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Evaluation of Anemic Pupils Nutritional Status Fed with Recipes Based on Sweet Potatoes, Soya and Cowpea in Nawa Region, Côte d'Ivoire

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Abstract In underdeveloped countries a great number of school-age children suffered of malnutrition and anemia. This is due to a less diversified diet and had an impact on their intellectual capacities. A study was conducted in four schools in Nawa region of Côte d'Ivoire with the aim to evaluate the impact of selected foods on anemic children nutritional status. One meal was proposed by school: rice with tomato sauce and meat, sweet potatoes stew with soya, sweet potatoes stew with cowpea and sweet potatoes stew with soya and cowpea. A total of 75 children aged from 6 to 15 years old participate, and they ate the meals twice in a week for 3 months. Anthropometric measurements (weight and height) and blood sampling were taken at 3 periods: at the beginning, middle and end of the study. The results showed that hemoglobin values were under normal rate for all children except in Petit-Bondoukou and Takoreagui in period 1 (11.67 and 11.82 g/dl respectively). There was an increase of anemia prevalence from 18.18 % to 40.91 % for children who ate rice with tomato sauce and meat and from 43.75 % to 50.00 % for children who ate potatoes stew with cowpea. But there was a decrease of anemia rate from 61.54 % to 53.83 % for children who ate potatoes stew with soya. Nutritional status according to anthropometric measurement increased for children of Gnaboya and Petit-Bondoukou. Albumin (33.25 g/l) and orosomucoid (0.69 mg/l) value of children who ate tomato sauce and meat were lower in period 1 than that of children of the other villages. According to prognostic inflammatory nutritional index, children present a low malnutrition risk which varied between 7.69 to 43.75 %. Diet diversification should be applied for a long period to better appreciate their impact on nutritional and anemia status improvement.

Keywords: *children, diversified diets, anemia, nutritional status*

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1. Introduction

Malnutrition is a public health problem in the world, particularly in developing countries [1]. For instance, chronic malnutrition prevalence was 40.6 % including 15.7 % for the severe form for children under 5 years in 2014 in Cote d'Ivoire [2]. This form of food insecurity is partly due to a lack of food diversification and micronutrients deficiency, particularly during weaning period [3,4]. Anemia caused by iron deficiency but also by vitamin B9 or vitamin B12 deficiency is the most widespread affecting 75% of the children in Côte d'Ivoire [2,3,4,5]. Anemia led to reduced work capacities, reduced ability to execute daily living activities, reduced cognitive functions and risky pregnancy delivery [6]. Iron deficiency anemia in young children results from the higher demand of this micronutrient at growth stage while its bioavailability is often poor in their poorly diversified diets [5]. In most cases, their diet is a porridge of cereals or tubers which are deficient in some amino acids, vitamin A, iron, and folic acid, necessary to cover children needs [7]. As malnutrition, specifically micronutrients deficiency, is linked to food consumption, there is a need to fortify food in essential micronutrients or simply to diversify eating habit.

Côte d'Ivoire is the first producer of cocoa in the world [8] and one would expect that the revenues generated by

this crop allow children of its production area to be better-off with more balanced diets. Unfortunately, surveys conducted in this area revealed, like everywhere in the country, less diversified diets based on rice, white roots, and tubers (92% of households) with little consumption of food rich in vitamin A (9%) and iron (10.76%) [9]. Therefore, high chronic malnutrition prevalence rates of 49% in 2014 and 39.8% in 2015 were recorded [9,10]. This calls for corrective actions aiming at improving nutritional status and thus decrease children vulnerability to anemia [11]. Several studies have revealed possible relations between anemia and diets and nutritional status indices. Indeed, [12] have showed that a minimum dietary diversity was positively associated with hemoglobin concentration among children aged between 6-23 months. Some authors, [13] have indicated that good diet quality, higher total dietary antioxidant capacity and lower energy density were positively associated with dietary anti-inflammatory potential like C-Reactive Protein, homocysteine. But, in these studies, food data was collected according to the 24 hours recall which did not reflect the best usual food intake. To evaluate the improvement of anemic children nutritional status, a food diversification program has been initiated in some school canteens in cocoa production area in Côte d'Ivoire by the integration of sweet potatoes, soya, and cowpea in children's diets.

