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Research Article

Culinary Practices as a Strategy for Food Security and Nutritional Transition in the Context of Climate Change in Soudano-Sahelian Zone of Cameroon

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Abstract

Northern Cameroon is highly vulnerable to climate change, resulting in persistent food and nutritional insecurity among rural households. This study aims was to assess dietary habits in northern Cameroon during periods of food abundance and scarcity, and to evaluate the contribution of underutilized and climate-resilient foods to food and nutritional security under climate change conditions. Data were collected using a survey of 720 randomly selected households in four localities (Bame; Bang, Gambour and Douroum). Samples were collected and analyzed for nutritional content. The Kruskal-Wallis test and analysis of variance (ANOVA) were used to compare the consumption of staple foods and nutritional parameters. R-studio software has using for analysis. Dietary diversity was low, with cereals contributing 80% of total food intake, followed by legumes (15%) and tubers (5%). Seventeen food consumption forms were identified, with frequencies ranging from 0 to 10 times per week. In the case of leafy vegetables, 15 varieties are consumed. Foods derived from roots and tubers are less popular than those derived from cereals. The FCS during the period of food abundance varies between 23.3 and 28.5, while during the lean season, the variation is between 23.3 and 25.5. Diversity Score (FDS) varied from 2.13 to 3.3 during abundance and from 3.1 to 4.4 during the lean period, remaining well below FAO thresholds. Sixteen underutilized foods were consumed as coping strategies during food shortages and exhibited high nutritional potential. These foods have a high nutritional potential, so the average variation is: in ash from 0.3 ±0.00 to 5.793 ±0.58, in dry matter from 83.24 ±0.83 to 94.93 ±0.80, in crude protein from 6.68 ±0.10 to 44.68 ±2.91, in total lipids from 8.79±0.79 to 48.33 ±3.24, total carbohydrate from 11.45 ±2.86 to 50.52±2.4, fiber from 0.00 ±0.00 to 5.22 ±1.58, calcium from 23.54 ±0.16 to 316.95 ±0.31 and iron from 5.35 ±0.077 to 7.66.05 ±0.02. The FCS and FDS values are well below the FAO standard, which is greater than or equal to 35.5 and 6 respectively. Nutritional analyses show that these foods play a very important role in the fight against food insecurity, as they have very high macro and micronutrient values. Overall, underutilized foods represent valuable resources for improving dietary quality and strengthening resilience to

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climate-induced food insecurity in northern Cameroon.

Keywords

Culinary Practices, FCS, FDS, Food and Nutritional Security, Under-valued Foods, Hunger, Abundance

1. Introduction

Sustainable, healthy eating is an important factor that can impact an individual's optimal health and well-being [1, 2]. According to WHO (2018) diet evolves over time and is influenced by many socio-economic factors that combine in complex ways to shape each person's eating habits [3, 4]. The ingestion of a food (raw, cooked, grilled, boiled, steamed, sweet or salty) carries a symbolic charge that arouses pleasure or disgust. It is accompanied by multiple beliefs, taboos, habits and customs concerning food [5]. Despite global efforts to improve nutrition, undernourishment remains a major challenge. In 2016, approximately 815 million people worldwide were undernourished [6, 7]. According to FAO and WHO reports, nearly one in nine people globally consumes fewer than 1,800 kcal per adult per day, and malnutrition accounts for nearly 45% of deaths among children under five years of age [8, 9]. Developing countries, particularly those in Africa, are disproportionately affected by these challenges [10, 11]. In 2019, Africa recorded approximately 250.3 million undernourished individuals, including 15.6 million in North Africa and 234.7 million in sub-Saharan Africa [12-14].

In Cameroon, about 11% of the population approximately three million people faces acute food insecurity, with higher prevalence in rural (33.3%), peri-urban (28%), and urban (26%) areas [15, 16]. The North and Far North regions are the most affected [17-19].

These regions are also among the most vulnerable to climate change in Cameroon, which has significantly reduced agricultural productivity [20, 21]. As a result, households experience seasonal food shortages, leading to marked variations in dietary habits throughout the year. During the period of food abundance, eating habits are largely based on cereals (e.g., *Zea mays*, *Sorghum bicolor*, *Oryza sativa*) and legumes (groundnuts and cowpeas).

In contrast, during the lean season (July–September), which precedes the harvest and is characterized by depleted food stocks, resource scarcity, and rising market prices, households adopt coping strategies such as reducing meal frequency or relying on alternative food sources [22]. These strategies include consuming food by-products and foods derived from underutilized crops that require minimal inputs, as well as traditional “soudure” practices based on wild fruits and tubers [23].

However, this nutritional transition toward resilience in the context of climate change remains poorly documented, particularly regarding the nutritional value of underutilized foods [24, 25]. Therefore, the objective of this study was to assess dietary habits in northern Cameroon during periods of food abundance and scarcity, and to evaluate the contribution of underutilized and climate-resilient foods to food and nutritional security under climate change conditions.

2. Materials and Methods

2.1. Presentation of the Study Area

The Sudano-Sahelian zone of Cameroon comprises two regions: the Far North and the North. The Far North region covers an area of 34,263 km^2. Located between 10 ° and 30 ° north latitude and between 13 ° and 15 ° east longitude, it stretches some 325 km from the Sudanian countries to the unlikely shores of Lake Chad. It is bordered to the east by Nigeria, to the west by Chad and to the south by the North Cameroon region. According to the National Institute of Statistics, the North region is geographically located between 7 ° and 10 ° North latitude, and between 12 ° and 16 ° East longitude [26]. It borders the Far North Region to the north, Adamaoua to the south, the Republic of Chad and the Central African Republic to the east, and the Federal Republic of Nigeria to the west. It covers a total area of 65, 576 Km^2, divided between four departments (Benoue, Mayo Louti, Mayo Rey and Faro) and twenty-one districts. In 2005, its population was estimated at 1,687,959, with a density of 26 inhabitants/km^2. The climate is Sudanese, with 6 months of rainy season and 6 months of dry season, and an average temperature of 35 ℃.

The survey was carried out in four localities: Bame, Bang, Gambou and Douroum (Figure 1), Following the geographical gradient of each region. Bame and Gambou are located to the south of the two regional capitals, while Bang and Douroum are to the north. Bame is in the Benoue department, Lagdo arrondissement, while Bang is in the Mayo-Louti department, Guider arrondissement. In the Far North region, Gambour is located in the Mayo-Kani department, Kaele arrondissement, and Douroum in the Diamare department, Meri arrondissement. These villages were selected on the basis of criteria such as the notably high incidence of climate change population dynamics (ethnic groups grouped into neighborhoods), high production potential and farming prac-

tices. These localities group together several ethnic groups: the Moufou, the Guiziga, the Hyllagas, the Toupouri, the Moundangs, the Doupas, the Douayo, the Peulhs and the Matakames, the Dabas, the Guidars, the Lames, the Massas, the Madagalis, the Mbororos, the Mouyang, the Mathakam: and the Matal [27]. In these localities, agriculture and animal husbandry are the main activities, and culinary practices differ from one locality to another.

