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Amazonian Fruits in Exercise and Sport: narrative review study

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Abstract

The use of plants and their fruits as ergogenic aids as become apopular among physiologists, sportspeople and the physically active. Studies conducted mainly on animals demonstrate the potential of the bioactive and nutritional constituents of certain fruits, which when absorbed and metabolised can influence the performance parametersof athletes and physically active. Camu camu ***(Myrciaria dubia (H.B.K.) McVaugh)*** *which is rich in vitamin C, guarana* ***(Paullinia cupana)*** *with its high caffeine content, açaí* ***(Euterpe oleracea Mart)*** *which is a great source of energy, the aphrodisiac marapuama (****Ptychopetalum olacoides Bentham (Olacaceae)*** *which has alkaloids among its biochemical constituents. Cubiu* ***(Solanum sessiliflorum Dunal)***

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which is rich in zinc, magnesium and selenium and the Castanha de cutia ***(Couepia edulis (Prance) Prance - Chrysobalanaceae)*** *which is abundant in mono and polysaturated oils besides vitamin E, are all fruits that originate from the Amazon Rainforest. As the quantity of research on Amazonian herbs and fruits and their effects on sporting performance is low, the objective of this review was to highlight and substantiate the possible effects of these fruits in this type of application.*

Keywords: Plants, Amazonian fruits, ergogenic, supplementation

INTRODUCTION

There is much discussion regarding the main active ingredients present in plants and their fruits and how these can help athletes to increase their levels of performance, accelerate recovery, maintain health status, increase hypertrophy and eliminate body fat.

These active ingredients can be extracted from seeds, roots, leaves, bark and flowers (Yavuz & Özkum, 2014). Other studies indicate that the bioactive components present in plants and fruits increase the state of readiness of the central nervous system, stimulate fat burning pathways and improve muscle endurance and increase the level of strength (Castell et al., 2015).

However, there are studies that have not found satisfactory results or efficacy in the application of such natural products (Chen et al., 2014). In this way, physical activity practitioners can use supplements due to poor diet quality and ignorance of how to feed themselves. This is true for both amateur and professional athletes.

In addition, these nutritional products have the promise of increasing performance and are often indicated without professional guidance, by consumer experience or simply following media guidance. Therefore, the targeted consumption of a certain active compound present in a fruit or plant needs to be done correctly in order to indicate the possible dose for the best use, increasing the nutritional and physiological state of the consumer. Thus, avoiding inadequate consumption, which often leads to liver or kidney overload, negatively influencing physical performance.

Betting on the great diversity of active components present in fruits, plants, seeds, bark and flowers is to believe that the specific needs and a fast muscle recovery after exercise, body weight reduction, hypertrophy, caloric intake and energy reserve can be met.

In this review, the focus will be on plants and fruits from the Amazon region, such as Camu camu, Guarana, Marapuama, Açaí, Cubiu and Castanha de cutia.

2. METHODOLOGY

Several research digital platforms, such as Google Scholar, popular global digital databases, including Science Direct, Springer, PubMed, Web of science, Scielo and Scopus were instruments in the search for relevant data. "Starch and dioscorea and applications" were chosen as the keywords to obtain relevant informations.

The survey was done individually for each fruit or plant, i.e. camu camu, guarana, marapuama, açaí, and castanha de cutia. After careful screening, data related to the current topic were extracted from 63 articles published from the last 10 years.

The keywords for obtaining the information were also collected from published articles, master's and doctoral theses.

3. CAMU-CAMU *(MYRCIARIA DUBIA (H.B.K.) MCVAUGH)*

The intensity involved in the frequent overloads induced by physical exercise causes lesions and inflammations in muscle fiber. One of the hypotheses, in addition to eccentric contractions would be the production of reactive oxygen species (ROS) (Pingitore et al., 2015). Therefore, there is a search for phytotherapics that attenuate the inflammatory agents and favor the treatment and recovery of the muscle injury.

In this sense, camu camu *(Myrciaria dubia (H.B.K.) McVaugh)* (figure 1), a native fruit found in flooded regions of the Amazon, with an ascorbic acid content above 1,600 mg/100 g of pulp, in addition to phenolic, carotenoid and flavanoid compounds, and great antioxidant and inflammatory capacity, appears to be an interesting candidate (Grigio et al., 2017).

Schwertz et al. (2012) observed a reduction in body weight and lipid profile in an experiemntal group of rats that received 10mL.kg^{-1} of camu-camu juice.

Similarly, Nascimento et al. (2013) supplemented experientially obese rats with 25 mL/day of camu-camu pulp and found it reduced abdominal and visceral fat.

Recently Thieme et al. (2019); Abanto-Rodriguez et al. (2016) indicated the high levels of polyphenols and vitamin C (vit C) present in the peel, and the seeds of camu camu present a high concentration of antioxidants.

Evidence proves the antioxidant effect of vit C against diseases caused by oxidative damages such as atherosclerosis and cancer, Alzheimer's and Parkinson's [10]. Thus, analyses have been carried out by researchers regarding the ascorbic acid content found in camu camu pulp (Kocot et al., 2017).

