

COMPARISION OF NUTRITIONAL STATUS BETWEEN STUDENTS WHO CONSUME AND DO NOT CONSUME BIOFORTIFIED GRAINS, CHIQUIMULA, GUATEMALA

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ABSTRACT

Background: The lack of statistical data in Guatemala raises the question of knowing the biofortification of grains and its benefits on the nutritional status of primary school students. **Objective:** To determine the nutritional benefits of the consumption of biofortified grains as part of the school feeding program of the official mixed schools in the Veguitas village of the municipality of San Juan Ermita, Chiquimula, in comparison with the Linda Vista school, which do not implement grain consumption biofortified. **Method:** Prospective observational research, with a cross-sectional design, evaluating 67 students with a range of 8 to 14 years, divided into two schools. **Results:** The average height for the Linda Vista school for both sexes was 1.37 cm and in Aldea Veguitas it was 1.39 cm for girls and 1.38 cm for men, observing greater growth in students from Aldea Veguitas. The average weight for the female students of Linda Vista was 33.80 kg and for males 34.55 kg, in Aldea Veguitas for females it was 33.21 kg and for males it was 33.41 kg. **Conclusions:** During the two years of implementation of the biofortified grains program at the Aldea Veguitas school, the children have reached a nutritional status within the normal ranges based on the criteria provided by the Body Mass Index. In comparison between the children who are part of this program and those who are not, the evidence collected is insufficient to ensure the benefits of biofortification.

KEYWORDS: Malnutrition, Guatemala, Biofortified grains.

INTRODUCTION

Biofortified grains are the result of a nutritionally enriching food applied especially to seeds such as beans, corn, cassava, and rice, with the aim of combating malnutrition.

This research is based on the comparison of two schools in Guatemala in the community of San Juan Ermita, the Veguitas school where students consumed biofortified grains and the Linda Vista school where they were not incorporated into their school plan.

The first years of life of the human being are fundamental, since it is a stage where the bases of growth are developed, in addition to their cognitive, social and biological development, this defines the capacity in which an individual manages to consolidate in his adulthood. Malnutrition is a pathology that mainly affects children because it causes growth retardation, poor cognitive and behavioral development, school

learning difficulties, which leads to the individual being affected in their productivity in the future.

In Guatemala, malnutrition represents a current problem in the child population, according to CEPAL, it is considered to be the country with the highest rates of chronic malnutrition. Based on the above, the use of biofortified foods was implemented to reduce malnutrition rates, however, currently in our country there are no studies that correlate their effectiveness against malnutrition.

For the above reason, a prospective observational research was carried out, with a quasi-experimental design of a mixed approach, which seeks to explain the benefits of consuming biofortified grains in school-age children between the ages of eight and fourteen, who have consumed it for a period of two years.

METHODOLOGY

The present research is a type of prospective observational research because it seeks to observe the influence of the consumption of biofortified grains on the nutritional status of children, to determine if their intake presents a difference in the body mass index in the children who consume them, based on the weight in kilograms and height in centimeters of each student from third to sixth grade, in comparison with the children who do not consume them, being students of the same academic grades. It was decided to study a topic related to nutrition because in Guatemala 49.8% of children suffer from chronic malnutrition, that is, 1 in 2. It is the first place in Latin America and the sixth in the world in terms of child malnutrition^{2,6}.

Furthermore, Guatemala does not have enough studies to know the benefits of food biofortification specifically for at-risk age groups such as school-age children. Cardona briefly mentions the characteristics of biofortified grains or crops, of which it can be mentioned that: “they are obtained through conventional genetic improvement techniques, the process of which begins in seed banks with the identification and characterization of the genotypes, that naturally present higher contents of micronutrients; Subsequently, these are crossed with varieties with high yield potential and good adaptability to biotic and abiotic factors, in order to obtain productive progenies with nutritional quality.”³

Research Design

A quasi-experimental design was chosen for this research where the study subjects were not grouped randomly, as they were previously established. In this research, the groups were defined according to those who consumed biofortified grains and those who did not consume biofortified grains. So the objective was to determine the influence of the independent variable, that is, the consumption of biofortified grains, on nutritional status, which was the dependent variable.

