

1 NUTRITIONAL QUALITY OF FOODS SOLD IN PRIMARY EDUCATION 2 ESTABLISHMENTS IN THE DEPARTMENT OF TIASSALE, CÔTE D'IVOIRE.

3

4 **Summary :**

5 Access to food of good nutritional quality is essential for students' well-being and academic
6 performance. Consequently, assessing the nutritional quality of food sold in schools is
7 necessary. This cross-sectional study was conducted to evaluate the nutritional potential of
8 foods sold to and consumed by students in primary schools in the Tiassalé department, located
9 in the southern region of Côte d'Ivoire. The food consumption survey was conducted from
10 October to November 2024 and allowed the collection of Twenty-seven (27) food samples
11 from four (4) primary schools in the Tiassalé department. Physicochemical analysis was
12 performed to determine the macronutrient composition and energy content of the food.
13 ANOVA and Tukey's HSD tests were used to analyze and compare means. The survey
14 revealed a variety of foods, including prepared meals, breads, fritters, juices, and snacks. The
15 physicochemical analysis covered twenty-seven (27) samples of prepared meals, bread, and
16 fritters. The results showed a high fat and energy content, with average values ranging from
17 9.85 ± 3.41 g/100 g DM and 30.30 ± 7.74 g/100 g DM to 174.05 ± 26.80 kcal/100 g DM and
18 512.90 ± 52.77 kcal/100 g DM, respectively. In contrast, protein content was low (0.83 ± 0.04
19 g/100 g DM to $15.6^{19} \pm 0.03$ g/100 g DM). Some foods had a high fiber content
20 (15.62 ± 5.05 g/100g DM and 21.12 ± 3.40 g/100g DM) and carbohydrate content
21 (24.65 ± 0.89 g/100g DM and 54.18 ± 5.63 g/100g DM).

22 Students consume a variety of foods that differ from one school to another. These foods are
23 high in energy and more concentrated in fat than in protein and fiber. Excessive and
24 prolonged consumption of some of these foods can lead to nutritional disorders in children.

25 **Keywords: Food, nutritional quality, macronutrients, students, Tiassalé.**

26

27 **Introduction**

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28 Consuming high-quality, nutrient-dense foods is essential for a healthy life and disease
29 prevention (Catherine et al., 2025). School-aged children require adequate nutrition in both
30 quantity and quality to maintain health and achieve optimal academic results(Rufina et al.,
31 2018). In recent decades, dietary patterns worldwide, characterized by food habits and
32 choices, have shifted towards more processed, high-energy, and less varied diets (Leite et al.,
33 2022).

34 High-energy diets are typically rich in sugar, saturated fats, and sodium. A suboptimal or
35 nutritionally inadequate diet is a major driver of health, growth, and developmental issues in
36 children (Laurencia et al., 2016 ; Leech et al., 2014).

37 Children spend most of their time at school and consume food estimated to provide nearly a
38 third of their daily energy intake (Tugault-Lafleur and Black 2020 ; Tugault-Lafleur et al.
39 2017). In Côte d'Ivoire, studies have been conducted on the nutritional status of primary
40 school students and their academic performance (Touré et al., 2023 ; Zahe et al., 2017), but
41 very little data exists on the nutritional quality of food sold in schools. This food constitutes a
42 significant part of the school food system in Côte d'Ivoire. It is within this context that this
43 study was conducted to assess the nutritional potential of food sold and consumed by students
44 in primary schools in the Tiassalé department.

45 **Material and methods**

46 This cross-sectional food consumption study was conducted from October to November 2024
47 in four (4) primary schools in the Tiassalé department.

48 The Tiassalé department is located in southern Côte d'Ivoire, 120 km from Abidjan. It is
49 divided into four (4) sub-prefectures: N'douci, Morokro, Tiassalé, and Gbolouville. The sites
50 were selected from two (2) sub-prefectures (Tiassalé and N'douci) that had a high number of
51 schools and students, according to the 2023-2024 data from the Preschool and Primary
52 Education Inspectorates (IEPP) of Tiassalé and N'douci.

