

**Technical Note**

# Caffeine Content of Energy Drinks, Carbonated Sodas, and Other Beverages

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## Abstract

The caffeine content of 10 energy drinks, 19 carbonated sodas, and 7 other beverages was determined. In addition, the variability of the caffeine content of Coca-Cola® fountain soda was evaluated. Caffeine was isolated from the samples by liquid-liquid extraction and analyzed by gas chromatography with nitrogen-phosphorus detection. The caffeine concentration of the caffeinated energy drinks ranged from none detected to 141.1 mg/serving. The caffeine content of the carbonated sodas ranged from none detected to 48.2 mg/serving, and the content of the other beverages ranged from < 2.7 to 105.7 mg/serving. The intra-assay mean, standard deviation, and % coefficient of variation for the Coca-Cola fountain samples were 44.5, 2.95, and 6.64 mg/serving, respectively.

## Introduction

Recently there has been an increase in the popularity of caffeine-containing "energy drinks" or "functional beverages". Functional beverages are also known as nutraceutical foods, which are substances considered to be a food or part of a food that may provide some health benefit (1). Because of their nature, such beverages are touted as "highly vitalizing", leading to an "improvement of performance" and a "stimulation of metabolism". However, there are important health concerns that cannot be ignored with regards to the amount of caffeine contained in these drinks.

The American Dietetic Association takes the position that women of childbearing potential should adopt a health-promoting lifestyle. Their recommendation includes the avoidance of the ingestion of > 300 mg/day of caffeine, citing studies finding increased risk of spontaneous abortion and low birth weight children born to women consuming more than 150 mg/day of caffeine (2). Although there are studies demon-

strating no association between fetal growth retardation and maternal caffeine consumption (3,4), there are a plethora of other studies demonstrating a positive association between maternal caffeine consumption and fetal growth retardation or decreased birth weight. One such study found that women whose caffeine intake was 71–140 mg per day had infants weighing 116 g less than those who consumed 0–10 mg per day (5). Another study found mothers of small-for-gestational-age (SGA) infants had a higher mean intake of caffeine in the third trimester than mothers of non-SGA infants (6). Further, another study linked caffeine consumption to the risk of miscarriage, finding that caffeine consumption > 300 mg/day doubled the risk of miscarriage (7). Though the literature is inconsistent on fetal growth and spontaneous abortion as it relates to caffeine ingestion, there remains a need for caution when caffeine is consumed by pregnant women.

Children are another group that should be considered vulnerable to excess caffeine. A nationwide caffeine consumption survey conducted of children aged 5 to 18 years found that 98% studied consumed caffeine on a weekly basis, derived mostly from carbonated beverages (8). One study concluded that children and adolescents consuming caffeine in high concentrations suffered from caffeine-induced headaches (9). In that study, 36 children were evaluated. They ranged in age from 6 to 18 years and were soda consumers, ingesting on average 192 mg of caffeine a day. When the subjects ceased drinking soda, 33 experienced complete cessation of all headaches. In a separate study involving 191 youths aged 12–15 years, it was found that an average of 52.7 mg of caffeine was consumed daily and 18.8% of the total number of subjects consumed 100 mg or more daily (10). The primary source of caffeine was from consumption of soft drinks. The study found that the high caffeine consumers experienced more interrupted sleep during the night.

## Materials and Methods

In Phase One of this study, we evaluated the caffeine content of 10 energy drinks, 19 carbonated sodas, and 7 other beverages.

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The beverages were purchased from various convenience stores located in Gainesville, FL. In Phase Two of this study, we evaluated the caffeine content of nine samples of fountain Coca-Cola which were purchased from various eating establishments located in Gainesville, FL.

The extraction procedure and instrumental parameters were previously reported (11). Caffeine was isolated from the beverages by liquid-liquid extraction, and the final extracts were subjected to a gas chromatographic analysis utilizing nitrogen-phosphorus detection. Quantitation of caffeine was based on a calibration curve prepared in a concentration range of 25–250 mg/L for the caffeinated samples and 10–100 mg/L for the decaffeinated samples, with the limit of quantitation arbitrarily set

at the concentration of the lowest standard. Control samples were prepared at 75 mg/L for the caffeinated sample batches and 50 mg/L for the decaffeinated sample batches.

