Food Fortification

TO END MICRONUTRIENT MALNUTRITION

STATE OF THE ART

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Sugar Fortification With Vitamin A: A Central American Contribution to the Developing World

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Abstract *Sugar was first fortified with vitamin A in Guatemala in the mid 1970s, cutting VAD in children in half. With the political unrest and economic turmoil of the ensuing decade, fortification ceased and within a few years VAD once again assumed alarming proportions. Recently, a partnership of government, the sugar producers, INCAP/PAHO, USAID, UNICEF and others worked to reestablish conditions for fortification. The government granted producers a temporary exemption from import duties on vitamin A concentrate and new machinery. Technical assistance was offered by a number of organizations. Once again, VAD in children has been cut in half.*

Introduction

Sugar fortification with vitamin A in Central America has a long history, starting in the 1970s. The technological and economical feasibility, as well as the biological impact, was clearly proven, and its efficacy was the precipitating factor for its introduction as a national program in Costa Rica, Guatemala and Honduras. However, the programs had very short lives mostly because of economic reasons. Fortunately, the programs came back to life during the early 1990s, when the world looked at the year 2000 as the deadline to overcome many human afflictions, among them, vitamin A deficiency.

Nowadays, sugar fortification takes place as a national program in El Salvador, Guatemala and Honduras. Other countries, such as Nicaragua, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Mexico, India, the Philippines and Zambia have plans in this regard.

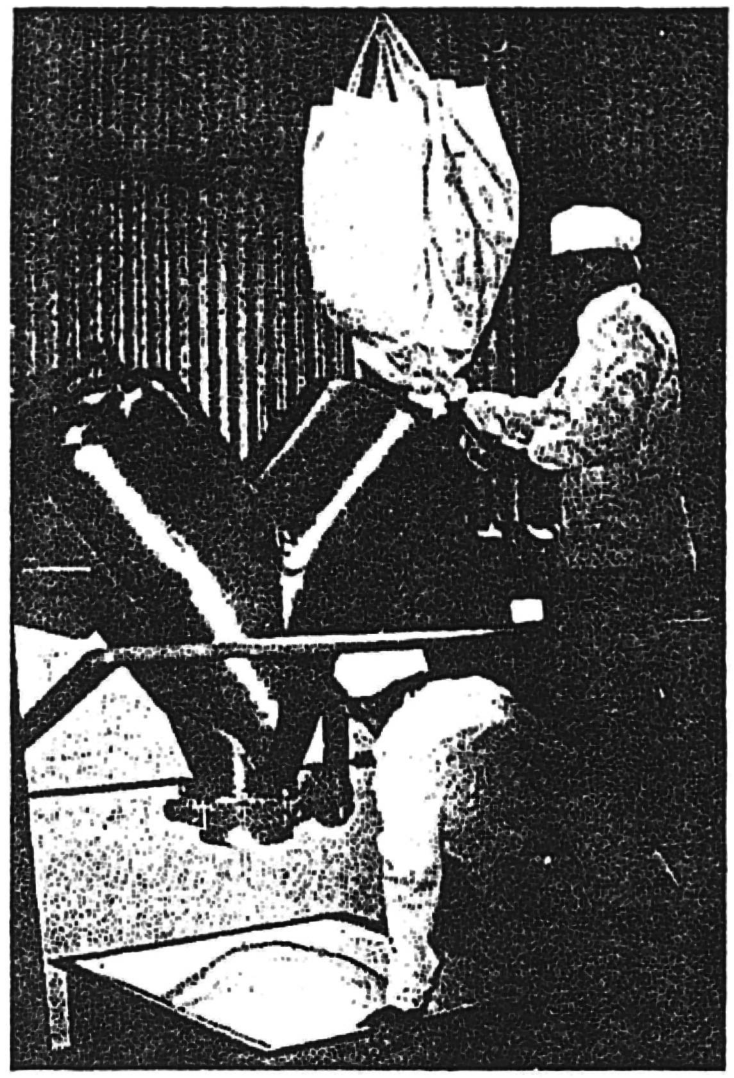
During this new phase in the life of sugar fortification as a public health program, we have reviewed the original process and determined the behavior of the fortified sugar under "true life conditions". This new knowledge pertains to the stability of the retinol during sugar production, marketing, and during its use by relevant food industries.

Characteristics of Sugar Fortification Programs

Sugar fortified with vitamin A is a mixture of sugar, either standard or refined, retinyl-palmitate beadlets, vegetable oil and antioxidants. The beadlets contain, in addition to retinol, antioxidant substances and a gelatin matrix, which are there to increase the stability of vitamin A under adverse environmental and commercial conditions, and to make it water dispersable. Vegetable oil is used as the adhesive between the beadlets and the sugar crystals.