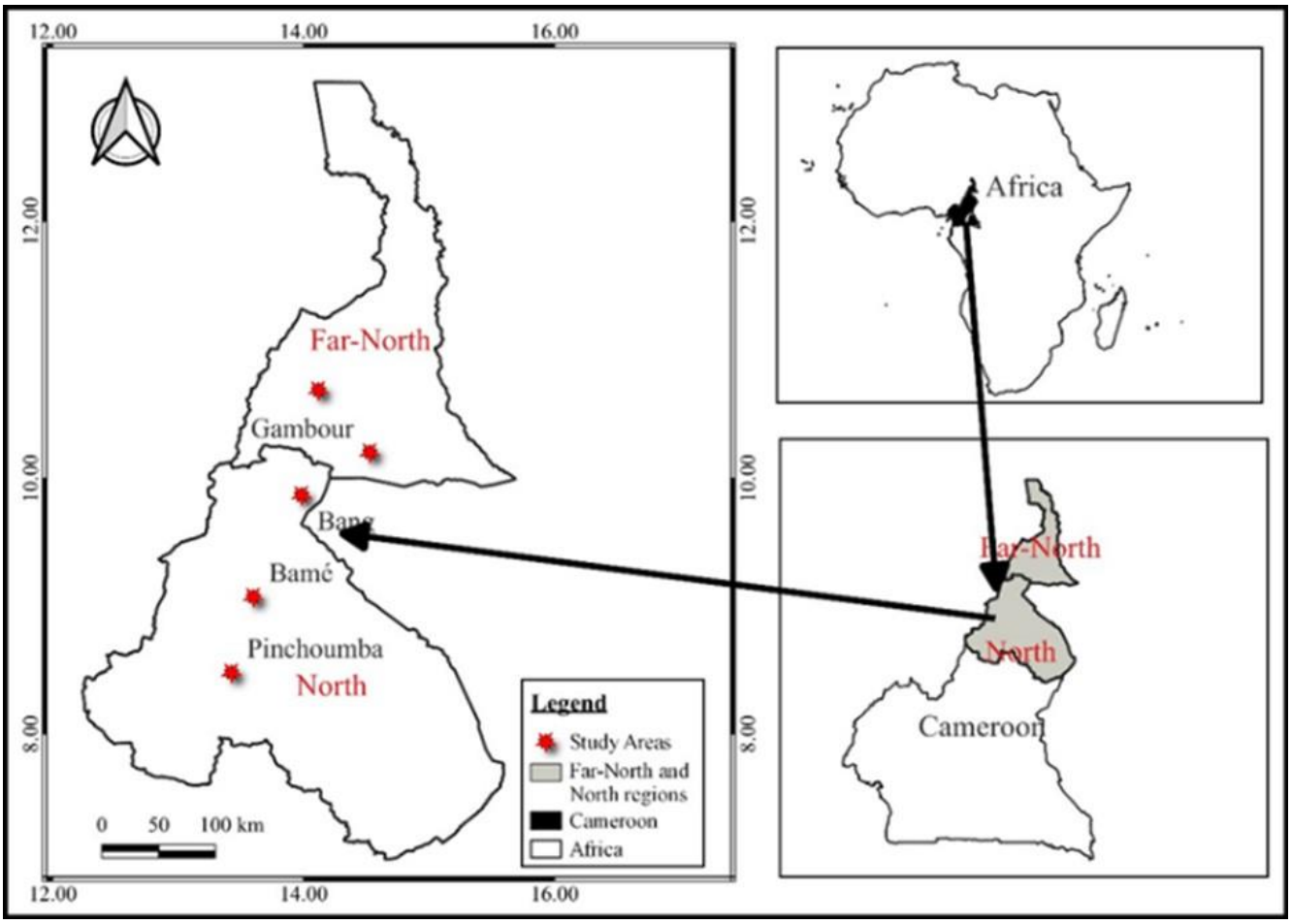

Figure 1. *Map showing location of study area.*

2.2. Survey

A household survey was conducted using a structured questionnaire administered to 720 households, corresponding to 180 households per locality. Data collection took place during two distinct periods: the food abundance period (October–May) and the lean season (June–September). The lean season corresponds to the period of greatest food insecurity, characterized by depleted food stocks, limited local production, and increased food prices. Women were exclusively targeted as respondents, as they are primarily responsible for food preparation and household nutrition. The household was selected as the unit of analysis because it provides the most reliable information on family food consumption. Food consumed outside the household was not considered due to the difficulty of obtaining consistent and reliable data. Households were selected based on two groups of variables: household characterization variables (age of respondents, number of persons per household, ethnolinguistic group, religion, income and habitat) and common consumption characterization variables, namely:

Foodstuffs available in localities: availability indicates the quantity of food physically present in the study area.

Forms of consumption of available foodstuffs: this refers to the way in which households organize themselves to prepare food.

Frequency of consumption of each food: this refers to the regularity with which we include certain foods in our diet. It was calculated on a weekly basis in this study.

Level of acceptance of different foods: This was calculated which presents it on a scale of 1 to 9, broken down as follows: Poor = 1-3; Average = 4-5; Good = 6-7 and Very good = 8-9.

Dietary diversity score (DDS): this was calculated using the FAO (2011) method [28]. This method records the number of food groups consumed over the last seven (7) days.

Food Consumption Score (FCS): Patrik Webbn method [29]. Was used to calculate this parameter. This method involves multiplying the weighting of each food group by the number of days consumed over the last seven (7) days.

Sample collection: The stratified random probabilistic approach was carried. To this end, seven (7) samples of the under-valued foodstuffs most consumed in these localities were collected in labelled glass jars and taken to the laboratory for nutritional analysis. Sampling was carried out according to the formula:

$$n = \frac{N*Z^2*p(p-1)}{E^2*(N-1)+Z^2*p(p-1)}$$

Where: N = village population, Z = 1.96 (95% confidence interval), p = 0.5 (conservative proportion maximizing variability), E= 0.05 (acceptable margin of error).

2.3. Nutritional Analysis

The following parameters were analyzed in each sample: Water content was determined according to the standard Association of Official Analytical Chemists [30]. The crude proteins were obtained by determination of nitrogen content using Kjeldahl method and the nitrogen value multiplied by a factor of 6.25 population [31]. Total fats were achieved by extraction method [32]. Iron, Calcium and Zinc contents were obtained after incineration [33]. The method prescribed by Dubois [34] and colorimetric method of were used for total carbohydrates.

2.4. Statistical Analysis

Data collected were entered in Excel 2016 and subjected to descriptive analyses. The Food Consumption Score (FCS) and the Food Diversity Score (FDS) were calculated using SPSS software. Analysis of variance Kruskal-Wallis was used to compare samples, with statistical significance set at $p \leq 0.05$.

3. Results and Discussion

3.1. Socio-economic Characteristics of Surveys

The majority (53%) were aged between 20 and 35 years, followed by 37% aged between 35 and 50 years, and 10% aged between 50 and 65 years (Figure 2). Women aged 50–65 years provided particularly detailed information, reflecting their extensive experience and knowledge of traditional culinary practices.

