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Evolution of Physical, Biochemical and Hematological Characteristics of Children Aged 6 to 59 Months under the Influence of Spirulina at DJUMA

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Abstract

Introduction: Currently, many information sites and distributors of food supplements highlight the benefits of spirulina, generally presenting it as the richest food on the planet. This cyanobacterium considered as a microalgae can be the source of molecules potentially active on certain functions of the human body, making it interesting for the development of functional foods and food supplements. The objective pursued in this study was to analyze the evolution of anthropometric, biochemical, and hematological parameters in children aged 6 to 59 months. **Methods:** Spirulina was distributed to households in the DJUMA Health Zone, at the rate of 2 sachets of 5 grams per day for a period of 30 days, it was mixed with the family dish shared by the rationers. **Results:** The results obtained show a positive and significant evolution of weight, arm circumference, Weight-for-Age index, total proteins, and serum albumin. **Conclusion:** These results indicate that the daily addition of spirulina to the family meal contributes to improving the health status of the beneficiaries.

Subject Areas

Nutrition and Dietetics Field

Keywords

Spirulina, Family Dish

1. Introduction

Spirulina is a cyanobacteria traditionally used for several hundred years by certain populations and still today in Chad for its nutritional properties. It therefore belongs to the domain of bacteria (Bacteria) and is classified among gram-negative bacteria. Cyanobacteria form the majority of bacteria capable of photosynthesis with oxygen production and can be unicellular or multicellular. Spirulina belongs to the order Nostocales (=Oscillatoriales), the family Oscillatoriaceae, the genus Oscillatoria and the subgenus Spirulina or Arthrospira [1].

Indeed, spirulina has long been classified among blue-green algae. The Aztecs of Mexico harvested it in a now-disappeared lake in Mexico City. Spirulina is traditionally harvested on the shores of Lake Chad where it is used as a nutritional supplement to enrich local dishes [2]. Spirulina preferentially grows in warm, alkaline waters rich in nitrogen and phosphorus nutrients. More commonly, it is observed in brackish waters, as well as in saline lakes in tropical and semi-tropical regions. Its strong ecological plasticity allows it to be found in its natural state in alkaline lakes in Africa (Chad, Ethiopia, Tunisia), Latin America (Mexico, Peru), and South Asia (India, Sri Lanka, Thailand). This organism is said to be ubiquitous. However, it is much less abundant in North America and Europe [3].

In the Democratic Republic of Congo, spirulina is a well-known algae and commonly consumed in Congolese circles. It is harvested in the province of Kasai-Occidental at the Katende waterfall, and in the province of North Kivu in Goma where it is produced artisanally.

Spirulina contains a large amount of proteins. Its dry weight varies from 50% to 70% [4]. According to Henrikson (1994), this rate is significantly higher than that of fish (25%), soy (35%), milk powder (35%) and cereals (14%) [5]. According to BUJARD (1970), spirulina proteins are perfect from a qualitative point of view, because they contain all the essential amino acids, which represent 47% of the total weight of proteins [6]. This observed abundance allows the use of spirulina as a food supplement (less than 10g per day) [2].

There is no cellulose wall in this microorganism, but a fragile envelope, composed of polysaccharides, which explains its digestibility of 75% to 83%. Thus, Spirulina does not require cooking or even specific treatment for good protein digestibility [7].

The aim of this research is to promote the improvement of the nutritional status of malnourished Congolese children under 5 years old.

The general objective pursued is to determine the evolution of biochemical and hematological anthropometric characteristics in children who receive spirulina in their diet.

The main question is whether the incorporation of spirulina into the family meal can have an impact on anthropometric, biochemical and hematological changes in children under 5 years of age.

Considering that improving nutritional status depends on food availability and access to food in sufficient quantity and quality. Knowing that the composition of spirulina is of high-quality nutritional value, we believe that it is an asset for improving anthropometric and biological parameters in the children studied. This study does not constitute a treatment for malnutrition, but rather an introduction of nutritional supplements in the family meal. This study finds its interest in promoting local foods that are cheaper, accessible to all and recognized as having good nutritional value. It aims to analyze the evolution of anthropometric, biochemical and hematological parameters in children aged 6 to 59 months.

2. Materials and Methods

We conducted an uncontrolled clinical trial based on the administration of a food supplement. The study material consisted of spirulina powder from ACF-USA/DRC.

The study population consists of children aged 6 to 59 months living in the DJUMA health zone, in the province of BANDUNDU. The sample size was 140 children, including 92 children whose parents freely accepted the two blood samples, for an analysis of different parameters studied.

