

Technical Data Report

for

GUARANÁ

Paullinia cupana



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Guaraná

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Family: Sapindaceae

Genus: *Paullinia*

Species: *cupana*

Synonyms: *Paullinia sorbilis*

Common Names: Guarana, guarana kletterstrauch, guaranastruik, quarana, quarane, cupana, Brazilian cocoa, uabano, uaranzeiro

Parts Used: Fruit, seed

Guaraná is a creeping shrub native to the Amazon (and particularly the regions of Manaus and Parintins). In the lushness of the Brazilian Amazon where it originates, it often grows to 12 m high. The fruit is small, round, bright-red in color, and grows in clusters. As it ripens, the fruit splits and a black seed emerges—giving it the appearance of an “eye” about which Indians tell legends.

The uses of this plant by the Amerindians predates the discovery of Brazil. South American Indian tribes (especially the Guaranis, from whence the plant’s name is derived) dry and roast the seeds and mix them into a paste with water. They then use it much the same way as chocolate—to prepare various foods, drinks, and medicines. The rainforest tribes have used guaraná mainly as a stimulant and astringent, and in treating chronic diarrhea. It is often taken during periods of fasting to tolerate dietary restrictions better. Botanist James Duke cites past and present tribal uses in the rainforest: as a preventive for arteriosclerosis; as an effective cardiovascular drug; as an analgesic, astringent, febrifuge, stimulant, and tonic used to treat diarrhea; and for hypertension, migraine, neuralgia, and dysentery.

Over centuries the many benefits of guaraná have been passed on to explorers and settlers. European researchers began studying guaraná (in France and Germany) in the 1940s, finding that Indians’ uses to cure fevers, headaches, cramps, and as an energy tonic were well-founded. Guaraná is used and well known for its stimulant and thermogenic action. In the United States today, guaraná is reputed to increase mental alertness, fight fatigue, and increase stamina and physical endurance. Presently, guaraná is taken daily as a health tonic by millions of Brazilians, who believe it helps overcome heat fatigue, combats premature aging, detoxifies the blood, and is useful for flatulence, obesity, dyspepsia, fatigue, and arteriosclerosis. The plant, considered an adaptogen, is also used for heart problems, fever, headaches, migraine, neuralgia, and diarrhea. Guaraná has been used in body care products for its tonifying and astringent properties, and in the treatment of cellulite for its lipolytic and vasodilation actions. Guaraná also has been used as an ingredient in shampoos for oily hair and as a coadjutant in hair-loss treatments. In Peru the seed is used widely for neuralgia, diarrhea, dysentery, fatigue, obesity, cellulite, cardiac problems, hypertension, migraine, and rheumatism.

Today the plant is known and used worldwide (and is the main ingredient in the “national beverage” of Brazil, Guaraná Soda!). Eighty percent of the world’s commercial production of guaraná paste is in the middle of the Amazon rainforest in northern Brazil—still performed by the Guarani Indians, who wild-harvest the seeds and process them into paste by hand. The Brazilian government has become aware of the importance of the local production of guaraná by traditional methods employed by indigenous inhabitants of the rainforest. Since 1980, FUNAI (National Indian Foundation) has set up a number of projects to improve the local production of guaraná. Now, under the direction of the FUNAI regional authority in Manaus, many cooperatives in the rainforest support indigenous tribal economies through the harvesting and production of guaraná.¹

The first chemical examination of guaraná seeds was performed by the German botanist

Theodore von Martius in the 1700s. He isolated a bitter, white crystalline substance with a remarkable physiological action. Von Martius named this substance *guaranine*, and it was later renamed *caffeine*. Many today still believe guaranine to be a unique phytochemical in guaraná . It is, however (according to chemists), caffeine.^{2,3} As one group of researchers put it, guaranine is a product of crude laboratory processes and “should be considered non-existent, being in reality impure caffeine.”⁴ Guaranine is probably just caffeine bound to a tannin or phenol. In living plants, xanthines (such as caffeine) are bound to sugars, phenols, and tannins, and are set free or unbound during the roasting process. Guaraná seeds contain up to 4-8% caffeine (25,000 to 75,000 ppm), as well as trace amounts of theophylline (500 to 750 ppm) and theobromine (300 to 500 ppm).^{5,6} They also contain large quantities of alkaloids, terpenes, tannins, flavonoids, starch, saponins, and resinous substances.^{1,7}

Caffeine Content Comparison Common Beverage Products		
Plant Beverage	Caffeine Content	Avg. Caffeine (6 oz. serving)*
Guaraná seed (<i>Paullinia cupana</i>)	4–8%	200–400 mg
Coffee beans (<i>Coffea sp</i>)	1–2.5%	100–250 mg
Black tea (<i>Camellia sinensis</i>)	2.5–4.5%	10–60 mg
Yerba maté leaves	0.7–2%	50–100 mg
Chocolate (Cacao seed)	0.25%	13 mg

*Based on quantities used in standard preparation methods.

The xanthine alkaloids (caffeine, theophylline, theobromine) are believed to contribute significantly to guaraná 's therapeutic activity. In clinical studies, theophylline stimulates the myocardium⁸ and central nervous system,⁹ enhancing alertness and alleviating fatigue. It also has strong diuretic activity⁹ and reduces constriction of the bronchials, making it useful in asthma.⁸ Theobromine has similar effects. Certainly many traditional uses of guaraná may be explained by its caffeine content. Among its many documented effects, caffeine has been shown to facilitate fat loss^{10,11} and reduce fatigue.⁹

Toxicology studies with animals (in 1998) have shown that guaraná is non-toxic, even at high dosages (up to 2 g/kg of body weight).¹² Toxicity has been reported in only one human: a female who had an existing heart condition (mitrial valve prolapse).¹³

While the Indians have been using guaraná for centuries, Western science has been (slowly but surely) validating that the indigenous uses are well-grounded. In 1989, a U.S. patent was filed on a guaraná seed extract which was capable of inhibiting platelet aggregation in mammalian blood. The patent described guaraná 's ability to prevent the formation of blood clots and to help in the breakdown of already-formed clots.¹⁴ Clinical evidence was presented in conjunction with the 1989 patent and again in 1991 by a Brazilian research group that reported these antiaggregation properties.^{15,16} Once again, scientific validation is given to a plant used for centuries by the Indians as a heart tonic and to “thin the blood.”

