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ORIGINAL RESEARCH

# The Impact of Yogurt, Legumes, and Coffee on Health Outcomes in HIV: You are What You Eat?

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**Background:** HIV-induced immunodeficiency and comorbidities highlight the importance of nutritional support. While the World Health Organization (WHO) advocates for dietary interventions in people living with HIV (PLWH), robust clinical evidence remains limited.

**Methods:** This study continuously enrolled 280 newly diagnosed PLWH (≥16 years) without opportunistic infections or malignancies. Participants were stratified into high- and low-consumption groups based on dietary intake: yogurt (≥300 mL/week vs <300 mL/week), legumes (≥180 g/week vs <180 g/week), and black coffee (≥3 cups/week vs <3 cups/week), excluding sugary and milk-based coffee. Clinical assessments included laboratory tests, liver fibrosis and steatosis evaluation (FibroScan, AST-to-platelet ratio index [APRI], and controlled attenuation parameter [CAP]), and physical and mental health assessments using the 36-Item Short Form Health Survey (SF-36), the Self-Rating Anxiety Scale (SAS), and the Self-Rating Depression Scale (SDS).

**Results:** At baseline, high-yogurt consumption group had higher CD4+ (P=0.027) and higher CD8+ T-cell counts (P=0.043), lower alcohol use (P=0.001), and higher alanine aminotransferase (ALT) levels (P<0.001). Post antiretroviral therapy (ART), the T-cell count differences disappeared, but BMI and weight gain remained higher (both P<0.001). Legume consumption was not significantly associated with serum lipid profiles but was correlated with lower smoking prevalence (P=0.021), higher ALT levels (P=0.007), and higher CD4+ T-cell counts (P=0.011) at baseline. High coffee consumption was associated with lower APRI scores post-ART (P=0.025) but showed no other significant associations with clinical parameters. No significant associations were found between diet and SF-36, SAS, or SDS scores, except reduced social functioning in high legume and coffee groups.

**Conclusion:** High yogurt consumption was associated with high baseline CD4+ and CD8+ T counts but also associated with increased BMI after ART. However, no significant interactions between dietary intake and ART outcomes were observed.

**Keywords:** HIV/AIDS, nutritional interventions, dietary patterns, immune reconstitution, metabolic complications

## Introduction

Human immunodeficiency virus (HIV) infection induces systemic immune compromise through CD4+ T-cell depletion, predisposing individuals to opportunistic infections and malignancies.[1] Concurrently, HIV directly damages multiple tissues via monocyte infection and activation (eg, gut mucosal disruption, neuroinvasion) and indirectly contributes to end-organ injury through chronic immune activation and endothelial dysfunction, driving cardiovascular, hepatic, and other systemic comorbidities.[2–5] Nutrition emerges as a critical determinant of health outcomes in PLWH.[6] Appropriate dietary consumption enhances immune function, mitigates the progression of HIV infection and opportunistic infections, and modulates weight gain trajectories and depressive symptomatology.[7] The World Health Organization (WHO) guidelines emphasize that optimal nutritional support enhances immune recovery, improves ART adherence, and mitigates treatment-related metabolic

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complications such as dyslipidemia and insulin resistance.[8] Conversely, malnutrition—encompassing both macronutrient deficiencies and micronutrient insufficiencies—exacerbates disease progression and susceptibility to opportunistic infections. For instance, deficiencies in vitamin A and zinc are associated with accelerated CD4+ T-cell decline and increased mortality among PLWH, underscoring the necessity for targeted nutritional interventions in this population.[9–11]

