Study of EDTA intake of children for potential use of FeNaEDTA for breakfast cereal fortification

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SUMMARY. EDTA is used as disodium salt or disodium-calcium in foods, to prevent lipid oxidation or as color and flavor stabilizer. In some countries, FeNaEDTA is also used as a source of iron for fortification. However, EDTA has an Acceptable Daily Intake (ADI) of 2.5 mg / kg/day. The aim of this study was to estimate the intake of EDTA in children of school age and the potential use of FeNaEDTA as iron source for breakfast cereal fortification. A qualitative-quantitative food frequency questionnaire was conducted on 225 schoolchildren of both sexes, aged between 4 and 13, from school canteens, public and private schools, from the city of Santa Fe (Argentina). Only those foods which EDTA addition is allowed in Argentina: packaged ice cream, soda, soft drinks and powdered soft drinks (upper limit of Na_2EDTA o $Na_2CaEDTA$: 35 mg/kg) and dressings and margarines (upper limit of $Na_2CaEDTA$: 75 mg/kg) were considered. EDTA Average Daily Consumption (ADC) was 0.06 mg/kg/day with a median of 0.011 mg/kg/day, representing 2.4% of the ADI. In the hypothetical case that FeNaEDTA would be used as iron source for breakfast cereal fortification at level of 11 mg Fe%, the potential EDTA ADC would be 0.46 ± 0.32 mg/kg/day, representing 18.4% of the ADI (2.5 mg/kg/day). Results indicate that children from Santa Fe city have an EDTA ADC currently well below the maximum ADI of EDTA, which would remain low even if FeNaEDTA is used for breakfast cereal fortification.
Key words: EDTA consumption, iron fortification, FeNaEDTA, breakfast cereals, food frequency questionnaire.

RESUMEN. Estudio de la ingesta de EDTA en niños para la utilización potencial de FeNaEDTA en la fortificación de cereales para desayuno. El EDTA es utilizado en alimentos como sal disódica o disódica-cálcica, para prevenir la oxidación lipídica o como estabilizante del color y sabor. En algunos países, FeNaEDTA es también usado como una fuente de hierro para la fortificación de alimentos. Sin embargo, posee una Ingesta Diaria Admisible (IDA) de 2,5 mg/kg/día. El objetivo de este estudio fue estimar la ingesta de EDTA en niños y el potencial uso de FeNaEDTA como fuente de fortificación de hierro en cereales para desayuno (CPD). Se realizó un cuestionario de frecuencia alimentaria cuali-cuantitativo a niños de ambos sexos, en edades comprendidas entre 4 y 13 años, que asistían a comedores escolares, escuelas públicas y privadas de la Ciudad de Santa Fe, Argentina. Solo se evaluaron aquellos alimentos en los que se halla permitido el agregado de EDTA en Argentina: helados envasados, gaseosas, bebidas sin alcohol y jugos en polvo, aderezos y margarina. La Ingesta Diaria Promedio (IDP) de EDTA fue de 0,06 mg/Kg/día con una mediana de 0,011 mg/kg/día, lo que representa el 2,4% de la IDA. En el hipotético caso de que FeNaEDTA fuera usado como fuente de hierro para fortificación de CPD en un nivel de 11 mg Fe%, la potencial IDP de EDTA sería de 0,46 ± 0,32 mg/kg/día, lo que representa un 18,4 % de la IDA. Los resultados indican que la IDP de EDTA está muy por debajo de la IDA máxima, la cual seguiría siendo baja incluso si el FeNaEDTA se utilizara como fortificante de hierro en CPD.
Palabras clave: Consumo de EDTA, fortificación con hierro, FeNaEDTA, cereales para desayuno, cuestionario de frecuencia alimentaria.

INTRODUCTION

Iron-deficiency anemia is the most prevalent disease in developed and undeveloped countries, affecting two million people worldwide (1, 2). Risk groups are young children and women of childbearing age. During periods of rapid growth, blood volume expands and more iron for red blood cells is needed. Iron deficiency can result in neurological and muscular diseases in pregnant women, premature birth and diseases of the fetus (3).

International organizations such as UNICEF and the World Health Organization (WHO) have been actively working to eradicate malnutrition, recommending four strategies: education, dietary diversification, supplementation and fortification (2).

Fortification of foods, namely micronutrients addition to staple foods, has been done in many industrialized countries for many years with considerable success, proving to be effective in correcting nutritional deficiencies of the population or specific groups at risk. Foods from all major groups such as flour, bread, cereals, dairy, oils, sugar, sweets and non-alcoholic beverage, can be fortified without altering the taste and appearance of food (4).