A cross-sectional design was also chosen since all data were collected on a single occasion and on a single planned date, in order to evaluate the variables and their interrelationship.

Approach

The mixed approach was chosen for this research because quantitative variables were used when evaluating the anthropometric measurements of the students, both from the EORM Aldea Veguitas and Barrio Linda Vista, and qualitative variables when interviewing parents about grain intake, biofortified foods that are given to students as part of the School Feeding Program at the EORM Aldea Veguitas, which consists of providing “nutritious, healthy, safe, cultural, ethnic, socially and biologically acceptable food that students receive punctually in educational centers, during the school period. These foods complement the

household diet and contribute to satisfying their daily diet.”⁴

The department of Chiquimula was chosen because it is part of the Dry Corridor, which is characterized by the irregularity of climatic changes that prevent the adequate harvest of basic foods, which contributes to the high rates of malnutrition in Guatemala. According to Action Against Hunger, “Guatemala has the highest rate of chronic malnutrition in Latin America and one of the highest in the world (49%). In some rural areas, especially in the Department of Chiquimula, it reaches 80%.”⁵

Variables

The variables studied during the research process were: nutritional status, biofortified grains and the school feeding program in order to obtain results for the research analysis.

Study population

In the field research, a census was carried out with a total of 67 students, to take anthropometric measurements in both units of analysis. These are the EORM of Aldea Veguita distributed as follows: 14 students from 3rd primary, 13 from 4th, 12 from 5th and 7 from 6th primary. On the other hand, in EORM of Barrio Vista Hermosa, there are 6 students from 3rd Primary, 7 from 4th, 7 from 5th and 1 from 6th Primary.

Sampling

A sampling of volunteers was carried out, which consists of a non-probabilistic sampling, in the application of interviews to parents. It is necessary to indicate that only those who were interested in supporting the study and who were communicated through the link of the World Food Program in Guatemala were interviewed, said program is in the process of implementing the production and consumption of biofortified grains in the Veguitas Village.

Hypothesis

HO: The difference between the median BMI of children who consume biofortified grains and those who do not consume them has a difference equal to 0.

HI: The difference between the median BMI of children who consume biofortified grains and those who do not consume them does not have a difference equal to 0.

Data processing and analysis

The data was extracted into electronic Excel sheets and subsequently the data modeling was carried out. Firstly, the calculation of the body mass index was carried out, with the application of the formula: $BMI = \text{weight (Kg)} / \text{height (m}^2\text{)}$. Data modeling was carried out, with the calculation of the measures of central tendency, typical error, standard deviation, kurtosis, asymmetry coefficient, of both units of analysis, to proceed with the comparison of the BMI for each group analyzed.

Likewise, statistical software such as R Studio and SPSS were used for subsequent analysis to check the normality of the distribution of the data: weight, height and BMI and to verify the hypothesis of difference in medians.

Limits and obstacles of research

The limitations found in carrying out the study were: Lack of previous research at the national level on the topic of interest, time limitations to carry out data collection, due to the work and educational activities of the researchers and finally the availability of time, the engineer who supported with the mobilization and transportation to the establishments of interest; since the first planned date had to be modified to receive support and accompaniment to the study areas.

Different obstacles were found to obtain data that were real, reliable and truthful, among which are: Non-attendance of the students who would be part of the census for various reasons, difficulty of access to the Veguitas Village since the land is irregular.

Autonomy

Those people with the characteristics described in the inclusion criteria and who also fully agreed to participate were taken into account. The respective procedures were carried out for authorization of entry to schools and access to students in charge of the institutional authorities. Additionally, a dialogue was held with directors and parents; in which the purpose and benefits

of the research and the reason why it was taken into account were explained to them in a clear and simple way; Participants were informed that they have the right not to be part of the study or, if they wished at any time, to withdraw from it at any time. They were also made aware that the information provided was confidential and access is exclusively for team members and for study use. Finally, it was explained that personal information such as name (if they do not wish to give it), address and telephone number were not necessary in the surveys.