To address these needs, WHO advocates context-specific strategies, including community kitchens and ready-to-use therapeutic food (RUTF).[12] Community kitchens in Sub-Saharan Africa have demonstrated efficacy in improving dietary diversity among PLWH, with interventions providing probiotic-rich yogurt linked to reduced gastrointestinal inflammation and enhanced gut barrier integrity.[12] RUTF, formulated with legumes, fruits, and energy-dense ingredients, has shown promise in reversing severe malnutrition. The dairy industry represents the foremost sector utilizing the greatest quantity and diversity of probiotic strains in food production, with the majority of commercially available yogurts incorporating single or multiple functional probiotic strains such as *Lactobacillus acidophilus* CL1285, *Lacticaseibacillus casei* LBC80R, and *Lacticaseibacillus rhamnosus* CLR2.[13] These probiotics have been demonstrated to exert direct inhibitory effects on various pathogenic bacteria by producing organic acids (such as lactic acid, acetic acid, or citric acid) or generating hydrogen peroxide and bacteriocins, thereby reducing the incidence of antibiotic-associated diarrhea (AAD).[14] However, there is still a lack of definitive statistical evidence regarding the efficacy of probiotic-containing yogurt in restoring immune function in PLWH undergoing ART.

Cardiovascular disease (CVD), a leading global cause of mortality, is addressed in preventive guidelines through recommendations for high-quality diets rich in fruits, vegetables, nuts, and legumes.[15] The Mediterranean diet has been consistently shown in multiple studies to be negatively correlated with the incidence and mortality of CVD. Among its dietary components, legumes such as alfalfa, green peas, clover, and peanuts are important sources of plant-based protein, and are considered the cornerstone of many ancient dietary patterns, including the Mediterranean diet.[16,17] In addition, the diet is rich in complex carbohydrates and unsaturated fats, mainly monounsaturated fatty acids (MUFAs, such as oleic acid) and polyunsaturated fatty acids (PUFAs), which are essential plant components in heart-protective diets.[18,19] Regular consumption of legumes has been shown to lower total cholesterol and low-density lipoprotein (LDL) cholesterol levels. However, as CVD is one of the main factors affecting the prognosis and quality of life of PLWH, it remains unclear whether this diet has the same lipid-lowering and cardiovascular disease-reducing effects in PLWH.[20]

Due to the heightened susceptibility of PLWH coupled with prolonged exposure to ART medications, patients frequently present with concurrent progressive liver injury.[21] Concurrently, lipid abnormalities are commonly associated with various antiretroviral drugs, increasing the risk of developing non-alcoholic fatty liver disease (NAFLD) or non-alcoholic steatohepatitis (NASH).[22,23] Furthermore, NAFLD and NASH are prone to progress to liver fibrosis.[24] Existing literature has confirmed that polyphenols (eg, chlorogenic acid) and caffeine in coffee may inhibit the activation of hepatic stellate cells through antioxidants and anti-inflammatory mechanisms, thereby attenuating the progression of fibrosis.[25,26] Additionally, coffee consumption is associated with a reduced risk of developing NAFLD. However, whether these protective effects extend to lowering the concurrent risks of liver fibrosis and fatty liver disease in PLWH remains unclear.

In summary, robust clinical evidence validating the efficacy of dietary components in reducing comorbidities among PLWH remains scarce. Therefore, this study investigated laboratory data (including immune markers such as CD4+T counts), quality of life, and physical/mental health parameters, aiming to analyze their correlations with immune dysfunction, cardiovascular diseases, liver fibrosis, and NAFLD.

# Methods

## Study Cohort and Inclusion Criteria

This cohort study continuously enrolled 280 newly diagnosed PLWH without concurrent opportunistic infections or malignancies from one medical center, Nanfang Hospital, Southern Medical University. Strict inclusion criteria were implemented: only individuals without concurrent opportunistic infections or malignancies at diagnosis were included, thereby promoting homogeneity within the study population. Eligible participants were aged between 16 and 67 years, comprising 13 females and 267 males.

Dietary patterns, laboratory tests, Health-Related Quality of Life, SAS and SDS were conducted on the 280 participants and different indicators were compared. Exclusion criteria were as follows: 1) individuals with other opportunistic infections; 2) individuals with severe liver or kidney failure, malignancies, or autoimmune diseases; 3) pregnant women; and 4) individuals unable to attend regular follow-ups or missing critical clinical data. The participants were dichotomized based on dietary consumption thresholds: High- and low-consumption groups were defined for yogurt (≥300 mL/week vs <300 mL/week), legumes (≥180 g/week vs <180 g/week of single/mixed legumes), and black coffee (≥3 cups/week vs < cups/week). To ensure analytical rigor, coffee beverages containing sugar or milk were systematically excluded to mitigate confounding effects. This standardized stratification protocol allowed comparative evaluation of dietary components within the same cohort while maintaining methodological consistency across variables.

