Chemical Forms of Iron, Calcium, Magnesium and Zinc in Coffee and Rat Diets Containing Coffee

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ABSTRACT

Chemical forms of iron, calcium, magnesium and zinc (mineral profiles) were measured in brews of regular and decaffeinated instant coffee and diets containing these coffees. Iron, calcium and magnesium were highly soluble (90-98%) in brews of both coffees and zinc could not be detected. All iron was in the ferric state and 40-48% of total iron was in soluble complexes. Iron was less soluble in a rat diet containing regular instant coffee (57%) and a diet containing decaffeinated coffee (62%) than in a control diet (74%). Diets had the same amounts of ferric and ionic iron (43-45%). More iron was in solubles complexes in control (29%) and decaffeinated coffee (21%) diets than a regular coffee diet (12%). Calcium had low solubility (12-14%) while magnesium had high solubility in diets. Zinc was more soluble in both coffee diets than in the control. Some mineral profiles of rat diets containing coffee were similar to mineral profiles of coffee alone. Differences indicated that mixing coffee into diets induced changes in coffee. Mineral profiles of diets predicted some results of a rat bioavailability assay.

Coffee is one of the most popular beverages in the United States and Europe. The U.S. per capita consumption of all coffee products in 1982 was 1.9 cups per day and 20% of this amount was decaffeinated coffee (11). In 1985, 52% of all surveyed women in the U.S. reported that they consumed coffee on the day surveyed (7). Several researchers have reported that coffee consumption may reduce iron and zinc availability (2,6,9,12,13). It is of interest that iron deficiency anemia is a problem in young American women, a segment of the population that commonly consumes coffee.

Very little has been published on the mechanisms by which coffee may inhibit iron availability or the effect of coffee on solubility of other minerals. Our purpose was to determine a chemical basis for inhibition of iron absorption by coffee and to explore the effect of coffee on solubility of calcium, magnesium and zinc. Chemical availability of several minerals in instant coffee and rat diets containing instant coffee was measured. Chemical availability of minerals in rat diets containing coffee was compared to bioavailability of these minerals in rat assay reported earlier by Greger and Emery (5).

MATERIALS AND METHODS

Reagents

All reagents were reagent grade unless specified. Water was deionized (Millipore, Bedford, MA), distilled (Barnstead, Boston, MA) and free of detectable minerals. Glassware was acid soaked for at least 8 h and rinsed with distilled water before use. Hydrochloric acid (Baker, Phillipsburg, NJ) was suitable for use in mineral analyses.

Stock iron solution containing 1000 ppm of ferrous iron was prepared by dissolving 1000 mg of iron wire in 50 ml concentrated hydrochloric acid (HCl) and diluting to 1 L with water. Atomic absorption (AA) standards (1000 ppm) for iron, magnesium and zinc were purchased from Ricca (Arlington, TX). The calcium AA standard (1000 ppm) was purchased from American Scientific Products (McGaw Park, IL). All AA standards were diluted to the desired concentration according to Perkin Elmer (14). All AA standards contained 20% HCl and 0.1% (w/v) lanthanum chloride (Fisher, Fair Lawn, NJ).

Coffee and rat diet samples

Taster's Choice freeze dried instant regular coffee and Taster's Choice freeze dried instant decaffeinated coffee (Nestle, White Plains) were purchased at a local market. Rat diets without coffee (control diet), containing regular instant coffee and containing decaffeinated instant coffee were prepared at the Department of Nutritional Sciences (University of Wisconsin-Madison) and were based on the AIN-76 (1) purified diet (3,5). Control diet contained 20% (w/w) lactalbumin (Teklad Test Diets, Madison, WI), 50% sucrose, 15.3% cornstarch, 5% cellulose (Teklad), 5% corn oil (Mazola, Best Foods, Englewood Cliffs, NJ), 1% AIN-76A vitamin mixture (Teklad), 3.5% AIN-76 mineral mixture (Teklad) containing added iron, copper and zinc sulfates and 0.2% choline dihydrogen citrate (Teklad). Coffee diets contained 6.6% regular or decaffeinated instant coffee (Taster's Choice, Nestle, White Plains, NY) in the place of some of the cornstarch. These diets contained an amount of coffee equivalent to a human consumption level of 15 cups of coffee per d.