The use of guaraná as an effective energy tonic, for mental acuity, and to enhance long-term memory recently was validated by scientists. In a 1997 *in vivo* study, guaraná increased physical activity of rats, increased physical endurance under stress, and increased memory with single doses as well as with chronic doses. Interestingly, the study revealed that a whole-seed extract performed more effectively than did a comparable dosage of caffeine or ginseng extract.¹⁷ Another Brazilian research group has been studying guaraná 's apparent effect of increasing memory,^{18,19}

thought to be linked to essential oils found in the seed.²⁰ The plant also was found to enhance memory retention and to have an anti-amnesic activity in mice and rats.¹⁷ A U.S. patent has been filed on a combination of plants (including guaraná) for promoting sustained energy and mental alertness “without nervousness or tension.”²¹ Guaraná (often in combination with other plants) also has been found to facilitate weight loss, by creating a feeling of fullness²² and having a mild thermogenic effect.²³

Guaraná has traditionally been used for headaches and migraines. A recent (1997) study found the plant to have analgesic activity,²⁴ which may explain its use for not only headaches but neuralgia, lumbago and rheumatism. More recently (in 2001) a U.S. patent was filed on a combination of plants, including guaraná , to “relieve pain and other symptoms associated with migraines and headaches.”²⁵

Guaraná ’s antibacterial properties against *Escherichia coli* and *Salmonella* have been documented as well.²⁶ Guaraná has demonstrated antioxidant properties; researchers concluded, “Guaraná showed an antioxidant effect because, even at low concentrations (1.2 mcg/ml), it inhibited the process of lipid peroxidation.”¹² In 1998, scientists demonstrated that a guaraná extract significantly increased the blood glucose levels and suppressed exercise-induced hypoglycemia in mice.²⁷

Guaraná ’s good health benefits and its standing as a natural stimulant, has caused its popularity to grow steadily worldwide. It can be found under many labels and as an ingredient in many herbal formulas, energy drinks, and protein bars. Unfortunately, too many (unethical) manufacturers are simply adding the guaraná name to their labels to capitalize on its popularity—and adding caffeine to their products instead. New, standardized extracts of guaraná are available these days that “guarantee” and “standardize” the extract to the caffeine content. Unfortunately, many of these comprise a seed powder or extract to which caffeine has been added—rather than a naturally-occurring concentration of all phytochemicals found in the seed. Recently, the Food and Drug Administration published results of their testing of 24 commercial guaraná products sold over the counter. They determined that “results and chromatographic profiles for 14 commercial products in solid dosage form indicate that a number of these products may not contain authentic guaraná as an active ingredient or contain less than the declared quantity of guaraná .”²⁸ Consumers and manufacturers need be aware of these inconsistencies to deal with reputable suppliers in purchasing guaraná products and supplements. Manufacturers buying guaraná extracts and standardized extracts should demand assays that show not only the caffeine content—but the theobromine and theophylline content as well. This will determine if the actual seed was concentrated into an extract. A good hint is to compare the prices of a supplement and a kilo of guaraná extract—if the extract is less than 3–4 times the cost of natural seed powder, it is likely a natural seed powder with some added caffeine.

Documented Properties and Actions: Analgesic, anti-amnesic, antibacterial, anticoagulant, antiobesity, antioxidant, aphrodisiac, astringent, cardiogenic, diuretic, febrifuge, hyperglycemic, nervine, purgative, stimulant, tonic, vasodilator

Main Phytochemicals: Adenine, allantoin, alpha-copaene, anethole, caffeine, carvacrol, caryophyllene, catechins, catechutannic acid, choline, dimethylbenzene, dimethylpropylphenol, estragole, glucose, guanine, hypoxanthine, limonene, mucilage, nicotinic acid, proanthocyanidins, protein, resin, salicylic acid, starch, sucrose, tannic acid, tannins, theobromine, theophylline, timbonine, xanthine

Traditional Remedy: One-half to one cup seed decoction 1–3 times daily or 1–3 ml of a 4:1 tincture twice daily; 1–2 g of powdered seed in tablets or capsules (or stirred into water or juice) 1–3 times daily can be substituted, if desired. Therapeutic dosages are reported to be 4–5 g daily. Relatively new to the U.S. market are guaraná extracts that are concentrated and standardized to the caffeine content (between 5% and 15%). Follow the labeled instructions and dosages for these

products.

Contraindications:

- Not to be used during pregnancy or while breast-feeding.
- Guaraná contains caffeine and should not be used by those who are sensitive or allergic to caffeine or xanthines. Excessive consumption of caffeine is contraindicated for persons with high blood pressure, cardiac disorders, diabetes, ulcers, epilepsy, and other disorders.

Drug Interactions:

- May potentiate anticoagulant medications such as Warfarin.
- May have adverse effects if used with MAO-inhibitor medications.

WORLDWIDE ETHNOBOTANICAL USES

Region	Uses
Amazonia	Arteriosclerosis, aphrodisiac, astringent, cardi tonic, coffee, cramps, depurative, diarrhea, dysentery, dyspepsia, fasting, fatigue, fever, flatulence, headache, malaria, obesity, stimulant
Brazil	Adaptogen, aphrodisiac, antiseptic, appetite suppressant, astringent, constipation, convalescence, CNS-stimulant, depression, diarrhea, digestive, diuretic, dysentery, exhaustion, fasting, fatigue, fever, flatulence, gastrointestinal, headache, heart, heat stress, intellect, jet lag, lumbago, malaria, memory, menstruation, migraine, nervine, nervous asthenia, nervousness, neuralgia, rheumatism, skin, stimulant, stomachic, stress, tonic, weakness
Canada	Aphrodisiac, febrifuge, narcotic, nervine, stimulant, tonic
Europe	Cardi tonic, depression, diarrhea, diuretic, exhaustion, headache, intoxicant, leucorrhea, migraine, nervine, neuralgia, stimulant, tonic
Latin America	Diarrhea, hangover, headaches, stimulant
Mexico	Coffee, diarrhea, stimulant
Peru	Aphrodisiac, astringent, bitter, cellulite, convalescence, diarrhea, dysentery, fatigue, fever, heart, hypertension, intoxicant, migraine, nervine, neuralgia, obesity, paralysis, piscicide, rheumatism, stimulant, tonic
South America	Aphrodisiac, arteriosclerosis, analgesic, bowel, diarrhea, febrifuge, heart, narcotic, nervine, stimulant, tonic