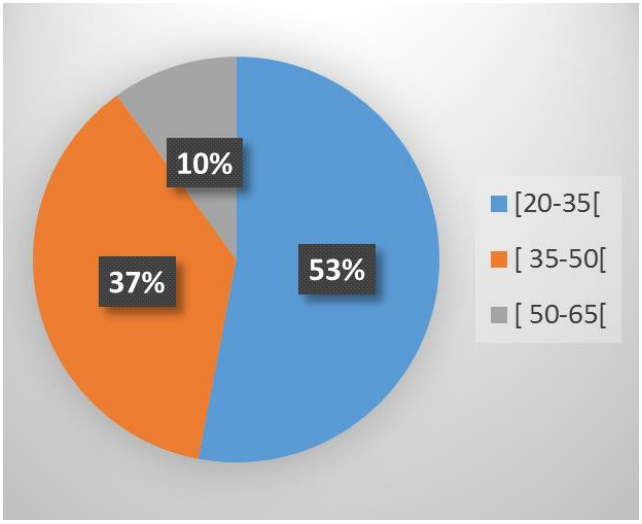

Figure 2. *Age distribution of women.*

3.2. Culinary Practices in Northern Part of Cameroon

3.2.1. Foodstuffs Available in Rural Sudano-Sahelian Areas of Cameroon

Figure 3 illustrates the main foodstuffs available in rural Sudano–Sahelian areas and commonly consumed by households. Cereals and legumes were the dominant food groups. Maize (*Zea mays*), cowpeas (*Vigna unguiculata*), and groundnuts (*Arachis hypogaea*) were available in 100% of households. These were followed by sorghum (*Sorghum bicolor*, 99.16%), Bambara groundnut (*Vigna subterranea*, 76.33%), and sesame (*Sesamum indicum*, 74.16%). These commodities are least represented by rice (48.33%), followed by soya (40.83%), potatoes (22.5%), millet (5%), fonio (4.66%), souchet (2.5%) and teff (2.5%). This result shows that nutrition is essentially based on cereals (maize and sorghum) and that the percentage of tuber consumption in this part of the country is lower due to the high purchase cost, which is only accessible to a high-income category of people, hence the name "food for the rich" (sources). Barbier et *al*., in 2002, have shown that diet is centred on the consumption of maize in the North and sorghum in the Far North, while roots and tubers predominate in Adamawa. All these households obtain 62% of their supplies from fields and 38% from markets. The low consumption of fonio (*Digitaris exilis*) may be due to the fact that it is much more as a food for lean times (Eric Vall, 2011).

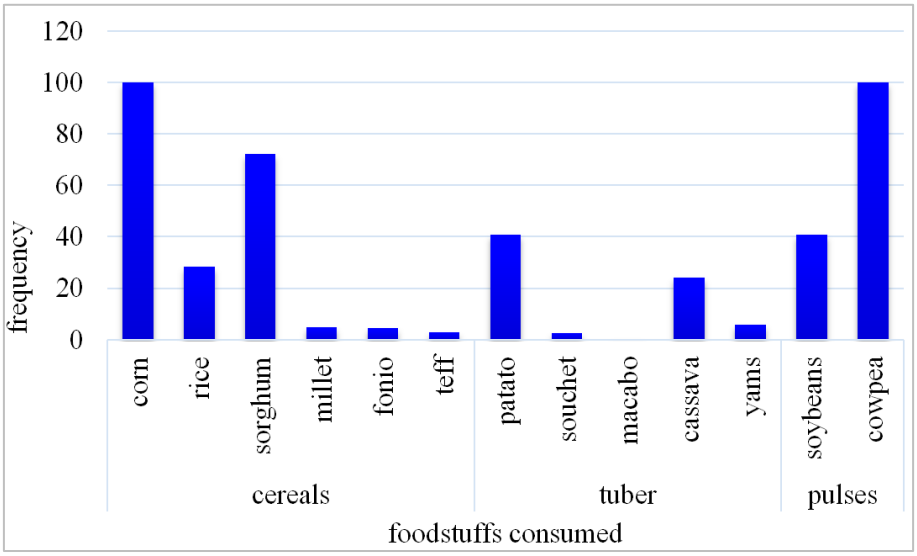

Figure 3. *Foodstuffs consumed in rural areas of the Sudano-Sahelian zone of Cameroon.*

3.2.2. The 9 Food Groups Aggregated by the FAO and Consumed in Rural Localities in the Sudan-Sahelian Zone of Cameroon

Figure 4 illustrates the variety of food groups included in dietary diversity. As can be seen, all food groups are available, with variation between species. Starchy foods, dark green leafy vegetables, legumes, nuts and seeds are generally the most frequently consumed foods across households, while offal (0%), vitamin A-rich fruit and vegetables (4%) and other fruit and vegetables (14%) are the least frequently consumed. Improved dietary diversification and better use of available foodstuffs in these localities could positively impact the nutritional status of populations in Greater Northern Cameroon.

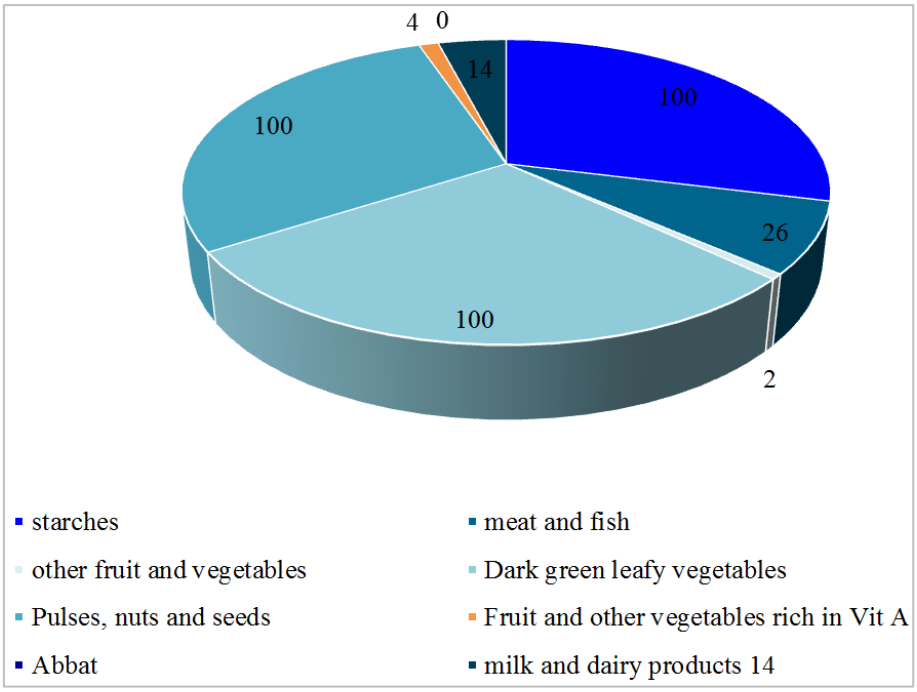

Figure 4. *Food groups aggregated and included in the Food Diversity Score in rural localities in the Sudano-Sahelian zone of Cameroon.*

