



Safety issues associated with commercially available energy drinks

Kevin A. Clauson, Kelly M. Shields, Cydney E. McQueen, and Nikki Persad

Abstract

Objective: To describe benefits and adverse effects associated with the consumption of energy drinks.

Data sources: Searches were conducted using Medline, IPA (International Pharmaceutical Abstracts), EMBASE, and MANTIS; databases such as Natural Medicines Comprehensive Database, Natural Standard, ALTMEDEX, and AltHealthWatch; and Google (range 1980 to September 2007). Search terms included *energy drink*, *Red Bull*, *caffeine*, *glucose*, *ginseng*, *guarana*, *taurine*, and *bitter orange*.

Data synthesis: Most energy drinks contain natural products such as guarana, ginseng, and taurine. As much as 80 to 300 mg of caffeine and 35 grams of processed sugar per 8-ounce serving are commonly present in energy drinks such as Cocaine, Pimp Juice, Red Bull, and Spike Shooter. No reports were identified of negative effects associated with taurine, ginseng, and guarana used in the amounts found in most energy drinks. Commonly reported adverse effects seen with caffeine in the quantities present in most energy drinks are insomnia, nervousness, headache, and tachycardia. Four documented case reports of caffeine-associated deaths were found, as well as four separate cases of seizures associated with the consumption of energy drinks.

Conclusion: The amounts of guarana, taurine, and ginseng found in popular energy drinks are far below the amounts expected to deliver either therapeutic benefits or adverse events. However, caffeine and sugar are present in amounts known to cause a variety of adverse health effects.

Keywords: Energy drinks, natural products, functional foods, adverse drug effects, caffeine, sugar.

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Learning objectives

- List at least three health issues associated with the consumption of energy drinks.
- Name four ingredients commonly found in energy drinks.
- Name the two ingredients in energy drinks most likely responsible for adverse effects.
- State the range of caffeine included in energy drinks.
- List at least two uses for which energy drinks have been studied.
- Name two energy drinks that contain bitter orange.
- State the most common cause of caffeine overdose–related death.

From 1998 to 2003, the sale of energy drinks in the United States increased an estimated 465%.¹ These products generated \$5 billion in sales in 2006, with market leader Red Bull commanding 49% of all revenues.^{2,3} Teens and young adults make up a large portion of this market, as they accounted for almost \$2.3 billion of product sales. One of the more recent energy drinks to target this demographic is Cocaine, which has drawn the ire of the Food and Drug Administration (FDA). FDA sent a warning letter about the claims on the product's Web site to the company; the letter was also copied to the California Board of Pharmacy.⁴ After removing the drink from store shelves in the United States, the manufacturer has rebranded

it under the name No Name and reintroduced its product.⁵ The product is still marketed as Cocaine in Europe.

Many energy drinks, which are also considered as functional foods, are fortified beverages with added dietary supplements such as ginseng, guarana, and bitter orange. These drinks are aggressively marketed but are not always transparent in providing ingredient information and quantities on their labels. The promotion of natural ingredients in energy drinks to supply increased energy, increased alertness, and improved athletic performance leave the average consumer wondering if these claims deliver on their promise and prompt concern among health professionals regarding the negative health effects associated with these products.

At a Glance

Synopsis: The potential benefits and adverse effects of consuming energy drinks, which contain natural products such as guarana, ginseng, and taurine, as well as caffeine and processed sugar, are described in this review article. Although some health benefits may be associated with ingredients such as ginseng, energy drinks generally do not contain sufficient amounts of dietary supplements to achieve any beneficial effects. Additionally, no reports have identified negative effects associated with taurine, ginseng, and guarana used in the amounts found in most energy drinks. Most energy drinks contain a high quantity of caffeine, which is associated with, for example, nervousness, headache, insomnia, and tachycardia. Research has also shown that the high glucose content of energy drinks and other flavored beverages plays a considerable role in weight gain, which can lead to serious health consequences such as diabetes. In addition, deaths, new-onset seizures, and manic episodes have been linked to ingestion of large amounts of energy drinks.

Analysis: *Pharmacists practicing in settings in which energy drinks are sold are ideally situated to educate patients, particularly those with preexisting health conditions such as pregnancy, sensitivity to caffeine, diabetes, and cardiovascular disorders, on the adverse effects of consuming excessive caffeine and glucose. The potential adverse effects of energy drinks also reinforce the importance of pharmacists gathering complete patient information, including use of natural products and natural energy enhancers, to best help patients manage their diseases. Evidence is insufficient to conclude that energy drinks are more effective at improving cognitive function or increasing energy than traditional caffeinated beverages such as coffee, tea, and colas. They are also more expensive (\$2–\$5/can) than a standard 12-ounce cola drink (<\$1/can).*

Objective

The purpose of this review is to identify the potential for any benefits or adverse effects (AEs) associated with the consumption of energy drinks.

