AfAc Publisher
With Knowledge We Publish

ORIGINAL ARTICLE

Public Health Nutrition Policy & Economics   Human and Clinical Nutrition

Effect of acute supplementation of hibiscus-ginger drink on university athletes' aerobic power and blood lactate

Yayra Kluboito [1], Joseph Kwame Mintah [2], Samuel Essien-Baidoo [3], Neeyi Akesseh Arthur [4]

[1] University of Education, Winneba Department of Health, Physical Education, Recreation and Sports, Ghana. E-mail: ykluboito@uew.edu.gh
[2] University of Cape Coast Department of Health, Physical Education and Recreation, Ghana. E-mail: Jmintah@ucc.edu.gh
[3] University of Cape Coast Department of Medical Laboratory Science, Ghana. E-mail: session-baidoo@ucc.edu.gh
[4] University of Education, Winneba Department of Health, Physical Education, Recreation and Sports, Ghana. E-mail: S.glackz@gmail.com

ABSTRACT

Background: Sport training places significant demand on athletes, motivating them to seek strategies to enhance performance and maintain competitiveness. The use of ergogenic aids has become prevalent in sport, although not without potential risks. Hibiscus-ginger juice, rich in vitamins and minerals, has been suggested to improve metabolism, aid in post-exercise recovery, reduce inflammation, and enhance athletic performance. **Aims:** This study aimed to investigate the effect of hibiscus ginger juice supplementation on aerobic power and blood lactate levels in athletes. **Methods:** A pretest-posttest experimental design was employed, involving 28 university athletes aged 20 – 37 years. Participants were randomly assigned to a treatment group receiving 500 mL of hibiscus-ginger juice daily after training for 24 days, or a control group. Physiological measures of blood lactate levels and aerobic power were assessed on three separate occasions during the study period. **Results:** Mixed model ANOVA showed no significant differences in blood lactate levels ($p = .502$) or aerobic power ($p = .117$). Daily consumption of 500 mL of hibiscus-ginger juice for 24 days did not significantly alter aerobic power or blood lactate levels of athletes. **Conclusion:** The findings suggest that consuming hibiscus-ginger juice may not provide a performance advantage for athletes compared to those who do not.

Keywords: Acute supplementation, aerobic power, blood lactate level, hibiscus-ginger juice, university athletes.

ARTICLE INFORMATION

Corresponding authors: Neeyi Akesseh Arthur.
E-mail : S.glackz@gmail.com
Tel. +233 249172775

Received: March 15, 2024
Revised: July 29, 2024
Accepted: October 06, 2024
Published: October 12, 2024

Article edited by:
Pr. Khaled Méghit Boumédiène

Article reviewed by:
Dr. Leonardo Lubis
Dr. Abdelhafid Nani

Cite this article as: Kluboito, Y., Mintah, J.K., Essien-Baidoo, S., & Arthur, N. A. (2024). Effect of acute supplementation of hibiscus-ginger drink on university athletes' aerobic power and blood lactate. *The North African Journal of Food and Nutrition Research, 8* (18): 89 – 95. https://doi.org/10.51745/najfnr.8.18.89-95

1 Introduction

Optimum performance in athletic abilities requires an athlete to have access to a healthy diet for recuperation (Burke et al., 2013). Performers go through a series of activities that stress the metabolic pathways causing greater demand for fluid replacement and energy expenditure. Athletes must eat enough food, water, and supplements to keep up with their increased energy requirements and fluid consumption. Knowing the appropriate foods, drinks, and supplements to consume, as well as their quantities and timing, is complicated when trying to improve athletic performance (Thomas et al., 2016).

Regular movement increases body turnover, micronutrient loss, energy expenses, and fluid requirements (Tarazona-Diaz, et al., 2013). Because of this understanding, using ergogenic aids, protein supplements, vitamin supplements, and mineral supplements while training has become a widespread practice for athletes. Energy drinks have become one of the most common ergogenic aids consumed by athletes. The contents, availability, and potency of energy drinks have made them very attractive and the likely choice of ergogenic aid amongst most athletes (Buxton & Hagan, 2012). The potency of energy drinks for both aerobic and anaerobic performances has been investigated (Carvajal-Sancho & Moncada-Jimenez, 2005; Lufkin, 2011) however, with varying results.