3.2.3. Diversity of Leafy Vegetables Consumed in Rural Areas of the Sudano-Sahelian Zone of Cameroun

Eating habits of the population in this part of Cameroon are much more focused on the consumption of leafy vegetables. All these vegetables are prepared as soups to accompany couscous balls, and rarely as tubers. Overall, 15 vegetables are grown and consumed in this part of the country (Figure 5). Folére leaves *(Hibiscus sabdariffa*), lalo (*Corchorus sp*), okra (*Abelmoschus esculentus*), gouboudo (*Ceratotheca sesanoides*), hako tignére (*Allium cepa*), cowpea leaves (*Vigna unguiculata*) and baobab leaves or boko leaves (*Adansonia digitata*) are eaten by 100% of respondents. Tasba (*Senna tora*) and folong (*Amarantus viridis*) are consumed by 97.5% and 94.5% of households respectively. The least consumed vegetables are hako mindelo (*Gymnanthemum amygdalinum*) (19%), worba leaves (*Ziziphus maurittiana Lam*) (25.16%), alkia *(Kigelia africana*) (25.33%) and Lalo karal (25.64%). These vegetables are mostly grown in the rainy season, then harvested and dried for later preparation. All these vegetables are prepared with or without dried fish, fresh fish or meat. Some are prepared in a soup containing groudnut paste (*tasba, folere*, hako tignere, folong, cowpea leave etc.). The eating habits of rural populations in these areas are the same from one locality to another, and preferences also differ from one person to another. In some localities, when the means to buy fish or meat are lacking, the soup is prepared simply or with cowpea. The addition of cowpea to soup is a way of improving the nutritional status of the local population, as cowpea is a source of vegetable protein that provides many essential nutrients for the body [35]. Most of these vegetables are sourced 52% from the local market, 28% from city markets and 20% from the fields.

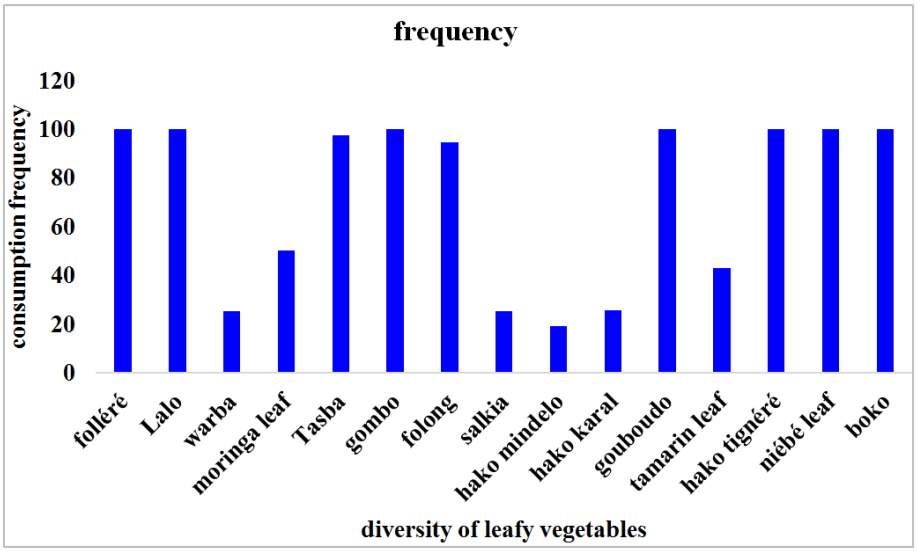

Figure 5. *Diversity of leafy vegetables consumed in the Sudano-Sahelian zone of Cameroon.*

3.2.4. Different Forms of Consumption of Foodstuffs Available in the Rural Sudano-Sahelian Zone of Cameroon

(i). Cereals

The eating habits of the population in the far North of Cameroon are very much centered on cereal consumption. Maize is consumed in several forms: fufu (100%), maize-based porridge (100%), roasted maize (62%), fresh boiled maize on the cob (100%) and maize fritters (12%). As for sorghum, there are only three forms of consumption: 100% in the form of couscous and porridge, and 45% in the form of boiled seeds. Rice is consumed in five forms, the most common being rice couscous (72%), followed by steamed rice (66%), rice porridge (64%), sauted rice (21%) and rice fritters (12%), known locally as "Masse". Fufu is the most widely consumed cereal in northern Cameroon, and is eaten between 10 and 15 times a week. It is always combined with various soups during consumption. This result corroborates those of Tchuenga [35] and Hama (2016). These authors demonstrate that fufu is the most widespread form of maize consumption in the far north and west Cameroon. Cereal porridge on the other hand, is a highly appreciated dish eaten by many people living in Northern Cameroon. Cereal porridge is a secondary maize product prepared using either crushed flour (4.39%) or uncrushed flour (95.61%) (Figure 5). The high consumption of uncrushed cereals can be a cause of malnutrition in localities, as the inactive structure of the cereal kernel hampers digestion and absorption of nutrients by the body, resulting in reduced digestibility. This idea corroborates that of Joel Fofiri (2010) [36]. Who believe that crushing leads to better digestion of the starch and proteins contained in food (Boakye et *al.*,

2021) [37, 38]. Also believe that regular consumption of uncrushed flour increases the risk of deficiency in fiber, iron, zinc and B vitamins. Roasted flour is eaten as a snack and is often accompanied by peanuts, while boiled flour is more common during the harvest period, consumed 5 to 10 times a week. As for rice and tubers, they are consumed less frequently (less than 5 times a week) than maize, as most households obtain their supplies in town. Figure 6 shows the different processes used to obtain maize flour.