Region	Uses
U.S.	Aphrodisiac, appetite suppressant, athlete, concentration, diarrhea, diuretic, endurance, exhaustion, fatigue, headaches, leucorrhea, mental depression or irritation, migraine, nervine, obesity, PMS, stimulant, tonic
Elsewhere	Analgesic, aphrodisiac, astringent, chlorosis, convalescence, diarrhea, debility, diuretic, dysentery, headache, intoxicant, lumbago, migraine, nerves, nervine, neuralgia, rheumatism, stimulant, tonic

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The information contained herein is intended for education, research, and informational purposes only. This information is not intended to be used to diagnose, prescribe or replace proper medical care. The statements contained herein have not been evaluated by the Food and Drug Administration. The plant described herein is not intended to diagnose, treat, cure, mitigate, or prevent any disease.

Ethnomedical Information on Guaraná (Paullinia cupana)

Part / Location	Documented Ethnomedical Uses	Type Extract / Route	Used For	Ref #
Not Stated Amazonia	Used for headaches, fevers and cramps.	Not Stated	Human Adult	BK1003
Not Stated Amazonia	Used during periods of fast to better tolerate dietary restrictions. Believed to be an aphrodisiac and to protect from malaria and dysentery.	Not Stated	Human Adult	BK1008
Seed Brazil	Used to cure fevers.	Roasted Oral	Human Adult	K15254
Seed Brazil	Used for alleviation of heart problems.	Roasted Oral	Human Adult	K15254
Seed Brazil	Used for treatment of diarrhea.	Roasted Oral	Human Adult	K15254
Seed Brazil	Used for treatment of headache.	Roasted Oral	Human Adult	K15254
Seed Brazil	Used for reduction of heat stress.	Roasted Oral	Human Adult	K15254
Seed Brazil	Used as a stimulant.	Roasted Oral	Human Adult	K15254
Seed Brazil	Used as a stimulant.	Hot H2O Ext Oral	Human Adult	M08151
Seed Brazil	Used as a tonic.	Hot H2O Ext Oral	Human Adult	M08151
Seed Brazil	Used for neuralgia.	Hot H2O Ext Oral	Human Adult	M08151
Seed Brazil	Used for diarrhea.	Hot H2O Ext Oral	Human Adult	M08151
Seed Brazil	Used as a supplemental food in seasons of starvation.	Fruit Oral	Human Adult	M08151
Seed Brazil	Used as a CNS-stimulant.	H2O Ext Oral	Human Adult	K20643
Seed Brazil	Used for chronic diarrhea and dysentery. Used in the morning as a stimulant.	H2O Ext Oral	Human Adult	ZZ1081
Seed Brazil	Used for migraines and headaches, particularly headaches affecting one side of the head.	Decoction Oral	Human Adult	ZZ1081
Seed Brazil	Used for oily skin.	Paste External	Human Adult	ZZ1081

Part / Location	Documented Ethnomedical Uses	Type Extract / Route	Used For	Ref #
Seed Brazil	Used as a tonic, stomachic and stimulant. Used for general weakness, exhaustion, nervous asthenia, depression, regeneration of the organism, prevention and curing of perturbations, gastrointestinal disorders, dyspepsia, flatulence, fermentation abnormalities, diarrhea, gas, constipation, to enhance the defense of the organism and to act against the elements that cause physiological disturbances.	Hot H2O Ext Oral	Human Adult	ZZ1007
Seed Brazil	Used to stimulate cerebral function, enhance intellectual activity and productivity. Used for migraines and to balance heart rhythm. While it is used as a stimulant it does not cause insomnia or nervous agitation.	Hot H2O Ext Oral	Human Adult	ZZ1007
Seed Brazil	Used as a stimulant, tonic, diuretic, aphrodisiac, cardioactive, intestinal antiseptic and excitant; used for neuralgia, migraine, fever and nervousness. Helps to suppress the sensation of hunger.	H2O Ext Oral	Human Adult	ZZ1099
Seed Brazil	Used as a stimulant to increase mental alertness and fight fatigue.	Not Stated	Human Adult	ZZ1061
Seed Brazil	Used as a stimulant and astringent for chronic diarrhea. Used for fevers, heart problems, headaches (associated with menstrual or rheumatic conditions), rheumatism, lumbago, migraine and reduction of heat stress; used as a diuretic.	Paste Oral H2O Ext Oral	Human Adult	BK1002
Seed Brazil	Used as a stimulant, astringent, nervine tonic and diuretic. Used for cardiac derangements, headaches (caused by menstrual or rheumatic derangements), intestinal disorders, migraine, neuralgia, rheumatic complaints, lumbago, fatigue and to curtail hunger.	H2O Ext Oral	Human Adult	ZZ1049
Seed Brazil	Used as a tonic, nutrient, nerve relaxant, anti-stress agent, astringent, adaptogen, diuretic, aphrodisiac, antidepressant, revitalizer and as a general stimulant for the adrenals. Sustains the immune system, increases stamina, used for recovery after long illness, hang-over symptoms, for diarrhea, nervous depression and jet-lag, to adapt circadian rhythm after long-distance travel, for stress-related headaches and to sustain the brain after prolonged mental effort.	H2O Ext Oral	Human Adult	ZZ1011
Seed Brazil	Used as an aphrodisiac, diuretic and energy booster, for headaches, fevers, cramps and diarrhea.	Not Stated	Human Adult	BK1004

