Chapter 9
Evaporated Sugarcane Juice as a Food Fortificant

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Key Points

- Iron deficiency anemia (IDA) is the most widespread preventable nutritional problem in the world, despite continuous efforts for its control.
- The nutritional compositions of *rapadura* (evaporated sugarcane juice) and standard refined sugar are different in many aspects, especially iron content.
- The use of *rapadura* is extensive and differs according to the eating habits of each region where it is used.
- *Rapadura* has traditionally been used in prelacteal feeding of newborns in various regions of Asia.
- In Brazil and other countries, r*apadura* is used as a substitute for refined sugar or in direct consumption as a sweet.
- *Rapadura* is effective in increasing hemoglobin levels and reducing IDA in different populations.

Keywords Anemia • Iron • Hemoglobins • Evaporated sugarcane juice • Rapadura

Abbreviations

GDP	Gross domestic product
IDA	Iron deficiency anemia
WHO	World Health Organization

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Introduction

Iron deficiency anemia (IDA) is the most widespread preventable nutritional problem in the world, despite continuous efforts for its control. The World Health Organization (WHO) estimates more than two billion people suffer from this condition worldwide [1]. The prevalence estimate of global anemia in preschoolers is 293.1 million cases, or 47.4 % of the total population in this age range [2]. More recent evidence from studies in animals and humans associates anemia in the first years of life to impaired cognitive development in later stages [3]. Estimates report that in developing countries annual losses due to reduction in physical productivity through anemia are US$ 3.54 per person or 0.81 % gross domestic product (GDP), and that median total losses (physical and cognitive) are US$ 16.78 per person or 4.05 % GDP [4]. To combat anemia WHO advocates three main methods: dietary diversification, to include foodstuffs rich in iron, with high bioavailability; fortification of staple food items; and iron supplements for at-risk populations [5]. Dietary diversification is probably the most sustainable means of addressing the problem of IDA. According to WHO, the most promising diversification strategies are those that include the use of locally consumed foodstuffs [5]. Popular locally consumed foodstuffs with high iron content and bioavailability are of key interest, as they can be used to tackle anemia in populations with low iron stocks and/or high iron requirements such as growing children and women of childbearing age [5, 6].

In South America, the Caribbean and parts of Asia, one regional foodstuff that is high in iron content, easily purchased, and of low-cost is *rapadura (or jaggery)*—an unbleached, unrefined sweetener. *Rapadura* is essentially pure, dried sugarcane juice, obtained from the sugarcane plant (*Saccharum officinarum*), prepared and distributed in tablet form (historical method still used today to facilitate transportation and storage). It is produced on a large scale at sugarcane plantations in tropical regions; it is used as a cheaper, more accessible substitute for refined or industrialized sugar (Figs. 9.1, 9.2, and 9.3). It contains more micronutrients than refined sugar as its preparation helps to retain most of its essential nutrients, vitamins, and minerals. The nutritional compositions of *rapadura* and standard refined sugar are different in many aspects, especially iron content: *rapadura* contains 6.43 mg iron per 100 g, whereas the amount of iron in standard refined sugar is minimal (0.02 mg per 100 g) (Table 9.1) [7].

The History and Use of *Rapadura*

The plant source of evaporated sugarcane juice is *Saccharum officinarum*, believed to have originated from New Guinea and still cultivated today in tropical and subtropical regions. Evaporated sugarcane juice is known as *panela* in countries like Colombia, Venezuela, Mexico, Equator, and Guatemala, as *piloncillo* in Mexico, *papelón* in Venezuela and Colombia, *chancaca* in Bolivia and Peru, *empanizao* in Bolivia or *tapa de dulce* in Costa Rica, and *jaggery* or *gur* in India. The name *rapadura* is used in Brazil as well as in Argentina, Guatemala, and Panama.

Man has long cultivated sugarcane, records indicate that it was already cultivated in India before 400 B.C. Attempts were first made to cultivate sugarcane in the New World by Columbus; however, he was not successful. Nevertheless, other explorers who followed were able to introduce cultivated sugarcane into the West Indies, Brazil, and Mexico [8].

The use of *rapadura* is extensive and differs according to the eating habits of each region where it is used. In Brazil, it is used as a substitute for refined sugar or in direct consumption as a sweet. Until the nineteenth Century, it was a foodstuff for slaves. In the northeast of Brazil, it was widely consumed by the low-income population, especially in rural areas, together with manioc flour as a meal consumed in the workplace; today, consumption is becoming popular again but in families with different levels of income, many children or elderly consider it a tasteful sweet [9].

