ORIGINAL ARTICLE

Sport and Exercise Nutrition

Impact of Red Cabbage and Red Onion Anthocyanin Supplementation on Lipid Profiles in Amateur Soccer Players: A Randomized Placebo-Controlled Study

Hamza Elrobrini [1] ✉ **Salim Zaabar** [1] **Naïma Bouchefa-Guendouze** [1] **Fatiha Brahmi** [1] **Hocine Remini** [2] **Nesrine Sana Kerrour** [1]

1 University of Bejaia, Faculty of Natural and Life Sciences, Laboratory of Biochemistry, Biophysics, Biomathematics, and Scientometrics (L3BS), 06000 Bejaia, Algeria. hamza.elrobrini@univ-bejaia.dz / salim.zaabar@univ-bejaia.dz / naima.guendouze@univ-bejaia.dz / fatiha.brahmi@univ-bejaia.dz / nesrinesana.kerrour@univ-bejaia.dz

2 Département de Biologie, Faculté des Sciences de la Nature et de la Vie et des Sciences de la Terre, Université de Bouira, 10000 Bouira, Algeria h.remini@univ-bouira.dz

ABSTRACT

Background: Dietary anthocyanins have been recognized for their potent antioxidant and hypolipidemic properties. However, the efficacy of anthocyanin-rich dietary interventions in modulating the lipid metabolism of physically active cohorts remains unclear.

Aims: This exploratory, placebo-controlled pilot study aimed to evaluate whether a short-term (22-day) dietary supplementation with anthocyanin-rich red cabbage juice or red onion salad significantly modulates lipid profile parameters, including low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), and triglycerides (TG), in healthy amateur soccer players.

Methods: Fifteen male amateur soccer players (mean age: 24.86 ± 5.93 years) were enrolled and randomly assigned to three groups: red cabbage, red onion, and placebo. Over a 22-day period, participants consumed their assigned supplement while maintaining their regular physical activity levels. Venous blood samples were collected via the cubital vein before baseline and post-intervention for lipid profile parameters. Statistical significance was assessed using paired *t*-tests and Analysis of Variance (ANOVA) or Welch's ANOVA where appropriate, with the significance threshold set at $p \leq 0.05$.

Results: Intra-group analyses revealed no statistically significant amelioration in lipid parameters within the red cabbage or red onion cohorts. However, a significant elevation in LDL-C concentrations was observed in the placebo group, increasing from 0.63 ± 0.13 to 0.70 ± 0.11 g/L ($p = 0.037$). This observation likely reflects the influence of extraneous, uncontrolled variables rather than a direct consequence of the intervention.

Conclusions: The findings indicate that short-term dietary supplementation with anthocyanins does not significantly alter the lipid profiles of amateur soccer players. This lack of physiological response may be attributable to the optimized lipid metabolism characteristic of physically active individuals or the exploratory nature of the study design. While these preliminary data provide a foundation for future, adequately powered investigations in athletic populations, the results should be interpreted with caution due to the limited sample size.

Keywords: Anthocyanins; Red Cabbage; Red Onion; Amateur Soccer Players; Lipid Profile.

ARTICLE INFORMATION

✉ **Corresponding author:** Hamza ELROBRINI
E-mail : hamza.elrobrini@univ-bejaia.dz
Tel. +213 (542 708 808)

Received: April 12, 2025
Revised: January 01, 2026
Accepted: January 15, 2026
Published: March 07, 2026

Article edited by:
Prof. Khaled Méghit Boumèdiene
Article reviewed by:
Prof. Malika Bendahmane-Salmi
Prof. Mustapha Diaf

Cite this article as: Elrobrini, H., Zaabar, S., Bouchefa-Guendouze, N., Brahimi, F., Remini, H., & Kerrour, N.S. (2026). Impact of Red Cabbage and Red Onion Anthocyanin Supplementation on Lipid Profiles in Amateur Soccer Players: A Randomized Placebo-Controlled Study. *The North African Journal of Food and Nutrition Research, 10*(21): 59–68 https://doi.org/10.51745/najfnr.10.21.59-68

1 INTRODUCTION

Cardiovascular diseases (CVDs) persist as the primary etiology of global mortality, necessitating the development of robust and preventive strategies (Lindstrom *et al.*, 2022). Anthocyanins—a prominent subclass of flavonoids ubiquitous in pigmented flora such as berries, grapes, red cabbages, and onions—have garnered considerable scientific interest for their potential role in mitigating CVD risk through the modulation of lipid profiles (Habanova *et al.*, 2019).

Recent systematic reviews and meta-analyses have reported that anthocyanin supplementation exerts a favorable influence on key cardiovascular biomarkers, specifically through the reductions in of low-density lipoprotein (LDL) cholesterol and triglyceride levels, highlighting their potential as viable dietary interventions for cardiovascular health (Wallace *et al.*, 2016).

The physiological and psychological rigors inherent to athletic performance necessitate optimized nutritional and

recovery patterns. Soccer players, encompassing both professional and amateur cohorts, participate in a discipline requiring high levels of endurance, agility, and strength—factors that typically correlate with superior cardiovascular health (Safonicheva *et al.*, 2023). Nevertheless, despite the established cardiovascular benefits of regular physical activity, amateur athletes may still exhibit fluctuations in lipid profiles driven by inconsistent training intensities, dietary variability, and the oxidative stress associated with competitive environments. Existing literature suggests that targeted dietary interventions may further enhance both the metabolic health and performance outcomes of this population (Krustrup *et al.*, 2009).