Part / Location	Documented Ethnomedical Uses	Type Extract / Route	Used For	Ref #
Seed Brazil	Produces a slightly euphoric effect. Used for restlessness, to quicken perception, for depression, wakefulness, slow pulse, impaired appetite, migraine, menstrual problems, diarrhea, convalescence and as a general tonic.	H2O Ext Oral	Human Adult	BK1006
Seed Brazil	Used as a stimulant and digestive tonic. Used to give relief from the heat. Acts as an aphrodisiac and used to prevent malaria and amoebic dysentery.	Not Stated	Human Adult	BK1010
Seed Canada	Used as a nervine, tonic, narcotic, stimulant, aphrodisiac and febrifuge.	ETOH Ext Oral	Human Adult	BK1006
Seed Europe	Used for leucorrhoea, diarrhea, headache of rheumatic nature, mental depression or irritation, fatigue or exhaustion from hot weather, nervous headaches, menstrual headaches and to promote dysuria.	H2O Ext Oral	Human Adult	ZZ1052
Seed Germany	Used as a stimulant and tonic. Used for headaches.	Not Stated Homeopathic Tincture Oral	Human Adult	BK1009
Seed Latin America	Used as a stimulant and to treat chronic diarrhea, hangovers and menstrual headaches.	Not Stated	Human Adult	ZZ1049
Seed Peru	Used as a tonic, stimulant and astringent. Used for neuralgia, to regulate the nervous system and to help in some forms of paralysis. As an astringent it helps in diarrhea and dysentery. Also it is used against obesity, cellulite and fatigue, as well as assisting in convalescence. Not recommended for those with digestive problems and may cause insomnia.	Not Stated	Human Adult	ZZ1093
Seed Peru	Used as an aphrodisiac. Used to prevent cardiac problems, to treat chronic diarrhea, fevers, hypertension and migraine.	Decoction Oral	Human Adult	L04137
Seed Peru	Used for rheumatism and diarrhea. Used as a stimulant without having a depressing effect, nor an effect on the liver.	Not Stated	Human Adult	ZZ1084
Seed Peru	Used as an astringent, bitter and nervine tonic.	Decoction Oral	Human Adult	ZZ1027
Seed Peru	Used as an aphrodisiac, astringent, febrifuge, intoxicant, piscicide, stimulant and tonic for diarrhea, dysentery, hypertension, migraine and neuralgia.	Not Stated	Human Adult	ZZ1050 ZZ1041
Seed South America	Considered a preventive for arteriosclerosis and an effective cardiovascular drug as well as an analgesic; used to treat chronic diarrhea.	Not Stated	Human Adult	BK1001

Part / Location	Documented Ethnomedical Uses	Type Extract / Route	Used For	Ref #
Seed South America	Used as a nervine, tonic, narcotic, stimulant, aphrodisiac and febrifuge. Used for bowel complaints but is not indicated for constipation.	H2O Ext Oral	Human Adult	ZZ1052
Seed South America	Used as a stimulant and antipyretic agent.	H2O Ext Oral	Human Adult	BK1005
Seed USA	Used as a stimulant, diuretic, nervine tonic, antifatigue, aphrodisiac and antidiarrheic to reduce hunger, relieve headaches and migraines and to alleviate PMS symptoms.	ETOH Ext Oral	Human Adult	ZZ1051
Seed USA	Used for leucorrhoea, diarrhea, headache of rheumatic nature, mental depression or irritation, fatigue or exhaustion from hot weather, nervous headaches, menstrual headaches and to promote dysuria.	H2O Ext Oral	Human Adult	ZZ1052
Seed USA	Used by athletes to enhance determination and focus concentration. Assists in increasing stamina and endurance.	H2O Ext Oral	Human Adult	ZZ1053
Not Stated USA	Used as a weight loss aid and as an appetite suppressant.	Not Stated	Human Adult	BK1008
Seed Not Stated	Used for headaches, rheumatic complaints and lumbago, as a diuretic and tonic, for when nerve action is impaired, for convalescence and debility; as an analgesic. Said to affect the sensory and motor nerves. Used as an astringent for diarrhea and dysentery; for chlorosis and as an aphrodisiac.	H2O Ext Oral	Human Adult	BK1005
Not Stated	Used as an astringent, stimulant, intoxicant, nervine and tonic for diarrhea, migraine and neuralgia.	Not Stated	Human Adult	ZZ1095

Presence of Compounds in Guaraná (Paullinia cupana)

Compound	Chemical type	Plant Part	Plant Origin	Quantity	Ref #
Adenine		Not Stated Seed	Not Stated Not Stated	Not Stated Not Stated	BK1002 ZZ1095
Allantoin		Seed	Not Stated	Not Stated	BK1007
Anethole	Phenylpropanoid	Seed Essential Oil	Germany	Not Stated	J11197
Benzene, 1-4-dimethyl	Benzenoid	Seed Essential Oil	Germany	Not Stated	J11197
Caffeine	Alkaloid	Seed	Brazil	Not Stated	K20643
		Seed	Brazil	Not Stated	M29919
		Seed	Not Stated	Not Stated	K11103
		Seed	Brazil	02.0-04.5%	K13202
		Seed	Brazil	Not Stated	J16577
		Seed	Brazil	Not Stated	L20928
		Seed	Brazil	Not Stated	M11957
		Seed	Brazil	00.91-3.24%	M12292
		Seed	Brazil	02.15%	K22551
		Seed	Brazil	03.0-4.5%	M29816
		Seed	Brazil	03.69-4.79%	M08151
		Seed	Brazil	04.28%	K28609
		Seed	Brazil	Not Stated	J18122
		Testa	Brazil	01.64%	K28609
		Pericarp	Brazil	00.02%	K28609
		Septa	Brazil	00.67%	K28609
		Arillus	Brazil	Not Stated	K28609
		Not Stated	Brazil	02.5%	W03499
		Seed Hulls	Not Stated	Not Stated	A2230B
		Seed	Not Stated	25,000-76,000 ppm	ZZ1095
		Seed	Germany	3.6-5.8%	BK1012