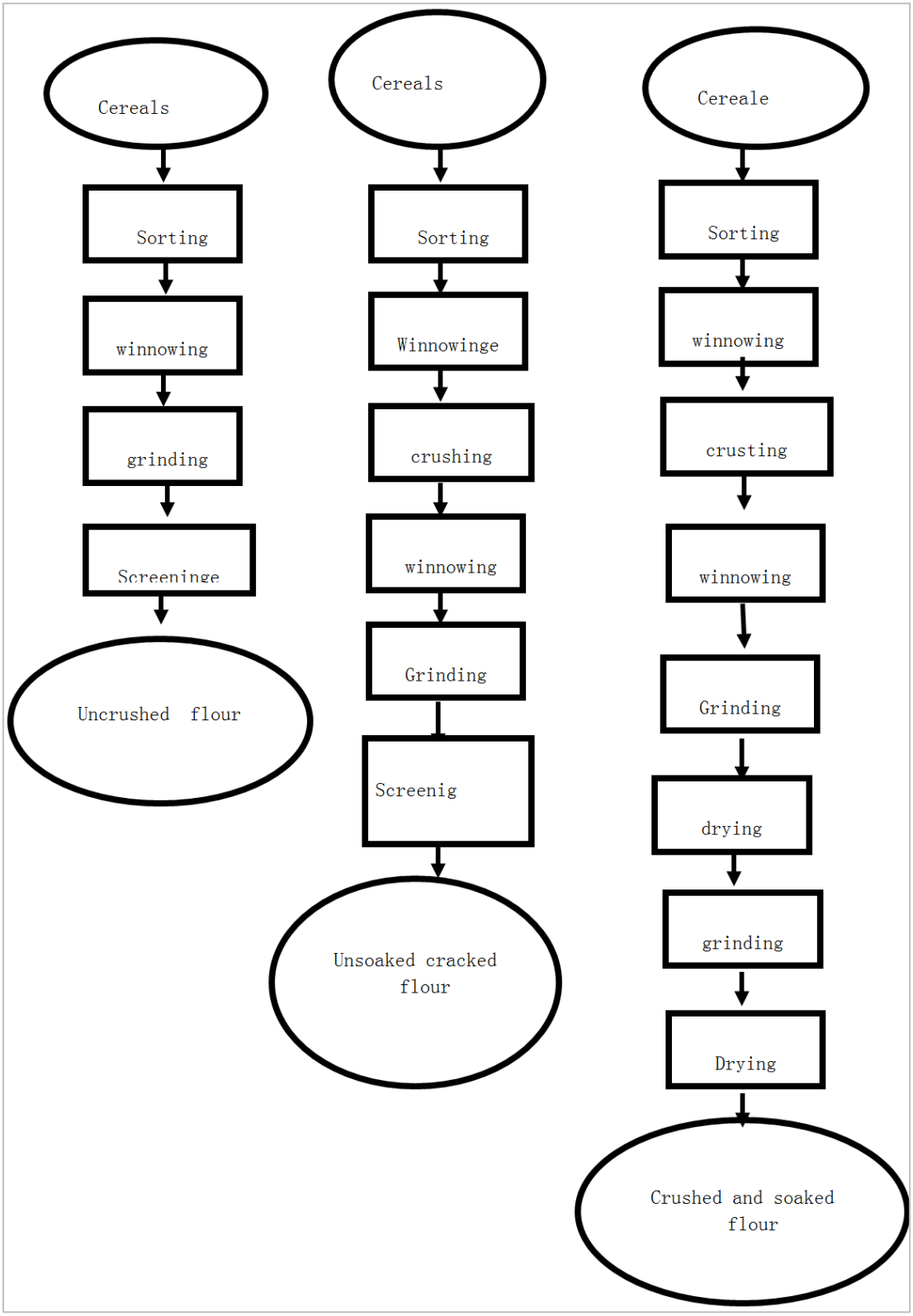

Figure 6. *Corn flour production process.*

(ii). The Tubers

Tubers are the least consumed food group in the study area. All respondents (100%) reported consuming sweet potatoes in steamed and raw forms, while only half consumed them in fried form (Figure 4). Similarly, all respondents consumed yam in the steamed form, whereas fried and sautéed forms were consumed by only 50% of respondents (Figure 4). Overall, tubers are predominantly consumed in boiled form, as this mode of preparation facilitates digestion among the population. These findings are consistent with those of Abena (2018), who reported that boiling enhances the digestion of starchy and protein compounds in tubers, thereby improving their intestinal absorption. The low consumption of fried tubers can be attributed to limited access to cooking oil, largely due to low household income.

The low frequency of tuber consumption (less than five times per week) is also linked to their limited cultivation in the study area (particularly yams and potatoes). Approximately 42% of tubers are obtained from urban markets, 39% from local markets, and only 19% from household fields. For many households, tubers are consumed mainly during major events or ceremonies, as they are often perceived as foods reserved for wealthier populations. According to Akande et al. (2020) [39], low tuber consumption may negatively affect nutritional status, given that tubers are important sources of minerals (iron and magnesium), B vitamins, and complex carbohydrates such as starch and dietary fiber.

(iii). Leguminous Plants

Peanuts are the most widely cultivated legume in Northern Cameroon. Figure 7 illustrates the different forms of peanut consumption, showing that boiled, grilled, raw, and sauce forms are consumed by all households. In contrast, caramelized peanuts and *bakourou* are consumed by only 5% and 23% of households, respectively. Cowpeas are highly appreciated by the population and are consumed in six different forms, including cake or koki (63%), boiled (36%), porridge (25%), fritters (23%), sautéed or kneaded (23%), and raw (33%). Sesame is consumed raw by all households, while more than one-quarter consume it in caramelized (34%), sauce (28%), or toasted (27%) forms. All these products are consumed between zero and five times per week, depending on the household. Soybean is consumed in several forms, mainly boiled (36%), awara (32%), grilled (10%), and broth (3%), with consumption frequencies of less than five times per week. In contrast, almost all households consume voandzou (Bambara groundnut) in boiled (100%), kneaded or sautéed (89%), and grilled (94%) forms, also between zero and five times per week. However, the consumption of certain legumes in their raw form by children, particularly cowpeas and voandzou, often leads to digestive disorders such as diarrhea and flatulence [40]. According to Arsene Marcelle [41], legumes may pose digestion and nutrient bioavailability challenges due to the presence of anti-nutritional factors, as well as their tendency to cause flatulence and gastrointestinal discomfort. Figure 6 illustrates the consumption patterns of these foodstuffs.

