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Formulation of Senescent Plantain Dish with Various Local Cereal and Leguminous Flours for Feeding Rats: Growth Performance Evaluation

Kouadio N. Joseph[1], Akoa E. Edwige[1], Kra K. A. Séverin[1] & Niamké L. Sébastien[1]

[1]Laboratoire de Biotechnologies, UFR Biosciences, Département de Biochimie, Université Félix Houphouët-Boigny, 22 BP 582 Abidjan 22, Côte d'Ivoire

Correspondence: Kra K. A. Séverin, Laboratoire de Biotechnologies, UFR Biosciences, Département de Biochimie, Université Félix Houphouët-Boigny, 22 BP 582 Abidjan 22, Côte d'Ivoire. E-mail: kra_severin@yahoo.fr

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Abstract

The aim of this study was to valorize senescent plantain. Therefore, a traditional dish named Dockounou was prepared with a mixture of senescent plantain and various millet, soybean, sorghum, cassava, maize or rice flours. The growth performance of several Wistar rats feed by Dockounou was followed. Thus, batches of rats were fed for 15 days with three formulations (F1, F2, F3) in proportion of 90:10, 80:20 and 75:25 (senescent plantain dough/flours) obtained after two cooking modes (dry cooking: baked ; wet cooking: boiled). The effects of these formulations were compared to control diet (C. diet). Beyond the control diet, rats fed with the soybean baked Dockounou presented, the best following growth parameters: weight gain (2.82 to 4.19 g/d), food intake (8.92 to 9.72 g/d), feed efficiency (0.10 to 0.42), proteins intake (8.28 to 19.67), proteins efficiency (0.13 to 3.15). The physicochemical and nutritive characteristics of soybean baked Dockounou were as follow: ash (2.93 ±0.15 %), proteins (10.62±0.59 %), carbohydrates (15.46±1.53 %), calcium (232.04 – 558.20 mg/100g), potassium (313.97 – 385.11 mg/100g), magnesium (42.40 – 72.22 mg/100g), sodium (211.24 – 303.85 mg/100g) and phosphorus (330.70 – 433.71 mg/100g). Also, the study showed that, two formulations, 80:20 and 75:25, have really impact on rats growth. These results suggest that soybean baked Dockounou with important proportions, 80 % and 75 %, of senescent plantain dough can be effectively used in the diet of laboratory Wistar rats regarding the good zoological performances there are obtained.

Keywords: senescent plantain, baked and boiled Dockounou, rats feed, growth performance

1. Introduction

Plantain provides more than 25 % of the carbohydrate requirements for over 70 million people in Africa (IITA, 1998). In Ivory Coast, plantain is the third crop (1 624 354 tons/year) after yam (5 731 719 tons/year) and cassava (2 436 495 tons/year) (FAOSTAT, 2013). In spite of this importance, plantain is a highly perishable foodstuff due to ethylene production associated with rudimentary conditions of harvesting, transport and storage (Rodríguez et al., 1999; Emaga, Wathelet, & Paquot, 2008). This perishability leads to post-harvest losses estimated at 35 to 60 % of the annual production (Atanda et al., 2011). Indeed, the production of plantain depends on season marked by a period of high abundance which goes from September to April (Kuperminc, 1998; Sery, 1988). During this period, the difficulties of plantains conservation make the fruits, while ripening at the ambient temperature undergo depreciation, and also qualitative and quantitative degradations throughout the distribution chain (Chia & Huggins, 2003). In order to reduce the post-harvest losses, the ripe fruits of plantain are often processed by Ivorian farmer women into traditional dish called Dockounou (N'guessan, Yao, & Kehe, 1993; Lassois, Jean-Pierre, & Haïssam, 2009; Dzomeku, Dankyi, & Darkey, 2011; Honfo, Tenkouano, & Coulibaly, 2011). Indeed, the Dockounou is a baked or boiled mixture of over ripe banana paste and cereals flours (Akoa et al., 2012 & 2013). Several studies have been performed on this food primarily designed for human consumption. In this way, Kra et al. (2013) and Kouadio et al. (2014) have showed that Dockounou is an energetic dish for human. Moreover, the reports of Akoa et al. (2014) have revealed the optimized parameters for this food preparation with best hygienic and nutritive qualities. As far as animal feeding is concerned, preliminary studies of Kouadio et al. (2015) highlighted the Wistar rats interest for this dish. Indeed, rats are experimental mammals, mostly used in biomedical, behavioral, toxicological and nutritional research projects

(Baker, Lindsey, & Weisbroth, 1979). Therefore, using rats in experimental design could give an accurate response to some issues related to nutritional aspects of Dockounou dish. Furthermore, the use of senescent plantain in laboratory rats diet can contribute to reduce plantain post-harvest losses. Thus, several formulations using feed ingredients such as cereal or leguminous flours in mixture with various proportions of senescent plantain dough were investigated in order to evaluate their effect on the Wistar rats growth performance and contribute therefore to valorize the fruits at the senescent stage.

2. Materials and Methods

2.1 Sampling

Material used for the Dockounou production composed of senescent plantain fingers (*Musa paradisiaca*), grains of maize (*Zea mays*), rice (*Oriza sativa*), millet (*Pennisetum americanum*), sorghum (*Sorghum bicolor*), soybean (*Glycine max*) and roots of cassava (*Manihot esculenta Crantz*). The whole previous material were bought on the market of Adjame (in Abidjan - Côte d'Ivoire).

As for the animal material, it consisted in a total of one hundred and eighty five (185) young Wistar rats (60 to 75 g) with 50±3 days age. They were kindly provided by the animals' barn of the UFR Biosciences of Felix Houphouët-Boigny University (Abidjan, Côte d'Ivoire).

2.2 Production of Grains and Roots Flours

2.2.1 Sorghum, Millet, Maize and Soybean Flours

Sorghum, millet, maize and soybean flours were prepared using the method described by Lombor, Umoh, & Olakumi (2009). The grains were cleaned and soaked in clean tap water and covered container. The soaked grains were allowed to ferment at room temperature (27 °C) for 24 h. After fermentation, the water was removed and the grains rinsed with 500 mL of water and oven dried at 80 °C for three (3) hours. The soybean grains were sorted, cleaned and blanched at 100 °C for 10 min. The blanched grains were, dehulled and rinsed with 500 mL of water in order to remove the seed coat. The rinsed seed were then dried in oven at 80 °C for five (5) h. Each dried sample was separately milled and sieved with a 100 µm particle size sieve.

2.2.2 Cassava Flour

Method described by Younoussa et al. (2013) was used. The cassava roots were peeled, cut in small pieces and washed before being sun-dried for three to seven (3-7) days. After drying, the pieces were then ground to obtain the flour which was sifted with 100 µm size sieve.