Amateur soccer players represent a distinct demographic in which even marginal lipidic alterations could present significant physiological implications given their elevated metabolic demands (Mizelman *et al.*, 2020). Consequently, investigating targeted dietary strategies within this group may provide broader insights into preventive measures for individuals maintaining moderate-to-high levels of physical activity (Aguinaga-Ontoso *et al.*, 2023).

While dietary anthocyanins have demonstrated potential in improving lipid profiles and mitigating oxidative stress, their application as a targeted intervention for physically active cohorts remains insufficiently characterized (Bendokas *et al.*, 2020). Although a limited number of studies have indicated that specific phenolic compounds—such as quercetin (Askari *et al.*, 2013) and resveratrol (Lagouge *et al.*, 2006) —or polyphenol-rich foods like grape extract (Lafay *et al.*, 2009) and beetroot juice (Nyakayiru *et al.*, 2017) may enhance athletic performance, the evidence remains fragmented. As noted by Bojarczuk and Dzitkowska-Zabielska (2023) research concerning the impact of polyphenol supplementation on exercise-induced oxidative stress and antioxidant status in athletes is characterized by sparse and occasionally discordant findings, in contrast to the extensive data available from sedentary human or animal models.

Thus, further empirical exploration is required to determine whether anthocyanin supplementation confers additional cardiovascular benefits, even with populations possessing relatively optimized lipid profiles. The present study was therefore designed as an exploratory, placebo-controlled pilot intervention to evaluate whether short-term (22-day) supplementation with anthocyanin-rich red cabbage juice or red onion salad could induce detectable trends in lipid parameters—specifically total cholesterol, LDL-cholesterol, HDL-cholesterol, and triglycerides—in healthy amateur soccer players. Given the baseline metabolic efficiency of this cohort, the primary objective was not to establish definitive clinical efficacy, but rather to generate preliminary data to inform and direct future larger-scale investigations.

2 Material and Methods

2.1 Study Design

This randomized controlled trial (RCT) was conducted to assess the efficacy of dietary supplementation with anthocyanin-rich vegetables—specifically red cabbage and red onion—on the lipid profiles of amateur soccer players. The investigation was performed over a 22-day period (November - December 2024) at the National Specialized Institute for Vocational Training (INSFP) in Blida, Algeria (Figure 1).

Ethical oversight was provided by the Institutional Review Board (IRB) of the Laboratory of Sciences of Physical Activities (C1680300) at the University of Algiers 3 (Ethical Approval Code: CE-N002/2025; Approval Date: January 5, 2024). All procedures were executed in strict adherence to the principles of the Declaration of Helsinki (Bibbins-Domingo

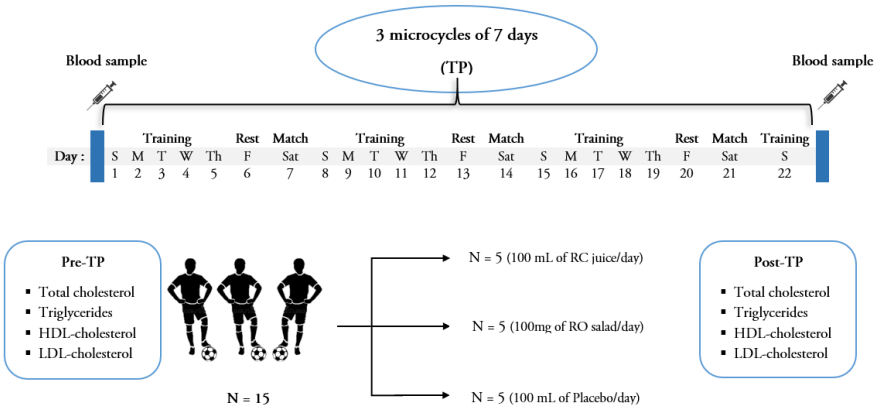

Figure 1. Overview of the Study Design

et al., 2024). Prior to enrollment, all participants provided written informed consent following a comprehensive briefing on the study's objectives and potential risks.

2.2 Participant Recruitment and Selection Criteria

A cohort of 24 individuals was initially screened for eligibility. Of these, 15 male amateur soccer players (Mean Age: 24.86 ± 5.93 years; BMI: 23.69 ± 3.80kg/m^2) were successfully enrolled and randomized. Nine candidates were excluded: four failed to meet the inclusion criteria, three declined participation, and two encountered logistical challenges during the screening phase.

Inclusion and Exclusion Criteria:

- **Inclusion**: Active amateur soccer players affiliated with the vocational training institute.
- **Exclusion**: Pre-existing metabolic or cardiovascular pathologies (e.g., diabetes mellitus, dyslipidemia), gastrointestinal disorders, and the administration of pharmacological agents known to modulate lipid metabolism.

The sample size (n = 15; 5 per group) was determined by the feasibility of recruitment within a single training center and the exploratory nature of this pilot investigation. While not powered to detect subtle effect sizes, this study aimed to identify physiological trends and assess the viability of anthocyanin interventions in athletic cohorts (Figure 2).

2.3 Experimental Interventions

Participants were randomized into three parallel groups:

- **Group 1 (n=5):** Daily consumption of 100 mL of freshly extracted red cabbage juice.
- **Group 2 (n=5):** Daily consumption of 100 g of fresh red onion salad.
- **Group 3 (n=5; Placebo):** Daily consumption of 100 mL of an anthocyanin-free placebo beverage.

