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Effects of Ivorian Local Food Substitute (PASLocs) on Blood Glucose, Transaminases (ASAT and ALAT), and Markers of Kidney Function (Urea, Creatinine, and Uric Acid) in Malnourished Rat

Zannou-Tchoko Viviane Jocelyne[1*], Koko Koffi Bruno[1], Yéboué Kouamé Hermann[1], Kati-Coulibaly Séraphin[1]

[1]Laboratory of Biology and Health, Félix Houphouet-Boigny University, Abidjan, Côte d'Ivoire, 22 PO Box 582 Abidjan 22, Côte d'Ivoire

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***Corresponding author:** Zannou-Tchoko Viviane Jocelyne
Laboratory of Biology and Health, Félix Houphouet-Boigny University, Abidjan, Côte d'Ivoire, 22 PO Box 582 Abidjan 22, Côte d'Ivoire

Abstract **Original Research Article**

Malnutrition is a disease that primarily affects developing countries. Children under 5 years of age are the most affected. Nutritional intervention is therefore necessary, even urgent. Ready-to-use therapeutic foods such as Plumpynut have been recommended by WHO and UNICEF for the nutritional care of children suffering from severe acute malnutrition. Unfortunately, recurring stock shortages compromise the care of malnourished children. The objective of this study was to evaluate the effects of local foods (PASLocs) on the health of malnourished subjects. To this end, rats were fed with Anagobaka, a low-protein food, for 14 days. These rats were then refed for 16 days with local foods (PASLocs) and Plumpynut (reference food). Biochemical analyses performed on the malnourished rats, revealed the following abnormalities: decreased blood glucose, and increased levels of transaminases and uric acid. However, after refeeding the malnourished animals with local food (PASLocs fortified and unfortified) and Plumpynut. All the observed abnormalities were corrected. The local foods promoted the recovery of liver and kidney function in the malnourished rats. This study showed that, micronutrient enrichment optimized the results. Local foods can therefore be substituted for conventional products such as Plumpynut. Their use would thus prove effective in the treatment of severe acute malnutrition.

Keywords: Severe acute malnutrition, Plumpynut, PASLocs, Wistar rats, Biochemical parameters, Local foods.

INTRODUCTION

Regardless of the geographical area, malnutrition is a significant threat to human health [1,2]. Worldwide, in 2022, 45 millions children were acutely malnourished, including at least 13.6 millions with severe acute malnutrition (SAM). Malnutrition is a public health problem, especially in developing countries [3,4]. Malnutrition has many causes at different levels: access to safe drinking water, sanitation and hygiene, income, education and quality health services. Moreover, the common cause of all these forms of malnutrition is an inadequate diet, including poorly orchestrated weaning. In Côte d'Ivoire, the nutritional situation remains worrying with regional disparities and rates approaching the emergency threshold of 10%. In 2021, 8% of children suffered from acute malnutrition, 23% from chronic malnutrition (the most common form), 14% from underweight, 3% from overweight and obesity, and 26.7% from vitamin A deficiency [5,6]. The management of malnutrition is therefore necessary, even urgent. Ready-to-use therapeutic foods such as Plumpynut have been recommended by WHO and UNICEF for the nutritional care of children suffering from severe acute malnutrition. However, recurring stock shortages and difficulties in procuring these specialized products compromise the nutritional treatment of patients and lead to users abandoning the program [7,8]. Products made from local foods, called PASLocs, have therefore been developed as an alternative to Plumpynut. Previous studies have shown that these substitutes have good nutritional value and have led to weight recovery in severely malnourished rats [9,10]. The objective of the current work is to evaluate the effect of Local Food Substitution Products (PASLocs) on the health of a subject suffering from severe acute malnutrition. Specifically, we will determine the effect of PASLocs on blood glucose, ASAT and ALAT transaminases and markers of renal function (urea, creatinine and uric acid) in young malnourished rats.

MATERIALS AND METHODS

1. Material

1.1. Animal Materials

The animal material consisted of young Wistar rats weighing an average of 55 ± 0.5 g and aged 4 to 6 weeks. They were obtained from the Vivarium of the École Nationale Supérieure (ENS), Abidjan, Côte d'Ivoire.

1.2. Food Materials

The food materials consisted of four local products (maize, millet, soybeans, and sorghum), milk, sugar, refined palm oil, Anagobaka flour, Plumpynut, micronutrients (vitamin and mineral complex) used for food fortification, and the standard diet (composed of bread, peanuts, and millet). Apart from the Plumpynut provided by Nutriset and the micronutrients provided by UNICEF and WFP, all other ingredients were commercially available. Plumpynut is a specialized food product commonly used for nutritional rehabilitation and as a reference food.