2.2.3 Rice Flour

Rice flour was obtained using the method described by Akoa et al. (2014). The rice grains were soaked in water for two (2) hours. After drying, the grains were crushed in a home clean wooden mortar and the flour was sieved (100 µm).

2.3 Preparation of Dockounou

Methods described by Kra et al. (2013) and Akoa et al. (2014) were used in the processing step. Fruits of senescent plantain were washed, peeled and crushed in a traditional mortar to obtain homogenous dough. Three (3) types of formulations (plantain dough: flour) were obtained. Thus, the first formulation F1 (90:10) was made with 90 % of senescent plantain dough and 10 % of flour. The second formulation F2 (80:20) was achieved with 80 % of senescent plantain dough and 20 % of flour and the third formulation F3 (75:25) was achieved with 75 % of senescent plantain dough and 25 % of flour. Each sample obtained was fermented during four (4) hours before being wrapped (in portions of 100 g) in leaves of *Thaumatococcus danieilii*. One part of samples has been boiled (1 h) and the second part was baked in oven at 150 °C for one (1) h.

2.4 Animals Feeding

The experiments were conducted with young Wistar rats from the animals' house of the UFR Biosciences of the Felix Houphouët-Boigny University (Abidjan, Côte d'Ivoire). The average temperature of the room was 26 °C, and the humidity was 70 %, with 12 hours of daylight. Thirty seven (37) groups of five (5) Wistar rats each were used. They were divided as follow: one (1) group of five (5) young rats was fed with control diet (C), and for each formulation (F1, F2, F3), twelve (12) groups of five (5) young rats were fed with baked and boiled Dockounou (six groups for each cooking mode). The control diet (see Appendix A) used in this study was a granular provided by SFACI Company. Rats were acclimatized for three (3) days during which, they were fed with control diet and thereafter, fed with different experimental diets. Rats were disposed in individual screened bottomed cages designed separately to feed "*ad libitum*" for fifteen (15) days.

2.5 Experimental Design for Data Statement

Method described by Adrian, Rabache, & Fragne (1991) was used to determine the growth parameters. During the experimental period, the feed intake was measured daily while the body weight, length of body, tail and shin were measured each 3 days between 7h30 and 8h30 am. Each food was weighed before being given to rats and the following day, the leftover food was also weighed, in order to determine the food intake. The dry matter of each feed was determined according to AOAC (1990). The table in Appendix B shows the formulas used to determinate growth parameters.

During the experimental period, faeces of each rat were collected and the nitrogen (N) balance was evaluated by using the Kjeldahl method (AOAC, 1990).

2.6 Physicochemical and Biochemical Analysis of Dockounou

Physicochemical and biochemical characteristics of Dockounou involving best zoological performances were determined. Moisture, dry matter and ash content were determined by using the AOAC (1990) methods while the pH was directly measured with a pH-meter (Roucaire, Metr Ohm 632, Germany). Total titrable acidity was evaluated on the puree of Dockounou obtained from 40 g of paste. Raw proteins contents were measured by the Kjeldahl method according to BIPEA (1976) using 6.25 as conversion factor. Lipid content was determined after extraction with hexane in a Soxtherm system during 6 h (BIPEA, 1976). Total sugars contents were evaluated with the method of Dubois et al. (1956). As for carbohydrate and starch contents, they were calculated by the expression described by Coulibaly (2008):

Carbohydrate content = 100 - (Moisture (%) + Ash (%) + Fat (%) + Proteins (%))

Starch content = 0.9 (Carbohydrate (%) - total sugars (%)).

Energy value was also calculated using the relation described by Atwater and Rosa (1899).

2.7 Mineral Analysis of Dockounou

Minerals contents were determined by the AOAC (1990) method. Five (5) grams of samples were digested with a mixture of concentrated nitric acid, sulfuric acid and perchloric acid (10:0.5:2, v/v) and analyzed using an atomic absorption spectrophotometer (GBC 904AA; Germany). Total phosphorus was determined as orthophosphate by the colorimetric ascorbic acid method (APHA, 2001). After acid digestion and neutralization using phenolphthalein as indicator reagent, the absorbance was read at 880 nm in a spectrometer (Spectronic 21 D, Miltonroy, New York, USA). Blank analysis was performed before, in the same conditions using distilled water.

2.8 Statistical Analysis

Statistical analysis of data was done by the one way Analysis of Variance (ANOVA) using software IBM SPSS Statistics version 17.0. Differences between means were tested using the Duncan Multiple Range Test with 5 % level of significant difference and figures were drawn on EXCELL 2013 Software.