2. Materials and Methods

2.1. Studied Population

In Nawa region (localized in South-west Côte d'Ivoire), there are several cocoa production villages. In 72 of them, a MARS incorporated, and World Agroforestry Research Center Vision for Change program (V4C) has implemented a cocoa plantation rehabilitation and communities' development program. These villages are grouped in 4 lands. This study is a preliminary one. One village has been chosen randomly in each land before extending the results to the others. The 4 cocoa production villages were: Kragui, Gnaboya, Petit-Bondoukou and Takoreagui.

2.2. Population Size Calculation

A total of 400 children were usually take meals in canteens (100 children per schools). Children sample size (75) was calculated in equation (1) according to [14] and with the expected malnutrition prevalence of children in school-age in cocoa zone (18.36 %) [15].

$$n = Nxp \quad (1)$$

n: sample size
N: enumerated children eaten in school canteens
p: malnutrition rate of studied population (18.36 %)

2.3. Selection Criteria

2.3.1. Inclusion Criteria

- Be regularly registered in the selected school
- Be regular during the study
- Be between 6 and 15 years old
- Have parents' acceptance
- Agree to participate.

2.3.2. Exclusion Criteria

- Not be regularly registered in the selected school
- Be absent or sick during the study
- Be under 6 and over 15 years old
- Refusal of parents
- Disagree to participate.

Children aged have been confirm by consulting birth certificate or child Health-Passport.

2.4. Meals' Distribution and Preparation

2.4.1. Meals' Distribution

Four recipes composed of (1) rice with tomato sauce and meat, (2) sweet potatoes stew with soya, (3) sweet potatoes stew with cowpea and (4) sweet potatoes stew with cowpea and soya were fed twice a week (in respect to what is usually performed at the school canteens of the region) for a three-month period to the children of the canteens of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui, respectively (Table 1). Rice with tomato sauce and meat given in Kragui school canteens was taken as reference because this meal is commonly given in public school canteens.

Table 1. Distribution of Children Participating to Food Diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa Region in Côte d'Ivoire

Village	Number of children enrolled	Meals
Kragui	22	Rice with tomato sauce and meat
Gnaboya	13	Sweet potatoes stew with soya
Petit-Bondoukou	16	Sweet potatoes stew with cowpea
Takoreagui	24	Sweet potatoes stew with cowpea and soya
Total	75	

2.4.2. Meals' Preparation

- Rice with tomato sauce and meat: a total of 5 kg of rice were cooked for 30 minutes in a saucepan containing tap water, oil, and onions. The tomato sauce was prepared by roasting the meat in a little oil. Then, the onions, garlic, and tomato paste were added and the whole was simmered for 30 to 40 minutes with the addition of cooking salt, and nutmeg.

- Sweet potato stew with soya: a total of 1 kg of green soybeans was soaked in hot water for 30 minutes, then pre-cooked for 30 minutes in water with a little salt. Then, 10 kg of sweet potato were peeled and cut. The onions, tomato paste, and garlic were quickly fried in a little oil, to which the pre-cooked soybeans and water were added. The whole content was simmered for 20 to 30 minutes, followed by the addition of sweet potato. The whole was left to cook for another 30 minutes after being salted and seasoned with nutmeg.

- Sweet potato stew with cowpea: a quantity of 1 kg of white cowpea was soaked in hot water for 1 hour, dehulled, and then pre-cooked for 45 minutes in water with a little salt. Then, 10 kg of sweet potato were peeled and cut. The onions, tomato paste, and garlic were swiftly fried in a little oil, to which the recooked cowpea and water were added. The whole content was simmered for 20 to 30 minutes, followed by the addition of the sweet potato. The whole was left to cook for another 30 minutes after being salted and seasoned with nutmeg.