This study was approved by the Ethics Committee of Nanfang Hospital, Southern Medical University (NFEC-2021-448), and followed the ethical guidelines of the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all participants. Especially, the informed consent for adolescent volunteers necessitated signatures from both the participants themselves and their legal guardians.

## Data Collection

We gathered an array of clinical data via the hospital's digital medical record system. The data encompassed demographic details, dietary characteristics, Demographic characteristics, quality of life, and quantitative HIV RNA testing, as well as various laboratory parameters.

In this study, health-related quality of life was assessed using the 36-Item Short Form Health Survey (SF-36), a widely used and validated multidimensional instrument that evaluates individuals perceived physical and mental health status. The SF-36 consists of 36 items grouped into eight domains: Physical Functioning (PF), Role Limitations due to Physical Health (RP), Bodily Pain (BP), General Health Perceptions (GH), Vitality (VT), Social Functioning (SF), Role Limitations due to Emotional Problems (RE), and Mental Health (MH). Each domain score is transformed to a 0–100 scale, with higher scores indicating better perceived health and quality of life. The eight domains can be further aggregated into two summary measures: the Physical Component Summary (PCS), derived from PF, RP, BP, and GH; and the Mental Component Summary (MCS), derived from VT, SF, RE, and MH. Specifically, PF assesses limitations in physical activities (eg, walking, climbing stairs), RP evaluates the impact of physical health on work or daily roles, BP measures pain intensity and its interference with functioning, and GH reflects overall health perceptions. VT assesses energy and fatigue levels, SF evaluates the influence of health on social activities, RE measures the extent to which emotional problems hinder daily functioning, and MH captures general mood, including symptoms of anxiety and depression.[27]

Anxiety symptoms were evaluated using the SAS, a widely recognized psychometric instrument consisting of 20 items designed to assess the severity of anxiety-related symptoms. Each item is scored on a 4-point Likert scale (ranging from 1 = "none or a little of the time" to 4 = "most or all of the time"), with total scores ranging from 20 to 80. Higher scores indicate greater levels of anxiety.

Depressive symptoms were assessed using the SDS, a validated psychometric tool comprising 20 items designed to measure the severity of depression-related symptoms. Each item is rated on a 4-point Likert scale (ranging from 1 = "a little of the time" to 4 = "most or all of the time"), with total scores ranging from 20 to 80. Higher scores reflect greater levels of depressive symptomatology.

## Laboratory Assays

Complete blood count (CBC) analysis was performed using the Sysmex SE9000 (Kobe, Japan) automated hematology analyzer, measuring white blood cell (WBC) count, lymphocyte (LYM) count, hemoglobin (HGB) level, and platelet (PLT) count. Liver function tests were conducted with the Olympus AU5400 (Tokyo, Japan) automated biochemical analyzer to ALT, aspartate aminotransferase (AST), and albumin (ALB) levels. Kidney function was evaluated based on serum creatinine (CR) measurements. Additionally, lymphocyte subpopulation counts including CD4+ and CD8+ T cells were assessed using flow cytometry.

## Assessment of Liver Fibrosis and Fatty Liver Disease

Hepatic steatosis and liver fibrosis were evaluated non-invasively using a vibration-controlled transient elastography (VCTE) device (50 Hz for LSM and SSM [SSM@50 Hz], FibroScan®502) for all patients and the controlled attenuation parameter CAP using a vibration-controlled transient elastography (VCTE) device (50 Hz for LSM and SSM [SSM@50 Hz], FibroScan®502) for all patients. The acquired FibroScan data and CAP values were analyzed as follows: Liver fibrosis severity was quantified in kilopascals (kPa). Higher kPa values indicate increased liver stiffness and more advanced fibrosis. Hepatic steatosis was assessed using CAP. A CAP value <240 dB/m suggests minimal or no hepatic steatosis, while progressively higher values correlate with greater severity of fat accumulation.[28]

## Assessment of Liver Fibrosis Using the APRI

The APRI (AST to Platelet Ratio Index) is a validated non-invasive biomarker for assessing liver fibrosis severity, particularly in chronic liver diseases such as hepatitis B and C. Elevated APRI reflects a combination of hepatic injury (indicated by elevated AST levels) and thrombocytopenia (low platelet count), which are hallmarks of progressive fibrosis and portal hypertension.[29] The calculation formula for APRI is as follows: APRI = (Aspartate aminotransferase / Upper limit of normal for Aspartate aminotransferase) * 100 / Platelet count.

