

The Effect of Beetroot Juice on VO_2 Max in Futsal Athletes

Andi Nur Halisa^{1A-E*}, Ishak Bachtiar^{2B-D}, Andi Ridwan^{3B-D}

^{1,2,3} Universitas Negeri Makassar, Sulawesi Selatan, Indonesia

andinurhalisa080@gmail.com^{1*}, ishak.bahtiar@unm.ac.id², andi.ridwan@unm.ac.id³

ABSTRACT

Cardiorespiratory endurance is a crucial component of performance in futsal because athletes are required to perform repeated high-intensity activities throughout a match. One nutritional strategy that has gained attention for improving aerobic capacity is beetroot juice (*Beta vulgaris*), which is rich in dietary nitrates and may enhance oxygen utilization during exercise. This study aimed to determine the effect of beetroot juice consumption on VO_2 Max among futsal athletes of SMA Negeri 8 Makassar. This study employed a quantitative approach with a pre-experimental one-group pretest-posttest design. The sample consisted of 22 futsal athletes selected using a total sampling technique. Participants received 200 ml of beetroot juice for 16 intervention sessions over four weeks. VO_2 Max was measured using the Multistage Fitness Test (Bleep Test) before and after the intervention. Data analysis included the Shapiro-Wilk normality test followed by the Paired Sample t-Test to compare pretest and posttest scores. The results showed a significant improvement in VO_2 Max after beetroot juice supplementation. The mean VO_2 Max increased from 44.50 ± 3.76 ml·kg⁻¹·min⁻¹ before the intervention to 54.61 ± 4.64 ml·kg⁻¹·min⁻¹ after the intervention, with an average increase of 10.11 ml·kg⁻¹·min⁻¹. Statistical analysis revealed a p-value of 0.000 ($p < 0.05$), indicating a significant effect of beetroot juice on VO_2 Max. These findings suggest that the nitrate content in beetroot juice may enhance nitric oxide production, improve blood circulation, and increase oxygen utilization efficiency. Therefore, beetroot juice has potential as a natural ergogenic supplement to improve cardiorespiratory endurance in futsal athletes.

ARTICLE HISTORY

Received: 2026/05/26

Accepted: 2026/05/29

Published: 2026/05/31

KEYWORDS

Beetroot Juice

VO_2 Max;

Cardiorespiratory

Endurance;

Futsal Athletes;

Sports Nutrition

AUTHORS' CONTRIBUTION

- Conception and design of the study;
- Acquisition of data;
- Analysis and interpretation of data;
- Manuscript preparation;
- Obtaining funding

Cites this Article : Halisa, A.N.; Bachtiar, I.; Ridwan, A. (2026). The Effect of Beetroot Juice on VO_2 Max in Futsal Athletes. **Competitor: Jurnal Pendidikan Kepeleatihan Olahraga**. 18 (2), p.4297-4309

INTRODUCTION

Futsal is one of the most popular sports among adolescents due to its dynamic nature, high intensity, and relatively short playing duration compared to conventional football. Despite the shorter match duration, futsal requires players to perform repeated high-intensity activities such as sprinting, accelerating, changing direction, dribbling, passing, and transitioning rapidly between offensive and defensive situations (Aliman et al., 2023). These physiological demands place significant stress on the cardiovascular

and respiratory systems, making cardiorespiratory endurance a critical determinant of performance in futsal athletes (Ramadhan et al., 2025).

Cardiorespiratory endurance is commonly assessed through maximal oxygen uptake ($VO_2\text{Max}$), which represents the highest capacity of the body to consume, transport, and utilize oxygen during intense physical activity (Dieny et al., 2017). $VO_2\text{Max}$ is widely recognized as a key indicator of aerobic fitness and athletic performance because it reflects the efficiency of oxygen delivery to working muscles and the body's ability to sustain prolonged exercise (Buchheit & Laursen, 2019). Athletes with higher $VO_2\text{Max}$ values generally demonstrate better endurance capacity, delayed fatigue onset, and superior recovery during intermittent high-intensity exercise (Raghuveer et al., 2020).

In futsal, maintaining optimal $VO_2\text{Max}$ is particularly important because players continuously alternate between anaerobic and aerobic energy systems throughout a match. A decline in aerobic fitness can negatively affect technical execution, tactical decision-making, concentration, and overall match performance (Mauludiyah et al., 2023). Consequently, improving $VO_2\text{Max}$ has become a primary objective of conditioning programs designed for futsal athletes (Anggraini & Widodo, 2021).

Several factors influence $VO_2\text{Max}$ levels, including genetic predisposition, training status, age, body composition, environmental conditions, and nutritional intake (Jones et al., 2021). Among these factors, nutritional strategies have recently gained considerable attention due to their potential to enhance physiological adaptations and exercise performance. One nutritional component that has attracted significant scientific interest is dietary nitrate, which can improve oxygen utilization efficiency and exercise tolerance (Domínguez et al., 2017).