Research risk

Data collection was carried out through interviews and surveys, both considered observational techniques, where the privacy of people is not invaded physically, emotionally, psychologically, economically, the study is classified as category I. Therefore, The values or rights of the study subjects were not affected in any way.

RESULTS

The study included 46 students from the Official Mixed Rural School —EORM— Aldea Veguitas, who have consumed biofortified grains for at least 2 years as part of the School Feeding Program —PAE—, and 21 students from the EORM Barrio Linda Vista, who have also been beneficiaries of the PAE, but it has not included biofortified grains. Both schools are located in the San Juan Ermita municipality, Chiquimula, Guatemala.

Student Demographic Characteristics

Table 1: Data from the students who participated in the study.

Grade / Description	Students Aldea Veguitas			Students Barrio Linda Vista			Age Group	
	F	M	Total	F	M	Total	EORM Veguitas	EORM Linda Vista
Sex								
Third	4	10	14	4	2	6	8 - 12	8 - 14
Fourth	4	9	13	2	5	7	9 - 14	10 - 12
Fifth	6	6	12	2	5	7	11 - 12	10 - 12
Sixth	3	4	7	1	0	1	12 - 15	12
Total	17	29	46	9	12	21		

Note. Student data by grade and sex from the Official Mixed Rural Schools Aldea Veguitas and Barrio Linda Vista. Own elaboration, carried out with Excel.

Students Eating Habits

Table 2: Diet diversification.

Eating Group	EORM Aldea Veguitas	EORM Barrio Linda Vista
Milk and others	24%	16%
Meat, eggs	40%	41%
Legumes	67%	65%
Vegetables and greens	17%	15%
Bread, cereal and derivatives	59%	50%
Fruit	4%	5%
Fats and oils	4%	4%

Note. Diet diversification expressed in percentage of consumption, of the students participating in the study. Own elaboration, carried out with Excel.

Weight and height of students

At the EORM Aldea Veguitas, the heights of 46 students were analyzed. A mean height of 1.38 m (95% confidence interval: 1.35-1.41 m) and a standard deviation of 0.093 m was obtained. The minimum size obtained was 1.16 m and the maximum was 1.58 m.

The Shapiro-Wilk normality test was applied to the height data set of the students of Aldea Veguitas, which gave a value of $p = 0.993$, with a significance level of 0.05, it was established that the sizes have a normal distribution.

At the EORM Aldea Veguitas, the weights of 46 students were analyzed. A mean weight of 33.34 kg (95% confidence interval: 31.19-35.46 kg) and a standard deviation of 7.19 kg was obtained.

The Shapiro-Wilk normality test was applied which gave a value of $p = 0.039$, with a significance level of 0.05, effectively establishing that the sizes do not have a normal distribution.

Nutritional status of students

Table 3: Nutritional status of the students of the EORM Aldea Veguitas and Barrio Linda Vista.

Nutritional Status	EORM Aldea Veguitas		EORM Barrio Linda Vista	
	Students	Porcentaje	Students	Porcentaje
Severe Malnutrition	0	0%	0	0%
Malnutrition Moderate	1	2.17%	0	0%
Normal	39	84.78%	18	85%
Overweight	5	10.87%	3	14%
Obesity	1	2.17%	0	0%
TOTAL	46		21	

Note. The previous table was prepared based on the BMI classification for age of children from 5 to under 20 years of age, adapted from FANTA III. Obtained from the Ministry of Public Health and Social Assistance (2018). Manual of Comprehensive Health Care Standards for first and second level. Own elaboration, carried out with Excel.

Comparison of the Body Mass Index –BMI– of the students

Before comparing the BMI of the students from the EORM Aldea Veguitas and the students from the EORM Barrio Linda Vista, the Shapiro-Wilk normality test was applied to each group. In the students of the EORM Aldea Veguitas, the Shapiro-Wilk test gave a value of $p = 0.001993$ and with a significance level of 0.05, it was established that the BMI of this group of students did not have a normal distribution.