Yuyma et al. (2011) found 26 73.55 mg of ascorbic acid 100 g.[1]. This fruit has a high vitamin C content when compared to other fruits, and 20 times higher in vit C than acerola *(Malpighia punicifolia L)* and 100 times higher in vit C than the lemon *(Citrus limon*) (Vidigal et al., 2011)

Figure 1 camu camu fruit

It is important to remember that the frequency of exercise accelerates the production and synthesis of pro-inflammatory cytokines, TNFα and IL-1ß (McLeay et al., 2017). In research on the juice from camu camu, reduction of body fat deposits which may have also reduced the synthesis of cytokines has been demonstrated (Nasciento et al., 2018; Chandra et al., 2015) suggests that the polyphenols present in certain fruits may inhibit the enzyme thyroxine 5'-desiodinase and potentiate the action of triodotironin (T3), which may lead to an increase in the volume of mitochondria and thermogenesis, thus reducing the adipose tissue. The flavanoids present in fruits and vegetables can control inflammatory processes, mainly red, yellow or purple colored fruits (Yuyama, 2011; Vidigal et al., 2011).

Therefore, the red, yellow or purple camu camu and Myrtaceae family are a source of anthocyanins, quercetin, rutin and catechins, ellagic acid and may exert biological and protective activity (Villanueva-Tiburcio et al., 2010)

4. MUIRAPUAMA *PTYCHOPETALUM OLACOIDES BENTHAM (OLACACEAE*)

The marapuama or muirapuama *(Ptychopetalum olacoides Bentham),* from the Olacaceae botanical family, has alkaloids, as an active ingredient. The Amazonians use this plant, in a tea used for the treatment of sexual impotence (Dos Reis & Mendes, 2018). Research shows that alkaloid-based supplementation results in improvements in speed running exercises and increased muscle strength, as well as body composition modification in both humans and animals (Liu & Liu, 2016).

Following this reasoning, Paoli et al. (2012) studied marapuama extract for 6 weeks in 106 individuals with a body mass index $\geq$ 25. The results showed improvements in the lipid profile, loss of body fat with the preservation of lean mass.

The same study was repeated in 8 artistic gymnasts. The experiment lasted 60 days. 30 days of ketogenic diet with the addition of 40 ml daily of marapuama extract and 30 days without ketogenic diet.

The protocols of the two diets did not influence the results of the strength tests, However, in the body composition, there was a significant increase in muscle mass ($p < 0.001$). Alessadro et al. (2015) studied 32 individuals divided into 2 groups (n=16). The supplemented group, after ketogenic diet ingested marapuama extract for 20 days and the control group were not fed a ketogenic diet.

Both groups had a BMI between of 25 and 30 kgm^2. Group 1 presented significant reductions in carbon dioxide production; however, there was no significant change in VO_2 (max (ml/kg.min-1), VCO_2 ($ml.min^{-1}.kg^{-1}$) and RER. Additionally, research has observed that extract of marapuama root presents some anxiogenic responses, what can soften the anti-fatigue effect during exercise (Piato et al., 2010).

Although, there is no evidence to support that marapuama increases the secretion of testosterone, there is, however, evidence proposing its ability to improve sexual function, libido and maintenance of erection (Silveira & Silveira, 2017). This has aroused great interest among athletes in sports where great strength and hypertrophy are required.

So much so, that Borrione et al. (2012) studied 740 sportspeople (420 bodybuilders, 70 cyclists and 250 fitness athletes) over a period of 6 months. All used protein derivatives (2-2.5 g/kg/day, associated with marapuama extracts) for at least one year. The results indicated that most athletes had increased plasma levels of progesterone, estrogen, testosterone with associated suppression of luteinizing hormone and follicle-stimulating hormone. The great advantage of marapuama as a supplement is the presence of certain alkaloids (Figure 2), activators of testosterone receptors, which can increase muscle hypertrophy (Borrione et al., 2012).

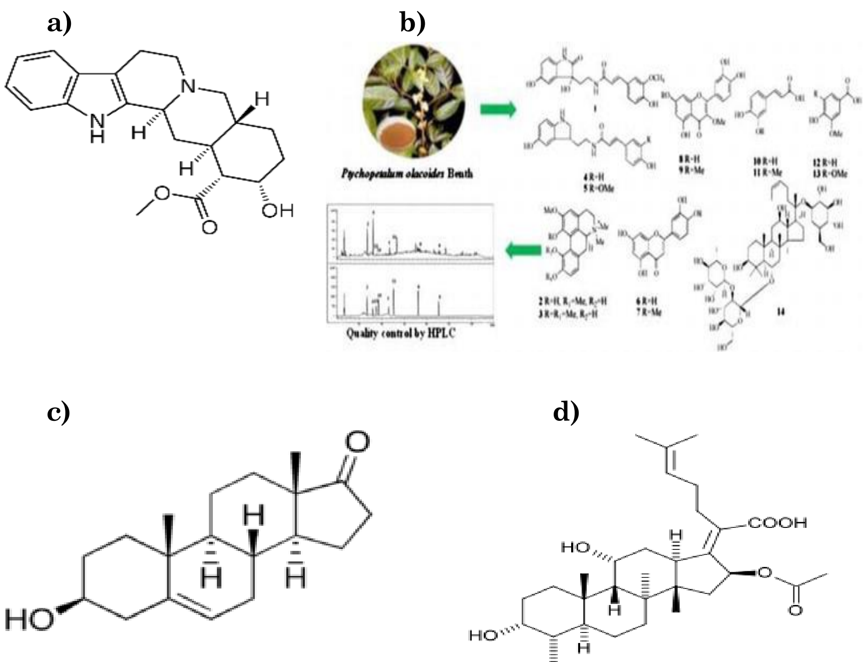

Figure 2. Certain alkaloids found in *Ptychopetalum olacoides Bentham (Olacaceae) a)*17α-hydroxy-yohimban-16α- carboxylic acid methyl ester; b)N-trans-feruloyl-3,5-dihydroxyindolin-2one magnoflorine and menisperine; c) p-Sitosterol; d) a-Esterol; Adapted from: Xiao Adapted:Tian et al. 2018; Tian X. et al. 2018; and Colombo, R., et al. 2010

5. GUARANA *(PAULLINIA CUPANA)*

Guarana (*Paullinia cupana*) is a typical plant of the Amazon region, and has methylxanthines as its main constituents, among them caffeine and tannins. Approximately 50 mg of caffeine is found in each gram of guarana (Marques et al., 2019).