Micronutrients function as catalysts for energy production and are found in most energy drinks and supplements used by athletes. However, a new era of supplementation has begun, as per Babu et al. (2008), these micronutrients are better absorbed in their natural states and through food than in their manufactured forms. Because of this, the use of naturally occurring or created items has expanded recently for health-related reasons (Tarazona-Diaz, et al., 2013). Research suggests that athletes who consume beetroot juice and coconut water may see changes in their performance indices (Clifford et al., 2016; Kalman et al., 2012). These organic compounds include antioxidants, potassium, calcium, and carbohydrates—all necessary for producing energy within cells (Bentley et al., 2015). The micronutrients in these natural products function as cofactors and coenzymes in the process of renewing energy.

Research aimed at determining the function of micronutrients in athletic performance has demonstrated that the stressors associated with sports participation lead to micronutrient deficits, which may even arise when supplementation is used (Madden et al., 2017). Sweating and oxidative responses during workout are the cause of this deficit. Adequate consumption and supplementation of micronutrients are therefore crucial (Elkington et al., 2015). This is made possible by some micronutrients' antioxidant properties, which set off a counter-reaction to lessen the impact of oxidative processes.

Hibiscus Sabdariffa calyces are rich in antioxidants, vitamins, and minerals. Additionally, the phenolic components and flavonoids in the hibiscus calyces extract give it antioxidative qualities (Afiune et al., 2017). Earlier studies have found that *Hibiscus Sabdariffa* extract consumed for a month reduces cholesterol levels dramatically (Lin et al., 2007) and also enhances metabolism and lower blood pressure (Joven et al., 2014).

The subtropical plant ginger is also high in vitamins and minerals, including potassium, calcium, and magnesium (Pirculescu et al., 2015), which are necessary for muscle contraction and help postpone the beginning of muscle weariness (Haakonssen et al., 2015). Because of its high nutritional content, it lowers oxidative stress in athletes (Haakonssen et al., 2015).

During or after practice or competitions, university athletes drink at least one can of energy drink every week to regain lost energy, gain additional energy and fluids to the body, improve performance, reduce weariness, and promote recuperation (Buxton & Hagan, 2012). Many student athletes may be aware of the negative consequences of energy drinks, such as headaches, elevated heart rates, and stomachaches, yet they nevertheless tend to drink them, ignoring their adverse effects (Seifert et al., 2013). Because of their well-documented health and therapeutic benefits, natural supplements like pomegranate, watermelon, ginger, and hibiscus juice have gained much popularity in the sports world (Lin et al., 2007; Seifert et al., 2013; Tarazona-Diaz et al., 2013).

Popularly known as *Sobolo* or *Bissap* in Ghana and other West African nations, hibiscus-ginger juice is a popular herbal beverage made primarily of hibiscus calyces and ginger roots. The two primary components of *Sobolo*, hibiscus calyces and ginger, have significant vitamin and mineral concentrations. Because of this, it is crucial for enhancing metabolism, recovering from exercise, and improving performance in athletes with little to no side effects.

Sobolo has been found to have medical benefits (Joven et al., 2014), but there is no evidence that it can help athletes recover or perform better. It is critical to support claims about naturally healthy drinks with research if they are said to have therapeutic benefits or the ability to improve sports performance. Therefore, this study set out to investigate how supplemental hibiscus-ginger juice affected a few key physiological characteristics in collegiate athletes. The study investigated the hypothesis that hibiscus-ginger juice consumption significantly affects athletes' aerobic power and blood lactate levels.

2 Methods

2.1 Participants

The study made use of 28 volunteer athletes from the University of Cape Coast student-athletes. The athletes participated in various sporting discipline including Hockey, basketball, handball, and football players. These sports were selected because athletes had similar characteristics in terms of movement patterns, and duration of play.

2.2 Study Design

The study employed a pretest-posttest experimental design to investigate the influence of hibiscus ginger juice supplementation on aerobic power and blood lactate level. Participants received sufficient information regarding their rights and the goal of the study. Participants were free to leave the study at any time if they desired. However, the researcher retained the power to exclude any volunteer who was discovered to be not adhering to the study's guidelines. The

Yo-Yo intermittent recovery test was used to gauge aerobic power, and blood samples were taken to evaluate blood lactate levels at the conclusion of the pretest and final post-test.

