Nutritional Performances of Diet Made with Soya/Maize and 'Pistachio'/Rice in the Rehabilitation of Underfed Rats

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ABSTRACT---- ***The aim of this work is to compare the nutritional efficiency of two rehabilitation diets made with soya/maize (SOMA) and 'pistachio'/rice (PIRI) to a control diet (Plumpynut) on underfed young rats. This malnutrition was caused by "Anagobaka" which contains 2.04 % of protein. The underfed rats have been fed with the diets SOMA, PIRI and Plumpynut. The chemical analysis has revealed that Plumpynut contains 15.29 ± 0.07% of protein with an energetic value of 574.40±3.2kcal. As for the diet soya/maize, the content in protein and energy are respectively 14.97±0.6%and 570.19±4.0 kcal. Concerning the diet pistachio/rice, the content are 15.26±0.1% of protein and 570.16±5.0 kcal of energy. Rats fed with the diets soya/maize and pistachio /maize have respectively got a consumption of 7.01±0.93g/day and 5.45±0,16g/day, a growth in weight of 2.82±0.73g/day and 2.03±0.48g/day with real digestibility of 89.48±1.16 % and 96.16±0.37%. The Net protein used of SOMA and PIRI are respectively 90.25±0.24% and 96.22±0.42% and that of the biologic value are 91.21±0.22% and 96.58±0.42%. The results show that experiment diets have similar performances, even superior to those of Plumpynut.***

Keywords---- nutritional efficiency, rehabilitation, Anagobaka, malnutrition

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1. INTRODUCTION

Developing countries are the most affected by malnutrition despite the diversity of agricultural products [25]. The consequences of this malnutrition are the damage of mothers' health and children [11]. Children's malnutrition in these countries is often due to the consumption of cereal porridge, poor in protein, energy and unbalanced in micronutrients [16, 19]. This is the case of Anagobaka usually used by mothers in weaning their children whose age vary between 6 and 59 months in Ivory Coast [9].

These feeding practices do not respect the norms established by international institutions [3]. Beyond these limits, the recurrent imbalance reduces the possibilities of regulation and causes a negative energetic balance sheet as well as serious metabolic and deficiency trouble on children [12, 20].The healing of these metabolic and deficiency trouble is done with specialized alimentary products, rich in energy as Plumpynuts, Plumpy sup and Corn Soya Blend (CSB). However, the products used in the nutritional rehabilitation are distributed in the prevalence zones of malnutrition in Ivory Coast or sometimes in lack of stock [18]. These lacks not only expose children under nutritional treatment, but also expose those who should have access. Thus, the diversification of ingredients used to make these foods is a way to explore. This study aims at evaluating the nutritional performance of two diets made with local products in the rehabilitation of underfed rats after ten days of consumption of Anagobaka.

2. MATERIAL AND METHODES

2.1. Material

2.1.1. Animals and dwellings

The animal experiment has been made with growing rats wistar coming from the nutrition and pharmacology laboratory of Biosciences of the University Felix Houphouet-Boigny, Abidjan (Ivory Coast). 18 rats aged 45 to 65 days, with an average weight 63.25 ±2.57g have been used. Rats were gathered in groups of six per diet in cages. These cages were made with grid which permit to retain wastes upstream and collect urines downstream through funnel. Cages are provided with feeding bottles to feed and make animals drink.

2.1.2. Diets

Four infant diets have been submitted to growing rats, one coming from the trade Anagobaka (Milk Custard), two other composed flour made with maize (Zea mays), rice (oriza sativa), soya (glycine max), citrullus lanatus (Cucurbitacées) usually called pistachio and the control diet (Plumpynut). Except the Plumpynut, the other diets have been bought at the "Forum market" of Adjaméin Abidjan, Ivory Coast. These food have been selected because they can be found easily on the market.

