Revista Brasileira de Nutrição Esportiva
ISSN 1981-9927 *versão eletrônica*

Periódico do Instituto Brasileiro de Pesquisa e Ensino em Fisiologia do Exercício

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COMMERCIAL PRODUCT BASED ON CAFFEINE AND *CITRUS AURANTIUM* DID NOT PROMOTES IMPROVEMENT IN ANAEROBIC TESTS: DOUBLE-BLIND, CROSSOVER STUDY

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ABSTRACT

This study was aimed at analyzing the effect of using products with ergogenic properties on the women's performance during anaerobic physical tests. Materials and Methods: A double-blind experimental crossover randomized and controlled study with administration of commercial products or placebo substance was performed. Commercial products containing 2.31 $mg.kg^{-1}$ of caffeine and 1.88 $mg.kg^{-1}$ of *Citrus aurantium*, as well placebo products were administered to 8 women aged 18-30 (21.5 ± 2.1), who were performing strength physical training at least for six months. After sample randomization, four trials were made and the groups were reversed (supplement group and placebo group). The static strength including muscle potency and resistance were evaluated by abdominal resistance tests, flexion and extension of the elbow, vertical jump, lumbar traction and handgrip strength, with the latter two variables assessed by mechanical dynamometer. Results: There was no statistical difference in the performance of women in the anaerobic tests (p>0.05) when the four trials were compared, independent of the supplement use group (GS) or placebo group (GP). Conclusion: In the present study, the recommended dose of commercial products showed a non-significant effect during static strength, potency and muscle strength. Moreover, we suggest that the inexperience of the subjects in performing the proposed tests, particularly the vertical jump, arm flexion and extension, associated to unknown factors, caused no results in relation to performance improvement.

Key words: Ergogenic products. Anaerobic physical tests. Performance.

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RESUMO

Produto comercial baseado na cafeína e no citrus aurantium não promove a melhoria nos testes anaeróbios: estudo crossover e duplo cego

Este estudo teve como objetivo analisar o efeito do uso de produto com propriedades ergogênicas no desempenho das mulheres durante testes físicos anaeróbios. Materiais e Métodos: Foi realizado um estudo duplo-cego, randomizado, cruzado e controlado, com administração de produto comercial ou substância placebo. Produto comercial contendo 2,31 $mg.kg^{-1}$ de cafeína e 1,88 $mg.kg^{-1}$ de *Citrus aurantium*, bem como produto placebo foram administrados a 8 mulheres com idades entre 18 e 30 anos (21,5 ± 2,1), que realizavam treinamento físico de força pelo menos a seis meses. Após a randomização da amostra, quatro ensaios foram feitos e os grupos foram revertidos (grupo de suplemento e grupo placebo). A força estática, incluindo potência e resistência muscular, foi avaliada por testes de resistência abdominal, flexão e extensão do cotovelo, salto vertical, tração lombar e força de preensão manual, sendo as duas últimas variáveis avaliadas pelo dinamômetro mecânico. Resultados: Não houve diferença estatística no desempenho das mulheres nos testes anaeróbios (p> 0,05) quando os quatro ensaios foram comparados, independente do grupo que usou suplemento (GS) ou grupo placebo (GP). Conclusão: No presente estudo, a dose recomendada do produto comercial não mostrou efeito significativo durante a força estática, potência e força muscular. Além disso, sugerimos que a inexperiência dos sujeitos em realizar os testes propostos, particularmente o salto vertical, a flexão e a extensão do braço, associados a fatores desconhecidos, não gerou resultados em relação à melhora do desempenho.

Palavras-chave: Produtos ergogênicos. Testes físicos anaeróbicos. Desempenho.

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INTRODUCTION

The use of ergogenic resources has been employed for many years, in order to promote increased capacity for work, whether in day to day activities, whether in physical exercise with aesthetic and / or high efficiency purposes.

According to McArdle, Katch and Katch (2008), the use of these substances can be classified as a procedure or nutritional, physical, mechanical, psychological or pharmacological resource that is able to enhance both the ability to perform physical work as well as athletic performance.