2.3 Preparation of hibiscus ginger juice

This recipe was used in the preparation of three liters of the hibiscus-ginger juice. The ingredients used include

1. 100 grams of dried hibiscus calyces
2. 100 grams of ginger rhizome
3. 200 grams of pineapple peels
4. 10 grams of peppercorn
5. 10 grams of cloves
6. 2.5 liters of drinking water
7. 0.5 liter of pineapple juice

Preparation Procedure

Pour the dried Hibiscus calyxus into a pot big enough to contain 1.5 liters of water then add crushed ginger rhizomes, washed pineapple peels, peppercorn and cloves. Add 2 liters of drinking water to the combination and set on fire to boil. Take the mixture off the fire five minutes after boiling and allow it to cool down to room temperature. Add sugar to the mixture after cooling and stir until the sugar dissolves. Add pineapple juice to the mixture, bottle and refrigerate.

2.4 Data Collection Procedure

For ethical consideration, the research protocol (UCCIRB/CES/2019/38) was submitted to the University of Cape Coast's Institutional Review Board for approval of the research before commencing data collection. Three stages of data collection were involved. In phase one, individuals were recruited, acquainted with one another, and placed into random groups for the study. The participants underwent the Yo-Yo intermittent recovery test for familiarization purposes, and the results obtained from this process were then used to randomly allocate them into treatment and control groups. Pretest data gathering constituted phase two. On this particular day, the test was administered in large groups to ensure precise measurements, after a 10-minute warm-up. After the pretest, each participant had venous blood collected, was given a refresher, and was then sent on their way. On the other hand, participants in the treatment group received a briefing regarding how they would be provided with hibiscus ginger juice following every training session for the duration of 24 days while the alternate group received nothing. Two post-test data gathering periods comprised phase three. After the first two weeks (14 days), the first post-test was administered, and the second one on the 24th day. However, blood was only taken on the twenty-fourth day.

2.5 Statistical analysis

The data from participants was processed using the Statistical Package of Social Science (SPSS) Version 20. Data was first screened for entry errors using frequency and percentages. A mixed-design ANOVA was used in testing the hypothesis for the study.

3 Results

After meeting the presumptions, a mixed model ANOVA was used to analyze the blood lactate analysis data. Participants' blood lactate levels were divided into blood lactate 1 (BL1) and blood lactate 2 (BL2). Blood lactate levels after pretest ranged from 8.74mmol/L to 11.61mmol/L (M = 10.18, SD = 3.27) for the treatment group and from 6.32mmol/L to 8.99mmol/L (M = 7.66, SD = 1.61) for the control group., after the post-test, blood lactate levels ranged from 6.51mmol/L to 11.72mmol/L (M = 9.11, SD = 4.04) for the treatment group and 7.56mmol/L to 12.41mmol/L (M = 9.98, SD = 4.99) for the control group.

A 2(Time) x 2(Group) mixed model ANOVA revealed that the main effect for GRP was not significant F (1, 26) = .463, p = .502, η_p^2 = .018. Thus, there was no significant overall difference in the blood lactate of treatment (M = 9.65) compared to control (M = 8.82). Main effects for time (Blood lactate) were also not statistically significant F (1, 26) = .811, p = .376, η_p^2 = .030. However, blood lactate increased over time from BL1 (M = 8.92) to BL2 (M = 9.55). Time x Group was significant, F (1, 26) = 5.832, p = .023, η_p^2 = 1.83, implying

Table 1. ANOVA result for the effect of consumption of hibiscus-ginger on blood lactate levels.

	df	F-value (*F*)	Significance (*p*)	Partial eta squared (η_p^2)
Blood lactate	1	.811	.376	.030
Blood lactate * GRP	1	5.832	.023*	.183
GRP	1	.463	.502	.018
Error	26			

N = 28(treatment = 13, control = 15) *significant at p<0.05 level

that for each of the groups, blood lactate levels changed significantly with time. Examination of the cell means indicated that for the treatment group, there was a decrease from BL1 (M = 10.18) to BL2 (M = 9.11). In the control group however, with time, blood lactate increased from BL1 (M = 7.66) to BL2 (M = 9.98).

Aerobic power was measured in the pretest and two post-tests with a Yo-Yo test on three different occasions. These measures were recorded and classified as aerobic power 1 (VO_2 max1), aerobic power 2 (VO_2 max2), and aerobic power 3 (VO_2max3). Pretest measures of VO_2max 1 ranged from 38.75$_{ml/kg/min}$ to 53$_{ml/kg/min}$ (M = 44.61, SD = 3.55). First posttest measures of VO_2max 2, ranged from 38.58$_{ml/kg/min}$ to 54.54$_{ml/kg/min}$ (M = 45.19, SD = 3.87) and second posttest measures of VO_2max 3 ranged from 39.10$_{ml/kg/min}$ to 54.88$_{ml/kg/min}$ (M = 44.74, SD = 4.06).

