Effect of the addition of *Moringa oleifera* to fruit drinks on clinical parameters associated with iron deficiency anaemia in schoolchildren

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Summary: Effect of the addition of *Moringa oleifera* to fruit drinks on clinical parameters associated with iron deficiency anaemia in schoolchildren. Worldwide, iron deficiency anaemia (IDA) is one the most significant nutritional maladies, especially in low and middle-income countries. This is mainly due to the associated morbidity, economic implications on the health system and the welfare state. One of the most prevalent causes of IDA in children is insufficient food intake, which has an obvious connection with the social environment. The main strategy in the management of this condition is counteracting such deficiency through the improvement of nutrition and family upbringing. Aiming to explore affordable, novel and straightforward approaches to treat this nutritional condition, we developed a descriptive study associated with the incorporation of *Moringa oleifera* in homemade fruit beverages delivered to 32 children from low-income families, in order to assess the evolution of IDA, evaluating specific clinical parameters such as red blood cells volume, as well as hemoglobin, ferritin and serum iron levels, within a two months lapse. At the end of this period, we observed a significant statistical rise in the levels of all the assessed parameters, finding about a 1.3-fold increase in hemoglobin and ferritin levels and in red blood cells volume; serum iron was 1.1 times higher. These findings are demonstrative of the wide spectrum of the medicinal features of Moringa and establish a promising and accessible strategy easy to incorporate into the diet of families of children suffering this pathology. **ALAN, 2019; 69(1): 2-11.**

Key words: Iron deficiency anaemia, *Moringa Oleifera*, nutrition, schoolchildren, functional food, serum iron.

Resumen: Efectos de la incorporación de la *Moringa oleifera* en las bebidas de frutas sobre parámetros clínicos que miden la deficiencia de hierro y anemia en niños. La anemia ferropénica (AF) es una de las carencias nutricionales más significativas a nivel mundial, especialmente en los países de bajos y medios ingresos, debido principalmente a la morbilidad asociada, las implicaciones en el sistema de salud y el estado de bienestar. Una de las causas más frecuentes de esta deficiencia en los niños es la ingesta insuficiente, que tiene una evidente conexión con el entorno social. La principal estrategia en el manejo de esta afección es contrarrestar esta deficiencia a través de la mejora de la nutrición y la educación familiar. Con el objetivo de explorar enfoques asequibles, novedosos y directos para el tratamiento de esta enfermedad, se desarrolló un estudio descriptivo asociado a la incorporación de la *Moringa oleifera* en bebidas de frutas caseras que se suministraron a 32 niños de familias de bajos ingresos para hacerle seguimiento a la evolución de la anemia por deficiencia de hierro, evaluando parámetros clínicos específicos como el volumen de células rojas y los niveles de hemoglobina, ferritina y hierro sérico en un lapso de dos meses. Se observó un aumento estadísticamente significativo en los niveles de todos los parámetros evaluados una vez finalizado el período de intervención. Al final del ensayo, observamos un aumento estadístico significativo en los niveles de todos los parámetros evaluados, encontrando un aumento de aproximadamente 1.3 veces en los niveles de hemoglobina y ferritina y en el volumen de los glóbulos rojos; el hierro sérico fue 1.1 veces mayor. Estos hallazgos son una demostración del amplio espectro de las características medicinales de la Moringa y establecen una estrategia prometedora y accesible, fácil de incorporar a la dieta de las familias de los niños que sufren esta patología. **ALAN, 2019; 69(1): 2-11.**

Palabras clave: Anemia ferropénica, *Moringa oleifera,* nutrición, escolares, alimentos funcionales, hierro sérico.

Introduction

According to World Health Organization WHO (1), nutrition is the intake of food in relation to the dietary needs of the body, and a deficient nutrient uptake can affect immunity, increase vulnerability to disease, alter physical and mental development, and reduce cognitive productivity. Nutrition and feeding are complementary