## Results

The results of the caffeine analyses of the energy drinks, carbonated sodas, and other beverages (Phase One) are listed in Table I. Brand names, serving sizes, and measured concentrations of caffeine per serving are provided. The results of the caffeine analyses of fountain Coca-Cola samples (Phase Two) are listed in Table II. The names of the eating establishments where the samples were purchased, serving sizes, and measured concentrations of caffeine per serving are provided.

In Phase One of the study, all beverages purported to be caffeine-free contained no caffeine. The caffeine concentration of the caffeinated carbonated sodas ranged from 18.0 to 48.2 mg/serving. The caffeine concentration of the nine caffeinated energy drinks ranged from 33.3 to 141.1 mg/serving. The caffeine concentration of the remaining seven beverages ranged from < 2.7 to 105.7 mg/serving.

In Phase Two of the study, the caffeine concentration of the nine Coca-Cola fountain samples were within the range of 40.9 to 48.4 mg per 16-oz serving. The intra-assay mean ( $N = 9$ ), standard deviation, and % coefficient of variation were 44.5 mg/serving, 2.95, and 6.64, respectively.

## Discussion

The Food and Drug Administration (FDA) has included caffeine in the list of substances that are generally recognized as safe and has set the maximum concentration of caffeine in cola beverages at 32.4 mg of caffeine per 6-oz bottle or 65 mg of caffeine per 12 oz (12). Of the carbonated sodas evaluated, the caffeine concentrations were in the range of 0–48.2 mg/serving (12 oz). Such findings are well below the maximum allowable limits of caffeine concentration per serving as specified by the FDA.

**Table I. Caffeine Content of Energy Drinks, Carbonated Sodas, and Other Beverages**

| Beverage                       | Serving Size (oz) | Caffeine (mg/serving) |
|--------------------------------|-------------------|-----------------------|
| <b>Energy Drinks</b>           |                   |                       |
| Red Devil®                     | 8.4               | 41.8                  |
| SoBe® Adrenaline Rush          | 8.3               | 76.7                  |
| SoBe® No Fear                  | 16                | 141.1                 |
| Hair of the Dog®               | 8.4               | none detected         |
| Red Celeste™                   | 8.3               | 75.2                  |
| E Maxx™                        | 8.4               | 73.6                  |
| Amp™                           | 8.4               | 69.6                  |
| Red Bull® Sugarfree            | 8.3               | 64.7                  |
| Red Bull®                      | 8.3               | 66.7                  |
| KMX™                           | 8.4               | 33.3                  |
| <b>Carbonated Sodas</b>        |                   |                       |
| Coca-Cola® Classic             | 12                | 29.5                  |
| Diet Coke®                     | 12                | 38.2                  |
| Diet Coke® with Lime           | 12                | 39.6                  |
| Caffeine Free Diet Coke®       | 12                | none detected         |
| Vanilla Coke®                  | 12                | 29.5                  |
| Pepsi®                         | 12                | 31.7                  |
| Diet Pepsi®                    | 12                | 27.4                  |
| Mountain Dew®                  | 12                | 45.4                  |
| Mountain Dew® Live Wire™       | 12                | 48.2                  |
| Dr Pepper®                     | 12                | 36.0                  |
| Diet Dr Pepper®                | 12                | 33.8                  |
| Sierra Mist™                   | 12                | none detected         |
| Celeste™ Cola                  | 12                | 19.4                  |
| Sprite®                        | 12                | none detected         |
| Seagram's® Ginger Ale          | 12                | none detected         |
| Barq's® Root Beer              | 12                | 18.0                  |
| Pibb®Xtra                      | 12                | 34.6                  |
| A&W® Root Beer                 | 12                | none detected         |
| 7-UP®                          | 12                | none detected         |
| <b>Other Beverages</b>         |                   |                       |
| Nestea® Cool Lemon Iced Tea    | 12                | 11.5                  |
| Lipton® Brisk Lemon Iced Tea   | 12                | 6.5                   |
| Yoohoo® Chocolate Drink        | 9                 | < 2.7                 |
| Starbucks Doubleshot™          | 6.5               | 105.7                 |
| Starbucks Frappuccino® Mocha   | 9.5               | 71.8                  |
| Starbucks Frappuccino® Vanilla | 9.5               | 63.8                  |
| Velda Farms® Chocolate Milk    | 16                | < 3.8                 |