Table 1. *Diets formulation (g/100g)*

Diets	Ingredients	Flour quantites (g/100)
SOMA (Soya/ maize)	Soya	28.58
	Maize	33.41
	Oil	28.0
	Sugar	10.01
PIRI (Pistachio/rice)	Pistachio	40.28
	Rice	24.31
	Oil	24.67
	Sugar	10.74

2.2. Methods

2.2.1 Process of producing composed flour

All the seeds have been cleaned. Maize seeds have been crushed and winnowed. Soya and Pistachio seeds have been cooked for 30 minutes at 100°C and dried at a stove temperature of 45° for 4 hours. As for crushed maize and rice seeds, they have been soaked in water at an ambient temperature for 12 hours, then dried for 12 hours at a stove temperature of 45 °C on a grid. The peel of soya and pistachio seeds have been removed before drying the seeds. And then, the different foods have been crushed in a grinder. The different flour obtained have been toasted at 100°C for 10 minutes. After all the process, the quantities of flour obtained have been strained successively with sieves of 500 µm, 400 µm, 160 µm. The different ingredients (Cereal flour, sugar powder, refined palm oil) have been weighed separately and mixed to obtain a homogeneous flour [5].

2.2.2. Chemical analyses (Table 2)

2.2.2.1. Total protein

The products protein have been tested according to Kjeldahl technic with a conversion coefficient of nitrogen equal to 6.25 [4].

2.2.2.2. Fat

The crude fat has been extracted in the boiling step from 5 g of a sample in a machine of soxhlet at 80°C. After evaporation of hexane from the Rota vapor, the ball is cooled down and weighed [22].

2.2.2.3. Carbohydrates and ash

The carbohydrates are obtained by difference between the measured out elements and the first sample. The content in ash is obtained by weighing 5g of the sample incinerated at 550°c during six hours in an oven (select horn, pselecta) [2].

2.2.2.4. Determination of energy

The energetic value of the diet has been obtained through the sum of the products of each major element (carbohydrates, proteins, lipids) and its thermal coefficient.

3.2.2.2. Expressing the parameters of the nutritional study

The parameters of the nutritional study are registered in the Table 2.

Table 2. *Expressing the parameters of the nutritional study*

Parameter	Mathematical Expressions
Dry Substance Ingested (D.S.I) g/d	Total amount of dry substance ingested during the experimental period.
Total Protein (T.P) g/d	P.T (g) = D.S x % Protein of diet
Growth in weight (G.W) g/d	Final weight– initial weight/number of days
Food Coefficient(F.C)	F.C = G.W (g) / D.S (g)
Protein Efficient(P.E)	P.E = G.W (g) / T.P (g)
real Digestibility	R.D = I-(F-Fpp/I) x 100
Net Protein Utilized (NPU)	N.P.U. = (I – (F - Fpp) - (U - Upp))/I
Biological value (BV)	B.V = (I-(Fi-Fpp) – (U-Upp)/I-(Fe-Fpp)

D.S.I: Dry Substance Ingested, T.P: Total Protein, F.C : Food Coefficient, P.C : Protein Coefficient, N.P.U : Net Protein Used, r.D : real Digestibility , B.V : Biologic Value, Growth in weight (G.W), F: excreted protein; I: Ingested Protein, I=T.P/6.25; U: Excreted Protein by urines, pp: protein secreted in the urine of a subject being protein-free diet.
Fpp: protein secreted by the feces of a subject submitted to the diet without protein.

2.2.4. Experiment conditions and constitution of rats groups

The experiment room had a temperature of 25 °C with a hygrometry degree comprised between 70 and 80%. The lots of six rats have been submitted to a rehabilitation diet after induction of malnutrition.

2.2.5. Development of the experiment

It has been done in two steps. In the first step, rats have been fed during ten days with Anagobaka to induct malnutrition, then have been rehabilitated by three days (Table 1). For each diet, corresponds a group of six underfed rats. The experiment that followed [1].method is composed of two phases: a growing experiment which lasted 31 days and that of the nitrogenous balance sheet which covered the last five days of the first experiment. During the nitrogenous experiment, urines and feces were collected every day, weighed and kept at -10°C for analyze. At the end of the experiment, the food coefficient, the digestibility, the net protein used and the biological value of diets are determined and compared to the control diet.

2.2.6. Statistical analysis

The analysis of data has been made by the software STATISTICA version 6.0. The comparison of averages has been made by the test of student Newman-keuls at a rate of 5%.

