Mineral balances in humans as affected by fructose, high fructose corn syrup and sucrose

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Abstract. The utilization of selected minerals when sugars were supplemented to basal diets was investigated in two separate, laboratory-controlled human feeding studies. Fructose-fed subjects had higher fecal excretions of iron and magnesium than did subjects fed sucrose. Apparent iron, magnesium, calcium, and zinc balances tended to be less positive during the fructose feeding period as compared to balances during the sucrose feeding period. Conversely, high fructose corn syrup (HFCS) did not affect the mineral balances when compared to sucrose feeding. Subjects fed fructose experienced diarrhea which possibly decreased absorption of minerals and thus increased fecal mineral losses. No such adverse effects were noticed when HFCS was fed.

Introduction

Sucrose from sugar cane or sugar beets for centuries has been the primary sweetening agent used in foods for humans. In industrialized societies, including the United States, changes in the use of food commodities by humans may occur without noticeable changes in food consumption patterns. This may occur because of ingredient alterations in processed foods by food manufacturers [1]. An example of one of these changes is the widespread substitution of high fructose corn syrups (HFCS) for sucrose in a wide variety of products [2]. It is reported that since the introduction of HFCS in 1967, market acceptance has been very high [1–2].

Sucrose and HFCS differ in their functional characteristics [3]. HFCS contains free fructose in varying amounts (40%–90%), glucose, maltose, and dextrose [1]. Thus, the utilization and physiological effects of sweeteners may differ. Since free fructose has some chemical reducing properties while sucrose does not, and since absorption of some mineral nutrients such as iron and copper are known to be influenced by their oxidation state, one
physiological effect of altering intakes of HFCS, fructose, or sucrose might be on utilization of selected mineral nutrients [4–5].

Various carbohydrates have been shown to affect mineral availability in humans [6], poultry [7], and swine [8]. Wilson et al. [9] found that the plasma magnesium level of grazing dairy cattle was increased by drenching feed with a starch solution. Bates et al. [10] found that complexes of ferric iron with fructose are more efficiently absorbed than is ferrous sulfate and theorized that the absorption of iron in this complex involves a redox mechanism in which fructose may serve as the reducing agent. The objective of this project was to compare effects of sucrose and fructose and of sucrose and high fructose corn syrup (HFCS) on utilization of selected minerals by humans.

Materials and methods

The project consisted of two 35-day studies, Studies A and B. The studies consisted of a 7-day adjustment or pre-period and two 14-day experimental periods that were randomly arranged in a crossover design. Thus, all subjects within each study received both experimental treatments.

During the experimental periods of Study A, supplements of either 60 gm sucrose/subject/day or 60 gm fructose/subject/day along with the basal diet were given. In study B, the subjects received the basal diet plus supplements of 60 gm sucrose or 60 gm HFCS/subject/day. Order of feeding the test sweeteners was randomized according to the crossover design. The sugar additives were incorporated into fruit flavored drinks fed at three daily meals.

A total of 24 healthy men and women participated in this project. Complete urine and feces collections were made by each subject daily throughout the study. Creatinine was determined daily to ascertain completeness of the urine collection [11]. Urine collections were composited into 7-day lots. Fecal collections were composited into lots representing food eaten during each 7-day period by use of dye markers and colored beads. Fecal transit times were also measured by use of fecal dye markers and colored beads.

Mineral content of food, feces, urine, blood, and serum was determined using the Varian Techtron Model 150 Atomic Absorption Spectrophotometer (AAS) and Carbon Rod Atomizer 90 (CRA-90). Intakes of minerals were rechecked using a computer program based on the USDA food composition tables. Phosphorus was measured by Fiske-Subbarow method [12].

Statistical analyses of the data were accomplished with consultation of the Biometric Center, University of Nebraska–Lincoln. These included analyses of variance and Duncan’s Multiple Range Test using the computer program.