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Nutritional Potentialities of Main Traditional Dishes Regularly Consumed in Côte d'Ivoire

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Abstract The aim of this work was to determine the nutritional potentialities of the main traditional dishes of Côte d'Ivoire, starting from experiments *in vivo* carried out with rats. The selected starchy food dishes were dried and crushed and the sauces were freeze-dried. The biochemical parameters were determined by the AOAC and BIPEA methods. Different coefficients of nutritional efficiency of these dishes and the biometrics of the organs after their consumption have been determined. Results revealed that all the typical Ivorian dishes studied lead to a normal weight gain, ranging between 2.28 and 3.03 g per day. The coefficients of food efficiency, protein efficiency and digestive use are satisfactory with values respectively between 0.31 and 0.41, 0.36 and 0.51, 0.94 and 0.96. All the dishes studied did not train any abnormal changes in the weight of the kidneys, heart, and liver, for normal consumption and over the study period. In conclusion, the typical Ivorian traditional foods are rich in nutrients. Their nutritional coefficients efficiency were satisfactory. The consumption of these dishes is without any direct pathological risk for the noble organs in particular the kidney, the heart and the liver.

Keywords: *nutritional potential, traditional Ivorian dishes, nutritional efficiency, biometrics of organs*

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1. Introduction

Eating habits remain for each people, one of the characteristic elements with which one can sometimes identify it [1]. Today, even if the various African peoples, like others in the world, still remain attached to some of their eating habits and behaviors [2], the rapid urbanization of populations increasingly suggests a trend towards cohabitation between traditional and Western food [3,4] which is characterized by the consumption of increasingly refined foods, often too sweet, too salty and/or too fatty [3,5]. However, this type of Western diet, which is at the root of the continued high prevalence of certain non-communicable diseases (diabetes, high blood pressure, cancers, etc.) in developed countries, is now one of the causes of the expansion of these civilizational diseases in developing countries [6]. In Côte d'Ivoire, this mixed diet is also observed regardless of the social level of the population. The main role of a good diet is to provide, in quantity and quality, the nutrients that are useful for the harmonious functioning of the organism, while avoiding diseases by excess and by default [7]. Our Ivorian type of food, without being combined with Western food, can it play this role fully? The objective of this work was to determine some biochemical and nutritional characteristics of the main Ivorian typical dishes most commonly consumed. For this purpose, after determining the biochemical composition of these dishes, the nutritional efficiency and biometry of rat organs after consumption of these dishes were studied by starting from in vivo experiments carried out with rats.

2. Materials and methods

2.1. Biological Material

The plant material of the study consists of plantain banana (*AAB musa*), cassava (*Manihot esculenta Crantz*), rice (*Oriza satva L.*) and yam (*Dioscorea alata*) for preparation of starchy dishes namely banana *foufou* (mashed cooked banana plantain pulp), *attiéké* (cooked semolina of cassava) with red palm oil, white rice, yam *foutou* (mashed cooked tuber of yam). On the other hand, for the preparation of sauces such as *namoukou* (based on the powder of dried leaves of the cheesemonger), *baouin* (based on fresh leaves of cassava) and clear (based on tomato and eggplant), the ingredients used were: eggplant (*Solanum gilo*), pepper (*Capsicum fruescens*), onion (*Allium sativum*), tomato (*Solanum lycopersium*), palm nuts (*Elaesis gueneesis*), cheese monger leaves, cassava leaves and spices. The animal material was composed of 40 young rats of wistar stock.