The time of absorption of caffeine by the body is 15 to 45 minutes, which is the time taken to increase the levels of catecholamines, the hormone responsible for the warning actions by the body (Sellami et al., 2014). In fact, noradrenaline increases the heart rate, respiratory rate and blood pressure, which are important factors in athletic performance (Zouhal et al., 2013)

Silveira et al. (2018) studied the ergogenic properties of powdered guarana extract when taken by six adolescent jiu-jitsu wrestlers 60 minutes before specific training. The experiment was repeated for three consecutive days. The results indicated an increase in lactacidemia, which indicates direct action of catecholamines on carbohydrate metabolism. To test this hypothesis, Gant & Foskett, (2010) examined the influence of a mixture of caffeine with carbohydrates in fifteen soccer players.

One group consumed a solution of carbohydrates and electrolytes (1.8 g/kg/body weight) while the other group ingested the same plus caffeine supplementation (3.7 mg/kg of body weight). The solutions were ingested one hour before soccer practice and fifteen minutes before the ninety-minute intermittent running test. The results indicated an improvement in the average fifteen meter sprint times ($p = 0.04$), and the stress preemption and fatigue resistance were lower in this group when compared to the control group.

Caffeine acts as an antogonist of adenosine, which leads to an excitatory effect of the central nervous system, and causes a reduction in the perception of effort. Stein et al. (2019) determined the effects of caffeine treatment in thirteen men who did Cross Fit training.

The athletes performed a seven-day workout with 5 mg/kg of caffeine/kg body mass.

It was determined that during twenty minutes the participants should perform a circuit with a high number of push-ups and squats.

The results indicated an increase in the numbers of repetitions and turns, push-ups and squats in the caffeine group in comparison with the placebo group.

However, some authors warn that the prolonged ingestion of caffeine can lead to alterations in sleep, besides having a reduced ergogenic effect (Pomportes et al., 2019).

Nevertheless, gurana may be a viable strategy for athletes of various modalities where concentration, resistance to fatigue and perception of effort are primordial factors for athletic performance.

Table 1 Effect studies of caffeine present in Gurana in sports and exercises

Reference	Population	The intervention	Period and execution of the exercise	Results
Jagim et al. 2016	n =12 football players	1 portion of supplement containing caffeine, branched-chain amino acids (BCAA's).	Supplement given 20 minutes before the four sessions of sprint tests	Supplement ↑ the number of repetitions performed, improved the subjective markers of fatigue, ↑ in the average power observed during the anaerobic exercise.
Duncan & Oxford 2012	n =13 males in resistance training	5 mg/kg of gurana	Maximum supine force test (60% 1RM) until failure	↑ the number of repetitions
Hurley et al. 2018	n =12 untrained males	5 mg/kg gurana in capsule	4x 10 repetitions + 1 series until failure at 75% 1RM Biceps thread	It ↑ the number of repetitions in the biceps thread, ↑ subjective perception of effort and pain.
Doering et al. 2013	n =10 cyclists	35 mg of caffeine anidra	Time trial (the fastest possible time), which was equivalent to cycling 75% of the peak aerobic power for 60 min.	There was no ↑ in the performance of the duration test against the watch, nor do they ↑ the plasma concentration of caffeine.
Pomporteset al. 2018	**n**=17 athletes (squash and fencing)	Nutritional supplement based on creatine (1,000 mg) and guarana (1,500 mg).	The supplementation ingested in the intervals of 60 and 30 minutes before a test of 6 sprints of 6 seconds with 25 seconds of recovery performed on a cycle ergometer	The results indicate a positive effect of creatine + guarana supplement on muscle power and cognitive performance.
Astley et al.2018	**n**=15 males trained in endurance sports	2.5 mg of caffeine per kg of body weight	Subjects performed maximum repetition tests (80% 1RM) in supine exercise and unilateral knee extension (dominant leg), isometric test of maximum grip in both hands, long jump and repeated sprint test.	Acute caffeine intake ↑ performance only in specific strength and isometric tests of the wrist and right hand muscles,
Valentim-Silva et al 2014	**n=** 24 male Wistar rats	8 and 16 mg.kg^{-1} of caffeine	1 session of aerobic swimming exercise to exhaustion	8 mg.kg-1 and 16 mg.kg-1 did not modify aerobic performance, but 8mg was able to increase platelet count and decrease the

				immunosuppressive tendency of exercise.
França et al.2015	Wister rats	6 mg/Kg	1 acute session of swimming exercise for 60 minutes	After the acute swimming session the muscle glycogen and lactate did not ↔,between groups. Caffeine preserved blood glucose and hepatic glycogen levels ($P<0.05$). Caffeine raised plasma glycerol levels by 31.2% ($P<0.05$) when compared to the group exercised without supplementation.
Hodgson et al.2013	**n=** 8 thiathletes	5mg /kg/body weight of caffeine	Bike test for 30 minutes	The group that took the caffeine was able to perform the highest mileage in 30 minutes when compared to the placebo group.