Dietary micronutrients are found in different chemical forms, which absorption depends not only on the content and chemical form of the mineral, but also on other occurring food components, interactions between elements and individual physiological factors (4).

Consequently, to estimate the effectiveness of the micronutrient contribution from the diet, it is not enough to determine the content in the food, but also the absorption and utilization by the body's cells, i.e. the bioavailability (5, 6).

Several organizations promote the use of sodium iron EDTA salt (FeNa EDTA) as iron source in developing countries. The main advantage of using FeNa EDTA in food fortification is that Fe is protected in gastrointestinal tract from iron absorption inhibitors, such as phytates and polyphenols. Another proposed strategy is the use of the disodium salt of EDTA (Na_2EDTA) as an enhancer of iron absorption when it is added as ferrous sulfate (7).

Cereal-based foods are found among the most commonly suggested vehicles for iron fortification (4). It has been reported that iron from FeNaEDTA is 2 to 4 times better absorbed than iron from ferrous sulfate in a variety of cereals and legumes based foods. It does not promote lipid oxidation and is stable during food processing and storage (8).

Iron is better absorbed when the ratio EDTA: Fe is 0.25 to 1. The protective action of EDTA is independent of whether it is added as FeNaEDTA or Na_2EDTA (9).

EDTA is also used as disodium salt or disodium calcium in foods such as heavy metal scavenger to prevent lipid oxidation or as a color and flavor stabilizer.

Many countries permit EDTA addition to foods. The European Union allows the addition of EDTA in a very small number of foods and prohibits it use intended for infant food. In Latin America there are different policies. In Argentina, the Argentine Food Code (CAA) allows the addition of Na_2EDTA or $Na_2CaEDTA$ to packaged ice cream, soda, soft drinks and powdered soft drink with a limit of 35 mg/kg and in dressings (mayonnaise and mustard) and margarines, $Na_2CaEDTA$ is allowed with a limit of 75 mg/kg. In other countries, including Brazil, Chile and Colombia the addition of these additives is allowed in a greater number of foods (10).

It should be noted that EDTA has an ADI of 2.5 mg/kg/day. Therefore, it should be considered the potential daily intake of this additive not only for controlling the levels of addition, but also for the possibility of using FeNaEDTA for food fortification.

According to a report by the Organization of the United Nations Food and Agriculture Organization and WHO (2) there are three groups of additives on which it is important to evaluate the intake: the additives permitted in high concentrations in many foods, the additives in foods that are highly consumed and those with an ADI of 0 to 5 mg / kg.

There are two types of groups where EDTA intake should be carefully controlled, the population of higher economic strata because of their greater access to industrialized food and children (11).

The aims of this work were estimate EDTA consumption by children and adolescents in order to determine EDTA employment levels and evaluate the potential consumption of EDTA in the hypothetical case of using FeNaEDTA as fortification iron source in breakfast cereals.

MATERIALS AND METHODS

Participants:

A population of 225 children and adolescents of both sexes (97 female and 128 male) from the city of Santa Fe (placed in the center of Argentina), aged between 4 and 13 years old, who attend schools canteens (20.9 %), public and private schools (36% and 43.1% respectively), were classified as belonging to low (L), middle (M) and upper middle (UM) social class, respectively. The survey was carried out between October 2009 and April 2010. The sample was drawn randomly and parent consensus was asked. Surveys corresponding to children between 4 and 10 years were answered by their parents and those made for people over 10 years old were answered by themselves.

Data collection instrument and study procedures:

A qualitative-quantitative food frequency questionnaire considering only foods where EDTA as additive is allowed by the CAA was performed. The food groups used for the preparation of this survey were: dressings (mayonnaise and mustard), soda, soft drink, powdered soft drink, packaged ice cream, and margarine. For each food group the frequency of consumption (how often the food is consumed at day, week or month), the number of servings consumed each time and the brand most frequently consumed were asked. The survey suggested different serving sizes depending on the food, for example: cups, soup spoons, teaspoons, etc.

The weight of each individual was measured in order to calculate the EDTA ADC, expressed as mg/kg/day.

The survey also requested details about the age and sex of the subject.

In the same survey, the consumption of breakfast cereals was assessed.

Analysis of the questionnaires:

The ADC of each food was recorded. The presence of EDTA in a product was considered from the label of each food. If the food contained EDTA, the maximum concentration allowed by the CAA was taken.

Serving sizes were considered according those established in the MERCOSUR Technical Resolution 47/03 (Spoonful of soup: 10 g, spoonful of tea: 5 g, glass: 200 ml, can: 354 ml, bottle: 250 ml) (12).

To study the potential use of FeNaEDTA as fortificant in breakfast cereal, a level of 11mg Fe/100 g product was considered. This is the amount stated in the majority of commercially available breakfast cereals. This value corresponds to 57.4 mg EDTA, because molar ratio iron: EDTA of 1:1 (11).