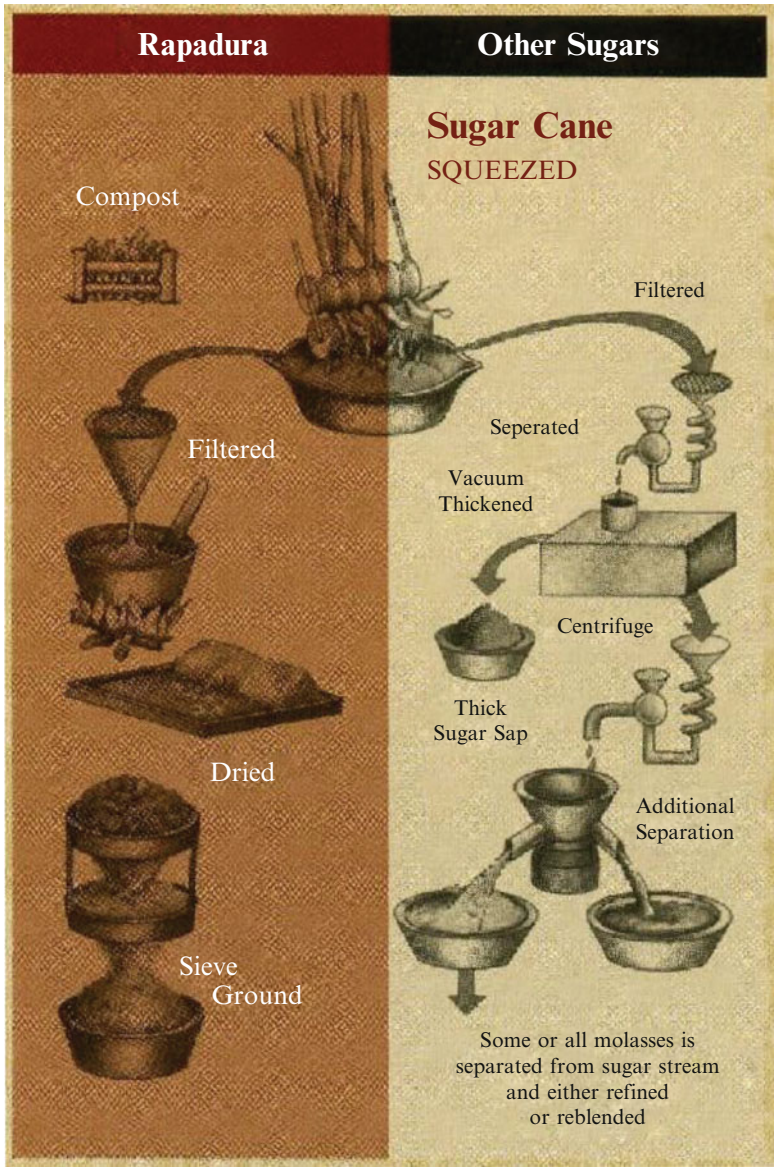

Fig. 9.1 Preparation of *rapadura* compared with refined sugar

Rapadura/jaggery has traditionally been used in prelacteal feeding of newborns in various regions of Asia. Even today, it is still common practice in India to delay breast-feeding of newborns for 48–72 h after birth, replacing it with inaugural feeds that include boiled water, tea, and diluted animal milk, with *jaggery*, sugar, or honey added [10–13]. In Ayurveda, the ancient system of Indian medicine, it has been associated with beneficial effects against several health conditions, including coughs, gastritis, diarrhea, and arthritis [8, 14]. In the northeast of Brazil, its consumption by breast-feeding women is traditionally associated to an increase in breast-milk production [9].

Fig. 9.2 Final processing of *rapadura*

Fig. 9.3 *Rapadura* as sold commercially for consumption

Table 9.1 Nutritional composition of *rapadura* and standard refined sugar per 100 g

	Calories (kcal)	Protein (g)	Total lipids (g)	Carbohydrates (g)	Fe (mg)	Mg (mg)	K (mg)	Zn (mg)	Mn (mg)	Se (mcg)	Vitamin C (mg)	Folic acid
Rapadura	430	5.6	12.8	73.8	6.43	52	346	0.45	1.26	5.6	0	89
Refined sugar	389	0	0.1	99.6	0.02	0	2	0	0	0.6	0	0

Source: USDA nutrient database for standard reference, release 14 (July 2001)

Rapadura as a Health Protector

Beneficial effects for the regular consumption of *rapadura* have been observed in Indian factory employees working in smoky and dusty environments, those consuming jaggery presented less respiratory illnesses than their non-*jaggery*-consuming counterparts. Sahu and Saxena reported on the use of *jaggery* in dust-exposed rats, results identified a preventive effect on smoke-induced pulmonary lesions in rats, providing more evidence for the potential use of the sweetener as a protective agent for workers in dusty and smoky environments [15].

Rapadura as a Food Fortificant

Despite the benefits of *rapadura* (or *jaggery*), there is little scientific evidence on the actions of systematic consumption of the sweetener. It has high iron content; however, only two clinical studies have been conducted on its use to improve hemoglobin levels and reduce anemia prevalence (Table 9.2).