Mothers sensitized by the Community Relays brought their children to the health center where they received spirulina at the rate of 2 sachets of 5g per day for a week for a period of 4 weeks (*i.e.* 56 sachets per child for a period of 30 days). Spirulina was mixed with the family dish shared by its members (either with tea or with fufu, *i.e.* a paste made from cassava and corn flour).

The various anthropometric measurements were carried out at the beginning and end of the intervention. The weight was weighed using a 25 kg SALTER scale, the brachial perimeter (BP) was measured using a MUAC millimeter tape (Mid Upper Arm Circumference) and height was measured using a wooden measuring rod, in a vertical position for children over 24 months and in a horizontal position for children under 24 months.

Weight-for-age (W/A) and weight-for-height (W/H) indices expressed as Z-scores were calculated based on the children's weight, height and age using the ENA for SMART (Emergency Nutrition Assessment for Standardized Monitoring and Assessment of Relief and Transitions) software.

Total proteins were measured using an SP 2100 spectrophotometer at 546 nm, and serum albumin accounted for 57% of total proteins.

Hemoglobin was measured using the SAHLI method.

White blood cells were enumerated according to the THOMAS method.

Statistical analysis of the data was carried out using SPSS software version 16.0 (Statistics Package for Social Science) following the statistical test of the reduced deviation for the comparison of two paired means at the significance threshold of 5%.

3. Results

The sample of children followed is described according to socio-demographic characteristics including age and sex. It appears that male children represent more than half of the children followed and the age group of 24 months and over is predominantly represented (**Table 1**). The evolution of anthropometric parameters is statistically significant for weight, brachial circumference and weight/age index with the exception of the weight/height index which is not significant (**Table 2**). The evolution of the parameters studied is statistically significant for white blood cells, total proteins and serum albumin with the exception of hemoglobin, the difference of which is not statistically significant (**Table 3**).

Table 1. Distribution of children monitored by sex and age.

Variables (n = 140)	**Frequency**	**Percentage**	**Average ± standard deviation**
Sex			
Male	76	54.3	
Female	64	45.7	
Age (in months)			
Less than 12	8	5.8	
12 to 24	17	12.1	39.5 ± 17.2
24 and over	115	82.1	years

Table 2. Mean change in weight, brachial perimeter, P/A index and P/T index at the start and end of the intervention.

Variables (n = 140)	Mean ± standard deviation	Meaning P-value
1. Weight (Kg)		
Weight at start	10,300 ± 2.46	0.000
Weight at the end of the procedure	10,630 ± 2.58	S
2. Brachial perimeter (BP, Cm)		
PB at the beginning	13.37 ± 1.30	0.000
PB at the end of the intervention	13.80 ± 1.36	S
3. P/A Index		
P/A at the beginning	−2.01 ± 1.35	0.000
P/A at the end of the intervention	−1.84 ± 1.41	S
4. P/T Index		
P/T at the beginning	−0.76 ± 2.50	0.931
P/T at the end of the intervention	−0.74 ± 2.09	NS

Table 3. Mean evolution of hemoglobin, white blood cells, total proteins and serum albumin at the beginning and end of the intervention.

Variables (n = 92)	Mean ± standard deviation	Meaning P-value
Hematological parameters		
1. Hemoglobin (%)		
Hb at the beginning	10.99 ± 1.80	0.79
Hb at the end of the intervention	11.03 ± 2.08	**NS**

Continued

2. White blood cells (WBC/mm³)		
GB at the beginning	7176.09 ± 3371.41	0.000
GB at the end of the intervention	6380.43 ± 2045.96	S
Biochemical parameters		
3. Total protein (PROT in g/dl)		
PROT at the beginning	4.01 ± 1.01	0.000
PROT at the end of the intervention	5.14 ± 0.75	S
4. Serum albumin (AlB in g/dl)		
AlB at the beginning	2.12 ± 0.57	0.000
AlB at the end of the intervention	2.84 ± 0.47	S

4. Discussion

The sociodemographic characteristics studied show that male children over 24 months of age are predominant in this study, based on the introduction of spirulina as a dietary supplement to various household dishes. When considering their anthropometric index, it appears that these children suffered from moderate acute malnutrition. The latter may be a consequence of insufficient diet or poorly conducted dietary diversification.

