EUROPEAN ACADEMIC RESEARCH
Vol. X, Issue 6/ September 2022

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Amazon Guarana (Paullinia Cupana Var. Sorbilis): Effect of Consumption on Physical Performance – A Narrative Review

IVAN DE JESUS FERREIRA[1]
DAURIMAR PINHEIRO LEÃO[2]
OZANILDO VILAÇA DO NASCIMENTO[3]
VINICIUS CAVALCANTI[4]
MARNE CARVALHO DE VASCONCELLOS[5]

Abstract

Guarana is an abundant fruit in bioactive compounds, responsible for different pharmacological actions, which guarantees enormous economic and social interest. For this reason, it has become a product used on a large scale for the manufacture of beverages, food, pharmaceuticals and cosmetics. In this narrative review we seek to present the current status of the effect of guarana consumption as a food supplement on physical performance. In this context, we gathered several studies that used guarana alone or in combination with other substances in order to identify its ergogenic effects associated with physical exercise and sports. However, the information available requires research involving the participation of human beings who practice and do not practice sports and physical activity.

Keywords: Physical performance; Guarana; Sports supplementation.

1 INTRODUCTION

Sports modalities and physical activities in general depend directly on the muscle contractions that promote the various forms of motor actions, and can cause damage to

[1] IVAN DE JESUS FERREIRA. He is Teacher at the Federal University of Amazonas and a doctoral student at the Biodiversity and Biotechnology Network of the Legal Amazon. Has experience in Physical Assessment. E-mail: ijf@alumni.usp.br
[2] DAURIMAR PINHEIRO LEÃO. He is Teacher at the Federal University of Amazonas and PhD in Biodiversity and Biotechnology Network of the Legal Amazon. Has experience in Physical Education, on Individual and collective physical training. E-mail: daurimarleao61@gmail.com
[3] OZANILDO VILAÇA DO NASIMENTO. He is Teacher at the Federal University of Amazonas and PhD in Biotechnology. research in the area of Genetic Polymorphism Applied to Health and Athletic Performance. E-mail: ozanildo@bol.com.br
[4] VINICIUS CAVALCANTI. He is Teacher at the Federal University of Amazonas and PhD in Biodiversity and Biotechnology Network of the Legal Amazon. He works as a researcher in the Human Performance area of runners and cyclists. E-mail: viniciuscavalcanti@ufam.edu.br
[5] MARNE CARVALHO DE VASCONCELOS. She is a Professor at the Federal University of Amazonas and a PhD in Pharmacology. She works as a researcher in the field of Clinical Pharmacology and Experimental Oncology. E-mail: marne@ufam.edu.br

the muscles at different levels, depending on the characteristics of the training load, competition load and level of physical conditioning. of practitioners (LIMA, 2019; PLA, 2022). For example, endurance events and team sports in general, require extreme actions of the muscles that induce fatigue, cause structural damage, and with that, reduce the capacity for motor performance. These sports have attracted more and more fans in Brazil, with 38.8 million Brazilians of both sexes practicing or practicing some sport (IBGE, 2018). Therefore, it is important to identify effective means to support rapid recovery between intensive training sessions or during physically demanding competitions such as tournaments, games and extended championships (BOWTELL, 2019; JUSZKIEWICZ, 2019).

Although regular physical exercise is responsible for increasing or improving motor performance, physical exercise and sports training with high loads have the power to damage muscles and affect their functions (D'ANGELO, 2020a). In sports, plants and foods rich in polyphenols have been gaining popularity, as they represent a rich source of antioxidants. In addition, they are found in the context of foods with potent biological activities in the fight against oxidative stress (D'ANGELO, 2020b; MASSARO, 2019).

In the search for effective strategies to support rapid recovery and observed improvements in performance capacity in endurance sports, recreational sports practitioners and professional athletes are increasingly employing plant-based diets. In this context, it is known that natural foods, rich in polyphenols and carbohydrates, present an effective possibility of modulating the performance of the motor resistance capacity, from an antioxidant, anti-inflammatory and immunological point of view (CRADDOCK et al., 2020; NEBL, 2019; NIEMAN, 2017).

Although the regular practice of physical exercises has numerous health benefits, particularly in the treatment and prevention of chronic-degenerative diseases, physical exercise is also related to the production of reactive oxygen and nitrogen species, which in excess have the potential to produce toxic effects. and damage to muscle structures (WIGHTMAN, 2020; YFANTI, 2019). In this scenario, food supplements have been used in an attempt to protect and improve the performance of high-performance exercise and sports practitioners (MARTÍNEZ-NOGUERA, 2019).

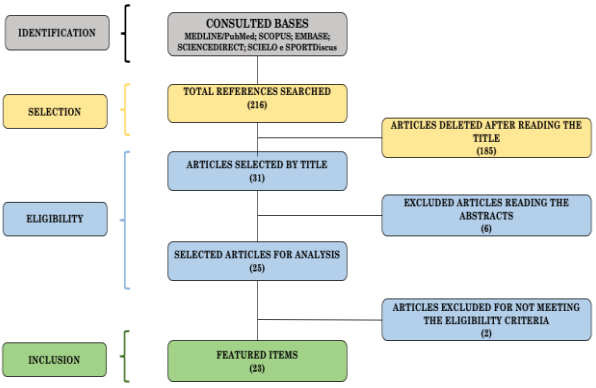
The most common antioxidant nutritional supplements used in studies related to exercise and endurance sport and their effects on redox status in humans are: vitamin C, vitamin E, polyphenols, N-acetylcysteine and whey protein (YFANTI, 2019). Other research used plants and fruits, rich in antioxidants such as cocoa, pomegranate, grape, black currant and cherry (MASSARO, 2019; BLOEDON et al., 2019).