Sood and Sharada used a locally produced supplement food (*laddoo*). *Laddoo* is composed of *jaggery*, processed rice flakes, garden cress seeds (100 mg% iron), and amaranth seeds (11 mg% iron) in the proportion (45:40:10:5), each *laddoo* contributing approximately 39 mg% iron. In the intervention group, 24 anemic children (aged 7–9 years) were given one *laddoo* per day for a period of 60 days, to investigate its effect on hemoglobin levels. The authors concluded that this intervention was effective in increasing hemoglobin and reducing anemia prevalence [16].

Arcanjo et al. [17], in a randomized, placebo-controlled, double-blind trial held in the northeast of Brazil, investigated whether regular consumption of *rapadura* as a natural sweetener in fruit juices (mixed with ascorbic acid) was capable of preventing and/or treating anemia in preschool children (2–3 years), during 12 weeks. Each participant in the experimental group ($n=75$) was given 200 mL cashew fruit juice sweetened with 25 g of *rapadura* mixed with 40 mg of ascorbic acid, while the individuals in the control group ($n=77$) received the same quantity of cashew fruit juice and ascorbic acid sweetened with refined sugar. The results of this study were as following: the group consuming the beverage with *rapadura*, 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, $p=0.042$ and <0.0001, respectively. For the control group, 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, $p=0.44$ and 0.0035, respectively; anemia prevalence reduced significantly in the intervention group from 40 to 20 %, whereas there was

Table 9.2 Review of literature on evaporated sugarcane juice and its effects on hemoglobin levels and anemia prevalence

Authors, country, year	Title	Design, sample size	Outcomes	Results
Sood M, Sharada D, India, 2002	Iron food supplement	Before-and-after design, 60-day intervention in anemic children aged 7–9 years; intervention $n=24$, control $n=12$	Hemoglobin, height, weight	Increase in hemoglobin levels, no effect on height or weight
Arcanjo FP, Pinto VP, Arcanjo MR, Amici MR, Amâncio OM, Brazil, 2009	Effect of a beverage fortified with evaporated sugarcane juice on hemoglobin levels in preschool children	RCT, 12-week intervention in children aged 2–3 years; intervention $n=75$, control $n=77$	Hemoglobin, anemia prevalence	Increase in hemoglobin levels, 50 % reduction in anemia prevalence

Table 9.3 Intra-group comparison of the effects of consuming beverage sweetened either with *rapadura* (evaporated sugarcane juice) or refined sugar on hemoglobin levels and anemia prevalence among preschool children

	Group A (*rapadura*) ($n=75$)			Group B (refined sugar) ($n=77$)		
Mean age of study participants in years (SD)	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[a]	Before	After	*P*-value[a]
Mean Hb (g/dL)	11.1	11.6	0.042	10.2	10.3	0.44
(SD; Cl)	(1.09; 10.68–11.45)	(2.10; 11.24–12.01)		(1.20; 9.88–10.44)	(1.26; 10.04–10.59)	
Hematocrit (%)	36.6	34.4	<0.0001	33.8	32.4	0.0035
(SD; Cl)	(3.01; 35.96–37.33)	(3.01; 33.74–35.11)		(3.11; 33.11–34.40)	(2.61; 31.74–33.03)	
	Before	After	Reduction	Before	After	Reduction
Iron deficiency anemia[b] (%)	40	20	50	72.7	72.7	0

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

no decrease in the control group. The mean daily consumption of iron with the fortified beverage was 1.04 mg per child, which produced a mean increase of 0.5 g/dL in hemoglobin in the intervention group. The authors of the study concluded that *rapadura* is effective in increasing hemoglobin levels, and reducing IDA in preschool children aged 2–3 years (Table 9.3).

Despite the evidence from these studies, this is a need for more scientific investigation to evaluate its effects on hemoglobin and anemia prevalence. More research studies that contemplate other at-risk populations, especially children and women of child-bearing age, during longer intervention periods, with larger samples, which evaluate iron stocks, and studies with and without the use of iron absorption enhancers should be conducted.

Guidance on Safe Levels and/or Guidance on Levels to be Added

There are no currently available published reports from clinical studies that establish maximum levels of consumption.

Conclusions

The studies that investigate the effectiveness of foodstuffs fortified with evaporated sugarcane juice (*rapadura, jaggery, gur*), with high iron content, on hemoglobin levels and anemia are few, but their results witnessed an increase in hemoglobin levels and a reduction of anemia prevalence [16, 17]. Indicating that, these foodstuffs may be useful in the prevention or treatment of anemia in populations with high IDA prevalence. Their consumption should be stimulated within the perspective from WHO on diet diversification, which is to increase the consumption of foodstuffs with high iron content and good bioavailability [5, 6].

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