3. RESULTS

3.1. Chemical composition of the three diets

The compositions in protein, fat, carbohydrate, ash and energy have been determined (**Table 3**). The protein rate of the control diet, the PIRI and SOMA are respectively 15.29 ± 0.02; 15.26 ± 0.01 and 14.97 ± 0.6. No important difference has been observed between these values ($P \geq 0.05$). The most important fat rate has been measured on the control diet and the weaker has been measured on the diet (SOMA). The fat rates have showed important differences ($P \leq 0.05$). The carbohydrate rates of the diets SOMA, PIRI and the control diet are respectively 53.4 ± 0.07; 52.68 ± 0.06; and 42.71 ± 0.02. These carbohydrate rates have presented important differences ($P \leq 0.05$). The registered energetic values varied between 561.12 ± 0.11 kcal and 574.75 ± 0.94 kcal and did not show important difference ($P \geq 0.05$). As for the content in ash, a difference has been observed the control diet (2.12 ± 0.02) and the diets SOMA, 2.6 ± 0.05; 2.1 ± 0.09) ($P \leq 0.05$).

3.1.2.1. Dry substance* Ingested *(DSI)

The control diets, SOMA and PIRI have respectively obtained a dry material ingestion of 5.97 ± 0.92 g/j; 7.01 ± 0.93 g/j and 5.45 ± 0.16. An important difference has been observed with rats consuming the diet SOMA and those consuming the rehabilitation diets (PIRI and control) ($P \leq 0.05$). However, there was not important difference between the diet PIRI and the control diet ($P \geq 0.05$) (Table 4).

Table 3. Chemical composition of the three diets

Parameter	Control diet	SOMA	PIRI
Protein g/100g d.m	15.29 ± 0,07[a]	14.97 ± 0,6[a]	15.26 ± 0.1[a]
Fat g/100g d.m	37.3 ± 0.07[a]	32.45 ± 0.03[b]	34.92 ± 0,03[d]
Carbohydrates g/100 d.m	0.4 ± 0.01[a]	0.4 ± 0.01[a]	0.4 ± 0.01[a]
Energy kal/100g d.m	574.40 ± 3.02[a]	570.19 ± 4,0[a]	570.19 ± 5.0[a]
Ash g/100 d.m	2.12± 0.02[a]	2.6 ± 0.05[b]	2.1 ± 0.09[c]

Each value is the average followed by the standard deviation of three experiments.
[abc:] There is not important difference between two values of the same line topped by the same letter.
Dry matter: d.m

3.1.2. Growth parameters

3.1.2.3. Growth in height and weight

From the first to the tenth day, rats have lost 20% of their weight. By the tenth day, a growth in weight has been observed with the diet SOMA.

The growth in weight permits to evaluate growth performances. Underfed rats which consumed rehabilitation diets grew in weight (figure 3). The growth performances of the SOMA, the control diet and PIRI are respectively 2.82 ± 0.73; 2.64 ± 0.61 and 2.03 ± 0.48. The growth in weight averages didn't show important differences ($P \leq 0.05$).

3.1.2.2. Total Protein ingested

The levels of protein ingestion are organized in a decreasing order (SOMA, control diet, PIRI): 1.04 ± 0.43; 0.91 ± 0.32 and 0.83 ± 0.2. The control diet and PIRI did not show important difference ($P \geq 0.05$).

3.1.2.3. Food Coefficient

The most important Food Coefficient has been registered with the control diet, and the less important with the PIRI. However, there was not important difference between the control diet (0.45 ± 0.05) and SOMA (0.40 ± 0.08) (P ≥ 0,05) contrary to PIRI (0.37 ± 0.03) ($P \geq 0.05$).

3.1.2.4. Protein coefficient (P.C)

The control diet, SOMA and PIRI have respectively presented their protein coefficient as follows: 2.90 ± 0.11; 2.73 ± 0.12 and 2.44 ± 0.21. The control diet and SOMA didn't show important difference ($P \geq 0.05$), but are different to PIRI.

3.1.3. Study parameters of the nitrogenous balance sheet

3.1.3.1. Real Digestibility (r.D)

The real digestibility of the control diet, SOMA and PIRI row in an ascending order 87.36 ± 0.12; 89.48 ± 1.16 and 96.16 ± 0.37. Statistically, the real digestibility of diets are significantly different (p ≤ 0 05). (Table 4)

3.1.3.2. Net Protein Used (NPU)

The Net Protein used (NPU) of the control diet, SOMA and PIRI are respectively 90.23±0.06%; 90.25±0.24%; 96.22 ±0.42%. The (NPU) of the control diet is almost identic to that of the SOMA and very different to that of PIRI ($p \leq 0.05$).

3.1.3.3. Biologic Value (BV.)

The Biologic Value (BV) expresses the bio-avaibility of food protein in the organism. All the diets have presented important biologic values which vary between 91.13 ± 0.05% and 96.58 ± 0.42. The diet PIRI presented the best biologic value (96.58 ± 0.42). The control diet is almost identic to SOMA and very different to PIRI ($p \leq 0.05$).

