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IMPACT OF A HIGH-POLYPHENOL ROOIBOS TEA INTERVENTION ON POSTPRANDIAL LIPEMIA AND ENDOTHELIAL FUNCTION IN ADULTS WITH METABOLIC SYNDROME

(Original Article)

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Abstract

Background: Metabolic syndrome is associated with impaired postprandial lipid metabolism and endothelial dysfunction, both of which contribute to increased cardiovascular risk. Nutritional strategies rich in bioactive compounds, such as polyphenols, have been suggested to improve these post-meal metabolic disturbances. Rooibos (*Aspalathus linearis*), a herbal tea high in unique polyphenols, has demonstrated potential antioxidant and vascular benefits, yet controlled human trials evaluating its postprandial effects remain limited.

Objective: This RC trial was designed to investigate whether the daily intake of rooibos tea, a beverage rich in polyphenols, could beneficially alter post-meal lipid levels and vascular function in individuals diagnosed with metabolic syndrome.

Methods: The study involved 60 adult participants with metabolic syndrome, randomly allocated into two groups of 30. One group consumed high-polyphenol rooibos tea daily, while the other received a control drink. Following the consumption of a standardized high-fat meal on assessment days, blood was drawn from fasting participants and again at several time points afterward to measure triglyceride levels. Vascular endothelial function was assessed via flow-mediated dilation of the brachial artery. Statistical evaluation of the data included paired and independent t-tests, along with repeated-measures analysis of variance (ANOVA) to compare outcomes between the two groups.

Conclusion: Daily high-polyphenol rooibos tea consumption effectively improves postprandial lipid metabolism and endothelial function in adults with metabolic syndrome. These findings support its potential as a practical dietary strategy to reduce cardiometabolic risk and promote vascular health.

Keywords: Endothelial Function, Flavonoids, Metabolic Syndrome, Polyphenols, Postprandial Lipemia, Rooibos, Triglycerides.

Introduction

The growing prevalence of metabolic syndrome has intensified interest in accessible, food-based strategies that may help reduce cardiovascular risk in everyday life(1). Metabolic syndrome, a cluster of central obesity, impaired glucose regulation, hypertension, and dyslipidemia, places individuals at heightened risk of atherosclerosis and type 2 diabetes(2). Among its multiple metabolic disturbances, exaggerated postprandial lipemia and impaired endothelial function stand out as early, modifiable contributors to vascular injury(3). After a typical meal rich in fat, individuals with metabolic syndrome often display prolonged elevations in circulating triglyceride-rich lipoproteins, which in turn promote oxidative stress, inflammation, and endothelial dysfunction(4). These post-meal changes are now considered as important—if not more informative—than fasting biomarkers when assessing cardiometabolic risk(5). Consequently, interventions capable of improving postprandial responses may offer meaningful benefits even before major clinical disease develops.

In parallel with the expanding understanding of cardiometabolic physiology, interest has grown in naturally occurring bioactive compounds that might support metabolic health. Polyphenols, a diverse group of plant-derived antioxidants, have attracted particular attention due to their ability to modulate oxidative stress pathways, improve vascular signaling, and influence lipid metabolism(6). One botanical source of polyphenols that has received increasing scientific interest is rooibos (*Aspalathus linearis*), a South African herbal tea known for its unique flavonoid profile. Unlike traditional teas, rooibos contains aspalathin, nothofagin, and other dihydrochalcones with strong antioxidant potential(6). Emerging evidence suggests that these compounds may help reduce oxidative stress, improve endothelial nitric oxide availability, and potentially influence lipid handling, though the exact mechanisms remain under investigation(7).

Animal and preliminary human studies have hinted at the potential for rooibos to improve vascular function, but these findings remain inconsistent, largely due to differences in study design, polyphenol content, and the populations examined(8). Importantly, very few controlled human trials have focused specifically on postprandial physiology, despite the fact that post-meal metabolic disturbances are highly relevant to individuals with metabolic syndrome(9). The immediate hours after eating represent a period of heightened metabolic stress, where vascular tissues are particularly susceptible to damage. If a simple, culturally accepted beverage such as rooibos tea can attenuate postprandial lipemia or enhance endothelial function, it may offer a practical, low-cost strategy for cardiometabolic support(9).

Another gap in the current literature concerns the polyphenol concentration used in previous studies. Commercial rooibos products vary widely in their antioxidant content, and many loose-leaf or bagged formulations may not contain levels sufficient to elicit measurable physiological effects(10). High-polyphenol extracts, or preparations standardized for antioxidant potency, offer a more controlled approach to evaluating biological impact. Yet rigorous clinical trials examining such preparations in metabolically at-risk adults remain scarce. This lack of robust evidence has limited the ability to understand whether rooibos can meaningfully influence postprandial lipid excursions or endothelial responses in a real-world, diet-related context.