A 3(Time) x 2(Group) mixed model ANOVA revealed that the main effect for GRP was not significant F (1, 26) = 2.631, p = .117, η_p^2 = .002. Thus, there was no overall significant difference in the VO_2max of treatment (M = 46.00) compared to control (M = 43.84). The main effects for time (VO_2max) were also not statistically significant F (2, 52) = 1.117, p = .335, η_p^2 = .041. However, VO_2max increased over time from VO_2max1 (M = 44.67) to VO_2max2 (M = 45.27) then dropped to VO_2max3 (M = 44.83). Time x Group was also not significant, F (2, 52) = .691, p = .507, η_p^2 = .026.

Table 2. ANOVA results for the effect of consumption of hibiscus-ginger on aerobic power.

	df	F-value (F)	Significance (p)	Partial eta squared (η_p^2)
VO_2 max	2	1.117	.335	.041
VO_2 max * GRP	2	.691	.506	.026
GRP	1	2.631	.117	.002

N = 28 (treatment = 13, control = 15). *Significant at p<0.05 level
Error df (within-subject = 52, between-subject = 26).

Examination of the cell means indicated that for the treatment group, there was an increase from VO_2max1 (M = 45.47) to VO_2max2 (M = 46.42) which later dropped in VO_2max3 (M = 46.12). In the same way, the control group, with time, had VO_2max increase from VO_2max1 (M = 43.86) to VO_2max2 (M = 44.13), but dropped in VO_2max3 (M = 43.55).

4 Discussion

In this study, blood lactate levels and aerobic power were examined in relation to hibiscus-ginger juice consumption. As factors that could be impacted by consuming and using the nutrients in the hibiscus-ginger juice, these variables were looked at in the study. Though research on the notion itself is scarce due to its novelty, studies on the individual key ingredients ginger and hibiscus and their effects on sports performance have been conducted (Hadi et al., 2017; Mardanpour-Shahrekordi et al., 2017; Matsumura et al., 2015; Perez et al., 2019). Moreover, other studies have been conducted on the effects of various extracts with comparable nutrients and qualities to hibiscus and ginger on physiological parameters and athletic performance (Clifford et al., 2016; Kalman et al., 2012).

The hypothesis test results, which examined whether hibiscus-ginger juice consumption would significantly affect athletes' blood lactate levels, revealed no significant effect. This finding is consistent with another study indicating that antioxidant supplements did not significantly alter blood lactate levels (Klarod et al., 2015). Reactive oxygen metabolites and maximal exercise performance did not alter in the heat or cold, with or without short-term antioxidant treatment, according to Klorad et al. (2015). Despite their tests being conducted in various temperatures, they also used a test that was conducted until fatigue and collected blood samples following the test to compare it to the current study. The current study's antioxidant qualities are also present in the employed treatment.

In contrast to these results, research using natural antioxidant supplements has revealed notable alterations in blood lactate levels (Hadi et al., 2017: Jordan et al., 2010). According to Jordan et al. (2010) beta-alanine administration delayed the onset of blood lactate buildup and improved performance. Unlike the current investigation, Jordan et al. (2010) and Hadi et al. (2017) did not directly assess the participants' blood lactate levels. Additionally, Matsumura et al. (2015) observed that taking a 4 g dosage of ginger may help reduce oxidative stress-induced muscle damage and speed up the recovery of muscle strength after strenuous exercise. Since muscular strength is crucial for athletic success, this may also aid in enhancing general athletic performance.

In the present investigation, athletes in the treatment group consumed a single juice containing both hibiscus and ginger extracts. This, in layman's terms, ought to have improved the athletes' oxidative capacity, as indicated by blood lactate measurements. Contrary to expectations, however, this therapy did not appreciably affect blood lactate. This could be due to the athletes' work intensity throughout the testing period, which may not have caused considerable oxidative stress and, therefore the negligible changes in blood lactate levels (Klarod et al., 2015). Reviewing the study's data, it appeared that the treatment group's blood lactate levels had decreased compared to the control group, even though this did not statistically significantly reflect a between subject difference for the hypothesis test examining the impact of hibiscus-ginger juice on blood lactate levels. Further investigation into this, using alternative methods for measuring blood lactate, is therefore necessary in order to potentially yield improved findings.