53 The survey sites in the two sub-prefectures were selected based on inclusion and exclusion
54 criteria. All schools that simultaneously have a food production and sales area at the entrance
55 and/or inside the school were included in the study. A total of four (4) schools per sub-
56 prefecture were selected, two public and two private.

57 **Survey on food consumption in schools**

58 The survey was conducted at the Plateau School Group in N'douci, the Methodist School in
59 N'douci (urban area), the N'zianouan School Group, and the AT-TABIAT School in
60 N'zianouan (rural area). It consisted of observing and interviewing vendors and school
61 principals about the various food items sold in the primary schools. Using a document, the
62 listed food items were recorded, and twenty-seven (27) of them were collected as samples for
63 physicochemical analysis.

64 **Determination of the physicochemical composition of food**

65 The method used for determining moisture and ash content is that described by **AOAC**
66 **(1990)**.

67 The crude protein content of the samples was determined according to the Kjeldhal **AOAC**
68 method **(1990)**, from the determination of total nitrogen.

69 The lipid content of the samples was determined according to the method described by
70 **AFNOR (1996)**, using the Soxhlet as the extractor.

71 The fiber content of the food samples was determined by the **Wolf** method **(1968)**.

72 The total carbohydrate content was determined by difference according to the calculation
73 method recommended by the **FAO (2002)**.

74 The theoretical energy value of the samples was calculated from the specific coefficients for
75 proteins, lipids and total carbohydrates **(FAO,2002)**.

76 **Principal Component Analysis (PCA)**

77 Principal component analysis (PCA) is an exploratory statistical method used in the statistical
78 analysis of physicochemical data. It was described by **Gilbert and Ndèye(2003)**.

79

80 **Statistical analysis**

81 For statistical analysis, the data were entered into an Excel file and analyzed with the R
82 software (version 4.5.1).

83 The statistical tests used in the data processing were ANOVA followed by Tukey's HSD
84 multiple comparison test at the 0.05 threshold. This latter test made it possible to compare the
85 variance of the means of the different physico-chemical parameters when the analysis of
86 variance revealed significant differences (marked by the asterisk symbol).

87 Principal Component Analysis (PCA) was performed with the physico-chemical parameter
88 data and the results are presented in table and figure form.

89 **Results**

90 **Survey on food consumption in schools**

91 The food consumption survey conducted in schools in the two sub-prefectures revealed a
92 variety of foods that differed from one school to another. These foods included prepared
93 dishes, baked breads, juices, fritters, and sweets. Prepared dishes consisted of attieké (cassava
94 semolina) with fish, beef liver and stomach or chicken meat, rice with fat, attoupkou (steamed
95 cassava cake) with sauce, baked bread with condiments, and fritters. A local dish called
96 "NOUGOU," made with broken rice and moringa (*Moringa oleifera*) leaves, was also found
97 in two schools. Juices included hibiscus, tomi, baobab, and mint-flavored milk, as well as
98 imported juices in sachets or plastic containers. Snacks included candies, cookies, and chips.

99 **Determination of the physicochemical composition of food**

100 **Table I** presents the physico-chemical composition of food consumed by students in schools.

101 Foods such as seasoned rice and broken rice combined with moringa leaves had the highest
102 moisture content, at 65.00 ± 1.36 g/100 g dry matter (DM) and 59.20 ± 6.20 g/100 g DM,
103 respectively. Following these were attieke served with chicken, fish, or cooked beef liver,
104 with moisture content levels of 53.20 ± 0.85 g/100 g DM, 52.82 ± 3.02 g/100 g DM, and
105 51.76 ± 3.71 g/100 g DM, respectively. Fried bread was the least moist food, with a moisture
106 content of 7.90 ± 3.12 g/100 g DM. The observed difference in moisture content between the
107 foods was significant ($P < 0.05$). Regarding fat content, all foods had a high content except for
108 the attoupkou and sauce dish and the rice with seasoning, with respective average values of
109 4.30 ± 0.14 g/100 g DM and 9.85 ± 3.42 g/100 g DM. Fried bread had a high fat content, with
110 an average of 30.30 ± 7.74 g/100 g DM. The observed difference in fat content between the
111 foods was significant ($P < 0.05$). Dietary fiber was most abundant in fried bread, attoupkou
112 and chicken, and the other foods, with respective averages of 21.12 ± 3.40 g/100 g DM and
113 19.50 ± 0.70 g/100 g DM. Attoupkou and sauce was the food with the lowest fiber content
114 (2.25 ± 0.35 g/100 g DM). The results of the analysis show a statistically significant
115 difference ($P < 0.05$). Foods such as bakery bread and cooked beef liver or egg had the highest
116 protein content, at 15.70 ± 0.03 g/100 g DM and 15.65 ± 0.03 g/100 g DM, respectively. The
117 observed difference was significant ($P < 0.05$). The results showed that some foods were rich

