Effect of a beverage fortified with evaporated sugarcane juice on hemoglobin levels in preschool children

Francisco P. Arcanjo,[1] Vicente P. Pinto,[1] Maria R. Arcanjo,[2] Márcia R. Amici,[2] and Olga M. Amâncio[3]

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ABSTRACT *The study objective was to measure the effect of consumption of a beverage mixed with a high-iron sweetener (evaporated sugarcane juice known as* rapadura*) on hemoglobin levels in preschool children, and to compare it with the effect of consuming the same beverage sweetened with refined sugar. Research consisted of a 12-week randomized, controlled double-blind trial conducted in 2007 at a state-run school in Sobral, Brazil, among children aged 2–3 years. The study sample was divided into two groups—one consuming cashew juice mixed with 25 g of* rapadura *and 40 mg of ascorbic acid (per 200-mL serving), and another consuming the same quantity of juice and ascorbic acid sweetened with 25 g of standard refined sugar. A significant statistical increase in hemoglobin was observed in the group consuming the* rapadura*-fortified beverage. It was therefore concluded that consumption of* rapadura *increased hemoglobin and thus reduced iron deficiency anemia in preschool children.*

Key words Anemia; *rapadura*; child, preschool; hemoglobins; iron; dietary carbohydrates; Brazil.

Iron deficiency anemia (anemia) is the most widespread preventable nutritional problem in the world, despite the continuous implementation of global programs for its control. The World Health Organization (WHO) estimates more than 2 billion people suffer from this condition worldwide; according to the United Nations Children's Fund (UNICEF), more than 750 million of them are children (1, 2).

Increasing evidence from studies in animals and humans relates anemia in the first years of life to impaired intelligence in later stages (3).

It has been estimated that in 10 developing countries (Bangladesh, Bolivia, Egypt, Honduras, India, Mali, Nicaragua, Oman, Pakistan, and Tanzania) annual losses due to reduction in physical productivity through anemia are US$ 3.54 per person or 0.81% GDP, and that median total losses (physical and cognitive) are US$ 16.78 per person or 4.05% GDP (4).

WHO promotes three main approaches to deal with anemia: dietary diversification, to include foodstuffs rich in iron, with high bioavailability; fortification of staple food items, such as wheat and maize flour; and the supply of iron supplements to at-risk groups (5).

Dietary diversification is probably the best and most sustainable means of addressing the problem of anemia. According to WHO, the most promising dietary

[1] Federal University of Ceará, Sobral (CE), Brazil. Send correspondence and reprint requests to: Francisco Plácido Arcanjo, Federal University of Ceará, Av. Gerardo Rangel 100, Sobral, CE 62041-040, Brazil; telephone: +55 88 3611-4879; fax: +55 88 3677-4241; e-mail: placidoarcanjo@terra.com.br
[2] Secretariat of Education of Sobral, Sobral (CE), Brazil.
[3] Federal University of São Paulo, São Paulo (SP), Brazil.

diversifications schemes are those that include use of local or regional foodstuffs (5). Popular regional foodstuffs with high iron content are of specific interest, as they can be used to combat anemia in populations with low iron reserves, or high iron requirements, such as growing children and women of childbearing age (5, 6).

The use of regional foodstuffs to improve iron status has been evaluated in various studies, including a randomized controlled trial conducted among children aged 6–12 months to analyze the effects of a mixture of 20% fish powder and 80% porridge, consumed in some parts of Africa, on anemia. In that study, the authors concluded consumption of the fish-porridge mixture was not sufficient to prevent iron deficiency (7).

In Latin America (especially Brazil and Venezuela) and the countries of the Caribbean, one regional foodstuff that is high in iron content, readily available, and of low-cost is *rapadura*—an unbleached, unrefined sweetener. *Rapadura* is essentially pure, dried juice, obtained from the sugarcane plant (*Saccharum officinarum*), and prepared and distributed in the form of a block (a method originally created to facilitate its transport). Produced in large scale at sugarcane plantations in tropical regions, *rapadura* is used as a cheaper, more accessible replacement for refined sugars. It is also healthier than refined sugar, as the only sugar product in which the sugar stream is not separated from the molasses, which helps it retain most of its essential nutrients, vitamins, and minerals (8).

Various uses of *rapadura* worldwide have been studied, including the tradition of prelacteal feeding of newborns in some regions of Asia. For instance, in some parts of India, it is common practice to delay breast-feeding of newborns for 48–72 hours after birth, replacing it with inaugural feeds that may include boiled water, tea, sugar, honey, *jaggery* (the Indian term for *rapadura*), or glucose mixed with drinking water or diluted animal milk (9, 10).