## Statistical Analysis

Data analyses were conducted using SPSS (IBM Corp., Armonk, NY) and R software (version 4.2.1, R Foundation). Categorical variables (eg, smoking status, dietary habits) across yogurt, legume, and coffee consumption groups were compared using chi-square tests or Fisher's exact tests for small sample sizes. Continuous variables, including CD4+/CD8+ T-cell counts, BMI, blood glucose, and lipid profiles, were analyzed via independent Student's t-tests for intergroup comparisons. Longitudinal changes in clinical parameters (eg, lipid profiles, hepatic fibrosis indices) between baseline and 24-week follow-up across consumption groups were evaluated using repeated-measures ANOVA for normally distributed data or Wilcoxon signed-rank tests for non-parametric distributions, supplemented by paired t-tests to assess temporal effects within groups. All statistical tests were two-tailed, with significance defined as $P < 0.05$. Data normality was verified using Shapiro–Wilk tests, and homogeneity of variance was confirmed via Levene's test prior to parametric analyses. Sensitivity analyses excluded participants with missing critical variables (<5% of the cohort) to ensure robustness.

# Results

## Clinical Variables with Different Yogurt Consumption

The study included a total of 280 PLWH. Based on yogurt consumption, participants were classified into two groups: low yogurt consumption (<300 mL/week) and high yogurt consumption (≥300 mL/week). As shown in Table 1, individuals in the high yogurt consumption group had significantly lower alcohol consumption (P=0.001) and higher alanine aminotransferase (ALT) levels (P<0.001) compared to those in the low yogurt consumption group. Furthermore, the high yogurt consumption group exhibited significantly higher CD4+ T-cell counts (P=0.027) and CD8+ T-cell counts (P=0.043).

## The Impact of Different Yogurt Consumption Habits on Clinical Parameter Changes in HIV Patients During Antiretroviral Therapy

Our results demonstrated that, at baseline, the high yogurt consumption group exhibited significantly higher CD4+ and CD8+ T-cell counts compared to the low yogurt consumption group (P<0.05 for both). However, these differences were no longer statistically significant after 24 weeks of ART. Notably, post-ART analysis revealed that the high yogurt consumption group had significantly greater body weight and BMI compared to the low yogurt consumption group (P<0.001 for both) (Figure 1).

We further assessed the virological response rate and RNA quantification in both the low and high yogurt consumption groups. In the low yogurt consumption group, HIV RNA levels decreased significantly from 4.162 to 0.017 $\log_{10}$

**Table 1** Characteristics of HIV Patients with Low or High Yogurt Consumption Group

| Characteristics | Low Yogurt Consumption Group N = 181 | High Yogurt Consumption Group N = 99 | P Value |
|---|---|---|---|
| **Gender** | | | 0.292 |
| **Male** | 170 (93.9) | 97 (98.0) | |
| **Female** | 11(6.1) | 2 (2.0) | |
| **Age, years** | 31.64±8.41 | 30.90±8.393 | 0.482 |
| **Tobacco smoking** | | | 0.061 |
| **Active** | 50(27.6) | 17 (17.2) | |
| **Non-active** | 131 (72.4) | 82 (82.8) | |
| **Alcohol drinking** | | | 0.001* |
| **Active** | 25 (13.8) | 9 (8.9) | |
| **Non-active** | 156 (86.2) | 90 (91.1) | |
| **WBC**, $10^9$/L | 5.45±1.61 | 5.78±1.48 | 0.051 |
| **HGB**, g/L | 144.87±17.12 | 146.20±17.20 | 0.271 |
| **PLT**, $10^9$/L | 217.40±57.82 | 220.84±63.02 | 0.324 |
| **ALT**, U/L | 22.12±15.70 | 30.77±26.40 | <0.001* |
| **AST**, U/L | 22.79±14.12 | 23.97±11.29 | 0.241 |
| **ALB**, g/L | 45.49±4.82 | 45.89±5.00 | 0.262 |
| **CR**, μmol/L | 78.33±13.68 | 77.72±12.27 | 0.358 |
| **CD4**+T cells counts, cells/μL | 282.39±170.33 | 332.83±197.57 | 0.027* |
| **CD8**+T cells counts, cells/μL | 1007.79±483.75 | 1138.02±552.09 | 0.043* |