- Sweet potato stew with soya and cowpea: a total of 1 kg of green soybeans was soaked in hot water for 30 minutes and then pre-cooked for 30 minutes in water with a little salt. Also, 1 kg of white cowpea was soaked in hot water for 1 hour, dehulled, and then pre-cooked for 45 minutes in water with a little salt. Besides, 10 kg of sweet potato were peeled and cut. The onions, tomato paste, and garlic were quickly fried in a little oil, to which the pre-cooked cowpea and soybeans were added. The whole was simmered for 20 to 30 minutes, followed by the addition of sweet potatoes. The whole content was left to cook for another 30 minutes after being salted and seasoned with pepper and nutmeg.

2.5. Anthropometric Measurements and Blood Sampling and Analysis

Children parameters, anthropometric measurements (weight and height) and blood sampling (for hematological and biochemical tests) were taken at the beginning (period 1), at the middle (at 1 and ½ month of the beginning) (period 2) and the end (at 3 months of the beginning) (period 3) of the study. Blood sampling was done by professional caregivers of infirmary of each village and blood samples were kept cooler with ice before being routed to laboratory for analysis.

2.5.1. Anthropometric Measurements

Anthropometric measurements (weight and height) were determined using standard tools. Children were weighted on digital weighing scales (SEKA, precision 100.00 g). Their height was measured to the nearest millimetre using a wall height gauge (graduated in mm) in the standing position [16]. These measurements allowed to calculate the Body Mass Index (BMI) which was compared to the WHO BMI per age table for the determination of children nutritional status [17].

2.5.2. Blood Analysis

Hematological tests (blood count) were conducted with SYSMEX (XN-1000) apparatus and biochemical tests (albumin, prealbumin, C-Reactive Protein, orosomucoid) were conducted with COBAS c 311 Spectrophotometer. Anemia severity was determined against two ranges of Hemoglobin (Hg) content as follows: Hg < 11.5 g/dl for anemia in general and Hg < 7.5 g/dl for severe anemia. Hypochromic microcytic anemia was determined based on Mean Corpuscular Volume (MCV < 82 fl) and Mean Corpuscular Hemoglobin Volume (MCHC < 31 g/100ml). Iron deficiency anemia prevails when ferritin value was < 30 µg/l. According to [18], the prognostic inflammatory nutritional index (PINI) was calculated by associating C-Reactive Protein (CRP) and orosomucoid (two inflammation proteins) and albumin and prealbumin (two nutritional proteins) (equation 2).

$$PINI = \frac{CRP\ x\ Orosonucoid}{Albumin\ x\ Prealbumin} \quad (2)$$

Classification:
- PINI < 1: normal
- 1 < PINI < 10: low denutrition risk
- 11 < PINI < 20: moderate denutrition risk
- 21 < PINI < 30: high denutrition risk
- PINI > 30: vital risk.

2.6. Ethical Standards Disclosure and Consent

This study has been approved by the National Ethical and Research Committee of Côte d'Ivoire N / Ref: 009 // MSHP / CNER-kp). In each village, authorities, male nurses and caregivers, school directors and school canteens managers were contacted and informed. Free and written informed consent to participate to the study was obtained from each male nurse, school canteens managers, parents, and children before given food (for meals preparation in canteens) and taking anthropometric measurements and blood sampling on children.

2.7. Statistics

Data were analyzed using STATA-SE 64 software. A Friedman test was used to compare period and correlation was established between anemia, BMI and PINI according to Spearman test at $\alpha = 0.05$.