According to De Rose and Nóbrega (2002) the use of nutritional ergogenic date from 2,700 BC in China, where the stimulating effects of machuang infusion, whose leaf contains high concentrations of ephedrine, has been known. Still, according to the reports of Philostratus, during the Ancient Olympic Games in Greece, made in the year 800 BC, athletes drank teas of various herbs and certain types of mushrooms in order to increase performance during competitions (De Rose and Nóbrega, 2002).

The increasing consumption of products with potential ergogenic properties by athletes and non-athletes, who seek to increase performance in a particular activity, is being observed in clinical practice. In this regard Ahmed (2002) reports that the use of nutritional ergogenic is associated with retardation and/or perception of fatigue. Moreover, the lack of consensus in the scientific literature on the use of such substances is evident (Spriet, 2014), particularly in anaerobic activities with low dosage of caffeine.

Several studies report that thermogenic products, which typically contains in its formulation caffeine as an ergogenic property and, lately, bitter orange (*Citrus aurantium*), possess the ability to increase the basal metabolic rate at rest, increase alertness and improve muscle contraction mechanism (Altimari and collaborators, 2000; Goldstein and collaborators, 2010; Gougeon and collaborators, 2005; Hoffman and collaborators, 2006; Knopp, Wang and Back, 1997; Tarnopolsky, 2008), the facts that possibly contribute to a better performance in both aerobic and anaerobic exercises (Beck and collaborators, 2006; Goldstein and collaborators, 2010; Guttierres and collaborators, 2009; Haller and collaborators, 2008; Jackman and collaborators, 1996; Materko and Santos, 2011; Woolf and collaborators, 2008).

Thus, this study aimed to analyze the effect of consumption of a commercial product with ergogenic properties containing caffeine and *Citrus aurantium* on performance in tests of strength, power and muscle strength in young women.

MATERIALS AND METHODS

Study design

This study is double-blind experimental type, crossover, randomized and controlled with administration of a commercial product based on caffeine and *Citrus aurantium* or placebo substance.

Inclusion and exclusion criteria

The study inclusion criteria were: age between 18 to 30 years; be practicing bodybuilding for at least six months with a weekly frequency of at least three times; absence of heart disease; free of using drugs and/or food that contain some stimulant and being female. Subjects were excluded if they were unable to perform the physical tests, have been consuming supplements aimed at weight loss in the three months prior to the start of the study, or those who consumed caffeinated beverages throughout the study period.

Sample

The sampling was done in a non-probabilistic fashion and had eight women recruited from two tertiary educational institutions in the city of Cuiabá-Mato Grosso through direct invitation and/or advertisement on posters in in the universities themselves.

Ethical aspects

The volunteers were informed about the purpose of the study and the procedures to which they would be submitted and, after this, they were invited to sign the informed consent form, being an integral part of the project submitted to the Ethics Committee in Research (protocol No. 658/CEP/HUJM/09, in 26/06/2009) of Júlio Müller University Teaching Hospital of the Faculty of Medicine of Federal University of Mato Grosso (HUJM-UFMT).

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Anthropometric evaluation

Anthropometric assessments were performed by a single experienced evaluator, having standardized location of same and the day of realization. All measurements were performed in the afternoon and in triplicate and the arithmetic mean as final result was used for each group.

Body Mass and Height

For determination of body mass (BM), the volunteers were positioned on foot in the center of the scale platform (digital scale SOEHNLE® Professional 7755, Brazil; capacity for 200 kg and accuracy of 100 g) with feet together and arms along the body (Guedes and Guedes, 2006). Height was measured with the volunteer barefooted, standing in an upright position, with the feet close together on the scale, and was measured by stadiometer available on the same scale, with a precision of 0.5 cm according to the procedure previously described by Guedes and Guedes (2006).

Body mass index (BMC)

The BMC was calculated according to the equation BMC= body mass (kg)/Height (m^2) and its classification was based on recommendations of World Health Organization (WHO, 1999).

