



## **Evolution of the Pronostic Inflammatory and Nutritional Index (PINI) of the Malnourished Children of 6-59 Months during Supplementation with Soya and Spirulina in Côte d'Ivoire**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Author YGP designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Authors KYKF and BA managed the analyses of the study. Author KYKF managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Aims:** This study aimed to evaluate the evolution of the Pronostic of Inflammatory and nutritional Index (PINI) during the supplementation with soya and spirulina in children from 6 to 59 months.

**Study Design:** Hundred ninety-five (195) children moderate malnourished selected according to WHO standards.

**Place and Duration of Study:** Children selected were distributed in three groups in order to receive in addition to the family food during one month respectively millet porridge (group 1; 65 children), millet porridge strengthened in the soya (group 2; 65 children) and millet porridge enriched in the spirulina (group 3; 65 children).

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**Methodology:** Nutritional and inflammatory parameters were measured at the beginning and the end of study. PINI was also calculated in this study.

**Results:** The group 3 (Spirulina) recorded significant variations ( $p < 0.05$ ) regarding all the parameters (decrease of CRP and  $\alpha 1$ -GPA and increase of albumin and prealbumin). As for the PINI, it has been significantly ( $p < 0.05$ ) reduced in group 2 and a high significant decrease was shown in group 3 ( $p < 0.01$ ). It emerges from the study that the spirulina improves more quickly the PINI as nutritional supplement than the Soya compared to family food.

**Conclusion:** This study indicates spirulina and soybean could be used to improve nutritional status in children suffering from acute malnutrition.

*Keywords: PINI supplementation; soya; Spirulina; Côte d'Ivoire.*

## 1. INTRODUCTION

The malnutrition in the childhood is a grave problem of public health in the world [1]. It contributes to morbidity and mortality increased, slows down the intellectual development [2], decreases the working capacity in the adulthood, even entails an increase of the risk of disease in the adulthood [3]. On 7.6 millions deaths arising in the world every year at the children of less than 5 years, approximately 20% can be attributed to a weight insufficiency of the child [4]. Numerous studies in sub-Saharan Africa indicated that more than 50% children below 5 years die because of the malnutrition; the diarrheas, pneumonias, malaras and other parasitoses observed in malnourished children contributed to this increase in mortality [5]. The nutritional status evaluation of populations in Côte d'Ivoire by an investigation multi-clusters in 2006 [6] revealed that the acute malnutrition affects 7% children from 0 to 59 months, among which 1% of severe forms. A transverse nutritional survey led in the North of Côte d'Ivoire in 2008 [7], revealed alarming figures with a rate of global acute malnutrition in 17.5% with 4% of severe forms and a rate of global anemia in 80.8% in children from 6 to 59 months. The acute moderated malnutrition (MAM) in child corresponds to an index weight for size between 3 and 2 Z-scores below the median according to the child growth standard indicated by WHO [8]. In infants and young children, the malnutrition settles down generally during period going from the first 6 months to 18 months [9] and it is frequently associated with the intake of low-nutrient and low-energy foods; This consists essentially of basic foods that are rich in starch and supplied as a supplement to the maternal milk. The nutritional management of moderate acute malnutrition is based on the optimal use of locally available nutrient-rich foods to improve the nutritional status of children and prevent severe acute malnutrition or stunting [10-11]. The

contribution of present nutriment in inappropriate quantity in the usual diet can be improved by the diversification and enrichment in vitamins and minerals of certain basic food. Food supplements in varied nutritional compositions are then essential to facilitate the cure of children with moderate acute malnutrition [12]. These food supplements are specially formulated food [13], in ready-to-eat or powder form, called ready-to-use supplementary (ASPE). They are used in the care of moderately malnourished people or to prevent deterioration in the nutritional status of those incur risk of malnutrition. Several indicators allow to estimating the risk among which one there is the prognosis inflammatory and nutritional index (PINI) which is the combination of two inflammatory parameters (CRP and  $\alpha 1$ -GPA) and of two nutritional parameters (Albumin and Prealbumin) [14].