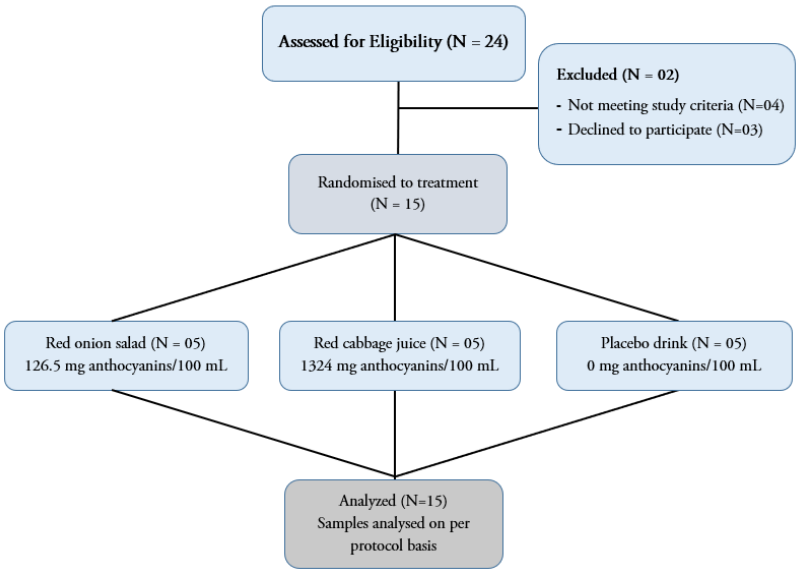

Figure 2. Flowchart of Participant Enrollment, Group Allocation, and Analysis

The supplementation was administered with the participants' regular meals, at the same restaurant where they resided, ensuring consistency in their overall dietary intake.

Preparation and Storage

Fresh produce was procured from local markets in Blida. Red cabbage was processed using a cold-press extractor (Moulinex Juice & Clean ZU420E10) to minimize thermal degradation of bioactive compounds. The juice was portioned and stored at -20°C to preserve antioxidant integrity. Red onions were finely comminuted into 100 g portions and refrigerated until service. Supplements were administered alongside standardized meals to ensure dietary consistency.

Blinding Protocol

The placebo group received plain water served in opaque, purple-tinted bottles identical to the red cabbage juice containers. This measure was implemented to maintain participant blinding regarding the antioxidant content of the beverage (Figure 3).

Figure 3. Preparation of Study Samples; Red Cabbage Juice (RC), Red Onion Salad (RO), and placebo drink

2.4 Biochemical Analysis and Lipid Profiling

Venous blood samples (5 mL) were collected via the antecubital vein following an overnight fast (10-12 hours) at baseline and post-intervention. Samples were collected in clot-activator tubes and centrifuged at 8000 rpm for 15 minutes at 4°C. Serum aliquots were stored at -20°C until analysis.

Lipid parameters—including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C)—were quantified via colorimetric assays using a Selectra Pro-M automated analyzer and AMP Diagnostic kits. All analyses adhered to the manufacturer's standardized operating protocols. For each parameter, calibration standards were prepared, and 200 µL of serum was transferred into a Selectra serum cup. The cup was then placed in the automated Selectra rotor, and analysis was conducted according to the manufacturer's standard operating protocol. Data, including participant age and lipid profile results, were respectively collected (Ahmad *et al.*, 2021).

2.5 Quantification of Total Anthocyanin Content

The total anthocyanin concentration in the experimental substrates was determined using the pH differential method. This technique exploits the structural transformation of anthocyanins between pH 1.0 (flavylium cation) and pH 4.5 (hemiacetal form). Absorbance was measured at 530 nm and 700 nm to correct for turbidity. The difference in absorbance (ΔA) between the two pH conditions was used to calculate anthocyanin concentration, expressed as mg of cyanidin-3-glucoside equivalent (C3G) per 100 mL of sample (Erken, 2022).

Table 1 summarizes the anthocyanin content and pH of red cabbage juice, red onion salad, and placebo drink per 100 mL or 100 g serving.

Table 1. Content of Red Cabbage Juice, Placebo drink in a 100 mL Serving and Red Onion Salad in a 100 g Serving

	Red cabbage	Red onion	Placebo
Anthocyanins (mg)	1324	126.5	0
pH	6	5.5	7.2

2.6 Athletic Training Mesocycle

To ensure ecological validity, the 22-day intervention was synchronized with a standard three-week training mesocycle. The 7-day microcycle structure included:

- **Days 1–5:** High-intensity conditioning (sprints, interval training) and tactical development.
- **Day 6:** Complete physiological recovery (rest).
- **Day 7:** Competitive match play against regional vocational institutes.

2.7 Statistical Analysis

Statistical processing was performed employing IBM SPSS Statistics (v. 27). Intra-group comparisons (pre- vs. post-intervention) were conducted using paired-samples *t*-tests. Inter-group differences were evaluated using one-way Analysis of Variance (ANOVA). In instances where the assumption of homogeneity of variances was violated (Levene's test), Welch's ANOVA was utilized. Post-hoc pairwise comparisons were conducted using Tukey's HSD test when homogeneity of variances was met. When Welch's ANOVA was applied, no post-hoc testing was performed due to the absence of significant omnibus effects. Statistical significance was set at $p < 0.05$. Results are presented as mean ± standard deviation (SD).

3 Results

3.1 Baseline Characteristics and Low-Density Lipoprotein (LDL) Cholesterol

The baseline anthropometric and biochemical characteristics of the study cohort are summarized in Table 2.