Beetroot (*Beta vulgaris*) is recognized as one of the richest natural sources of dietary nitrate. Through the nitrate–nitrite–nitric oxide pathway, nitrate supplementation may enhance endothelial function, increase blood flow, improve mitochondrial efficiency, and reduce oxygen cost during exercise (Jones et al., 2018). Therefore, beetroot juice supplementation has emerged as a promising ergogenic aid for endurance-related sports performance.

At SMA Negeri 8 Makassar, the futsal team has consistently participated in regional and national competitions, achieving notable accomplishments such as reaching the semifinals of the Makassar City Student Futsal Tournament in 2023, becoming finalists in the Makassar Student League in 2024, and participating in the national BYU Student Tournament in Semarang in 2025. Nevertheless, coaching evaluations have revealed recurring decreases in player stamina during the second half of matches, which often affect performance consistency and competitive outcomes. This phenomenon indicates that cardiorespiratory endurance remains an important aspect requiring improvement among these athletes.

Recent advances in sports nutrition have highlighted the role of dietary nitrate supplementation in improving aerobic performance. Dietary nitrate derived from beetroot juice is converted into nitrite and subsequently nitric oxide, which contributes to vasodilation, enhanced muscle oxygenation, and improved exercise economy (Jones

et al., 2018; McMahon et al., 2017). These physiological adaptations are particularly beneficial in intermittent sports where repeated high-intensity efforts are required.

Several studies have demonstrated positive effects of beetroot juice supplementation on aerobic capacity and endurance performance. Domínguez et al. (2017) reported that nitrate supplementation significantly improved exercise efficiency and reduced oxygen consumption during submaximal exercise. Similarly, Senefeld et al. (2020) found that beetroot juice supplementation enhanced endurance performance through improved oxygen delivery and utilization.

In team sports settings, dietary nitrate has shown promising results. Wylie et al. (2019) observed improvements in intermittent running performance among trained athletes following nitrate supplementation. Mosher et al. (2021) further reported that beetroot juice increased exercise tolerance and delayed fatigue during repeated sprint activities. These findings suggest potential applicability in futsal, where athletes repeatedly perform high-intensity actions interspersed with brief recovery periods.

In Indonesia, research concerning beetroot supplementation has also expanded. Sanrebayu (2020) reported that beetroot consumption contributed to improved aerobic endurance among athletes through increased nitrate availability. Zahra and Muhlisin (2020) emphasized that, besides nitrate content, beetroot contains antioxidants such as betalains, vitamin C, potassium, and polyphenols, which may reduce oxidative stress and support recovery during intense exercise. Furthermore, contemporary sports science literature highlights the synergistic relationship between nutritional interventions and physical conditioning programs. The integration of evidence-based nutritional strategies with regular training is increasingly recognized as an effective approach for optimizing athletic performance (Kerksick et al., 2018; Thomas et al., 2016). Therefore, investigating beetroot juice supplementation in adolescent futsal athletes represents a scientifically relevant and practically important area of research.

Despite the growing body of literature regarding beetroot juice supplementation, several research gaps remain. First, most previous studies have focused on endurance athletes, cyclists, runners, or recreationally active adults, while evidence involving adolescent futsal athletes remains limited (Senefeld et al., 2020; Wylie et al., 2019). Given the unique physiological demands of futsal, findings from endurance sports cannot be directly generalized to futsal players. Second, existing studies predominantly originate from European and North American populations, whereas research involving Indonesian adolescent athletes is still scarce. Differences in dietary habits, training environments, genetic characteristics, and competitive structures may influence the effectiveness of nutritional interventions (Sanrebayu, 2020). Third, previous investigations have frequently examined performance variables such as time-trial outcomes, sprint performance, or exercise economy. Comparatively fewer studies have specifically evaluated changes in $VO_2\text{Max}$ as a primary outcome among school-based futsal athletes. Considering that $VO_2\text{Max}$ is a fundamental indicator of cardiorespiratory fitness, further empirical evidence is needed to clarify the effectiveness of beetroot juice supplementation in this population. Finally, no published study has specifically investigated the effects of beetroot juice

supplementation on the VO_2 Max of SMA Negeri 8 Makassar futsal athletes. Therefore, the present study seeks to address this contextual and empirical gap.