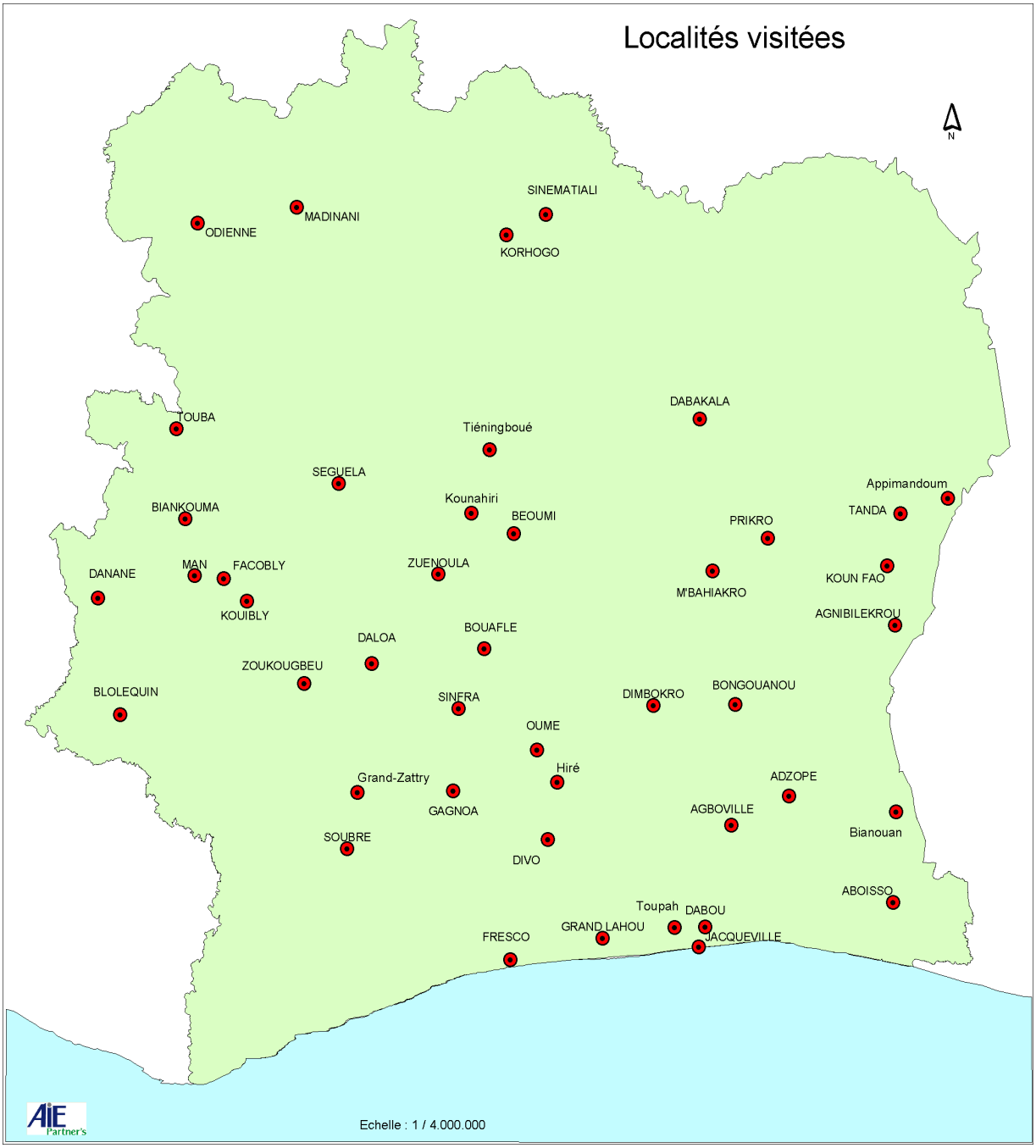

Figure 1. Localities visited during the survey

2.2. Methods

2.2.1. Selection of traditional Ivorian dishes

Based on a family food consumption survey that took place over a one-month period (from 21 April to 30 May 2015) in localities in Côte d'Ivoire (Figure 1), the main traditional Ivorian typical dishes were selected on the basis of their frequency of consumption. The survey cards were filled in by the head of the household and an adult housewife or any adult who regularly practices household cooking.

2.2.2. Constitution of Experimental Dishes

Four (4) of the most consumed traditional Ivorian dishes and a control dish cooked according to Garcin *et al* [8] with modifications**,** were proposed to rats. These are *attiéké* with red oil and *clear* sauce (ATR/CS), cooked white rice and baouin sauce (RI/BAS), yam *foutou* accompanied by *namoukou* sauce (YF/NAS), banana *foufou* accompanied by *clear* sauce (BFF/CS) and the control food. Starch-based foods were dried in an oven (at 45°C for 72 h) while the sauces were freeze-dried. The dishes were reconstituted in the proportions 70/30, ie 70 g of starch-based food and 30 g of the accompanying food.

2.2.3. Determination of Dishes Biochemical Composition

The ash content was determined according to AOAC [9] method. The fat content was determined by BIPEA [10] method using the Soxhlet. For determination of protein content, [10] method of Kjeldahl was used. The total

carbohydrates were determined by difference according to the following formula:

$$\%\ \text{Total carbohydrate} = 100\% - \%\ \text{Fat} - \%\ \text{Protein} - \%\ \text{Ash} - \%\ \text{Moisture}. \quad (1)$$

The energy value was determined by calculation according to the specific coefficients for proteins, fats and total carbohydrates [11].

2.2.4. Constitution of Experimental Rat Batches

This experimental study was conducted using 40 young growing rats from the Wistar strain, divided into five lots, at a rate of eight (8) rats per dish. The Adrian model [12] was used to conduct this study which lasted 22 days including 2 days of adaptation of the rats and 20 days for the growth phase. The nitrogen balance was carried out over the last five days of the growth phase.