118 in carbohydrates, with average values ranging from 41.57 ± 0.89 g/100 g DM to 54.18 ± 5.63
119 g/100 g DM. The energy value of the foods was high, ranging from 174.05 ± 26.80 kcal/100 g
120 DM to 512.90 ± 52.77 kcal/100 g DM. The observed difference between carbohydrate values
121 was significant ($P < 0.05$). The same was true for energy values.

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Food	Moisture (g/100g MF)	Lipid (g/100g DM)	Fiber (g/100g DM)	Ash (g/100g DM)	Protein (g/100g DM)	Total carbohydrate	Energy values (kcal/100g DM)
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Table I : Physicochemical composition of different foods

	(g/100g DM)						
Atoukpou_sauce	50,90±0,42 ^{bcd}	4,30±0,14 ^c	2,25±0,35 ^b	2,40±0,28 ^{ab}	0,83±0,04 ^e	41,57±0,89 ^{ab}	208,30±2,12 ^d
Attieke_liver	51,76±3,71 ^{bc}	14,36±3,1 ^{bc}	9,50±3,52 ^{ab}	2,13±0,37 ^b	3,71±1,34 ^{de}	28,02±1,70 ^c	256,23±27,48 ^{cd}
Attieke_fish	52,82±3,02 ^{bc}	14,32±2,82 ^{bc}	16,62±9,07 ^{ab}	3,60±0,91 ^a	6,80±1,19 ^c	22,45±4,33 ^{cde}	245,93±21,86 ^{cd}
Attieke_chicken	53,20±0,85 ^{abc}	12,00±0,57 ^{bc}	19,50±0,70 ^{ab}	2,90±0,14 ^{ab}	4,95±0,04 ^{cde}	26,96±0,46 ^{cd}	235,60±6,79 ^{cd}
Attieke_beef tripe	50,60±0,00 ^{bcd}	15,10±0,99 ^{bc}	18,00±0,00 ^{ab}	2,90±0,14 ^{ab}	6,75±0,04 ^{cd}	24,65±0,89 ^{cde}	261,50±5,52 ^{cd}
Fritters	15,23±11,05 ^e	20,90±8,58 ^{ab}	14,67±3,64 ^{ab}	1,43±0,73 ^b	8,25±2,03 ^c	54,18±5,63 ^a	437,83±89,08 ^{ab}
Avocado_bread	47,20±3,11 ^{bcd}	17,70±0,42 ^{abc}	4,5±0,70 ^b	3,20±0,00 ^{ab}	9,84±0,01 ^{bc}	22,07±3,53 ^{cde}	286,90±10,32 ^{cd}
Liver_bread	35,10±0,14 ^d	16,60±1,13 ^{bc}	14,50±2,12 ^{ab}	2,50±0,42 ^{ab}	15,70±0,04 ^a	30,11 ±1,73 ^{bc}	332,60±3,39 ^{bc}
Fried_bread	7,90±3,12 ^e	30,30±7,74 ^a	21,12±3,40 ^a	1,75±0,41 ^b	8,24±1,12 ^c	51,81±3,11 ^a	512,90±52,77 ^a
Egg_bread	44,50±0,14 ^{cd}	12,80±0,00 ^{bc}	6,75±0,35 ^{ab}	2,60±0,28 ^{ab}	15,65±0,04 ^a	24,46±0,46 ^{cde}	275,60±1,70 ^{cd}
Fish_ver_bread	40,73±1,09 ^{cd}	17,57±3,88 ^{bc}	10,33±5,22 ^{ab}	2,83±0,15 ^{ab}	11,48±0,98 ^{ab}	27,39±5,04 ^c	313,57±17,36 ^c
Fat_rice_seas	65,00±1,36 ^a	9.85±3,42 ^c	4,87±4,77 ^b	3,80±1,17 ^a	8,80±0,30 ^{bc}	12,54±1,37 ^{de}	174,05±26,80 ^d
Moringa_rice	59,20±6,20 ^{ab}	13,30±2,61 ^{bc}	15,62±5,05 ^{ab}	2,00±0,56 ^b	8,70±2,66 ^{bc}	16,79±6,81 ^e	221,70±29,49 ^d
Pr(>F)	2e-16 ***	2.4e-06 ***	0.000223 ***	4.35e-06 ***	2.44e-13 ***	1.6e-06 ***	0.000567 ***