Based on the identified gaps, this study aims to examine the effect of beetroot juice supplementation on VO_2 Max among futsal athletes of SMA Negeri 8 Makassar. Specifically, the study seeks to determine whether regular consumption of beetroot juice can significantly improve cardiorespiratory endurance as measured through VO_2 Max values. The novelty of this research lies in four aspects. First, it investigates beetroot juice supplementation within the context of adolescent futsal athletes, a population that remains underrepresented in current literature. Second, it focuses specifically on school-level competitive athletes in Indonesia, thereby providing contextually relevant evidence for sports development programs. Third, it evaluates VO_2 Max as the primary physiological outcome, offering direct insight into cardiorespiratory adaptations. Fourth, the study integrates sports nutrition and performance physiology perspectives to develop practical recommendations for enhancing endurance performance among student-athletes.

In conclusion, considering the high aerobic demands of futsal and the emerging evidence regarding dietary nitrate supplementation, investigating the effect of beetroot juice on VO_2 Max among SMA Negeri 8 Makassar futsal athletes is both scientifically justified and practically significant. The findings are expected to contribute to the development of evidence-based nutritional strategies that support athlete endurance, performance optimization, and long-term sports achievement.

METHODS

This study employed a quantitative approach with a pre-experimental design to examine the effect of beetroot juice supplementation on VO_2 Max among futsal athletes at SMA Negeri 8 Makassar. Experimental research is widely recognized as an appropriate method for evaluating causal relationships between interventions and physiological outcomes because it enables researchers to observe changes resulting from a specific treatment under controlled conditions (Thomas et al., 2022). The present study adopted a one-group pretest–posttest design, which is commonly used in sports science to assess the effectiveness of nutritional or training interventions when all participants receive the same treatment (Fraenkel et al., 2019). This design allows for the comparison of participants' physiological conditions before and after the intervention, thereby providing evidence regarding the effectiveness of beetroot juice supplementation in improving aerobic fitness.

The study was conducted from December 27, 2025, to January 27, 2026, at SMA Negeri 8 Makassar, Indonesia. This period was selected to ensure the implementation of a structured supplementation protocol while maintaining the athletes' regular training schedules. Previous studies have demonstrated that a supplementation period of three to six weeks is sufficient to induce physiological adaptations associated with dietary nitrate intake and aerobic performance enhancement (Jones et al., 2018; Senefeld et al., 2020).

The population consisted of all students actively registered in the futsal extracurricular program at SMA Negeri 8 Makassar, totaling 22 athletes. Because the population size was relatively small and homogeneous, the total sampling technique was employed, resulting in a sample of 22 participants. Total sampling is recommended when the entire accessible population can be included, thereby minimizing sampling bias and increasing the representativeness of findings (Creswell & Creswell, 2018). All participants were male adolescent athletes who regularly participated in futsal training and competitions. The intervention administered in this study consisted of 200 ml of beetroot juice prepared from approximately 350 grams of fresh beetroot (*Beta vulgaris*). Beetroot was selected because it is a rich source of dietary nitrate, which has been shown to enhance nitric oxide bioavailability, improve vascular function, increase oxygen delivery, and reduce the oxygen cost of exercise (Dominguez et al., 2017; McMahon et al., 2017). Participants consumed the beetroot juice over a four-week period, with a total of 16 supplementation sessions conducted according to the training schedule. Previous investigations have reported that regular beetroot juice supplementation can positively influence aerobic capacity, endurance performance, and exercise efficiency in athletes (Wylie et al., 2019; Mosher et al., 2021).

VO_2 Max was assessed before and after the intervention period to evaluate changes in cardiorespiratory endurance. VO_2 Max is considered one of the most valid and reliable indicators of aerobic fitness and sports performance because it reflects the body's maximal capacity to transport and utilize oxygen during intense physical activity (Bassett & Howley, 2017; Raghuveer et al., 2020). The pretest was conducted prior to the first supplementation session, while the posttest was administered after the completion of the four-week intervention program.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS). Before hypothesis testing, data normality was examined using the Shapiro-Wilk test, which is recommended for studies involving small sample sizes due to its high statistical power and accuracy (Ghasemi & Zahediasl, 2019). After confirming normal distribution, the Paired Sample t-Test was employed to compare pretest and posttest VO_2 Max values. This statistical procedure is widely utilized in intervention studies to determine whether significant differences exist between two related measurements obtained from the same participants (Field, 2018). Statistical significance was established at the 0.05 level, indicating that p-values below 0.05 were considered evidence of a significant effect of beetroot juice supplementation on VO_2 Max among futsal athletes.

RESULTS AND DISCUSSION

Result

Characteristics of Participants

A total of 22 futsal athletes from SMA Negeri 8 Makassar participated in this study. Participant characteristics were analyzed based on age, body mass index (BMI), and smoking history to provide a comprehensive overview of the study population.

Table 1.