2.2.5. Progress of the Experiment

The rats were housed in individual metabolism cages with wire mesh bottoms that retained feces and food scraps. At the time of distribution, the various dishes were reconstituted into a paste, using 1 L of water (at 100 C) for 1 kg of food. The dry matter of the reconstituted products was measured daily on samples taken. The next day, before distributing the assigned food, the refusals (leftover and waste of the food brought the day before) were collected and their dry matter was determined. An average amount of 40 g of food was distributed *ad libitum* (at will) to each rat in the same batch in the morning from 7 am to 8 am for 20 days. Water was also served at will in a drinking trough and renewed every two days. Rats were weighed at the beginning of the experiment and throughout the experiment at two days intervals. The feces and urine of each animal were collected daily and individually during the last five days. Urines were collected in tubes containing bacteriostatic agents and dried feces. The total nitrogen level was then determined in both feces and urine.

2.2.6. Nutritional Efficiency of Dishes

The nutritional efficiency of the dishes was evaluated using total ingested dry matter (TDMI), the weight gain (WG) of the rats and the coefficients feed efficiency (CFE), protein efficiency (CPE) and apparent digestive use (CDUa) coefficients determined according to the following formulas :

$$\text{TDMI} = \text{Total dry matter intake (of the food) ingested during the experimental period} \quad (2)$$

$$\text{WG}(\text{g per day}) = \frac{(\text{Final Weight} - \text{Initial Weight})}{\text{Number of days}} \quad (3)$$

$$\text{CFE} = \frac{\text{Weight gain}(\text{g per day})}{\text{Total dry matter ingested}(\text{g per day})} \quad (4)$$

$$\text{CPE} = \frac{\text{Weight gain}(\text{g per day})}{\text{Total protein ingested}(\text{g per day})} \quad (5)$$

$$\text{CDUa} = \frac{100[\text{Ingested Food}(\text{g}) - \text{Amount of Feces}(\text{g})]}{\text{Ingested Food}(\text{g})}. \quad (6)$$

2.2.7. Biometrics of the Organs Sampled

At the end of the experimental period, the rats were anesthetized and then sacrificed for kidneys, heart and liver sampling. These organs were dehumidified on filter paper and weighed, then their relative weights (RW) were determined according to the following formula:

$$\text{RW} = 100\text{X}\frac{\text{Weight of the organ}(\text{g})}{\text{Final live weight of the animal}(\text{g})}. \quad (7)$$

2.2.8. Statistical Analysis

The results of the study were analyzed by SPSS 20 and Excel software. The statistical analysis of the data was done using IBM SPSS STATISTICS software version 19.0. The comparison of averages was made using the Duncan Test with a significance level of 5%.

3. Results and Discussion

3.1. Biochemical Composition of Experimental Dishes

In this study, two complementary conventional approaches, the analysis of chemical composition and biological tests in growing rats [13], were used to assess the nutritional characteristics of traditional Ivorian dishes. The results showed that experimental dishes have variable biochemical compositions and statistically different overall. Table 1 shows the composition of the control dish. The Flours of traditional Ivorian dishes have normal levels of ash, protein and carbohydrates with values of between 5.4 % and 9.2 %, 12.62 g/100g dry matter and 14.34 g/100g dry matter and 45.65 g/100g dry matter and 69.01 g/100g dry matter. Fats contents are variable with low values in the dish YF/NAS (4.43 ± 0.03 g/100 g dry matter) and normal in BFF/CS dishes (31.10 ± 0.01 g/100g dry matter), ART/CS (28.06 ± 0.02 g/100g dry matter), RI/BAS (29. 78 ± 0.01 g/100g dry matter) (Table 2). Flours of traditional Ivorian dishes are mainly composed of carbohydrates. Their protein levels comply with official recommendations of 12 to 15% for a balanced meal [14]. These results are consistent with those of [15] who showed that a reference food should have a protein content of 15 g/100 g m.s.h. and 30 g/100 g m.s.h. in fat. In view of all these results, Ivorian typical dishes are able to provide sufficient carbohydrates, proteins and fats to provide the energy necessary for the harmonious development of the body, hence the observed weight gain.

Table 1. Composition of the control dish

Ingredients	Quantity taken for 1 kg of dry food
Fish Powder (g)	176.9
Maizena Corn starch (g)	758.1
Sugar (g)	9
Premix (g)	1
Agar agar (g)	5
Sunflower oil (mL)	50
Water (mL)	1000

Control dish based on fish meal, its protein level 12.62 % and its energy level 4279.07 kcal/kg. Premix: premix of minerals and vitamins.