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processes that are extremely significant at all stages of human development and biologically critical in childhood. A balanced diet is necessary in the early stages on the growth of an individual to consolidate his or her development and thus establish a solid biological basis for the following phases. An imbalance in the feeding-nutrition process could lead to the onset of a plethora of negative physiological outcomes, including the well-known iron deficiency anaemia (IDA). A quarter of the world's population is affected by anaemia and half of these individuals suffer from IDA. Iron is an inorganic mineral found in a variety of food that plays a main role in the physiology of living beings, as it is crucial for tissue development, synthesis of hormones and enzymes as well as oxygen intake in red blood cells. Twenty years ago, the International Nutritional Anaemia Consultative Group (INACG) estimated that about 80% of the world's population could be iron-deficient (2), whereas in Colombia the prevalence of iron-deficiency anaemia is 47% among schoolchildren (3). It is well known that critical social conditions are intimately linked with the appearance of IDA. There are geographic regions in Colombia that reach malnutrition rates similar to those observed in child population of Southern Sudan. Intense efforts are being made to develop social and experimental IDA control strategies based on the use of iron supplements, the intake of fortified food and drinks and the improvement of food safety. Based on this background, there was the need to develop a study whose main objective was to determine the effect of the addition of Moringa oleifera in daily household beverages to assess the evolution of anaemia in the population under study. This plant has a strong precedent in studies concerning traditional medicine and has been shown to play role as a an anti-pyretic, anti-oxidant, anti-cancer, anti-inflammatory, anti-obesity, hepatic and gastric-protector, anti-diabetic, immunomodulator, analgesic, among others (4), due to its phytochemical and pharmacological properties. Based on the generous empirical literature, we provided homemade beverages supplemented with Moringa oleifera to school students from low-income families in order to assess the condition of anaemia through various clinical parameters during two months of treatment.

Materials and Methods

Population and type of study.

This research was constructed as a prospective field study based on repeated measurements where every single individual was her/his control. A sample of 32 schoolchild from the Juan Bautista Scalabrini Institution located in Cucuta city was evaluated, according to the guidelines required for human research and under the approval of the Research Committee of Bacteriology and Clinical Laboratory program of the University of Santander, Cucuta campus. This study lasted two months

The inclusion criteria applied for selection of individuals were: students between 4 to 8 years old, hemoglobin levels (Hb) lower than 12 g/dl, volume of red cells lower than 33%, according to the criteria of the World Health Organization (WHO) for the diagnosis of anaemia in relation to hemoglobin levels and red blood cell volume in children from 5 to 11 years of age, (5). Children should be free of immunohematological diseases and cancer diagnosis. For children to be included in the study, the representative figure had to sign an informed consent beforehand. A family survey was conducted to assess the level of knowledge about anaemia status and assiduity in children's consumption of vegetables, fruit and protein. This study followed the guidelines established in the Declaration of Helsinki for research in human groups, pointing out that this research was carried out by individuals with adequate scientific preparation and under the supervision of health professionals. On the other hand, the willingness of each individual to decide whether or not to participate in this study was respected, always safeguarding their personal integrity. (Council of International Organizations of the Medical Sciences 1993).

Survey

We performed a survey looking to support the descriptive investigation in order to collect data through a previously designed questionnaire, without modifying the environment or the phenomenon. We collected this information in the form of a table. Data was obtained by performing a set of standardized questions addressed to the parents of the children selected for the study. We applied the conventional pencil and paper method for the physical filling of the questionnaire and we implemented open and closed response questions related to the lifestyle and specific topics on the nutrition of their children and the state of health, as well as related to the condition of anaemia.

Plant material

Moringa oleífera was collected in the presentation of dry leaves obtained from a food processing company. The dry leaves were packaged into bags that weighted 1 kilogram, thus gathering a total of 29.44 kilograms of the plant material that was used in the study. Leaves were pulverized in an industrial blender (HBH ECLIPSE HAMILTON® BEACH 12101034), obtaining portions of 10 gr of plant that were packaged into plastic bags made of low-density polyethylene.

Sampling

As a first step in the methodological process, an individual selection was made based on clinical criteria evaluating hematological parameters, as mentioned before. A portable hemoglobin and hematocrit meter (MISSION® XRT ACON origin China, BG Analyzers) were used for sample analysis and further selection. Children with hemoglobin (Hb) levels lower than 12 g/dl and volume of red cells lower than 33% were selected for the study. 10 ml of venous blood was extracted per individual and collected into sterile 5 mL tubes; one of them with EDTA as anticoagulant (IMPROVE® EDTA.K3) for obtaining whole blood in order to perform the assessment of volume of red cells and hemoglobin. Another sample was taken in tubes without anticoagulant to evaluate ferritin and serum iron levels (PRECISION CARE® PLAIN) and both were centrifuged at 3000 rpm to separate plasma and serum.

Supply of Moringa oleifera

The ideal fruits were chosen to mix with Moringa (orange, soursop, tree tomato, lulo and melon). 10 g of Moringa oleifera were added per 250 ml of fruit juice. The juices were prepared in the kitchen of the Juan Bautista Scalabrini Educational Institution in compliance with the cleaning and disinfection protocols. The juices were delivered to the students from Monday to Friday for 67 days (2 months).