Distribution of Participants Based on Age, BMI, and Smoking History

| Variable | Category | n | % |
|-----------------|-------------|-----------|------------|
| Age (Years) | 15 | 6 | 27.3 |
| | 16 | 9 | 40.9 |
| | 17 | 4 | 18.2 |
| | 18 | 3 | 13.6 |
| BMI Status | Obesity I | 4 | 18.2 |
| | Overweight | 2 | 9.1 |
| | Normal | 12 | 54.5 |
| | Underweight | 4 | 18.2 |
| Smoking History | Yes | 9 | 40.9 |
| | No | 13 | 59.1 |
| Total | | 22 | 100 |

Table 1 shows that the majority of participants were 16 years old (40.9%), followed by 15 years old (27.3%), 17 years old (18.2%), and 18 years old (13.6%). Regarding nutritional status, most athletes had a normal BMI (54.5%), while 18.2% were classified as Obesity I, 18.2% were underweight, and 9.1% were overweight. Concerning smoking history, 59.1% of participants reported that they did not smoke, whereas 40.9% had a history of smoking.

These findings indicate that most participants were in the middle-adolescent age category and possessed a normal nutritional status, factors that are generally associated with better physiological adaptation to exercise and nutritional interventions.

Effect of Beetroot Juice Supplementation on $VO_2\text{Max}$

The primary objective of this study was to determine the effect of 200 ml beetroot juice supplementation on $VO_2\text{Max}$ among futsal athletes. $VO_2\text{Max}$ measurements were conducted before (pre-test) and after (post-test) four weeks of intervention.

Table 2.

Paired Sample t-Test Analysis of $VO_2\text{Max}$ Before and After Beetroot Juice Supplementation

| Variable | Pre-Test Mean \pm SD | Post-Test Mean \pm SD | Mean Difference | n (%) | p-value |
|--|------------------------|-------------------------|-----------------|-----------|---------|
| $VO_2\text{Max}$ (ml·kg ⁻¹ ·min ⁻¹) | 44.50 \pm 3.76 | 54.61 \pm 4.64 | 10.11 | 22 (100%) | 0.000* |

The results presented in Table 2 indicate a substantial increase in $VO_2\text{Max}$ following beetroot juice supplementation. The mean pre-test $VO_2\text{Max}$ value was 44.50 \pm 3.76 ml·kg⁻¹·min⁻¹, while the mean post-test value increased to 54.61 \pm 4.64 ml·kg⁻¹·min⁻¹. This represents an average improvement of 10.11 ml·kg⁻¹·min⁻¹ after four weeks of intervention.

The paired sample t-test revealed a p-value of 0.000 (p < 0.05), indicating a statistically significant difference between pre-test and post-test $VO_2\text{Max}$ values. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted, demonstrating that beetroot juice supplementation significantly improved cardiorespiratory endurance among SMA Negeri 8 Makassar futsal athletes.

The magnitude of improvement observed in this study suggests that dietary nitrate derived from beetroot juice contributed positively to aerobic capacity enhancement.

Increased nitric oxide bioavailability may have improved blood flow, oxygen delivery, and mitochondrial efficiency, thereby enabling athletes to utilize oxygen more effectively during exercise.

Visual Representation of $VO_2\text{Max}$ Improvement

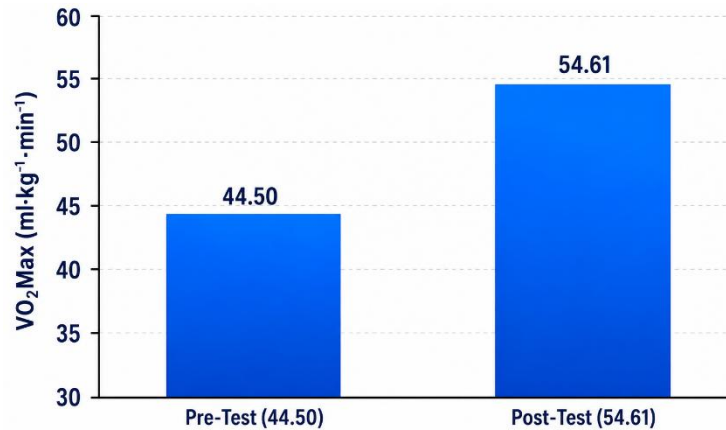


Figure 1.

Mean $VO_2\text{Max}$ Values Before and After Beetroot Juice Supplementation

Figure 1 clearly illustrates the increase in average $VO_2\text{Max}$ values from 44.50 ml·kg⁻¹·min⁻¹ before supplementation to 54.61 ml·kg⁻¹·min⁻¹ after the intervention period. The graphical trend confirms that beetroot juice supplementation produced a positive effect on aerobic fitness and endurance performance.

Overall, the findings demonstrate that regular consumption of 200 ml beetroot juice for four weeks significantly enhanced $VO_2\text{Max}$ levels in futsal athletes. This improvement indicates better cardiorespiratory fitness, which may contribute to improved match endurance, reduced fatigue, and enhanced athletic performance during competitive futsal activities.