Compound	Chemical type	Plant Part	Plant Origin	Quantity	Ref #
Caffeine (continued)	Alkaloid	Leaf	Not Stated	0.38%	BK1014
		Bark	Not Stated	0.98%	BK1014
		Seed	Not Stated	4.4%	BK1014
		Stem wood	Not Stated	0.19%	BK1014
		Root rind	Not Stated	1.74%	BK1014
		Kernals	Not Stated	4.8%	BK1015
		Seed	Not Stated	3.91%	BK1016
		Seed paste	Not Stated	2.29%	BK1016
		Leaf	Not Stated	0.38%	BK1016
		Root	Not Stated	0.27-1.74%	BK1016
		Stem	Not Stated	0.17%	BK1016
Carvacrol	Monoterpene	Seed Essential Oil	Germany	Not Stated	J11197
Caryophyllene	Sesquiterpene	Seed Essential Oil	Germany	Not Stated	J11197
Catechin, (+)	Flavonoid	Seed	Brazil	Not Stated	J16577
Catechin, d	Flavonoid	Not Stated	Not Stated	Not Stated	BK1002
		Seed	Not Stated	Not Stated	ZZ1095
Catechin, epi: (-)	Flavonoid	Seed	Brazil	Not Stated	J16577
Catechutannic acid	Tannin	Not Stated	Not Stated	Not Stated	BK1008
		Seed	Not Stated	Not Stated	ZZ1095
Choline		Not Stated	Not Stated	Not Stated	BK1002
		Seed	Not Stated	Not Stated	ZZ1095
Copaene, alpha	Sesquiterpene	Seed Essential Oil	Germany	Not Stated	J11197
Estragole	Phenylpropanoid	Seed Essential Oil	Germany	Not Stated	J11197
Glucose		Seed	Japan	Not Stated	BK1013
Guanine		Not Stated	Not Stated	Not Stated	BK1002
		Seed	Not Stated	Not Stated	ZZ1095
Guaranine	Tetramethylxanthine	Seed	Not Stated	Not Stated	ZZ1052
		Not Stated	Not Stated	Not Stated	BK1010
		Seed	Not Stated	3-5%	BK1004
		Not Stated	Not Stated	Not Stated	BK1018

Compound	Chemical type	Plant Part	Plant Origin	Quantity	Ref #
Hypoxanthine	Alkaloid	Not Stated Seed	Not Stated Not Stated	Not Stated Not Stated	BK1002 ZZ1095
Limonene	Monoterpene	Seed Essential Oil	Germany	Not Stated	J11197
Nicotinic acid		Seed	Not Stated	Not Stated	BK1033
Phenol, 4-(dimethyl-propyl)	Benzenoid	Seed Essential Oil	Germany	Not Stated	J11197
Proanthocyanidins		Seed	Germany	10.7-11.7%	BK1011
Protein	Inorganic	Seed	Not Stated	98,600 ppm	ZZ1095
Salicylic acid		Seed	Not Stated	Not Stated	BK1033
Theobromine	Alkaloid	Seed	Brazil	Not Stated	J16577
		Seed	Brazil	Not Stated	K13202
		Seed	Brazil	Not Stated	J18122
		Seed	Brazil	00.015%	K28609
		Seed	Brazil	00.02-0.04%	M08151
		Seed	Brazil	Traces	M29816
		Testa	Brazil	00.027%	K28609
		Pericarp	Brazil	00.203%	K28609
		Septa	Brazil	00.217%	K28609
		Arillus	Brazil	Not Stated	K28609
		Seed	Not Stated	330 ppm	ZZ1095
		Seed	Germany	0.03-0.17%	BK1012
		Leaf	Not Stated	1.2%	BK1014
		Bark	Not Stated	0.15%	BK1014
		Flower	Not Stated	1.54%	BK1016
		Peduncle	Not Stated	0.38%	BK1016
		Leaf	Not Stated	1.2%	BK1016
		Stem	Not Stated	0.98%	BK1016
		Flower	Not Stated	0.38-1.54%	BK1016

Compound	Chemical type	Plant Part	Plant Origin	Quantity	Ref #
Theophylline	Alkaloid	Seed	Brazil	Not Stated	J16577
		Seed	Brazil	Not Stated	M29919
		Seed	Brazil	Not Stated	K13202
		Seed	Brazil	Not Stated	J18122
		Seed	Brazil	Not Stated	M11957
		Seed	Brazil	00.01-0.13%	M12292
		Seed	Brazil	00.0-0.25%	M08151
		Seed	Brazil	00.007%	K28609
		Seed	Brazil	Traces	M29816
		Testa	Brazil	00.005%	K28609
		Pericarp	Brazil	00.001%	K28609
		Septa	Brazil	00.084%	K28609
		Arillus	Brazil	Not Stated	K28609
		Seed	Not Stated	570 ppm	ZZ1095
		Seed	Germany	0.02-0.06%	BK1012
Timbonine	Saponin	Not Stated	Not Stated	Not Stated	BK1010
		Seed	Not Stated	Not Stated	ZZ1095
Xanthine	Alkaloid	Not Stated	Not Stated	Not Stated	BK1002
		Seed	Not Stated	Not Stated	ZZ1095

Biological Activities for Extracts of Guaraná (Paullinia cupana)

Part - Origin	Activity Tested For	Type Extract	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Seed Brazil	Toxic Effect (general)	Not Stated	Oral Dog	Not Stated	Active	Accidental ingestion of herbal supplements containing primarily guarana and ma huang in dogs can lead to a potentially lethal condition that may require prompt detoxification and supportive treatment for several days. Effects described are from a multi-component rx.	L10981
Seed Brazil	Toxic Effect (general)	Not Stated	Oral Human Adult Female	Not Stated	Equivocal	A single case report of a female patient with severe heart palpitations after taking two combination herbal supplements for 3-4 months. She was also taking multiple prescription medications. After discontinuation of the herbal supplements the palpitations stopped, no direct correlation of guarana was presented. Effects described are from a multi-component rx.	E01236
Seed Brazil	Toxic Effect(general)	Infusion	IG Rat	0.3 mg/ml	Inactive	No difference was reported upon evaluation of life-span of experimental and control groups treated for 23 months.	J11778
Seed Brazil	Toxic Effect(general)	Infusion	IG Rat	3.0 mg/ml	Inactive		J11778
Seed Brazil	Toxic Effect(general)	Lyophilized Extract	IP Rat Oral Rat	1000-2000 mg/kg 1000-2000 mg/kg	Inactive Inactive		L04285
Seed Brazil	Toxic Effect(general)	Lyophilized Extract	Rat	Not Stated	Inactive	Histopathological exam revealed no alteration in heart, lungs, stomach, small and large intestine, liver, pancreas, kidneys, bladder and spleen.	L04285
Not Stated Australia	Toxic Effect(general)	Health Drink	Oral Human Adult	Not Stated	Active	One female with pre-existing mitral valve prolapse developed intractable ventricular fibrillation.	BK1023
Not Stated USA	Toxic Effect(general)	Not Stated	Oral Human Adult	240 mg (of caffeine from guarana)	Active	Adverse symptoms reported included dry mouth, insomnia and headache.	BK1024