It appears that to date the effectiveness and profitability of these ASPE has not been not only fully satisfactory and even less fully proven. That is therefore to contribute to value these local products that this study was thus introduced to estimate the PINI during the nutritional supplementation with soya (Glycin max) and spirulina (Spirulina platensis).

## 2. MATERIALS AND METHODS

### 2.1 Materials

In this study, some millet porridge, soya porridge, spirulina (*Mali Spiruline, Centre Père Michel-Niaréla, Rue 459, Bamako*), peanut and some oil it were used in the preparation of the various dishes; Then a automated biochemical analyser (FULLY, Biosystem Italy) was used for the analysis of the various parameters studied. Biochemistry reagents and small required materials such as glassware were also used.

## 2.2 Methods

It is about a study of type case controls which was led to the General Hospital of Yopougon (GHY) and Cocody Urban Sanitary Training (Abidjan) in order to evaluate the PINI during the nutritional supplementation with soya and spirulina compared to the family food (AF); the family diet is generally contains bananas, rice, yams, cassava, fish, millet.

Children of roughly the same age were put together in the same group. It concerned a total staff of 195 children distributed in three groups fed in a selective way by:

- Group 1 (compared group): AF + Millet porridge (65 children)
- Group 2: AF + Millet porridge + Soya (65 children)
- Group 3: AF + Millet porridge + Spirulina (65 children)

The formulation concerning these porridges compositions was calculated so as to supply 50% of the daily recommended contributions (DRC) in energy such as recommended by the WHO /FAO [15].

### 2.2.1 Criteria of inclusion and exclusion

Children in the 6-59 months range, reached by MAM (Moderate Acute Malnutrition) without complications and HIV negative serology were taken into account in this study. On the other hand every child achieves of any other shape of malnutrition or except the range 6-59 months or in positive HIV serology was excluded.

### 2.2.2 Informed consent

An informed consent and a paper were obtained from the accompanying person before blood collection.

At the beginning and at the end of the study, the venous blood taken from tube with heparin at every child served the year dosage of the Albumin, CRP, Prealbumin and  $\alpha$ 1-GPA using the automaton. Next, the PINI was calculated according to the following formula:

$$\text{PINI} = \frac{[(\text{CRP (mg/L)} \times \alpha\text{-GPA (mg/L)}) / (\text{Albumin (g/L)} \times \text{Prealbumin (mg/L)})]$$

## 2.3 Statistical Analysis

The statistical analysis was carried out using one way analysis of variance (ANOVA) followed by Dunnet, Student-test,  $P < 0.05$  was considered as significant.

## 3. RESULTS

In the beginning of study, the studied parameters (nutritional and inflammatory) were perturbed compared to normal values.

The reduction in prealbumin was 45%, 39% and 43%, respectively for children in groups 1, 2 and 3. As for albumin, we obtained 33%, 24% and 25% respectively for the same groups 1, 2 and 3. As regards the inflammatory proteins, the disturbances (increases) concerned respectively 53%, 46% and 40% of children in groups 1, 2 and 3 for  $\alpha$ 1-GPA while CRP was increased by 48%, 45% and 35 respectively in the same children groups 1, 2 and 3.

Regarding the set of children, the albumin and the prealbumin were lowered at respectively 27.33% and 42% of children whereas CRP and  $\alpha$  1-GPA were respectively increased to 42.67% and 46.33% (Table 1).

At the end of the study, all evaluated parameters have been variable that is to say an increase in nutritional markers and decreased inflammatory proteins (Table 2).

**Table 1. Distribution of malnourished children as a percentage**

Parameters	Group 1		Group 2		Group 3		Cumulation	
	J0	J30	J0	J30	J0	J30	J0	J30
PALB (%)	45	0	39	0	43	0	42.33	0
Alb (%)	33	1.58	24	0	25	0	27.33	0.53
CRP (%)	48	25	45	4.83	35	3.17	42.67	11
$\alpha$ 1-GPA (%)	53	31.66	46	20.96	40	9.63	46.33	20.75

J0: Day before treatment of children with food supplements

J30 Day at the end of the treatment of children with food supplements

PALB: Prealbumin; Alb: Albumin; CRP: Protein Creative;  $\alpha$ 1GPA: alpha1 – glycoprotein acid