Methods

Searches were conducted using the terms *energy drink, sports drink, Red Bull, caffeine, glucose, ginseng, guarana, taurine, bitter orange, ephedra, alcohol, efficacy, and safety* using databases such as Medline, IPA (International Pharmaceutical Abstracts), EMBASE, and MANTIS (range 1980 to September 2007), as well as Natural Medicines Comprehensive Database, Natural Standard, ALTMEDEX, and AltHealthWatch. Internet search engines such as Google were also used to locate relevant information. In addition to the database search, a bibliographic search was also performed. Company Web sites were used for product information, and manufacturers' public relations departments were consulted for unpublished product information.

Results

Overview of ingredients

Ginseng, taurine, bitter orange, guarana/caffeine, and glucose are among the most common ingredients used in energy drinks. They are used in combination for their real or supposed synergistic effects of increased stimulation. Each of these popular components is discussed in detail in the following sections.

Ginseng

Many varieties of ginseng exist. The most commonly studied variety is *Panax ginseng*, also known as Korean or Asian ginseng, which is found principally in Korea, Japan, and China.⁶ Other names of ginseng root can be found in Table 1.^{7,8} Another form of ginseng, *Panax quinquefolius* or American ginseng, may also be used, but this product has a different chemical makeup and therefore would be expected to have different bodily effects.

Ginseng is promoted to stimulate immune function, improve physical and athletic stamina, enhance overall well-being, and

increase resistance to environmental stress. The most widely known therapeutic use of ginseng is improving cognitive function, concentration, and memory. In addition to the potential health benefits of ginseng, AEs are also associated with its use. Ginseng has been linked with estrogen-like effects and associated with reports of breast tenderness, loss of menstrual periods, vaginal bleeding after menopause, and breast enlargement in women.⁸ Unlike the estrogen-like effects, which were largely reported via cases in the 1970s and 1980s, the most common and well-documented AE associated with ginseng is insomnia. Other AEs for ginseng are listed in Table 2.^{7,8} One case report described a patient who developed Stevens-Johnson syndrome, although the causality was not definitive.⁹

Although energy drink manufacturers claim that ginseng can improve physical performance, studies generally have not shown a significant benefit. A study in 19 healthy adult women taking ginseng 200 mg/day showed no change in physical work performance, energy metabolic responses, or oxygen

uptake. Using the Borg scale, ratings of perceived exertion were obtained during exercise when participants in the study performed a maximal bicycle ergometer test. The Profile of Mood States and the Positive and Negative Affect Schedule administered before and after the 8-week treatment period found no differences in ratings of perceived exertion during exercise testing.¹⁰ Another study in 38 healthy adults using a concentrate equivalent to ginseng 2 grams/day for 8 weeks also found no improvement in laboratory testing of exercise performance or recovery of heart rate.¹¹

Therapeutic doses for ginseng commonly range between 100 and 200 mg/day, with doses as high as 2,000 mg daily. A review of several popular energy drinks revealed subtherapeutic quantities of ginseng. For instance, SoBe Adrenaline Rush contains 25 mg, Full Throttle 90 mg, and Rockstar Juiced 25 mg.^{12,13} To get the lowest therapeutic dose, a consumer would have to drink a minimum of two to four cans per day. See Table 3 for a listing of specific energy drink ingredients.¹²⁻¹⁴

Table 1. Common and scientific names of dietary supplements routinely found in energy drinks^{7,8}

Ingredient	Common names	Scientific names
Bitter orange	Aurantii pericarpium, chisil, Fructus aurantii, green orange, kijitsu, neroli oil, Seville orange, shangzhou zhiqiao, sour orange, synephrine, zhi qiao, zhi shi	<i>Citrus aurantium</i>
Ginseng	Asian ginseng, Asiatic ginseng, Chinese ginseng, ginseng asiatique, Ginseng radix alba, ginseng root, guigai, hong shen, Japanese ginseng, jen-shen, jinsao, jintsam, insam, Korean ginseng, Korean <i>Panax ginseng</i> , Korean red ginseng, ninjin, Oriental ginseng, radix ginseng rubra, red ginseng, renshen, renxian, sheng shai shen, white ginseng	<i>Panax ginseng</i>
Guarana	Brazilian cocoa, zoom	<i>Paullinia cupana</i> , <i>Paullinia sorbilis</i>
Taurine	Aminoethanesulfonate, L-aurine	2-aminoethane sulfonic acid

Table 2. Adverse events and interactions associated with energy drink ingredients^{7,8}

Ingredient	Adverse effects	Interactions
Bitter orange	Myocardial infarction, stroke, seizure, hypertension, photosensitivity, dysrhythmias, migraine, headache	<i>Panax ginseng</i> , caffeine, guarana, cola nut, maté, ma huang
Ginseng	Insomnia, mastalgia, vaginal bleeding, amenorrhea, tachycardia, palpitations, hypertension, edema, headache, vertigo, euphoria, mania	Bitter orange, caffeine, guarana, bitter melon, country mallow, ginger, willow bark, ma huang
Guarana	Insomnia, nervousness, restlessness, tachycardia, tremors, anxiety, chest pain, dysrhythmia	Bitter orange, caffeine, cola nut, maté, alcohol, creatine, ma huang
Taurine	Insufficient reliable evidence to suggest any adverse events at this time	None reported

Table 3. Ingredients of selected energy drinks based on 8.0- to 8.4-ounce servings¹²⁻¹⁴

Product name	Ginseng (mg)	Taurine (mg)	Guarana (mg)	Caffeine (mg)	Sugar (grams)
Arizona Caution Extreme Energy Shot	100	1,000	0	100	33
Cocaine	0	750	25	280	18
Full Throttle ^a	90	605	0.70	72	29
Pimp Juice	0	7	100	81	34
Red Bull	0	1,000	0	80	27
Rockstar Energy ^a	25	946	200	80	27
Rockstar Juiced ^b	25	1,000	25	80	21
SoBe Adrenaline Rush	50	1,000	50	79	33
SoBe No Fear ^a	50	1,000	50	87	33
Spike Shooter	0 ^c	0	0	300	0

^aSold as a 16-ounce can; consumption of one can is the equivalent of double the listed ingredients.