Instrumentation

A Perkin Elmer model 2380 double beam AA spectrophotometer (Perkin Elmer, Norwalk, CT) with air-acetylene flame, 4.25 inch 3-slot burner head and Pt-Rd nebulizer was used for mineral analysis. Iron, calcium, magnesium and zinc specific hollow cathode lamps (American Scientific Products, McGaw Park, Madison, WI), 50% sucrose, 15.3% cornstarch, 5% cellulose (Teklad), 5% corn oil (Mazola, Best Foods, Englewood Cliffs, NJ), 1% AIN-76A vitamin mixture (Teklad), 3.5% AIN-76 mineral mixture (Teklad) containing added iron, copper and zinc sulfates and 0.2% choline dihydrogen citrate (Teklad). Coffee diets contained 6.6% regular or decaffeinated instant coffee (Taster's Choice, Nestle, White Plains, NY) in the place of some of the cornstarch. These diets contained an amount of coffee equivalent to a human consumption level of 15 cups of coffee per d.

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Rochester, NY) double beam UV-VIS spectrophotometer was used to measure the concentration of these minerals in coffee brews and rat diets. A Spectronic 2000 (Bausch & Lomb, Rochester, NY) were used to measure the concentration of these minerals in coffee brews and rat diets. A Spectronic 2000 (Bausch & Lomb, IL) double beam UV-VIS spectrophotometer was used to measure the concentration of these minerals in coffee brews and rat diets. A Spectronic 2000 (Bausch & Lomb, IL) were used to measure the concentration of these minerals in coffee brews and rat diets. A Spectronic 2000 (Bausch & Lomb, IL) were used to measure the concentration of these minerals in coffee brews and rat diets. A Spectronic 2000 (Bausch & Lomb, IL) were used to measure the concentration of these minerals in coffee brews and rat diets. A Spectronic 2000 (Bausch & Lomb, IL) were used to measure the concentration of these minerals in coffee brews and rat diets. 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with a 50 mg dose of zinc sulfate. The reduced zinc availability may have been due to soluble zinc complexes. Calcium had low solubility (12-14%) while magnesium had high solubility (92-96%) in the diets (Fig. 2).

Greger and Emery (5) studied the effect of ingestion of coffee on growth, mineral metabolism and hematological status in anemic rats. Rats fed a regular coffee diet absorbed iron more efficiently than rats fed control or decaffeinated coffee diets. However, tissue iron concentrations and hematocrit levels did not differ from the control group. Rats fed decaffeinated coffee apparently did not affect iron utilization directly (for example, by forming insoluble or soluble complexes of iron). These compounds or others in decaffeinated coffee may indirectly alter iron utilization.

Rats fed coffee diets had higher tibia calcium and zinc levels than rats fed the control diet (5). Rats fed decaffeinated coffee had the highest tibia calcium concentrations. Mineral profiles of both coffee brews and diets containing coffee did not indicate any differences in calcium solubility, but zinc was more soluble in coffee diets.

Greger and Emery (5) found that rats fed both coffee diets had higher tibia and kidney magnesium concentrations than their control rats. However, there were no significant differences between groups with respect to magnesium absorption. These findings are not explainable by our magnesium profiles of either diets or brews of coffees.

Our estimates of chemical availability of several minerals in rat diets substantiate some findings in a rat bioassay. Also, some mineral profiles of diets were similar to mineral profiles of coffee alone. Differences between these chemical and biological assays indicate that (a) components of rat diets may have indirectly influenced mineral availability and (b) mineral profiles of coffee are altered by mixing with dry diet ingredients.

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REFERENCES