Use of this sweetener has also been observed and studied among Indian factory employees working in smoky and dusty environments, with results indicating that those who regularly consumed it suffered less from respiratory illness than their non-*jaggery*-consuming counterparts. In Ayurveda, the ancient traditional system of Indian medicine, *jaggery* has been associated with beneficial effects against several health conditions, such as cough, gastritis, diarrhea, and arthritis (11).

More recently, researchers have reported on the characterization of *jaggery* in dust-exposed rats. In one such study by Sahu and Saxena, *jaggery* was found to have a preventive effect on smoke-induced lung lesions in rats, providing more evidence for the potential use of the sweetener as a protective agent for workers in dusty and smoky environments (12).

Despite these various studies on the benefits of *rapadura* (or *jaggery*), there is a lack of scientific research evaluating the systematic consumption of the sweetener on hemoglobin (Hb) and anemia. Although a clinical research study was conducted on the use of *laddoo* (an Indian food composite containing *jaggery*) and its effects on anthropometric parameters and Hb levels, the effects of *jaggery* alone were not investigated (9). The current study was undertaken in an effort to fill this gap.

The study objective was to evaluate whether regular consumption of *rapadura* as a natural sweetener in fruit juices (mixed with ascorbic acid) is capable of preventing or treating anemia in preschool children. The study was carried out over 12 weeks among two groups of children aged 2–3 years. One group was given cashew fruit juice sweetened with 25 g of *rapadura* mixed with 40 mg of ascorbic acid (per individual serving), while the other group received the same quantity of cashew juice and ascorbic acid sweetened with refined sugar. The nutritional compositions of *rapadura* and standard refined sugar vary greatly in many different aspects, including iron content: *rapadura* contains 6.43 mg per 100 g, whereas the amount of iron in standard refined sugar is minimal (0.02 mg per 100 g) (8).

The research was conducted in the City of Sobral, located in the northeastern part of Brazil. Fieldwork was done between September and November 2007. The study population comprised all preschool children aged 2–3 years (202 students) from one randomly chosen state-run school, which was located in an urban zone. The students were randomized into two groups (one intervention group and one control group). The allocation code was generated using a table of random numbers. Children enrolled in the study were examined by a qualified medical officer. Children already receiving iron supplements and those with chronic or acute anemia were excluded from the study. The *rapadura*-fortified beverage was previously tested with students in schools that did not participate in the study to assess acceptability. The intervention started and ended for all participants on the same day.

The study consisted of a randomized, placebo-controlled, double-blind trial. Participants were not aware of the different compositions of the two beverage mixtures (which were prepared daily and offered to the children by school professionals who were not involved in data collection), and the staff involved in collecting data and measuring the main research outcomes were blinded to the allocation of the intervention group (group A) versus the control group (group B). The study took place over 56 school days (Monday through Friday). The *rapadura*-fortified beverage and the beverage sweetened with refined sugar were offered to the intervention group and the control group, respectively, in individual (200-mL) portions. The cashew juice used in both beverage mixtures was prepared by a nutritionist at the school. Cashew juice was chosen for the study due to its ready availability in the region and habitual consumption as part of the normal school menu. The prepared beverages were similar in appearance (color); however, there was some difference in taste. The beverages were consumed once daily. The quantity of ascorbic acid used in each individual serving (40 mg) was based on the 1989 Recommended Dietary Allowance (RDA) for children aged 2–3 years.

Inclusion in the study was determined as follows: The total number of students at the school was 483. From this total school population, 202 students met the age criterion (being 24–36 months old at the beginning of the study). The eligible students were then offered the opportunity to participate in the study, with their participation made official through the signing of a parental consent form. At the beginning of the study (baseline), before the initial blood sample, 32 (12.9%) of the eligible students were eliminated from the sample for the following reasons: 12 (4.8%) refused to participate; six (2.4%) presented acute or chronic anemia; five (2.0%) were not able to provide parental consent (as their parents were absent at the time of the screening); and nine (3.6%) were already receiving iron supplementation. After the initial blood sample, 10 more students were excluded from the study (seven who decided not to participate; and three more students who were determined to be suffering from acute or chronic anemia). The final study sample of 160 students was then randomized into two groups (A and B), for an initial total of 80 students in each group. During the research period, group A lost five participants (one due to migration, two that were absent for the final blood analysis, and two that refused to provide a blood sample) and group B lost three (one due to migration and two that were absent for the final blood analysis), resulting in a final total of 75 and 77 participants respectively.

All final study participants underwent two biochemical evaluations (one at baseline and one after the intervention) to determine Hb and hematocrit levels. A questionnaire was distributed among the participants' mothers to gather information about the sample and to define its general characteristics.