At the initiation of the study, LDL-C concentrations were 0.77 ± 0.23 g/L in the red cabbage group, 0.66 ± 0.09 g/L in

Table 2. Baseline Characteristics of the Participants in the Study (Mean values and standard deviations; N = 15)

Characteristics	Results	Standards
Participants (N)	15	
Age (years)	24.86 ± 5.93	
BMI (kg.m-2)	23.69 ± 3.80	18.5 – 25
Blood Pressure (mmHg)		
Systolic	121.33 ± 13.17	120 – 129
Diastolic	70.80 ± 7.55	< 80
Triglycerides (g/L)	0.77 ± 0.23	0.00 – 1.50
Total cholesterol (g/L)	1.22 ± 0.17	0.00 – 2.00
HDL-cholesterol (g/L)	0.38 ± 0.03	> 0.35
LDL-cholesterol (g/L)	0.69 ± 0.17	0.00 – 1.60
Glucose (g/L)	0.94 ± 0.04	0.60 – 1.15

BMI: Body Mass Index; HDL: High-Density Lipoprotein; LDL: Low-Density Lipoprotein.

the red onion group, and 0.63 ± 0.13 g/L in the placebo group (Table 3).

0.36 ± 0.03 g/L to 0.37 ± 0.03 g/L, p = 0.552), red onion group (from 0.38 ± 0.01 g/L to 0.37 ± 0.01 g/L, p = 0.351), and placebo group (from 0.41 ± 0.04 g/L to 0.39 ± 0.04 g/L, p = 0.530).

3.3 Total Cholesterol (TC)

Baseline TC levels were 1.26 ± 0.24 g/L in the red cabbage group, 1.19 ± 0.07 g/L in the red onion group, and 1.21 ± 0.16 g/L in the placebo group. Analysis confirmed that TC concentrations remained stable throughout the study period, with no significant intra-group variations detected: red cabbage (from 1.26 ± 0.24 g/L to 1.30 ± 0.25 g/L, p = 0.244), red onion (from 1.19 ± 0.07 g/L to 1.25 ± 0.11 g/L, p = 0.092), and placebo (from 1.21 ± 0.16 g/L to 1.25 ± 0.17 g/L, p = 0.408).

3.4 Triglycerides (TG)

Pre-intervention TG levels were recorded at 0.67 ± 0.13 g/L for the red cabbage group, 0.80 ± 0.29 g/L for the red

Table 3. Changes in Lipid Profile Following 22 Days of Red Cabbage Juice, Red Onion Salad with Anthocyanins, and Placebo without Anthocyanins

	Red cabbage #		Red onion #		Placebo #	
	Before	After	Before	After	Before	After
N	05		05		05	
Age (years)	23.20 ± 2.63		25.00 ± 6.78		26.40 ± 6.88	
Triglycerides (g/L)	0.67 ± 0.13	0.87 ± 0.32	0.8 ± 0.29	0.95 ± 0.27	0.85 ± 0.21	0.86 ± 0.33
	(p = 0.365)		(p = 0.208)		(p = 0.915)	
Total cholesterol (g/L)	1.26 ± 0.24	1.30 ± 0.25	1.19 ± 0.07	1.25 ± 0.11	1.21 ± 0.16	1.25 ± 0.17
	(p = 0.244)		(p = 0.092)		(p = 0.408)	
HDL-cholesterol (g/L)	0.36 ± 0.03	0.37 ± 0.03	0.38 ± 0.01	0.37 ± 0.01	0.41 ± 0.04	0.39 ± 0.04
	(p = 0.552)		(p = 0.351)		(p = 0.53)	
LDL-cholesterol (g/L)	0.77 ± 0.23	0.75 ± 0.19	0.66 ± 0.09	0.68 ± 0.12	0.63 ± 0.13	0.70 ± 0.11
	(p = 0.56)		(p = 0.277)		(p = 0.037*)	

Note: * No significant changes were observed except for LDL cholesterol in the placebo group (p = 0.037)
Mean Values and Standard Deviations; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol

Intra-group analysis via paired-samples t-tests revealed no statistically significant alterations in LDL-C levels for either the red cabbage group (from 0.77 ± 0.23 g/L to 0.75 ± 0.19 g/L, p = 0.560) or the red onion group (from 0.66 ± 0.09 g/L to 0.68 ± 0.12 g/L, p = 0.277). Unexpectedly, the placebo group exhibited a statistically significant increase in LDL-C levels post-intervention (from 0.63 ± 0.13 g/L to 0.70 ± 0.11 g/L, p = 0.037). These trends are summarized in Table 3 and visually depicted in Figure 4.

3.2 High-Density Lipoprotein (HDL) Cholesterol

At baseline, Mean ± SD concentrations for HDL-C levels were 0.36 ± 0.03 g/L in the red cabbage group, 0.38 ± 0.01 g/L in the red onion group, and 0.41 ± 0.04 g/L in the placebo group. Across all groups, no significant changes in HDL levels were observed post-intervention: red cabbage group (from

onion group, and 0.85 ± 0.21 g/L for the placebo group. Post-intervention assessments indicated a non-significant trend toward increased TG levels in the red cabbage (from 0.67 ± 0.13 g/L to 0.87 ± 0.32 g/L, p = 0.365), red onion group (from 0.80 ± 0.29 g/L to 0.95 ± 0.27 g/L, p = 0.208) and placebo group (from 0.85 ± 0.21 g/L to 0.86 ± 0.33 g/L, p = 0.915).