**Note**: *Indicates that this feature has clinical significance.
**Abbreviations**: WBC, white blood cells count; HGB, hemoglobin; PLT, platelets count; ALT, alanine aminotransferase; AST, aspartic aminotransferase; ALB, albumin; CR, creatinine; CD4+T, cluster of differentiation 4 positive T lymphocytes; CD8+T, cluster of differentiation 8 positive T lymphocytes.

copies/mL ($P < 0.001$), accompanied by an increase in virologic response rate 94.5% at week 24. Similarly, in the high yogurt consumption group, HIV RNA levels declined from 4.243 to 0.015 $\log_{10}$ copies/mL ($P < 0.001$), with the virologic response rate of 94.9%. However, no significant differences were observed between the two groups either at baseline or at week 24.

## Clinical Variables with Different Legumes Consumption Habits

Based on existing research on the impact of legumes on cardiovascular diseases, we classified PLWH into low and high legumes consumption groups according to their dietary habits. The low consumption group consumed legumes less than 180g per week, while the high consumption group consumed legumes 180g or more per week. Patients in the high legumes consumption group had significantly higher levels of alanine aminotransferase (ALT) (P=0.007) and CD4+ T-cell counts (P=0.011) compared to the low legumes consumption group. Additionally, the high legumes consumption group exhibited significantly lower smoking rates (P=0.021) (Table 2).

To evaluate the impact of legume consumption on the health status of HIV patients, we analyzed lipid profile parameters (CHOL, HDL, LDL, VLDL). No statistically significant differences were observed between the low and high legumes consumption groups at baseline or after 24 weeks of ART. In the low legumes consumption group, total cholesterol (CHOL) significantly increased from baseline to week 24 (P<0.001), while a similar trend was observed in the high legumes consumption group, though not statistically significant (Figure 2A). Both groups experienced a statistically significant increase in HDL levels over 24 weeks (P=0.005, P=0.017, respectively) (Figure 2B). LDL levels did not change significantly in either group (Figure 2C). A notable increase in VLDL was observed only in the high legumes consumption group (P=0.025) (Figure 2D).