Statistical analysis:

Data were processed using the Statgraphic Plus 5.1 for Windows. In order to determine if the sample belong to a normal population the determination of kurtosis was made. As samples were from a non-normal distribution, data were compared using Kruskal-Wallis Test. When p value was less than 0.05, the difference was considered significant.

RESULTS

Food Average Daily Consumption:

Table 1 shows food ADC for each one of the foods evaluated and the percentage of participants who consumed them. The Multifactor ANOVA shows that there were no statistically significant differences in the consumption of these foods by gender and social class.

TABLE 1
Food average daily consumption (ADC) and consumption percentage

Food	%	ADC (g or mL/day)*
Mayonnaise	79.1	7.2 ± 10.9
Mustard	24.0	1.0 ± 2.5
Margarine	16.0	3.1 ± 29.4
Soda	98.2	343.5 ± 395.0
Soft drinks	63.5	110.0 ± 235.0
Powdered soft drink	89.8	335.7 ± 479.0
Packaged ice-cream	62.7	14.0 ± 28.1

*Median value ± SD

These foods supply about 1226.2 KJ/day (293.3 Kcal/day), considering the ADC values showed in Table 1 and average energy values of 1676.2 Kj for mayonnaise, 200.6 Kj for soda and 54.3 Kj for powdered soft drinks (13), which would represent from 15 to 17% of the energy needs of this age group (7213-8175 Kj/día) (14).

EDTA Average Daily Consumption:

Considering the foods that actually use EDTA and the maximum EDTA supply that each type of food could do according CAA, an EDTA ADC of 0.0603 ± 0.0145 mg/kg/day was obtained. This represents a 2.4% of the ADI (2.5 mg / kg / day; ADI). The range of EDTA consumption was 0.001 - 1.26 mg/kg/day, with a median of 0.011 mg/kg/day.

Factors affecting EDTA Average Daily Consumption:

When EDTA ADC was analyzed by sex and age, no statistically significant differences were found. However, when the factor was the social class, middle-class children consumed more EDTA and upper middle class had the lower EDTA consumption (Table 2).

When EDTA ADC was analyzed by kind of consumed food, it could be observed that soda and mayonnaise were the foods which did the major contribution. Soft drinks, powder soft drinks and packaged ice cream consumed did not contain EDTA (Table 3).

TABLE 2
Kruskal-Wallis Test for EDTA Average Daily Consumption (ADC) analyzed by social class.

Social class	n	EDTA ADC (mg/Kg/day)*
Lower class	47	0.0198 ± 0.0024 [b]
Middle class	81	0.0276 ± 0.0076 [c]
Upper middle class	97	0.0130 ± 0.0045 [a]

*Median value ± SD. LSD test was used for statistic analysis. When p value was less than 0.05, the difference was considered significant.

TABLE 3
Kruskal-Wallis Test for EDTA Average Daily Consumption (ADC) analyzed by food groups.

Food	EDTA ADC (mg/Kg/day)*
Mayonnaise	0.0104 ± 0.0040 [c]
Mustard	0.0010 ± 0.0004 [a]
Margarine	0.0070 ± 0,0010 [b]
Soda	0.0420 ± 0.0090 [d]
Soft drinks	0
Powdered soft drinks	0
Packaged Ice-cream	0

*Median value ± SD. LSD test was used for statistic analysis. When p value was less than 0.05, the difference was considered significant.

Potential EDTA Daily Consumption:

In the unlikely event that all brands of food where EDTA addition is permitted would use it, the potential EDTA daily consumption would increase to 0.6 mg/kg/day, which represents 24.12% of the ADI.

Potential EDTA consumption in case of using FeNaEDTA as fortificant in breakfast cereals:

The ADC of breakfast cereals was 27 g/day, with a standard deviation of 61.58 g/day. No statistically significant differences were found when these data were evaluated according to sex and social class.

The hypothetical EDTA consumption from breakfast cereals, in the case of iron fortification with 11 mg Fe/100g using FeNaEDTA as iron source, would be 0.4 mg/kg/day.

If this value adds to EDTA ADC calculated from the intake of food which EDTA addition is allowed, the potential EDTA ADC would be 0.46 ± 0.32 mg/kg/day.

DISCUSSION

The children population under study belongs to L (20.9%), M (36%) and UM social class (43.1%).

Table 1 show that almost all participants consumed soda, powdered soft drinks and mayonnaise on a regular basis. The energy come mainly from lipid and refined sugars. Taking into account the increased incidence of obesity observed in this age group in recent years, the consumption of these foods would be an unhealthy habit for a population in the middle stage of growth and adoption of eating habits.