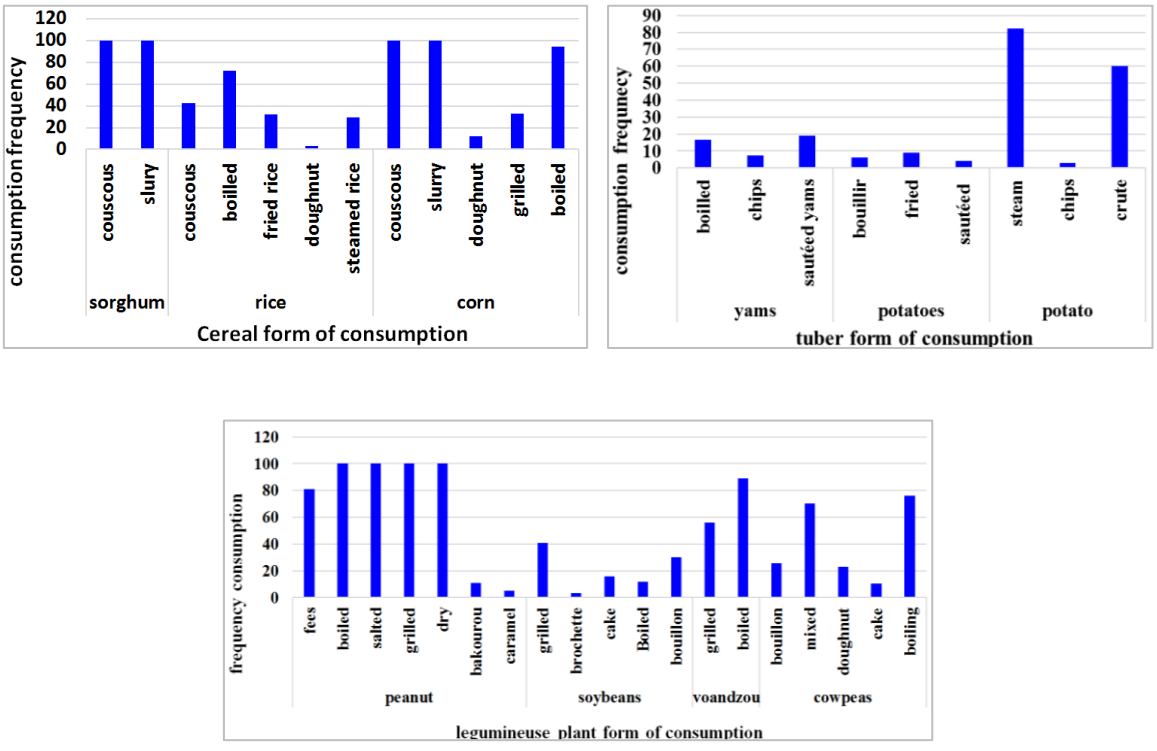

Figure 7. *Form of food consumption.*

3.2.5. Perception and Level of Food Acceptance

The level of food acceptance refers to a person's willingness and ability to consume a given food. The level of food acceptance vary from person to person, depending on personal preferences, dietary habits, allergies or intolerances, and even culinary education. Table 1 shows food acceptance levels by household.

Table 1. food acceptance levels by household.

	Al	fu	Bo	Bi	V	Su	G	B
Corn	medium	0	5	-	44.17	-	37.50	10.84
	good	100	87.5	-	55.83	-	62.50	89.16
	very good	0	7.50	-	0	-	0	0
Sorghum	medium	17.50	15	-	10	-	-	-
	good	82.50	85	-	-	-	-	-
Rice	medium	0	0	-	0	2.50	-	5.16
	good	50	93.33	-	70.63	77.50	-	94.84
	very good	50	6.66	-	29.37	0	-	0
Potato	medium	-	-	-	5.84	0	0	-
	good	-	-	-	94.16	0	-	-
Potatoes	very good	-	-	7	100	100	-	-
Yams	very good	-	-	-	100	100	-	-
Macabo	good	-	-	-	100	0	-	-
Cowpeas	medium	-	-	0	35	0	-	-
	good	-	0	100	65	0	-	100
Soybeans	medium	-	3	-	8	-	1	-
	good	-	97	25	7.50	-	85.33	-
Voandzou	medium	-	-	-	0	-	21.66	-
	good	-	-	-	100	-	78.33	-
Peanut	medium	-	-	-	3.33	-	36.66	-
	good	-	90	-	96.67	-	63.33	-
	very good	-	10	-	0	-	0	-
Sesames	medium	-	0	-	-	-	0	-
	good	-	100	-	-	-	54	-

Table 1. Continued.

	Al	F	M	Gs	Ca	Sp	dr	Ba	G
Corn	-	-	-	0	-	-	-	-	0
	-	-	-	0	-	-	-	-	0
	-	-	-	0	-	-	-	-	0
Sorghum	-	-	-	-	-	-	-	-	-

	Al	F	M	Gs	Ca	Sp	dr	Ba	G
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
Rice	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
Potato	0	65. 84	0	0	0	95.85	-	-	-
	-	34.16	9	-	-	4.16	-	-	-
Potatoes	-	100	-	-	-	-	-	-	-
Yams	-	-	-	-	-	-	-	-	-
Macabo	-	-	-	-	-	-	-	-	-
Cowpeas	0	-	-	-	-	-	43	-	0
	100	-	100	-	-	-	0	-	100
Soybeans	4	16	-	-	-	-	-	-	5.84
	0	0	-	-	-	-	-	-	94.16
Voandzou	0	0	20.83	0	-	-	-	-	0
	-	49	79.17	65	-	0	0	-	0
	-	0	-	0	0	3.33	91.6	63.33	-
Peanut	100	46	-	100	100	96.67	8.33	32.77	-
	0	39	-	0	0	0	0	0	-
Sesames	3.33	64	-	0	0	24	92.5		-
	70.7	31	-	100	100	0	7.50	-	-

Al: acceptance level, fu: fufu, Bo: porridge, Bi: broth, V: steam, Su: stir-fry, Sa: sauce, F: fried, M: kneaded, Gs: grilled salted, G: grilled, B: doughnut, Ca: caramel, Sp: spawn, Dr: dry, Ba: barkourou, G: cake.

Corn fufu (100%), porridge (87.5%), boiled corn (55.83%), grilled corn (62.5%) and corn fritters (89.16%) are widely accepted by the population (Table 1). (Table 1). However, some preparations such as corn porridge (5%) and fritters (10.84%) received lower appreciation in a small proportion of households. The high consumption of corn fufu may be attributed to its availability and its ability to sustain households during periods of food scarcity.

Regarding sorghum, 17.5% of households rated sorghum fufu as moderately appreciated, while 15% expressed the same opinion for sorghum porridge. In contrast, high acceptance rates were recorded for sorghum fufu (82.5%) and porridge (85%). The strong preference for sorghum porridge may be explained by its high iron content, particularly in red sorghum, and its frequent use as a complementary food for children under five years of age to prevent iron and folic acid deficiencies, as reported by Barbi et al. (2024) [42]. Concerning rice-based foods, rice fritters (5.16%) and stir-fried rice (2.5%) were moderately accepted by a minority of households, whereas rice fritters (94.84%), rice porridge (93.33%), stir-fried rice (77.5%), steamed rice (70.63%), and rice fufu (50%) were well accepted overall. Notably, 50% of households reported very high acceptance of rice fufu, compared with 6.66% for rice porridge and 29.37% for steamed rice. Potatoes were well accepted in steamed (94.16%), fried (34.16%), and raw (4.16%) forms, although moderate acceptance was reported by 5.84%, 65.84%, and 95.84% of households, respectively. In general, potatoes, yams, and cocoyams were very well appreciated by all households when prepared in sautéed, fried, or steamed forms. The high acceptance of roots and tubers may be related to their relative rarity in daily diets, which increases their perceived value and desirability. Cowpeas were appreciated by 35% of households when steamed, while boiled (100%), steamed (65%), frittered (100%), sauced (100%), and kneaded (100%) forms were highly accepted. This strong preference for cowpeas among rural consumers can be explained by their role as a major source of plant protein in soup preparation, often substituting for meat and fish, which are less accessible due to economic constraints. Peanuts were moderately appreciated in steamed (3.33%), roasted (36.66%), fresh (3.33%), dried (8.33%), and *bakourou* (63.33%) forms. In contrast, peanut porridge (90%),

steamed peanuts (96.67%), peanut paste used in sauces (100%), and salted and roasted peanuts locally known as mandawa (Fulfulde) were highly appreciated by households. Only 10% of respondents rated peanut porridge as "very well appreciated."Sesame was well accepted by all households (100%) when consumed roasted, caramelized, or in porridge form, and by 70.83% when used in soup preparation. Differences in food acceptance may be influenced by sensory characteristics such as taste, texture, aroma, and appearance. According to Corbeau et al. (2010), respecting individual food preferences is essential when promoting dietary diversification to improve nutrient intake.