Part - Origin	Activity Tested For	Type Extract	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Seed Brazil	Genotoxicity Activity	Lyophilized Extract	Agar Plate	LC50=0.0 mg	Active	<i>Escherichia coli</i> wp2s(lambda) lysogenesis induction assayed. Catalase, superoxide dismutase, thiourea, or s9 fraction inhibited effect.	K16178
Seed Brazil	Genotoxicity Activity	Lyophilized Extract	Agar Plate	LC50=0.0 mg	Active	<i>Escherichia coli</i> wp2s(lambda) lysogenesis induction assayed. Catalase, superoxide dismutase, thiourea, or s9 fraction inhibited effect.	K16178
Seed Brazil	Mutagenic Activity	Lyophilized Extract	Agar Plate	30.0 mg 30.0 mg LC50=0.0 mg	Inactive Inactive Inactive	<i>Salmonella typhimurium</i> ta100. <i>Salmonella typhimurium</i> ta102. <i>Salmonella typhimurium</i> ta98.	K16178
Not Stated Brazil	Radiouptake Inhibition	Not Stated	Cell Culture	Not Stated	Active	Inhibited the uptake of radioactivity by RBC and altered the shape of the RBC.	BK1019
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext	Cell Culture Rabbit platelets	100.0 mg/ml	Active	Decreased platelet aggregation by 37%.	K16359
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext H2O Ext	Cell Culture Cell Culture	50.0 micromols 50.0 micromols	Active Active	vs. arachidonic acid-induced aggregation. vs. ADP-induced aggregation.	M22988
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext	Cell Culture	50 mu.l 100 mu.l	Active Strong Activity	Decreased aggregation seen. No aggregation seen.	BK1033
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext	IG Rabbit	20.0 ml 20.0 ml	Active Active	vs. ADP-induced aggregation. vs. arachidonic acid-induced aggregation.	M22988
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext	IG Rabbit	20 ml	Active Active	vs. arachidonic acid-induced aggregation. vs. ADP-induced aggregation.	BK1033
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext	IV Rabbit	1.0 ml 1.0 ml	Active Active	vs. ADP-induced aggregation. vs. arachidonic acid-induced aggregation.	M22988
Seed Brazil	Platelet Aggregation Inhibition	H2O Ext	IV Rabbit	1 ml	Active Active	vs. arachidonic acid-induced aggregation. vs. ADP-induced aggregation.	BK1033
Not Stated Denmark	Fibrinogen Reduction	Not Stated	Human Adult	2000 mg	Active	In an 8 week and 3 month trial a drop in plasma fibrinogen was seen.	BK1004
Seed Brazil	Thromboxane B-2 Synthesis Inhibition	H2O Ext	Cell Culture Rabbit platelets	100.0 mg/ml	Active	Decreased platelet thromboxane formation from arachidonic acid by 78%.	K16359

Part - Origin	Activity Tested For	Type Extract	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Seed Brazil	Thromboxane B-2 Synthesis Inhibition	H2O Ext	Cell Culture Rabbit platelets	Not Stated	Active		BK1033
Seed England	Pharmacokinetic Study	Powder	Rat	Not Stated	Intestine	Release and absorption of caffeine from extract not different from those of pure compound.	K11103
Seed Brazil	Antifatigue Activity	Infusion	IG Mouse	0.3 mg/ml 3.0 mg/ml	Active Inactive	vs. forced swimming test. vs. forced swimming test.	J11778
Not Stated Denmark	Energy Enhancement	Not Stated	Human Adult	2000 mg	Active	Subjective report of more energy and less tiredness.	BK1004
Not Stated	Energy Enhancement	Not Stated	Human Adult	Not Stated	Active	US Patent on a combination of plants including guarana to provide sustained energy and mental alertness without nervousness or tension.	BK1031
Not Stated	Weight Loss	Chewing gum	Human Adult	0.05 mg - 5 g	Active	Creates energy and gives a feeling of fullness.	BK1017
Seed Not Stated	Weight Loss	Not Stated	Oral Human Adult	Not Stated	Inactive	Dosing 3 times a day for 10 days. The effect was found in a mixture of <i>Cola acuminata</i> , <i>Paullinia cupana</i> , <i>Turnera diffusa</i> , <i>Agathosma species</i> and <i>Ilex paraguariensis</i> .	T15449
Not Stated USA	Weight Loss	Not Stated	Oral Human Adult	240 mg (of caffeine from guarana)	Active	35 subjects received Ma Huang-Guarana combination; weight and fat loss seen after 8 weeks.	BK1024
Not Stated Denmark	Weight Loss	Not Stated	Human Adult	2000 mg	Active	In an 8 week and 3 month trial weight loss was seen.	BK1004
Seed Brazil	Thermogenic Activity	Seeds	Oral Human Adult	2.72 gm	Inactive	No significant increase in energy expenditure. No change in respiratory quotient.	L05756
Seed Denmark	Thermogenic Activity	Not Stated	Oral Human Adult	Not Stated	Active	In combination with Yerba mate and Damiana it prolonged gastric emptying time, reduced body weight and maintained weight over 12 months.	BK1021
Not Stated Brazil	Neurological Effect	Not Stated	Human Adult	Not Stated	Inactive	No significant cognitive alterations.	BK1025