3.5 Inter-Group Comparison of Lipid Parameters

A one-way ANOVA was performed to assess differences among groups for LDL-C, HDL-C, TC, and TG levels, where the assumption of homogeneity of variance was violated (Levene's test), Welch's ANOVA was applied. Inter-group analyses revealed no statistically significant differences for any of the lipid parameter (p > 0.05). As no significant omnibus

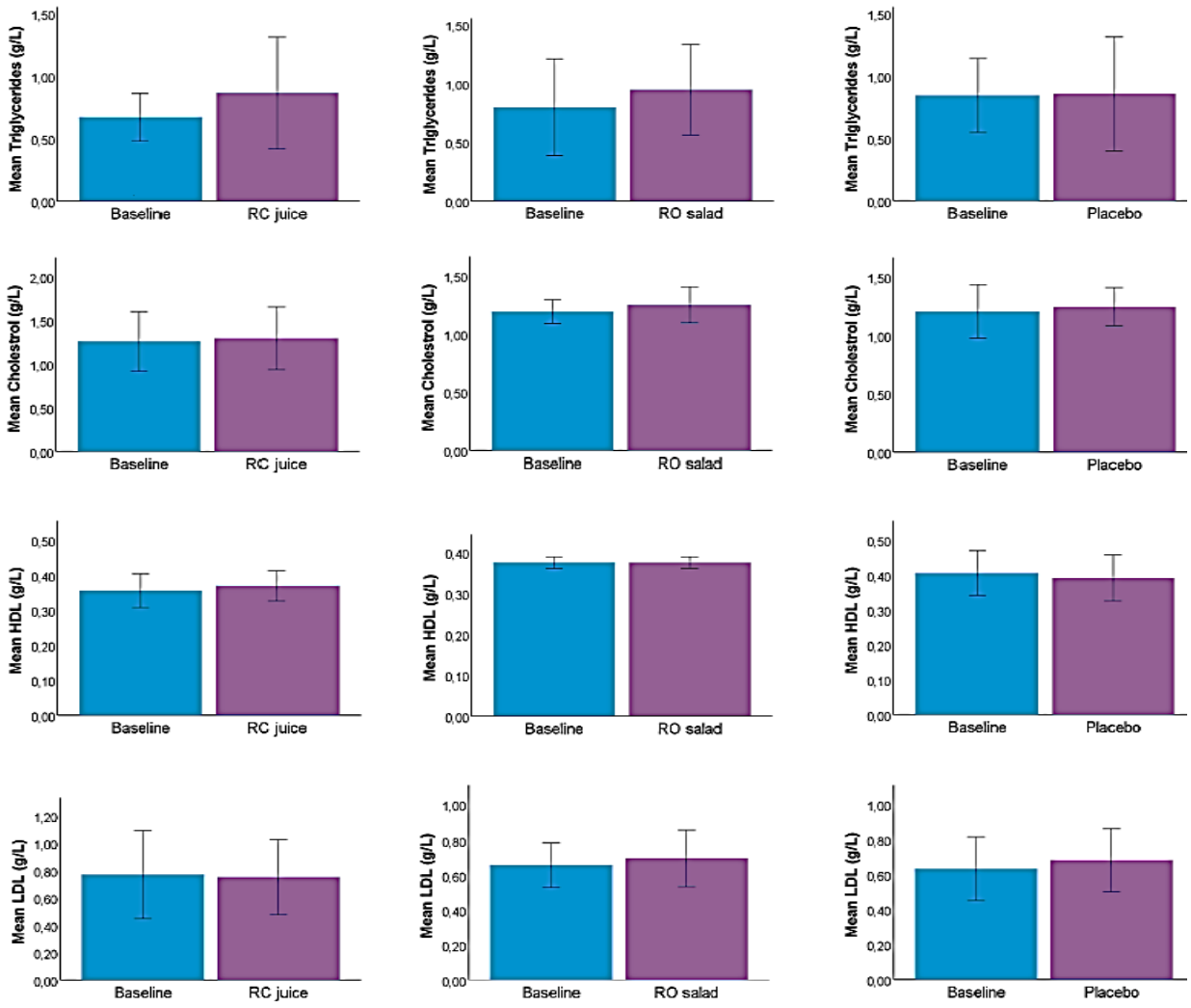

Figure 4. Effects of Red Cabbage Juice (RC Juice), Red Onion Salad (RO Salad), and Placebo Supplementation on Lipid Parameters * Indicates a statistically significant difference compared with baseline within the same group ($p < 0.05$)

effects were observed, post-hoc analyses did not reveal any meaningful pairwise differences.

3.6 Inter-Group Comparison of Lipid Parameters

A one-way ANOVA was performed to assess differences among groups for LDL-C, HDL-C, TC, and TG levels, where the assumption of homogeneity of variance was violated (Levene's test), Welch's ANOVA was applied. Inter-group analyses revealed no statistically significant differences for any of the lipid parameter ($p > 0.05$). As no significant omnibus effects were observed, post-hoc analyses did not reveal any meaningful pairwise differences.

3.7 Safety and Tolerability

The dietary intervention demonstrated high tolerability across all participants. No adverse clinical events, gastrointestinal distress, or unexpected complications were reported throughout the 22-day supplementation period, indicating that 100 mL of red cabbage juice or 100 g of red onion salad is safe for consumption in athletic populations.

4 DISCUSSION

4.1 Low-Density Lipoprotein (LDL) Cholesterol Dynamics

In the present investigation, supplementation with red cabbage juice ($p = 0.560$) or red onion salad (p = 0.277) did not yield statistically significant changes in LDL-C

concentrations. Conversely, the placebo group exhibited a significant elevation in LDL-C levels (p = 0.037). This unexpected trend in the control group remains unexplained and may reflect uncontrolled confounding variables—such as seasonal dietary shifts, minor variations in training load, or inherent biological fluctuations—which may become more pronounced in reduced cohorts. Importantly, the absence of significant inter-group differences ($p < 0.05$) suggests that the observed intra-group change in the placebo arm may represent a random statistical variation rather than a robust physiological shift.

While no significant variations were noticed in lipid parameters in the current study, Bacchetti *et al.* (2014) reported significant reductions in LDL-C and oxidized LDL-C levels following red cabbage supplementation. Likewise, Qin *et al.* (2009) observed a 13.6% decrease in LDL-C following anthocyanin supplementation. These findings align with the hypothesized effects of anthocyanins but contrast with our results, suggesting that factors such as study design, participant characteristics, and intervention length may explain the inconsistencies.