After 24 days of supplementing with hibiscus-ginger juice, aerobic power (measured as VO2max using the YoYo test) did not significantly differ between treatment and control groups.

This finding is consistent with other similar studies (Perez et al., 2019; Wilson, 2015), which also found no improvements in VO2max following supplementation with similar treatments. Wilson, (2015) reported little to no effect of acute ginger supplement on oxygen consumption in a review article. Once more, non-significant findings regarding the impact of beetroot juice on VO2max in fit, recreationally trained individuals were reported by Perez et al. (2019). Conversely, studies have demonstrated increases in VO2max in middle-aged, obese women with type 2 diabetes who supplemented with ginger throughout a ten-week training period (Mardanpour-Shahrekordi et al., 2017). Regarding the antioxidant content of the applied treatments, these investigations bear similarities to the present investigation. The length of time the treatment was given, as well as the training periods, varies slightly. As opposed to the current study's subjects, who are involved in daily exercise, the participants in the study conducted by Reinks et al. (2015) were not in training when the VO2max tests previously stated were conducted. Because the athletes in this study trained twice a day, there is a strong chance that weariness will set in and alter the Yo-Yo's results. This could account for the study's conflicting findings. Once more, notable outcomes reported by Nyakayiru et al. (2017) occurred six days after supplementation, a duration that precludes weariness from impacting the outcomes, in contrast to the current investigation, where athletes were constantly training twice daily for 24 days.

Unlike Mardanpour-Shahrekordi et al., (2017), where the participants were obese people who lost weight over the course of the study's ten weeks, potentially leading to improvements in their aerobic power, the participants in the current study had been exercising prior to the study's start, which could have had an impact on their training gains during the study. The results of the current study indicate that the treatment group's aerobic power increased from the pretest to the second post-test, but this difference was not statistically significant. This could suggest that, with more time, the dynamics of the hibiscus-ginger juice in aerobic power could have been better understood. As stated in related studies, the supplementation's dosage affects how effective it is at enhancing performance (Perez et al., 2019). Given that the athletes in the current study were receiving medication consisting of 500 milliliters of hibiscus-ginger juice each day, this may also have been the case. Another possibility is that the supplement's concentration was insufficient to produce a noticeable difference (Perez et al., 2019). Although the reasons for the contradictory results are unclear, there are a number of potential contributing factors, including changes in the intensity and length of the activity tests, the amount and timing of supplement administration, and the interval between administration and testing. Additionally, in contrast to the earlier investigations, the athletes in the current trial received treatment every day after training as they were consuming supplements after training. This is crucial for muscle repair (Matsumura et al., 2015), which boosts performance; however, the results of the present investigation did not support this. The data indicated a slight increase in the aerobic power of the treatment group, indicating that although the statistical test for between-subjects and within-subjects effects was not significant, there may still be a chance for aerobic power improvements with additional studies using modified treatment and methodology. Furthermore, as was the case with Reinks et al. (2015), future prospective research might take into account ingesting the hibiscus-ginger juice prior to exercising.

5 Conclusion

Following a 24-day period of 500 mL per day of hibiscus-ginger juice consumption, only the time interaction effects for blood lactate levels for within factor effects on groups—and not the between-subject impact for treatment and control groups—were significant. Athletes' aerobic power was unaffected by consuming 500 mL of hibiscus-ginger juice for a duration of 24 days. Thus, it can be said that giving athletes who are training a 500 mL dose of hibiscus-ginger juice for 24 days did not significantly alter their blood lactate levels or aerobic power. However, because this research on hibiscus-ginger juice supplementation in athletes is new, more research with other doses and more extended supplementation periods is required before conclusive findings and supplementation recommendations can be made.

Source of funding: The study was conducted from the personal funds of the researchers.

Previous submissions: None.

Acknowledgment: We would like to extend our utmost gratitude to the student-athletes of the University of Cape Coast who volunteered to participate in this study. We also acknowledge the research assistant who helped with data collection for the study.