The Roche Corporation and INCAP have been carrying out experiments designed to identify other compounds that could replace vegetable oil as the adhesive element, because the oil tends to become rancid in the premix after two months of storage under tropical conditions. So far, we have confirmed that peanut oil and other vegetable oils with a lower amount of unsaturated fatty acids and a lower tendency to become rancid continue to be the best options. Once the premix is diluted into sugar, this oxidation does not have any importance.

The process of fortification consists of diluting this vitamin A premix over the sugar during the final steps of its production. The premix has a retinol concentration 1000 times larger than the expected final level in the product. The ideal point of the premix addition is after the drying step in the turbines, because part of the vitamin A beadlets are separated from the sugar crystals due to exposure to warm-wind currents inside this apparatus. Originally, fortification was done before the drying turbines, because they act as large mixing devices. However, the disadvantage of adding the vitamin A premix after this point is that most sugar mills lack a mixing system to assure retinol homogeneity. To overcome this limitation, the Department of Food Technology of the University of Campinas in Brazil has designed a simple system that consists of two feeding chutes – one for sugar and the other for the vitamin A premix, and an endless screw that performs the blending. The system requires a minimum length to ensure sufficient mixing. Initial results are promising, and it is expected that sugar mills will be willing to introduce this additional structure into their actual system.



In Guatemala, a small facility centrally produces premix for all the nation's sugar processors.

New Insights Into the Sugar Fortification Process

During the last two years, a quality assurance system for the complete program has been introduced in Guatemala and Honduras, in the latter country with support from the International Life Science Institute (ILSI). It consists of a quality control component carried out by producers; monitoring at factories, warehouses and retail stores by governmental personnel; and surveillance of the final product at the household level. This simple quality assurance system has provided us with a great deal of interesting and useful data, on which most of the following information is based.

Efficiency of the fortification process at factories

Mass balance analysis of the retinol content from the premix and its final product, the fortified sugar, has revealed that the process has an efficiency between 70 and 85% when the fortification takes place before the drying turbines. That means that the theoretical 1:1000 dilution of the premix over the sugar should be reduced to 1:700 to 1:850, according to the particular situation of each sugar mill. These data strengthen the need to apply the premix after the drying turbines. However, the actual system is still valid because of its clear usefulness and biological impact.

Stability of retinol in sugar through the marketing chain

Sugar samples have been obtained from households, using nationally representative survey samples, both in Guatemala and in Honduras. Sampling has taken place five to six months after the end of one sugar cane harvest season and two to three months before the next one. Therefore, the data are fairly representative of the average values that could be obtained during the year.

In 1996 the mean content of retinol in sugar at homes was 6.9 mg/kg in Guatemala, and 6.6 mg/kg in Honduras. In Honduras, this value is confounded by the leaking of non-fortified sugar into the households, which adds up to 20% of the sugar available in the market for human consumption. If that portion of sugar is eliminated from the calculation, the average is increased to 8.0 mg/kg. Those results suggest that in Guatemala, 63% of the initial retinol in sugar reaches homes, whereas in Honduras this value is 51%.

It is important to point out that for the 1995-96 harvest of sugar cane, 98% of Guatemalan households and 82% of Honduran households had sugar fortified with vitamin A at the moment of the surveys; and that in 75% and 66% of the samples the retinol content was above 5 mg/kg, respectively. We are proposing that four to six months after the conclusion of the sugar harvest, 100% of the households should have fortified sugar and 80% of these should have sugar with retinol levels above 5 mg/kg. These criteria assure that the mean retinol content in sugar would be at least 9 mg/kg during the year. This retinol level would provide nearly 100% of the RDA for most persons from sugar alone, completely fulfilling the nutritional goal of providing 50% of the RDA for most populations; only children younger than two years old would be receiving less than this amount.

Under the actual circumstances, it is valid to say that severe vitamin A deficiency has been overcome in Guatemala and in Honduras, with the exception of children below three years of age, whose sugar intake is naturally low. Children between two and three years of age will also be covered once the mean average of sugar retinol reaches 9 mg/kg or greater. The results from recent national surveys demonstrate the biological impact of this intervention. The percentage of preschoolers with low levels of plasma retinol (< 20 μg/dL) reduced from 40% to 13% in Honduras, and from 27% to 15% in Guatemala. Comparatively, similar surveys in the neighboring countries of El Salvador and Nicaragua revealed that the situation is a public health problem in the absence of sugar fortification and other interventions.