Physical tests

Dynamometry (Force)

Lumbar

'It was analyzed by means of the dynamometer KRATOS® (Brazil) according to the protocol described by Guedes and Guedes (2006) as follows: the volunteer was positioned on the platform of the dynamometer and the knees fully extended, the trunk slightly flexed in front forming an angle of approximately 120^0 and the head together with the extension of the trunk with his gaze fixed ahead; under these conditions of posture, the participants have imposed maximum force on the legs with the purpose of stand (extensions of the knees and hips).

Handgrip test

The test of handgrip strength was conducted by means of a dynamometer (JAMAR®), according to the procedures described by Figueiredo and collaborators (2007), which recommend that the volunteers should be comfortably seated, with the shoulder abducted, the elbow flexed at 90º, the forearm in neutral position and the handle oscillating between 0º to 30º of extension.

Arm flexion

The volunteers underwent the flexion arm test with a modified position (facilitated), i.e. having the knees as support of the body. The test began with the arms of the participants fully extended, which allowed for the completion of the requested motion, i.e. until the chest touched the ground, always keeping the back straight, returning later to the extended position of arms (Pollock and Wilmore, 1993). The test lasted for 60 seconds or until the muscular exhaustion.

Abdominal strength test (abdominal flexions)

Volunteers remained in the supine position, with knees bent and feet flat on the floor, keeping a distance of 30 to 46 cm of the buttocks. Hands were held next to the head. The volunteers had the foot movements prevented by the main researcher, so that they remained fixed to the ground. The volunteer were asked to carry out the largest number of repetitions in sixty seconds, valid only when the elbows touched the knees. At the end of each repetition, the participants returned to the starting position (Pollock and Wilmore, 1993).

Vertical jump

We used the protocol recommended by Johnson and Nelson (1979), where volunteers are asked to jump as high as possible and flexing the hip and knees, and also use the arms balanced for the execution of the test.

The volunteers were positioned standing next to the wall with graduated markings every centimetre. Initially, there was a request to voluntarily extend the arm, making a mark with the tips of fingers soiled with chalk in the highest position that could be reached and keeping the feet flat on the ground. The

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result was noted by subtracting the highest mark of the lowest in the jump, the latter obtained without the jump.

Commercial product and placebo material

The thermogenic product TERMO Plus (Vitafor®, Brazil) was administered to the participants 1 h prior to the execution of physical tests. A sachet of the supplement (4 g) was dissolved in 300 ml of water. The ingredients of the TERMO Plus are: green tea extract, bitter orange, guarana, niacin, chromium chelate (GTF), inulin, aroma identical to natural lemon, curcuma dye, the acidulant citric acid, the antioxidant ascorbic acid, sweetener sucralose and xylitol.

Substrates with thermogenic and ergogenic properties contained in the TERMO Plus and their amounts are: 136.74 mg of caffeine from green tea extract (*Camellia sinensis*) and guarana (*Paullinia cupana*) and 111.11 mg of bitter orange (*Citrus aurantium*).

As a placebo substance, a non-caloric juice powder with taste similar to thermogenic product, diluted in 300 ml of water was administered according to the procedures described for the product.

Experimental procedures

In this study, cross-over design, with two experimental units randomly assigned to placebo group (PG) and supplement group (SG); after a week interval "wash-out" treatments were reversed. The same procedure was repeated four times (Figure 1).

In Table 1 the administered values of caffeine available in the Green tea (*Camellia sinensis*) and guaraná (*Paullinia cupana*), as well as the amount of the bitter orange (*Citrus aurantium*).

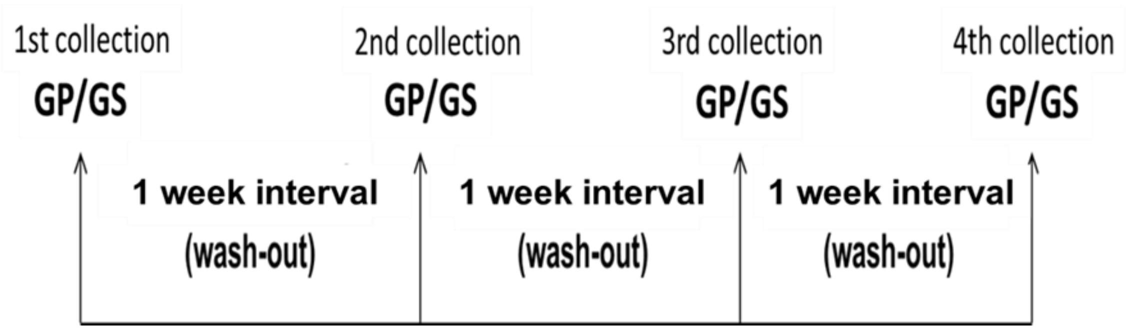

Figure 1 - Experimental design. PG (placebo group); SG (supplement Group).