**Table 2. Evolution of the nutritional and inflammatory parameters and the PINI during the supplementation**

Parameters	Group 1			Group 2			Group 3			Normal values
	J0	J30	Variation	J0	J30	Variation	J0	J30	Variation	
Alb (g/l)	34.79±4.56	37.65± 4.58	+4.09±4.22	33.75± .90	39.43± 7.11	+8.69±5.78**	32.23± 6.25	41.90± 9.91	+15.67±7.06***	35-50 g/l
Palb (mg/l)	0.21±0.5	0.28± 0.51	+ 0.07±0.8	0.22± 0.6	0.30± 0.47	+0.08± 0.5 <sup>ns</sup>	0.22± 0.5	0.33± 0.36	+0.11±0.6*	0.20-0.40 mg/l
CRP (mg/l)	15.36±3.06	11.46± 1.84	-3.89±2.19	17.14±4.56	7.77± 3.09	-9.24±4.1**	16.25± 3.74	4.95± 1.97	-11.30±7.2***	<6 mg/l
α1-GPA (mg/l)	1.31±0.31	1.02± 0.29	-0.33±0.20	1.33± .33	0.81± 0.31	-0.51±0.21 <sup>ns</sup>	1.35± 0.38	0.69± 0.25	-0.67± 0.42*	0.5-1.20 mg/l
<b>PINI</b>	<b>2.75</b>	<b>1.11</b>	<b>-1.64</b>	<b>3.07</b>	<b>0.53</b>	<b>-2.54*</b>	<b>3.09</b>	<b>0.24</b>	<b>-2.85**</b>	

\*  $p < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$  : significant difference compared with the group 1

The prealbumin value became normal within every 3 groups and the reduction in the albumin disappeared within the groups 2 and 3 but in the group 1, we record a residual rate about 5% of children with low prealbumin compared with the reference values. Concerning the inflammatory profile, CRP and  $\alpha$ 1-GPA normalized within all the groups. In absolute value, the variation of albumin rate was +4.09 g in group 1 ( $p > 0.05$ ), +8.69 g in group 2 ( $p < 0.01$ ) and + 15.67g in group 3 ( $p < 0.001$ ). As regards the prealbumin, the increases in groups 1 and 2 were not significant (0.07 mg and 0.08 mg); However, in group 3, this increase (0.11 mg) was significant ( $p < 0.01$ ). As for inflammatory proteins, the decrease of CRP in the various groups was -3.89 in group 1, -9.24 in group 2 ( $p < 0.01$ ) and -11.30 in group 3 ( $p < 0.001$ ) whereas that of  $\alpha$ 1-GPA was respectively 0.33, 0.51 and 0.67 ( $p < 0.05$ ) in groups 1, 2 and 3. We observed at the end of the study that the PINI value is situated still more than 1.0 in group 1 and fell underneath in groups 2 and 3.

#### 4. DISCUSSION

The aim of this study was to follow the PINI evolution in children malnourished whose food was supplemented with soya and the spirulina. The choice of these two types of supplements results from recommendations of WHO which exhorted cheaper and accessible local supplements in the coverage of the moderate malnourished children. We chose to follow the evolution of inflammatory and nutritional parameters in order to determine the PINI. After one month of supplementation (30 days), all the subjected parameters to evaluation were favorably evolved so proving the link between food and preservation or improvement of the health.

After one month of supplementation, all parameters evaluated were favorably evolved, demonstrating the link between diet and preservation or improved health. The results can be explained either independently of the received food or by recognizing the received dietary supplement. Independently of food, it was noted that in the three groups, the various parameters all knew a positive progress. This evolution would be bound at the same time to the received treatment as well as to the lavished advice. Indeed, according to Lemonkpe et al. [16] malnutrition causes are attributed to many factors, including the socio-economic

environment, education and the educational level mother.