3. Results

3.1. Children Initial Sample Characteristics

The mean sex ratio was 1.273 with 42 boys and 33 girls and it ranges between 0.625 in Gnaboya and 2.667 in Kragui. On average children were 7 and 8 years old in Gnaboya and Petit-Bondoukou respectively with a median at 7 years. The values were about 9 and 11 years old for both the mean and median for Takoreagui and Kragui, respectively (Table 2).

3.2. Children Anemia Prevalence

Table 3 present the hemoglobin, mean corpuscular volume (MCV) and mean corpuscular hemoglobin volume (MCHC) value of children blood analysis. In general, hemoglobin values were under normal rate (11.5 g/dl) for all children except in Petit-Bondoukou and Takoreagui in period 1 (11.67 and 11.82 g/dl respectively). All MCV values were under normal rate (82 fl) and all MCMH values were upper the normal rate (31 g/100 ml). There is no significant difference of hemoglobin and MCMH value along the study. However, in period 1, there was a significant difference of MCV value between children who ate rice with tomato sauce and meat and children who ate potatoes stew with cowpea and those who ate potatoes stew with soya.

Table 2. Distribution per Sex and Age of Children Participating to Food Diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa Region in Côte d'Ivoire

Villages	Boys	Girls	Sex ratio	Age (years) Means ± S. D	Age (years) median
Kragui (N=22)	16	6	2.667	10.75 ± 2.03	11 years Under: 6-9 Upper: 13-14
Gnaboya (N=13)	5	8	0.625	7.23 ± 1.17	7 years Under: 6 Upper: 8-9
Petit-Bondoukou (N=16)	9	7	1.286	7.81 ± 1.91	7 years Under: 6 Upper: 9-12
Takoreagui (N=24)	12	12	1.000	8.75 ± 1.92	8.5 years Under: 5-7 Upper: 10-12
Total	42	33	1.273		

Table 3. Hematological Parameters Analysis of children Participating to Food diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa Region in Côte d'Ivoire

Periods	Village	Kragui (N=22)	Gnaboya (N=13)	Petit-Bondoukou (N=16)	Takoreagui (N=24)
1	Hg (g/dl)	11.36 ± 1.30[a]	11.25 ± 1.16[a]	11.67 ± 0.87[a]	11.36 ± 1.10[a]
	MCV (fl)	77.04 ± 4.17[a]	79.10 ± 5.07[b]	79.24 ± 5.54[b]	77.04 ± 4.97[a]
	MCMH (g/100ml)	34.21 ± 1.04[a]	33.01 ± 1.50[a]	33.98 ± 1.20[a]	34.21 ± 1.42[a]
2	Hg (g/dl)	11.31 ± 1.05[a]	11.32 ± 1.04[a]	11.04 ± 1.80[a]	11.49 ± 0.89[a]
	MCV (fl)	78.96 ± 5.03[a]	79.78 ± 5.34[a]	78.70 ± 11.62[a]	76.76 ± 4.67[a]
	MCMH (g/100ml)	34.29 ± 1.30[a]	33.38 ± 1.45[a]	33.36 ± 2.95[a]	34.24 ± 1.71[a]
3	Hg (g/dl)	11.82 ± 1.29[a]	10.68 ± 1.10[a]	10.88 ± 0.94[a]	10.88 ± 1.05[a]
	MCV (fl)	81.16 ± 4.69[a]	80.95 ± 5.17[a]	81.10 ± 4.98[a]	80.06 ± 4.45[a]
	MCMH (g/100ml)	33.06 ± 1.36[a]	32.60 ± 1.77[a]	32.94 ± 1.05[a]	32.38 ± 1.57[a]

In line, value with different letter differed significantly (Dunnett test, $p \leq 0.05$), Hg: Hemoglobin, MCV: mean corpuscular volume, MCMH: mean corpuscular hemoglobin volume.