However, some studies are in line with the current survey indicating no substantial effects of anthocyanins on lipid profiles. For instance, a study by Aboufarrag *et al.* (2022) revealed no significant variations in LDL-C, HDL-C, TC, or TG following anthocyanin supplementation in individuals with hyperlipidemia. This aligns with our findings, where no significant reductions in LDL-C was reported.

4.2 High-Density Lipoprotein (HDL) and Total Cholesterol

The stability of HDL-C levels observed in this study (p = 0.552, p = 0.351, p = 0.530 across groups) diverges from research on *Hibiscus sabdariffa* anthocyanins, which significantly elevated HDL-C levels in patients with metabolic syndrome (Gurrola-Díaz *et al.*, 2010). The absence of modulation in our cohort may could be due to the healthy lipid profiles of our participants, the short duration of the intervention (22 days), or differences in specific anthocyanin profiles present in red cabbage and onions versus other botanical sources.

Similarly, total cholesterol concentrations remained unchanged (p = 0.244, p = 0.092, p = 0.408), aligning with findings by Stankiewicz *et al.* (2021) regarding chokeberry supplementation in athletes. However, some studies on red cabbage supplementation have demonstrated reductions in TC (Bacchetti *et al.*, 2014). These differences may reflect the complex bioavailability and bioactivity of anthocyanins and other phytochemicals, as well as the dietary patterns of the participants.

4.3 Triglyceride Concentrations

Triglyceride (TG) levels demonstrated no significant differences across groups (p = 0.365, p = 0.208, p = 0.915). This suggests limited effects of red cabbage and red onion supplementation on triglycerides in our cohort. This finding contrasts with research on *Hibiscus sabdariffa*, which demonstrated a triglyceride-lowering effect in individuals with metabolic syndrome (Gurrola-Díaz *et al.*, 2010). While red onion extracts have demonstrated potential for inhibiting pancreatic lipase *in vitro* (Escalante-Aburto *et al.*, 2023) our data suggests that 100 g of fresh onion salad may not provide a sufficient dosage to elicit systemic TG-lowering effects in the short term.

4.4 Inter-group Comparisons

The one-way and Welch's ANOVA confirmed that no significant omnibus effects existed between the treatment arms, a finding further substantiated by the absence of pairwise differences in the Tukey's HSD post-hoc analysis. Overall, the interventions did not significantly affect lipid profiles, suggesting the need for further research to validate these findings and identify potential influencing factors.

4.5 Study Limitations and Future Directions

As an exploratory pilot study, several limitations must be acknowledged:

- *Statistical Power*: The small sample size (n=15) increases the risk of a Type II error, potentially masking subtle biological effects.
- *Intervention Duration*: 22 days may be insufficient to observe significant shifts in lipid metabolism, which often require 6 – 12 weeks of sustained dietary modification.
- *Ecological Validity vs. Control*: While the study was conducted within a structured training mesocycle, the inclusion of additional precise dietary monitoring (e.g., 24-hour recalls) would further mitigate confounding.

Recent evidence supports the potential of polyphenols beyond anthocyanins in influencing physical performance and health markers. For instance, Parenteau *et al.* (2024) reported that polyphenol-rich berry supplementation, while not significantly improving exercise biomarkers, exhibited a positive trend in extending time to exhaustion in athletes. Similarly, Bibi *et al.* (2024) demonstrated that pomegranate, rich in polyphenols, could enhance performance and health parameters such as HDL and blood pressure. These findings underscore the importance of exploring diverse polyphenolic compounds for their potential to optimize both performance and metabolic health outcomes.

Therefore, the absence of statistically significant effects should not be interpreted as evidence of inefficacy but rather

as a consequence of limited statistical power inherent to pilot studies.

5 CONCLUSIONS

This pilot study evaluated the impact of a 22-day dietary intervention with red cabbage juice and red onion salad on the lipid profiles of healthy amateur soccer players. the interventions did not yield significant reductions in TC, LDL-C, HDL-C, or TG, the stability of the intervention groups relative to the elevation observed in the placebo group suggests a potential "stabilizing" effect of anthocyanins against metabolic fluctuations.

These findings underscore the complexity of translating the known bioactivity of polyphenols into measurable clinical outcomes in normolipidemic, physically active populations. Our results support the necessity for higher-powered, longitudinal randomized controlled trials to determine the efficacy of anthocyanin-rich foods as a targeted cardioprotective strategy for athletes.

Furthermore, exploring the molecular mechanisms underlying anthocyanin bioactivity, such as their influence on lipid metabolism enzymes or anti-inflammatory pathways, could provide deeper insights. Comparative studies with other polyphenol-rich compounds, including those from berries or pomegranate, may also help identify synergistic effects on lipid profiles and cardiovascular health.

These findings contribute to the growing body of evidence on the potential cardioprotective effects of anthocyanins, while underscoring the complexity of translating these benefits into practical dietary recommendations. By addressing the limitations noted in this study, future research can better delineate the role of dietary anthocyanins in promoting metabolic and cardiovascular health in diverse populations.

Overall, these results should be viewed as hypothesis-generating rather than confirmatory and support the need for larger, longer-term randomized trials to clarify the role of anthocyanin-rich foods in lipid metabolism among athletes.

Acknowledgment: The VLIR-UOS-IUC Project is acknowledged for its support.

Source of funding: NA

Previous submissions: We declare that this manuscript is originAL, has not been published before and is not currently being considered for publication elsewhere.