3. Results

3.1 Weight Gain

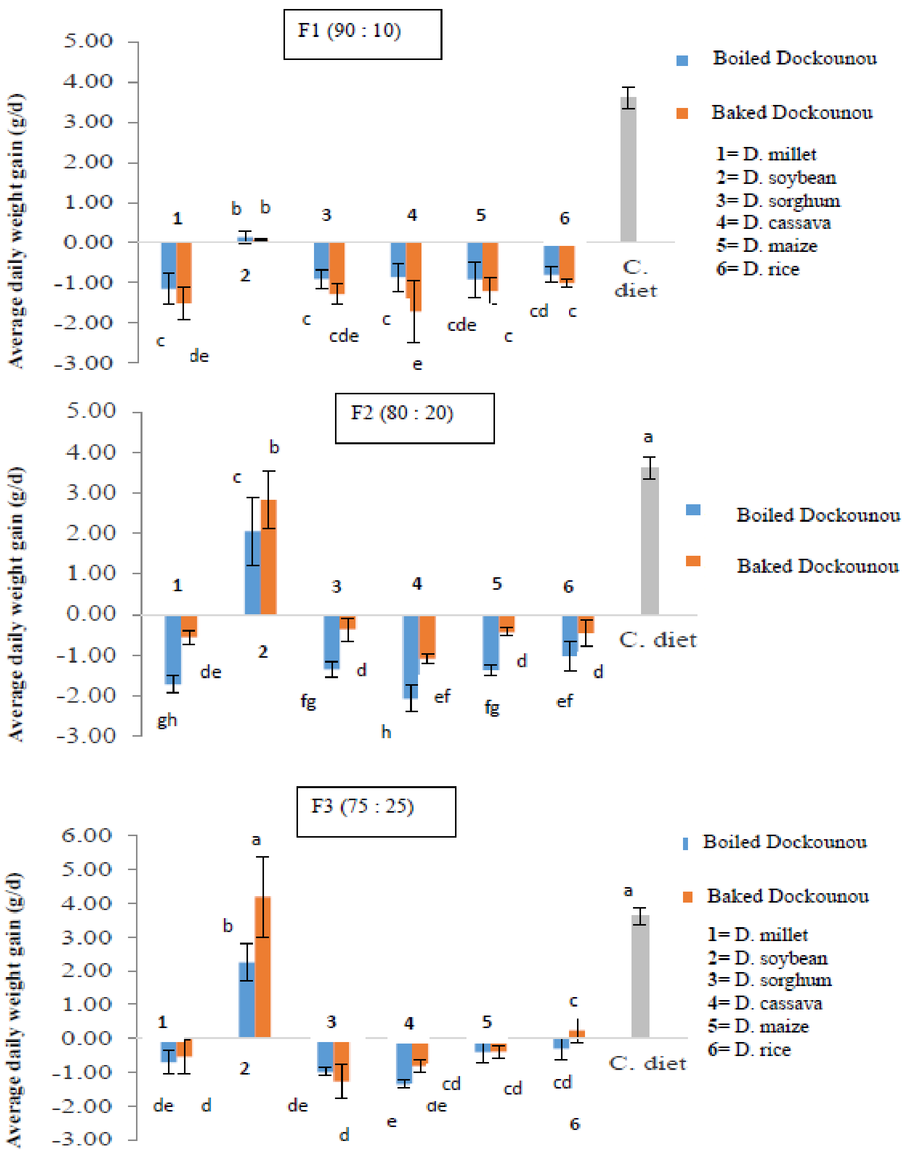

Figure 1. Weight gain per day of rats fed with various types of boiled and baked Dockounou for F1, F2 and F3 formulations and control diet

Data are represented as Means ± SD (n=5). Means with no common letter (a, b, c, d) are significantly different ($p<0.05$)

The weight gain of Wistar rats fed with F1, F2 and F3 formulations of boiled and baked Dockounou are presented in Figure 1. The results showed that the weight of rats fed with the control diet, range was higher (3,34±0,27 g/d) than those fed with formulated diets F1, F2 and F3. Considering these formulated diets, only the D soybean diet allowed slight gain of weight in rats, in all the formulations with the following order: F1 < F2 < F3. The values obtained for F1 were 0.09±0.02 g/d for baked D. soybean and 0.13±0.17 g/d for boiled D. soybean. For the formulation F2 the values were closed to 2.82±0.71 g/d (baked D. soybean) and 2.05±0.84 g/d for boiled D. soybean. The reported values for the F3 formulation were 4.19±1.2 g/d for baked D. soybean and 2.25±0.55 g/d for boiled D. soybean. Contrary to tweight gain after feeding D. soybean diet, the feed of D. millet, D. sorghum, D. cassava, D. maize and D. rice diets induced a decrease of rat's weight.

3.2 Dry Matter Intake

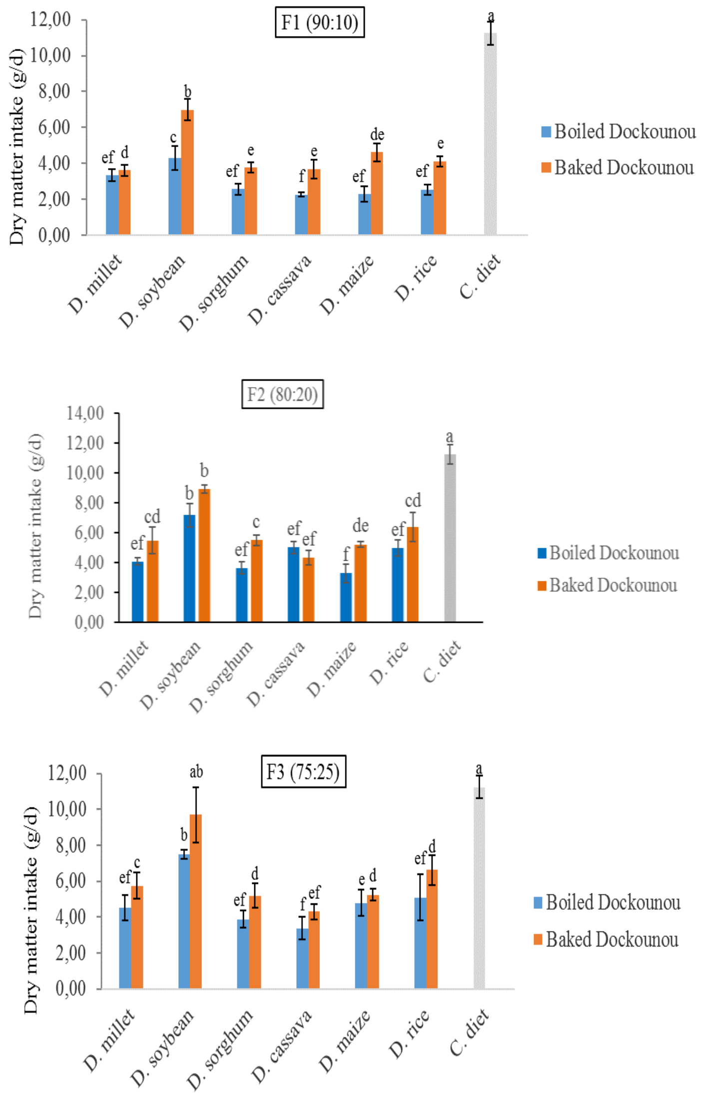

Figure 2. Dry matter intake by rats with F1, F2 and F3 formulations of boiled and baked dockounou and control diet. DMI= dry matter intake

Data are represented as Means ± SD (n=3). Means with no common letter (a, b, c, d) are significantly different ($p<0.05$)

Dry matter intake of rats is given in Figure 2. For all formulations, feed intake is higher for baked Dockounou, than boiled Dockounou. Except for the C diet where the highest intake noted for F2 and F3 formulations was recorded by the baked D soybean. The registered values were 8.92±0.28 g/d and 9.72±1.54 g/d for F2 and F3 formulations, respectively. However, C diet registered the most important intake, followed by D. soybean.