Discussion

Based on the results of the study, further analysis was used to see whether there were changes or effects after giving beetroot juice to the $VO_2\text{max}$ value of futsal athletes at SMAN 8 Makassar, because the data was normally distributed using the Shapiro Wilk test, a further stage was carried out with a paired sample t-test and the results showed a significant effect with a p-value of 0.000, where this value is smaller than 0.05 so it can be concluded that there are changes and effects of beetroot juice on the $VO_2\text{max}$ value of futsal athletes at SMAN 8 Makassar.

Physiologically, NO triggers relaxation of smooth muscle in blood vessel walls, resulting in vasodilation and increased blood flow. This dilation of blood vessels improves cardiac output and oxygen distribution to tissues, thus supporting more efficient oxygen transport and utilization by muscle cells. This condition contributes to increased aerobic capacity, including $VO_2\text{max}$, because optimal oxygen supply helps delay fatigue, reduces the risk of cramps, and increases energy production through optimized mitochondrial function. Thus, nitrate supplementation has the potential to provide ergogenic effects

through mechanisms that increase NO bioavailability and aerobic metabolic efficiency. This is what causes the increase in VO_2 max in athletes after consuming beetroot juice (Febriyanah et al., 2023).

The general condition of the field sample was dominated by age, with participants aged 16 years and predominantly male. This age range represents the age range during which physical capacity, including cardiorespiratory endurance, is still developing. In futsal, VO_2 max plays a crucial role because it relates to the body's ability to maximally utilize oxygen during high-intensity physical activity. Athletes with good cardiorespiratory capacity are generally able to maintain longer performance during training and matches. In addition to age, an athlete's physical condition can also be influenced by their nutritional status, or body mass index (BMI). BMI indicates that most athletes have normal nutritional status, although some athletes are obese, overweight, and underweight. Nutritional status can provide a general overview of an athlete's body composition, which is theoretically related to physical ability and body efficiency during sports activities.

Athletes with a balanced body composition tend to have better movement ability and endurance than athletes who are overweight or underweight. In addition to nutritional status, there are lifestyle factors that can be related to the condition of an athlete's cardiorespiratory endurance, one of which is smoking habits. Physiologically, smoking habits can affect lung function and the circulatory system, potentially reducing the body's ability to transport oxygen to muscle tissue. This condition can be associated with decreased cardiorespiratory endurance or VO_2 max. VO_2 max values were measured twice: one at the beginning before the intervention and one day after the intervention, a total of 16 times. This study was conducted without a control group, conducted for 4 weeks with the intervention given, each week, four times with an intervention of 200 ml of beetroot juice.

During the bleep test, coaches and researchers directly observed the athletes' physical condition throughout the test. Athletes continued running to the rhythm of the bleep sounds, which became faster at each level. However, if the athlete was no longer able to maintain the specified running tempo, the test was stopped. This was done when signs of physical fatigue were observed, such as the athlete's breathing becoming labored, running speed decreasing, footsteps slowing, and the athlete being unable to reach the boundary line at the bleep sound. After the athlete was declared unable to continue the test, the results of the last level and return achieved were then recorded by the researchers as the athlete's VO_2 Max results. Following the pretest measurements, an intervention in the form of beetroot juice was administered one hour before training.

During the intervention, several athletes missed training sessions due to holidays or were unable to attend. Athletes who were unable to attend training sessions contacted the researchers in advance to inform them of their absence. Therefore, the intervention was still administered at the time available, specifically during the school break after lunch, so that the intervention could continue as scheduled. Challenges encountered during the intervention included variations in the response to beetroot

juice. Several athletes reported that the taste and aroma of beetroot juice were unfamiliar, requiring some athletes to adapt to consuming it initially. Furthermore, one athlete who participated in the intervention experienced decreased acceptance, complaining of nausea and dizziness after the initial administration, which is thought to be related to the physiological response to the nitrate content and the strong taste characteristics of beetroot juice. To address these concerns, the researchers then added green apples before and after beetroot juice consumption as a supportive strategy to increase gastrointestinal comfort and improve taste acceptance.

This approach has been shown to help reduce perceived complaints, allowing the intervention to continue successfully, despite four missed intervention sessions during the study period. Green apples were chosen because they are rich in vitamin C, potentially helping to increase the body's tolerance to beetroot juice, thus reducing nausea and dizziness. They also contain soluble fiber, particularly pectin, and natural sugars such as fructose, which play a role in supporting digestive function (Hogwood et al., 2023). Pectin is known to help improve gastrointestinal motility and provide a soothing effect on the stomach, potentially reducing mild nausea that can occur after consuming juices with strong flavors and compositions, such as beetroot juice (JULIA, 2021).