^bSold as a 24-ounce can; consumption of one can is the equivalent of triple the listed ingredients.

^cContains yohimbine.

Taurine

Another ingredient often found in energy drinks is the beta-amino acid taurine. Taurine is the most abundant intracellular amino acid in the human body.¹⁵ The scientific name of taurine is 2-aminoethane sulfonic acid; other names can be found in Table 1.^{7,8} It is a conditionally essential nutrient; in other words, healthy adults can manufacture taurine from other amino acids, but infants and ill adults must obtain it via foods or supplements.¹⁶ Many important physiological functions are associated with taurine, the most common of which is its role in the formation of taurine bile acid conjugates in the liver, which are essential for micelle formation and fat absorption.^{17,18} Taurine has also been shown to have positive inotropic, chronotropic, and antidysrhythmic effects.¹⁵ For specific taurine indications and dosing regimens by condition, see Table 4.¹⁹⁻²²

A double-blind placebo-controlled study of 10 graduate students demonstrated improvement in cognitive performance by the measured motor reaction time and the d2 test for assessment of attention after consumption of Red Bull, which contains taurine as one of three key ingredients.¹⁵ However, the effects of taurine alone were not addressed in this study. The treatment groups consisted only of a placebo compared with the whole drink, containing taurine, caffeine, and glucuronolactone. Therefore, determining whether the increases in cognition and memory were a result of the taurine component, the caffeine component, the glucuronolactone component, or all three is difficult.

Drinks containing taurine and caffeine (1,000 mg and 80 mg/240 mL, respectively) were evaluated for effects on mood, memory, and information processing in healthy volunteers.²³ The 42 participants were tested with a rapid visual information test,

a verbal reasoning test, a set of mood measures, and a verbal and nonverbal memory test. Attention and verbal reasoning improved with the caffeinated taurine-containing drink, which was compared with both a sugar-free and a sugar-containing placebo. However, as with the previous study, whether the effects resulted from the individual taurine or caffeine components could not be determined.

Few AEs are attributed to taurine use, even in relatively high doses. However, mild diarrhea and constipation have been rarely reported with oral taurine.²² One study found that taurine administered to patients with uncompensated adrenocortical insufficiency induced hypothermia and hyperkalemia.²⁴ Other studies reported intense, temporary itching in patients with psoriasis at taurine doses of 2 grams daily, as well as nausea, headache, dizziness, and gait disturbances at doses of 1.5 grams daily in some patients with epilepsy.^{25,26} Energy drinks containing taurine and caffeine have been linked with athlete deaths in Europe, and some countries have banned or limited their sales.²⁷

Bitter orange

With the action taken by FDA against ephedra and its subsequent removal from the market, manufacturers began looking for a replacement in weight loss supplements and energy drinks. Bitter orange was used in many reformulated products. Unfortunately, it shares some of the same AEs as ephedra. The active components of bitter orange are synephrine and octopamine, which are structurally related to epinephrine and norepinephrine, respectively. Both components exert their therapeutic effects via alpha-adrenergic receptor activation. Orally, bitter orange is used as a treatment for nasal congestion, chronic fatigue syndrome, and stimulation

of heart and circulation, while topical uses include inflammation, retinal hemorrhage, bruises, and bedsores.⁷

Concern exists regarding whether bitter orange, when combined with other stimulant products, is associated with severe cardiovascular adverse effects because of additive stimulant actions. According to a study of the hemodynamic effects of ephedra-free weight loss supplements, these effects are not likely caused by bitter orange alone but may be due to synergistic effects with caffeine and other stimulants in multicomponent formulations.²⁸ Several case reports document adverse events associated with use of dietary supplements containing bitter orange, including ischemic stroke in a 38-year-old man, exercise-induced syncope and QT prolongation in a 22-year-old woman, and a possible myocardial infarction in a 55-year-old woman.^{29–32} Although this dose was shown effective for weight loss, bitter orange has the potential to increase diastolic and systolic blood pressure and heart rate for up to 5 hours after a single 900-mg oral dose in young healthy adults.³³

Not all energy drinks contain bitter orange. Two energy drinks currently on the market that contain bitter orange are Extreme Ripped Force and Piranha. Selected products containing bitter orange are listed in Table 5.¹³ While not all manufacturers supply the specific amounts of bitter orange contained in their products, the average amount of bitter orange extract (standardized to 8% synephrine content) in energy drinks is approximately 200 mg. This is well below the amount required for therapeutic effects or AEs when used alone; however, bitter orange combined with other stimulants such as caffeine and guarana may produce additive stimulant effects. This could result in adverse events at lower doses than required for any of the components alone.