3.3 Food Efficiency Ratio

Table 1. Food efficiency ratios of rats fed with baked and boiled Dockounou diets

Type of formulation	Diets	Boiled Dockounou	Baked Dockounou
Reference food	Control	0.25±0.02a	0.30±0.04a
	D. Millet	-0.33±0.10a	-0.42±0.14a
	D. Soybean	0.02±0.03a	0.10±0.07a
F1	D. Sorghum	-0.34±0.06a	-0.34±0.08a
[90:10]	D. cassava	-0.40±0.15a	-0.50±0.30a
	D. Maize	-0.38±0.12a	-0.26±0.08a
	D. Rice	-0.31±0.06a	-0.24±0.03a
	D. Millet	-0.42±0.07b	-0.10±0.04a
	D. Soybean	0.25±0.10a	0.31±0.07a
F2	D. Sorghum	-0.36±0.05b	-0.06±0.05a
[80:20]	D. cassava	-0.63±0.13b	-0.25±0.02a
	D. Maize	-0.34±0.03b	-0.08±0.02a
	D. Rice	-0.20±0.06b	-0.07±0.05a
	D. Millet	-0.15±0.06a	-0.10±0.09a
	D. Soybean	0.29±0.06b	0.42±0.06a
F3	D. Sorghum	-0.26±0.04b	-0.09±0.08a
[75:25]	D. cassava	-0.40±0.07b	-0.19±0.60a
	D. Maize	-0.88±0.06b	-0.07±0.03a
	D. Rice	-0.31±0.06a	0.03±0.05a

Values are mean ± standard deviation of five determinations. Values with different letters in the same line of each parameter indicate statistical difference ($p < 0.05$). D: Dockounou, F: Formulation

Food efficiency ratios of all diets are reported in Table 1. The statistical analysis showed that there is no significant difference at 5 % level between food efficiency ratios of boiled and baked Dockounou for F1 formulation. Nevertheless, a significant difference ($p<0.05$) was observed between food efficiency ratios of boiled and baked Dockounou for F2 and F3 formulations. At the whole, food efficiency ratios of baked D soybean (0.31±0.07 to 0.42±0.06) are higher than those of boiled D soybean (0.25±0.10 to 0.29 ± 0.06) for F2 and F3 formulations. However, the food efficiency ratios of D soybean for both formulations were higher than those of the others Dockounou.

3.4 Physical Parameters of Growth

Table 2. Length of body, shin and tail of young rats fed with control diet and various types of baked and boiled Dockounou in the three formulations F1, F2, F3

Type of formulations	Diets	Length of body (cm)		Length of shin (cm)		Length of tail (cm)	
		Boiled	Baked	Boiled	Baked	Boiled	Baked
Reference food	Control	2.28±0.07a	2.28±0.07a	0.57±0.15a	0.57±0.15a	1.47±0.29a	1.47±0.29a
	D. Rice	-		0.12±0.02a	0.12±0.02a	-	
	D. Soybean	0.26±0.18b	0.82±0.69a	0.04±0.08b	0.54±0.11a	0.30±0.18b	0.88±0.71a
F1	D. Sorghum			-		-	
[90 :10]	Cassava, Maize,Millet	-					
	D. Rice	-	0.02±0.04a	0.12±0.03a	0.08±0.01a	-	
	D. Soybean	0.92±0.56b	2.02±0.47a	0.22±0.10b	0.44±0.11a	1.18±0.60a	1.32±0.66a
F2	D. Sorghum					-	
[80 :20]	Cassava, Maize,Millet	-		-			
	D. Rice	-	0.54±0.18a	0.06±0.01a	-	-	0.2±0.01a
	D. Soybean	2.70±0.48a	2.76±0.30a	0.44±0.21a	0.40±0.20a	0.9 ± 0.30a	1.3±0.50a
F3	D. Sorghum	-		-		-	
[75 :25]	Cassava, Maize,Millet						

Values are mean ± standard deviation of five determinations. Values with different letters in the same line of each parameter indicate statistical difference ($p < 0.05$). D: Dockounou, F: Formulation, - : any variation of the parameter measured during experimental period.

Results showed (Table 2) that only the D soybean diets resulted in a visible variation of length of body, shin and tail of young rats followed by the rice Dockounou diet which had just given a relatively weak variation of these parameters. There are significantly different ($p<0.05$) between both cooking method and type of formulations, mainly as F1 and F2 are concerned. The higher length of body was obtained for rats fed with the C diet (2.28±0.07 cm), followed by those of the D soybean (0.26±0.18 cm < 0.92±0.56 cm < 2.76±0.30 cm in F1, F2 and F3 formulations, respectively). The rats body length evolution was similar with both boiled and baked D soybean in the F3 formulation (2.70±0.48 cm and 2.76±0.30 cm for boiled and baked D soybean, respectively). Rats fed with the baked D rice, in 75:25 proportions (F3) sleazy, obtained an increase in length of body estimate to 0.54±0.18 cm. About the other diets (D. millet, D. sorghum, D. cassava and D. maize),, there was no increase in length of body, tail and shin for rats whatever the cooking mode was.

3.5 Proteins Intake

Table 3. Proteins intake of rats fed with baked and boiled Dockounou diets

Type of formulations	Diets	Boiled Dockounou (g)	Baked Dockounou (g)
Reference food	Control	25.25±1.45a	25.25±1.45a
	D. Millet	0.31±0.05b	1.82±0.15a
	D. Soybean	1.15±0.38b	8.28±0.72a
F1	D. Sorghum	0.25±0.05b	1.33±0.10a
[90:10]	D. cassava	0.16±0.02b	1.34±0.19a
	D. Maize	0.20±0.09b	1.51±0.16a
	D. Rice	0.22±0.04b	1.53±0.11a
	D. Millet	0.50±0.04b	2.76±0.44a
	D. Soybean	5.65±0.64b	14.22±0.44a
F2	D. Sorghum	0.80±0.03b	1.95±0.12a
[80:20]	D. cassava	0.22±0.02b	1.27±0.14a
	D. Maize	0.58±0.09b	1.71±0.06a
	D. Rice	0.63±0.06b	2.36±0.35a
	D. Millet	0.52±0.10b	2.98±0.39a
	D. Soybean	5.95±0.49b	19.67±3.18a
F3	D. Sorghum	0.36±0.04b	3.32±0.44a
[75:25]	D. cassava	0.22±0.03b	1.30±0.13a
	D. Maize	0.72±0.09b	2.25±0.14a
	D. Rice	0.58±0.09b	3.58±0.44a

Values are mean ± standard deviation of five determinations. Values with different letters in the same line of each parameter indicate statistical difference ($p < 0.05$). D: Dockounou, F: Formulation

Table 3 presents the amount of total proteins intake in rats. At the whole, it was observed that the contents of proteins ingested by rats fed with baked Dockounou were higher than those of rats fed with boiled Dockounou. The proteins intakes for the baked preparations were 14.22 ±0.44 g and 19.67 ±3.18 g for D soybean in F3 and F2 formulations, respectively. Whatever, the amount of proteins intake of rats increased with incorporation of flours. The amount of proteins intake by rats fed with C diet (25.25±1.45 g) was higher than those of baked D soybean (8.28±0.72 g < 14.22±0.44 g < 19.67±3.18 g for F1, F2 and F3 formulations, respectively).