Local products (maize, millet, soybeans, and sorghum), milk, sugar, and refined palm oil were used to formulate the PASLocs. Anagobaka flour is a low-protein infant flour that has been used to induce malnutrition in rats [10]. The standard diet (mixture of dry bread, maize, millet, soybeans, and peanuts) is the diet given to normal, healthy, untreated control rats. Micronutrient powder (vitamin and mineral complex) provided by UNICEF and WFP was used for home food fortification.

2. Methods

2.1. PASLocs Formulation

The formulation was carried out in two stages in accordance with the recommendations of the National Nutrition Program [8]. First, the grains of each ingredient (maize, millet, sorghum, and soybeans) were separately cleaned manually to remove all impurities, then washed with tap water. The grains were then rehydrated for 24 hours, drained, and germinated. The germinated grains were hulled and then ground. The resulting flours were sun-dried for 3 days, protected from contamination, then sifted and subsequently roasted over low heat. The flours were then air-cooled, protected from dust and insects, etc., and then stored in screw-top plastic containers, away from moisture [8]. Secondly, three PASLocs were formulated from mixtures of Maize, Millet, Sorghum and Soy flours and other ingredients in the proportions recorded in Table I [8]. These are: the Maize-Milk (MaLait), Millet-Soy (MiSoj) and Soybean-Sorghum (SoSorg) diets.

2.2. Chemical composition of the diets

The chemical constituents of the diets are listed in Table II. The PASLocs (MaLait, MiSoj and SoSorg), Plumpynut, Anagobaka and standard diets contain protein (2 to 16.85 ± 0.01%), fat (6.04 ± 0.11 to 20.22 ± 0.01%) and carbohydrate (48.91 ± 0.0 to 82.1 ± 0.94%).

2.3. Preparation of porridge from test-diet flours

Except for the reference food, Plumpynut, which is a ready-to-use therapeutic food, the PASLocs and Anagobaka diets have been subjected to cooking. At the rate of 100 g of flour per 50 mL of tap water, Anagobaka flour and each PASLocs (mixture of ingredients) were separately dissolved in water and brought to low heat under constant agitation. After 5 minutes of cooking, the bouilles were left in the air for cooling before being served to the animals [10]. Two types of porridge were served: porridge with micronutrients added before feeding and porridge without micronutrients.

2.4. Animal testing

The experiment used 47 rats. Each was housed in metabolic cages and maintained under normal laboratory conditions (temperature 25 °C) with a cycle of darkness and light (12/12 h). Rats were treated according to good laboratory practices [11]. The experimental protocols were followed in accordance with the protocols for the protection of experimental animals of the European Council on Legislation 2012/707 [12]. According to the method of Egnon *et al.,* (2016b), the experiment lasted 30 days and was carried out in two phases: the phase of undernutrition with Anagobaka and the phase of re-feeding animals malnourished with local food (PASLocs) and the reference food (Plumpynut). The undernutrition phase lasted 14 days. 42 young rats, divided into seven groups of six animals, were all fed the Anagobaka diet daily. At the end of this phase, 7 malnourished rats (one rat randomly selected from each batch) were sacrificed [13]. Their blood was collected for biochemical analyses (glucose, ASAT and ALAT transaminases, urea, creatinine and uric acid). The refeeding phase lasted 16 days. The malnourished rats, numbering 35, were divided into 7 batches of 5 rats per batch. The 5 malnourished rats from lot 7 received the reference food Plumpynut daily. As for those from batches 1, 2 and 3, they were fed respectively with the PASLocs MaLait, MiSoj and non-fortified SoSorg diets, while those from batches 4, 5 and 6 received the fortified MaLait^{+}, MiSoj^{+} and SoSorg^{+} diets. The day after the end of the nutritional rehabilitation phase, all the animals were sacrificed. As before, blood was collected for biochemical analyses (glucose, ASAT and ALAT transaminases, urea, creatinine, and uric acid).