↑, increased; ↔, without difference

6. AÇAÍ (*EUTERPE OLERACEA* MART.)

The acaí palm *(Euterpe oleracea Mart and Euterpe precatoria Mart)* is polarly consumed as health food. The presence of cyanidine 3-glucoside and cyanidine 3-rutinoside, catechins and picatechins potentiates the anti-inflammatory and antioxidant activity in both humans and animals Schauss, (2016). To prove this finding, Sadowska-Krępa et al. (2015) examined daily intake of 100 mL for six weeks of acai juice in seven sprint athletes and found it improved the antioxidant status.

At the end of the treatment, there was an increase in the total antioxidant capacity in the plasma. The authors concluded that the donation of hydroxyl and methylates by the flavanoids was able to neutralize the free radicals.

Carvalho-Peixoto et al. (2015) analyzed the markers of muscle and oxidative stress, cardiorespiratory responses, perceived effort and time to exhaustion during maximum treadmill running in 14 athletes after supplementation with acai pulp with 27.6 mg of anthocyanins per dose.

The 14 athletes performed a test until running exhaustion on the treadmill with inclination and at a capacity of 90% VO_2 max, with and without supplementation. The supplemented group increased the total time of exercise execution until exhaustion ($p<0.05$), in addition to a 23% increase in cardiorespiratory responses. Fantini, (2017 evaluated the effect of acai supplementation on muscle pain after a training session. A total of twenty athletes were divided in two equal groups, all had experience in strength training.

The experimental group ingested a 1000 mg capsule of acai extract 48 hours before the exercise, while the control group ingested a gelatin placebo capsule twenty minutes before dinner on day one and, on day two, twenty minutes before breakfast. The results indicate that the supplemented group reported less muscle pain in the quadriceps ($p = 0.011$) when compared to the placebo group.

Supplementation with polyphenols and flavanoids are capable of inhibiting the NADPH oxidase enzymes and the cyclooxygenase generated by the neutrophils, thus reducing oxyadactive stress and inflammation (Biswas, 2016).

De Castro et al. (2014) investigated the effects of acai pulp consumption, with or without exercise, on oxidative and inflammatory stress in mice with ApoE deficiency (ApoE -/-). The animals were divided into four groups: C (control - AIN-93M diet); CA (control AIN-93M diet plus 2% freeze-dried açaí pulp); EXA (exercise - AIN-93M diet plus 2% freeze-dried açaí pulp) and EX (exercise - AIN-93M diet). The EX and EXA groups ran 5 days/week, 60 minute/day for 12 weeks. Exercising mice reduced hepatic superoxide dismutase activity (40.85%; $p <0.05$) when compared to C group mice, regardless of the acai diet.

The EXA and EX mice had lower percentages of lipids in the liver cells (70% and 56%, respectively; p<0 - 05) when compared to C mice. The EX mice had a smaller area (58%; $p <0.05$) of aortic injuries when compared to C mice.

Retailers often mix acai with pieces of banana, granola, chocolates, syrups, condensed milk or tapioca, which increases the caloric value and reduces the antioxidant effect of the fruit. Table 2. Studies of the effect of açaí present in sports and exercises.

Table 2 Studies of the effect of acai supplementation in sports and exercises

references	Object of study	intervention	Period	Results
De Bem et al. 2018	Rats	200 mg /kg/day per gavage	30 days	the treatment of acai associated with physical training ↓ lipogenesis and increased antioxidant defense and ↓ CT.
Terrazas et al.2019	Cyclists	400 g/day of pasteurized acai pulp	15 days	Diet with açaí ↑ serum antioxidant capacity ($p = 0.006$) and ↓ lipid peroxidation ($p = 0.01$)
Cruz et al. 2019	Runners 10km	200 g/day	25 days	After the intervention, a significant ↓ of CK was observed in 24 hours
Carvalho-Peixoto et al. 2015	Runners	Acai juice supplemented with 27.6 mg anthocyanins	2 sessions of aerobic exercise on treadmill	It ↓ metabolic stress and increased cardiorespiratory capacity.
Viana et al. 2017	Bodybuilders athletes	45 g of gel with acai	3 consecutive days	Modulation in immunological parameters with ↓ activity of CK, GOT, GPT and GPx, suggesting that the gel increased muscle stress control.
Copetti et al.2020	Active individuals	250 mL of acai	1 hour before the exercise	Intake increased activity of reduced glutathione enzyme 1 h after exercise ($P = 0.044$)
Barbosa et al. 2016	Healthy women	200 ml/days	4 weeks	↓ in serum plasma levels of protein carbony and increased in total sulfidryl groups.
Minagawa et al.2015	Rats	10% freeze dried acai/Kg	6 weeks	↑ of the enzymes SC in the exercised group

↔, without difference; ↑, increased; ↓, reduced; TC, total cholesterol; CK, creatine kinase; GOT, Oxalacetic glutamic transaminase; GPT; transaminase glutamic piruvic; GPx, glutathione peroxidase; SC, citrate synthase.

7. *CASTANHA-DE-CUTIA (COUEPIA EDULIS)*

The castanha-de-cutia (*Couepia edulis* Prance*)*, belongs to the Chrysobalanaceae family, and is a species found in the central region of the Amazon. The "almonds" have a taste similar to the Brazil nut *(Bertholletia excelsa)*, and produce about 73% of oil (Costa-Singh et al., 2012)

These oils have a high content of mono- and polyunsaturated fatty acids which act in the reduction of the hepatic production of VLDL, and consumption of these oils contribute to lower rates of obesity, metabolic syndrome, and occurrences of inflammatory diseases (Patterson et al., 2012). The literature reports that high-intensity physical exercise leads the athlete to obtain muscle injuries, caused by the exacerbated production of reactive oxygen species (Mickleborough, 2013).