Table 4. Growth parameters of rats that consumed the different diets.

Parameters	**Control**	**SOMA**	**PIRI**
DSI (g/d)	5.97 ± 0.92^{a}	7.01 ± 0.93^{b}	5.45 ± 0.16^{a}
TP (g/d)	0.91 ± 0.32^{a}	1.04 ± 0.43^{b}	$0.83 \pm 0{,}2^{a}$
GW (g/d)	2.64 ± 0.61^{a}	2.82 ± 0.73^{a}	2.03 ± 0.48^{a}
FC	0.45 ± 0.05^{a}	0.40 ± 0.08^{a}	0.37 ± 0.03^{b}
PC	2.90 ± 0.11^{a}	2.73 ± 0.12^{a}	2.44 ± 0.21^{b}

Each reading is the average followed by the examination of three tests.
a,b,c : there is not significant difference between two values of the same line topped by the same letter.
T.P: Total Protein; FC: Food Coefficient; P.C: Protein Coefficient (P.C)

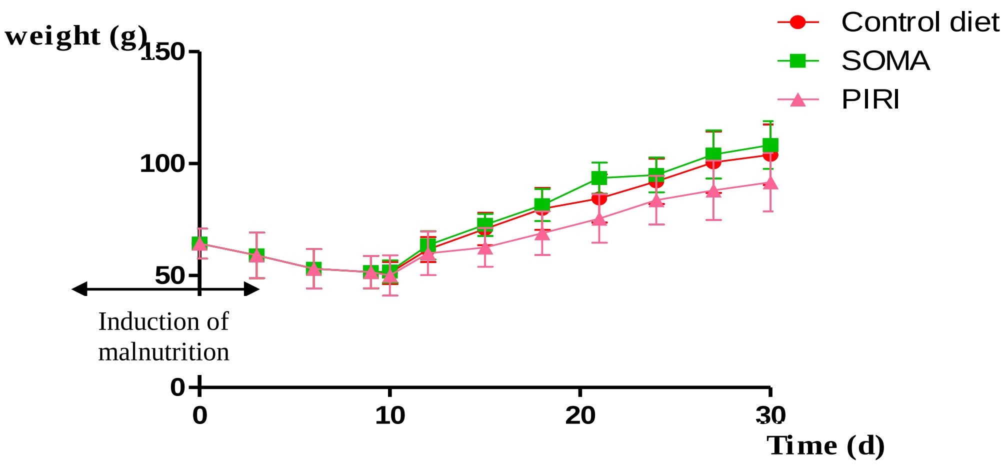

Figure 1: Growth in weight of the three groups of rats

Control diet: Plumpy nut, SOMA: Soya- Maize, PIRI: Pistachio-rice

Table 5. *real Digestibility (r.D), Net Protein used (NPU) and Biologic Value (B.V) of the different diets*

	Control	SOMA	PIRI
r.D (%)	87.36±0.12[a]	89.48±1.16[b]	96.16±0.37[c]
N.P.U (%)	0.91±0.32[a]	1.04±0.43[b]	0.83±0.2[a]
B.V (%)	91.13±0.05[a]	91.21±0.22[a]	96.58±0.42[b]

Each reading is the average followed by the examination of three tests.
[a,b,c] : there is not significant difference between two values of the same line topped by the same letter

4. DISCUSSIONS

The analysis of the chemical composition, the growth and the balance sheet diets have been used to evaluate the performance of underfed rats' nutritional rehabilitation. The quantity of consumed foods for the SOMA, the control diet and PIRI classified in descending order are respectively 7.01 ± 0.93 g/day, 5.97 ± 0.92 g/day and 5.45 ± 0.16 g/day. Every diet has been appreciated according to the food consumption and has also helped to restart the growth in weight of underfed rats. The reasons can be multiple (aroma, taste, color, texture and chemical composition of food). So, the taste, the color, the aroma and the texture have an indispensable role in the qualitative appreciation of food [21]. This growth could be justified by the good nutritional quality of diets. Indeed, the chemical analyses of diets have shown that their contents in nutriments are balanced in comparison with the control diet.