3. RESULTS

3.1. Glucose levels

The glucose level recorded in normal rats from the standard control batch was 1.70 ± 0.02 mg/mL. The Anagobaka diet led to a drop in animal weight with a significant decrease ($p > 0.05$) in glucose levels (1.12 ± 0.13 mg/mL). The unfortified and fortified diets (MaLait, MiSoj and SoSorg) and (MaLait^{+}, MiSoj^{+} SoSorg^{+}), like

Plumpynut, reduced blood glucose levels to values close to those of the normal control rats. However, no significant difference was observed ($p > 0.05$). The fortification did indeed increase glucose levels but had no significant impact ($p > 0.05$) on blood sugar levels compared to the values measured in animals fed with fortified PASLocs and those fed with unfortified PASLocs (Table III).

3.2. ASAT levels

The results of the blood ASAT assay in the experimental rats are given in Table IV. The ASAT level measured in normal rats was 231 ± 6 µmol/min.L. Malnourished rats fed with Anagobaka showed a high value of 241 ± 5 µmol/min.L, indicating a significant difference ($p < 0.05$). When the malnourished rats were refed with the test diets (Local Diet and Plumpynut), there was a decrease in ASAT levels, bringing them closer to those of normal control rats. Statistical analysis revealed no significant difference ($p > 0.05$), except with the SoSorg$^+$ diet. The recorded levels were 230.5 ± 5.50 µmol/min.L with Plumpynut, 230 ± 8 µmol/min.L with MaLait, 235.5 ± 7.25 µmol/min.L with MiSoj, and 233 ± 7 µmol/min.L with SoSorg. For the fortified diets, the levels recorded were 226.50 ± 7.5 µmol/min.L with MaLait$^+$, 229.75 ± 9.75 µmol/min.L with MiSoj$^+$, and 200 ± 10 µmol/min.L with SoSorg$^+$. Fortification reduced ASAT levels, but the difference was statistically significant compared to that obtained with SoSorg$^+$ diet ($p < 0.05$).

3.3. ALAT levels

The ALAT level recorded in control rats was 90 ± 10 µmol/min.L. This level increased to 135 ± 10 µmol/min.L in malnourished rats fed with Anagobaka. There was a significant increase ($p < 0.05$). Refeeding with rehabilitation diets reduced ALAT levels, bringing them closer to those obtained in normal control rats. Statistical analysis shows no significant difference ($p > 0.05$). The recorded values were 89.33 ± 7.10 µmol/min.L with Plumpynut, 91 ± 10.50 µmol/min.L with MaLait, 92 ± 9 µmol/min.L with MiSoj and 91,50 ±10 with SoSorgh. The fortified diets showed the following values: 81.50 ± 13 µmol/min.L with MaLait$^+$, 85.50 ± 12.50 µmol/min.L with MiSoj$^+$ and 87 ± 7 µmol/min.L with SoSorg$^+$. Although fortification reduced ALAT levels in the refed rats, no significant difference ($p > 0.05$) was observed in Table IV.

3.4. Urea Levels

The urea levels measured in experimental rats are reported in Table VIII. The Anangobaka diet caused an increase, in urea levels in rats, without any significant difference ($p > 0.05$). This urea level, which was 0.27 ± 0.02 mg/L in normal control rats, reached an average value of 0.32 ± 0.02 mg/L in rats fed with Anogobaka. In undernourished rats fed with Plumpynut for 16 days, the urea level was estimated at 0.27 ± 0.02 mg/L. The urea level varied between 0.27 ± 0.02 and 0.30 ± 0.02 mg/L in malnourished rats refed with unfortified PASLocs (MaLait, MiSoj and SoSorg). Urea values ranging from 0.26 ± 0.02 to 0.28 ± 0.02 mg/L were recorded at the end of the 16 days period in malnourished rats treated with fortified PASLocs (MaLait$^+$, MiSoj$^+$ and SoSorg$^+$). The PASLocs and Plumpynut have thus restored in an identical manner, the disruption of the urea rate induced by the occurrence of malnutrition in animals under the Anangobaka diet. No statistically significant difference was observed ($p > 0.05$) between the urea levels of malnourished and refed rats and those of normal control animals. Also, no significant difference was observed between the fortified and unfortified PASLocs diets.