Assess of clinical parameters

Hemoglobin and hematocrit levels from whole blood were determined in the 32 samples as follows: First sample was taken before starting the intervention (supplementation with Moringa) and the following two samples were taken 25 and 67 days after the daily supplementation, respectively. Levels were measured with Mindray BC-2300 fully automatic analyzer (SB Santa Fe Provider-Argentina). Determination of ferritin and iron were assessed from serum. Ferritin levels (BioSystems S.A), and iron serum (Wiener Lab), were measured through the Clinical Chemistry Analyzer ATAC 8000, manufacturer: ELITech Group. Data were further statically analyzed.

Statistical analysis

Statistical analysis was based on the representation of data through graphical bar charts, simple frequency distributions and contingency tables. The calculation of descriptive measures was developed as averages and standard deviation, hypothesis test for mean difference, as well as Mauchly sphericity test and comparison of variables by significant minimum difference of Turkey. The conclusions of the analysis were provided under a 95% confidence level.

Results

Social-economic lifestyles of the assessed population.

Initially, we conducted a survey seeking to identify trends of social-economical behavior that might be associated with the presence of the disease in the children of the families surveyed. We identified a high frequency among parents in terms of an appropriate understanding regarding the meaning of anaemia, but on the other hand, we also observed a general lack of knowledge about the alternatives or actions to be taken to avoid or counteract the appearance of this entity. It is quite interesting that the main biological consequence of having IDA is reflected in the low capacity of infants to carry out their school activities efficiently. In terms of lifestyles, we identified a recurrent phenomenon associated with the low-income status that characterized the population under study, which was a poor intake of essential nourishment according to the stage of development in which these children are. Chicken and beef were the protein foods that more often were given to the children on a weekly basis. As a positive observation, most children consume grains weekly, specifically lentils (Figure 1).

Adding Moringa oleifera to homemade beverages has positive effects on IDA.

Seeking to test our hypothesis on the biological effect that Moringa could promote in children suffering from IDA, we assessed a series of clinical parameters, which are the most appropriate for a clinical follow-up of this condition. Tables 1 y 2 represents all the measures of everyone analyzed. The collected data was submitted for statistical analysis, specifically comparison of variables by significant minimum difference of Turkey due to the nature of the assessed variables and the design of our work. Although no obvious difference was observed for absolute values, once the statistical tools were applied a significant difference was observed for all parameters. The mean values increased for the volume of red blood cells, hemoglobin, ferritin and serum iron in the population under study at the end of treatment in a significant trend, so the statistical evaluation gives a p-value < 0.01 for each intervention. The Mauchly sphericity test determined that the data met the homogeneity requirement except for the red cells volume (6). In order to present our findings in a more descriptive way, we present the output data through a graphical representation in which it is possible to observe the increasing trends of each parameter over time in a statistically significant way (Figure 2). These positive observations derived from the study were also identified in the proportion of children influenced by the effects of treatment. According to the histogram depicted in Figure 3, it is possible to observe a clear trend in the intervention time with respect to the increasing number of children who showed an improvement in the measurement of the biological parameters evaluated. Due to the design of the study, all individuals exhibited measurements below the normal cutoff in all the parameters at the beginning of the treatment, but this appreciation began to revert throughout the intervention, showing an increasing number of children who eventually began to recover normal values in the volume of red cells, hemoglobin, ferritin and serum iron.