Guarana (Paullinia cupana var. sorbilis) is rich in polyphenols, when compared to other foods such as green tea and chocolate, with a tenfold higher concentration of catechins (CAMPOS, 2018). In addition, it has a high content of caffeine, tannin, theobromine, theophylline, phosphorus, potassium, iron, calcium, thiamine, vitamin A, protein and sugars (SCHIMPL et al., 2013). As a product, it has been used mainly in the soft drinks, cosmetics, pharmaceuticals and food supplements industry (MACHADO et al., 2018; YONEKURA, et al., 2016). Thus, this work aimed to make a narrative review on the current state of the effect of consumption of guarana as a sports supplement on physical performance.

2 METHODOLOGY

References were extracted from PubMed, Embase, SportDiscus databases; Web of Science, Scopus, Scielo and Sciencedirect, in any language, without period restrictions (**Figure 1**). The descriptors used for the search: "paullinia cupana" OR "guaraná" OR "guarana powder" OR guarana extract" AND "sports performance" AND "physical activity" AND "physical exercise" AND "food supplement". any gray literature. Incomplete and/or unavailable works in full, manuscripts without information about authorship and/or origin were excluded.

Figure 1 - Narrative review search steps



3 GUARANA (*Paullinia cupana*, var. *sorbilis*)

The guarana tree (Paullinia cupana, var. sorbilis) is a plant native to the Amazon region, originating in Maués, a municipality in the State of Amazonas. It is a shrub and climbing plant species, adapted to low altitude and hot and humid climate, belonging to the subfamily of Sapindoideae, genus Paullinia with about 200 species (FIGUEROA, 2016; TRICAUD; PINTON; PEREIRA, 2016).

The guarana tree has a furrowed stem and a yellowish-brown coloration when lignified. The leaves are alternate and odd with well-developed sheaths approximately 1.5 cm long. The main petiole measures 8 to 19 cm and the petioles of the leaflets are very short. The leaflets have an approximately oval shape and a serrated apex, ranging in width from 10 to 14 cm and length from 27 to 33 cm. The leaves are dark green with a glossy upper part (CAVALCANTI et al., 2020a).

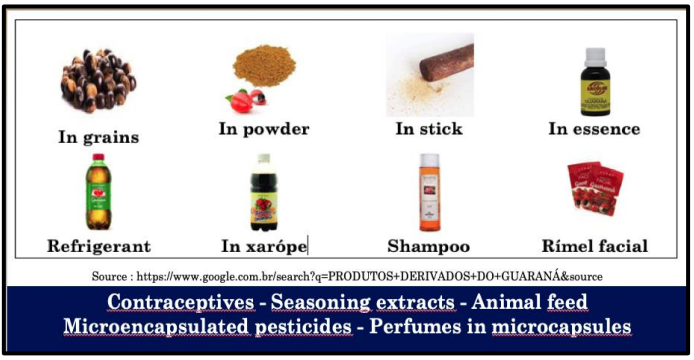
The guarana fruit (**Figure 2**) is spherical, dark shiny, capsule-shaped with one to three leaflets, with only one seed. When ripe, it has red and orange color and opens showing its seeds. The pericarp is dark brown, slightly taken up by a white substance serving for seed dispersal (MARQUES et al., 2019). In addition, this fruit is rich in bioactive compounds, mainly methylxanthines and tannins, with prolonged stimulant effects, which guarantees great commercial value (DALONSO; PETKOWICZ, 2012; NINA, 2019).

Figure 2 - Guarana fruit from the Amazon

Source: EMBRAPA Western Amazon, 2021
Photo: ROSA, Felipe Santos da

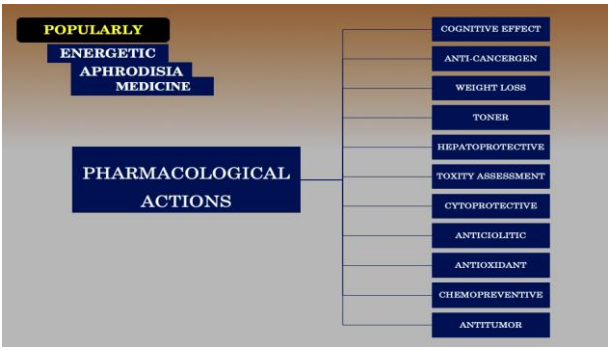
As it is of economic and social interest, it has become a product used on a large scale for the manufacture of beverages, food, pharmaceuticals and cosmetics (TORRES et al, 2022). The main commercial products derived from guarana found in the national and international market (**Figure 3**), in its natural form or mixed with other ingredients are: soft drinks, energy drinks, roasted beans, stick, powder, encapsulated, syrups, extracts, distillates, flavorings, essences, ice cream, creams, shampoo and facial mask (PORTELLA, 2013). In addition to other applications in the form of contraceptives, extracts for seasoning, animal feed, pesticides and perfumes.

Figure 3 - Commercial products derived from guarana



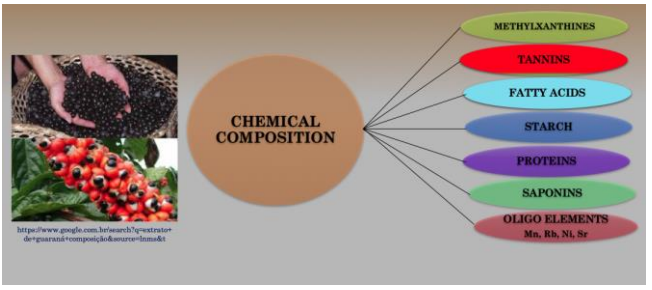
Popularly, guarana is used as an energy drink, aphrodisiac and medicine. This is because its seeds are abundant in bioactive compounds responsible for different pharmacological actions (Figure 4) such as: cognitive effect; anticancer; weight loss; tonic action; cognitive effect; hepatoprotective; cytoprotectant; anticolytic; antioxidant; chemopreventive and antitumor (MARTINS, 2020; PATEIRO et al., 2018; MARQUES et al., 2019).