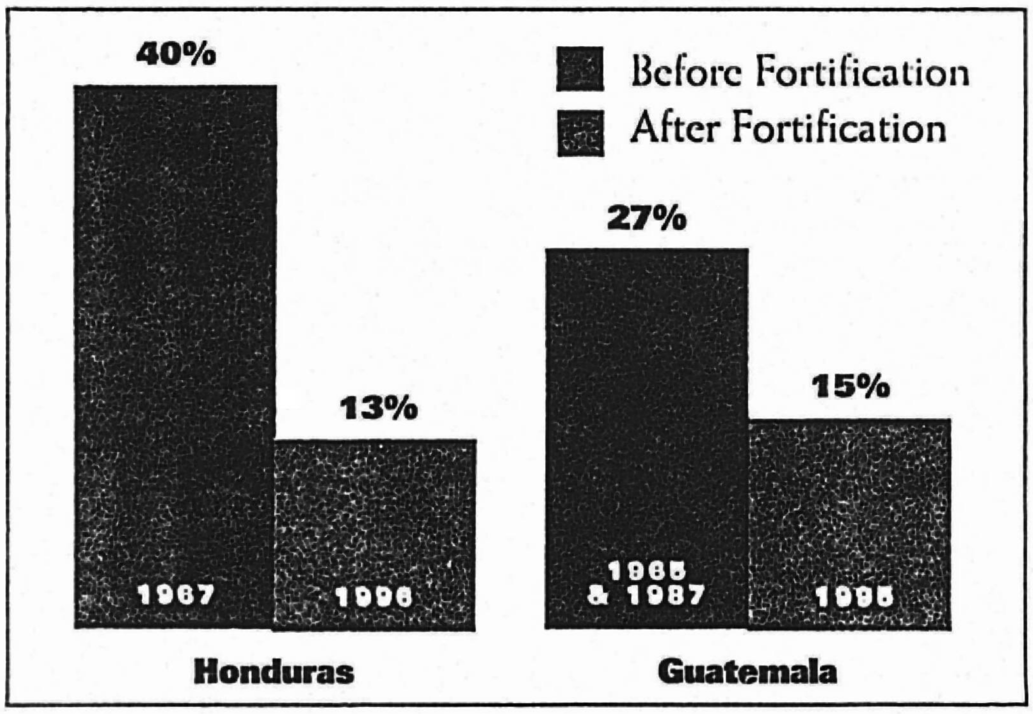
Stability of retinol when sugar is used as an ingredient

Currently, the soft-drink industry is the main consumer of sugar in Central America; 15 to 25% of the total national consumption is devoted to this use. Other important sugar consumers are candy factories and bakeries, which represent an additional 10% of the sugar consumption at the national level. Our recent studies revealed that retinol from sugar is very stable in the two latter industries, in which 70 to 90% of the added retinol is maintained, and it remains in considerable amounts during the entire shelf-life of the products.

The situation with the soft drink industry is different. If standard sugar is used, retinol is completely destroyed because of the clarification (or whitening) process of the sugar syrup with active charcoal and diatomaceus earth. In the case of refined sugar, the procedure of whitening is avoided, and 33% of the retinol from sugar is destroyed during soft-drink production. Retinol content in drinks made in this manner decreases a further 30% during the first week of storage. Further losses occur very slowly after this period, the reason why soft drinks in Guatemala made with refined and fortified sugar contain some retinol (25% RDA for adults). These results suggest that if it were possible to separate sugar destined for the soft drink industries, that type of sugar might not be fortified.

Use of nonfortified sugar for the candy and bakery industries is a matter of internal decision of each country. Retinol remains in these products, and its presence does not mean any health risks to consumers. Indeed, retinol intake, through all sources in which fortified sugar is an ingredient, is much lower than the level recommended as safe (3.3 mg/day) for pregnant women, whose child-to-be may suffer due to high dosages of retinol. Nevertheless, countries with universal programs of fortified sugar with retinol should consider abstaining from adding retinol to other foods above restitution levels.