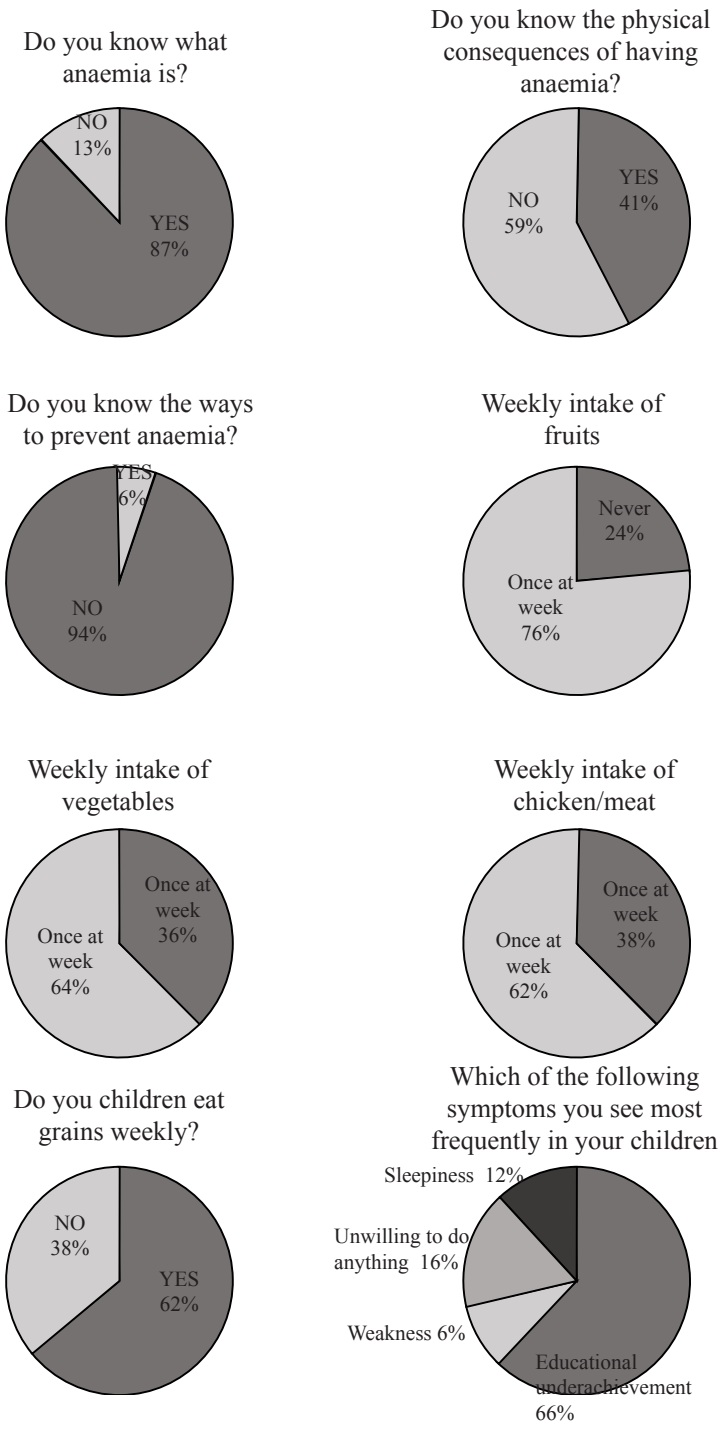

Figure 1. Questions addressed to parents of the 32 schoolchildren under study. In these pie charts are represented the most significant data obtained from the survey applied to the parents in order describe plausible descriptive associations with further assessment of the clinical parameters.

Table 1. Measurements in boys participants in the study. In this table are depicted every value for every parameter in every time lapse of intervention according to sex

	RED VOLUME CELLS ≤ 32%			HEMOGLOBIN ≤ 12,5 Gr/L			FERRITIN Male ≤ 29 µg/L ; Female ≤ 19 µg/L			SERUM IRON Male ≤ 64 µg/dL ; Female ≤ 49 µg/dL		
Code	1 Mx	2 Mx	3 Mx	1 Mx	2 Mx	3 Mx	1 Mx	2 Mx	3 Mx	1 Mx	2 Mx	3 Mx
NUES001	28	30	32	9,8	11,4	12,1	21	23	28	48	49	55
NUES002	21	28	31	8,1	9,2	11,2	25	26	29	37	38	43
NUES006	28	29	31	9,9	9,8	11,2	23	24	27	55	57	60
NUES011	30	32	33	11,2	11,1	11,9	24	26	29	41	45	46
NUES012	26	28	32	9,1	9,6	11,1	26	29	33	39	40	47
NUES022	14	19	30	5,6	6,7	10,1	26	28	31	54	55	59
NUES026	28	30	34	9,5	10,9	12,4	21	27	30	51	54	61
NUES027	24	31	35	8,3	11,1	12,6	25	27	31	39	41	49
NUES032	29	30	33	10,5	11,1	11,9	21	25	29	53	55	62
NUES036	26	30	32	9	10,7	11,1	27	28	31	45	46	57
NUES038	23	32	34	8,1	11,7	12,5	23	24	30	39	40	48
NUES039	27	33	36	10,1	11,9	12,6	24	25	29	45	48	55
NUES047	30	41	42	10,7	12,9	13,2	24	29	32	54	59	65
NUES048	29	36	41	10,1	11,9	12,9	26	30	31	61	68	69
NUES050	18	29	33	7,4	9,3	10,6	25	26	30	60	67	67
NUES054	27	28	32	9,5	9,3	10,1	27	28	31	54	56	64
NUES055	25	28	34	8,4	8,9	11,2	20	23	28	45	48	55
NUES057	23	25	30	7,9	8,1	10,6	25	26	26	39	41	47
NUES062	30	33	34	10,5	10,5	10,9	23	26	31	53	55	63
NUES066	23	34	34	7,6	8,1	10,6	25	23	28	56	57	61
NUES067	20	29	31	6,9	8,9	10,1	21	21	27	61	64	67
NUES070	19	25	30	6,7	8,3	10,3	19	23	29	52	55	64
NUES072	21	29	33	8	9,8	10,7	22	25	31	48	50	57

Table 2. Measurements in girls' participants in the study. In this table are depicted every value for every parameter in every time lapse of intervention according to sex.