Ver: vermicelli; seas : seasoning; MS: Dry Matter; MF: Fresh Matter

The data are expressed as mean ± standard error (M±SEM).

a, b, c, d, e: Values assigned different letters in the same column are significantly different (P<0.05).

Principal Component Analysis

Principal Component Analysis (PCA) was performed to classify and process information on the physicochemical parameters of the food by examining the correlations between variables. It revealed five (5) principal components, whose eigenvalues for the axes or dimensions (Dim 1, Dim 2, Dim 3, Dim 4, and Dim 5) are shown in (Table II) and (Figure 1). The two dimensions, Dim 1 and Dim 2, describe the correlations between the variables related to the physicochemical parameters, representing 74.13% of the total information, with respective values of 56.76% and 17.37%. The correlation circle resulting from the PCA allowed for the examination of the relationships between the variables in the factorial space defined by the first two principal components (Dim 1 and Dim 2) (Figure 2). This circle shows a positive correlation between lipids and energy value, between fiber and lipids, and between energy value and total carbohydrates. There is a negative correlation between protein and total carbohydrates, between protein and energy value, and between moisture and other physicochemical components. These variables are well represented in Dim1 and Dim2 and indicate a strong contribution to the explained variance (74.13%).

The factorial design, represented by the two dominant dimensions of total variance (Dim 1 and Dim 2) with respective values of 56.76% and 17.37%, showed the distribution of food consumption by study area. Foods such as attoukpou and sauce, bread and avocado, attieké and cooked beef tripe, bread and cooked beef liver, fried bread, and attieké and fried chicken are consumed specifically in schools in both rural and urban areas. However, foods such as fritter, bread and egg, bread and vermicelli, rice with moringa leaves, attieké and fish, and attieké and cooked beef liver are consumed in schools in both rural and urban areas and are highly represented (Figure 3).

Table II:Principal Component Analysis of the Physicochemical Parameters of Food

Main components	1	2	3	4	5
Equity	3.97	1.22	0.89	0.57	0.36
Variance (%)	56.76	17.37	12.63	8.13	5.11
Cumulative variance (%)	56.76	74.13	86.76	94.89	100

