sample) and moisture (5g of ball and 3g of sauce).**

| Meals                   | Carbohydrates (%) | Moisture (%) |
|-------------------------|-------------------|--------------|
| moringa Sauce           | 4,00              | 25,57        |
| Dried okra sauce + fish | 3,90              | 10,29        |
| Sorrel Sauce            | 7,14              | 80,88        |
| Kawal Sauce             | 3,58              | 93,41        |
| Red meat sauce          | 2,95              | 89,04        |
| Spinach Sauce           | 4,58              | 71,92        |
| Fresh okra sauce + meat | 3,05              | 77,84        |
| Corn ball               | 3,75              | 32,03        |
| Béré-béré ball          | 3,25              | 35,12        |
| Red millet ball         | 3,73              | 61,81        |
| Penicillaria ball       | 7,31              | 61,14        |
| Cassava ball            | 2,82              | 65,98        |
| Rice ball               | 6,85              | 66,10        |

Among the balls, the penicillaria ball is the richest in carbohydrates (7.31%), followed by the rice ball (6.85%). In terms of humidity, the sauces are generally richer in water than the balls, especially the kawal sauce (93.41%) and the sorrel sauce (80.88%), which suggests a low energy density. In contrast, the corn and béré-béré balls

have relatively low humidity (32% to 35%), indicating a higher concentration of dry matter.

Overall, the analysis shows that sauces, particularly those made with meat or leafy vegetables are richer in protein and fat, while balls serve primarily as energy sources via complex carbohydrates. However, some combination dishes (e.g., penicillaria ball + meat okra sauce) offer a good overall nutritional balance. Conversely, dishes such as cassava or rice balls with light sauce present a risk of protein imbalance. These results are essential for guiding nutritional recommendations in Abéché. They help identify the most balanced dishes and suggest improvements in meal composition, particularly for children, pregnant women, and vulnerable people.

## 4. Discussion

The results of this study highlight a marked variability in the nutritional composition of traditional meals consumed in Abéché, revealing both nutritional potential and worrying imbalances. This diversity of nutritional profiles is particularly important to analyze in a context where Chad, like many Sahelian countries, is facing a double nutritional burden: the persistence of undernutrition and the emergence of new pathologies linked to the dietary transition.

The observed protein contents are significantly higher in sauces containing animal products (meat, dried fish) or rich leafy vegetables such as moringa and spinach. These results are consistent with those of in Nigeria [7], who showed that traditional sauces made from green leaves and peanuts contributed significantly to protein intake in preschool children. Similarly, a study conducted in Niger [8], confirmed that the addition of meat or fish to traditional sauces significantly increased the protein density of meals. This suggests that certain local practices, when they include protein-rich ingredients, can effectively contribute to preventing protein-energy deficits.

On the other hand, sauces low in animal products or very diluted, such as kawal or dried okra, have shown protein contents below 3%. This observation is not new: in Ghana [9], they already reported that in many local preparations based on vegetables or leaves, the actual quantity of protein is often low due to the dilution of the ingredients or the low protein content of the plants used. This low protein content can be problematic, particularly for children and pregnant women, for whom the need for essential amino acids is increased.

Regarding lipids, okra sauces with meat, moringa sauce, and red meat sauce showed relatively high levels (above 4%), which is consistent with traditional recipes, often enriched with peanut oil or fatty meat. Lipids are essential for the absorption of fat-soluble vitamins, but their role is ambivalent in contexts where the quality of fats is not always controlled. A study conducted in Ivory Coast [10] showed that while traditional sauces can be rich in lipids; they are sometimes unbalanced in essential fatty acids, particularly omega-3. This point was not explored here, but it could be the subject of further work.

Carbohydrates are mainly found in balls accompanying sauces. The penicillaria and rice balls showed the highest levels. These results are consistent with data from the

study in Central Africa [11], which highlights that local cereals, particularly millet and sorghum, remain the main energy source of African diets, with carbohydrate contents often exceeding 65%. However, these balls are low in protein and sometimes excessively rich in rapidly digestible starch, which can be problematic in the context of diabetes or emerging obesity.