	RED VOLUME CELLS ≤ 32%			HEMOGLOBIN ≤ 12,5 g/L			FERRITIN Male ≤ 29 µg/L ; Female ≤ 19 µg/L			SERUM IRON Male ≤ 64 µg/dL ; Female ≤ 49 µg/dL		
Code	1 Mx	2 Mx	3 Mx	1 Mx	2 Mx	3 Mx	1 Mx	2 Mx	3 Mx	1 Mx	2 Mx	3 Mx
NUES003	23	25	30	8,2	8,6	10,9	14	19	23	29	31	40
NUES013	21	26	30	7,5	8,4	10,9	16	18	24	28	32	40
NUES021	19	23	29	7,2	7,5	10,6	14	17	24	31	35	42
NUES031	21	28	32	7,4	8,9	12,1	15	17	25	28	29	38
NUES046	21	27	30	8,2	10,1	10,9	16	17	26	38	36	40
NUES051	27	30	32	8,7	8,9	10,9	17	17	24	47	55	61
NUES060	21	31	32	7,5	9,8	10,1	15	16	21	42	46	54
NUES064	21	27	31	8,1	9,2	11,1	15	16	24	40	42	49
NUES065	26	30	32	8,2	10,9	11,2	18	18	23	33	35	44

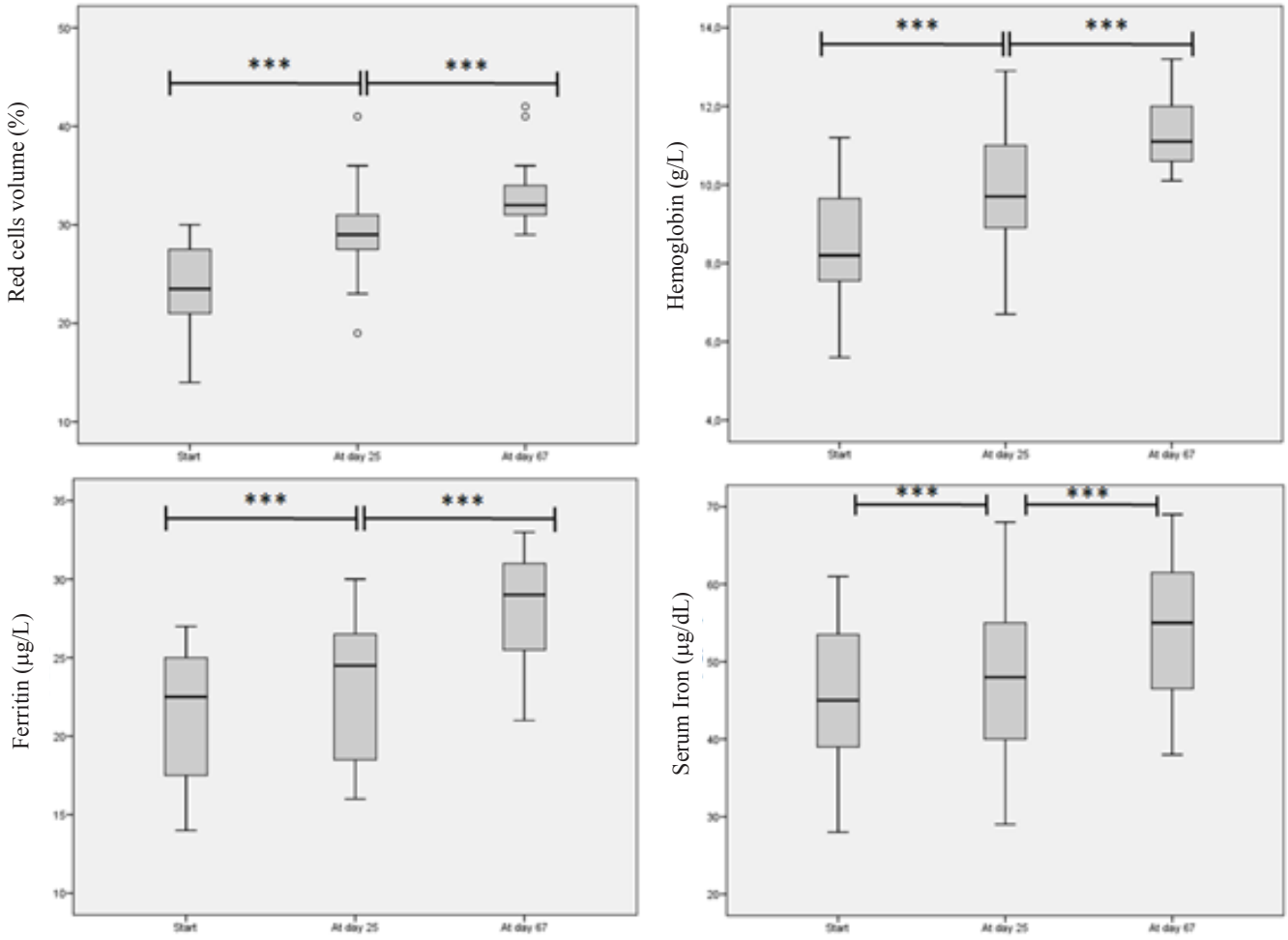

Figure 2. Evolution of anaemia based on the clinical assessed parameters. We estimated the behavior of each biological item over time looking to identify fluctuation due to the addition of Moringa in the beverages given to the children. It can be inferring from this representation the rising trend from the beginning of the intervention and during the whole time lapse of the study. Asterisk represents the p-value < 0.01.

An interesting observation is that a high proportion of children reached the normal values of volume of red cells and ferritin at the end of treatment, thus 65.6% of individuals restored their values in both parameters (Figure 3). All these data contributed to support that the strategy that we applied in this study regarding combining homemade juices with the plant under investigation has positive biological outcomes related to the recovery of the main physiological reference parameters applied in the clinical prognostic of iron deficiency anaemia.