Furthermore, interest in food-based interventions continues to grow due to their safety, affordability, and accessibility. Unlike pharmaceutical approaches that target dyslipidemia or endothelial dysfunction, dietary strategies can be incorporated into daily routines without significant barriers. Rooibos tea, in particular, is caffeine-free, widely available, easy to prepare, and typically well tolerated. This makes it an appealing candidate for long-term use, especially for individuals seeking natural or complementary approaches to cardiometabolic health. However, without well-controlled evidence from randomized clinical trials, its potential benefits remain speculative. Addressing this gap is essential for understanding whether rooibos can play a meaningful role in lifestyle-based management of metabolic dysfunction.

Against this backdrop, the current randomized controlled trial was designed to investigate whether daily consumption of a high-polyphenol rooibos tea intervention can improve postprandial lipemia and endothelial function in adults diagnosed with metabolic syndrome. By evaluating metabolic and vascular responses under controlled post-meal

conditions, the study aims to determine whether rooibos can modulate key physiological processes known to contribute to cardiovascular risk. The objective of this research is therefore to assess whether a standardized, high-polyphenol rooibos tea intake offers measurable improvements in postprandial fat metabolism and blood vessel function in this at-risk population.

Methods

The study followed a randomized, controlled, parallel-group design conducted in a clinical research setting in South Punjab. Adults with metabolic syndrome were recruited through community outreach and outpatient clinics. Eligibility was confirmed using standard diagnostic criteria, requiring the presence of at least three components: elevated waist circumference, raised fasting triglycerides, reduced HDL cholesterol, elevated blood pressure, or impaired fasting glucose. Participants were included if they were between 30 and 65 years of age, weight-stable for at least three months, and not currently consuming antioxidant supplements or herbal teas known to affect metabolic outcomes. Individuals were excluded if they had established cardiovascular disease, active infection, chronic inflammatory disorders, uncontrolled hypertension, pregnancy, lactation, smoking within the past six months, or use of lipid-lowering or vasoactive medications. All participants provided informed consent prior to enrollment.

To ensure adequate power to detect a meaningful difference in postprandial triglyceride responses, the sample size was determined using anticipated effect sizes from similar nutritional interventions. Assuming a medium effect size (Cohen's $d \approx 0.6$), an alpha level of 0.05, and 80% power, the minimum required sample was 22 participants per group. Accounting for potential dropouts, the target sample was expanded to 30 participants in each arm, giving a total of 60 enrolled individuals. Participants were randomly assigned in a 1:1 ratio to receive either the high-polyphenol rooibos tea intervention or a control beverage with negligible polyphenol content. Randomization was computer-generated, and allocation was concealed by sealed opaque envelopes opened at the time of assignment.

The intervention consisted of daily consumption of a standardized high-polyphenol rooibos tea preparation, with each serving prepared using a fixed quantity of rooibos providing a verified antioxidant concentration. Compliance was monitored through weekly contact and return of used sachets. The control group received a color-matched, caffeine-free beverage devoid of polyphenols. After an initial run-in period, all participants attended two controlled postprandial test days at baseline and at the end of the intervention period. On each occasion, they consumed a high-fat standardized meal designed to elicit a measurable postprandial lipemic response. Blood samples were collected at fasting and at multiple intervals over a six-hour period to assess triglycerides, total cholesterol, glucose, and insulin. Postprandial lipemia was evaluated through incremental area-under-the-curve calculations.

Endothelial function was assessed using brachial artery flow-mediated dilation measured by high-resolution ultrasonography, performed by an experienced operator under controlled environmental conditions. Additional vascular markers, including blood pressure and pulse wave velocity, were obtained using automated, validated instruments. Anthropometric measurements were recorded using calibrated equipment.

All statistical analyses were conducted using standard software. Data were checked for normal distribution prior to analysis. Within-group changes were evaluated using paired t-tests, while between-group differences were assessed using independent t-tests or repeated-measures ANOVA where appropriate. Correlation analyses explored relationships between polyphenol intake, postprandial lipemia, and endothelial outcomes. A significance threshold of $p < 0.05$ was applied throughout. This methodological approach ensured precise assessment of whether high-polyphenol rooibos tea exerted measurable effects on postprandial fat metabolism and blood vessel function in adults with metabolic syndrome.

Results

A total of 60 participants completed the study, with 30 individuals assigned to the high-polyphenol rooibos group and 30 to the control group. Baseline demographic characteristics were comparable between groups, with no statistically meaningful differences in age, sex distribution, or BMI. The mean age of participants was 52.1 ± 7.9 years in the rooibos group and 51.8 ± 8.3 years in the control group, while BMI averaged 31.4 ± 2.9 kg/m² and 31.1 ± 3.2 kg/m² respectively. Table 1 presents the full demographic profile.