Authors' Contribution: Elrobrini H.: Conceptualization and Study Designed, Intellectual content, Data acquisition and Analysis, Manuscript Drafting. **Bouchefa-Guendouze N.**: Supervision, Editing and Review, and Revisions. **Brahmi F.**: Manuscript preparation, Editing, and Review. **Remini H.**: Statistical Analysis and Review. **Zaabar S.**: Project leader, Drafting manuscript. **Kerrour S.N.**: Statistical Analysis and Conception of the Study.

Conflicts of Interest: There are no conflicts of interest to declare.

Preprint deposit: Authors did not share this manuscript as a preprint deposit.

REFERENCES

Aboufarrag, H., Hollands, W. J., Percival, J., Philo, M., Savva, G. M., & Kroon, P. A. (2022). No effect of isolated anthocyanins from bilberry fruit and black rice on LDL cholesterol or other biomarkers of cardiovascular disease in adults with elevated cholesterol: A randomized, placebo-controlled, cross-over tri*al. Molecular Nutrition & Food Research*, *66*(21), e2101157. https://doi.org/10.1002/mnfr.202101157 [Crossref] [PubMed] [Google Scholar] [Publisher]

Aguinaga-Ontoso, I., Guillen-Aguinaga, S., Guillen-Aguinaga, L., Alas-Brun, R., & Guillen-Grima, F. (2023). Effects of nutrition interventions on athletic performance in soccer players: A systematic review. *Life (Basel, Switzerland)*, *13*(6), 1271. https://doi.org/10.3390/life13061271 [Crossref] [PubMed] [Google Scholar] [Publisher]

Ahmad, I., Jan, H., Ahmed, A., Ihteshamulhaq, Khan, A. A., Shahab, M., Rehmat, N., Iftakhar, F. B., Ahmad, B., & Shan, F. (2021). Determination of serum lipid profile in elderly and non-elderly Pakistani Acute myocardial infarction patients. *Annals of the Romanian Society for Cell Biology*, *25*(7), 708–717. http://annalsofrscb.ro/index.php/journal/article/view/10088 [Crossref] [Google Scholar] [Publisher]

Askari, G., Ghiasvand, R., Paknahad, Z., Karimian, J., Rabiee, K., Sharifirad, G., & Feizi, A. (2013). The effects of quercetin supplementation on body composition, exercise performance and muscle damage indices in athletes. *International Journal of Preventive Medicine*, *4*(1),https://pubmed.ncbi.nlm.nih.gov/23412140/ [Crossref] [PubMed] [Google Scholar] [Publisher]

Bacchetti, T., Tullii, D., Masciangelo, S., Gesuita, R., Skrami, E., Brugè, F., Silvestri, S., Orlando, P., Tiano, L., & Ferretti, G. (2014). Effect of black and red cabbage on plasma carotenoid levels, lipid profile and oxidized low density lipoprotein. *Journal of Functional Foods*, *8*, 128–137. https://doi.org/10.1016/j.jff.2014.02.020 [Crossref] [Google Scholar] [Publisher]

Bendokas, V., Stanys, V., Mažeikienė, I., *et al.* (2020). Anthocyanins: From the field to the antioxidants in the body. Antioxidants, 9(9), 819. https://doi.org/10.3390/antiox9090819 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bibbins-Domingo, K., Brubaker, L., & Curfman, G. (2024). The 2024 revision to the declaration of Helsinki: Modern ethics for medical research: Modern ethics for medical research. *The Journal of the American Medical Association*. https://doi.org/10.1001/jama.2024.22530 [Crossref] [Google Scholar] [Publisher]

Bibi, J., Lei, Y., Kotwica-Mojzych, K., Głowacka, M., & Mojzych, M. (2024). The power of pomegranate as natural supplement remedy for sportsmen and athletes: A systematic review and meta-analysis. *Journal of Functional Foods*, *121*(106453), 106453. https://doi.org/10.1016/j.jff.2024.106453 [Crossref] [Google Scholar] [Publisher]

Bojarczuk, A., & Dzitkowska-Zabielska, M. (2023). Polyphenol supplementation and antioxidant status in athletes: A narrative review. *Nutrients*, *15*(1), 158. https://doi.org/10.3390/nu15010158 [Crossref] [PubMed] [Google Scholar] [Publisher]

Erken, O. (2022). Some bioactive metabolites' response to long-term water stress in red cabbage. *Scientia Horticulturae*, *293*(110731), 110731. https://doi.org/10.1016/j.scienta.2021.110731 [Crossref] [Google Scholar] [Publisher]

Escalante-Aburto, A., Mendoza-Córdova, M. Y., Mahady, G. B., Luna-Vital, D. A., Gutiérrez-Uribe, J. A., & Chuck-Hernández, C. (2023). Consumption of dietary anthocyanins and their association with a reduction in obesity biomarkers and the prevention of obesity. *Trends in Food Science & Technology*, *140*(104140), 104140. https://doi.org/10.1016/j.tifs.2023.104140 [Crossref] [Google Scholar] [Publisher]

Gaamouri, N., Zouhal, H., Hammami, M., Hackney, A. C., Abderrahman, A. B., Saeidi, A., El Hage, R., & Ounis, O. B. (2019). Effects of polyphenol (carob) supplementation on body composition and aerobic capacity in taekwondo athletes. *Physiology & Behavior*, *205*, 22–28. https://doi.org/10.1016/j.physbeh.2019.03.003 [Crossref] [PubMed] [Google Scholar] [Publisher]