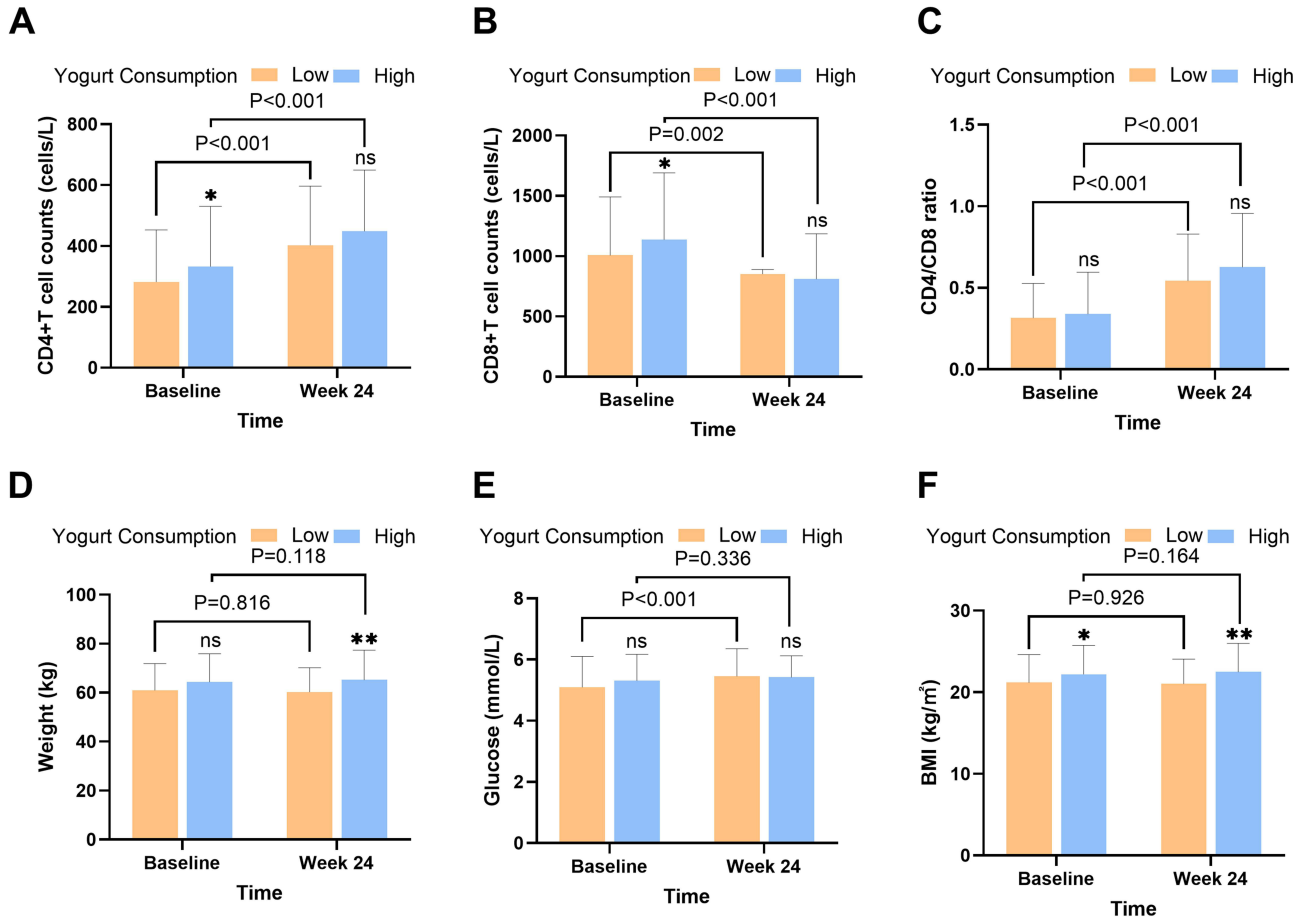


**Figure 1** Comparative Analysis of Clinical Characteristics from Baseline to Week 24 of Antiretroviral Therapy Between Low and High Yogurt Consumption Groups. (**A**) CD4+T cell levels in PLWH between the Low and High-Yogurt Consumption group. (**B**) CD8+T cell levels in PLWH between the Low and High-Yogurt Consumption group. (**C**) CD4+/CD8+ T cell ratio in PLWH between the Low and High-Yogurt Consumption group. (**D**) weight in PLWH between the Low and High-Yogurt Consumption group. (**E**) glucose in PLWH between the Low and High-Yogurt Consumption group. (**F**) BMI in PLWH between the Low and High-Yogurt Consumption group. (ns P>0.05 vs Low, *P<0.05 vs Low, **P<0.01 vs Low).
**Abbreviations**: CD4+T, cluster of differentiation 4 positive T lymphocytes; CD8+T, cluster of differentiation 8 positive T lymphocytes; BMI, body mass index.

## Clinical Variables with Different Coffee Consumption Habits

In the comparing the characteristics of HIV patients with low coffee consumption and high coffee consumption. No differences of statistical note were detected between the two groups (Table 3).

PLWH have a high prevalence of metabolic dysfunction-associated fatty liver disease (MAFLD), which is further elevated in those receiving ART. To investigate the impact of coffee consumption on fatty liver and liver fibrosis in HIV patients, we analyzed CAP, FibroScan values, BMI, and APRI indices. No significant differences were observed in CAP values (Figure 3A), FibroScan results (Figure 3B), or BMI (Figure 3C) between the two groups. Regarding the APRI, only the high coffee consumption group showed a significant decrease from baseline to week 24 (P = 0.025). However, no significant differences in APRI scores were found between the two groups either at baseline or after 24 weeks of ART (Figure 3D).