Table 4. Therapeutic doses of taurine for various indications^{19–22}

Therapeutic use	Doses required for treatment (total daily dose)
Alcohol withdrawal	3,000 mg
Congestive heart failure	2,000–6,000 mg
Adjunct to TPN	10 mg/kg
Cystic fibrosis	30 mg/kg
Palpitations/dysrhythmias	1,000–2,000 mg
Hypertension	6,000 mg
Diabetes	1,500 mg
Seizure disorders	50–300 mg/kg or 750 mg
Hepatitis	12,000 mg

Abbreviation used: TPN, total parenteral nutrition.

Guarana/caffeine

Another ingredient found in most energy drinks is guarana, also known as Brazilian cocoa or zoom. The active component in guarana is caffeine in concentrations of 3.6% to 5.8%.⁷ The uses for guarana are virtually the same as those for caffeine. It exerts its main therapeutic effect via adenosine receptor blockade and phosphodiesterase inhibition, which leads to an increase in neurotransmitters such as dopamine.^{7,34}

Caffeine has many physiologic effects, including stimulation of the central nervous system, heart, and skeletal muscles and possibly the pressor centers that control blood pressure. The increase in catecholamine release caused by caffeine produces positive inotropic and chronotropic effects on the heart and causes an acute elevation of diastolic and systolic blood pressures. Caffeine is also a diuretic that can produce water losses estimated at

Table 5. Selected energy drinks containing bitter orange¹³

- | | |
|-----------------------------|----------------------------|
| ■ ABB Adrenaline Stack | ■ Hot Pure Energy |
| ■ Extreme Ripped Force | ■ Piranha by EAS |
| ■ Forza: Sustainable Energy | ■ Sentinel Vigilant Energy |

1.17 mL/1 mg caffeine.³⁵ This is particularly important because many energy drinks are promoted in conjunction with sports activities and athletic enhancement, which can increase the risk for dehydration. Caffeine is also associated with insomnia, nervousness, restlessness, gastric irritation, nausea, vomiting, tachydysrhythmia, tachypnea, tremors, and anxiety. These adverse effects have occurred at doses as low as 250 to 300 mg.

Large doses of caffeine cause massive catecholamine release and subsequent sinus tachycardia, metabolic acidosis, hyperglycemia, and ketosis. Fatal caffeine overdose usually results from ventricular tachycardia and occurs at doses of 10 to 14 grams (150–200 mg/kg).³⁶ This can occur at lower doses depending on variation in caffeine sensitivity such as smoking, age, cardiac health, and prior caffeine use. In one case report, a 25-year-old woman with preexisting mitral valve prolapse developed intractable ventricular fibrillation and death after ingesting a 55-mL energy drink with guarana and ginseng.

The amount of caffeine found in that product (550–1,045 mg) was more than the equivalent of 5 to 10 cups of coffee.³⁷ Although no clear consensus exists in the literature, some organizations have recommended that women of childbearing age should minimize their intake of caffeine; this recommendation is based on studies that associate an increased risk of spontaneous abortion and low birth weight with consumption of more than 150 mg caffeine/day.^{12,38}

Caffeine is found in nearly all commercially available energy drinks at a concentration of approximately 75 to 80 mg

per 8-ounce serving, although some products contain up to 300 mg per 8 ounces. Most products list the serving sizes in fluid ounces, but several include an approximate conversion of 8 ounces to 240 mL on the label. Table 3 details the amounts of caffeine present in a sample of specific brands.¹²⁻¹⁴ Of note, although these brands list the serving size as approximately 8 fluid ounces, some brands are sold in 16- and 24-ounce sizes and are most likely consumed in those quantities rather than in the 8-ounce serving size listed on the labels. Depending on the product size and average amount consumed, this could lead to a daily ingestion of up to 720 mg caffeine. This amount does not take into consideration the caffeine content of guarana (3.6–5.8%). The daily intake of caffeine varies from one individual to another, but, for most people, 300 mg or less is not harmful. However, this range already exceeds the level at which AEs begin to manifest. The amount of caffeine contained in soft drinks is regulated, by FDA, to a maximum of 32.4 mg per 6-ounce bottle.¹² While most soft drinks contain far less than the limit, most energy drinks exceed this amount with approximate caffeine content of 9 to 28 mg per fluid ounce.

Glucose

Except for sugar-free versions, all energy drinks contain sugars in the form of sucrose, glucose, and/or high-fructose corn syrup. The sugar content varies among energy drinks but ranges from 21 to 34 grams per 8-ounce can.¹³ If consumption of these drinks is limited, this range of sugar may be primarily for palatability and taste, as it is similar to amounts found in beverages ranging from Coca-Cola to Slim-Fast. The amounts in specific brands of energy drinks can be found in Table 3.¹²⁻¹⁴

Glucose is a major source of energy for the brain, red blood cells, muscles, and other cells of the body and is essential to the normal functioning of the central nervous system and the entire human body. However, relatively little glucose can be stored. Consequently, the body relies on a continuous supply of glucose as its primary fuel delivered via the bloodstream.