**Table II. Caffeine Content of Fountain Coca-Cola**

| Establishment          | Serving Size (oz) | Caffeine (mg/serving) |
|------------------------|-------------------|-----------------------|
| Burger King®           | 16                | 41.5                  |
| Wendy's®               | 16                | 41.5                  |
| McDonald's®            | 16                | 44.0                  |
| Chick-fil-A®           | 16                | 48.4                  |
| Fast Track             | 16                | 45.5                  |
| Steak N Shake®         | 16                | 43.5                  |
| Atlanta Bread Company® | 16                | 40.9                  |
| Checkers®              | 16                | 46.9                  |
| Citgo® Food Mart       | 16                | 48.4                  |

The caffeine content of energy drinks and cold coffee beverages is not currently regulated by the FDA. Further, these beverages do not fall under the same FDA regulation that limits caffeine content of cola beverages. Caffeine content for the majority of energy drinks included in this study was higher than the maximum allowed limit for cola beverages (45.3 mg/8.4 oz or 86.4 mg/16 oz). One of the energy drinks packaged as a 16-oz can contained 141.1 mg of caffeine, well above the maximum allowed limit for cola beverages. Six of the energy drinks evaluated contained caffeine concentrations in the range of 64.7 to 76.7 mg per serving (8.3 or 8.4 oz). The caffeine content of one of the cold coffee beverages was 105.7 mg per 6.5 oz, which is approximately three times the maximum allowed limit for cola beverages (32.4 mg/6 oz).

We decided to assess the variability of Coca-Cola fountain samples because of potential variation in dispensing. For example, some establishments may opt to mix their sodas much "heavier", that is, with less carbonated water and more syrup, thus leading to a more concentrated drink with more caffeine per serving, whereas some establishments may serve a more dilute drink with less caffeine per serving. Surprisingly, we found little variability in concentration of caffeine in the fountain samples evaluated.

Because of the previously mentioned health concerns arising from the consumption of caffeine, it seems appropriate that warning labels should accompany all caffeinated beverages. None of the carbonated sodas evaluated in this study were so labeled. Of the 10 energy drinks studied, only 4 were labeled with some form of warning. Three such labels (SoBe Adrenaline Rush, SoBe No Fear, AMP) advise that the product is not recommended for children and pregnant women, and the fourth label (Red Devil) advises that "kids, pregnant women, and caffeine-sensitive persons" should not use their product in "large" amounts. The term "large" was not specified, leaving its interpretation entirely up to the consumer. In addition to warning labels, additional labeling, such as expanding the nutrition facts panel to include the amount of caffeine per serving, would be appropriate. The nutrients label currently contains substances such as total fat, cholesterol, carbohydrates, and sodium recommended for limited consumption. The modification of the product label to include caffeine content would be beneficial for the caffeine-sensitive consumer. Considering the documented effects of caffeine on children and pregnant women, it would be prudent for the consumer product labeling of all caffeinated beverages to indicate the maximum amount of caffeine rec-

ommended for such groups. Of particular concern are those non-cola beverages that currently contain 150–300% of the FDA regulated amount per serving for cola beverages. Although the caffeine content of the energy drinks and cold coffee beverages may seem alarmingly elevated as compared to the caffeine content of the carbonated sodas, our previous caffeine study found much higher caffeine concentrations in specialty coffees with a mean caffeine content of 188 mg per 16-oz serving (11).

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