Table 2. Biochemical composition of Ivorian traditional dishes flours

Dishes	ART/CS	RI/BAS	YF/NAS	BFF/CS
Ash (% dm)	5.4 ± 0.6[a]	6.4 ± 0.0[b]	9.2 ± 0.0[c]	6.2 ± 0.0[b]
Proteins (% dm)	12.62 ± 0.02[a]	14.19 ± 0.01[b]	14.34 ± 0.02[c]	13.55 ± 0.01[d]
Lipids (% dm)	28.06 ± 0.02[a]	29.78 ± 0.01[b]	4.43 ± 0.03[c]	31.10 ± 0.01[d]
T C (% dm)	48.91 ± 0.59[a]	47.64 ± 0.03[b]	69.01 ± 0.05[c]	45.65 ± 0.01[d]
Energy (Kcal/100g dm)	498.73 ± 2.79[a]	515.41 ± 0.06[b]	373.33 ± 0.15[c]	516.78 ± 0.08[d]

The values are averages of three determinations (n = 3). In each line, the assigned values of the same letters are not significantly different (p = 0.05). TC: Total Carbohydrates; dm: dry matter, ATR / CS, RI / BAS, YF / NAS and BFF / CS are the different dishes analyzed. ATR / CS: Attiéké with red oil accompanied by *claire* sauce, RI / BAS: white rice accompanied by *baouin* sauce, YF / NAS: Yam *foutou* accompanied by *namoukou* sauce, BFF / SC: Banana *foufou* accompanied by *claire* sauce.

3.2 Effectiveness of Experimental Traditional Dishes

3.2.1. Weight Gain of Rats

Table 3 shows the weight evolution of rats fed with the four Ivorian dishes and the control dish for twenty days. All of the Ivorian type of dishes resulted in a weight gain lower than the control meal (3.21 ± 0.48 g per day), with values ranging between 2.40 ± 0.19 g per day (BFF/CS) and 3.03 ± 0.32 g per day (RI/BAS). The weight gain observed can be explained by the richness of these dishes studied in carbohydrates, fats and proteins and especially by their good metabolic use. A study with a cassava and soy diet conducted by [16] gave similar results. Several other studies including that of [17] have also shown that the weight gain is due particularly to proteins and major minerals. [18] has, in the same vein, shown the value of the proteins administered by subjecting rats to protein-rich diets and others to protein-free diets.

Table 3. Weight gain of experimental rats

Dishes	Average weight at the beginning of the experiment	Average weight at the end of the experiment	Weight gain (g per day)
ART/CS	55.66 ± 1.96[a]	105.5 ± 3.2[a]	2.62 ± 0.18[ab]
RI/BAS	54.66 ± 2.58[a]	114 ± 1.67[c]	3.03 ± 0.32[ab]
YF/NAS	55.83 ± 2.85[a]	106 ± 3.74[a]	2.87 ± 0.31[ab]
BFF/CS	54.66 ± 2.56[a]	100.8 ± 2.4[d]	2.4 ± 0.19[b]
Dish control	56.83 ± 1.47[a]	117.8 ± 2.31[e]	3.21 ± 0.48[a]

The values are averages of three determinations (n = 3). In each column, the assigned values of the same letters are not significantly different (p = 0.05). ATR / CS, RI / BAS, YF / NAS and BFF / CS are the different dishes analyzed. ATR / CS: Attiéké with red oil accompanied by *claire* sauce, RI / BAS: white rice accompanied by *baouin* sauce, YF / NAS: Yam *foutou* accompanied by *namoukou* sauce, BFF / SC: Banana *foufou* accompanied by *claire* sauce.