Figure 4 - Pharmacological actions of guarana



Its chemical composition (Figure 5) presents methylxanthines (caffeine, theobromine, theophylline), tannins (catechins and epicatechins), procyanidin (A2, B1, B2, B3, B4 and C1), saponins, polysaccharides, proteins, fatty acids and trace elements (Mn, Rb, Ni and Sr) (SCHIMPL et al., 2013; MARTINS, 2010; DE GOIS et al., 2016 DA SILVA LIMA et al., 2018; PATEIRO et al., 2018; MARQUES et al., 2019) .

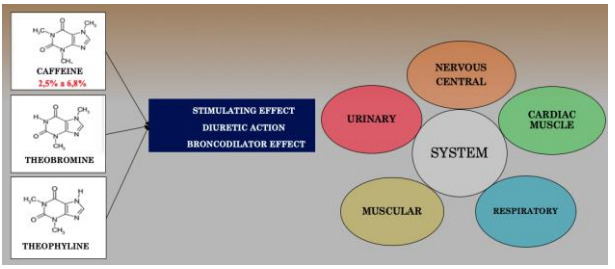
Figure 5 - Chemical composition of guarana



Guarana is one of the richest vegetables in caffeine (2.5% to 6.8%) and depending on the brand considered, we can find concentrations four times higher when compared to ground coffee. The amount of caffeine can range from 40 to 80 mg per gram of extract (MARQUES et al., 2019). Furthermore, this is the main substance responsible for the stimulant characteristic of guarana (MARTINS,2020; YONEKURA et al., 2016; MACHADO et al., 2018; CAVALCANTI et al, 2020a).

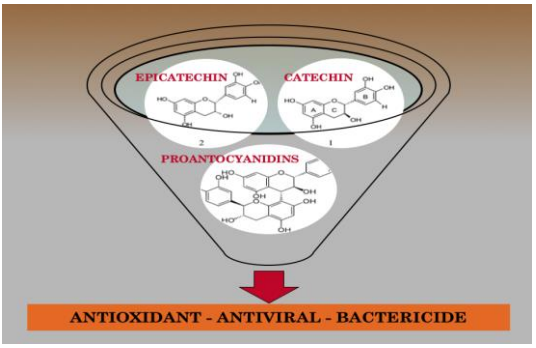
Methylxanthines exert the following effects on the human body (Figure 6): Caffeine (1,3,7-trimethylxanthine) has a stimulant effect on the central nervous system, cardiac muscles, respiratory system, muscular system and urinary system, and is also considered a weak diuretic and muscle relaxant. Theobromine (3,7-dimethylxanthine) has a diuretic action, and theophylline (1,3-dimethylxanthine) has a bronchodilatory effect (CAVALCANTI et al., 2020b).

Figure 6 - Effect of methylxanthines on the human body



The tannins found in guarana have mainly antioxidant, antiviral and bactericidal activity. Its catechin concentrations are ten times higher than most foods considered to be a source of this compound, such as green tea and chocolate. It is an excellent source of polyphenols (Figure 7), with the ability to reduce health risks and improve sports performance related to oxidative stress (MARTINS, 2020).

Figure 7 - Main activities of tannins



In this way, natural products with antioxidant activity are excellent substitutes for synthetic products that are associated with problems such as toxicity and carcinogenesis (BITTENCOURT et al., 2013; PORTTELA et al, 2013).

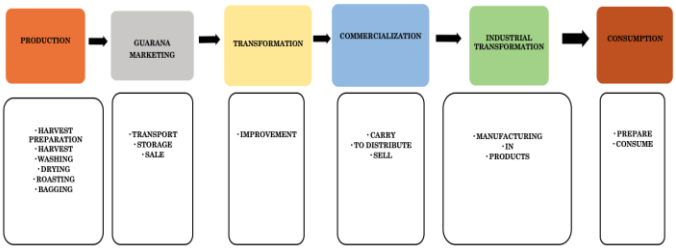
Considering its energetic, medicinal and antioxidant properties, guarana is a product with high economic and industrial power, particularly for the State of Amazonas (NINA et al., 2021). In Brazilian territory, the main states involved in the cultivation of guarana are: Acre, Amazonas, Bahia, Mato Grosso, Pará, Rondônia and São Paulo. In the northern region of Brazil, the State of Amazonas, in the municipality of Maués, the cultivation of guarana is encouraged mainly by the beverage, cosmetic and pharmaceutical industries, being the second largest producer in the country, losing only to the state of Bahia (IBGE, 2016; MACHADO et al., 2018).

Although guarana has a well-defined production chain (Figure 8), which goes from the rural producer to the final consumer, guarana productivity is low in the State of Amazonas. According to the Systematic Survey of Agricultural Production in Brazil (IBGE, 2018), the state of Bahia is currently the largest producer with 862.1 ton/ha, followed by the state of Amazonas with 501.5 ton/ha. The main factors that led to this

low productivity in Amazonas are: lack of public policies; concentration of production in the municipality of Maués and lower Amazon regions; and high cost of implementing the culture for the small producer (MERIGUETE, 2020).

Regardless of the low productivity, the guarana-do-Amazonas has greater added value, which values the work of producers in the municipality of Maués and stimulates local production. Added to this, the phytochemical diversity of several guaraná genotypes regarding the variability in the concentrations of caffeine, catechin and epicatechin, which recently allowed a classification according to the genotypes in three groups: energetic and antioxidant guarana, energetic and antioxidant (NINA et al., 2021).

Figure 8 - Guaraná Production Chain



Source: Modified and adapted from MERIGUETE, 2020

4 EFFECTS OF GUARANA ON PHYSICAL PERFORMANCE

In general, the ergogenic effects produced by the consumption of guarana on physical performance have been attributed to methylxanthines, in addition to other potentially stimulating components such as tannins, saponins and polysaccharides.