The analysis of the weight evolution of children subjected to spirulina-based complementary feeding shows a positive change in the average weight of children which increased significantly from 10.300 ± 2.46 kg at the first contact to 10.630 ± 2.58 kg at the end of the intervention, *i.e.* a weight gain of 330 g ($P < 0.0001$). This result predicts a weight gain of more or less 10 g per day for a period of 30 days of the intervention. According to the Integrated Management Protocol for Acute Malnutrition in the Democratic Republic of Congo (PCIMA), the duration of 30 days is sufficient to observe the nutritional response, otherwise we speak of non-responder [8]. However, the effectiveness of the treatment and the absence of medical complications favorably influence the duration of nutritional recovery.

The observed weight evolution shows that spirulina, even in small daily doses, is beneficial for the human body. This is demonstrated by the daily amount of spirulina that was mixed with family food (Tea and Fufu) shared by all the rationers. The addition of spirulina to tea and fufu allowed us to solve the problem of acceptability of the product, due to its very dark green coloring of food. There was a rejection, by most children, of corn porridge mixed with 5 grams of spirulina.

According to CRUCHOT (2008), the fact that spirulina is acceptable in food constitutes an argument against its integration into nutritional programs. Its intense green color and its strong coloring power on other foods prevent it from hiding in culinary preparation. In addition to the color, the criticisms also concern the taste and smell [9].

Freshly harvested spirulina has no aroma or taste; this is when it is pleasant to consume. However, to preserve it, it must be dried and reduced to powder or fine granules. However, in this form, it gives off a specific odor reminiscent of hay or dried fish. It also has a salty taste, which explains its use as a flavor enhancer. It is difficult for adults (compared to children) to accept new foods: the fact of having associated certain tastes, odors and colors with what is "good" for years, handicaps the introduction of a new food.

While in the study by SALL et al conducted in Dakar, Senegal (1999), children undergoing nutritional rehabilitation received a daily dose of 10 grams of spirulina powder divided into two doses, mixed with cereal porridge for 30 days in a hospital setting and then 30 days at home. The results observed showed a positive variation in weight and different anthropometric indices (W/A, W/T) similar to our observations [10].

If the children followed in our study had individually consumed the 5 or 10 g of spirulina, like the study cited above, our results would have been even better. It should be noted that the SMALL study focused on sick (malnourished) children followed in treatment centers; while the present study targeted children under 5 years old without apparent nutritional problems and living in their households.

The results obtained on the measurement of the MUAC of the children followed show that the average MUAC goes from 13.37 ± 1.30 cm at the first contact to 13.80 ± 1.36 cm at the end of the intervention, *i.e.* an increase in arm circumference of 0.43 cm ($P < 0.0001$). These results reflect a satisfactory nutritional status for most of the children followed and confirm to a certain extent an expected improvement in children subjected to the spirulina-based food supplement.

The results obtained 30 days after injection of spirulina show a significant change in the mean P/A index at the beginning of the intervention (−2.01 ± 1.35) compared to that recorded in the fourth week (−1.84 ± 1.41). This suggests that children suffering from moderate underweight significantly change to mild underweight ($P < 0.0001$). This score could improve further if the duration of consumption were extended beyond 60 days or more.

As for serum proteins, PETER and MARGARET (1994) argue that the preservation of the body's protein mass is based on the dynamic balance between two opposing processes: protein production and degradation. Synthesis is more important during the growth of the organism than catabolism, while in cases of malnutrition or other diseases, the degradation phenomenon is more important, leading to a decrease in the body's protein mass [11].

The information provided by our study shows a protein renewal of the body going from 4.01 ± 1.01 g/dl on average at the first contact to 5.14 ± 0.75 g/dl at the end of the nutritional intervention based on the intake of spirulina ($P < 0.0001$). The proteins synthesized by the body induce the difference in albuminemia ranging from 2.12 ± 0.57 g/dl at the beginning of the intervention to 2.84 ± 0.47 g/dl at the end of the intervention. This observed hyperalbuminemia proves necessary for the proper functioning of the body [12].

5. Conclusions

The analysis of the evolution of anthropometric, biochemical and hematological parameters of children subjected to complementary feeding based on spirulina shows a significant modification of weight, brachial perimeter, weight-for-age index, total proteins as well as serum albumin.

These results allow us to affirm that the daily addition of spirulina to the family dish contributes to the improvement of the health status of the beneficiaries. However, we suggest a complementary study with a control group in order to identify the impact of spirulina in the nutritional rehabilitation of children under 5 years old.

Conflicts of Interest

The authors declare no conflicts of interest.

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