## Physical and Mental Health of HIV Patients Based on Three Food Habits

We investigated the impact of yogurt, legumes, and coffee consumption on the physical and mental health of patients, using SF, SAS, and SDS scale scores. Participants were divided into low and high consumption cohorts based on dietary habits.

**Table 2** Characteristics of HIV Patients with Low or High Legumes Consumption Group

| Characteristics | Low Legumes Consumption Group N = 200 | High Legumes Consumption Group N = 80 | P value |
|---|---|---|---|
| **Gender** | | | 0.896 |
| **Male** | 193 (96.5) | 75 (93.8) | |
| **Female** | 7(3.5) | 3 (3.8) | |
| **Age, years** | 31.92±8.07 | 31.58±8.61 | 0.331 |
| **Weight, kg** | 61.74±11.06 | 63.28±11.57 | 0.300 |
| **BMI**, $kg/m^2$ | 21.41±3.48 | 21.96±3.47 | 0.122 |
| **Tobacco smoking** | | | 0.021* |
| **Active** | 52 (26.0) | 11 (13.8) | |
| **Non-active** | 141(70.5) | 68 (85.0) | |
| **Alcohol drinking** | | | 0.917 |
| **Active** | 43 (5.1) | 14 (17.5) | |
| **Non-active** | 143(94.9) | 62 (77.5) | |
| **WBC**, $10^9/L$ | 5.52±1.58 | 5.79±1.48 | 0.077 |
| **HGB**, g/L | 145.12±17.73 | 142.64±18.27 | 0.427 |
| **PLT**, $10^9/L$ | 220.84±59.65 | 231.85±62.43 | 0.232 |
| **ALT**, U/L | 21.37±15.24 | 29.70±26.97 | 0.007* |
| **AST**, U/L | 21.12±9.37 | 25.02±21.23 | 0.072 |
| **ALB**, g/L | 45.50±5.23 | 45.55±4.15 | 0.549 |
| **CR**, μmol/L | 79.22±14.22 | 75.60±11.25 | 0.052 |
| **CD4**+T cells counts, cells/μL | 270.26±158.42 | 352.79±198.12 | 0.011* |
| **CD8**+T cells counts, cells/μL | 1010.52±494.24 | 1101.40±488.53 | 0.672 |

**Note**: *Indicates that this feature has clinical significance.
**Abbreviations**: WBC, white blood cells count; HGB, hemoglobin; PLT, platelets count; ALT, alanine aminotransferase; AST, aspartic aminotransferase; ALB, albumin; CR, creatinine.

Yogurt consumption revealed no associations with quality of life (SF-36 scale) or mental health outcomes (SAS/SDS scales) (Figure 4A–C). Legumes consumption: In the SF scale, the high legumes consumption cohort had significantly lower scores in the SF dimension (P = 0.039), and higher scores in the GH dimension (Figure 4D). There were no significant divergences in SAS and SDS scores between the two groups. (Figure 4E and F). Coffee consumption: In the SF scale, the high coffee consumption group had lower scores in the SF dimension (P = 0.011), while scoring higher in the BP dimension, though this variation was not statistically significant (Figure 4G). No meaningful variations were found in SAS and SDS scores between the two groups (Figure 4H and I).

## Discussion

Our study aims to assess the effects of specific dietary patterns on immune function, cardiometabolic and hepatic comorbidities, and psychosocial health outcomes among PLWH receiving ART. In addition, our research team expand the scope to comprehensively investigate post-treatment physical and mental health trajectories in this population.[30] Guided by the WHO dietary recommendations for PLWH, we selected three widely consumed food groups—yogurt, legumes, and coffee—for focused analysis. While these dietary components have demonstrated health benefits in general populations, robust clinical evidence supporting their protective roles in PLWH remains scarce. To address this gap, we conducted a cross-sectional study in our center, supplemented by longitudinal clinical data collection (from baseline to 24 weeks post-ART initiation) and standardized psychological evaluations.[8]