In the field of performance sports, recent studies using guarana are focused on its ergogenic effects, such as: a) improving cognitive performance: speed of attention; task accuracy; improvement in decision making and memory (KENNEDY et al., 2004; CAMPOS et al., 2005; OTOBONE et al., 2005; HASKELL et al., 2007; KENNEDY et al., 2008; LE VAN & BRISSWALTER, 2012; SCHOLEY et al., 2013; POMPORTES et al., 2014; VEASEY et al., 2015; WHITE et al., 2017; POMPORTES et al., 2015; POMPORTES et al., 2017; POMPORTES et al., 2018); b) Increased fatigue tolerance, especially in aerobic endurance events (ESPINOLA et al., 1997; MIURA et al., 1988; KENNEDY et al., 2008; RONCOn et al., 2011; VEASEY et al., 2015; POMPORTES et al., 2015; HURLEY et al., 2018; POMPORTES et al., 2018; POMPORTES et al., 2019; and SILVEIRA et al. 2018); c) improvement in general physical fitness (ASTLEY et al., 2018; POMPORTES et al., 2017; CAMPOS-PÉREZ, J.; CÁMARA-MARTOS, 2019).

One of the most frequent deleterious effects caused by physical exercise is muscle damage, leading to a delay in the process of recovery of motor functions. For this reason, food supplementation with antioxidant potential can play an important role in the recovery process of athletes, reducing the sequelae left by oxidative stress (GOULART et al., 2020).

Guarana has also demonstrated antioxidant activity (PORTELLA et al., 2013), which can be an excellent strategy for athletes who resort to the use of antioxidant and anti-inflammatory drugs (ROJANO ORTEGA et al., 2020). It is a practice used to reduce muscle damage, however, it has gastrointestinal, renal and cardiovascular implications, justifying the search for supplements from natural sources with the aim of decreasing inflammation and muscle recovery during the training process (SEMEN, et al. ., 2020).

The consumption of guarana has also been shown to be an efficient ally for weight loss in humans, which can help athletes in controlling their body weight.

In Table 1 we present the studies that used guarana supplementation and its effects on physical performance.

Table 1 - Studies that used guarana supplementation and effects on physical performance

REFERENCES	PARTICIPANTS	SUPPLEMENTATION	PROTOCOL	EFFECT OF SUPPLEMENTATION
1997 ESPINOLA et al.	mouse	Ingestion of guarana suspension at a dose of 0.3 mg /ml.	Forced swimming test after 100 and 200 days of treatment.	Significant increase in physical capacity with two doses of guarana with longer swimming time compared to the control group.
1998 MIURA et al.	mouse	Guarana aqueous ex-tract (500 mg/kg) oral administration.	60 min aerobic exercise .	100 and 500 mg /kg increase blood glucose level. It does not affect glycemia in glycogenolytic and epinephrine-induced exercise mice.
1998 MATTEI et al.	rats and mouse	Acute and chronic administrations sus-pension at concen-trations of 0.3 and 3.0 mg/ml. of guarana and ginseng.		Antioxidant effect because, even at low concentrations (1.2 μ g/ml), it inhibited the lipid peroxidation process. In addition to the absence of toxicity in the histopathological examination.
2004 KENNEDY et al.	19 female and 9 male volunteers (mean age 21.4 years)	*Panax ginseng* – stan-dardized extract; Gua-rana - standardized extract.	Cognitive Drug Re-search Computerized Assessment Battery	The ginseng/guarana com-bination was associated with faster 'Attention Speed' and 'Memory Speed'.
2005 CAMPOS et al.	Seven groups (n = 6) of mice	Guarana (25 and 50 mg/kg, po) and caffeine (10 and 20 mg/kg, po). the animals of groups 5, 6 and 7 received caffeine (10, 20 and 30 mg/kg).	Forced swimming and open field testing.	Guarana (100 mg/kg) and caffeine (30 mg/kg) doses significantly increased locomotor activity in the open field test .
2005 LIMA et al.	Adult male Wistar rats (160-250 g) sedentary and trained	Aqueous extract (GE) and decaffeinated gua-rana extract (DG), for 14 days. 0.130 (G1) and 0.325 (G2) mg /kg.	The training con-sisted of swimming in individual PVC tanks for 20 minutes.	The results show that guarana consumption is capable of inducing chan-ges in lipid metabolism, increasing fat con-sumption.
2005 OTOBONE et al.	Male Wistar Rats (50-55 days old, 220-250 g)	The animals were treated once a day for 40 days with the crude extract of guarana. (30.0 or 60mg/Kg); purified extract of guarana (2.0 and 4.0 mg /kg) and semi-purified extract of guarana (2.0 and 4.0 mg/kg).	Morris Water Maze Test (MWMT) - 1984	Increased cognitive perfor-mance, as they exhibited a significant nootropic effect. It is a useful therapeutic choice in the prevention and/or treatment of memory deficits.
2007 HASKELL et al.	18 women and 8 men with a mean age of 21.38 years.	Guarana extract stan-dardized in 37.5 mg, 75 mg, 150 mg and 300 mg capsules.	Administration of four different doses throughout the day (37.5mg, 75mg, 150mg and 300mg) Cognitive Drug Re-search (CDR) com-	Improved secondary me-mory performance and increased content alert and mood ratings.