Part - Origin	Activity Tested For	Type Extract	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Not Stated Brazil	Neurological Effect	Not Stated	Human Adult	Not Stated	Inactive	No effect on cognition, anxiety and sleep in 30 subjects.	BK1026
Entire Plant Not Stated	CNS Stimulant Activity	Hot H2O Ext	Oral Human Adult	Not Stated	Active	A chewing gum for preventing drowsiness.	T10251
Not Stated	CNS Activity	Not Stated	Human Adult	Not Stated	Active	Resulted in faster reaction times and improved speed-hand-eye coordination. Accuracy reduced.	BK1004
Seed Brazil	Sleep Time Increased	Lyophilized Ext	IG Rat Male	2000. mg/kg	Inactive	vs. barbiturate-induced narcosis.	L04285
Seed Brazil	Memory Retention Improvement	Infusion	IG Rat	0.3 mg/ml	Equivocal	vs. active avoidance test. Evaluation after 75 and 120 days of treatment.	J11778
Seed Brazil	Memory Retention Improvement	Infusion	IG Rat	3.0 mg/ml	Equivocal	vs. active avoidance test. Evaluation after 75 and 120 days of treatment.	J11778
Seed Brazil	Antiamnesic Activity	Infusion	IP Mouse IP Mouse IP Rat IP Rat	3.0 mg/ml 30.0 mg/ml 0.3 mg/ml 3.0 mg/ml	Active Active Active Inactive	vs. scopolamine induced amnesia in animals subjected to passive avoidance task test.	J11778
Not Stated Brazil	Muscle Relaxant Effect	Not Stated	Rabbit Corpus cavernosum	1 mg/ml	Active	Short-lived relaxation of the corpus cavernosum seen.	BK1020
Not Stated Brazil	cAMP Synthesis	Not Stated	Rabbit Corpus cavernosum	1 mg/ml 10 mg/ml 100 mg/ml	Strong Activity Active Active	Increased the cAMP levels by 200%. 150% increase in nucleotide levels. 89% increase in nucleotide levels.	BK1020
Seed Brazil	Analgesic Activity	Hydro-alcoholic Ext	IG Mouse	200.0 mg/kg 200.0 mg/kg 200.0 mg/kg 200.0 mg/kg 200.0 mg/kg	Active Active Active Active Active	vs. acetic acid-induced writhing. vs. hot plate method. vs. tail flick response to radiant heat. vs. formalin-induced algesia. vs. capsaicin-induced algesia.	J13503
Not Stated	Headache Relief	Not Stated	Human Adult	125 mg	Active	US Patent on a combination of plants including guarana to relieve pain and other symptoms associated with migraines and headaches.	BK1032
Seed Brazil	Hyperglycemic Activity	H2O Ext	Mouse	500 mg/kg	Active	Increased blood glucose level and decreased liver glycogen content 60 minutes after maltose administration.	J18356

Part - Origin	Activity Tested For	Type Extract	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Seed Brazil	Antihyperglycemic Activity	H2O Ext	Mouse Male	500.0 mg/kg	Inactive	vs. epinephrine-induced hyperglycemia.	J18356
Seed Brazil	Antihypoglycemic Activity	H2O Ext	Mouse	500 mg/kg	Active	Suppressed exercise-induced hypoglycemia.	J18356
Not Stated Denmark	Hypocholesterolemic Activity	Not Stated	Human Adult	2000 mg	Active	After 3 months of supplementation a rise in HDL was seen.	BK1004
Seed Brazil	Antioxidant Activity	Lyophilized Extract	Not Stated	1.2 mcg/ml	Active	Effect measured by thiobarbituric acid reactive substances. Inhibited lipid peroxidation.	L04285
Not Stated	Cytotoxic Activity	H2O Ext	Cell Culture	250.0 mcg/ml	Active	Ca-jtc-26.	J19374
Not Stated China	Cytotoxic Activity	Hot H2O Ext	Cell Culture	500.0 mcg/ml	Inactive	Cells-he-1 the inhibition rate was 11%.	M27219
Not Stated China	Cytotoxic Activity	Hot H2O Ext	Cell Culture	250.0 mcg/ml	Active	Ca-jtc-26 the inhibition rate was 82%.	M27219
Seed Brazil	Cytotoxic Activity	Infusion	Cell Culture	32.02 mg/ml 34.62 mg/ml 39.95 mg/ml	Inactive Inactive Inactive	Not Stated. vs. MTT-formazan assay. vs. kenacid blue assay.	J19973
Seed Brazil	Cytotoxic Activity	H2O Ext	Cell Culture	120.0 mcg/ml 120.0 mcg/ml 500.0 mcg/ml 500.0 mcg/ml	Equivocal Equivocal Inactive Inactive	Ca-mammary-microalveolar. Cells-human-embryonic he-1. Ca-mammary-microalveolar. Cells-human-embryonic he-1.	M26592
Seed Brazil	Cell Proliferation Inhibition	H2O Ext	Human Adult Lymphocytes	100.0 mcg/ml	Active	vs. phytohemagglutinin-induced proliferation. Effect reversible.	K19547
Kernel Brazil	Anticaries Activity	H2O Ext	Broth Culture	1.5%	Inactive	<i>Streptococcus mutans</i> stimulated plaque fermentation and had no influence on the synthesis of insoluble polysaccharides.	M25425
Seed Brazil	Effect on Teeth	Seeds	Not Stated	Not stated	Active	A carbonated beverage, "guarana" was tested against human teeth.	K27240
Leaf Not Stated	Tyrosinase Stimulation	Not Stated	External Human Adult	10.0%	Active	Used to prevent gray hair and sunburn.	J13191
Seed Brazil	Hyaluronidase Inhibition	Hot H2O Ext	Not Stated	0.002 %	Active	75% inhibition.	A00401
Seed Not Stated	Reductase, 5-alpha Inhibition	ETOH(95%)Ext	Not Stated	1.0%	Active		K22288

Biological Activities for Compounds of Guarana (Paullinia cupana)

Compound Tested	Activity Tested For	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Caffeine	Toxicity(general)	Not Stated	Not Stated	Active	May induce nervousness, insomnia and tremors; stimulates the respiratory center.	ZZ1048
Theophylline	Toxicity(general)	Not Stated	Not Stated	Active	May cause nervousness, sleeplessness, tachycardia, nausea, vomiting, headaches, tremors, epigastralgia, diarrhea, agitation and insomnia.	ZZ1048
Caffeine	Toxicity (in utero)	Oral Rat	0.02% Drinking water	Active	In utero exposure affects central respiratory control - higher respiratory frequency and hypoxic respiratory depression seen.	BK1034
Caffeine	Convulsant Activity	Human Adult	Not Stated	Active	Can exacerbate seizures in those with epilepsy.	BK1022
Xanthines	Platelet Aggregation Inhibition	Cell Culture Rabbit platelets	100.0 mg/ml	Active	Decreased platelet aggregation by 31%.	K16359
Chromatographic fraction without salicylic acid, xanthines and nicotinic acid	Platelet Aggregation Inhibition	<i>In vitro</i>	Not Stated	Strong Activity	Decrease in platelet aggregation seen as well as a deaggregation of platelet aggregates. vs. ADP-induced platelet aggregation.	BK1033
Chromatographic fraction containing xanthines and nicotinic acid	Platelet Aggregation Inhibition	<i>In vitro</i>	Not Stated	Active	Decrease in platelet aggregation seen. vs. ADP-induced platelet aggregation.	BK1033
Xanthines	Thromboxane B-2 Synthesis Inhibition	Cell Culture Rabbit platelets	100.0 mg/ml	Active	Decreased platelet thromboxane formation from arachidonic acid by 50%.	K16359
Caffeine	Cardiovascular Activity	Human Adult	250 mg	Active	Increased aortic stiffness, wave reflections and both aortic and radial systolic, diastolic and pulse pressure.	BK1027
Caffeine	Cardiovascular Activity	Not Stated	Not Stated	Active	Positive inotropic action, causes tachycardia, an increase in cardiac output and slight peripheral vasodilation.	ZZ1048

