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

Summary :

Access to food of good nutritional quality is essential for students' well-being and academic performance. Consequently, assessing the nutritional quality of food sold in schools is necessary. This cross-sectional study was conducted to evaluate the nutritional potential of foods sold to and consumed by students in primary schools in the Tiassalé department, located in the southern region of Côte d'Ivoire. The food consumption survey was conducted from October to November 2024 and allowed the collection of Twenty-seven (27) food samples from four (4) primary schools in the Tiassalé department. Physicochemical analysis was performed to determine the macronutrient composition and energy content of the food. ANOVA and Tukey's HSD tests were used to analyze and compare means. The survey revealed a variety of foods, including prepared meals, breads, fritters, juices, and snacks. The physicochemical analysis covered twenty-seven (27) samples of prepared meals, bread, and fritters. The results showed a high fat and energy content, with average values ranging from 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 512.90 ± 52.77 kcal/100 g DM, respectively. In contrast, protein content was low (0.83 ± 0.04 g/100 g DM to 15.619 ± 0.03 g/100 g DM). Some foods had a high fiber content (15.62±5.05g/100g DM and 21.12±3.40g/100g DM) and carbohydrate content (24.65±0.89g/100g DM and 54.18±5.63g/100g DM).

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

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

Introduction

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

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

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

Material and methods

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

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

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

per sub-prefecture were selected, two public and two private.

Survey on food consumption in schools

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

Determination of the physicochemical composition of food

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

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

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

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

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

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

Principal Component Analysis (PCA)

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

Statistical analysis

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

The statistical tests used in the data processing were ANOVA followed by Tukey's HSD

multiple comparison test at the 0.05 threshold. This latter test made it possible to compare the variance of the means of the different physico-chemical parameters when the analysis of variance revealed significant differences (marked by the asterisk symbol).

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

Results

Survey on food consumption in schools

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

Determination of the physicochemical composition of food

Table Ipresents the physico-chemical composition of food consumed by students in schools.

Foods such as seasoned rice and broken rice combined with moringa leaves had the highest moisture content, at 65.00 ± 1.36 g/100 g dry matter (DM) and 59.20 ± 6.20 g/100 g DM, respectively. Following these were attieke served with chicken, fish, or cooked beef liver, with moisture content levels of 53.20 ± 0.85 g/100 g DM, 52.82 ± 3.02 g/100 g DM, and 51.76 ± 3.71 g/100 g DM, respectively. Fried bread was the least moist food, with a moisture content of 7.90 ± 3.12 g/100 g DM. The observed difference in moisture content between the foods was significant ($P<0.05$). Regarding fat content, all foods had a high content except for the attoupkou and sauce dish and the rice with seasoning, with respective average values of 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 an average of 30.30 ± 7.74 g/100 g DM. The observed difference in fat content between the foods was significant (P < 0.05). Dietary fiber was most abundant in fried bread, attoupkou and chicken, and the other foods, with respective averages of 21.12 ± 3.40 g/100 g DM and 19.50 ± 0.70 g/100 g DM. Attoupkou and sauce was the food with the lowest fiber content (2.25 ± 0.35 g/100 g DM). The results of the analysis show a statistically significant difference (P<0.05). Foods such as bakery bread and cooked beef liver or egg had the highest protein content, at 15.70 ± 0.03 g/100 g DM and 15.65 ± 0.03 g/100 g DM, respectively. The observed difference was significant (P<0.05). The results showed that some foods were rich in carbohydrates, with average values ranging from 41.57 ± 0.89 g/100 g DM to 54.18 ± 5.63 g/100 g DM. The energy value of the foods was high, ranging from 174.05 ± 26.80 kcal/100 g DM to 512.90 ± 52.77 kcal/100 g DM. The observed difference between carbohydrate values was significant (P<0.05). The same was true for energy values.

Table I : Physicochemical composition of different foods

Food

Moisture (g/100g MF)

Lipid (g/100g DM)

Fiber (g/100g DM)

Ash (g/100g DM)

Protein (g/100g DM)

Total carbohydrate (g/100g DM)

Energy values (kcal/100g DM)

Atoukpou_sauce

50,90±0,42bcd

4,30±0,14c

2,25±0,35b

2,40±0.28ab

0,83±0,04e

41,57±0,89ab

208,30±2,12d

Attieke_liver

51,76±3,71bc

14,36±3,1bc

9,50±3,52ab

2,13±0,37b

3,71±1,34de

28,02±1,70c

256,23±27,48cd

Attieke_fish

52,82±3,02bc

14,32±2,82bc

16,62±9,07ab

3,60±0,91a

6,80±1,19c

22,45±4,33cde

245,93±21,86cd

Attieke_chicken

53,20±0,85abc

12,00±0,57bc

19,50±0,70ab

2,90±0.14ab

4,95±0,04cde

26,96±0,46cd

235,60±6,79cd

Attieke_beef tripe

50,60±0,00bcd

15,10±0,99bc

18,00±0,00ab

2,90±0,14ab

6,75±0,04cd

24,65±0,89cde

261,50±5,52cd

Fritters

15,23±11,05e

20,90±8,58ab

14,67±3,64ab

1,43±0.73b

8,25±2,03c

54,18±5,63a

437,83±89,08ab

Avocado_bread

47,20±3,11bcd

17,70±0,42abc

4,5±0,70b

3,20±0,00ab

9,84±0,01bc

22,07±3,53cde

286,90±10,32cd

Liver_bread

35,10±0,14d

16,60±1,13bc

14,50±2,12ab

2,50±0,42ab

15,70±0,04a

30,11 ±1,73bc

332,60±3,39bc

Fried_bread

7,90±3,12e

30,30±7,74a

21,12±3,40a

1,75±0,41b

8,24±1,12c

51,81±3,11a

512,90±52,77a

Egg_bread

44,50±0,14cd

12,80±0,00bc

6,75±0,35ab

2,60±0,28ab

15,65±0,04a

24,46±0,46cde

275,60±1,70cd

Fish_ver_bread

40,73±1,09cd

17,57±3,88bc

10,33±5,22ab

2,83±0,15ab

11,48±0,98ab

27,39±5,04c

313,57±17,36c

Fat_rice_seas

65,00±1,36a

9.85±3,42c

4,87±4,77b

3,80±1,17a

8,80±0,30bc

12,54±1,37de

174,05±26,80d

Moringa_rice

59,20±6,20ab

13,30±2,61bc

15,62±5,05ab

2,00±0,56b

8,70±2,66bc

16,79±6,81e

221,70±29,49d

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

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 2 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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