After the beetroot juice intervention was completed 16 times, another measurement was conducted using a bleep test as a posttest. This measurement aimed to determine changes and improvements in the athletes' abilities after the beetroot juice intervention. The bleep test results showed an improvement in the athletes' abilities compared to the pretest results. Athletes were seen to be able to persist longer and achieve higher levels in the test.

This improvement was influenced by the administration of beetroot juice intervention during the research process. The nutritional content, especially the nitrate content in beetroot juice, is thought to help improve the athletes' physical condition and endurance, thus improving their aerobic capacity. The athletes' increased ability to complete the bleep test indicates an increase in VO_2Max capacity. This is evident in the athletes' ability to maintain running speed for a longer period even though the test intensity continues to increase. By increasing cardiorespiratory endurance, the athletes' bodies become more effective in utilizing oxygen during physical activity. Therefore, the posttest results indicate that the administration of beetroot juice has a positive effect on improving the athletes' aerobic endurance. Based on the pretest and posttest results, there was an increase in the outcome categories after the intervention or treatment.

In the pretest, the majority of respondents were in the moderate category (12), followed by 8 in the very good category, and 2 in the poor category. There were no respondents in the superior, good, or very poor categories in the pretest. After the intervention, the posttest results showed significant changes. The very good category increased to 10, while the superior category, which had previously been absent, increased to 8. Furthermore, the good category also appeared with 4 respondents. In the posttest, there were no longer any respondents in the moderate, poor, or very poor

categories. This change in category distribution indicates that the intervention was able to improve respondents' performance to a higher category. This is evident from the shift in the majority of respondents from the moderate and poor categories to the good, very good, and superior categories in the posttest.

This is in line with previous research showing that beetroot juice can increase VO_2 max values in athletes. The results of this study showed an increase of 83.3% after 36 interventions were carried out 15 times with a dose of 200 ml of beetroot juice. The average VO_2 max value obtained was 43.57 ml/kg/minute with a variation of 6.26 ml/kg/minute, indicating a difference in aerobic endurance levels between respondents in the group. This finding indicates that beetroot juice consumption has the potential to have a positive effect on increasing aerobic capacity (Sanrebayu, 2020). This was then reinforced by research that obtained results, namely, an increase in cardiorespiratory endurance capacity (VO_2 max) in the group that received the 200 ml beetroot juice intervention, with a difference in increase of 3.717 ml/kg/minute. The average VO_2 max value changed from 39.85 ml/kg/minute before treatment to 43.57 ml/kg/minute after the intervention. This increase can be explained by the high nitrate content in beets which contributes to increased efficiency of oxygen use by muscles.

Biologically, nitrate is converted into nitric oxide (NO), which functions to widen blood vessels, so that oxygen flow and distribution to muscle tissue are more effective in accordance with the demands of physical activity (Arimbi, 2020). In this context, the use of beetroot juice supplementation, which has the effect of increasing aerobic capacity, can help athletes accelerate recovery between rounds or training sessions, while maintaining performance when the body begins to approach fatigue. Furthermore, this performance-enhancing effect is also seen in high-intensity activities, allowing athletes to continue producing optimal power and movement quality even in declining physical condition (Ribeiro et al., 2021).

increase in VO_2 max indicates that the athlete's body becomes more efficient in using oxygen during physical activity, which is very important in futsal which has high intensity and requires good endurance. Research has shown that beetroot consumption has the potential to increase athletes' VO_2 max through its nitrate content, which plays a role in increasing oxygen efficiency, blood flow, and aerobic performance. Research findings indicate an increase in cardiorespiratory endurance capacity after beetroot supplementation, making it a potential sports nutrition strategy to support improved aerobic capacity and physical performance in athletes.

CONCLUSION

Based on results research, can concluded that giving beetroot juice has an effect to improvement VO_2 max in futsal athletes of SMAN 8 Makassar. The influence of the shown through increasing capacity cardiorespiratory athlete after given beetroot juice intervention, so administration of beetroot juice has been proven contribute in increase ability Power stand aerobics futsal athletes.