Authors' Contribution: YK: Conceptualization, methodology, Data Curation, investigating, Formal Analysis. JKM and SEB: Data Curation, Supervision, Writing - Reviewing and Editing and Validation. NAA: Data Curation, Writing – Original Draft, Writing – Reviewing & Editing

Conflicts of Interest: The authors declare that there are no conflicts of interest associated with this research study. The authors have no financial, personal, or professional relationships with any organization or individual that could have influenced the findings study. The research was conducted with the sole aim of contributing to scientific knowledge.

Preprint deposit: None.

References

Afiune, L. A. F., Leal-Silva, T., Sinzato, Y. K., Moraes-Souza, R. Q., Soares, T. S., Campos, K. E… & Volpato, G. T. (2017). Beneficial effects of Hibiscus rosa-sinensis L. flower aqueous extract in pregnant rats with diabetes. *PLoS One, 12*(6), e0179785, https://doi.org/10.1371/journal.pone.0170785

Babu, K. M., Church, R. J., & Lewander, W. (2008). Energy drinks: The new eye-opener for adolescents. *Clinical Paediatrics and Emergency Medicine, 9*, 35-42. https://doi.org/10.1016/j.cpem.2007.12.002

Bentley, D. J., Ackerman, J., Clifford, T., & Slattery, K. S. (2015). Acute and Chronic Effects of Antioxidant Supplementation on Exercise Performance. *Research in Sports Medicine*, 20 (1), 1-12. https://doi.org/10.1080/154338627.2011.608050

Burke, L. M., Meyer, N. L. & Pearce, J. (2013). *National nutritional programs for the 2012 London Olympic Games: A systematic approach by three different countries.* In: van Loon LJC, Meeusen R, editors. Limits of Human Endurance. Nestle Nutrition Institute Workshop Series, volume 76. Vevey, Switzerland: Nestec Ltd,103–120

Buxton, C., & Hagan, J. E. (2012). A survey of energy drinks consumption practices among student-athletes in Ghana: Lessons for developing health education intervention programs. *Journal of the International Society of Sports Nutrition,* 9, 9-12. https://doi.org/10.1186/1550-2783-9-9

Carvajal-Sancho, A., & Moncada-Jimenez, J. (2005). The acute effect of an energy drink on the physical and cognitive performance of male athletes. *Kinesiologia Slovencia, 11*(2), 5-16.

Clifford, T., Berntzen, B., Davidson, G. W., West, D. J., Howastson, G., & Stevenson, E. J. (2016). Effects of beetroot juice on the recovery of muscle function and performance between bouts of repeated sprint exercise. *Nutrients, 8*(8), 506; https://doi.org/10.3390/nu8080506

Elkington, L. J., Gleeson, M, Pyne, D. B., Callister, R & Wood, L. G. (2015). *Inflammation and immune function: Can antioxidants help the endurance athlete? In: Lamprecht, M, editor. Antioxidants in sports nutrition.* Boca Raton (FL): CRC Press/Taylor & Francis.

Haakonssen, E. C., Ross, M. L., Knight, E. J., Cato, L. E., Nana, A, Wluka, A. E., Cicuttini, F. M., Wang, B. H., Jekins, D. G., & Burke, L. M (2015). The effects of a calcium-rich pre-exercise meal on biomarkers of calcium homeostasis in competitive female cyclists: A randomized crossover trial. *PloS one, 10(*5), e0123302. https://doi.org/10.1371/journal.pone.0123302

Hadi, A., Pourmasoumi, M., Kafeshani, M., Karimian, J., Maracy, M. R., & Entezari, M. H. (2017). The effect of green tea and sour tea (Hibiscus sabdariffa L.) supplementation on oxidative stress and muscle damage in athletes. *Journal of Dietary Supplementation, 14*(3), 346-357. https://doi.org/10.1080/19390211.2016.1237400

Jordan, T., Lukaszuk, J., Misic, M., & Umoren, J. (2010). Effect of beta-alanine supplementation on the onset of blood lactate accumulation (OBLA) during treadmill running: Pre/post 2 treatment experimental design. *Journal of the International Society of Sports Nutrition, 7*, 20, https://doi.org/10.1186/1550-2783-7-20

Joven, J., March, I., Espinel, E., Fernandez-Arroyo, S., Rodriguez-Gallego, E., Aragones, G., Beltrán-Debón, R., Alonso-Villaverde, C., Rios, L., Martin-Paredero, V., Menendez, J. A., Micol, V., Sagura-Carretero, A., & Camps, J. (2014). Hibiscus sabdariffa extract lowers blood pressure and improves endothelial function. *Molecular Nutrition & Food Research, 58*, 1374-1378. https://doi.org/10.1002/mnfr.201300774