In this respect, the nuts (figure 2) in chemical composition presents unsaturated fatty acids (52.78%), of which 40.39% are monounsaturated (oleic acid) and 12.39% polyunsaturated (linoleic) (Costa-Singh et al., 2012). For people who do regular physical exercises, supplementation with mono- and polyunsaturated fatty acids softens the process of inflammatory damage, thus leading to a reduction in recovery time, potentiation of aerobic resistance, modifies the fatigue threshold, reduces body fat, and increases the synthesis and secretion of testosterone in athletes (Da Boit et al., 2017; Kim et al., 2012).

Among the activities developed in the athlete's training schedule, muscular recovery is one that needs special attention. This is important because inadequate recovery periods can cause muscle injuries and frequent acute stress conditions, which can interfere in the athlete's performance level. Although the literature does not report any use of the castanha-de-cutia in athletes, studies demonstrate the action of mono and polyunsaturated fatty acids in muscle cell damage caused by training. Gray et al. (2012) supplemented 8 athletes with 3 g/day of fish oil for six weeks. After supplementation, there was an increase in cytokine IL-2, and NK cell activity, even with IFN-γ productions, and IL-6 plasma concentrations.

Identical results were obtained with the supplementation of CLA isomers by decreasing the production of eicosanoids by suppressing the release of proinflammatory cytokines, particularly TNF-α in animal (McCrorie et al., 2011). More evidence was described when the association between CLA in the decrease and expressions of inflammatory agents such as COX-2, TNF-α, iNOS, and also the plasma reduction of PGE2, NO, IL-6 and IL-1β in macrophages was shown (Joseph et al., 2011).

In some studies in humans, not enough results were found to indicate that there would be a reduction in these inflammatory agents. In addition to the presence of oils, the castanha de cutia has a value of approximately 484.50 mg kg^{-1} of tocopherols (Costa-Singh et al., 2012). The alpha-tocopherols are capable of neutralizing the peroxyl radicals, interrupting the cascade of lipid peroxidation and thus increasing the body's defense against infectious agents.

To observe the markers of oxidative stress and inflammation provided by exercise, Silva et al. (2010) supplemented twenty strength training athletes with 800 IU of vitamin E for 21 days. Blood samples were collected on days 0, 2, 4 and 7. There was a significant increase in LDH, lipid peroxidation and carbonylation in both the supplemented and placebo groups on days 2, 4 and 7 after the exercise sessions. Both groups showed significant increase in TNF-alpha on day 2 and concentration of IL-10 on day 4 and 7 after the exercise session. Yfanti et al. (2017) supplemented 8 athletes with 1 g of vit C plus one 400 IU vitamin E tablet. After five weeks of supplementation, the athletes performed 2 eccentric exercise sessions for 4 weeks.

The authors did not observe any modification in the parameters of muscle damage. However, there is no consensus among researchers if vitamin E minimizes muscle damage and promotes less oxidative stress in athletes.

This indicates the possibility of using new sources of tocopherols, not to mention those present in castanha de cutia. Moreover, these almonds contain mono- and polyunsaturated fatty acids, phenolic compounds (tannins, ellagic acid and curcumin), flavonoids (luteolin, quercetin, myricetin, campeferol and resveratrol), isoflavones (genistein and daidzein), terpenes, organosulfur compounds, and L arginine, which is a potent endogenous vasodilator. tocopherols (Costa-Singh et al., 2012).

Together, all these bioactive compounds may favor a synergism, leading to sastifactorial results in the treatment of muscle damage caused by exercise.

Figure 2. ***Castanha-de-cutia (Couepia edulis)*** **Adapted from:** Costa-Singh, T., T.B, Jorge, N. (2012)

8. CONCLUSIONS

The Amazon rainforest possesses a huge variety of plants of which many of these have not yet been studied.

Furthermore, very few studies verify the use of these species as ergogenic aids or supplementation for athletes or thosewho do a lot of physical activity.

Based on the current evidence regarding the use of diets with natural and organic products, many individuals look for active principles and other products derived from plants and their fruits in order to improve or enhance their performance levels.

Therefore, it is necessary to have, information based on research or guides which demonstrate the beneficial or harmful effects of the ingestion of these components.The potential of the biodiversity in the Amazon has been shown in this review and the fruits presented can be considered ergogenic resources.

REFERENCES

1. Abanto-Rodriguez, C., Pinedo-Panduro, M., Alves-Chagas, E., Cardoso-Chagas, P., Tadashi-Sakazaki, R., Santos de Menezes, P. H., ... & Murga-Orrillo, H. (2016). Relation between the mineral nutrients and the Vitamin C content in camu-camu plants (Myrciria dubia) cultivated on high soils and flood soils of Ucayali, Peru. *Scientia Agropecuaria*, *7*(3), 297-304.

2. Alessandro, R., Gerardo, B., Alessandra, L., Lorenzo, C., Andrea, P., Keith, G., .& Antonio, P. (2015). Effects of twenty days of the ketogenic diet on metabolic and respiratory parameters in healthy subjects. *Lung*, *193*(6), 939-945.

3. Astley, C., Souza, D. B., & Polito, M. D. (2018). Acute Specific Effects of Caffeine-containing Energy Drink on Different Physical Performances in Resistance-trained Men. *International journal of exercise science*, *11*(4), 260.

4. Barbosa, P. O., Pala, D., Silva, C. T., de Souza, M. O., do Amaral, J. F., Vieira, R. A. L., ... & de Freitas, R. N. (2016). Açai (Euterpe oleracea Mart.) pulp dietary intake improves cellular antioxidant enzymes and biomarkers of serum in healthy women. *Nutrition*, *32*(6), 674-680.