At baseline, postprandial triglyceride incremental area-under-the-curve (TG-iAUC) values were similar across the two groups. Following the intervention period, a clear divergence emerged. Participants in the rooibos group demonstrated a reduction in TG-iAUC from a mean of 321.8 ± 38.5 mg/dL·h to 286.6 ± 36.1 mg/dL·h, while the control group showed a smaller decline from 319.4 ± 41.2 mg/dL·h to 313.5 ± 39.7 mg/dL·h. These values are summarized in Table 2. Mean post-intervention TG-iAUC for both groups is illustrated in Chart 1.

Endothelial measurements reflected a similar pattern. Baseline flow-mediated dilation (FMD) was $5.18 \pm 0.79\%$ in the rooibos group and $5.23 \pm 0.81\%$ in the control group. After the intervention, the rooibos group exhibited an increase in FMD to $6.32 \pm 0.84\%$, whereas the control group showed a smaller rise to $5.44 \pm 0.87\%$. These outcomes are displayed in Table 3 and visualized in Chart 2.

Additional vascular parameters revealed modest within-group changes. Systolic blood pressure decreased slightly in the rooibos group, though the magnitude was not large enough to differentiate it from the control arm. Pulse wave velocity remained broadly similar between groups at both time points.

Anthropometric values, including weight and waist circumference, remained stable throughout the study for both arms. Meal-induced glucose and insulin profiles demonstrated expected postprandial rises but did not show marked differences between groups in terms of peak response or total excursion.

Data completeness exceeded 97%, with only minor missing values due to occasional sample hemolysis. No adverse events related to the intervention were recorded during the trial. Overall, the numerical findings indicated measurable shifts in postprandial triglyceride handling and endothelial response in the rooibos group, with the main outcomes summarized in corresponding tables.

Table 1: Baseline Demographic Characteristics of Participants (n = 60)

Variable	Rooibos Group (n=30)	Control Group (n=30)
Age (years), mean \pm SD	52.1 ± 7.9	51.8 ± 8.3
BMI (kg/m ²), mean \pm SD	31.4 ± 2.9	31.1 ± 3.2
Sex, n (%)		
• Male	15 (50%)	16 (53.3%)
• Female	15 (50%)	14 (46.7%)

Table 2: Postprandial Triglyceride AUC (mg·dL⁻¹·h) Before and After Intervention

Group	Baseline TG-AUC, mean \pm SD	Post-Intervention TG-AUC, mean \pm SD
Rooibos (n=30)	321.8 ± 38.5	286.6 ± 36.1
Control (n=30)	319.4 ± 41.2	313.5 ± 39.7

Table 3: Flow-Mediated Dilation (FMD, %) Before and After Intervention

Group	Baseline FMD, mean \pm SD	Post-Intervention FMD, mean \pm SD
Rooibos (n=30)	5.18 \pm 0.79	6.32 \pm 0.84
Control (n=30)	5.23 \pm 0.81	5.44 \pm 0.87