REFERENCES

- Aggil Ahmad Ramadhan, Raden Akhmad Aqtoo, Amrul Hayat, Qoyyum Saputra, Hikmal Soulisa, Tubagus Lucky Tri Iman Setiawan, Siti Nur Azizah, Nuri Maulida, Fauzan Amrullah Ramadhan, & Muhammad Faiza Akhira Ramadhan. (2025). Analysis of Endurance with Stamina on One of Tarkam Football Athlete. *Multidisciplinary Scientific Journal*, 2 (3), 71-77. <https://doi.org/10.69714/Bccdvn06>
- Aliman, R., Atiq, A., & Haetami, M. (2023). Physical fitness and performance characteristics in futsal athletes. *Jurnal Pendidikan Jasmani Indonesia*, 19(2), 115-124. <https://journal.uny.ac.id/index.php/jpji>
- Anggraini, D., & Widodo, A. (2021). Analysis of VO_2 Max as an indicator of cardiorespiratory endurance in athletes. *Jurnal Keolahragaan*, 9(1), 45-54. <https://doi.org/10.21831/jk.v9i1.38567>
- Anggraini, FS, & Widodo, A. (2021). Analysis of Maximal Aerobic Capacity (Vo2max) in Unesa Football Athletes. *Journal of Sports Health*, 09 (04), 103-108.
- Arimbi. (2020). Effect Of Beetroot Extract On Maximum Oxygen Volume Athletes .
- Dieny, FF, Fitranti, DY, Panunggal, B., & Safitri, I. (2017). The Effect of Beetroot (Beta Vulgaris) Juice on Hemoglobin Levels and the Performance of Soccer Athletes. *The Indonesian Journal of Nutrition*, 5 (2), 119-126. <https://doi.org/10.14710/Jgi.5.2.119-126>
- Bassett, D. R., & Howley, E. T. (2017). Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine & Science in Sports & Exercise*, 49(1), 70-84. <https://doi.org/10.1249/MSS.0000000000001142>
- Buchheit, M., & Laursen, P. B. (2019). High-intensity interval training, solutions to the programming puzzle. *Sports Medicine*, 49(12), 1813-1830. <https://doi.org/10.1007/s40279-019-01149-8>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications. <https://us.sagepub.com>
- Dieny, F. F., Jauharany, F. F., Tsani, A. F. A., & Nissa, C. (2017). Dietary intake, nutritional status, and VO_2 Max among adolescent athletes. *Journal of Nutrition and Metabolism*, 2017, 1-8. <https://doi.org/10.1155/2017/1484652>
- Domínguez, R., Cuenca, E., Maté-Muñoz, J. L., García-Fernández, P., Serra-Paya, N., Estevan, M. C. L., Herreros, P. V., & Garnacho-Castaño, M. V. (2017). Effects of beetroot juice supplementation on cardiorespiratory endurance in athletes. *Nutrients*, 9(1), 43. <https://doi.org/10.3390/nu9010043>
- Febriyanah, N., Dieny, FF, Nugraha, TW, & Afifah, DN (2023). The Effect of Pineapple Beet Juice (Beta Vulgaris L, Ananas Comosus) on Lactic Acid Levels in Soccer Athletes. *Journal of Nutrition College*, 12 (4), 327-335. <https://doi.org/10.14710/Jnc.V12i4.41149>
- Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). Sage Publications. <https://uk.sagepub.com>
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2019). *How to design and evaluate research in education* (10th ed.). McGraw-Hill Education. <https://www.mheducation.com>

- Ghasemi, A., & Zahediasl, S. (2019). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, 17(2), e55432. <https://doi.org/10.5812/ijem.55432>
- Hogwood, A. C., Anderson, K. C., Zevallos, J. O. De, Paterson, C., Weltman, A., & Allen, J. D. (2023). Limited Effects Of Inorganic Nitrate Supplementation On Exercise Training Responses : A Systematic Review And Meta - Analysis. *Sports Medicine - Open*, 1-13. <https://doi.org/10.1186/S40798-023-00632-1>
- Jones, A. M., Thompson, C., Wylie, L. J., & Vanhatalo, A. (2018). Dietary nitrate and physical performance. *Annual Review of Nutrition*, 38, 303-328. <https://doi.org/10.1146/annurev-nutr-082117-051622>
- Jones, A. M., Vanhatalo, A., Bailey, S. J., & Wylie, L. J. (2021). Dietary nitrate and exercise performance: Current evidence and future directions. *Sports Medicine*, 51(Suppl. 1), 1-15. <https://doi.org/10.1007/s40279-021-01422-y>
- JULIA, E. (2021). Consumption Of Nitrate-Rich Beetroot Juice With Or Without Vitamin C Supplementation Increases The Excretion Of Urinary Nitrate, Nitrite, And N-Nitroso Compounds In Humans.
- Kerksick, C. M., Wilborn, C. D., Roberts, M. D., Smith-Ryan, A., Kleiner, S. M., Jäger, R., Collins, R., Cooke, M., Davis, J. N., Galvan, E., Greenwood, M., Lowery, L. M., Wildman, R., Antonio, J., & Kreider, R. B. (2018). ISSN exercise and sports nutrition review update. *Journal of the International Society of Sports Nutrition*, 15(1), 38. <https://doi.org/10.1186/s12970-018-0242-y>
- Mauludiyah, N., Hidayat, T., & Prasetyo, Y. (2023). Relationship between aerobic endurance and futsal performance among youth athletes. *Jurnal SPORTIF*, 9(2), 211-223. https://doi.org/10.29407/js_unpgri.v9i2.21459
- Mauludiyah, N., Muhammad, HN, & Wibowo, S. (2023). Implementation of Station Rotation Learning in Physical Education Subjects on Activity Material for Fitness on Students' Agility Levels. *Eduinovasi: Journal of Basic Educational Studies*, 4 (1), 729-744. <https://doi.org/10.47467/Edui.V4i1.6002>
- McMahon, N. F., Leveritt, M. D., & Pavey, T. G. (2017). The effect of dietary nitrate supplementation on endurance exercise performance in healthy adults: A systematic review and meta-analysis. *Sports Medicine*, 47(4), 735-756. <https://doi.org/10.1007/s40279-016-0617-7>
- Mosher, S. L., Sparks, S. A., Williams, E. L., Bentley, D. J., & Mc Naughton, L. R. (2021). Ingestion of nitrate-rich beetroot juice improves repeated sprint performance. *European Journal of Sport Science*, 21(8), 1133-1141. <https://doi.org/10.1080/17461391.2020.1820778>
- R. Aliman, A. Atiq, M. Haetami, W. Et Al. (2023). *Journal of World Education*. *Journal of World Education*, 3 (November), 67-78. <http://Jurnal.Stokbinaguna.Ac.Id/Index.Php/JURDIP/Article/View/2083>
- Raghuveer, G., Hartz, J., & Lubans, D. (2020). Cardiorespiratory fitness and sports performance in youth athletes. *Progress in Cardiovascular Diseases*, 63(4), 431-438. <https://doi.org/10.1016/j.pcad.2020.05.004>