A nutritional imbalance is therefore observed in certain food combinations: for example, the combination of a cassava ball (low in protein) with a diluted sauce such as kawal or sorrel does not cover the minimum macronutrient requirements. This observation is in line with results of research in Burkina Faso [12], who reported that many traditional rural meals did not allow the recommended nutritional intake to be reached, especially in children under five years old.

Another important element concerns the water content of meals. Some sauces, such as kawal (93.41% moisture) or sorrel (80.88%), have a very high water content.

This can be beneficial for hydration, especially in a hot Sahelian context, but reduces the caloric density of the meal [13]. The moisture content of sauces is also a key element. Very watery sauces, such as kawal or sorrel (up to 93% moisture), have a low energy density. While this can contribute to hydration, as highlighted in some research [14], it can also be a factor in energy undernutrition when these sauces are the only available toppings. Young children, in particular, who have limited gastric volume, are at risk of not consuming enough energy to cover their daily needs.

On the other hand, some local combinations are proving interesting. For example, the combination of penicillaria ball (complex carbohydrates + fiber) with a meat okra sauce (protein + moderate lipids) constitutes a balanced meal, in line with the WHO and FAO recommendations on optimal food combinations in low-income countries [15]. Such combinations deserve to be promoted in nutrition education campaigns, especially since they are culturally accepted and economically accessible. The implications for public health are numerous. An unbalanced diet, even if derived from traditional practices, can maintain chronic deficiencies.

This study supports the observations of the Chad National Nutrition Program (PRONAT, 2021) [2], which highlights the need to qualitatively improve traditional meals in urban and semi-urban areas. By integrating the results of this study into community programs, it would be possible to propose simple improvements to recipes (adding legumes, dried fish, or peanuts), without disrupting eating habits.

From a public health perspective, these results are important. They allow us to reconsider certain preconceived ideas about traditional dishes [16]. Although culturally valued, not all of them are necessarily balanced or adapted to the specific nutritional needs of certain populations [4]. This highlights the need to integrate the nutritional dimension into strategies for promoting local food, as encouraged by Chad's Multisectoral Nutrition Strategy (2020–2025). In addition, the data obtained can feed into nutrition education tools adapted to the local context: improved cooking sheets, training for health workers, or modules for schools.

Finally, this study has some limitations that should be

mentioned. It focused only on macronutrients (proteins, lipids, carbohydrates, moisture), without taking into account essential micronutrients (iron, zinc, calcium, vitamins). Furthermore, the variability of recipes from one household to another can influence the results, even if the dishes were standardized for the analysis. A complementary study focusing on micronutrients or essential amino acids would enrich the analysis and refine the recommendations. In short, this research highlights both the richness and the limitations of local culinary practices in Abéché.

By relying on concrete data, it provides a solid basis for guiding food policies, raising awareness among communities, and improving the nutritional quality of meals through simple, accessible, and culturally acceptable adjustments.

## 5. Conclusion

This study analyzed the nutritional composition of several traditional meals commonly consumed in the city of Abéché, highlighting their macronutrient (protein, lipid, carbohydrate) and moisture content. The results revealed significant heterogeneity between the different dishes tested. Sauces containing leafy vegetables and animal sources (meat or fish) have higher protein and lipid intakes than diluted or exclusively vegetable sauces. As for cereal-based balls, they are the main source of complex carbohydrates, but their protein value generally remains low, particularly in the case of cassava and rice.

These observations confirm the value of certain traditional combinations, such as the penicillaria ball with meat okra sauce or the red millet ball with moringa sauce, which offer a better overall nutritional balance. Conversely, very watery or protein-deficient dishes should be improved, particularly for groups with specific needs (children, pregnant women, the elderly).

These results highlight the need for a nutritional approach based on local data to promote a balanced diet. They can serve as a basis for targeted nutrition education interventions, promoting traditional dishes while suggesting simple adjustments. They are also useful for decision-makers in the implementation of multisectoral nutrition strategies in Chad. Finally, this research paves the way for other complementary studies, particularly on micronutrient intake, amino acid profiles, and the impact of cooking methods on nutrient bioavailability. A better understanding of the nutritional qualities and limitations of local foods is essential for developing sustainable and culturally appropriate responses to the problem of malnutrition in Sahelian regions.

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