Gurrola-Díaz, C. M., García-López, P. M., Sánchez-Enríquez, S., Troyo-Sanromán, R., Andrade-González, I., & Gómez-Leyva, J. F. (2010). Effects of Hibiscus sabdariffa extract powder and preventive treatment (diet) on the lipid profiles of patients with metabolic syndrome (MeSy). *Phytomedicine: International Journal of Phytotherapy and Phytopharmacology*, *17*(7), 500–505. https://doi.org/10.1016/j.phymed.2009.10.014 [Crossref] [PubMed] [Google Scholar] [Publisher]

Habanova, M., Saraiva, J. A., Holovicova, M., Moreira, S. A., Fidalgo, L. G., Haban, M., Gazo, J., Schwarzova, M., Chlebo, P., & Bronkowska, M. (2019). Effect of berries/apple mixed juice consumption on the positive modulation of human lipid profile. *Journal of Functional Foods*, *60*(103417), 103417. https://doi.org/10.1016/j.jff.2019.103417 [Crossref] [Google Scholar] [Publisher]

Krustrup, P., Nielsen, J. J., Krustrup, B. R., Christensen, J. F., Pedersen, H., Randers, M. B., Aagaard, P., Petersen, A.-M., Nybo, L., & Bangsbo, J. (2009). Recreational soccer is an effective health-promoting activity for untrained men. *British Journal of Sports Medicine*, *43*(11), 825–831. https://doi.org/10.1136/bjsm.2008.053124 [Crossref] [PubMed] [Google Scholar] [Publisher]

Lafay, S., Jan, C., Nardon, K., Lemaire, B., Ibarra, A., Roller, M., Houvenaeghel, M., Juhel, C., & Cara, L. (2009). Grape extract improves antioxidant status and physical performance in elite male athletes. *Journal of Sports Science & Medicine*, *8*(3), 468–480. https://pmc.ncbi.nlm.nih.gov/articles/PMC3763295/ [Crossref] [PubMed] [Google Scholar] [Publisher]

Lagouge, M., Argmann, C., Gerhart-Hines, Z., Meziane, H., Lerin, C., Daussin, F., Messadeq, N., Milne, J., Lambert, P., Elliott, P., Geny, B., Laakso, M., Puigserver, P., & Auwerx, J. (2006). Resveratrol improves mitochondrial function and protects against metabolic disease by activating SIRT1 and PGC-1alpha. *Cell*, *127*(6), 1109–1122. https://doi.org/10.1016/j.cell.2006.11.013 [Crossref] [PubMed] [Google Scholar] [Publisher]

Lindstrom, M., DeCleene, N., Dorsey, H., Fuster, V., Johnson, C. O., LeGrand, K. E., Mensah, G. A., Razo, C., Stark, B., Varieur Turco, J., & Roth, G. A. (2022). Global burden of cardiovascular diseases and risks collaboration, 1990-2021. *Journal of the American College of Cardiology*, *80*(25), 2372–2425. https://doi.org/10.1016/j.jacc.2022.11.001 [Crossref] [PubMed] [Google Scholar] [Publisher]

Mizelman, E., Chilibeck, P. D., Hanifi, A., Kaviani, M., Brenna, E., & Zello, G. A. (2020). A low-glycemic index, high-fiber, pulse-based diet improves lipid profile, but does not affect performance in soccer players. *Nutrients*, *12*(5). https://doi.org/10.3390/nu12051324 [Crossref] [PubMed] [Google Scholar] [Publisher]

Nyakayiru, J., Jonvik, K. L., Trommelen, J., Pinckaers, P. J. M., Senden, 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*(3), 314. https://doi.org/10.3390/nu9030314 [Crossref] [PubMed] [Google Scholar] [Publisher]

Parenteau, F., St-Amant, A., & Bergdahl, A. (2024). Effects of polyphenol-rich, berry supplementation on exercise performance: A systematic review and meta-analysis. *Clinical Nutrition Open Science*, *56*, 241–253. https://doi.org/10.1016/j.nutos.2024.06.006[Crossref] [Google Scholar] [Publisher]

Qin, Y., Xia, M., Ma, J., Hao, Y., Liu, J., Mou, H., Cao, L., & Ling, W. (2009). Anthocyanin supplementation improves serum LDL- and HDL-cholesterol concentrations associated with the inhibition of cholesteryl ester transfer protein in dyslipidemic subjects. *The American Journal of Clinical Nutrition*, *90*(3), 485–492.

https://doi.org/10.3945/ajcn.2009.27814 [Crossref] [PubMed] [Google Scholar] [Publisher]

Safonicheva, O., Kryuchkova, K., Lazareva, I., Chekulaev, P., Ovchinnikova, M., Kurshev, V., Budanova, E., Gameeva, V., Gavrilov, V., Epishev, V., & Zaborova, V. (2023). Study of Morpho-functional characteristics of the cardiovascular system according to electrocardiography, phonocardiography, echocardiography in master athletics. *Clinical Interventions in Aging*, *18*, 2079–2092. https://doi.org/10.2147/CIA.S432202 [Crossref] [PubMed] [Google Scholar] [Publisher]

Stankiewicz, B., Cieślicka, M., Kujawski, S., Piskorska, E., Kowalik, T., Korycka, J., & Skarpańska-Stejnborn, A. (2021). Effects of antioxidant supplementation on oxidative stress balance in young footballers- a randomized double-blind tri*al. Journal of the International Society of Sports Nutrition*, *18*(1), 44. https://doi.org/10.1186/s12970-021-00447-z [Crossref] [PubMed] [Google Scholar] [Publisher]

Wallace, T. C., Slavin, M., & Frankenfeld, C. L. (2016). Systematic review of anthocyanins and markers of cardiovascular disease. *Nutrients*, *8*(1), 32. https://doi.org/10.3390/nu8010032 [Crossref] [PubMed] [Google Scholar] [Publisher]