EDTA ADC values were close to those obtained by Cagnasso et al (11), in a survey of children and adolescents of both sexes, aged from 3 to 18 years, from the city of Buenos Aires (EDTA ADC = 0.04 mg/kg/day, 1.6% of the ADI). However, the EDTA ADC value is lower than those obtained in other Latin American countries like Brazil, Chile and Mexico, where 0.18 mg/kg/day, 0.40 mg/kg/day and 0.48 mg/kg/day, EDTA ADC who were found, respectively (15). These differences could be due to the different food habits and because in these countries, the use of EDTA in a wider range of products is allowed. Coinciding with the results of Cagnasso et al (11), sex and age did not affect EDTA ADC, and soft drinks and mayonnaise were the foods that contribute most to the EDTA ADC.

The hypothetical EDTA consumption from breakfast cereals adds to EDTA ADC calculated from the intake of food which EDTA addition is allowed, the potential EDTA ADC would be 0.46 ± 0.32 mg/kg/day, representing 18.4% of the ADI (2.5 mg/kg/day). In this case, 4 subjects would have a consumption of 0.72 ± 0.06 mg/kg/day, representing 28.8% of the ADI.

CONCLUSIONS

The results show that the EDTA ADC observed in children and adolescents from the city of Santa Fe (0.06 mg/kg/day) was below to the maximum value of IDA (2.5 mg/kg/day), being soda the food that contributed most to EDTA intake.

This study shows that fortification of breakfast cereal with FeNaEDTA would have a significant influence on EDTA ADC. However, the EDTA ADC would not exceed the ADI for EDTA, especially when it is consider that the methodology used (food frequency questionnaire) tends to overestimate the consumption. Thus, it can be assumed that the actual intake of EDTA would be less than that found in this study.

Breakfast cereals would be an important vehicle for fortification using FeNaEDTA, particularly because of cereals have high phytate content and other iron sources have low bioavailability in this matrix.

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REFERENCES

1. Ferreyra PA, Vallejos NR. Desnutrición oculta: Una nueva forma de desnutrición. Revista de Posgrado de la VIa Cátedra de Medicina. 2003; 124: 14-17.
2. World Health Organization Department of Nutrition for Health and Development /United Nations University/UNICEF. Iron deficiency anemia, assessment, prevention and control: a guide for programme managers. Geneva: WHO, 2001.
3. Carmuega E, O' Donnell AM. Calidad de la dieta infantil en la salud de los niños hoy y mañana. Publicación CESNI, Ed Gaudian, Argentina, 1999
4. Hurrel R, Egli I. (2010) Iron bioavailability and dietary reference values. Am J Clin Nutr. 2010; 91: 1461-7.
5. O'Dell BL. Bioavailability and interactions among trace elements. J Nutr. 1985; 102: 653-660.
6. Southons S, Fairweather-Tait J, Hazell T. Trace element availability from de human diet. Proc Nutr Soc. 1998; 47: 27-35.
7. INACG. Iron EDTA for Food Fortification. A report of the International Nutritional Anemia Consultative Group. Lynch, S.R., Hurrell, R.F., Bothwell, T.H., MacPhail, A.P. Washington, USA 1993.
8. Hurrell RF, Reddy MR, Burri J, Cook JD. An evaluation of EDTA compounds for iron fortification of cereal-based foods. Br J Nutr. 2000; 84: 903-910.
9. Hurrel RF. Fortification: Overcoming technical and practical barriers. J Nutr. 2002; 132: 806-812.
10. Cagnasso CE, Lopez LB, Valencia ME. Sales del ácido etilendiaminotetraacético: una alternativa en la fortificación de alimentos con hierro. Act Nutr. 2010; 11: 140-148.
11. Cagnaso CE, López LB, Rodríguez VG, Valencia ME. Estimación de la ingesta potencial de ácido etilendiaminotetraacético en niños y adolescentes argentinos, influencia de la fortificación de cereales para desayuno con sal férrica de este ácido. Rev Chil Nutr. 2007; 34: 143-149.
12. MERCOSUR Technical Resolution 47/03. www.puntofocal.gov.ar. Access: March 2012.
13. Food composition table. Database ARGENFOODS. Edited by Universidad Nacional de Lujan. http://www.unlu.edu.ar/~argenfood.Access: March 2012.
14. FAO/OMS/UNU. Human energy requirements. Technical Paper Series, No. 1. Rome, 2004.
15. Fisberg RM, Torres EAFS, Morimoto JM, Fisberg M, Araya HL, Vera GA et al. Estimativa do consumo de EDTA em escolares. Rev Soc Bras Alim Nutr. 2002; 24: 71-83.

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