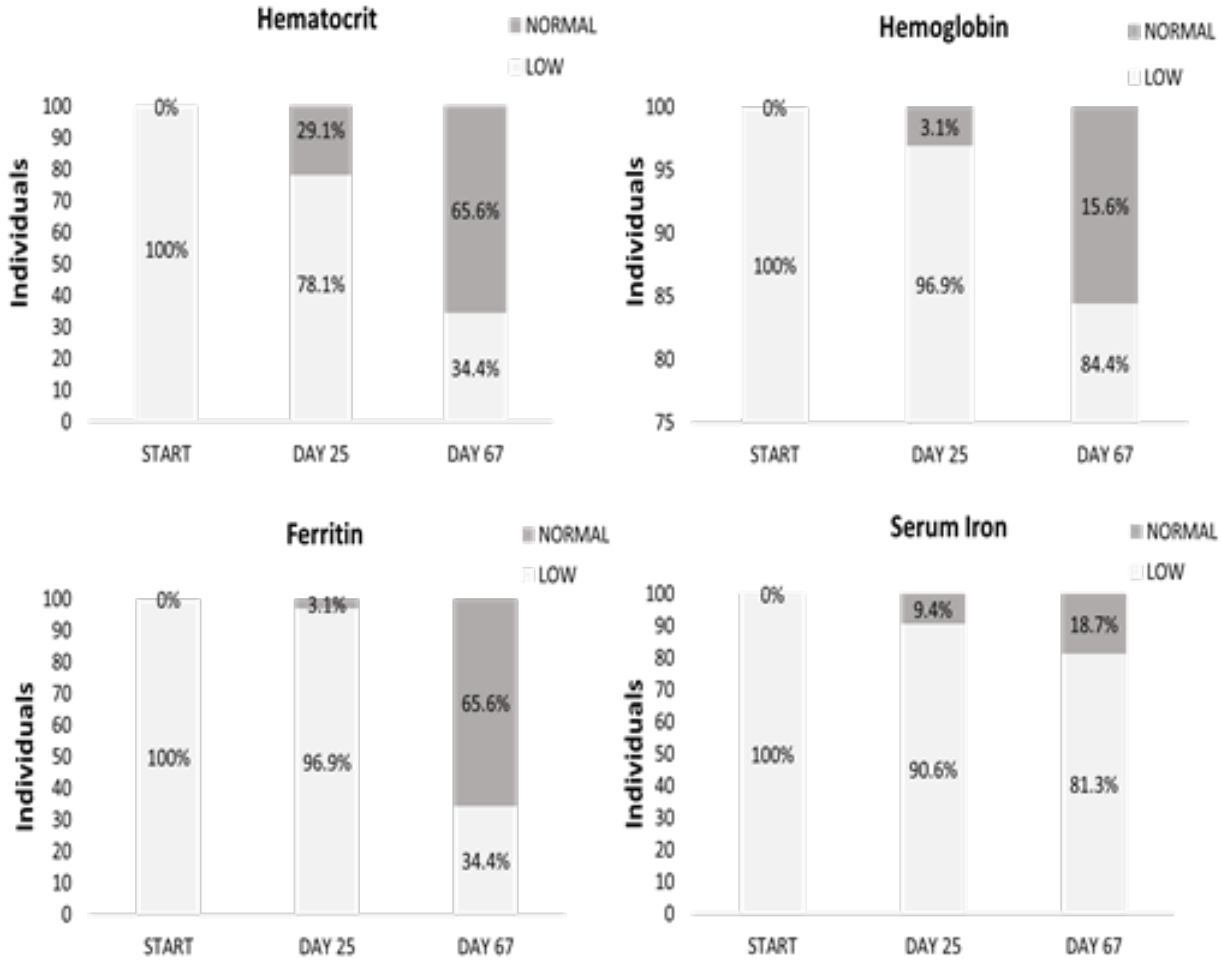

Figure 3. Proportion of individuals influenced by treatment. This histogram allows to identify a gradual increase in the number of children that start to recover the normal values in all the parameters during the time of the intervention.

Discussion

In terms of diet, it is essential to bear in mind that nutrition in the first stage of human life, i.e. in childhood, implies a commitment to the provision of enough elements to the body to carry out the necessary biological functions at this important stage of development. Assuming a balanced diet in children is key to avoiding the appearance of possible disorders such as obesity, anorexia, malnutrition, poor cognitive development, predisposition to cancer, among others. In addition to this panorama, it is common to identify inappropriate lifestyles, many of them associated with poor socioeconomic conditions. Mahan and Scote (2001) (7) state that nutrition is the intake of food in relation to the dietary needs of the body. A good nutrition (a balanced diet combined with regular physical exercise) is a key element of good health. Essential nutrients include vitamins, amino acids, fatty acids and a certain amount of carbohydrates as energy sources. The amounts needed for these nutrients differ with age and physiological status. Conditionally nutrients are those that can be synthesized in the body, such some amino acids and puric bases, in quantities that may be insufficient in certain states, so they should be provided to immature infants and individuals who do not synthesize them enough due to genetic defects or pathological conditions.

The FAO definition of undernourishment refers to the proportion of the population whose dietary energy consumption is low than a predetermined threshold. This threshold is country specific and is measured in terms of the number of kilocalories required to conduct sedentary or light activities (8). Undernourished is also referred to as suffering from food deprivation and it has a straight relation with social economic environment of a country. Colombia is one of the four countries that have managed to reduce malnutrition since 2014, however, malnutrition is a problem that affects all regions of the country. (9) Each federal agency dedicated to addressing this problem has taken steps to counteract it. Colombia's Family Welfare Institute warns that 13.2% of the country's children suffer from chronic malnutrition and ensures that strategies are already being implemented to fight this situation. (10). Thus, the government and the food companies have developed strategies that seek to confront this gloomy panorama. These alternatives include fortified public food delivery interventions such as Bienestarina, which is distributed to all children, or the free breakfast program for disadvantaged children, which distributes milk, biscuits and other cereals fortified with folic acid, iron and zinc. Among other examples in Latin America of these approaches is the work performed by Alvarez *et al* (2012), where they carried out a study regarding delivering of instant rice porridge fortified with micronutrients for children from 12 to 36 months, showing that this strategy is a potential alternative for infant feeding in a straightforward way (11). Hijar *et al* (2015) developed a systematic review of the literature related with the efficacy of fortified rice