For the students of the EORM Barrio Linda Vista, the Shapiro-Wilk test gave a value of $p=0.8948$ and with a significance level of 0.05, it was established that the BMI of this group of students did have a normal distribution.

The BMI variances of both groups were also compared using Fisher's F test. With a significance level of 0.05, the results reported that the variance between the two groups of students (not equivalent) was $F = 1.2305$ and with a value $p = 0.6277$, it was established that the variances of the BMI of both groups are equals.

At the EORM Barrio Linda Vista, the heights of 21 students were analyzed. A mean height of 1.37 m (95% confidence interval: 1.34 -1.40 m) and a standard deviation of 0.077 m was obtained. The minimum size obtained was 1.20 m and the maximum was 1.54 m.

The Shapiro-Wilk normality test was applied to the data set of the sizes of the students of Barrio Linda Vista, which gave a value of $p = 0.960$, with a significance level of 0.05, it was established that the sizes have a normal distribution.

A mean weight of 34.23 kg (95% confidence interval: 31.10-37.36 kg) and a standard deviation of 6.87 kg was obtained. The minimum weight obtained was 20.45 kg and the maximum was 46.40 kg. The Shapiro-Wilk normality test was applied which gave a value of $p = 0.156$, with a significance level of 0.05, it was established that the sizes have a normal distribution.

Because the populations could not be compared statistically with parametric tests, because the BMI results of the students of the EORM Aldea Veguitas did not present a normal distribution; However, both study groups did present equal BMI variance, so the non-parametric Wilcoxon Mann Whitney test was applied for the difference in medians between independent groups. It was observed that both groups showed that the difference between groups was equal to 0, ($W = 469.5$; $P < 0.7764$) with a significance level of 0.05, which allowed the acceptance of the null hypothesis of the research that states that, the difference between the median BMI of children who consume biofortified grains and those who do not consume them has a difference equal to 0.

DISCUSSION

It is important to analyze the age range of the students who were subjects of the study; It is observed that in both establishments in all primary grades there are underage, school-age and overage children, including adolescent students up to 14 years of age. Likewise, it was observed in the field visit that only in the Aldea

Veguitas EORM there is one classroom per grade, but not in the Barrio Linda Vista EORM, which uses the multigrade classroom modality.

Regarding eating habits, students from both educational centers have an average of three meals a day, the most consumed foods are: beans, tortillas, bread and sausages; This trend is considered to be due to the low cost and easy access of the products. There is little variety and low consumption of other food groups such as fruits, vegetables and dairy products, which have more significant nutritional contributions compared to those with greater consumption.

Additionally, students benefit from the School Food Program -PAE-, which consists of the delivery of a bag with food such as basic grains such as beans, rice, sugar, corn, oil, noodles, some fruits and vegetables, depending of local production and purchases that are approved by the Parents' Organization Program. This program only supports the family economy and contributes to increasing school coverage and permanence.

It is worth mentioning that, when comparing the status of weights and heights in both schools, the distribution of heights in the two locations studied is carefully examined. Through observations and records subjected to normality tests, it is determined that the sizes in both populations are relatively homogeneous and follow normal distribution patterns. This can be helpful in better understanding student health and well-being in these areas. It should be taken into account that the differences observed in weight distributions underline the importance of educational and awareness programs on nutrition and well-being. By addressing these issues in the local context, schools and communities can collaborate to improve student health and promote healthy living practices.

It is important to keep in mind that when analyzing the weights of the students of EORM Aldea Veguitas and EORM Barrio Linda Vista, patterns are observed that warrant careful analysis. While in Aldea Veguitas a distribution of weights is identified that differs from normality, with a slight asymmetry towards the right tail, in Barrio Linda Vista the weights follow a more typical distribution close to normal. These differences in distributions could be related – such as ratio, weight and height – to local and contextualized factors that could be the subject of future research.

Therefore, the results obtained are not conclusive, which will allow future and more extensive research to help investigate more closely the reasons behind the differences in distributions between the Aldea Veguitas and Barrio Linda Vista EORMs, exploring factors such as diet, access to medical services and socioeconomic conditions that may or may not be influencing these differences, being opportunities for targeted

interventions and more informed decision making and the design of effective student health programs.