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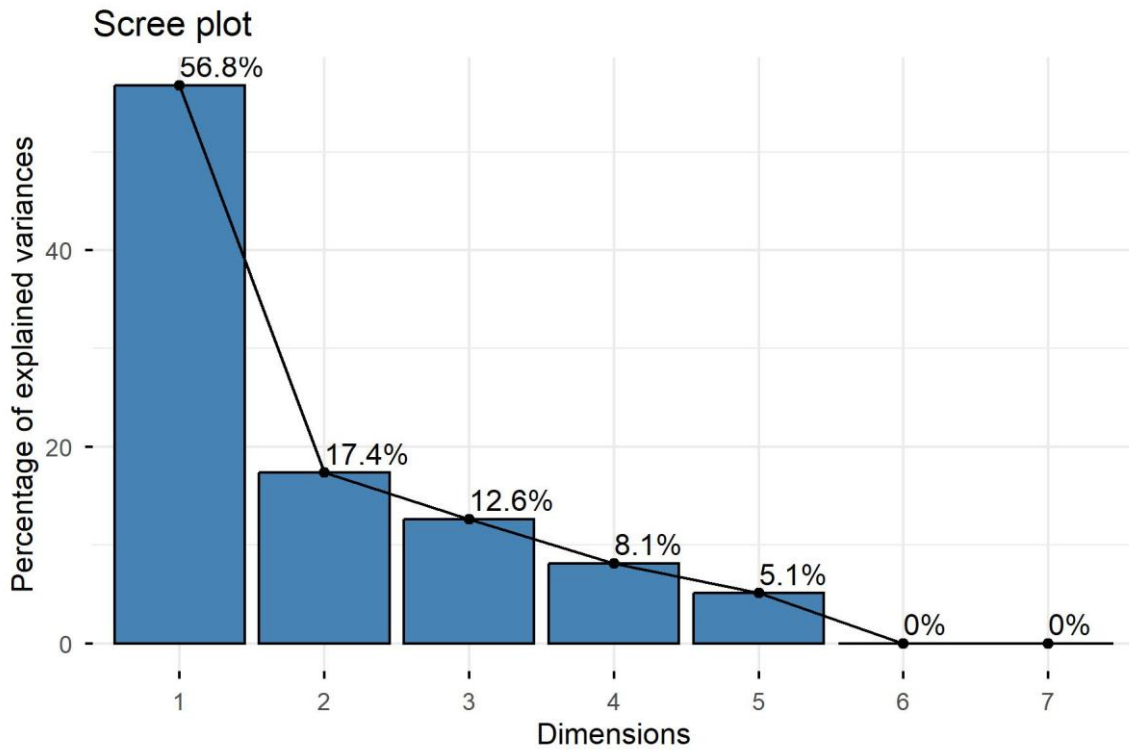