3.3. Food and Nutrition Insecurity Index

3.3.1. Food Consumption and Diversity Score in Rural Areas of the Northern Part of Cameroon

The Food Consumption Score (FCS) is an indicator used to assess food quality. The Food Diversity Score (FDS), on the other hand, is an indicator that measures the overall quality of an individual's or household's diet. The FCS is lowest in Gambour (Figure 8) during the period of abundance and hunger (23.3), while highest in Bame during both periods (27.5 and 25.5) This score is below the FAO 2014 Standard, which should be above 35. On the other hand, the dietary diversity score (DDS) varies between 2.213 (Gambour) and 3.3 (Bame) during the period of food abundance. During the lean season, it is lowest in Bang (3.1) and highest in Douroum (4.4). These figures indicate low dietary diversity and suggest a high risk of essential nutrient deficiency, as they fall below the FAO 2014 standard which would require it to be greater than or equal to 6. The low food consumption score is likely due to the worsening effects of climate change becoming more acute and manifesting itself in lower yields, hence widespread food shortages. Food insecurity affects many people whose only source of income is dependent on agriculture, as well as households where the number of people is very high. The Food Consumption Score varies from one household to another; this variation being linked to the number of meals consumed per day (a single meal during the day for some households and three meals per day for others). The dietary diversity score also varies across households, localities and seasons. The dietary diversity score is higher in high-income households and those with a low number of people per household [43]. It is also surprisingly higher during the lean season than during periods of food abundance. This increase in diversity during the lean period may be due to the fact that when there is nothing to eat at home, people tend to feed on non-timber forest products such as fruits, leaves, roots and wild tubers [44]. The Figure 8 shows the indices of food insecurity in the northern part of Cameroon.

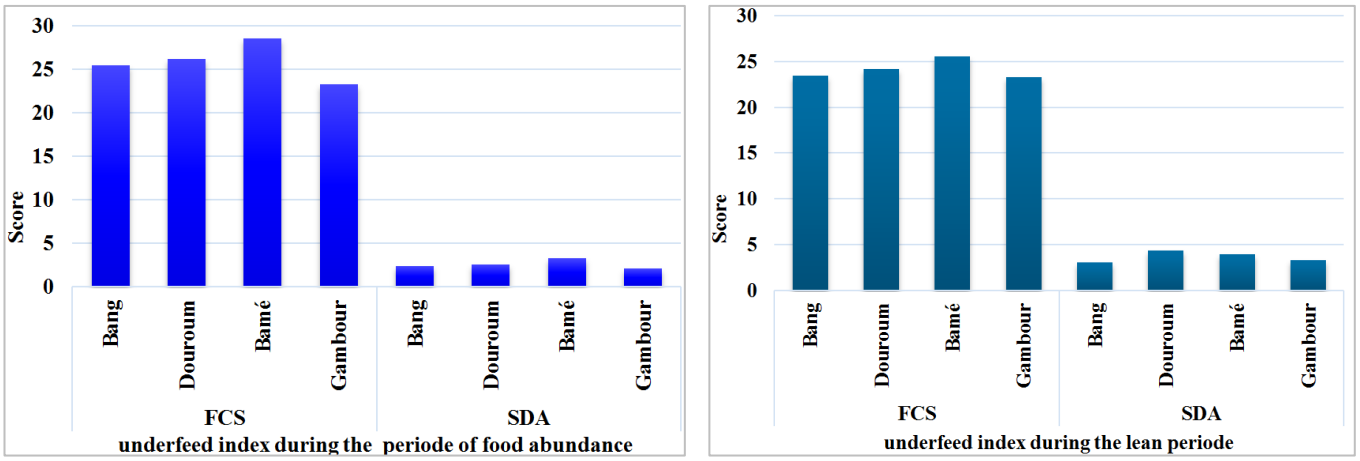

Figure 8. *Food consumption and diversity scores in rural areas of northern Cameroon.*

3.3.2. Contribution of Emergency Foods in the Fight Against Food and Nutritional Insecurity

The Sudano–Sahelian zone of Cameroon is characterized by recurrent food insecurity, which severely affects rural populations. To cope with food shortages during the lean season, households rely on traditionally prepared "soudure" or emergency foods. These include cereals, wild tubers, wild fruits, and wild leafy vegetables. Figure 8 presents the underutilized crops and staple foods consumed during the hunger gap, revealing that 16 staple food items are commonly consumed across the study sites. Consumption frequency varies by locality. The most frequently consumed foods include *chlori-ndiam* (83.35%), *namangal* (74.36%), and *helem* (62.45%). In contrast, shea fruit (14.59%), African peach (19.12%), and peach seed (18.89%) are the least consumed. Table 2 presents a comparative analysis of consumption rates of these underutilized food resources.

Table 2. Krusta-Wallis test.

	Namangal	*Cklori-ndiam*	*Helem*	Nere fruit	Shea fruit
Bam é	70b	93.35a	76.2a	22.22a	22.22ab
Bang	59.72b	93.05a	51.4b	22.22a	31.9a
Douroum	85.71a	69.65b	75a	7.15b	12.5b
Gambour	72ab	86.8ab	68 ab	20.75a	24.53ab
Kruskal-Wallis	16.9	20.6	13.6	10.4	10.4
df	3	3	3	3	3
p-value	0.00072***	0.000127***	0.00349**	0.0158*	0.0158*

Comparative analysis of consumption rates between villages shows that the intake of namangal (locally known as moufou), chlori-ndiam (Fulfulde), helem (Moudang), nere fruit, and shea fruit varies significantly across localities (Table 2). Namangal is more frequently consumed in the Far North region (Douroum and Gambour) than in the North region (Bang and Bame). This difference can be explained by the greater availability of small tree stumps used as raw material for namangal production in the Far North, particularly in Douroum. Conversely, krori-ndiam is more widely consumed in the North (Bang and Bame) than in the Far North (Douroum and Gambour). This pattern reflects the greater cultivation of maize in the North, as klori-ndiam is a maize-based product. Cowberry and shea fruits are less frequently consumed in Douroum (7% and 12%, respectively) compared with other villages (Bame, Bang, and Gambour). This disparity is linked to vegetation structure, as Douroum has a lower density of shea and cowberry trees than the other study sites.