consumption in relation to increase of iron and other micronutrients levels in children from 6 to 59 months of age, and found that rice fortification represented an effective intervention strategy to correct iron deficiency in this population (12). Rojas *et al* (2011) compared the efficacy of aminoquelate iron versus ferrous sulphate as a fortifying dietary supplement in iron-deficient preschool children. Fifty-six preschool children with iron deficiency were analyzed and after two months the levels of hemoglobin, volume of red cells and serum ferritin were measured, the two compounds being found to increase ferritin levels, but milk enriched with aminoquelated iron does so in a statistically significant way (13). The food industry contributes through fortified children's foods and preparations, but the disadvantage is that they are expensive and unavailable to the families that need them most. That is why these approaches should be focused on using as raw material items that are easy to consume and with a low production cost, as it could be Moringa oleifera. Moringa is a genus of shrub whose leaves, roots and unripe pods are eaten as a vegetable. All its parts (bark, pods, leaves, seeds, tubers, roots and flowers) are edible and its use dates back to 2000 BC. (14) The potential uses of this plant are several and can be applied in the nutritional field, to the treatment of water or soil and even in industry, so it is evident the importance of this plant for the future (15). Sanchez *et al* (2016) developed a study in order to assess the impact generated by the use of the plant in in the breeding of chickens, identifying that the animals that consumed the food and water mixed with Moringa presented blood analyses of total proteins, albumin, leukocytes and hematocrit superior to those of the control group (16). In 2013, Castro developed a study to propose that the Moringa tree could be implemented as a renewable source for the production of biodiesel with high yield and productivity in Colombia, as well as an instrument to the decontamination of surface water (17). The widest and most varied studies focus on the biomedical uses of the plant. Moringa Oleifera is a small tree that has great nutritional qualities, which can contribute to the supply of nutrients needed in the diet of children (18). The leaves have outstanding nutritional qualities, which are among the best of all vegetables (19). The protein content of the leaves is 27% and contains significant amounts of calcium, iron and phosphorus, as well as vitamin A and C. This nutritional value is particularly important in areas where food security may be threatened by periods of drought, as Moringa leaves can be harvested during dry periods when no other fresh vegetables are available (20). The most important micronutrients are iodine, iron and vitamin A, which are essential for physical growth, development of cognitive and physiological functions and resistance to infections, and it is well known the association between iron deficiency and onset of IDA. Several in vitro and in vivo approaches have been developed to evaluate the potential role of this plant in the treatment of anaemia. Mun'im *et al* (2016) conducted a study to assess the effect of ethanolic extract of Moringa leaves through the evaluation of hematological parameters in female rats, finding an increase in hemoglobin, red blood cells count and total iron