Participants' mothers were instructed to contact the medical officer assigned to the study in the case of any changes in their child's health. In addition, children were examined fortnightly by a qualified medical officer to monitor for any adverse events that could be related to the intervention.

The main study outcomes were Hb and hematocrit levels. Study results were obtained using the following methods: Venous blood was collected at baseline, in tubes containing EDTA (ethylene diamine tetraacetic acid), followed by Hb and hematocrit analysis using an automatic [open-tube] analyzer (model ABX Micros 60 OT, Horiba ABX, Irvine, CA, USA). The cutoff Hb value defining anemia in the study sample was based on WHO criteria for children aged 2–4 years (Hb <11 g/dL) (6). Analysis of venous blood samples was made to calculate the effect of the different interventions on Hb and hematocrit levels.

To detect a reduction of 50% in overall anemia in both study groups, assuming anemia prevalence at 70% with 90% power and a 2-sided type I error of 5%, and 10% losses in follow-up, a minimum of 76 baseline participants was required for each group.

Data was managed and analyzed using Epi Info™ 2000, version 3.3.2 (U.S. Centers for Disease Control and Prevention, Atlanta, GA, USA). Paired Student's *t*-tests were used to assess the difference in Hb and hematocrit levels within and between the groups before and after the intervention, and a *p*-value of <0.05 was used to define significant associations. Analyses were by intention to treat.

All children in the study sample had access to medical support upon request to treat any possible adverse effects caused by the intervention, or any other clinical alteration detected by the children or their legal guardians. Children who were still anemic after the intervention were referred for treatment.

The study was approved by the Ethics Committee for Research at Acaraú Valley State University (*Universidade Estadual do Vale do Acaraú*) and developed integrally following the ethical principles for research involving human beings established in Brazilian National Health Council Resolution no. 196/96.

Biological and demographic characteristics and breast-feeding history at baseline were similar for both the intervention and control group after the randomization of the study participants, who were quite similar in terms of age, gender, mother's schooling, family income, and birth weight.

Both the *rapadura*- and refined sugar–fortified beverage mixtures used in the study were well accepted by the participants, although mean consumption of

TABLE 1. Intra-group comparison of the effects of consuming beverages sweetened with either *rapadura* (sugarcane juice) or refined sugar on hemoglobin (Hb) levels among preschool children in Sobral, Brazil, September–November 2007

	Group A (*rapadura*) (*n* = 75)			Group B (refined sugar) (*n* = 77)		
Mean age of study participants in years (SD[a])	2.6 (0.6)			2.7 (0.6)		
Estimated mean daily consumption of beverage per child (SD)	129.9 mL (53.6)			151.7 mL (31.9)		
Estimated mean daily consumption of iron per child from beverage sweetener	1.04 mg			0 mg		
	Before	After	*P*-value[b]	Before	After	*P*-value[b]
Mean Hb (g/dL) (SD; CI[c])	11.1 (1.09; 10.68–11.45)	11.6 (2.10; 11.24–12.01)	0.042	10.2 (1.20; 9.88–10.44)	10.3 (1.26; 10.04–10.59)	0.44
Hematocrit (%) (SD; CI)	36.6 (3.01; 35.96–37.33)	34.4 (3.01; 33.74– 35.11)	<0.0001	33.8 (3.11; 33.11–34.40)	32.4 (2.61; 31.74–33.03)	0.0035
	Before	After	Reduction	Before	After	Reduction
Iron deficiency anemia[d] (%)	40	20	50	72.7	72.7	0

[a] SD = standard deviation.
[b] Based on paired Student's *t*-tests (considered significant at *p* <0.05).
[c] CI = confidence interval.
[d] Defined as Hb concentration <11.0 g/dL (as per World Health Organization criteria for children <5 years old).

TABLE 2. Comparison of hemoglobin (Hb) and hematocrit levels before and after an iron fortification intervention conducted among preschool children in Sobral, Brazil, September–November 2007, by study group

	Baseline			After intervention		
	Group A[a]	Group B[b]	*P*-value[c]	Group A	Group B	*P*-value[c]
Mean Hb (g/dL)	11.1	10.2	<0.0001	11.6	10.3	<0.0001
(SD[d]; CI[e])	(1.09;10.68–11.45)	(1.20; 9.88–10.44)		(2.10; 11.24– 12.01)	(1.26; 10.04– 10.59)	
Mean hematocrit (%)	36.6	33.8	<0.0001	34.4	32.4	<0.0001
(SD; CI)	(3.01; 35.96–37.33)	(3.11; 33.11–34.40)		(3.01; 33.74– 35.11)	(2.61; 31.74–33.03)	

[a] $n = 75$.
[b] $n = 77$.
[c] Based on paired Student's *t*-tests (considered significant at $p < 0.05$).
[d] SD = standard deviation.
[e] CI = confidence interval.

the beverage sweetened with refined sugar was slightly higher (Table 1).