5. Biswas, S. K. (2016). Does the interdependence between oxidative stress and inflammation explain the antioxidant paradox?. *Oxidative medicine and cellular longevity*, *2016*.

6. Borrione, P., Rizzo, M., Quaranta, F., Ciminelli, E., Fagnani, F., Parisi, A., & Pigozzi, F. (2012). Consumption and biochemical impact of commercially available plant-derived nutritional supplements. An observational pilot-study on recreational athletes. *Journal of the International Society of Sports Nutrition*, *9*(1), 28.

7. Carvalho, L. M. J. D., & Farinatti, P. D. T. V. (2015). Consumption of açai (Euterpe oleracea Mart.) functional beverage reduces muscle stress and improves effort tolerance in elite athletes: a randomized controlled intervention study. *Applied Physiology, Nutrition, and Metabolism*, *40*(7), 725-733.

8. Carvalho-Peixoto, J., Moura, M. R. L., Cunha, F. A., Lollo, P. C. B., Monteiro, W. D., Carvalho, L. M. J. D., & Farinatti, P. D. T. V. (2015). Consumption of açai (Euterpe oleracea Mart.) functional beverage reduces muscle stress and improves effort tolerance in elite athletes: a randomized controlled intervention study. *Applied Physiology, Nutrition, and Metabolism*, *40*(7), 725-733.

9. Castell, L. M., Stear, S. J., & Burke, L. M. (Eds.). (2015). *Nutritional supplements in sport, exercise and health: An AZ guide*. Routledge.

10. Chandra, A. K., Mondal, C., Sinha, S., Chakraborty, A., & Pearce, E. N. (2015). Synergic actions of polyphenols and cyanogens of peanut seed coat (Arachis hypogaea) on cytological, biochemical and functional changes in thyroid.

11. Chen, C. Y., Hou, C. W., Bernard, J. R., Chen, C. C., Hung, T. C., Cheng, L. L., ... & Kuo, C. H. (2014). Rhodiola crenulata-and Cordyceps sinensis-based supplement boosts aerobic exercise performance after short-term high altitude training. *High altitude medicine & biology*, *15*(3), 371-379.

12. Copetti, C. L. K., Orssatto, L. B., Diefenthaeler, F., Silveira, T. T., da Silva, E. L., de Liz, S., ... & Schulz, M. (2020). Acute effect of juçara juice (Euterpe edulis Martius) on oxidative stress biomarkers and fatigue in a high-intensity interval training session: A single-blind cross-over randomized study. *Journal of Functional Foods*, *67*, 103835.

13. Costa-Singh, T., Bitrncourt, T. B., & Jorge, N. (2012). Caracterização e compostos bioativos do óleo da castanha-de-cutia (Couepia edulis). *Revista do Instituto Adolfo Lutz (Impresso)*, *71*(1), 61-68.

14. Cruz, I. A., Mendes, R. R., Gomes, J. H., Silva, A. M. O., Souza, R. F., & Oliveira, A. S. (2019). Efeitos da suplementação crônica de açaí sobre danos musculares em corredores de rua. *Journal of Physical Education*, *30*.

15. Da Boit, M., Hunter, A. M., & Gray, S. R. (2017). Fit with good fat? The role of n-3 polyunsaturated fatty acids on exercise performance. *Metabolism*, *66*, 45-54.

16. De Bem, G. F., da Costa, C. A., Cordeiro, V. D. S. C., Santos, I. B., de Carvalho, L. C. R. M., de Andrade Soares, R., ... & Resende, A. C. (2018). Euterpe oleracea Mart.(açaí) seed extract associated with exercise training reduces hepatic steatosis in type 2 diabetic male rats. *The Journal of Nutritional Biochemistry*, *52*, 70-81.

17. de Castro, C. A., Natali, A. J., Cardoso, L. M., Ferreira-Machado, A. B., Novello, A. A., da Silva, K. A., ... & Peluzio, M. D. C. G. (2014). Aerobic exercise and not a diet supplemented with jussara açaí (Euterpe edulis Martius) alters hepatic oxidative and inflammatory biomarkers in ApoE-deficient mice. *British Journal of Nutrition*, *112*(3), 285-294.

18. Doering, T. M., Fell, J. W., Leveritt, M. D., Desbrow, B., & Shing, C. M. (2014). The effect of a caffeinated mouth-rinse on endurance cycling time-trial performance. *International journal of sport nutrition and exercise metabolism*, *24*(1), 90-97.

19. dos Reis, L. F., & Mendes, F. R. (2018). Ptychopetalum olacoides Benth. In *Medicinal and Aromatic Plants of South America* (pp. 401-411). Springer, Dordrecht.

20. Duncan, M. J., Smith, M., Cook, K., & James, R. S. (2012). The acute effect of a caffeine-containing energy drink on mood state, readiness to invest effort, and resistance exercise to failure. *The Journal of Strength & Conditioning Research*, *26*(10), 2858-2865.

21. Fantini, A. P. (2017). *The effects of acai (euterpe oleracea mart) on delayed muscle soreness (doms) in collegiate male athletes and non-athletes* (Doctoral dissertation, Kent State University). (Doctoral dissertation, Kent State University).2017

22. França, V. F., Malfatti, C. R. M., Silva, L. A. D., Wietzikoski, E. C., Osiecki, A., & Osiecki, R. (2015). Efecto de la suplementación aguda con cafeína en la respuesta bioquímica durante ejercicio de endurance en ratones. *Revista Brasileira de Medicina do Esporte*, *21*(5), 372-375.

23. Gant, N., Ali, A., & Foskett, A. (2010). The influence of caffeine and carbohydrate coingestion on simulated soccer performance. *International journal of sport nutrition and exercise metabolism*, *20*(3), 191-197.