Children anemia prevalence were evaluated according to hemoglobin value. At the beginning of the study (period 1), 18.18 % of children who ate rice with tomato sauce and meat suffer of anemia. This rate increased to 27.27 % in half study (period 2) and to 40.91 % at the end of the study (period 3). In Gnaboya, 61.54 % of children presented an anemia prevalence which increased to 69.23% in period 2 but decreased to 53.83 % at the end of the study. For children who ate potatoes stew with cowpea 43.75 % suffered of anemia in periods 1 and 2. At the end, this rate increased to 50.00 %. For children who ate potatoes stew with soya and cowpea, 62.50 % suffered of anemia before the study. This rate decreased to 50.00 % in period 2 but increased again to 62.50 % at the end of the study (Table 4). There was a significant statistical difference between the 3 phases of the study only in Gnaboya school canteen ($\alpha = 0.05$).

3.3. Children Nutritional Status According to Anthropometric Measurements

Table 5 shows the means of weight and height, for the children in each school. There is a slight evolution of children weight and height from period 1 to period 3 in each school canteens. Weight of children who ate potatoes stew with soya and potatoes stew with cowpea differed significantly to that of children which ate rice with tomato sauce and meat during periods 1, 2 and 3. Apart children of Gnaboya in period 1, children height value of the other village and at other periods differed significantly to that of children in Kragui. In period 1 the Body Mass Index (BMI) of children of Petit-Bondoukou differed significantly to that of the other villages.

The evolution of BMI (Body Mass index) was presented in Table 6. At periods 1 and 2 in Kragui, 81.81 % of children had a normal nutritional status and 18.18 % suffered of malnutrition. At the end of the study the rate of children who had a normal nutritional status decreased to 59.09 % and that of malnourished children increased to 36.36 %. For children who ate potatoes stew with soya (in Gnaboya) before the study, 46.15 % have a normal nutritional status, 46.15 % suffered malnutrition and 7.69% suffered of overweight. The rate of children who had a normal nutritional status increased to 69.23 % in period 2 but decreased to 61.54 % at the end of the study. For children who ate potatoes stew with cowpea (in Petit-Bondoukou) before the study, 87.5 % had a normal nutritional status and 12.5% suffer of overweight. In period 2 there was a slight decreased to 81.25 % for children who had a normal nutritional status. At the end of the study, 87.5 % of children had a normal nutritional status. For children who ate potatoes stew with soya and cowpea (in Takoreagui), 91.67 % have a normal nutritional status and 4.17 % suffer of malnutrition before the study. In periods 2 and 3, 95.83 % of children had a normal nutritional status and 4.17 % suffered of overweight. There was no significant statistical difference between the 3 phases of the study for all school canteens ($\alpha = 0.05$).

Table 4. Evolution of Anemia Prevalence of Children Participating to Food Diversification Program in school Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa Region in Côte d'Ivoire

	Period 1		Period 2		Period 3	
Villages	Anemia (%)	No Anemia (%)	Anemia (%)	No Anemia (%)	Anemia (%)	No Anemia (%)
Kragui (N=22)	18.18	81.82	27.27	72.73	40.91	59,09
Gnaboya (N=13)	61.54	38.46	69.23	30.77	53.83	46.17
Petit-Bondoukou (N=16)	43.75	56.25	43.75	56.25	50.00	50.00
Takoreagui (N=24)	62.50	37.50	50.00	50.00	62.50	37.50

Table 5. Weight and height values of children Participating to Food Diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa Region in Côte d'Ivoire