Figure 1: Distribution of inertia between dim1 and dim2

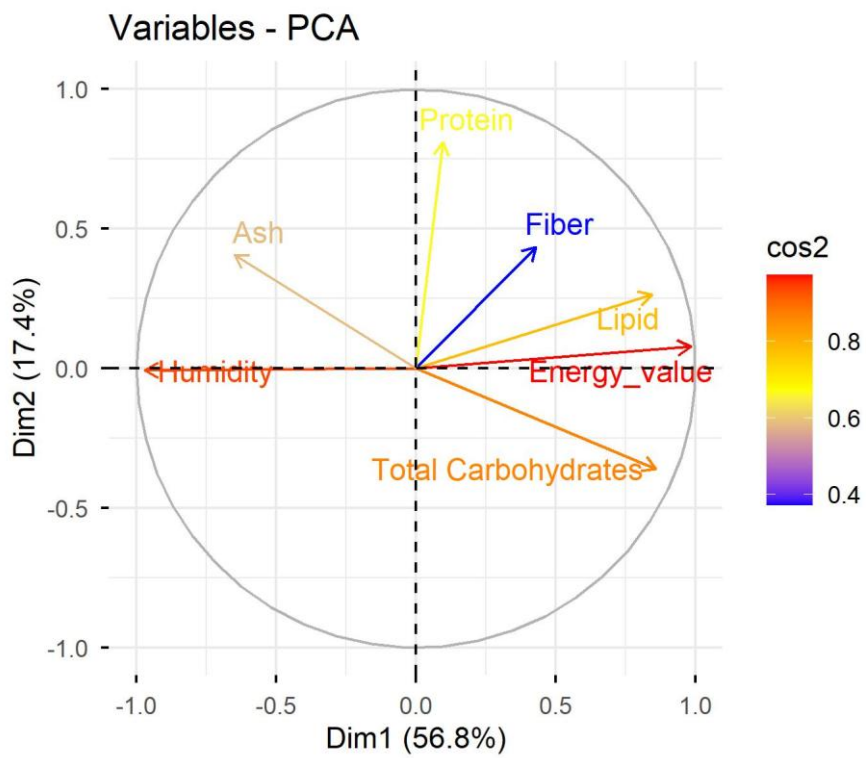


Figure 2: Correlation circle of physicochemical parameters

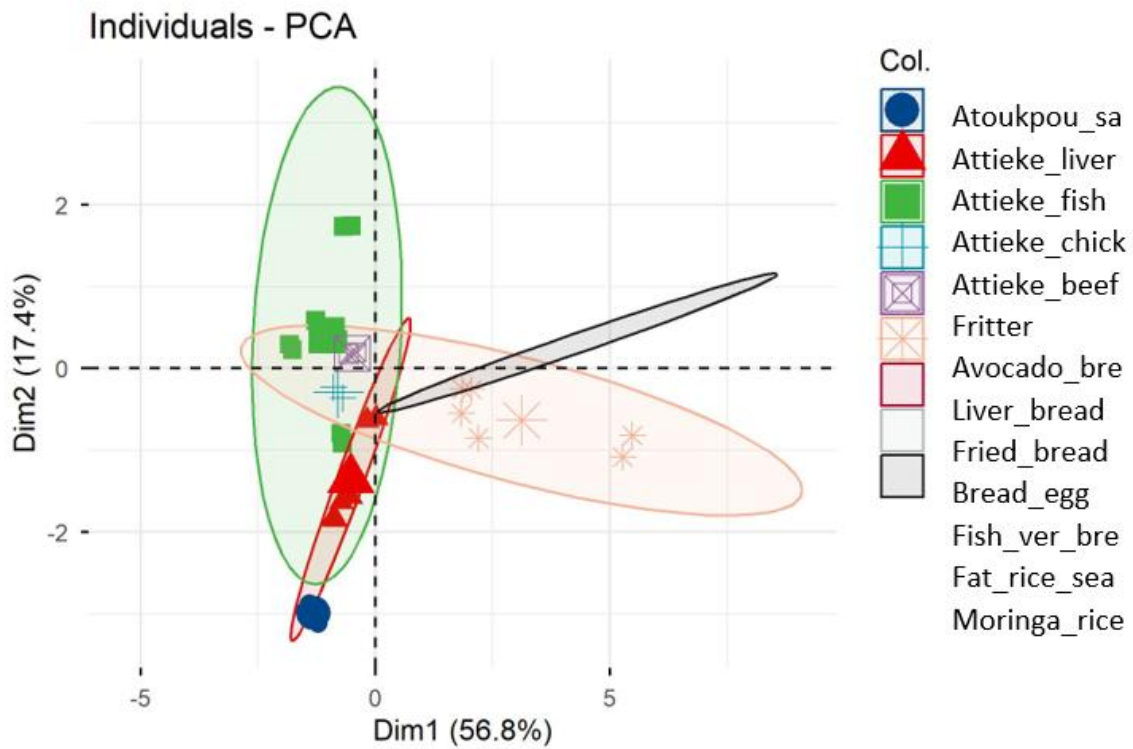


Figure 3:Factorial design of the foods studied

Attoukpou_sa : Attoukpou_sauce ; Attieke_chick : Attieke_chicken ; Avocado_bre : Avocado_bread ; Fish_ver_bre : Fish_vermicelli_bread ; Fat_rice_sea : Fat_rice_seasoning.

Discussion

This study examined the food sold to students in primary schools. This food was diverse and varied, including prepared meals, bread, fritters, juices, and sweets. Prepared meals, bread, fritters, and juices were the most frequently consumed foods by students in these schools. Similar observations were made in schools in Yaoundé 1st, Cameroon, and N'Djamena, Chad, where the categories of food sold included prepared meals, pastries, fritters, vegetables, snacks, drinks, and ice cream. Prepared meals accounted for 43% and pastries for 24% in Yaoundé, while cereal products represented 60% in N'Djamena (**Annie-Claude et al., 2017; Naibe, 2019**).