- Raghuveer, G., Hartz, J., Lubans, D. R., Takken, T., Wiltz, J. L., Mietus-Snyder, M., Perak, A. M., Baker-Smith, C., Pietris, N., & Edwards, N. M. (2020). Cardiorespiratory Fitness In Youth: An Important Marker Of Health: A Scientific Statement From The American Heart Association. *Circulation*, 142(7), E101–E118. <https://doi.org/10.1161/CIR.0000000000000866>
- Ramadhan, A. A., Putra, R., & Kurniawan, A. (2025). Physiological demands and performance indicators in youth futsal athletes. *International Journal of Sports Science*, 13(1), 55–64.
- Ribeiro, N., Bef, A., Alves, D., Ferreira, K., Bf, C., Raimundo, J., Bef, F., Cristiane, A., Queiroz, C., Ignacio, D., Perez, V., Ariel, E., Munoz, A., Acef, B. M., Jose, C., & Acedf, B. (2021). Coaching & Exercise Physiology Beetroot Extract Improves Specific Performance And Oxygen Uptake In Taekwondo Athletes : A Double-Blind Crossover Study. 21(4), 12–19. <https://doi.org/10.14589/Ido.21.4.3>
- Sanrebayu, M. (2020). Potensi beetroot sebagai suplemen peningkat daya tahan atlet. *Jurnal Gizi Olahraga Indonesia*, 4(2), 89–98. <https://ejournal.unesa.ac.id>
- Sanrebayu. (2020). The Effect of Beetroot Juice (Beta Vulgaris) on Hemoglobin Levels and $VO_2\text{MAX}$ Values of Badminton Athletes . Hasanuddin University.
- Senefeld, J. W., Wiggins, C. C., Regimbal, R. J., Dominelli, P. B., Baker, S. E., Joyner, M. J., & Limberg, J. K. (2020). Ergogenic effect of nitrate supplementation on endurance performance. *Medicine & Science in Sports & Exercise*, 52(11), 2250–2261. <https://doi.org/10.1249/MSS.0000000000002378>
- 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*, 116(3), 501–528. <https://doi.org/10.1016/j.jand.2015.12.006>
- Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2022). Research methods in physical activity (8th ed.). Human Kinetics. <https://us.humankinetics.com>
- Wylie, L. J., Kelly, J., Bailey, S. J., Blackwell, J. R., Vanhatalo, A., & Jones, A. M. (2019). Beetroot juice and intermittent exercise performance in trained athletes. *International Journal of Sports Physiology and Performance*, 14(4), 495–501. <https://doi.org/10.1123/ijsp.2018-0310>
- Zahra, N., & Muhlisin, M. (2020). Kandungan antioksidan dan manfaat beetroot dalam olahraga. *Jurnal Gizi Klinik Indonesia*, 17(3), 156–164. <https://doi.org/10.22146/ijcn.54758>
- Zahra, S., & Muhlisin, M.-. (2020). Nutrition for Adolescent Athletes. *Journal of Applied Sports Science* , 5(1), 81–89. <https://doi.org/10.17509/Jtikor.V5i1.25097>