Table 1 - Average quantity of caffeine and bitter Orange administered.

Thermogenic products	Dosage (mg.kg^{-1})
Caffeine (*camellia sinensis* and *paullinia cupana*)	2.31 ± 0.33
Bitter orange (*citrus aurantium*)	1.88 ± 0.27
Placebo product	Dosage (mg/kg)
Absent	Absent

Statistical analysis

Data were analyzed using BioEstat® 5.0 (Brazil) statistical package and expressed as mean ± standard deviation. The normality of the sample was calculated using the Kolmogorov-Smirnov test. Subsequently, the Student's t-test was conducted to compare the experimental condition (supplement) with the control condition (placebo). The variance between the periods (crossover) was verified with ANOVA, followed by Tukey's post hoc test where appropriate. The level of significance was preset at 5%.

RESULTS

In Table 2, the general characteristics of the results of the sample are displayed.

As for the four samples (crossover) carried out in different moments, as already explained in Figure 1, no statistically significant variances were identified for any of the tests performed (Table 3).

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Table 2 - General characteristics of the samples.

Variables	Mean ± Standard deviation
Age (years)	21.5 ± 2.1
Body mass (kg)	59.7 ± 8.8
Height (m)	1.61 ± 0.03
Body mass index (kg/m²)	22.9 ± 3.1

Table 3 - Comparison of performance during the anaerobic physical tests.

Variables/Collections	1st collection PG (n=8)	2nd collection SG (n=8)	3rd collection PG (n=8)	4th collection SG (n=8)	p-value
Arm flexion (rep)	20.5 ± 4.6	18.6 ± 5.6	23.4 ± 3.0	22.4 ± 5.4	0.22
Abdominal (rep)	24.4 ± 5.9	25.9 ± 5.1	24.5 ± 5.1	23.6 ± 5.2	0.86
Vertical jump (cm)	28.9 ± 6.5	31.6 ± 5.3	31.9 ± 4.8	30.7 ± 4.7	0.69
Lumbar (kgf)	60.2 ± 8.0	60.5 ± 13.2	64.9 ± 11.2	66.7 ± 7.1	0.51
Hand grip-R (kgf)	26.0 ± 4.7	24.7 ± 4.2	27.1 ± 2.1	27.7 ± 2.8	0.38
Hand grip-L (kgf)	25.3 ± 4.0	24.3 ± 4.1	25.9 ± 3.2	26.4 ± 4.0	0.73

Legends: Repetitions (rep); kilogram force (kgf); Placebo group (PG); Supplement group (SG). One way ANOVA. Significance level $p<0.05$.

DISCUSSION

After administration of the supplement, which contained on average 2.31 ± 0.33 $mg.kg^{-1}$ caffeine and 1.88 ± 0.27 $mg.kg^{-1}$ *Citrus aurantium*, there was no improvement in the performance of the women based on the tests composed of anaerobic exercise (muscular strength, muscular endurance and static strength) compared to the placebo condition. In addition, the lack of studies on the contribution of *Citrus aurantium* alone on physical performance, leads us to discuss our results in light of few other studies that also administered caffeine in associating with *Citrus aurantium*.

Among the few studies that use commercial products, which had in its composition caffeine and *Citrus aurantium*, we highlight the studies conducted by Sale and collaborators (2006) and Haller and collaborators (2008). Sale and collaborators (2006) analyzed the effect of a commercial product containing *Citrus aurantium*, green tea and caffeine on metabolic parameters (basal metabolic rate and use of energy substrates for ATP resynthesis) at rest and during 60 minutes of walking on a treadmill at 60% of heart rate reserve in overweight men. The results did not denote significant increase in the production of ATP at rest nor during exercise.