Periods	Village	Kragui (N=22)	Gnaboya (N=13)	Petit-Bondoukou (N=16)	Takoreagui (N=24)
1	Weight (kg)	28.54 ±5.32^{b}	22.69 ± 5.72^{a}	23.51 ± 6.50^{a}	24.08 ± 4.78^{b}
	Height (m)	1.36 ± 0.08^{b}	1.28 ± 0.09^{b}	1.21 ± 0.11^{a}	1.23 ± 0.10^{a}
	BMI	15.18 ± 1.79^{b}	12.88 ± 1.39^{a}	17.15 ± 2.11^{c}	15.77 ± 1.76^{b}
2	Weight (kg)	29.18 ± 5.24^{b}	22.65 ± 5.22^{a}	24.34 ± 6.97^{ab}	24.13 ± 5.08^{ab}
	Height (m)	1.36 ± 0.09^{b}	1.27 ± 0.08^{b}	1.21 ± 0.11^{a}	1.24 ± 0.10^{a}
	BMI	15.31 ± 1.27^{a}	15.25 ± 1.52^{a}	15.61 ± 2.11^{a}	15.58 ± 1.42^{a}
3	Weight (kg)	29.36 ± 5.39^{b}	22.38 ± 5.12^{a}	24.12 ± 7.11^{a}	25.04± 6.27^{ab}
	Height (m)	1.36 ± 0.09^{b}	1.29 ± 0.09^{a}	1.22 ± 0.12^{a}	1.25 ±0.10^{a}
	BMI	15.64 ± 1.32^{a}	13.26 ± 1.62^{a}	15.58 ± 1.54^{a}	15.82 ± 1.96^{a}

In line, value with different letter differed significantly (Dunnett test, $p \leq 0.05$) BMI: Body Mass Index.

Table 6. Evolution of Nutritional Status of Children Participating to Food diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa region in Côte d'Ivoire According to Anthropometric Measurements

Periods	Village	Kragui (N=22)	Gnaboya (N=13)	Petit-Bondoukou (N=16)	Takoreagui (N=24)
1	Nor (%)	81.81	46.15	87.50	91.67
	Mal (%)	18.18	46.15	0	4.17
	Over (%)	0	7.69	12.50	4.17
2	Nor (%)	81.81	69.23	81.25	95.83
	Mal (%)	18.18	30.77	0	0
	Over (%)	0	0	18.75	4.17
3	Nor (%)	59.09	61.64	87.50	95.83
	Mal (%)	36.36	38.64	0	0
	Over (%)	4.55	0	12.50	4.17

Nor: normal status, Mal: malnourish, Over: overweight.

3.4. Children Nutritional Status According to Biochemical Parameters

Children nutritional status evaluated according to biochemical parameters (albumin, prealbumin, C-reactive protein (CRP) and orosomucoid) helped determining the prognostic inflammatory nutritional index (PINI) which indicates malnutrition risk (Table 7). There was no statistical difference for children prealbumin, C-reactive protein and PINI value at all periods. However, children who ate rice and tomato sauce with meat albumin and orosomucoid rate differed significantly to that of the others village.

Table 7. Biochemical Parameters and PINI Values of children Participating to Food Diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa Region in Côte d'Ivoire