To determine the nutritional status, the anthropometric method was used, which consisted of measuring the weight and height of the students to subsequently calculate the Body Mass Index –BMI–. Having obtained the BMI of each student, it was classified according to the BMI Table for age, for boys or girls, from 5 to under 20 years of age.^[7]

This table classifies the results into the following groups: Severe malnutrition at BMI <-3 standard deviations –SD–. Moderate malnutrition at BMI ≥-3 to <-2 SD. Normal nutritional status at BMI ≥-2 to $\leq+1$ SD. Overweight at BMI $>+1$ to $\leq+2$ SD. Obesity at BMI $>+2$ SD.^[7]

As indicated in the results section, both in students who did consume and in students who did not consume biofortified grains, different cases of malnutrition were identified. Of these 10 cases, 1 was classified as moderate malnutrition and 1 as obesity, both cases corresponded to a student from the EORM Aldea Veguitas, and 8 cases were classified as overweight, of which 5 corresponded to students from the EORM Aldea Veguitas and 3 to students from the EORM Barrio Linda Vista. These results show that, despite the different types of foods usually consumed by these groups of students, they do not cover their optimal nutritional requirements.

To compare the nutritional status between the students of the Aldea Veguitas EORM, who consume biofortified grains, and the students of the Barrio Linda Vista EORM, who do not consume biofortified grains, the Shapiro-Wilk normality tests were used, with which it was determined that for the BMI variable in the EORM Aldea Veguitas the data are not normally distributed ($W = 0.91184$) since the results show that the p value is equal to 0.001993, at a significance level of 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted, which establishes that the BMI data of the EORM Aldea Veguitas do not follow a normal distribution.

In the case of the data of the BMI variable of the students of the EORM Barrio Linda Vista, using the Shapiro-Wilk normality test, also because it was a sample of less than 50 cases, it was determined that the data are distributed normally ($W = 0.97804$), with a significance level of 0.05, the p value is equal to 0.8948, which allows us to accept the null hypothesis that shows that the BMI data from the EORM Barrio Linda Vista follow a normal distribution.

The BMI of both groups was also compared by comparing their variances with Fisher's F test, at a significance level of 0.05, the results show that the variance between the two groups of students (non-equivalent) is $F = 1.2305$ at a confidence level of 95%,

where the p value is equal to 0.6277; the variation is 1.230541; Therefore, the null hypothesis is accepted, which allows us to establish that the BMI variances are the same whether they consume biofortified or traditional grains.

Because it was determined that one of the populations did not behave normally, the non-parametric Wilcoxon Mann Whitney test was applied for the difference in medians between independent groups, the results obtained that the difference between groups is equal to 0, ($W = 469.5$; $P < 0.7764$) at a confidence level of 95%, which allows accepting the null hypothesis of the present investigation, which states that the difference between the median BMI of children who consume biofortified grains and those who do not consume them have a difference equal to 0, so it can be determined that the consumption of biofortified grains does not make a statistically significant difference in the BMI of those who consume it.

CONCLUSIONS

- It was determined that the nutritional status of primary level students who consume biofortified foods compared to those who do not, as part of the school feeding program in official schools of the municipality of San Juan Ermita, Chiquimula, for the development of a benefits guide nutritional, do not show statistically significant differences.
- It was identified that the eating habits of primary level students who consume biofortified foods compared to those who do not consume them as part of the school feeding program in the official rural mixed schools, Veguitas and Barrio Linda Vista, do not vary except for consumption of biofortified grains in the EORM Aldea Veguitas.
- It was possible to identify that the implementation of biofortified grains did not lead to a significant increase in weight, height or BMI from one school to another.
- It was established that in the EORM Aldea Veguitas 87% of the students are overweight, 2.17% are obese, 2.17% have moderate malnutrition and no student has severe malnutrition. Compared to the students of the EORM Barrio Linda Vista where more than 85% of the students have a normal nutritional status and 14% are overweight. No student has severe malnutrition, moderate malnutrition or obesity.

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