3.6 Proteins Efficiency Ratios

Table 4. Proteins efficiency ratios of rats fed with the control, baked and boiled Dockounou diets

Type of formulations	Diets	Boiled Dockounou	Baked Dockounou
Reference food	Control	2.15±0.37a	2.15±0.37a
	D. Millet	-53.34±11.71b	-12.57±4.25a
	D. Soybean	1.46±1.67a	0.13±0.93a
F1	D. Sorghum	-54.63±4.28b	-14.60±3.60a
[90:10]	D. cassava	-78.90±24.73b	-20.29±12.35a
	D. Maize	-66.46±12.13b	-12.12±3.68a
	D. Rice	-54.41±9.65b	-10.02±1.31a
	D. Millet	-51.67±5.92b	-3.15±1.27a
	D. Soybean	4.73±1.94a	2.96±0.72a
F2	D. Sorghum	-33.72±5.02b	-2.88±2.33a
[80:20]	D. cassava	-158.40±38.71b	-12.95±1.45a
	D. Maize	-35.86±3.17b	-3.74±0.82a
	D. Rice	-24.39±8.24b	-2.98±0.72a
	D. Millet	-20.67±12.13b	-2.97±2.73a
	D. Soybean	5.71±1.38a	3.15± 0.44b
F3	D. Sorghum	-42.46±6.99b	-2.26±2.00a
[75:25]	D. cassava	-93.34±11.05b	-9.71±3.14a
	D. Maize	-8.74±4.40b	-2.61±1.37a
	D. Rice	-8.21±4.17b	0.88±1.40a

Values are mean ± standard deviation of five determinations. Values with different letters in the same line indicate statistical difference ($p < 0.05$). D: Dockounou, F: Formulation

Proteins efficiency ratios of different formulations for baked and boiled Dockounou are shown in Table 4. The whole values in the table were negative, except for those obtained with C. diet and D. soybean which were positive. The statistical analysis revealed that there was no significant difference (p>0.05) between values of proteins efficiency ratios of baked and boiled D soybean for F1 and F2 formulations. These values in the both formulations were higher than those of the C diet. However, for the F3 formulation, proteins efficiency ratios of boiled Dockounou were higher than those of baked Dockounou (5.71±1.38 > 3.15±0.44).

3.7 Proteins Content of Formulated Dockounou

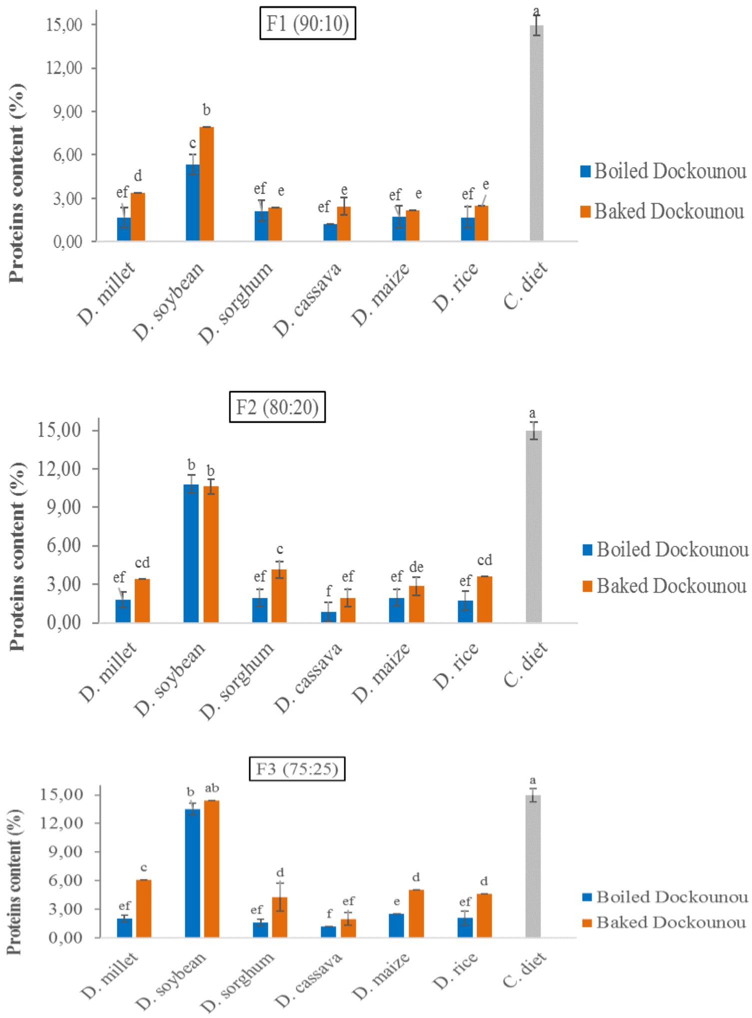

Figure 3. Proteins content of various Dockounou for F1, F2 and F3 formulations

Data are represented as Means ± SD (n=3). Means with no common letter (a, b, c, d) are significantly different (p<0.05)

Proteins content of Dockounou for F1, F2 and F3 formulations are presented in Figure 3. Values were significantly different (p<0.05) between cooking methods and between formulations. Proteins contents of types of Dockounou ranged from 1.23±0.00 % to 14.44±0.00 % for D cassava and D soybean in F1 and F3 formulations, respectively. Control diet recorded the highest protein content, followed by those of baked and boiled D soybean in F2 and F3 formulations. All the other contents were at far slighter and statistically similar.

3.8 Nutritive and Physicochemical Parameters of Soybean Dockounou

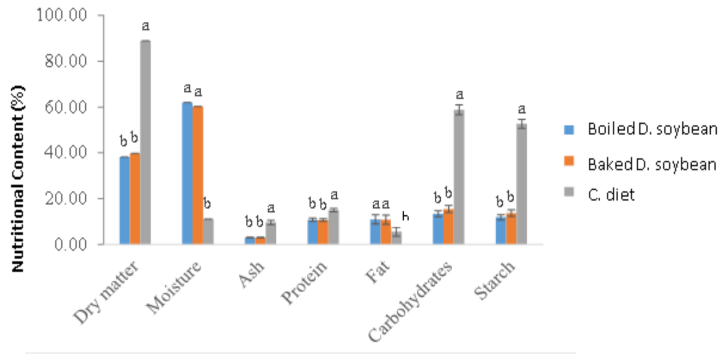

Figure 4. Nutritive properties of baked and boiled D soybean and C diet

Data are represented as Means ± SD (n=3). Means with no common letter (a, b, c, d) are significantly different (p<0.05) for each parameter.