In the study by Haller and collaborators (2008), who also used commercial product based on *Citrus aurantium* and caffeine in a sample of seven men and three women with a mean age of 24.3 years and exercised on a ergometer cycle in intensity between 75-80% of maximum heart rate subsequent to 1 h after the intake of the commercial product, noticed an increase in diastolic blood pressure and plasma glucose.

In the same study, the authors found lower sensation of effort after consumption of the commercial product, which according to the authors may be due to the stimulating effect of caffeine and not necessarily due to that of *Citrus aurantium*.

In research conducted by Beck, Housh, Schmidt and collaborators (2006), which used a similar caffeine dosage (2.4 $mg.kg^{-1}$) like the present study (Table 1), increased load was observed only for the one-repetition maximum test (1RM) bench press; on the other hand, the 1RM test for the leg extension and the total cargo volume for muscle endurance test with 80% of 1RM for the leg extension exercises and bench press were not affected by the administration of the product.

The dosage used in this study (4 mg of thermogenic product), which is recommended by the manufacturer, was not sufficient in order to act as ergogenic in anaerobic tests, which require static strength, power and / or muscular endurance.

This finding differs from the above in studies conducted by Bond and collaborators (1986) and Williams and collaborators (1988), who used doses of 5 $mg.kg^{-1}$ and 7 $mg.kg^{-1}$ body weight of caffeine, respectively, and both demonstrated an increase in maximum

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voluntary contraction for knee flexion and extension, as well as for testing maximum power on a cycle ergometer for 15 seconds.

However, we must emphasize that the studies cited used different tests to our study as well as different dosage of caffeine, which is approximately two to three times higher than that offered by dosage of the product of study.

In the study by Jackman, Wendling, Friars and collaborators (1996) conducted on the effect of the intake of 6 mg.kg-1 of caffeine on anaerobic endurance cycle ergometer in two experimental models: an intermittent and another until voluntary exhaustion.

These authors found an increase in muscle strength after administration of caffeine during the 4-6 min of exercise performed at high intensity cycle ergometer until exhaustion. However, these results do not corroborate the findings of our study, possibly by the characteristic of the conducted experimental models, since the tests performed by us were static strength, power and muscular endurance.

Astorino and collaborators (2008) evaluated 22 men who are practitioners of resistance training after ingestion of 6 $mg.kg^{-1}$ caffeine and found that acute ingestion (1 hour before exercise) of caffeine did not alter muscle strength during the 1RM test in the straight supine and leg press.

Moreover, Woolf, Bidwell and Carlson (2008) analyzing the consumption of 5 $mg.kg^{-1}$ of caffeine administered to a group of eight male volunteers, found increase in the total load in the supine straight exercise and higher peak power in the Wingate anaerobic test performed on a cycle ergometer.

Duncan (2009), on evaluating the effect of caffeine consumption at the same dosage used by Woolf, Bidwell and Carlson (2008) on the peak of maximum power at the Wingate test, also did not observe ergogenic effect for the eight men and six women, all college athletes of rugby, football or basketball.

Although we did not verified ergogenic effect with an average dose of 2.31 $mg.kg^{-1}$ of caffeine in physically active women, in the study by Goldstein, Jacobs, Whitehurst and collaborators (2010), which used 6 $mg.kg^{-1}$ of caffeine, increase in performance was observed during the supine straight test, with repetitions until fatigue, in the intensity of 60% of 1RM in 15 female bodybuilders in similar period to the volunteers in our study, that is, at least six months of training. The findings of Goldstein, Jacobs, Whitehurst and collaborators (2010) indicated that a higher dose of caffeine increased performance in muscle strength exercise.

Materko and Santos (2011) found a positive ergogenic effect after administration of 250 mg caffeine to 13 men experienced with regard to strength training, 10RM during the test. In this study, the average dose administered was 3.25 mg.kg-1 caffeine, which is slightly higher than used in this study.