The physicochemical analysis of commonly consumed foods, such as prepared dishes, baked breads, and fritters, revealed their macronutrient and energy composition. The lipid content of the studied foods was high, with average values ranging from 12.00 ± 0.57 to 30.30 ± 7.74 g/100 g DM, except for attoupkou with sauce and rice with seasoning, which had average values of 4.30 ± 0.14 and 9.85 ± 3.42 g/100 g DM, respectively. This high lipid content is primarily due to the significant use of refined palm oil or other oils in preparation. Attoupkou (steamed cassava cake) had a low lipid content, which came from the sauce. Research conducted by Lecerf has shown that palm oil contains 50% saturated fatty acids, generally in positions 1 and 3, and is rich in carotenoids and vitamin E. Copra oil (coconut oil) contains 94% saturated fatty acids, and cocoa butter 60%. Saturated fatty acids increase both HDL and LDL cholesterol, the latter being considered hypercholesterolemic. High LDL cholesterol levels are associated with an increased risk of cardiovascular disease (**Lecerf, 2013**).

The fiber content was high in some of the foods studied, ranging from 15.62 ± 5.05 to 21.12 ± 3.40 g/100 g DM. Fried bread had the highest content (21.12 ± 3.40 g/100 g DM). Studies conducted in Addis Ababa, Ethiopia, on school meals provided by programs showed an adequate daily fiber intake. Fiber-rich foods came from cereal-based meals such as white bread. However, these studies reported that the fat content of the meals was less than one-third of the recommended daily intake (**Zelalem et al., 2018**). Indeed, dietary fiber absorbs water and solidifies waste for healthy bowel movements and helps prevent certain nutritional disorders (**Chhabra, 2018**). Regarding protein content, the foods studied had low levels, except for bakery bread and cooked beef liver or egg, which had high levels of 15.70 ± 0.03 g/100 g DM and 15.65 ± 0.03 g/100 g DM, respectively. Indeed, the foods studied mostly contained fish, meat, eggs, and leafy green vegetables. However, this low protein content could be explained by the small portions used in food preparation. Furthermore, the foods

contained less plant-based protein. The protein values of the foods studied are lower than the recommended daily intake of protein for children and adolescents (**FAO/WHO/UNU, 1973**). These foods do not meet the protein requirements of students.

The total carbohydrate content of the foods ranged from 12.54 ± 1.37 g/100 g DM to 54.18 ± 5.63 g/100 g DM. More than half of the foods had a low total carbohydrate content according to WHO recommendations. The WHO guidelines on carbohydrate intake for adults and children indicate that total carbohydrate intake from foods represents approximately 40% to 70% of total energy intake and is considered compatible with a healthy diet (**WHO, 2023**). Furthermore, the study by **Seidelmann et al. (2018)** on dietary carbohydrate intake and mortality in an adult population showed that diets high (> 70%) or low (< 40%) in carbohydrates were associated with increased mortality. Carbohydrates provide energy to the body's cells, especially the brain, which is a glucose-dependent organ (**Rufina et al., 2018**).

The energy content of these foods was high, ranging from 174.05 ± 26.80 to 512.90 ± 52.77 kcal/100g DM. This intake could meet the energy requirements of children as indicated in the recommendations of **FAO/WHO/UNU (2001)**.

Principal Component Analysis (PCA), performed to analyze and describe the correlations between the variables of the physicochemical parameters of the foods, showed that 74.13% of the information was represented by the two dimensions (Dimension 1 and Dimension 2). The variances show that axis 1, represented by Dimension 1, is the most important, as it describes more than half of the information (56%). The positive correlation between the physicochemical parameters indicates a trend in the same direction. Conversely, the negative correlation between the parameters indicates a trend in opposite directions. The factorial plane defined by the two axes (Dimension 1 and Dimension 2) shows the distribution of foods by consumption area (urban or rural schools). Thus, some foods are consumed in rural or urban schools, and others are consumed in both study areas.

Conclusion

This study identified the foods sold in primary schools. These foods are diverse and varied in nature. Physicochemical analysis revealed a high energy content due to their high lipid content, but low protein and fiber content. Consuming these foods is important for providing energy and helping schoolchildren stay focused during class. However, their high lipid content and low protein content make these foods less nutritious, and excessive or prolonged consumption of some of them can lead to nutritional deficiencies in children.

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