24. Gray, P., Gabriel, B., Thies, F., & Gray, S. R. (2012). Fish oil supplementation augments post-exercise immune function in young males. *Brain, behavior, and immunity*, *26*(8), 1265-1272.

25. Grigio, M. L., Chagas, E. A., Rathinasabapathi, B., Chagas, P. C., da Silva, A. R. V., Sobral, S. T. M., & de Oliveira, R. R. (2017). Qualitative evaluation and biocompounds present in different parts of camu-camu (Myrciaria dubia) fruit. *African Journal of Food Science*, *11*(5), 124-129.

26. Hodgson, A. B., Randell, R. K., & Jeukendrup, A. E. (2013). The metabolic and performance effects of caffeine compared to coffee during endurance exercise. *PloS one*, *8*(4), e59561.

27. Jagim, A. R., Jones, M. T., Wright, G. A., Antoine, C. S., Kovacs, A., & Oliver, J. M. (2016). The acute effects of multi-ingredient pre-workout ingestion on strength performance, lower body power, and anaerobic capacity. *Journal of the International Society of Sports Nutrition*, *13*(1), 11.

28. Joseph, S. V., Jacques, H., Plourde, M., Mitchell, P. L., McLeod, R. S., & Jones, P. J. (2011). Conjugated linoleic acid supplementation for 8 weeks does not affect body composition, lipid profile, or safety biomarkers in overweight, hyperlipidemic men. *The Journal of nutrition*, *141*(7), 1286-1291.

29. Kim, J. H., Kim, J., & Park, Y. (2012). trans-10, cis-12 conjugated linoleic acid enhances endurance capacity by increasing fatty acid oxidation and reducing glycogen utilization in mice. *Lipids*, *47*(9), 855-863.

30. Kocot, J., Luchowska-Kocot, D., Kiełczykowska, M., Musik, I., & Kurzepa, J. (2017). Does vitamin C influence neurodegenerative diseases and psychiatric disorders?. *Nutrients*, *9*(7), 659.

31. Liu, Y., & Liu, C. (2016). Antifatigue and increasing exercise performance of Actinidia arguta crude alkaloids in mice. *journal of food and drug analysis*, *24*(4), 738-745.

32. Marques, L. L. M., Klein, T., & de Mello, J. C. P. (2019). Guarana. In *Nonvitamin and Nonmineral Nutritional Supplements* (pp. 283-288). Academic Press.

33. McCrorie, T. A., Keaveney, E. M., Wallace, J. M., Binns, N., & Livingstone, M. B. E. (2011). Human health effects of conjugated linoleic acid from milk and supplements. *Nutrition research reviews*, *24*(2), 206-227.

34. McLeay, Y., Stannard, S., Houltham, S., & Starck, C. (2017). Dietary thiols in exercise: oxidative stress defence, exercise performance, and adaptation. *Journal of the international society of sports nutrition*, *14*(1), 1-8.

35. Mickleborough, T. D. (2013). Omega-3 polyunsaturated fatty acids in physical performance optimization. *International journal of sport nutrition and exercise metabolism*, *23*(1), 83-96.

36. Minagawa, H., Matsunaga, Y., Takei, N., & Hatta, H. (2015). Effects of Acai berry supplementation on exercise adaptation of mice. *The FASEB Journal*, *29*(1_supplement), 733-11.
37. Nascimento, O. V. D., Boleti, A. P. D. A., Schwertz, M., & Lima, E. S. (2018). Dietary supplementation with camu-camu and continuous exercises in the treatment of obesity. *Revista de Nutrição*, *31*(1), 25-33.
38. Nascimento, O. V., Boleti, A., Yuyama, L. K., & Lima, E. S. (2013). Effects of diet supplementation with Camu-camu (Myrciaria dubia HBK McVaugh) fruit in a rat model of diet-induced obesity. *Anais da Academia Brasileira de Ciências*, *85*(1), 355-363.
39. Paoli, A., Moro, T., Marcolin, G., Neri, M., Bianco, A., Palma, A., & Grimaldi, K. (2012). High-Intensity Interval Resistance Training (HIRT) influences resting energy expenditure and respiratory ratio in non-dieting individuals. *Journal of translational medicine*, *10*(1), 237.
40. Patterson, E., Wall, R., Fitzgerald, G. F., Ross, R. P., & Stanton, C. (2012). Health implications of high dietary omega-6 polyunsaturated fatty acids. *Journal of nutrition and metabolism*, *2012*.
41, Piato, A. L., Detanico, B. C., Linck, V. M., Herrmann, A. P., Nunes, D. S., & Elisabetsky, E. (2010). Anti-stress effects of the "tonic" Ptychopetalum olacoides (Marapuama) in mice. *Phytomedicine*, *17*(3-4), 248-253.
42. Pingitore, A., Lima, G. P. P., Mastorci, F., Quinones, A., Iervasi, G., & Vassalle, C. (2015). Exercise and oxidative stress: potential effects of antioxidant dietary strategies in sports. *Nutrition*, *31*(7-8), 916-922.
43. Pomportes, L., Brisswalter, J., Hays, A., & Davranche, K. (2019). 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*, *14*(5), 576-582.
44. Pomportes, L., Davranche, K., Hays, A., & Brisswalter, J. (2015). Effet d'un complexe créatine–guarana sur la puissance musculaire et la performance cognitive chez des sportifs de haut niveau de performance. *Science & Sports*, *30*(4), 188-195.
45. Sadowska-Krępa, E., Kłapcińska, B., Podgórski, T., Szade, B., Tyl, K., & Hadzik, A. (2015). Effects of supplementation with acai (Euterpe oleracea Mart.) berry-based juice blend on the blood antioxidant defence capacity and lipid profile in junior hurdlers. A pilot study. *Biology of sport*, *32*(2), 161.
46. Schauss, A. G. (2016). Advances in the study of the health benefits and mechanisms of action of the pulp and seed of the Amazonian palm fruit, Euterpe oleracea Mart., known as "Açai". In *Fruits, Vegetables, and Herbs* (pp. 179-220). Academic Press.
47. Schwertz, M. C., Maia, J. R. P., Sousa, R. F. S. D., Aguiar, J. P. L., Yuyama, L. K. O., & Lima, E. S. (2012). Hypolipidemic effect of camu-camu juice in rats. *Revista de Nutrição*, *25*(1), 35-44.
48. Sellami, M., Abderrahman, A. B., Casazza, G. A., Kebsi, W., Lemoine-Morel, S., Bouguerra, L., & Zouhal, H. (2014). Effect of age and combined sprint and strength training on plasma catecholamine responses to a Wingate-test. *European journal of applied physiology*, *114*(5), 969-982.
49.Silva, L. A., Pinho, C. A., Silveira, P. C., Tuon, T., De Souza, C. T., Dal-Pizzol, F., & Pinho, R. A. (2010). Vitamin E supplementation decreases muscular and oxidative damage but not inflammatory response induced by eccentric contraction. *The journal of physiological sciences*, *60*(1), 51.