Table 5. Physicochemical and biochemical properties of baked and boiled D soybean and C diet

Parameters	Boiled soybean Dockounou	Baked soybean Dockounou	C diet
Acidity (meq/100 g)	116.67±2.89a	124.33±12.10a	113.33±11.55a
pH	5.70±0.10b	5.60±0.10b	6.20±0.10a
Energy (Kcal)	165.67±10.60b	171.35±9.98b	293.11±7.46a
Total sugars (g)	0.23±0.02b	0.29±0.03a	0.21±0.03b

Values are mean ± standard deviation of five determinations. Values with different letters in the same line of each parameter indicate statistical difference (p < 0.05). D: Dockounou, F: Formulation

The nutritive parameters of soybean Dockounou are presented in Figure 4. Results revealed significant difference (p < 0.05) between the parameters of the whole diets (C diet and the boiled and baked D soybean). Generally, the C diet recorded higher contents of dry matter, ash, proteins, total carbohydrate and starch than boiled and baked D soybean. However, both Dockounou registered the same amount of ash, proteins, fat, total carbohydrate and starch. Data in table 5 also revealed significant differences between the three types of Dockounou, as far as the pH, total sugar content and energy are concerned. If Control diet registered the most important pH (6.20±0.10) and energy (293.11±7.46), it also topped the slightest amount of total sugars (0.21±0.03). All the diets presented statistically, similar acidity, but the pH (5.70±0.10 and 5.60±0.10) of both boiled and baked D. soybean were lower than that of the Control diet. Acidity. Baked D. soybean is richer in total sugars (0.29±0.03 g) than boiled D. soybean (0.23±0.02 g) which is less energetic (165.67±10.60 Kcal) than the first (171.35±9.98 Kcal).

3.9 Minerals Composition of the Diets

Table 6. Minerals composition of soybean baked and boiled Dockounou and C diet

Parameters	Soybean boiled Dockounou	Soybean baked Dockounou	C diet
Ca	558.20±21.73b	232.04±12.08c	1944,05±182,13a
Cu	0.64±0.02b	0.71±0.03b	2.5±0.23a
Co	8.75±0.34b	4.85±0.25c	13.41±1.26a
Fe	1.86±0.07b	1.64±0.08b	9.11±0.85a
K	313.97±12.21b	385.11±20.05b	1025.40±96.06a
Mg	42.40±1.65b	72.22±3.72c	191.05±17.89a
Mn	trace	trace	3.43±0.32a
Na	211.24±8.22c	303.85±15.78b	389.85±36.52a
Pb	0.14±0.00b	0.15±0.01b	0.24±0.02a
P	330.70±11.80c	433.71±46.10b	642.14±74.95a
Zn	trace	trace	4.29 ±0.39a

Values are mean ± standard deviation of triplicate determinations. Values with different letters in the same line indicate statistical difference (p < 0.05).

The whole diets contained many various minerals such as calcium, sodium, phosphorus, magnesium, manganese, zinc, cobalt, iron, copper, but also lead (Pb). The mineral content of soybean Dockounou and C diet, showed no significant difference (p < 0.05) between copper (Cu), iron (Fe), potassium (K) and lead (Pb) contents of soybean baked Dockounou and those boiled D soybean as reported in the Table 6. At the whole, the C diet had higher mineral contents than soybean Dockounou, but Ca, Co and Mg contents of boiled D soybean are higher than those of baked D soybean.

4. Discussion

The length and weight are parameters that assess the growth and well-being of individual for a particular time (Morgane et al., 1993; Turlejski, 1996), but more especially appreciate of the nutritional state (WHO, 1995). Rats fed with Dockounou which were being incorporated the soybean flour had given best results zoological parameters at the end of the experiment. According to Ijarotimi & Oluwalana (2013), the weight gain is influenced by the quality of food composition and the quantity of food intakes by rats. Soybean is rich in protein and fats (Bender & Bender, 1999) and this could explained the fact that Dockounou without soybean could not allow Wistar rats growth. This fact highlights the importance to add nutrient-rich ingredients in formulations for better growth.

The consumption increased with proportion of soybean flour added and the cooking method. Thereby, an increase in weight of rats was also a link to these conditions. Udensi et al. (2012) reported the same observation in their study. In fact, soybean is a good source of protein and is generally used to enrich the foods poor in nutrients. The high food intake for baked D soybean might suggest that rats found this food more acceptable than the others as reported by Onweluzo & Nwabugwu (2009). The food efficiency ratio means the efficiency of food digestion, in other words, the weight gain obtained per unit of food consumed. Results of this parameter confirmed easly the lost or the gain of weight of rats according the diet.

The same applies to proteins intake and proteins efficiency ratio for which the statistical analysis revealed that there was no significant difference between baked and boiled Dockounou but proteins efficiency ratio of boiled Dockounou were higher than that baked. According to Ahenkora et al. (1997), the nature of the processing medium influenced nutritional qualities in the products. Indeed, the cooking mode influences proteins content. With the dry cooking, the food becomes dry and proteins which it contains are made difficult to digest by young rats. In contrast, with the wet cooking, the presence of water in the food makes easier the digestion of proteins by young rats. These proteins in a wet food are more accessible. Swaminathan & Gangwar (1961) estimated that the losses of nutrients are due to leaching into the cooking water. Generally, nutritional qualities of plantain fruits varied with the cooking processing method employed (Baiyeri et al., 2011). Thus, proteins content of the boiled D soybean were more ingested by young rats than proteins of baked D soybean. For the other types of formulated Dockounou, weak proteins intake could be explained by the fact that these cereal foods and roots of cassava are less rich in proteins and more important source of energy (Gomez, 1985; Tonukari, 2004). The high proteins intake, and protein efficiency ratio of baked D soybean could be due to his high food intake by the animals in the one hand and the other hand, by the content of soybean. Proteins content of the baked D soybean determined in our study highlight the wealth of soybean in protein. Indeed, this content of proteins is high than the others types of Dockounou. Moreover, the studies showed that a high food intake resulted in a sharp increase in proteins intake because proteins is required for proper growth, healthy living, maintenance and production tissues and cells of the young body (Messina, 1999). Also, the addition of legumes such as soybean to foods, increases the nutritional benefits by increasing of proteins content of food (Gomez, 1985; Nnam, 2001; Perez et al., 2008).

The quantity of proteins recommended in the diet of rats adults is least 12 % (Rogers, 1979). Consequently, the proteins content of soybean Dockounou in 80:20 formulation could be used for feeding adult rats. Concerning minerals, the recommended dietary allowance (RDA) (FAO, 2004) are: calcium (1000 mg/day) and phosphorus (800 mg/day). Thus, the soybean boiled Dockounou could cover 55 % of calcium RDA and 41 % of phosphorus RDA. While, the soybean baked Dockounou could cover 23 % of calcium RDA and 54 % of phosphorus RDA. Calcium and Phosphorus are associated for growth and maintenance of bones, teeth and muscles (Turan et al., 2003).