Preschoolers With Low Plasma Retinol

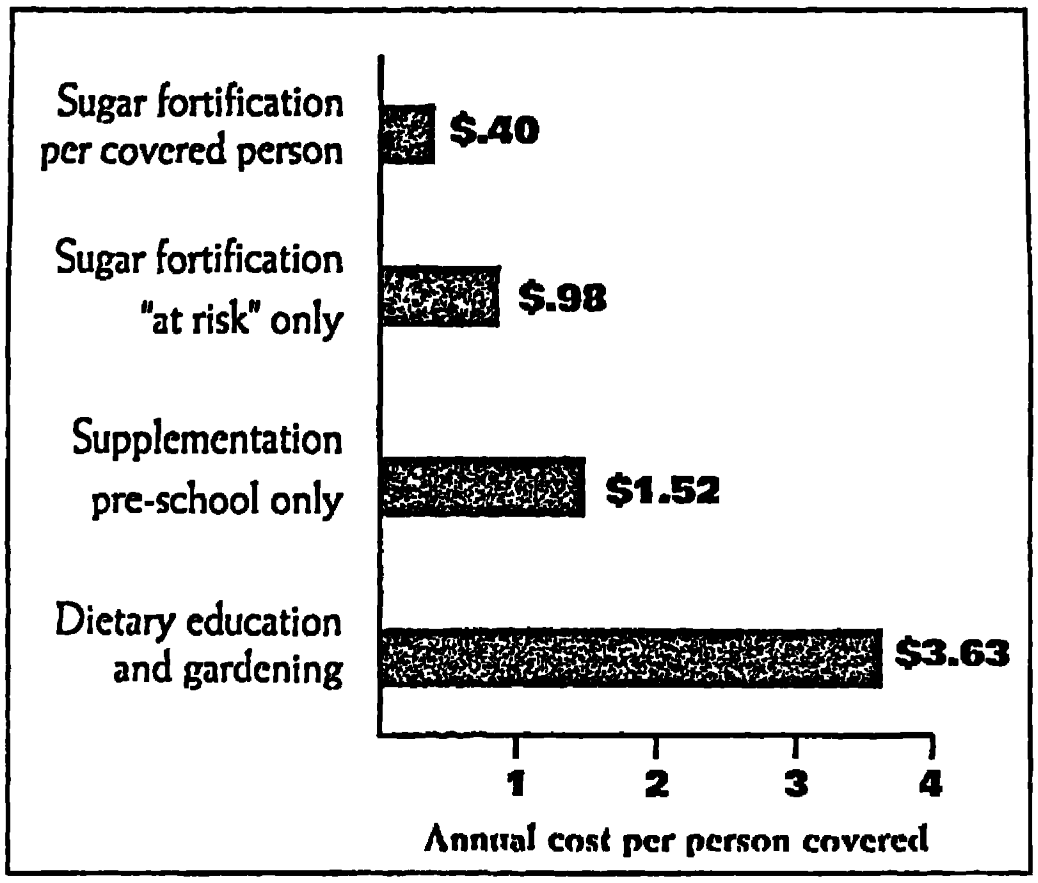


Recent national surveys demonstrate the biological impact of sugar fortification with vitamin A. The prevalence of preschool aged children with <20μg/dl was cut dramatically in both Honduras and Guatemala.

Cost-Effectiveness Analysis

In 1991 the Project of Latin America and Caribbean Health and Nutrition Sustainability, supported by USAID, made a cost-effectiveness evaluation of three interventions to prevent and correct vitamin A deficiency. These interventions were sugar fortification, supplementation with pharmaceutical dosages of vitamin A and promotion of vegetable production and consumption. The study concluded that sugar fortification was the strategy with the larger coverage and the best cost efficacy: US$0.98 per year per at-risk person (cost per person is US$0.40), US$1.52 for supplementation that covers only pre-school age children, and US$3.63 for vegetable consumption.

Intervention



A 1991 study in Guatemala comparing interventions to correct VAD concluded that sugar fortification provided the largest coverage and best cost efficiency.

Using all the information that we have now, we can re-estimate the cost of the sugar program. It is US $3,654,000 to fortify 350,000 M.T. of sugar. From this amount 95% corresponds to the cost of the fortificant. One must add the cost for monitoring and program evaluation, which represents an additional expenditure of US$60,000 to US$100,000 per year. Consequently, the yearly cost per person at risk who is recovered from deficiency is US$1.01 for the total program. This figure shows that sugar fortification continues being the most cost-effective intervention in Guatemala, even if the fortification is universal. Thirty percent savings might be obtained if production of non-fortified sugar for industrial use were allowed. However, the risk of losing control of the program might seriously affect the value of introducing this strategy. Therefore, it should not be implemented until the program is very stable.

Conclusion

Sugar fortification in Central America has been an effective and efficient intervention to overcome and to prevent vitamin A deficiency. In spite of the identified limitations, such as non-homogeneous final product, and 40 to 50% retinol losses during the shelf-life of the product (eight months), it continues being a good strategy, with favorable cost-effectiveness and coverage. Therefore, in its actual state it is valid to consider its introduction in other countries that are affected by this deficiency. However, this program should continue being a matter for research, to make it more efficient. Areas of investigation include searching for systems to add and to blend the fortificant mixture with sugar at the factories, and developing a retinol beadlet or similar compounds that might prove more stable under adverse environmental conditions. In essence, however, the program works as it currently exists.