3.5. Creatinine levels

Malnutrition induced by Angobaka decreased creatinine levels in rats without any significant difference ($p > 0.05$) (Table VIII). From a mean value of 7.5 ± 1 mg/L in normal control rats, creatinine levels decreased to 6.66 ± 0.88 mg/L. Consumption of PASLocs (fortified and unfortified) and Plumpynut by malnourished rats, did not significantly alter ($p > 0.05$) creatinine levels, compared to those measured in control rats. However, a normalization, marked by a slight increase was observed with MaLait, MiSoj, and SoSorg, reaching 7.5 ± 1 mg/L, 6.25 ± 1.25 mg/L and 6.75 ± 1.25 mg/L respectively. With MaLait$^+$, MiSoj$^+$, and SoSorg$^+$, creatinine levels were 6.25 ± 0.77 mg/L, 6.25 ± 0.87 mg/L, and 7.33 ± 1.11 mg/L, respectively. Plumpynut showed 6.44 ± 0.44 mg/L. No significant difference was reported between creatinine levels in rats malnourished fed with the local food ($p > 0.05$) and those fed with Plumpynut. The addition of micronutrients did not significantly impact the effect of PASLocs on creatinine levels.

3.6. Uric acid levels

The uric acid level measured in normal control rats was 51.25 ± 2.25 mg/L, and this level increased to a high and significant value of 58.2 ± 1 mg/L ($p > 0.05$) in malnourished rats.

Nutritional rehabilitation corrected the alteration. Indeed, the unfortified PASLocs diets (MaLait and SoSorg) and fortified diets (MaLait$^+$, MiSoj$^+$, and SoSorg$^+$), as well as the Plumpynut diet, reduced uric acid levels to between 49 ± 1.25 and 51 ± 2 mg/L. The Plumpynut and rehabilitation diets showed similar values, which were also comparable to those recorded in normal control rats. No significant difference was observed ($p > 0.05$). The comparison of uric acid levels measured with fortified and non-fortified PASLocs diets showed a decrease in uric acid levels with MaLait and SoSorg diets, however, no significant difference was reported at $p > 0.05$ (Table V).

4. DISCUSSION

This study showed that Anagobaka (the diet used to induce malnutrition) significantly altered biochemical parameters. The observed disturbances, namely a decrease in glucose levels and an increase in

ASAT, ALAT, and uric acid levels, were confirmed by the work of Lemille *et al.,*[14]. However, refeeding with the PASLoc diets (fortified and unfortified) and the reference diet Plumpynut restored blood glucose, transaminase, and uric acid levels to normal values close to those of normal control rats. Blood glucose levels, which had been affected in the malnourished rats [15], normalized with the rehabilitation diets. Indeed, the glucose level which was low in these sick rats, increased with refeeding. Because PASLocs are balanced, nutrient-rich foods, they regulated blood sugar levels by correcting hypoglycemia in malnourished animals [16]. Food fortification improved blood glucose levels compared to unfortified foods, although they did not exceed normal values [17]. The high values of ALAT and ASAT transaminases obtained at the end of the malnutrition phase reflected hepatic hyperactivity with consequent cytolysis [18] [19]. However, when the PASLocs diets (fortified and unfortified) and the reference diet Plumpynut were administered to the rats, ASAT and ALAT levels decreased significantly, approaching those recorded in untreated normal rats in the control group. PASLocs, like Plumpynut, therefore helped to correct the hepatic disturbance caused by malnutrition. These results corroborate those of Egnon [20] [21]. The elevated ALAT and ASAT transaminase levels observed at the end of the malnutrition phase reflected hepatic hyperactivity resulting in cytolysis [18] [19]. However, when the PASLocs diets (fortified and unfortified) and the reference diet Plumpynut were administered to the rats, ASAT and ALAT levels decreased significantly, approaching those recorded in untreated normal rats in the control group. PASLocs, like Plumpynut, therefore helped to correct the hepatic disturbance caused by malnutrition. These results corroborate those of Egnon [20]. Fortification significantly reduced ASAT levels in rats that were malnourished and then refed with the SoSorg$^+$ diet ($P < 0.05$).

Urea, creatinine, and uric acid levels measured in the malnourished rats had also increased. Refeeding with local foods reduced these elevated levels to values comparable to those of control rats [20]. The malnourished state led to glycemic, hepatic, and renal dysfunction in the rats. However, nutritional rehabilitation with PASLocs, restored these abnormalities. PASLocs thus promoted the recovery of vital functions disrupted by malnutrition, consistent with previous studies. Fortification potentiated the effects of PASLocs.

Table I: Ingredients proportions for the MaLait, MiSoj and SoSorg diets

Diets		**Corn**	**Millet**	**Sorghum**	**Soybeans**	**Milk**	**Sugar**	**Oil**
	MaLait	35 %	-	-	-	35 %	24 %	6 %
PASLocs	MiSoj	-	52 %	-	26 %	-	9 %	13 %
	SojSorg	-	-	52 %	26 %	-	9 %	13 %

PASLocs: Alternative Food Products Based on Local Food; MaLait: Corn-Milk; MiSoj: Millet-Soybean; SoSorg: Soy-Sorghum.