5. Conclusion

The present study showed that the cooking method could affect nutrients intake of Dockounou. The baking processing provides also,a better nutrients intake than the boiling one. However, soybean baked Dockounou formulated in 80:20 and 75:25 proportions used to feed the rats and which provide them a high physical and biological performance are the best diets. The proportions of senescent plantain (80 and 75 %) in this diet reveled that feeding rats with Dockounou could help to valorize the very ripe banana in order to reduce its post-harvest losses.

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References

Adrian, J., Rabache, M., & Fragne, R. (1991). Technique d'analyse nutritionnelle, *in*: Lavoisier Tec et Doc (Eds). Principes de techniques d'analyse, Paris, 451-478.

Ahenkora, K., Kye, A., Marfo, K., & Banful, B. (1997). Nutritional composition of false horn *pantu pa* plantain during ripening and processing. *Afr. Crop Sci. J., 5,* 243-248.

Akoa, E. E. F., Kra, K. A. S., Mégnanou, R-M., Akpa, E. E., & Ahonzo, N. L. S. (2012). Sensorial characteristics of senescent plantain empiric dish (Dockounou) produced in Côte d'Ivoire. *J. Food Res., 1*(4), 150-159. https://doi.org/10.5539/jfr.v1n4p150

Akoa, E. E. F., Kra, K. A. S., Mégnanou, R-M., Kouadio, N. J., & Niamké, L. S. (2014). Optimization of Dockounou Manufacturing Process Parameters. *Sust. Agri. Res., 3*(1), 67-75. https://doi.org/10.5539/sar.v3n1p67

Akoa, E. E. F., Megnanou, R-M., Kra, K. A. S., & Ahonzo-Niamke, L. S. (2013). Technical variation in the processing of dockounou, a traditional plantain derivate dish of Côte d'Ivoire. *Ame. J. Res. Com., 1*(5), 81-97.

AOAC (Association of Official Analytical Chemists). (1990). Official methods of analysis Ed. Washington DC, p. 684.

AOAC (Association of Official Analytical Chemists)..(1980). Official method of analysis, 13th ed.,Washington DC, USA, 376-384.

APHA (American Public Health Association), (2001). Phosphorus Determination using the Colorimetric Ascorbic Acid Technique. CEE 453: Laboratory Research in Environmental Engineering. 64-69.

Atanda, S. A., Pessu, P. O., Agoda, S., Isong, I. U., & Ikotun, I. (2011). The concepts and problems of post-harvest food losses in perishable crops. *Afr. J. Food Sci., 5*(11), 603-613.

Atwater, W., & Rosa, E. (1899). A new respiratory calorimeter and the conservation of energy in human body. *II-physical, 9*, 214-251.

Baiyeri, K. P., Aba, S. C., Otitoju, G. T., & Mbah, O. B. (2011). The effects of ripening and cooking method on mineral and proximate composition of plantain (*Musa* sp. AAB cv. 'Agbagba') fruit pulp. *Afr. J. Biotech., 10*(36), 6979-6984.

Baker, H. J., Lindsey, J. R., & Weisbroth, S. H. (1979). The laboratory rat, vol. I, Biology and diseases. A Subsidiary of Harcourt Brace Jovanovich Publishers, Academy Press, New York, London, Toronto, Sidney, San-francisco.

Bender, D. A., & Bender, A. E. (1999). Bender's dictionary of nutrition and food technology. Woodland pub., New York, 302-303. https://doi.org/10.1201/9781439834381

BIPEA (Bureau Interprofessionnel d'Etudes Analytiques), (1976). Dans : Recueil de méthodes d'analyse des communautés européennes. BIPEA, Gennevilliers, 51-52.

Chia, C. L., & Huggins, C. A. (2003). Bananas. Community Fact sheet BA-3(A) Fruit. Hawaii Cooperative Extension Service, CTAHR, University of Hawaii.

Coulibaly, N. (2008). Caractérisation physicochimique, rhéologique et analyse sensorielle des fruits de quelques cultivars de bananiers (Musa AAB, AAAA, AAAB). Thèse de Doctorat, UFR des Sciences et Technologies des Aliments, Université d'Abobo-Adjamé, Côte d'Ivoire, p.180.

Dubois, M., Gilles, K., Hamilton, J., Rebers, P., & Simith, F. (1956). Colorimetric method for determinations of sugars and related substances. *Anal. Chim., 280,* 350-356. https://doi.org/10.1021/ac60111a017

Dzomeku, B. M., Dankyi, A. A., & Darkey, S. K. (2011). Socioeconomic importance of plantain cultivation in Ghana. *The J. Ani. Plant Sci., 21*(2), 269-273.

Emaga, H. T., Wathelet, B., & Paquot, M. (2008). Changements texturaux et biochimiques des fruits du bananier au cours de la maturation, Leur influence sur la préservation de la qualité du fruit et la maîtrise de la maturation. *Biotech. Agro. Soci. Environ., 12*(1), 89-98.

FAO (Food and Agriculture Organization of the United Nations), (2004). Human vitamin and mineral requirements. FAO Ed., p. 361.

FAOSTAT (Food and Agriculture Organization of the United Nations Statistics), (2013). Food and Agricultural Organization, Statistics division, Crops, Rome, Italy.

Gomez, M. H. (1985). Development of a food of intermediate moistness from extracts of corn and soybean. *Archivos Latinoamericanos de Nutrición*, *35*(2), 306-314.

Honfo, F. G., Tenkouano, A., & Coulibaly, O. (2011). Banana plantain-based foods consumption by children and mothers in Cameroon and Southern Nigeria: A comparative study. *Afr. J. Food Sci.*, *5*(5), 287-291.

IITA (International Institute of Tropical Agriculture), (1987). Root, Tuber and plantain improvement program: Annual Report, Onne, Nigeria, p. 39.

IITA (International Institute of Tropical Agriculture), (1998). Plantain and Banana Improvement Program: Annual Report for 1997, Onne, Nigeria, p.19.