The hygiéno-dietary advice lavished as well as the care administered further to the consultation, allowed to break the vicious circle which maintained the children in a situation of almost permanent morbidity. It is also advisable to indicate the importance of the raising awareness such as recommended it by London School of Hygiene and Tropical Medicine (LSHTM) as well as the community participation (MSH) who allowed the relatives or the accompanying persons to understand that a minimum of knowledge and nutritional or hygienic know-how is enough for saving the children from dramatic situation [17-19]. This non-food aspect has an important role in preserving health in general and against malnutrition in particular. These results can be also analyzed according to the received food because according to WHO [20], children aged 6-59 months with moderate acute malnutrition have to receive rich food in nutriment in order to satisfy their additional needs to reach weight and size gain and to a functional cure.

In regards to group 1, the obtained results could be explained at first by the bad nutritional quality of family food which would be monotonous, most of the time solid and not containing enough nourishing elements [21]. The family food in the context of developing countries cannot consistently fight the malnutrition; Thus, it was observed persistence of morbid condition despite the care taken and which results in a persistent deficit of albumin and prealbumin as well as an inflammatory process in a number of children in group 1.

It is this health status not completely improved of children that were indicated by the final PINI the value of which is even superior to one. As for the other two groups, the action of nutritional supplements was more remarkable compared to the control group (Family Feeding). This would be explained by the fact that Soya and Spirulina would contain several nutrients, vitamins or trace elements in varying amounts and they are involved in several biological processes. According to the Nutrition Composition Table [22] and the Canadian Food Composition File [23], Spirulina is higher in protein purpose but it contains less carbohydrate and lipids than soya. This difference in nutritional composition could support the effect of one or the other in the fight against malnutrition whose biological signs

concern the disturbances of nutritional and inflammatory proteins. The greater contribution of spirulina to the improvement of PINI could therefore come from its richness in proteins. Indeed, during malnutrition, the body would be faced with two important requirements; On the one hand body must have sufficient resources (proteins) to combat malnutrition causes and on the other hand, it is necessary to repair malnutrition consequences by the reconstitution of its protein stock in order to support the proper functioning of other organs.

Therefore, in the case of insufficient food intake or containing little protein, the prolonged or sudden demand for compensation of loss protein leads to inflammation. Depending on the circumstances, certain nutrients would enter the scene to regulate inflammation, hence pro-inflammatory and anti-inflammatory character of some amino acids according to Calder, Delarue, McLean and McLean [24-27]. According to Paschalis and Morrisson, the presence of certain vitamins and trace elements in foods would have favored better absorption, which resulted in the nutritional and inflammatory profiles normalization [28-29]. Soya and Spirulina, which contain vitamins and trace elements in considerable quantity, would contribute to the fight against malnutrition. In the typical case of soya, the Research of Lunn and Simopoulos indicated several therapeutic activities of isoflavones and essential fatty acids including those related to inflammation [30-31]. So at the same time as Soya would have helped to fight malnutrition, it would have intervened in inflammation elimination. However this relative richness of Soya in nutrients is at the same time countered by the presence of phytates which prevent the perfect absorption of these nutrients and vitamins according to Lönnnerdal [32]. On the other hand, the particularity of Spirulina concerns histamine which is histidine precursor, a biogenic amine with multiple functions including roles in gastric acid secretion, immune response and inflammatory processes [33]. In addition, many minerals that intervene directly or indirectly in the fight against malnutrition effects would be found in Spirulina; their quantity and nutritional quality would be an advantage in food supplementation.

Compared with PINI, our results of groups 2 and 3 at the end of the study are in agreement with the research of Ahiboh et al. [34] who established at 0.35 the PINI of black African children Healthy. This study enables us indicate that soy and spirulina could indeed constitute

good nutrients against malnutrition but ultimately with a better performance for spirulina than soy in the improvement of the PINI compared to the family food. This performance of spirulina is acquired thanks to its richness in nutrients, vitamins, minerals and trace elements [35].

## 5. CONCLUSION

Malnutrition is a multidisciplinary pathology and its management also requires a whole range of measures including nutritional supplementation. If evidence of industrial or chemical supplements efficacy is not yet fully established, local products may be an interesting alternative. Thus, Soya and Spirulina have significantly reduced the PINI of malnourished children thanks to their nutritional compositions; their use and introduction into food preparations intended for children victims of MAM should be promoted. For this purpose, adequate training of health workers and education and awareness among mothers of better use of local products could reduce mortality and morbidity associated with malnutrition.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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