content in the blood of these animals (21). Similarly, Ajugwo *et al* (2017) evaluated the hematinic effect of Moringa in 15 rats which anaemia was induced by phenylhydrazine, finding as Mun'im, an increase in hematological parameters in a significant trend (22). At the translational level, Suzana *et al* (2017) developed a randomized controlled study in anemic women in which water extract of Moringa leaves was added to ferrous sulfate therapy, finding that the extract yielded a significantly increase of mean concentration of hemoglobin, ferritin, Mean Corpuscular Hemoglobin Concentration and volume of red cells compared to control group (23). Our work is closely related to the Rojas (13) and Suzana (23) studies, since these have been developed from the clinical field, however in our approach the study subjects were not under any type of treatment for IDA, a fact that confers robustness to our work. The other approaches related to the use of Moringa in the nutritional field as a food supplement allowed us to give our study the credit of postulating this plant as a potential element in both the treatment of diseases as a complement to the diet of malnourished children, as demonstrated by this work.

Although the clinical evidence in this study points to a remedial effect of Moringa in the treatment of IDA, it should be noted that one of the weaknesses of this work lies in the absence of a control group that received only the vehicle (homemade juice), in order to be certain that the effect observed is caused by the supplement itself and not by the iron or any other element contained in the fruits used to prepare drinks. The WHO recommends a daily intake of elemental iron of at least 10 mg for the age group under study (24). It is very likely that the amount of iron that the children received through Moringa was much lower than the recommended value, however, we identified positive results regarding the evolution of anaemia, which implies that other elements contained in the plant may be promoting the metabolism of iron, a fact that would be interesting to investigate through a study that contemplates the inclusion of a control group as mentioned above (19).

Based on the solid evidence of the potential use of this plant as a natural therapeutic element for IDA, we seek to demonstrate that this strategy could be effective in coupling the addition of these extracts to daily consumption foods and economic manufacturing, such as homemade beverages. The conclusions of this work allowed to demonstrate that the addition of Moringa to these foods allowed the restoration of all the analyzed parameters in a statistically significant way. These observations are very valuable from the descriptive analysis regarding the possibility of including this type of strategy in the state's food programs, giving priority to the low resources child population. These interventions cover a broad spectrum of positive outcomes in the future, both socially and economically and in the welfare state of the general population. This work is a proof of concept that this plant has the potential to help overcome iron deficiency and recover from anaemia in a natural and direct manner without the need for medication.

Regarding to a deep biological analysis of the possible effect of phytochemicals present in Moringa and the outcome on iron metabolism, it has been demonstrated through a study carried out in rats, that iron deficient animals treated with the leaves improved the evaluated parameters exhibiting changes in the mRNA of hepcidin gene in liver, a key molecule in the iron metabolism (25). So far, these observations have not been extrapolated in humans, which could be a possible continuation of this work in order to unveil the effector mechanism of Moringa on iron metabolism.

Conclusions

These findings are a demonstration of the broad spectrum of medicinal characteristics of Moringa Oleifera and establish a promising strategy that is accessible and easy to incorporate into the families of children with iron-deficiency anaemia. For this reason, the consumption of this substance is recommended, associated with a healthy diet can generate the development of a healthy life

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