50. Silveira, E. J. S. D., & Silveira, D. D. C. S. D. (2017). Garrafada, oração e feitiço na Amazônia oriental: O caso de uma "curadora evangélica"/Magic Bottle, prayer and witchcraft in the eastern Amazon: The case of an "evangelical female healer". *PLURA, Revista de Estudos de Religião/PLURA, Journal for the Study of Religion*, *8*(1, jan-jun), 5-38.
51. Silveira, J. Q., Burian, J. P., & Amorim, L. L. (2018). Efeito ergogênico da suplementação aguda de pó de guaraná em lutadores de Jiu-Jitsu. *RBNE-Revista Brasileira De Nutrição Esportiva*, *12*(70), 246-254.
52. Stein, J. A., Ramirez, M., & Heinrich, K. M. (2019). The Effects of Acute Caffeine Supplementation on Performance in Trained CrossFit Athletes. *Sports*, *7*(4), 95.
53. Terrazas, S. I. B. M., Galan, B. S. M., De Carvalho, F. G., Venancio, V. P., Antunes, L. M. G., Papoti, M., ... & de Freitas, E. C. (2019). Açai pulp supplementation as a nutritional strategy to prevent oxidative damage, improve oxidative status, and modulate blood lactate of male cyclists. *European Journal of Nutrition*, 1-11.
54. Thieme, C., Westphal, A., Malarski, A., & Böhm, V. (2019). Polyphenols, Vitamin C, in Vitro Antioxidant Capacity, α-Amylase and COX-2 Inhibitory Activities of Citrus Samples from Aceh, Indonesia. *International Journal for Vitamin and Nutrition Research*.
55. Valentim-Silva, J. R., Praseres, B. A. F., Mourinha, L. H., Lemos, D. C., & Bassoli, B. K. (2014). Efeito da suplementação de cafeína em parâmetros hematológicos, imunológicos e no desempenho físico. *RBONE-Revista Brasileira de Obesidade, Nutrição e Emagrecimento*, *8*(43), 2.
56. Viana, D. S., Carvalho, L. M. J. D., Moura, M. R. L., Peixoto, J. C., & Carvalho, J. L. V. D. (2017). Biochemical assessment of oxidative stress by the use of açai (Euterpe oleracea Martius) gel in physically active individuals. *Food Science and Technology*, *37*(1), 90-96.
57. Vidigal, M. C., Minim, V. P., Carvalho, N. B., Milagres, M. P., & Gonçalves, A. C. (2011). Effect of a health claim on consumer acceptance of exotic Brazilian fruit juices: Açaí (Euterpe oleracea Mart.), Camu-camu (Myrciaria dubia), Cajá (Spondias lutea L.) and Umbu (Spondias tuberosa Arruda). *Food Research International*, *44*(7), 1988-1996.
58. Villanueva-Tiburcio, J. E., Condezo-Hoyos, L. A., & Asquieri, E. R. (2010). Antocianinas, ácido ascórbico, polifenoles totales y actividad antioxidante, en la cáscara de camu-camu (Myrciaria dubia (HBK) McVaugh). *Food Science and Technology*, *30*, 151-160.
59. Yavuz, H. U., & Özkum, D. (2014). Herbs potentially enhancing sports performance. *Current Topics in Nutraceutical Research*, *12*.
60. Yfanti, C., Tsiokanos, A., Fatouros, I. G., Theodorou, A. A., Deli, C. K., Koutedakis, Y., & Jamurtas, A. Z. (2017). Chronic eccentric exercise and antioxidant supplementation: effects on lipid profile and insulin sensitivity. *Journal of sports*
61. Yuyama, K. (2011). The camu-camu culture in Brazil. Revista Brasileira de Frutifera, 33, pp. 1–14.
62. Zhabinskii, V. N., Khripach, N. B., & Khripach, V. A. (2015). Steroid plant hormones: effects outside plant kingdom. *Steroids*, *97*, 87-97.
63. Zouhal, H., Lemoine-Morel, S., Mathieu, M. E., Casazza, G. A., & Jabbour, G. (2013). Catecholamines and obesity: effects of exercise and training. *Sports Medicine*, *43*(7), 591-600.