			puterized assessment battery and Bond-Lader mood scales.	
2008 KENNEDY et al.	70 women, 60 men (18-24 years) – average age 20.98 years	vitamin/mineral/guarana effervescent tablets and placebo. The effer-vescent tablets were dissolved in 200 ml of water at room temperature.	6 x 10-minute version of the Cognitive Demand Battery and a Rapid Visual Information Processing (RVIP) task	The vitamin/mineral/guarana combination resulted in better task performance, compared to placebo, in terms of increased speed and accuracy of performing the RVIP task during the post-dose assessment. The increase in mental fatigue associated with prolonged task performance was also mitigated by the supplement.
2011 FROM COSTA KREWER	637 elderly patients (≥60 years), with 305 men and 355 women classified as those who regularly consumed guarana or those who never ingested guarana	Self-declaration of habitual consumption of guarana.	Diagnosis of metabolic disorders: obesity, hypertension, type 2 diabetes and metabolic syndrome; Analysis of the levels of oxidative metabolism biomarkers;	The habitual intake of guarana contributes positively to the prevention of several metabolic disorders in the elderly, such as: lower prevalence of arterial hypertension, obesity and metabolic syndrome.
2011 RONCON et al.	Male Wistar Rats (55 days old, 230-250 g)	Chronic administration of a semi-purified ex-tract (Purified Extract A – PEA; 4, 8 or 16 mg/kg) of *guarana seeds.*	Elevated T-maze (TME) model of generalized anxiety and panic disorders for 24 days PAR 3 mg/kg), PEA (4, 8 and 16 mg/kg) or VEH by gavage.	Guarana PEA fraction produced an antidepressant effect in the forced swimming test.
2012 LE VAN & BRISSWALTER	56 subjects aged 29.5 ± 8 years (32 men and 24 women).	vitamin complex and Guarana (60 mg of caffeine)	Simple reaction time test (TRS); Go no Go decision test ; Surveillance measurement; Measuring heart rate and blood pressure	Guaraná's positive effect on cognitive performance was observed only in decision-making tasks and, to a lesser extent, in the deterioration of alert-ness over time.
2013 PORTELLA et al.	42 healthy elderly	Usual consumption of guarana.	***in vivo*** - healthy elderly blood samples who habitually ingested guarana; (GI) or never ingested guarana (NG). ***in vitro*** - LDL obtained from 3 healthy, non-fasting, normolipidemic voluntary donors who did not habitually ingest them.	Subjects had lower LDL oxidation. In the GI group, total polyphenols were positively associated with LDL levels. Guarana showed high antioxidant activity *in vitro* at concentrations of 1 and 5 µg/mL,
2013 SCHOLEY et al.	20 healthy adults (8 males and 12 females) aged between 21 and 39 years (mean age = 28.35 years)	Two commercially available multivitamin and mineral efferves-cent tablets caffeine (40 mg) derived from guarana (222 mg) dissolved in 330 ml of water.	Computer-based Cognitive Demand Battery.	Multivitamins with guarana: increased self-assessment of contentment and improved attentional performance/working memory.
2014 POMPORTES et al.	56 (32 men and 24 women) Age group: 19-45 years	three paired treatments: a) vitamin/mineral/guara-na supplement; b) caffeine supplement ; and c) placebo supplementation.	Go/no-go task and simple reaction time : performed before ingestion, 15 minutes after ingestion, and then every 15 minutes for 3 h	Ingestion of multivitamin-minerals with the addition of guarana improves decision-making performance without any further impairment of autonomic nervous system regulation or anxiety side effects.

2015 VEASEY et al.	40 men who were active and able to run non-stop on a treadmill at a moderate pace for 30 minutes.	Multivitamin and mineral complex with guarana (Berocca Boost ®, MVM + G) and placebo (placebo effervescent tablet was dissolved in 250 mL of water) on separate days.	COMPASS (Computerized Mental Performance Assessment System, University of Northumbria at Newcastle) and comprised a selection of standard tasks.	MVM+G consumed 1 h before moderate-intensity exercise can reduce the feeling of exertion during exercise and improve cognitive performance up to 90 min after exercise .
2015 POMPORTES et al.	17 top-level athletes specializing in squash and fencing	Ingestion of a complex composed of creatine (1000 mg) + guarana (1500 mg) and a placebo.	Muscle power was assessed by a test of six maximal sprints in ergo-cycle sprints: 6 seconds of duration intercepted by 25s of rest.	The results indicate a positive effect of the creatine supplement + guarana on muscle power (peak power and fatigue) and cognitive performance recorded after exercise.
2016 YONEKURA et al.	12 participants	3 g of the powder diluted in 300 ml of water before ingestion, daily for 15 days before breakfast.	15-day run-in period followed by a 15-day intervention with a daily intake of 3 g of guarana seed powder containing 90 mg (+)-catechin and 60 mg (−)-epicatequina.	Reduction of oxidative stress in clinically healthy overweight individuals through the direct antioxidant action of absorbed catechins and increased regulation of detoxifying antioxidant enzymes.
2017 POMPORTES et al.	24 physically active participants (16 men and 6 women)	25 mL of a 7% carbohydrate complex; 67 mg of caffeine; 0.4 g of guarana complex; or a placebo	Submaximal exercise of 40 minutes (peak power in progressive test from 80 Watt (W) for women and 100 W for men with an increase of 15 W/min until exhaustion).	Serial administration of CHO, CAF and GUAc MR improves cognitive performance and decreases subjective perception of exertion.
2017 WHITE et al.	20 healthy, non-smoking adults aged 21 to 39 years (mean age = 28.35 years)	Effervescent drink made from two commercially available supplements: Berocca ® boost (multivitamin and mineral salts with 222.2 mg of guarana (40 mg of caffeine) per tablet); and Berocca (without guarana in its composition and the highest levels of B vitamins and vitamin C).	Measures of mood and cognitive function, in addition to hemodynamic and electrophysiological measures of functional brain activity using functional and potential MRI.	Single doses of multivitamin and mineral preparations, with and without guarana, influence functional brain activity in healthy young adults.
2018 HURLEY et al.	12 untrained men	5 mg/ kg guarana in capsule.	4x 10 reps + 1 set to failure at 75% 1RM biceps muscle.	↑ the number of repetitions of the biceps muscle. ↑ subjective perception of effort and pain.
2018 POMPORTES et al.	17 squach and fencing athletes	Nutritional supplement based on in creatine (1,000mg) and guarana (1500 mg).	Test of 6 sprints of 6 seconds with 25 seconds of recovery in cycle ergometer.	The results indicate a positive effect of creatine + guarana supplement muscle power and cognitive performance.
2018 SILVEIRA et al.	6 male adolescents, professional jiujitsu athletes; age group 14 and 18 years	500 mg of guarana powder per capsule, thus, 8 capsules provided an amount equivalent to 5.5 mg of caffeine/kg of body weight	The training consisted of simulations of the Morote Gari blow for 2 minutes with maximum intensity	Increase in exercise tolerance, resulting in a decrease in the feeling of fatigue and in sports performance in high-intensity, short-duration activities.
2019 POMPORTES et al.	10 high-level modern pentathlon athletes (6 men and 4 women)	guarana complex (intake of CHO (30 g), GUAc (300 mg), CAF (200 mg) or placebo during exercise.	40 minutes of running exercise on acting , rating of perceived exertion (RPE) and shooting. Shooting and Cognition (Simon's Task)	Improved physical performance both in the perception of effort and in the processing of information.