Table II: Chemical Composition and Energy Value of Test Diets

Diets		**Protéin** (% MS)	**Fat** (% MS)	**Carbohydrates** (% MS)	**Fiber** (% MS)	**EV**(Kcal)
Standard (Control)		14±0,06^b	19±0,04^c	52±0,1^c	11±0,06^b	435^c
Anangobaka		2,04±0,03^a	6,04±0,11^a	82,1±0,94^e	-	390,32^a
Plumpynut		13,91±0,00^b	32,91±0,0^f	48,91±0,0^a	-	543,47^d
	MaLait	16,85±0,01^e	6,47±0,02^b	72±0,05^d	2,96±0,02^a	413,63^b
PASLocs NF	MiSoj	14,89±0,01^d	20,22±0,01^e	50,42±0,02^b	12±0,3^c	443,22^c
	SoSorg	14,43±0,01^c	20,12±0,03^d	51,9±0,00^c	11±0,01^b	446,40^c
	MaLait$^+$	16,85±0,01^e	6,47±,02^b	72±0,05 ^{d}	2,96±0,3^a	413,63^b
PASLocs F	MiSoj$^+$	14,89±0,01^d	20,22±0,01^e	50,42±0,02^b	12±0,3^c	443,22^c
	Sosorg	14,43±0,01^c	20,12±0,03^d	51,90±0,01^c	11±0,01^b	446,40^c

Standard: Diet of the control batch (mixture of bread, millet, soybean, peanut). PASLocs NF: Alternative Food Products Based on Local unfortified Foods; PASLocs F: Alternative Food Products Based on Local fortified Foods; EV (Kcal): Energy value in kilocalories; % MS: Percentage of Dry Matter; MaLait: Corn-Milk; MiSoj: Millet-Soybean; SoSorg: Soybean-Sorghum; MaLait$^+$: Corn-Milk fortified; MiSoj$^+$: Millet-soybean fortified; SoSorg$^+$: Soybean-Sorghum fortified.

Table III: Blood sugar levels in malnourished rats then refed with PASLocs

Diets		**Glucose levels (mg/mL)**
Standard		1,70 ± 0,02^b
Anagobaka		1,12 ± 0,13^a
Plumpynut		1,78 ± 0,02^b

Diets		Glucose levels (mg/mL)
	MaLait	1,81 ± 0,04^{b}
PasLocs NF	MiSoj	1,82 ± 0,05^{b}
	SoSorg	1,81 ± 0,02^{b}
	MaLait^{+}	1,86 ± 0,04^{b}
PASLocs F	MiSoj^{+}	1,86 ±0,03^{b}
	SoSorg^{+}	1,85 ± 0,01^{b}

Rehabilitation duration: 16 days. m ± esm; n = 5. The averages are followed by letters in super script (a, b, c). The averages with different letters in the same column are statistically different ($p > 0.05$). There is no significant difference ($p > 0.05$) between two values in the same column topped by the same letter; Standard: Diet of the control group (mixture of bread, millet, soybean, peanut). PASLocs NF: Alternative Food Products Based on Local unfortified Foods; PASLocs F: Alternative Food Products Based on Local fortified Foods; MaLait: Corn-Milk; MiSoj: Millet-Soybean; SoSorg: Soy-Sorghum; MaLait^{+}: Corn-Milk fortified; MiSoj^{+}: Millet-soybean fortified; SoSorg^{+}: Soy-Sorghum fortified.

Table IV: ASAT and ALAT levels in malnourished rats refed with PASLocs

Diets		**ASAT** (µmol/min.L)	**ALAT** (µmol/min.L)
Standard (control)		231 ± 6^{b}	90 ± 10^{a}
Anagobaka		241 ± 5^{c}	135 ± 10^{b}
Plumpynut		230,5 ± 5,5^{b}	89,33 ± 7,10^{a}
	MaLait	230 ± 8^{b}	91 ± 10,50^{a}
PASLocs NF	MiSoj	235,25 ± 7,5^{b}	92 ± 9^{a}
	SoSorg	233 ± 7^{b}	91,50 ±10^{a}
	MaLait^{+}	226,50 ± 7,5^{b}	81,50 ± 13^{a}
PASLocs F	MiSoj^{+}	229,75 ± 9,75^{b}	85 ± 12,50^{a}
	SoSorg^{+}	200 ± 10^{a}	87 ± 7^{a}