The amount of glucose found in most energy drinks (approximately 30 grams/8 ounces) is similar to that found in other soft drinks such as colas and fruit drinks. FDA does not recommend a daily allowance for sugar. However, official U.S. guidelines recommend a maximum sugar intake of 32 grams for every 2,000 calories, which equates to approximately 7% to 8% of the total daily caloric intake.^{39,40} A 16- or 24-ounce energy drink contains approximately 60 to 90 grams of sugar, which is two to three times the maximum recommended daily intake.

Although some studies show that glucose alone can enhance memory, concentration, and energy, its effect in energy drinks may be synergistic with caffeine. One study of energy drinks found that glucose and caffeine together can enhance behavioral performance during demanding tasks requiring selective attention.⁴¹ In contrast, one study found that neither glucose

nor caffeine individually resulted in significant improvements of any studied cognitive or mood measure. However, the addition of a relatively modest amount of caffeine to the glucose component was shown to benefit cognitive performance.⁴²

Additional health issues

Energy drinks have been implicated in a number of health-related concerns in recent years. Their effects range from being a contributing factor in obesity to exacerbating symptoms in manic phases in patients with bipolar disorder to causing new-onset seizures. Effective identification of and intervention in at-risk patients by pharmacists is essential. Examples of the potential negative impact of energy drinks and their components on health are provided below.

Seizures

Four patients had seizures after consuming large amounts of energy drinks (multiple cans of product, usually on an empty stomach).⁴³ One patient experienced two separate episodes that were both related to intake of multiple cans of Monster. One patient experienced a seizure when using a “diet pill” (containing caffeine) in conjunction with one 24-ounce can of Monster. At follow-up, no further seizure activity was demonstrated by patients after abstaining from energy drinks. Patients did not report sleep deprivation, indicating that this effect may be dose related and may only manifest in susceptible individuals.

Energy drinks combined with alcohol

Mixing alcohol with energy drinks is an emerging trend in bars and dance clubs. Apart from the dangerous effects this combination may have on cardiac function, people who ingest large amounts of caffeine (a stimulant) along with large amounts of alcohol (a depressant) may not realize the degree to which they are intoxicated. One study noted that participants who consumed energy drinks with alcohol felt fewer symptoms such as headache, weakness, and muscular coordination but were still impaired in terms of motor coordination and visual reaction time.⁴⁴ As many people may use the physical symptoms they experience to gauge their sobriety, the danger is that they may misinterpret their level of inebriation and attempt to drive a car or perform other potentially hazardous activities.^{45,46}

Psychiatric effects

Several components of energy drinks can potentially exacerbate or initiate manic episodes for patients. Two case reports of depressed patients starting therapy with ginseng and experiencing a manic phase have been published.^{47,48} Another report describes a patient with no psychiatric illness experiencing mania after 2 months of using 500 to 750 mg of *Panax ginseng*.⁴⁹ In all three cases, the manic episode was controlled after stopping ginseng and initiating conventional treatment. Caffeine has also been associated with mania in a patient

with no history of psychiatric illness.⁵⁰ The patient increased caffeine consumption to approximately 1,000 mg daily. The patient's condition returned to normal within 30 days of stopping caffeine consumption. In addition to reports of mania in patients taking a single component of an energy drink, one report associates mania with consumption of Red Bull.⁵¹ A young man with bipolar disorder who had been maintained with lithium therapy for 5 years had a manic episode requiring hospitalization after drinking three cans of Red Bull on 2 days during the week before admission.

These reports indicate that reason for concern may exist regarding ingesting large amounts of the ingredients found in energy drinks, particularly for patients with poorly controlled or undiagnosed psychiatric conditions.

Obesity

Worldwide rates of obesity are increasing, and numerous factors contribute to this trend. Lifestyle and diet changes are the most common culprits, but recent research has proposed that the added sugar content of beverages may play a considerable role in weight gain.⁵² Americans older than 2 years consume an estimated 132 kilocalories daily from high-fructose corn syrup, a common base ingredient in carbonated beverages. Specifically, the question has been raised regarding the role of caffeine- and sucrose-containing drinks in the age of increasing obesity. One small study of 10 healthy women evaluated the effect of an energy drink (caffeine, guarana, and sucrose) compared with sucrose alone on fat and carbohydrate oxidation.⁵³ The authors concluded that the energy drink increased carbohydrate oxidation but decreased lipid oxidation, which could lead to lipogenesis. Some energy-drink makers have made efforts to deal with this health issue by reformulating their products (e.g., Red Bull Sugar Free) to reduce the glucose or sugar content of the product.

Athletic performance

Energy drinks are also commonly used in conjunction with athletic activities. In fact, the Red Bull product Web site recommends consuming the drink "prior to demanding athletic activities." Liz Applegate, PhD, a sports nutritionist at the University of California at Davis, maintains that the boost associated with energy drinks comes mainly from the caffeine and, therefore, the use of energy drinks by athletes is a poor idea.⁴⁶ Despite these concerns, many energy drink companies specifically target athletes and sporting venues in their marketing efforts. Red Bull, in particular, has been active in providing sponsorship for sports such as NASCAR, and it has purchased a professional men's soccer team and renamed it Red Bull New York.