Ijarotimi, O. S., & Oluwalana, (2013). Chemical Compositions and Nutritional Properties of Popcorn-Based Complementary Foods Supplemented With *Moringa oleifera* Leaves Flour. *J. Food Res.*, *2*(6), 117-132. https://doi.org/10.5539/jfr.v2n6p117

Kouadio, N. J., Rose-Monde, M., Eric, A., Severin, K., & Sebastien, N. (2014). In Vitro Digestibility of Dockounou a Traditional Plantain Derivate Dish of Côte d'Ivoire. *Am. J. Bio. Sci.*, *2*(6), 211-216. https://doi.org/10.11648/j.ajbio.20140206.14

Kouadio, N. J., Rose-Monde, M., Eric, A., Edwige, E. A., Séverin, K. K., & Sébastien, L. S. (2015). Impact of the nutritional supply of Dockounou with millet, soybean, cassava, sorghum flours in Wistar rat growth. *Inter. J. Inn. App. Stud.*, *10*(2), 576-583.

Kra, K. A. S., Akoa, E., Megnanou, R-M., Yeboue, K., Akpa, E. E., & Niamke, L. S. (2013). Physicochemical and nutritional characteristics assessment of two different traditional foods prepared with senescent plantain. *Afr. J. Food Sci.*, *7*(3), 51-55. https://doi.org/10.5897/AJFS12.087

Kuperminc, O. (1988). Saisonnalité et commercialisation de la banana plantain en Côte d'Ivoire. *Fruits*, *43*(6), 359-368.

Lassois, L., Jean-Pierre, B., & Haïssam, J. (2009). La banane: de son origine à sa commercialisation. Univ. Liège - Gembloux Agro-Bio Tech. Plant Pathology Unit, Passage des Déportés, 2. B-5030 Gembloux (Belgium). *Biotech. Agro. Soci. Environ.*, *13*(4), 575-586.

Lombor, T. T., Umoh, E. J., & Olakumi, E. (2009). Proximate composition and organoleptic properties of complementary food formulated from millet (*Pennisetum psychostchynum*), soybeans (*Glycine max*) and crayfish (Euastacusspp). *Pak. J. Nut.*, *8*(10), 1676-1679. https://doi.org/10.3923/pjn.2009.1676.1679

Messina, M.J. (1999). Legumes and soybeans: overview of their nutritional profile and health effects. *Am. J. Clin. Nut.*, *70*, 439-450.

Morgane, P. J., Austin-Lafrance, R. J., Bronzino, J., Tonkiss, J., Diaz-Cintra, S., Cintra, L., Kemper, T., & Galler, J. R. (1993). Prenatal malnutrition and development of the brain. *Neu. Biobe. Rev.*, 17, 91-128. https://doi.org/10.1016/S0149-7634(05)80234-9

N'guessan, A., Yao, N., & Kehe, M. (1993). La culture du bananier plantain en Côte d'ivoire. Spécial bananes II: systèmes de production du bananier plantain. *Fruits*, *48*(2), 133-143.

Nnam, N. M. (2001). Comparison of the protein nutritional value of food blends based onsorghum, bambara groundnut and sweet potatoes. *Int. J. Food Sci. Nut.*, *52*, 25-29. https://doi.org/10.1080/09637480020027246

Onweluzo, J. C., & Nwabugwu, C. C. (2009). Development and Evaluation of Weaning Foods from Pigeon Pea and Millet. *Pak. J. Nut.*, *8*(6), 725-730. https://doi.org/10.3923/pjn.2009.725.730

Pérez, A., González, R. J., Drago, S. R., Carrara, C., De Greef, D. M., & Torres, R. L. (2008). Extrusion cooking of a maize-soybean mixture: Factors affecting expanded product characteristics and flour dispersion viscosity. *J. Food Eng.*, *87*(3), 333-340. https://doi.org/10.1016/j.jfoodeng.2007.12.008

Rodríguez, M. J. L., Rodríguez, S. A., & Belalcázar, C. S. (1998). Importancia Socioeconómica del Cultivo del Plátano en la Zona Central Cafetera (Segunda Versión) Oficina Regional de Planeación - Corpoica, Regional Nueve, Manizales, marzo.

Rogers, H. E. (1979). Nutrition, *in*: The laboratory rat, vol I, biology and diseases, Baker H. J., Lindsey J.R. and Weisbroth S.H. eds. Academy Press, New York, NY, 123-152. https://doi.org/10.1016/b978-0-12-074901-0.50013-7

Sery, D. G. (1988). Rôle de la banane plantain dans l'économie ivoirienne. *Fruits*, *43*(2), 73-78.

Swaminathan, K., & Gangwar, B. M. L. (1961). Cooking losses of vitamin C in Indian potato varieties. *Indian Potato J.*, *3*, 86-91.

Tonukari, N. J. (2004). Cassava and the future of starch. *Electronic J. Biotech.*, *7*(1), 5-8. https://doi.org/10.2225/vol7-issue1-fulltext-9

Turan, M., Kordali, S., Zengin, H., Dursun, A., & Sezen, Y. (2003). Macro and micro-mineral content of some wild edible leaves consumed in Eastern Anatolia. *Plant Soil Sci.*, *53*, 129-137. https://doi.org/10.1080/090647103100095

Turlejski, K. (1996). Evolutionary ancient roles of serotonin: long lasting regulation of activity and development. *Acta Neur. Exp.*, *56*(6), 19-36.

Udensi, A. A., Odom, T. C., Nwaorgu, O. J., Emecheta, R. O., & Ihemanma, C. A. (2012). Production and evaluation of the nutritional quality of weaning food formulation from roasted millet and Mucuna cochinchinesis. *Sky J. Food Sci.*, *1*(1), 1-5.

WHO (World Health Organization), (1995). Physical Status: The Use and Interpretation of Anthropometry. Technical Report Series, 854, Geneva, OMS, p. 452.

Younoussa, D., Momar, T. G., Mama, S., Praxède, G., Amadou, D., Jean-Paul, B., & Georges, L. (2013). Importance nutritionnelle du manioc et perspectives pour l'alimentation de base au Sénégal (synthèse bibliographique). *Biotech. Agro. Soci. Environ.*, *17*(4), 634-643.

Appendix A. Composition of control diet (SFACI company).

Components	Proportion
Protein	15 %
Fat	3,5 %
Cellulose	12 %
Carbohydrate	58 %
Minerals	11,2 %
Vitamin A	15000 UI/Kg
Vitamin D	3000 UI/Kg
Vitamin E	10 mg/Kg

Appendix B. Formulas for growth parameters determination.

Parameters	Mathematical formulas
Food intake (FI)	Given food – Left-over food
Dry mater (DM)	100 - [((wet weight - dry weight) / wet weight) × 100]
Dry mater intake (DMI)	FI × DM
Average weight gain (AWG)	Final weight - Initial weight
Average daily weight gain (ADWG)	AWG / days
Feed efficiency (FE)	AWG / DMI
Total protein intake (TPI)	DMI × % protein of diet
Protein efficiency (PE)	AWG / TPI