Compound Tested	Activity Tested For	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Caffeine	Cardiovascular Activity	Oral Human Adult (hypertensive)	250 mg	Active	Systolic blood pressure and pulse pressure increased; no change in diastolic blood pressure; an increase in aortic stiffness seen.	BK1045
Caffeine	Cardiovascular Activity	Oral Human Adult	870 mg	Active	Increased fasting homocysteine by 0.4 micromol/L or 5%. Effect was stronger in women.	BK1046
Theophylline	Cardiovascular Activity	Not Stated	Not Stated	Active	Used for myocardial stimulation.	BK1035
Theophylline	Diuretic Activity	Not Stated	Not Stated	Active	Increases glomerular filtration.	ZZ1048
Theobromine	Diuretic Activity	Not Stated	Not Stated	Active		BK1036
Caffeine	Diuretic Activity	Not Stated	Not Stated	Active		BK1036
Theophylline	Diuretic Activity	Not Stated	Not Stated	Active		BK1036
Caffeine	Weight Loss	Human Adult	Not Stated	Active	Increases metabolic rate.	BK1030
Caffeine	Weight Loss	Human Adult	Not Stated	Active	Inhibits adenosine, thereby overcoming feedback inhibition of catecholamine release, promoting fat loss.	BK1029
Caffeine	Athletic Performance Activity	Oral Human Adult	250 mg	Inactive Active Active	Short-term performance. Blood lactate increased. Plasma insulin concentrations at rest, end of mock test and during recovery were increased.	BK1037
Caffeine	CNS Activity	Not Stated	Not Stated	Active	Enhances alertness, facilitates thought formation and decreases the sensation of fatigue.	ZZ1048
Theophylline	CNS Activity	Not Stated	Not Stated	Active	Enhances alertness, facilitates thought formation and decreases the sensation of fatigue.	ZZ1048
Caffeine	CNS Activity	Not Stated	Not Stated	Active	Stimulates the central nervous system; increases the activity of the heart.	BK1036

Compound Tested	Activity Tested For	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Caffeine	Cognitive Performance	Oral Human Adult	200 mg 300 mg	Active Active	Subjects received caffeine after 72 hrs of sleep deprivation and continuous exposure to stressors. Caffeine improved visual vigilance, choice reaction time, repeated acquisition, self-reported fatigue and sleepiness. Improved results on tests of vigilance, reaction time and alertness.	BK1038
Caffeine	Cognitive Performance	Oral Human Adult	1 or 2 mg/kg followed 60 minutes later with 1 mg/kg	Active Inactive	Improved performance on a sustained attention task and increased mental alertness in caffeine-deprived consumers. No effect on rated mental alertness and performance on an attention task in consumers who were not caffeine deprived.	BK1039
Caffeine	Cognitive Performance	IP Rat	0.3-10 mg/kg 30 mg/kg 0.3-30 mg/kg	Active Inactive Active	Post-training dose improved memory retention. Post-training memory retention. Pre-test dose increased memory retrieval.	BK1040
Caffeine	Cognitive Performance	Oral Human Adult	200 mg	Active	Increased alertness and anxiety and improved performance on simple and choice reactive tasks, a cognitive vigilance task, a task requiring sustained response and a dual task involving tracking and target detection.	BK1041
Caffeine	Headache Relief	Human Adult	Not Stated	Active	Helps to relieve migraines and headaches.	BK1032
Caffeine	Anti-inflammatory Activity	Cell Culture	5×10^{-6} - 1.5×10^{-4} mol/l	Inactive	No significant effect on endotoxin-induced PGE(2) formation nor on its inhibition by indometacin.	BK1043
Theobromine	Antispasmodic Activity	Not Stated	Not Stated	Active	Smooth muscle.	BK1036
Theophylline	Antispasmodic Activity	Not Stated	Not Stated	Active	Smooth muscle.	BK1036
Theophylline	Antispasmodic Activity	Not Stated	Not Stated	Active	Relaxed the smooth muscles of the bronchi and blood vessels.	BK1035
Theophylline	Bronchial Smooth Muscle Relaxant	Not Stated	Not Stated	Active		ZZ1048
Theophylline	Bronchodilator Activity	Not Stated	Not Stated	Active	Used for conditions such as obstructive airway disease and bronchial asthma.	BK1035

Compound Tested	Activity Tested For	Test Model	Dosage	Result	Notes/Organism tested	Ref #
Theophylline	Respiratory Activity	Not Stated	Not Stated	Active	Modest effect on FEV1 and FVC and slightly improved arterial blood gas tensions in COPD.	BK1042
(+)-Catechin	Anti-metastatic Activity	Rat	25 microM	Active	Anti-metastatic in invasive rat prostate adenocarcinoma.	BK1028
Caffeine	Cytotoxic Activity	Topical Mice	Not Stated	Active	Inhibited carcinogenesis and stimulated apoptosis of skin tumors. Decreased size of parametrial fat pads and the thickness of the dermal fat layer.	BK1044
Caffeine	Osteoporotic Activity	Oral Human Adult Female	200-300 mg (2.5-6 fl oz cups)	Active	Associated with a loss of bone mineral density in most skeletal sites. Attenuated with a higher calcium intake (750 mg/day).	BK1047

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BK1047	TO DRINK OR NOT TO DRINK: HOW ARE ALCOHOL, CAFFEINE AND PAST SMOKING RELATED TO BONE MINERAL DENSITY IN ELDERLY WOMEN? ILICH, JZ: BROWNBILL, RA: TAMBORINI, L: CRNCEVIC-ORLIC, Z: J AM COLL NUTR 21 6: 536-44 (2002) (UNIVERSITY OF CONNECTICUT, SCHOOL OF ALLIED HEALTH, STORRS, CT)