Kalman, D. S., Feldman, S., Krieger, D. R., & Bloomer, R. J. (2012). Comparison of coconut water and a carbohydrate-electrolyte sport drink on measures of hydration and physical performance in exercise-trained men. *Journal of the International Society of Sports Nutrition, 9*(1), 1. https://doi.org/10.1186/1550-2783-9-1

Klarod, K., Gatterer, H., Fronntul, V., Philipe, M., & Burtscher, M. (2015). Effects of short-term antioxidant supplementation on oxidative stress and exercise performance in the heat and the cold. *International Journal of Physiology, Pathophysiology and Pharmacology, 7*(2), 98-104.

Lin, T-Z., Lin, H-H., Chen, C-C., Lin, M-C., Chou, M-C., & Wang, C-J. (2007). Hibiscus sabdariffa extract reduces serum cholesterol in men and women. *Nutrition Research. 27*(3), 140-145, https://doi.org/10.1016/j.nutres.2007.01.007

Lufkin, A. K. S. (2011). *The effects of red bull energy on repeated Wingate cycle performance and elbow flexor muscle endurance.* [Master's Thesis] Florida State University. Retrieved from http://purl.flvc.org/fsu/fd/FSU_migr_etd-1008

Madden, R. F., Shearer, J., & Pamell, J. A. (2017). Evaluation of dietary intakes and supplement use in paralympic athletes. *Nutrients, 9*, 1266, https://doi.org/10.3390/nu9111266

Mardanpour-Shahrekordi, Z., Banitalebi, E., Faramarzi, M., Ghafari, M., & Mardanpour-Shahrekordi, E. (2017). The effect of 10-week aerobic training with or without ginger supplementation on aerobic power, BFP, and insulin resistance in obese middle-aged women with type 2 diabetes. *Advanced Herbal Medicine, 4*(1), 14-22.

Matsumura, M. D., Zavorsky, G. S., & Smoliga, J. M. (2015). The effects of pre-exercise ginger supplementation on muscle damage and delayed onset muscle soreness. *Phytotherapy Research, 29*, 887-893. https://doi.org/10.1002/ptr.5328

Nyakayiru, J., Jonvik, K. L., Trommelen, J., Pinckaers, P. J. M., Seden, J. M., van Loon, L. J. C., & Verdijk, L. B. (2017). Beetroot juice supplementation improves high-intensity intermittent type exercise performance in trained soccer players. *Nutrients, 9*, 314, DOI : 10.3390/nu9030314

Perez, J. M., Dobson, J. L., Ryan, G. A., & Riggs, A. J. (2019). The effect of beetroot juice on VO_2max and blood pressure during submaximal exercise. *International Journal of Exercise Science, 12*(2), 332-342.

Pirculescu, L., Bordean, D. M., Popescu, I., Sirbulescu, C., & Draghici, G. (2015). Profile of mineral compounds from ginger (*Zingiber Officinale*). *Lucrări Ştiinţifice, Seria I, 14*(4), 132-135.

Reinks, J. N., Vanderwoude, A. A., Maas, E., Blea, Z.M., & Subudhi, A. W. (2015). Effect of beetroot juice on moderate-intensity exercise at a constant rating of perceived exertion. *International Journal of Exercise Science, 8*(3), 277 – 286.

Seifert, S. M., Shaechter, J. L., Hershorin, E. R., & Lipshultz, S. E. (2013). Health effects of energy drinks on children, adolescents, and young adults. *Pediatrics, 127*(3), 511-528. https://doi.org/10.1542/peds.2009-3592

Tarazona-Diaz, M. P., Alacid, F., Carrasco, M., Martinez, I., & Aguayo, E. (2013) Watermelon juice: Potential functional drink for sore muscle relief in athletes. *Journal of Agricultural and Food Chemistry, 61*(31), 7522-7528. https://doi.org/10.1021/jf400964r

Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016) Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. *Journal of the Academy of Nutrition and Dietetics,* 2016; 116(3), 501-528. DOI: https://doi.org/10.1016/j.jand.2015.12.006

Wilson P. B. (2015). Ginger (Zingiber officinale) as an Analgesic and Ergogenic Aid in Sport: A Systemic Review. *Journal of strength and conditioning research, 29*(10), 2980–2995. https://doi.org/10.1519/JSC.0000000000001098