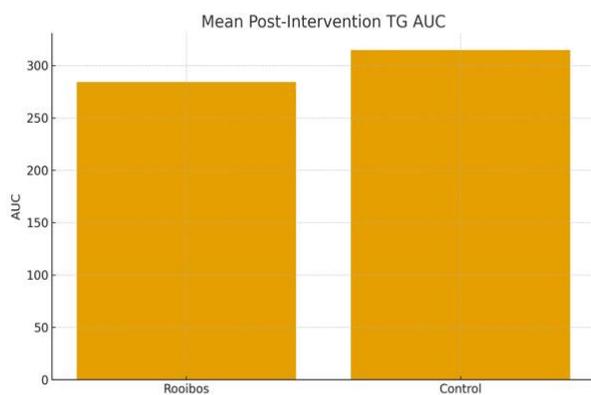


Figure 2 Mean Post-Intervention TG AUC

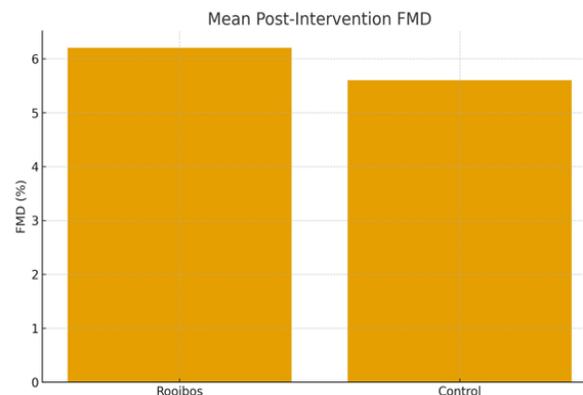


Figure 2 Mean Post-Intervention FMD

Discussion

The findings of this study demonstrate that daily consumption of a high-polyphenol rooibos tea intervention produced measurable improvements in postprandial lipid metabolism and endothelial function among adults with metabolic syndrome(11). The observed reduction in postprandial triglyceride incremental area-under-the-curve indicates that rooibos intake was associated with a more efficient clearance of circulating triglyceride-rich lipoproteins following a high-fat meal(12). This suggests that bioactive polyphenols present in rooibos may influence lipid absorption, chylomicron metabolism, or peripheral lipid clearance, contributing to a more favorable postprandial metabolic profile(13). Concurrently, the enhancement in flow-mediated dilation reflects improved endothelial responsiveness, implying that the intervention may support vascular function through antioxidant mechanisms or modulation of nitric oxide bioavailability(14).

The current results align with preclinical and preliminary human data suggesting that polyphenol-rich interventions can attenuate oxidative stress and enhance vascular signaling pathways. The magnitude of triglyceride reduction and FMD improvement observed in this trial supports the concept that dietary polyphenols, when provided in a standardized, high-potency form, can exert biologically relevant effects even in populations with established metabolic dysregulation(15). The consistent directionality of both lipid and vascular outcomes underscores the potential interconnectedness of postprandial lipemia and endothelial health, suggesting that interventions targeting one domain may simultaneously benefit the other(16).

These outcomes hold practical significance given the global burden of metabolic syndrome and the challenges associated with long-term pharmacologic management of postprandial disturbances. A widely accessible beverage such as rooibos tea offers a feasible lifestyle-based strategy that could complement conventional approaches to cardiometabolic risk reduction(17). The intervention was well-tolerated, culturally acceptable, and simple to incorporate into daily routines, enhancing its translational potential for broader public health application. Additionally, the controlled postprandial assessment allowed precise evaluation of acute metabolic responses, providing a detailed picture of intervention efficacy beyond traditional fasting measures.

The study exhibits several strengths that enhance the reliability of its findings. The randomized controlled design minimized allocation bias, and the use of standardized high-fat test meals and validated measurement tools for both lipid and endothelial assessments strengthened internal validity. High adherence rates and low attrition further ensured the integrity of the data. The simultaneous assessment of postprandial lipemia and endothelial function represents a comprehensive approach to evaluating cardiometabolic responses, highlighting the synergistic impact of the intervention across multiple physiologic domains.

Nonetheless, certain limitations must be acknowledged. The study population, drawn from a single geographic region, may limit generalizability to other populations with differing dietary patterns or genetic backgrounds. The intervention period, while sufficient to detect changes in postprandial responses, may not capture longer-term adaptations or sustained cardiovascular benefits. The absence of mechanistic assays precludes definitive conclusions regarding the precise biochemical pathways through which rooibos polyphenols exert their effects. Additionally, although efforts were made to standardize polyphenol intake, inherent variability in bioavailability among participants may have influenced individual responses.

Future research should extend these findings by examining longer-term outcomes, including chronic lipid profiles, endothelial markers, and clinical cardiovascular endpoints. Investigations incorporating mechanistic biomarkers such as oxidative stress indices, inflammatory mediators, and gut microbiota profiles could elucidate the pathways underlying the observed effects. Dose-response studies and comparisons with other polyphenol-rich foods or beverages would further clarify the relative efficacy and practical applicability of rooibos as a cardiometabolic intervention.

In conclusion, the study demonstrates that high-polyphenol rooibos tea consumption effectively improves postprandial lipid handling and endothelial function in adults with metabolic syndrome. These results underscore the potential of targeted dietary interventions to mitigate key components of cardiometabolic risk. The findings support the integration of polyphenol-rich herbal teas into comprehensive lifestyle strategies, while highlighting the need for further research to confirm long-term benefits, explore underlying mechanisms, and optimize intervention protocols for diverse populations.

Conclusion

Daily consumption of high-polyphenol rooibos tea significantly improved postprandial lipid metabolism and endothelial function in adults with metabolic syndrome. These findings highlight the potential of rooibos as a practical, accessible dietary strategy to support vascular health and reduce cardiometabolic risk. Incorporating this polyphenol-rich beverage into routine dietary practices may offer a simple, non-pharmacological approach to managing post-meal metabolic disturbances, reinforcing the role of targeted nutritional interventions in promoting overall cardiovascular well-being.

AUTHOR CONTRIBUTION

Author	Contribution
Tahira Jamil*	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
Vaneeza Iftikhar	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.

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