Dental health

A concern exists that increased intake of acidic beverages, including carbonated drinks and fruit juices, may be associated with dental erosion. A study evaluating the effects of beverages

on extracted premolar teeth indicated that immersion in Lucozade (a caffeine-based energy drink) showed a 16% reduction in enamel hardness after 30 minutes of immersion.⁵⁴ Although this study does not reflect "real-life" exposure of teeth to acidic beverages, it does raise questions as to the overall effect of these drinks on teeth. A comparison of extracted molars and premolars immersed in liquids for a 14-day period showed that enamel dissolution from lemonade and energy drinks was much greater compared with other beverages.¹ These studies each evaluated extended exposure and probably would not be a great concern for the average patient consuming moderate quantities of energy drinks.

Discussion

Although all of the natural products contained in energy drinks are touted for their use in various diseases and conditions, with several demonstrating some efficacy at improving either energy or cognitive function, recognizing that energy drinks generally do not contain the therapeutic doses of "natural" dietary supplements necessary to achieve these effects is important. Manufacturers would like consumers to believe that consuming energy drinks has beneficial health effects as opposed to widely available caffeine-containing soft drinks or coffee. However, energy drinks likely do not confer additional health benefits. Instead, they often have more caffeine and similar amounts of sugar, posing even more of a health threat than the familiar soft drinks and colas. They are also more expensive (\$2–\$5/can) than a standard 12-ounce cola drink (<\$1/can).

The AEs shown to be associated with these energy drinks are likely due to the high quantity of caffeine and its additive effects with guarana rather than to ginseng and taurine. These latter components are usually present in such small quantities that it would be more accurate to refer to them as flavor enhancers. Although drinking two to four cans of an energy drink containing ginseng might improve mental performance, this effect is minimal and the sugar and combined caffeine and guarana content would be in excess of the maximum recommended daily intake. Also of note, although energy drinks are consumed across multiple patient populations, few published reports of AEs exist. This fact may speak to the relative safety of the products, especially because the doses of most components are subtherapeutic. Alternately, a contributing factor to the lack of data may be that the mechanism for reporting AEs for these products may not be well known or well understood by health care professionals. The Dietary Supplement and Nonprescription Drug Consumer Protection Act (commonly known as the AER bill),⁵⁵ which went into effect in December 2007, mandates that manufacturers report serious AEs associated with dietary supplements, including energy drinks that contain dietary supplements. The potential impact remains unclear because only AEs defined as "serious" (i.e., those that cause inpatient hospitalization or death) will need to be reported, while any AEs that do not meet that threshold of severity will continue to be

reported voluntarily.

While energy drinks are safe for the majority of consumers when used in moderation (with caffeine intake of less than 300 mg/day), the high caffeine content poses serious health risks for certain populations. These include pregnant or lactating women and patients with diabetes, peptic ulcer disease, or preexisting cardiovascular conditions such as hypertension, congestive heart failure, and dysrhythmias. Also, patients susceptible to psychiatric or seizure episodes may be at increased risk of AEs. Also worth noting is that the similarity of bitter orange to the recently banned ephedra makes it a potentially harmful stimulant that consumers are advised to avoid. The new popularity of mixing energy drinks with alcohol is also worrisome because the opposing stimulant–depressant effects can lead consumers to believe they are less intoxicated than they actually are. Many also worry that athletes who consume these beverages before strenuous exercise could become dehydrated or develop cardiovascular difficulties because of the diuretic and stimulant effects of the caffeine.

Evidence is insufficient to conclude that energy drinks are more effective at improving cognitive function or increasing energy than traditional caffeinated beverages such as coffee, tea, and colas. Furthermore, the caffeine and sugar components could cause serious health problems for certain populations and for those who do not restrict their combined guarana and caffeine intake to less than 300 mg/day. Many consumers are unaware of the fact that energy drinks contain large quantities of these ingredients.

Pharmacists can play a critical role in counseling patients regarding the adverse effects of excessive caffeine and glucose consumption, especially in those with preexisting health conditions, such as patients who are pregnant, are sensitive to caffeine, have diabetes, or have cardiovascular or psychiatric disorders. The potential AEs of energy beverages also should reinforce the need for pharmacists to gather complete patient information, including use of natural products and natural energy enhancers, to best help patients manage their diseases. In addition, pharmacists who discuss energy drinks with patients will be in an ideal position to expand their patients' knowledge base regarding idiosyncratic AEs. Pharmacists, especially those practicing in a community setting where these drinks are sold, are in an ideal position to intervene on their patients' behalf. However, to make a difference, pharmacists must first educate themselves about these issues.

Conclusion

Little evidence exists in the literature to support beneficial effects of energy drinks. Mechanistically, purported benefits are equally unlikely because the amounts of guarana, taurine, and ginseng found in popular energy drinks are far below the amounts expected to deliver therapeutic benefits. Similarly, the potential for serious AEs is improbable because of the small amounts of those natural products added to the drinks. How-

ever, energy drinks can present a safety concern. In particular, caffeine and sugar are present in amounts known to cause a variety of adverse health effects. Consuming recommended amounts, or greater, of energy drinks has been implicated in seizures, obesity, and mania. Pharmacists have a prime opportunity to intervene and educate their patients about the safety concerns surrounding these products.