3.3.3. Nutritional Potential of Foods from Under-Valued and Lean Crops in the Sudano-Sahelian Zone of Cameroon

Under-valued foods play an important role in nutrition and food security in the Sudano-Sahelian zone of Cameroon. Indeed, most villages in this zone are food insecure, especially during the lean season, hence the use of lean foods to strengthen resilience in the face of climate change. Table 3 presents the nutritional values of a number of undervalued foods per 100 grams of dry matter (g/100g DM), showing that water content values vary between soap kernels (5.79g/100g DM) and *gouligouli* (0.03g/100g DM). This variation in content could be explained by the fact that they are not of the same nature, as some are made from cereals and legumes, while others are wild fruits. These results corroborate those of Bernard Tiencheu [45] who showed that the exchange of water vapor between the product and the surrounding atmosphere leads to weight loss or humidification, which is detrimental to product quality. A large quantity of water in the product can compromise its preservation, since water favors the proliferation of microorganisms with their amylases, which hydrolyze the starch contained in flours, thus facilitating their acidification. Protein contents range from 44.62g/100g (*hamham*) to 6.68g/100g (*namangal*). Some values are higher than those found by of barbi et *al* in certain cereals-based foods. According to FAO/WHO 2017, the processed cereal-based foods should not exceed 22.6g/100g DM [46]. Lipids are not only energy compounds, they are also structural and functional compounds [47]. The lipid contents obtained in this study vary from 48.33g/100g DM for soap kernels to 8.79g/100g DM for *chlori-ndiam*. Carbohydrate content ranged from 58.22g/100g DM for chl*ori-ndiam* to 11.55g/100g DM for *helem*. These values are higher than those of Louise Burke et *al.*, in 2004 who found 68g of carbohydrate in 100g of flour dry matter [48]. Table 3 shows the nutritional potential of some undervalued foods.

Table 3. Nutritional value of some undervalued foods.

Sample	Ac	Lp	DM	Zc	Fc
chl	0.64 ± 02^{aB}	8.79 ± 0.79^{bc}	$92.70 \pm 0,7^{a}$	$7.30 \pm 0,4^{bc}$	1.19 ± 0.5^{b}
Gs	$0,75 \pm 0,03^{a}$	48.33 ± 3.24^{a}	94.93 ± 0.80^{a}	5.07 ± 0.80^{c}	0.70 ± 0.12^{bc}
H	5.79 ± 0.33^{a}	21.52 ± 1.99^{b}	88.04 ± 1.13^{ab}	11.96 ± 1.13^{ab}	4.61 ± 1.12^{ab}

Sample	Ac	Lp	DM	Zc	Fc
Gm	5.79 ±0.58[a]	35.32 ±0.47[ab]	92.2 ±0.64[a]	7.80 ±0.64[bc]	5.22 ±1.58[a]
He	0.70 ±0.09[ab]	16.52 ±0.78[b]	83.24 ±0.83[b]	16.76 ±0.83[a]	0.00 ±0.00[bc]
NA	0.60 ±0.02[ab]	33.54 ±0.32[ab]	89.54 ±0.86[ab]	10.46 ±086[ab]	1.29 ±0.03[b]
Go	0.3 ±0.00[b]	10.14 ±1.13[bc]	85.58 ±0.56[ab]	14.42 ±0.56[a]	0.00 ±0.00[bc]

Table 3. *Continued.*

Sample	Pc	Cc	TFe	Cac
chl	10.64±0.593[bc]	58.22±2.4[a]	6.22 ±0.19[ab]	73.54 ±0.33[ab]
Gs	22.89 ±0.06[b]	22.26 ±2.32[bc]	7.66 ±0.05[a]	23.54 ±0.16[c]
H	44.68 ±2.91[a]	11.45 ±2.86[c]	7.39 ±0.05[a]	310.25 ±0.68[a]
Gm	34.15 ±2.42[ab]	11.72 ±1.75[c]	7.51 ±0.02[a]	316.95 ±0.31[a]
He	25.46 ±0.93[b]	40.55 ±1.29[b]	5.35 ±0.07[b]	32.79 ±0.26[b]
NA	6.68 ±0.10[bc]	47.42 ±1.21[ab]	6.51 ±0.0693[ab]	35.87 ±5.67[b]
Go	28.35 ±0.11[ab]	46.79 ±1.06[ab]	5.76 ±0.10[b]	74.89 ±0.34[ab]

Ac: Ach conten, C: carbohydrate content, DM: dry mater, Pc: protein content, Lc: lipid content, Fc: fiber content, TC: calcium content, Wc: water content, H: hamham, Gs: soap kernel, Go: gouli-gouli, Na: namangal, He: helem, Kr: chlori-ndiam, GM: roasted melon kernel, H: hamham, mg: milligram, g: gram.

Regarding micronutrients, iron content ranged from 5.35 mg/100 g DM to 7.66 mg/100 g DM, while calcium content varied widely from 23.54 mg/100 g DM to 316.95 mg/100 g DM. These differences were statistically significant among food types ($p \leq 0.05$). *Namnake* exhibited the highest iron content (7.66 mg/100 g DM), whereas roasted melon kernels showed exceptionally high calcium levels (316.95 mg/100 g DM). These micronutrient levels are particularly important for preventing deficiencies, especially among vulnerable groups such as young children and pregnant women [49]. Iron is essential for hemoglobin synthesis and the prevention of anemia, while calcium plays a vital role in bone health, prevention of osteoporosis, regulation of nerve transmission and cardiac rhythm, and maintenance of dental health. Consequently, integrating foods such as *namnake* and roasted melon kernels into local diets could significantly improve the nutritional status of rural populations affected by iron and calcium deficiencies, thereby contributing to enhanced food and nutritional security [50]. Overall, the nutritional data confirm the strong potential of underutilized foods to supply essential macro- and micronutrients, supporting their strategic inclusion in food security and nutrition programs in the Sudano–Sahelian zone of Cameroon.

4. Conclusion

This study shows that the population of the northern part of Cameroon relies predominantly on cereals, which account for approximately 80% of dietary intake, followed by vegetables (15%) and tubers (5%). A total of seventeen (17) different forms of food consumption were identified, with consumption frequencies ranging from 0 to 10 times per week. Cereals are mainly consumed in couscous and boiled forms (100%), while consumption in grain form remains limited. In contrast, only about fifteen varieties of fresh vegetables are regularly consumed. Current food preparation and preservation practices appear insufficient to meet the nutritional needs of the population. This is reflected in the overall Food Consumption Score (FCS) of 25.85 ± 4.71, which lies at the threshold of acceptability and indicates a high level of vulnerability to food insecurity. Similarly, the Dietary Diversity Score (DDS) of 2.61 ± 0.60 is well below recommended standards, suggesting poor dietary diversity and a high risk of deficiencies in essential nutrients. Despite these challenges, sixteen underutilized foods with high nutritional potential such as *chlori-ndiam*, *namangal*, *helem*, and *namnake* are locally consumed. These foods represent valuable resources that could be further promoted to improve dietary quality, strengthen resilience to food insecurity,

and enhance nutritional outcomes in northern Cameroon.

Abbreviations

INNOVACC	Innovation for Adaptation to Climate Change
FAO	Food and Agriculture Organization of the United States
NIS	National Institute of Statistics
WFP	World Food Program
FNSP	Food and Nutrition Security Plan of Action
SAOAC	Standard Association of Official Analytical Chemists
FAO	Food and Agriculture Organization
UN	United States

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Conflicts of Interest

The authors declare no conflicts of interest.

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