5. CONCLUSIONS

The bioactive compounds of guarana, such as methylxanthines, tannins, procyanidin, saponins, polysaccharides, proteins, fatty acids and trace elements, vary according to

genotype, cultivar, location and climatic conditions. In this way, they can exhibit different effects such as: increased attention and concentration, facilitation of the use of energetic substrates, favoring sports with characteristics of speed, strength, anaerobic resistance and aerobic resistance. The protocols and supplements used in the studies differ in relation to the type of exercise, exercise intensity, exercise volume, duration of intervention, origin of guarana and type of administration. Investigations related to guarana consumption and physical performance are insufficient, particularly the effect produced by bioactive compounds on the motor performance of athletes in their usual practice.

ACKNOWLEDGMENTS

Federal University of Amazonas
Laboratory of Biological Activities (BIOPHAR)
Amazonas State University
Postgraduate Program in Biodiversity and Biotechnology of the Bionorte Network.

REFERENCES

1. ASTLEY, Camilla; SOUZA, Diego B.; POLITO, Marcos D. Acute Specific Effects of Caffeine-containing Energy Drink on Different Physical Performances in Resistance-trained Men. **International journal of exercise science**, v. 11, n. 4, p. 260, 2018.
2. BAKER, Lindsay B.; NUCCIO, Ryan P.; JEUKENDRUP, Asker E. Acute effects of dietary constituents on motor skill and cognitive performance in athletes. **Nutrition reviews**, v. 72, n. 12, p. 790-802, 2014.
3. BITTENCOURT, L. S. et al. The protective effects of guaraná extract (Paullinia cupana) on fibroblast NIH-3T3 cells exposed to sodium nitroprusside. **Food and Chemical Toxicology**, v. 53, p. 119-125, 2013.
4. BOWTELL, Joanna; KELLY, Vincent. Fruit-derived polyphenol supplementation for athlete recovery and performance. **Sports Medicine**, v. 49, n. 1, p. 3-23, 2019.
5. BLOEDON, Taylor K. et al. Impact of anthocyanin-rich whole fruit consumption on exercise-induced oxidative stress and inflammation: a systematic review and meta-analysis. **Nutrition Reviews**, v. 77, n. 9, p. 630-45, 2019.
6. CAMPOS, A. R. et al. Acute effects of guarana (Paullinia cupana Mart.) on mouse behaviour in forced swimming and open field tests. **Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives**, v. 19, n. 5, p. 441-443, 2005.
7. CAMPOS-PÉREZ, J.; CÁMARA-MARTOS, F. Influence of Substances Present in Energy and Sports Drinks in Improving Athletic Performance. In: **Sports and Energy Drinks**. Woodhead Publishing, 2019. p. 297-337.
8. CAVALCANTI, VINICIUS et al. Bioproducts based on guarana (Paullinia cupana) for practitioners of physical activity, **European Academic Research.** v. 8, n. 3, p. 1746-59, jun. 2020a.
9. CAVALCANTI, VINICIUS et al. Antioxidant capacity of guaraná (Paullinia cupana) microcapsules. **European Academic Research.** v. 8, n. 7, p. 4337-55, out. 2020b.
10. CRADDOCK, J. C. et al. Plant-based eating patterns and endurance performance: A focus on inflammation, oxidative stress and immune responses. **Nutrition Bulletin**, v. 45, n. 2, p. 123-32, 2020.
11. CUI, Pengbo et al. Advances in sports food: sports nutrition, food manufacture, opportunities and challenges. **Food Research International**, p. 111258, 2022.
12. DA COSTA KREWER, Cristina et al. Habitual intake of guaraná and metabolic morbidities: an epidemiological study of an elderly Amazonian population. **Phytotherapy Research**, v. 25, n. 9, p. 1367-1374, 2011.
13. D'ANGELO, Stefania. Polyphenols: Potential beneficial effects of these phytochemicals in athletes. **Current Sports Medicine Reports**, v. 19, n. 7, p. 260-5, 2020a.
14. D'ANGELO, Stefania; ROSA, Roberta. The impact of supplementation with Pomegranate fruit (Punica Granatum L.) on sport performance. **Sport Sci**, v. 13, p. 29-37, 2020b.