Rehabilitation duration: 16 days. m ± esm; n = 5. The averages are followed by letters in super script (a, b, c). The averages with different letters in the same column are statistically different ($p > 0.05$). There is no significant difference ($p > 0.05$) between two values in the same column topped by the same letter; Standard: Diet of the control group (mixture of bread, millet, soybean, peanut). PASLocs NF: Alternative Food Products Based on Local unfortified Foods; PASLocs F: Alternative Food Products Based on Local fortified Foods; MaLait: Corn-Milk; MiSoj: Millet-Soybean; SoSorg: Soy-Sorghum; MaLait^{+}: Corn-Milk fortified; MiSoj^{+}: Millet-soybean fortified; SoSorg^{+}: Soy-Sorghum fortified.

Table V: Urea, creatinine, and uric acid levels in malnourished rats fed with PASLocs

Diets		**Urea** (mg/L)	**Creatinine** (mg/L)	**Uric acid** (mg/L)
Standard (control)		0,27 ± 0,02^{a}	7,5 ± 1^{a}	51,25 ± 2,75^{a}
Anagobaka		0,32 ± 0,02^{a}	6,66 ±0,88^{a}	58,20 ± 1^{b}
Plumpynut		0,27 ± 0,02^{a}	6,44 ± 0,44^{a}	49 ± 1,33^{a}
	MaLait	0,27 ± 0,02^{a}	7,50 ± 1^{a}	50,75 ± 2,80^{a}
PASLocs NF	MiSoj	0,29 ± 0,02^{a}	6,25 ± 0,80^{a}	50,25 ± 1,75^{a}
	SoSorg	0,30 ± 0,02^{a}	6,75 ± 1,25^{a}	51 ± 2^{a}
	MaLait^{+}	0,26 ±0,02^{a}	6,25 ± 0,77^{a}	49 ± 1,25^{a}
PASLocs F	MiSoj^{+}	0,27 ±0,02^{a}	6,25± 0,87^{a}	49 ±1,25^{a}
	SoSorg^{+}	0,28 ± 0,02^{a}	7,33 ± 1,11^{a}	50,50 ± 0,3^{a}

Rehabilitation duration: 16 days. m ± esm; n = 5. The averages are followed by letters in super script (a, b, c). The averages with different letters in the same column are statistically different ($p > 0.05$). There is no significant difference ($p > 0.05$) between two values in the same column topped by the same letter; Standard: Diet of the control group (mixture of bread, millet, soybean, peanut). PASLocs NF: Alternative Food Products Based on Local unfortified Foods; PASLocs F: Alternative Food Products Based on Local fortified Foods; MaLait: Corn-Milk; MiSoj: Millet-Soybean; SoSorg: Soy-Sorghum; MaLait^{+}: Corn-Milk fortified; MiSoj^{+}: Millet-soybean fortified; SoSorg^{+}: Soy-Sorghum fortified.

5. CONCLUSION

The present study showed that the biochemical abnormalities created by undernutrition in rats were repaired by PASLocs (fortified and non-fortified). The results of the work showed that, overall, the measurements carried out with PASLocs (fortified and non-fortified) and the reference Plumpynut diet are statistically identical and they are also identical with those of normal control rats. Micronutrient fortification had beneficial effects by improving the levels of ASAT and ALAT transaminases, uric acid, and glucose in rats that were degraded and then refed with PASLocs diets. The use of local food diets among children suffering from malnutrition would therefore prove to be effective, and these PASLocs could be used in disorders and certain nutritional pathologies.

Abbreviations

ASAT: Aspart Aminotransferase
ALAT: Alanine Aminotransferase
ENS: École Normale Supérieure (French National School of Teacher Training)
MaLait: Unfortified Corn-Milk
MaLait^{+}: Fortified Corn-Milk
MiSoj: Unfortified Millet-Soybean
MiSoj^{+}: Fortified Millet-Soybean
SoSorg: Unfortified Soybean-Sorghum
SoSorg^{+}: Fortified Soybean-Sorghum
PASLocs: Locally Produced Substitute Food Products
PASLocs F: Fortified Locally Produced Substitute Food Products
PASLocs NF: Unfortified Locally Produced Substitute Food Products
PNN: National Nutrition Program

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