3.2.2. Nutritional Efficiency of Experimental Traditional Foods

The CFE, CPE and CDUa of different dishes are presented in Table 4. The traditional Ivorian dishes have CFE and CDUa normal with statistically identical values to the control dishes. The values are between 0.31 (BFF/CS) and 0.41 (RI/BAS), 0.95 (RI/BAS) and 0.96 (YF/NAS) respectively for CFE and CDUa. However, these foods all had low CPE compared to the control (0.78) with values ranging from 0.36 (ATR/CS) to 0.51 (YF/NAS). According to [12], from an animal experiment, the measurement of the nutritional efficiency of a food can be made on the basis of the criteria that are the evolution of animal weights, the metabolism of studied substance (digestibility and retention by the animal), the biological value of the substance, body composition of animals, the biochemical blood profile and biometrics of the major organs that provide preliminary information on possible toxicity caused by the consumption of the test substance. The nutritional efficiency of the foods studied is satisfactory because it is characterized by normal food efficiency (CFE), protein efficiency (CPE) and digestive utilization (CDUa) coefficients. This reflects a good assimilation of nutrients contained in these dishes by the body and a good metabolism. The normal CDUa of Ivorian dishes is advantageous because low CDUa values in a diet result in a reduction in the availability of essential amino acids, required to satisfy the optimal growth needs of animals [19]. In addition, the cooking of dishes, composed of organic matter (carbohydrates, proteins and lipids) contributes to improve their digestibility [20]. This good digestibility can be explained by the positive effect of cooking on organic matter. These results are in agreement with those of [21] who showed that cooking improves food digestibility.

Table 4. Nutritional efficiency of experimental dishes

Dishes	CFE	CPE	CDUa
ATR/CS	0.33 ± 0.05[a]	0.36 ± 0.16[a]	0.95 ± 0.01[a]
RI/SBA	0.41 ± 0.05[a]	0.46 ± 0.16[ab]	0.46 ± 0.16[ab]
FI/NAS	0.36 ± 0.06[a]	0.51 ± 0.15[ab]	0.96 ± 0.0[a]
BFF/CS	0.31 ± 0.07[a]	0.37 ± 0.12[a]	0.94 ± 0.01[a]
Dish control	0.42 ± 0.07[a]	0.78 ± 0.18[b]	0.93 ± 0.01[a]

The values are averages of three determinations (n = 3). In each column, the assigned values of the same letters are not significantly different (p = 0.05). CFE: coefficient feed efficiency, CPE: coefficient protein efficiency, CDUa: coefficient digestive use apparent, ATR / CS, RI / BAS, YF / NAS and BFF / CS are the different dishes analyzed. ATR / CS: Attiéké with red oil accompanied by *claire* sauce, RI / BAS: white rice accompanied by *baouin* sauce, YF / NAS: Yam *foutou* accompanied by *namoukou* sauce, BFF / SC: Banana *foufou* accompanied by *claire* sauce.

3.3. Biometrics of Organs Harvested

All the traditional Ivorian dishes studied did not cause any abnormal changes in the weight of the kidneys, heart and liver compared to the body weight of the rats compared to the control dish. Values are included between 0.74 (BFF/CS) and 0.79 (YF/NAS), 0.54 (BFF/CS) and 0.57 (RI/BAS), 3.72 (YF/NAS) and 3.77 (ATR/CS) respectively for % Kidney weight/Body weight, % Heart weight/Body weight and % Liver weight/Body weight (Table 5). Similar results to ours were also obtained by [22] who subjected rats to the consumption of three typical Ivorian traditional dishes and a control diet. Their results showed that the consumption of typical Ivorian traditional foods, would offer good food nutritional aptitudes in view of the biometric and nutritional parameters obtained.

Table 5. Biometry of organs removed

Dishes	% Weight kidneys/Body weight	% Heart weight/Body weight	% Liver weight/Body weight
ATR/CS	0.76 ± 0.08^a	0.55 ± 0.02^a	3.77 ± 0.9^a
RI/SBA	0.78 ± 0.1^a	0.57 ± 0.02^a	3.74 ± 0.9^a
FI/NAS	0.79 ± 0.06^a	0.56 ± 0.05^a	3.72 ± 0.3^a
BFF/CS	0.74 ± 0.08^a	0.54 ± 0.03^a	3.75 ± 0.7^a
Dish control	0.79 ± 0.03^a	0.57 ± 0.02^a	3.76 ± 0.33^a

The values are averages of three determinations (n = 3). In each column, the assigned values of the same letters are not significantly different (p = 0.05). ATR/CS, RI/BAS, YF/NAS and BFF/CS are the different dishes analyzed. ATR/CS: Attiéké with red oil accompanied by c*laire* sauce, RI/BAS: white rice accompanied by *baouin* sauce, YF/NAS: Yam *foutou* accompanied by *namoukou* sauce, BFF/CS: Banana *foufou* accompanied by *claire* sauce.

4. Conclusion

Most of the traditional Ivorian dishes most consumed contain good levels of carbohydrates, fats and proteins. They are able to provide sufficient energy to the consumer when he consumes it in recommended quantities. The nutrients they contain are well digested, assimilated and metabolized by the organism for better use according to the nutritional needs of each individual. Their consumption, even regular in good conditions is without direct damaging risk for the consumer. This confers on these dishes, potential nutritional adequate for the well-being of consuming populations, both biochemically, nutritionally and in terms of health.

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