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Assessment Questions

Instructions: You may take the assessment test for this program on paper or online. For each question, circle the letter on the answer sheet corresponding to the answer you select as being the correct one. There is only one correct answer to each question. **Please review all your answers to be sure that you have circled the proper letters.** To take the CE test for this article online, go to www.pharmacist.com and click Education. To take the CE test for this article online, go to www.pharmacist.com/education.cfm, and click Education. Once you are on the Education welcome page, look in the Online CE Quick List for the title. Follow the online instructions to take and submit the assessment test. This CE will be available online at www.pharmacist.com after May 31, 2008.

1. **What is the maximum concentration of caffeine allowed by the Food and Drug Administration (FDA) in a 12-ounce cola?**
 - a. 15 mg
 - b. 32 mg
 - c. 65 mg
 - d. 105 mg
 - e. 112 mg
2. **A case report describing a patient who experienced new-onset seizures described the consumption of which energy drink?**
 - a. Cocaine
 - b. Monster
 - c. Pimp Juice
 - d. Red Bull Sugar Free
 - e. Spike Shooter
3. **The Borg scale is used to measure**
 - a. Manic symptoms
 - b. Perceived exertion
 - c. Substance abuse potential
 - d. Unipolar depression
 - e. Variables contributing to seizure activity
4. **The California Board of Pharmacy received a letter from FDA generated by the name and claims of which energy drink?**
 - a. Cocaine
 - b. Monster
 - c. Pimp Juice
 - d. Red Bull Sugar Free
 - e. Spike Shooter
5. **Energy drinks commonly contain what range of caffeine?**
 - a. 15–105 mg
 - b. 15–112 mg
 - c. 80–112 mg
 - d. 80–240 mg
 - e. 80–300 mg

CE Credit:

To obtain 1.5 contact hours of continuing education credit (0.15 CEUs) for “Safety issues associated with commercially available energy drinks,” complete the assessment exercise, fill out the CE examination form at the end of this article, and return to APhA. You can also go to www.pharmacist.com and take your test online for instant credit. CE processing is free for APhA members and \$15 for nonmembers. A Statement of Credit will be awarded for a passing grade of 70% or better. Pharmacists who complete this exercise successfully before May 1, 2011, can receive credit.



The American Pharmacists Association is accredited by the Accreditation Council for Pharmacy Education as a provider of continuing pharmacy education. The ACPE Universal Program Number assigned to the program by the accredited provider is 202-000-08-142-H01-P.

“Safety issues associated with commercially available energy drinks” is a home-study continuing education program for pharmacists developed by the American Pharmacists Association.

- 6. P.R. is a 54-year-old patient with diabetes who works in the local automotive plant and has recently moved from day shift to night shift. When he picked up his refills for metformin and pioglitazone, he mentioned that he is having difficulty with adjusting his sleep schedule. On the first 2 nights of his week, he has been experiencing excessive drowsiness and therefore has started drinking two cans of Pimp Juice during his 2:00 am break. Which of the following points would be most important to make in his counseling?**
- The likely interaction between metformin and taurine
 - The effect of guarana on glycosylated hemoglobin
 - The effect of this drink on glucose control
 - The effect on dental erosion
 - None of the above alternatives is correct.
- 7. Fatal caffeine overdose is usually caused by**
- Atrial fibrillation
 - Hyperventilation
 - Myocardial infarction
 - Sinus bradycardia
 - Ventricular tachycardia
- 8. Which energy drink component is most similar to ephedra?**
- Bitter orange
 - Caffeine
 - Guarana
 - Ginseng
 - Taurine
- 9. Bitter orange is sometimes listed as an ingredient of energy drinks as:**
- Allium sativum*
 - Citrus aurantium*
 - 2-aminoethane sulfonic acid
 - S-adenosyl-methionine
 - Ephedra sinica
- 10. Which of the following best describes the effects of herbal ingredients such as ginseng and taurine that are present in some energy drinks?**
- The amount of herbal ingredients in energy drinks causes harmful effects.
 - The amount of herbal ingredients in energy drinks does not cause harmful effects.
 - The amount of herbal ingredients in energy drinks is present in therapeutic doses.
 - The amount of herbal ingredients in energy drinks is neither therapeutic nor harmful.
 - The amount of herbal ingredients in energy drinks is completely safe in large quantities.
- 11. A high school nurse contacts you because she is concerned about the safety of Red Bull, which was recently added to the vending machines at school. She wants to know which students would be at greatest risk of adverse effects from the taurine component (1,000 mg/can).**
- Students with a strong family history of cardiovascular events
 - Students with previous psychiatric episodes
 - Students wearing braces
 - None of the above alternatives is correct.
- 12. During the health and wellness class that this nurse is teaching, she wants to discuss risks of energy drink use. In which scenario would a student be at greatest risk of an adverse event?**
- Consuming energy drinks and alcohol mixtures socially
 - Consuming energy drinks after an athletic event to rehydrate
 - Consuming energy drinks before a test for increased mental performance
 - Consuming an energy drink before driving to school in the morning

13. K.Z., a 34 year-old woman patient in your pharmacy, has recently started a new diet/exercise plan because she is approximately 20 pounds overweight. She is currently taking sumatriptan (as needed; usually once monthly), daily multivitamin, and levonorgestrel-releasing intrauterine implant for contraception. Her trainer has recommended that she consume a Bally Energy Drink (sucrose, taurine, *Panax ginseng*, vitamin C, vitamin B₁₂, and caffeine) before each daily workout. She wants your advice about the safety of this drink with her medications. Which of the following is the most likely concern?