15. DALONSO, Nicole; PETKOWICZ, Carmen Lúcia de Oliveira. Guarana powder polysaccharides: Characterisation and evaluation of the antioxidant activity of a pectic fraction. **Food Chemistry**, v. 134, n. 4, p. 1804-12, 2012.
16. ESPINOLA, E. B. et al. Pharmacological activity of Guarana (Paullinia cupana Mart.) in laboratory animals. **Journal of ethnopharmacology**, v. 55, n. 3, p. 223-229, 1997.
17. FIGUEROA, A. L. G. Guaraná, a máquina do tempo dos Sateré-Mawé. **Boletim do Museu Paraense Emílio Goeldi: Ciências Humanas**, v. 11, n. 1, p. 55–85, 2016.
18. GOULART, Maria Júlia VC et al. Effects of grape juice consumption on muscle fatigue and oxidative stress in judo athletes: a randomized clinical trial. **Anais da Academia Brasileira de Ciências**, v. 92, n. 4, 2020.
19. HASKELL, Crystal F. et al. A double-blind, placebo-controlled, multi-dose evaluation of the acute behavioural effects of guarana in humans. **Journal of psychopharmacology**, v. 21, n. 1, p. 65-70, 2007.
20. IBGE. **Systematic survey of agricultural production (in Portuguese).** In: Coagro (Ed.), Rio de Janeiro, 2016.
21. IBGE. **Systematic survey of agricultural production: monthly survey of forecast and monitoring of agricultural crops in the calendar year**. Rio de Janeiro, 2018.
22. JUSZKIEWICZ, A. et al. The effect of L-theanine supplementation on the immune system of athletes exposed to strenuous physical exercise. **Journal of the International Society of Sports Nutrition**, v. 16, n. 1, p. 7, 2019.
23. KENNEDY, David O. et al. Improved cognitive performance in human volunteers following administration of guarana (Paullinia cupana) extract: comparison and interaction with Panax ginseng. **Pharmacology Biochemistry and Behavior**, v. 79, n. 3, p. 401-411, 2004.
24. KENNEDY, D. O. et al. Improved cognitive performance and mental fatigue following a multi-vitamin and mineral supplement with added guarana (Paullinia cupana). **Appetite**, v. 50, n. 2-3, p. 506-513, 2008.
25. LE VAN, Philippe; BRISSWALTER, Jeanick. Influence d'un complément multivitaminé comprenant du Guarana sur la réponse cardiovasculaire et la performance cognitive. **Science & Motricité**, n. 76, p. 39-46, 2012.
26. LIMA, Waldecir P. et al. Lipid metabolism in trained rats: effect of guarana (Paullinia cupana Mart.) supplementation. **Clinical Nutrition**, v. 24, n. 6, p. 1019-1028, 2005.
27. LIMA, Natália da Silva et al. The effect of Guarana (Paullinia cupana) on metabolic and inflammatory parameters in adult male mice programmed by maternal obesity. **European journal of nutrition**, v. 58, n. 2, p. 765-774, 2019.
28. MACHADO, Kamilla Nunes et al. A rapid simultaneous determination of methylxanthines and proanthocyanidins in Brazilian guaraná (*Paullinia cupana* Kunth.). **Food chemistry**, v. 239, p. 180-8, 2018.
29. MATTEI, R. et al. Guarana (Paullinia cupana): toxic behavioral effects in laboratory animals and antioxidant activity in vitro. **Journal of ethnopharmacology**, v. 60, n. 2, p. 111-116, 1998.
30. MARTINS, Nicolli Cariello et al. Effects of grape juice consumption on oxidative stress and inflammation in male volleyball players: A randomized, double-blind, placebo-controlled clinical trial. **Complementary Therapies in Medicine**, ID 102570, 2020.
31. MARTÍNEZ-NOGUERA, Francisco Javier et al. Acute effects of hesperidin in oxidant/antioxidant state markers and performance in amateur cyclists. **Nutrients**, v. 11, n. 8, p. 1898, 2019.
32. MARQUES, Leila Larissa Medeiros et al. Guaraná (Paullinia cupana) seeds: Selective supercritical extraction of phenolic compounds. **Food Chemistry**, v. 212, p. 703-11, 2016.
33. MARQUES, Leila Larissa Medeiros et al. Paullinia cupana: a multipurpose plant–a review. **Revista Brasileira de Farmacognosia**, v. 29, n. 1, p. 77-110, 2019.
34. MASSARO, Marika et al. Effect of Cocoa products and its polyphenolic constituents on exercise performance and exercise-induced muscle damage and inflammation: A review of clinical trials. **Nutrients,** v. 11, n. 7, p. 1471, 2019.
35. MERIGUETE, Indramara Lôbo de Araújo Vieira. **Biotechnology transfer: a case study of guarana (Paullinia cupana var. sorbilis) cultivars in the State of Amazonas**. 2020. Thesis (Doctorate in Biological Sciences) - Institute of Biological Sciences, Federal University of Amazonas, Manaus, 2020.
36. MIURA, Toshihiro et al. Effect of guarana on exercise in normal and epinephrine-induced glycogenolytic mice. **Biological and Pharmaceutical Bulletin**, v. 21, n. 6, p. 646-648, 1998.
37. NEBL, Josefine et al. Ability to exercise vegan, ovo-lacto-vegetarian and omnivorous recreational runners. **Journal of the International Sports Nutrition Society**, v. 16, n. 1, pág. 23, 2019.
38. NIEMAN, David C.; MITMESSER, Susan Hazels. Potential impact of nutrition on immune system recovery from heavy exertion: a metabolomics perspective. **Nutrients**, v. 9, n. 5, p. 513, 2017.
39. NINA, Natasha Veruska dos Santos. Genetic divergence, adaptability and stability and selection gains for agroindustry characters of guarana genotypes. 2019. Doctoral Thesis. Federal University of Amazonas.
40. NINA, Natasha Veruska dos Santos et al. Phytochemistry divergence among guarana genotypes as a function of agro-industrial characters. **Crop Science**, v. 61, n. 1, p. 443-55, 2021.