For the group consuming the *rapadura*-fortified beverage mixture (group A), mean Hb and hematocrit was 11.1 ± 1.09 g/dL and 36.6 ± 3.01% at baseline and 11.6 ± 2.10 g/dL and 34.4 ± 3.01% after intervention (with *p*-values of 0.042 and <0.0001 respectively). For the control group (group B), mean Hb and hematocrit was 10.2 ± 1.20 g/dL and 33.8 ± 3.11% at baseline and 10.3 ± 1.26 and 32.4 ± 2.61% after the intervention (with *p*-values of 0.44 and 0.0035 respectively) (Table 1).

Prior to the intervention, there was a difference of more than 30% between the two groups in terms of prevalence of anemia (30 out of 75 or 40.0% in group A vs. 57 out of 77 or 72.7% in group B). This gap increased to 52.7% after the intervention, with prevalence dropping to 15 out of 77 or 20.0% in group A and remaining at 72.7% in group B (Table 1).

At baseline and after intervention, the mean values for Hb and hematocrit levels in groups A and B were statistically different ($p < 0.0001$) (Table 2).

The general characteristics of the two groups did not differ with regard to the variables studied. Therefore, in this regard, the two groups were comparable, eliminating the possibility of bias when comparing results across the groups. However, because both groups were significantly different in terms of anemia prevalence at baseline (despite randomization), a reduction in anemia prevalence was only registered in the intervention group (Table 1).

The mean daily consumption of iron with the fortified beverage was 1.04 mg per child (10% of the RDA for the age range of the study sample), which produced a mean increase of 0.5 g/dL in hemoglobin in the intervention group. This increase is significant when compared with the baseline values for both this group and the control group (Tables 1 and 2). As of the current study, no other research using beverages fortified with *rapadura* was available.

In developing countries, where elevated iron deficient anemia rates are common, various approaches have been used successfully for iron fortification, including the application of "sprinkles" (single-dose sachets containing powdered micronutrients); school meal fortification (conducted through clinical trials); maize flour fortification; and infant formula fortification, all of which have produced significant increases in iron levels (13–15).

The results of some intervention studies indicate that the lower the level of Hb at baseline, the better the response in increasing it (5). In this study, Hb levels were significantly increased only in the intervention group, despite the fact that the control group had much lower values at baseline (10.2 vs. 11.1 g/dL). This implies that these results were not causal, and that the intervention was responsible for the increase in Hb levels. The reduction in anemia prevalence in the intervention group was quite expressive, whereas in the control group there was no alteration in the number of anemic individuals. Based on these results it can be deduced that juice sweetened with *rapadura* has a positive effect on anemia levels (Tables 1 and 2).

Although iron stores were not measured in the study population, the significant increase in Hb values in the intervention group compared to the control group suggest that the high anemia prevalence in the intervention group was caused by iron deficiency, a common condition in developing countries in non-endemic malaria regions (6).

Based on these study results, it was concluded that a beverage sweetened with *rapadura* was effective in increasing Hb levels and reducing anemia in preschool children aged 2–3 years in one state-run school.

Recommended research in this area includes evaluation of 1) the effects of *rapadura* during longer intervention periods, with a larger sample size, and 2) iron stores in both intervention and control groups, without the use of iron absorption enhancers.

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RESUMEN

Efecto de una bebida fortificada con jugo de caña condensado sobre los niveles de hemoglobina en niños preescolares

El objetivo de este estudio fue evaluar el efecto del consumo de una bebida mezclada con un edulcorante de alto contenido en hierro (jugo de caña condensado, conocido como rapadura) sobre los niveles de hemoglobina en niños preescolares y compararlo con el efecto de consumir la misma bebida endulzada con azúcar refinada. Se realizó un estudio aleatorizado, controlado y con doble enmascaramiento durante 12 semanas de 2007 en una escuela estatal de Sobral, Brasil. La muestra compuesta por niños de 2 a 3 años se dividió en dos grupos: uno consumió jugo de marañón con 25 g de rapadura y 40 mg de ácido ascórbico (por porción de 200 mL) y otro que consumió la misma cantidad de jugo con 25 g de azúcar refinada estándar. Se observó un aumento significativo de la hemoglobina en el grupo que consumió la bebida fortificada con rapadura. Se concluye, por tanto, que el consumo de rapadura elevó los niveles de hemoglobina, con lo que se puede reducir la anemia por deficiencia de hierro en niños preescolares.

Palabras clave Anemia; rapadura; preescolar; hemoglobinas; hierro; carbohidratos en la dieta; Brasil.