Periods	Village	Kragui (N=22)	Gnaboya (N=13)	Petit-Bondoukou (N=16)	Takoreagui (N=24)
1	Alb (g/l)	33.25 ± 12.80^{a}	43.20 ± 10.39^{b}	45.54 ± 8.47^{b}	41.99 ± 9.19^{b}
	Prea (mg/l)	0.12 ± 0.03^{a}	0.15 ± 0.05^{a}	0.15 ± 0.04^{a}	0.17 ± 0.21^{a}
	CRP (mg/l)	4.00 ± 5.21^{a}	5.26 ± 8.33^{a}	4.15 ± 4.29^{a}	7.73 ± 12.77^{a}
	Oro (mg/l)	0.69 ± 0.38^{a}	1.07 ± 0.40^{b}	1.12 ± 0.34^{a}	1.24 ± 1.17^{a}
	PINI	0.80 ± 1.13^{a}	1.76 ± 4.02^{a}	0.84 ± 1.14^{a}	2.24 ± 4.24^{a}
2	Alb (g/l)	42.46 ± 4.63^{a}	41.93 ± 6.47^{b}	45.57 ± 10.54^{a}	42.54 ± 10.33^{a}
	Prea (mg/l)	0.14 ± 0.03^{a}	0.15 ± 0.03^{a}	0.15 ± 0.06^{a}	0.14 ± 0.04^{a}
	CRP (mg/l)	5.30 ± 5.41^{a}	3.46 ± 2.06^{a}	4.16 ± 4.69^{a}	3.86 ± 5.10^{a}
	Oro (mg/l)	0.91 ± 0.40^{a}	0.85 ± 0.30^{a}	1.13 ± 0.48^{a}	0.89 ± 0.29^{a}
	PINI	1.10 ± 1.43^{a}	0.53 ± 0.40^{a}	0.91 ± 0.86^{a}	0.78 ± 1.24^{a}
3	Alb (g/l)	43.79± 4.25^{a}	45.48 ± 4.20^{b}	41.51 ± 3.47^{a}	37.78 ± 8.31^{a}
	Prea (mg/l)	0.15 ± 0.03^{a}	0.16 ± 0.04^{a}	0.13 ± 0.03^{a}	0.13 ± 0.04^{a}
	CRP (mg/l)	3.10 ± 3.91^{a}	5.00 ± 4.83^{a}	4.54 ± 3.86^{a}	12.99 ± 3.14^{a}
	Oro (mg/l)	0.77 ± 0.18^{a}	0.90 ± 0.20^{a}	0.96 ± 0.30^{a}	0.84 ± 0.45^{a}
	PINI	0.46 ± 0.78^{a}	0.90 ± 1.13^{a}	0.91 ± 0.86^{a}	6.25 ± 1,92^{a}

In line, value with different letter differed significantly (Dunnett test, $p \leq 0.05$), Alb: Abumin, Prea: prealbumin, CRP: C-reactive protein, Oro: Orosomucoid, PINI: prognostic inflammatory nutritional index.

Table 8. Evolution of Prognostic Inflammatory Nutritional Index (PINI) Value of Children Participating to Food Diversification Program in School Canteens of the Villages of Kragui, Gnaboya, Petit-Bondoukou and Takoreagui in Nawa region in Côte d'Ivoire

Periods	Village	Kragui (N=22)	Gnaboya (N=13)	Petit-Bondoukou (N=16)	Takoreagui (N=24)
1	Nor (%)	72.73	61.54	87.50	66.66
	Low risk (%)	27.27	30.77	12.50	33.33
	Mod risk (%)	0	7.69	0	0
2	Nor (%)	77.27	76.92	56.25	70.83
	Low risk (%)	22.73	23.08	43.75	29.17
	Mod risk (%)	0	0	0	0
3	Nor (%)	77.27	92.31	68.75	70.83
	Low risk (%)	22.73	7.69	31.25	29.17
	Mod risk (%)	0	0	0	0

Nor: normal status, Mod risk: moderate risk.

For children who ate rice with tomato sauce and meat, before the study, 72.73 % of them had a normal nutritional status and 27.27 % presented a low risk of malnutrition. In period 2 and 3 the rate of children who presented a risk of malnutrition decreased to 22.73 %. (Table 8). In Gnaboya school, where children ate potatoes stew with soya, 61.54 % of them have a normal nutritional status, but 30.77 % presented a low risk of malnutrition and 7.69 % a moderate risk at the beginning of the study. The rate of children who had a normal nutritional status increased to 76.92 % in period 2 and to 92.31 % in period 3. At the beginning of the study, 87.50 % of children who ate potatoes stew with cowpea had a normal nutritional status and 12.50% of them a low malnutrition risk. However, in period 2 and 3, 43.75 % and 31.25 % of them presented a low risk to suffer of malnutrition respectively, reducing at 68.75 % the rate of children having a normal nutritional status at the end of the study. In Takoreagui, children ate potatoes stew with soya and cowpea. Before the study, 33.33 % presented a malnutrition risk and 66.66 % a normal nutritional status which increased to 70.83 % in period 2 and 3. There was a significant statistical difference between the 3 phases of the study only in Gnaboya school canteen ($\alpha = 0.05$).