Apparently, not only a higher dose would be required, but also knowledge about the absorption, availability in the bloodstream and addiction to caffeine would be important when you want to improve performance in anaerobic exercise (Altimari and collaborators, 2000) due to the stimulation caused by caffeine on the central nervous system, thereby increasing the state of readiness for exercise and favours greater availability of calcium by the sarcoplasmic reticulum, and thus promote greater muscle contractile activation (Altimari and collaborators, 2000; Caputo and collaborators, 2012).

Gutierres and collaborators (2009) noted an increase in capacity of the lower limbs in soccer players, which showed better results in the vertical jump test after 60 min of ingestion of 3.75 $mg.kg^{-1}$ of caffeine. The same was not observed in our study, which found an increase in the height of the vertical jump in relation to the first collection, although it was not statistically significant (Table 3). In the lower dose of caffeine used in our study, experience in vertical jump is higher in soccer players than for volunteers in this study, who only perform fitness exercises in the gymnasium.

Furthermore, and contrary to our findings, Del Coso and collaborators (2012) observed that 19 football players, after ingestion of 3 $mg.kg^{-1}$, showed improvement in vertical jump tests and 30 metres sprint, denoting that in addition to a higher dosage of caffeine, test performance in vertical jump favours those with more specific training, in this case, the soccer players, thus discarding the appearance of sex-dependence, since the work conducted by Haller and collaborators (2008) and Duncan (2009), who evaluated both men and women, such effects were not evident between the sexes.

In discordance with the studies of Gutierres and collaborators (2009) and Del Coso and collaborators (2012), the study by Pereira and collaborators (2010) did not observe improvement in the performance of

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high intensity and short duration motor in 13 judo female athletes after administration of 6 mg.kg-1 of caffeine, there was neither change in the final heart rate (after) and recovery (1 minute) after the performance tests specific for judo. These results support the findings of our study, which also found no performance improvement in strength training, capacity or endurance.

Factors such as addiction to caffeine intake, dosage, acute or chronic use, experience in physical exercise test protocol used, and the sample size should be further investigated, so that the confounding factors could be minimized and will therefore promotes understanding of the alleged ergogenic effects on anaerobic activities, since the ergogenic effects are well established in aerobic exercises, as postulated by Altimari and collaborators (2000) and Caputo and collaborators (2012).

The scarcity of studies evaluating the synergy between caffeine and *Citrus aurantium* on physical performance made difficult the comparison of results obtained in this study with others, so we chose to compare our results with others whose intervention was based on exclusive use of caffeine and with male individuals, although a study in which men and women were compared did not demonstrate any divergence between the sexes regarding the use of caffeine. We also note that the characteristics of the present study (crossover), there was sample loss of 57.9% (n = 11) compared to the first two collections.

Only eight (42.1%) of the 19 volunteers completed the four collections that characterized the crossover method. The withdrawals were for various reasons, among which was that one volunteer felt ill after using the product and reported tachycardia. The other did not complete inconvenience for the completion time of the data collection.

CONCLUSIONS

The results presented in this study denote that besides the small amount of caffeine per kilogram of body weight offered by recommended dose of thermogenic product, factors such as inexperience in some of the physical tests, particularly vertical jump and arm bending, may have had strong influence on the non-performance of thermogenic product as an ergogenic aid for better performance in physical tests employed.

We suggest that future studies should be conducted with greater product supply studied and/or physical testing protocols changed so that they can be compared to other studies with different experimental design, we can therefore that clarify the effects on performance testing in anaerobic conditions presented herein in a better way.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

ES designed study protocol, assisted in data collection, completed the data analyses, and led the writing of the manuscript. ADRF assisted in protocol design, led the data collection, directed data entry, and assisted in writing the manuscript. FAV assisted in writing the manuscript. CAF assisted in writing the manuscript. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

The authors would like to thank the subjects for their efforts.

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Revista Brasileira de Nutrição Esportiva
ISSN 1981-9927 ***versão eletrônica***

Periódico do Instituto Brasileiro de Pesquisa e Ensino em Fisiologia do Exercício

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Recebido para publicação em 06/01/2019
Aceito em 14/04/2019