- a. The risk of taurine-induced cardiovascular adverse effects
- b. The risk of vitamin B overdose with the product and the multivitamin
- c. The risk of decreased weight loss because of increased calorie intake
- d. The risk of new-onset seizures
- e. The risk of tooth decay

14. K.Z. asks you how likely this product is to help her with her exercise tolerance. Based on your knowledge of the product ingredients, which of the following is most accurate?

- a. The taurine component in this drink has been proven to help increase endurance.
- b. The ginseng component in this drink confers considerable changes in perceived exertion.
- c. The sucrose component in this drink has been shown to increase weight loss and increase endurance.
- d. The amounts of ingredients in this drink are unlikely to have a therapeutic effect.
- e. None of the above alternatives is correct.

15. Once-daily consumption of Monster energy drink is likely to have what effect on dental health?

- a. Protection against decay
- b. Improved tooth whitening
- c. Increased tooth decay
- d. Increased tooth erosion
- e. It is unlikely to have an effect on dental health.

CE EXAMINATION FORM

Safety issues associated with commercially available energy drinks

To receive **1.5** contact hours of continuing education credit (**0.15 CEU**), please provide the following information:

1. Type or print your name and address in the spaces provided.
2. Mail this completed form for scoring to:
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P.O. Box 791082
Baltimore, MD 21279-1082
3. CE processing is free for APhA members. If you are not an APhA member, please enclose a \$15 handling fee for grading the assessment instrument and issuing the Statement of Credit.

A Statement of Credit will be awarded for a passing grade of 70% or better. If you fail the exam, you may retake it once. If you do not pass the second time, you may no longer participate in this continuing pharmacy education program. Please allow 6 weeks for processing. Pharmacists who complete this exercise successfully before **May 1, 2011**, may receive credit.



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PARTICIPANT INFORMATION

NAME _____

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How long did it take you to read the program and complete this test?

____ Hours ____ Minutes

My signature certifies that I have independently taken this CE examination:

CE ASSESSMENT QUESTIONS—ANSWERS

Please circle your answers (one answer per question).

1. a b c d e

2. a b c d e

3. a b c d e

4. a b c d e

5. a b c d e

6. a b c d e

7. a b c d e

8. a b c d e

9. a b c d e

10. a b c d e

11. a b c d

12. a b c d

13. a b c d e

14. a b c d e

15. a b c d e

PROGRAM EVALUATION

EXCELLENT

POOR

PLEASE RATE THE FOLLOWING ITEMS.

1. Overall quality of the program	5	4	3	2	1
2. Relevance to pharmacy practice	5	4	3	2	1
3. Value of the content	5	4	3	2	1

PLEASE ANSWER EACH QUESTION, MARKING WHETHER YOU AGREE OR DISAGREE.

4. The program met the stated learning objectives:		Agree	Disagree
After reading this CE article, the pharmacist should be able to:			
• List at least three health issues associated with the consumption of energy drinks.		<input type="checkbox"/>	<input type="checkbox"/>
• Name four ingredients commonly found in energy drinks.		<input type="checkbox"/>	<input type="checkbox"/>
• Name the two ingredients in energy drinks most likely responsible for adverse effects.		<input type="checkbox"/>	<input type="checkbox"/>
• State the range of caffeine included in energy drinks.		<input type="checkbox"/>	<input type="checkbox"/>
• List at least two uses for which energy drinks have been studied.		<input type="checkbox"/>	<input type="checkbox"/>
• Name two energy drinks that contain bitter orange.		<input type="checkbox"/>	<input type="checkbox"/>
• State the most common cause of caffeine overdose-related death.		<input type="checkbox"/>	<input type="checkbox"/>
5. The program increased my knowledge in the subject area.		<input type="checkbox"/>	<input type="checkbox"/>
6. The program did not promote a particular product or company.		<input type="checkbox"/>	<input type="checkbox"/>

IMPACT OF THE ACTIVITY

The information presented (check all that apply):

7. Reinforced my current practice/treatment habits Will improve my practice/patient outcomes
 Provided new ideas or information I expect to use Adds to my knowledge
8. Will the information presented cause you to make any changes in your practice? Yes No
9. How committed are you to making these changes? (Very committed) 5 4 3 2 1 (Not at all committed)
10. Do you feel future activities on this subject matter are necessary and/or important to your practice? Yes No

FOLLOW-UP

As part of our ongoing quality-improvement effort, we would like to be able to contact you in the event we conduct a follow-up survey to assess the impact of our educational interventions on professional practice. Are you willing to participate in such a survey?

Yes No

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