The control diet contents in proteins and lipids are respectively 15.29 ± 0.07% and 37.3 ± 0.07%, those of PIRI (Protein 15.26 ± 0.1%, fats 34.92 ± 0.06 % dry matter) and SOMA (protein 14.97 ± 0.6 % and fats 32.45 ± 0.03 %). Moreover, the energetic values of the control diet (574.40 ± 3.02 kcal) and SOMA (570.19 ± 5.0 kcal) are approximately identical. The same observations have been made with the diets content in proteins. The growth in weight restart of the subjects which just consumed diets following a severe underfeeding could partially be explained by the biochemical profile of these diets. Proteins supply is the major nutritional determinant required to activate proteins synthesis. This is due to the increase of amino acids in the blood after the digestion [17].

Food efficiency (F.E) is the result of growth in weight timed by the quantity of Dry Substance Ingested (D.S.I) (g). It explains the production with which the nutriment is assimilated. The protein efficiency coefficient explains the production of the proteins. In this survey, the whole parameters which explain the efficiency of the global use are higher for the SOMA diet followed by the control diet and the PIRI. These values are largely superior to those of [5] which fluctuated from 1.07 ± 0,13 to 2.34 ± 0.69 for the Protein Efficient (P.E) and from 0.13 ± 0.00 to 0,25 ± 0,11 for the Food Coefficient.

Diets with a digestibility under 70% are not able to provide all the energetic needs, even though they are distributed ad libitum [26].

Besides, every value of the real digestibility (rD) of the diets analyzed are largely superior to 70%. They have fluctuated from 87.36 ± 0.12% to 96.16 ± 0.37%. The digestibility shows the potential protein rate that can be useful to the organism. These real digestibility values are comparable to those of [13]. (84.36 ± 3.41% to 97.13 ± 0.46%) in their survey on the normal breads and composite bread containing flour of seeds of delipidated Citrullus lanatus (Cucurbitaceae).

Indeed, cooking ameliorates foods digestibility and their attractiveness to consumers [23]. These diets are the combination of foods with diverse ingredients according to [6]. Cooking causes an amelioration of organic materials, which could cause its best digestibility. So, it would be just to deduce not only the good quality of the analyzed diets proteins but also the good quality of their digestibility. It exists a narrow relation between the nutritional value of the protein and its physicochemical and functional properties. This relation depends on protein digestibility [14]. These results confirm these observations and could partially explain the efficiency and weight of underfed rats submitted to different diets.

The use of infested proteins is determined by the proportion of absorbed proteinic nitrogen, but also by the diet composition in amino acid. The net protein used of the tested diets are respectively 90.23 ± 0.06%, 90.25 ± 0,24 and 96.22 ± 0,42 % for the control diet, the SOMA and PIRI. These NPU are superior or equal to that of the control diet (Plumpynut) and also superior or equal to that of the spiruline (53% to 61%) commonly used for the nutritional therapy of underfed children [8, 10]. That can also justify the good digestibility of the different diets proteins. Biological Values (B.V) express the biodisponibility of food proteins in the body. As well as the N.P.U, the diets PIRI (96.58 ± 0.42%) and SOMA (91.21 ± 0.22) have shown biological values (VB) that are superior or equal to the control diet (91.13 ± 0.05). These best biological values could be justified by the balance of diets fundamental amino acids. This confirms the good use of these diets protein. Biological values (BV) express the bio availability of foods proteins in the body. As well as the N.P.U, the diets PIRI (96.58 ± 0.42%) and SOMA (91.21 ± 0.22) have shown Biological values (VB) that are superior or equal to the control diet (91.13 ± 0.05). These best biological values could be justified by the balance of diets acids. This confirms the good use of these diets protein. Thus, all the parameters related to the nutritional value of diets have permitted good zoo-technic performances on young underfed rats.

5. CONCLUSION

The Dry substance Ingested (DSI), the Total Protein (T.P), the Growth in Weight (GW), the Food coefficient (FC), the Protein coefficient (PC), the real Digestibility (r.D), the Net Protein used (NPU) and Biologic Value *(*BV), have helped to know about the growth performances of the underfed rats submitted to the following diets. The survey undertaken reveals that the present diets of rehabilitation possess a best nutritional value and favor a growth in weight for the underfed rats. These results show that the experimental diets have similar performances or even superior to those of Plumpynut. Thus, these diets could also be hopeful to the nutritional criteria. Nevertheless, some additional surveys are needed to check if the consumption of these diets is pathologically harmful to the regulating organs of nutrition.

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