41. OTOBONE, Fernanda Jacques et al. Effect of crude extract and its semi purified constituents from guaraná seeds [Paullinia cupana var. sorbilis (Mart.) lucke] on cognitive performance in Morris water maze in rats. **Brazilian Archives of Biology and Technology**, v. 48, p. 723-728, 2005.
42. PATEIRO, Mirian et al. Guarana seed extracts as a useful strategy to extend the shelf life of pork patties: UHPLC-ESI/QTOF phenolic profile and impact on microbial inactivation, lipid and protein oxidation and antioxidant capacity. **Food Research International**, v. 114, p. 55-63, 2018.
43. PLÁ, Enrico Missura. Muscle fatigue response in trained men and women after strenuous running exercise. 2022.
44. PORTELLA, Rafael de Lima et al. Guaraná (Paullinia cupana Kunth) effects on LDL oxidation in elderly people: an in vitro and in vivo study. **Lipids in health and disease**, v. 12, n. 1, p. 1-9, 2013.
45. POMPORTES, Laura et al. Heart rate variability and cognitive function following a multi-vitamin and mineral supplementation with added guarana (Paullinia cupana). **Nutrients**, v. 7, n. 1, p. 196-208, 2014.
46. POMPORTES, L. et al. Effet d'un complexe créatine–guarana sur la puissance musculaire et la performance cognitive chez des sportifs de haut niveau de performance. **Science & Sports**, v. 30, n. 4, p. 188-95, 2015.
47. POMPORTES, Laura et al. Cognitive performance enhancement induced by caffeine, carbohydrate and guarana mouth rinsing during submaximal exercise. **Nutrients**, v. 9, n. 6, p. 589, 2017.
48. POMPORTES, Laura et al. Effects of Carbohydrate, Caffeine and Guarana on Cognitive Performance. **International Journal of Sports Physiology and Performance.** v. 14, n. 5, p.576-82, 2018.
49. POMPORTES, Laura et al. Effects of Carbohydrate, Caffeine, and Guarana on Cognitive Performance, Perceived Exertion, and Shooting Performance in High-Level Athletes. **International journal of sports physiology and performance**, v. 14, n. 5, p. 576-82, 2019.
50. SCHIMPL, Flávia Camila et al. Guarana: revisiting a highly caffeinated plant from the Amazon. **Journal of ethnopharmacology**, v. 150, n. 1, p. 14-31, 2013.
51. RONCON, Camila Marroni et al. Anxiolytic effects of a semipurified constituent of guaraná seeds on rats in the elevated T-maze test. **Planta medica**, v. 77, n. 03, p. 236-241, 2011.
52. ROJANO ORTEGA, Daniel et al. Tart cherry and pomegranate supplementations enhance recovery from exercise-induced muscle damage: a systematic review. **Biology of Sport**, v. 38, n. 1, 2021.
53. SILVA, Briane Pardinho da. Relação entre consumo de guaraná (paullinia cupana) e atenção: uma revisão sistemática. 2021.
54. SILVA, Antonio Mario Galvão E. Amazonian Fruits in Exercise and Sport: narrative review study, **European. Academic Research,** v. 8, n. 6, set., 2020.
55. SILVEIRA, Jacqueline Queiroz da; AMORIM, Leidiane Lara; BURIAN, Joao Paulo. Ergogenic effect of acute supplementation guarana in jiu-jitsu fighters. **Rbne-revista Brasileira De Nutricao Esportiva**, p. 246-254, 2018.
56. SCHOLEY, Andrew et al. Acute effects of different multivitamin mineral preparations with and without guaraná on mood, cognitive performance and functional brain activation. **Nutrients**, v. 5, n. 9, p. 3589-3604, 2013.
57. SEMEN, Khrystyna O. et al. Effects of Monomeric and Oligomeric Flavanols on Kidney Function, Inflammation and Oxidative Stress in Runners: A Randomized Double-Blind Pilot Study. **Nutrients**, v. 12, n. 6, p. 1634, 2020.
58. SOUSA, Sandra A. et al. Determination of tannins and methylxanthines in guarana powder (Paullinia cupana Kunth, Sapindaceae) by high performance liquid chromatography. **Brazilian Journal of Pharmacognosy**, v. 20, p. 866-870, 2010.
59. TORRES, Elizabeth AFS et al. Effects of the consumption of guarana on human health: A narrative review. **Comprehensive Reviews in Food Science and Food Safety**, v. 21, n. 1, p. 272-295, 2022.
60. TRICAUD, Solène; PINTON, Florence; PEREIRA, Henrique dos Santos. Local knowledge and practices of guarana (Paullinia cupana Kunth var. sorbilis) producers in the middle Amazon: two local organizations facing innovation. **Bulletin of the Museu Paraense Emílio Goeldi**. Human Sciences, v. 11, n. 1, p. 33-53, 2016.
61. VEASEY, Rachel C. et al. The effects of supplementation with a vitamin and mineral complex with guaraná prior to fasted exercise on affect, exertion, cognitive performance, and substrate metabolism: a randomized controlled trial. **Nutrients**, v. 7, n. 8, p. 6109-6127, 2015.
62. WIGHTMAN, Emma L. et al. Acute Effects of a Polyphenol-Rich Leaf Extract of Mangifera indica L.(Zynamite) on Cognitive Function in Healthy Adults: A Double-Blind, Placebo-Controlled Crossover Study. **Nutrients**, v. 12, n. 8, p. 2194, 2020.
63. WHITE, David J. et al. The effect of a single dose of multivitamin and mineral combinations with and without guaraná on functional brain activity during a continuous performance task. **Nutritional neuroscience**, v. 20, n. 1, p. 8-22, 2017.
64. YFANTI, Christina et al. Sports nutrition, redox homeostasis and toxicity in sports performance. **Current Opinion in Toxicology**, v. 13, p. 45-67, 2019.
65. YONEKURA, L. et al. Bioavailability of catechins from guaraná (Paullinia cupana) and its effect on antioxidant enzymes and other oxidative stress markers in healthy human subjects. **Food & Function**, v.13, n.7, p. 2970-8, Jul. 2016