4. Discussion

The evolution of children anemia prevalence revealed that there was an increase of anemia rate among children who ate rice with tomato sauce and meat and those who ate potatoes stew with cowpea. However, children who ate potatoes stew with soya presented a decrease of anemia prevalence. This could denote that anemia prevalence is due to many factors. Indeed, Côte d'Ivoire is in a malaria-endemic region and Malaria is an important predictor of anemia in young children [11]. Moreover, iron, vitamin B12 and vitamin A deficiencies are also implicated in anemia [19] as these are more required during growth phase of children [5].

The evolution of nutritional status according to anthropometric measurements revealed, for children who ate rice and tomato sauce with meat, a decrease of rate among children who had a normal nutritional status. But rate for children who suffered of malnutrition increase. For children who ate potatoes stew with soya, there was an increase in the rate of those who have a normal nutritional status but also for those who suffered of malnutrition. This could be because soya is not always appreciated. In addition, no change in nutritional status for children who ate potatoes stew with cowpea apart a few children who suffered of obesity instead of overweight have been observed. This denoted that children assimilate the meal, but the change could not be detected because of the short duration of the study. The rate of children who had a normal nutritional status for children who ate potatoes stew with soya and cowpea increased. Some of them presented an overweight and obesity status. This indicated a good assimilation of the meal by children and a stronger effect on malnutrition probably due to the mixed of soya and cowpea in the stew. The prevalence of children suffering of malnutrition in our study is lower than that indicated in some previous studies. Indeed, [20] revealed that among school-age children in developing countries the prevalence of stunting is between 48-52 % with an overall prevalence of underweight between 34-62 %. Other authors [21] indicated a stunting prevalence of 56 %, a wasting prevalence of 20 % and an underweight prevalence of 24 %.

The evolution of children nutritional status according to prognostic inflammatory nutritional index (PINI) revealed a reduction in the rate of low malnutrition risk for children who ate rice with tomato sauce and meat, potatoes stew with soya and potatoes stew with soya and cowpea. However, for children who ate potatoes stew and cowpea, the rate of those who presented a low malnutrition risk increased. All this suggested that potatoes stew with cowpea had a lower impact on children nutritional status and that other meals could better improve their nutritional status. Moreover, sweet potatoes had some anti-inflammatory virtues and soya a hypocholesterolemia effect which could improve C-reactive protein (the inflammation marker) and then the prognostic inflammatory nutritional index (PINI) [22,23].

Anemia was strongly correlated to BMI and PINI, indicator of nutritional status. This denoted that the nutritional status which was linked to diet could impact anemia status. Indeed, [12] have showed dietary diversity was positively correlated to hemoglobin. The weak correlation between BMI and PINI could supposed that each of them could independently determine nutritional status. The slight nutritional status improvement for anemic children and the appearance of malnutrition in some cases, revealed unclear trends in the effect of the

tested diets on anemic children nutritional status. This could be due to the short duration of the study and the number of meals taken.

5. Conclusion

This study had showed that the diversification of meals in canteens had a slight impact on anemic children nutritional status. Indeed, potatoes, soya and cowpea could improve children nutritional status. The best improvement of nutritional status was obtained by combining potatoes and soya or potatoes, soya, and cowpea in a same meal. They provide energy, protein, lipid, mineral and vitamin useful to human body. For a better impact, the meals should be eaten during a long period and in a short frequency. The fact that some recipes have also caused obesity is worth investigating in the future.

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List of Abbreviations

BMI: Body Mass index
CRP: C-reactive protein
Hg: Hemoglobin
MCV: Mean Corpuscular Volume
MCHC: Mean Corpuscular Hemoglobin Concentration
PINI: Prognostic Inflammatory Nutritional Index
WHO: World Health Organization

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