The findings from the study on yogurt consumption patterns indicate that high yogurt consumption at baseline was associated with elevated CD4+ T-cell counts and CD8+ T-cell counts. However, this association became obscured

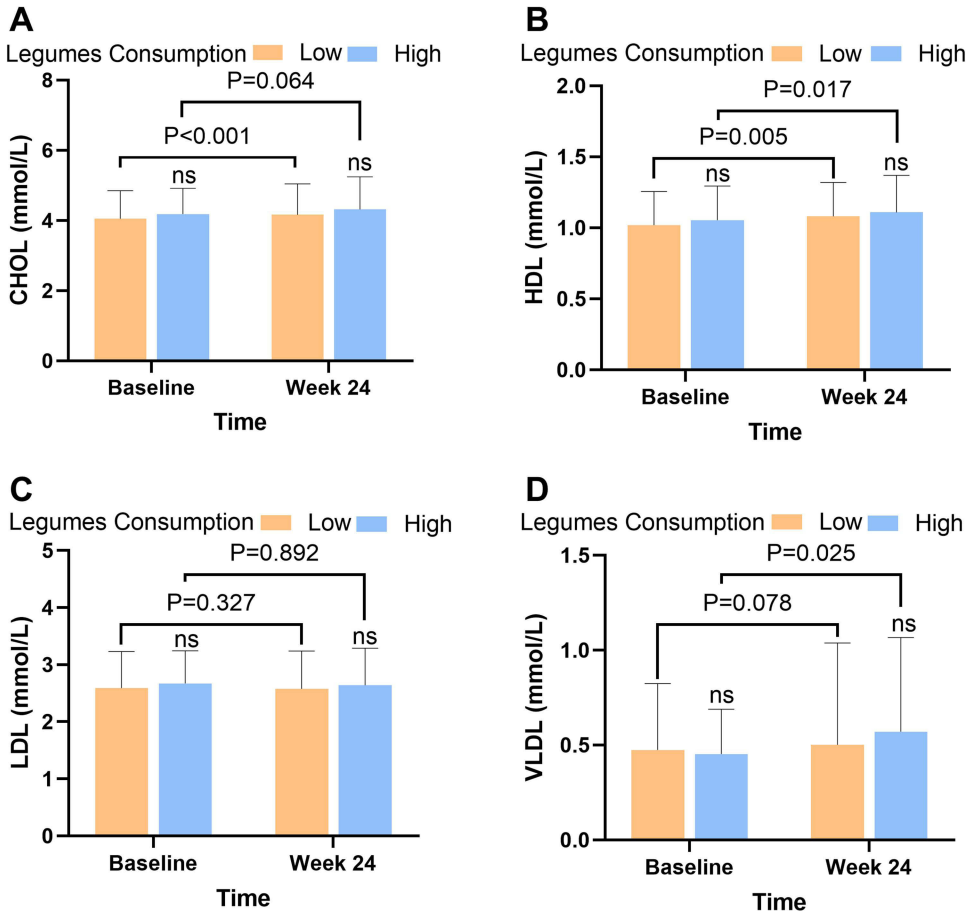


**Figure 2** The changes in Lipid Profile over different time-points between Low and High- Legumes Consumption group. (**A**) CHOL value in PLWH between the Low and High-Legumes Consumption group. (**B**) HDL value in PLWH between the Low and High-Legumes Consumption group. (**C**) LDL value in PLWH between the Low and High-Legumes Consumption group. (**D**) VLDL value in PLWH between the Low and High-Legumes Consumption group. (ns P>0.05 vs Low).
**Abbreviations**: CHOL, cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; VLDL: very low-density lipoprotein.

following 24 weeks of ART treatment. Notably, the high yogurt consumption group demonstrated elevated BMI compared to low consumers, these anthropometric measures cannot be causally linked to yogurt consumption patterns due to potential confounding dietary factors in this non-interventional cross-sectional study. Although existing evidence supports the immunomodulatory potential of yogurt-derived probiotics, including gut microbiota regulation and systemic inflammation reduction—both of which are particularly relevant for PLWH in mitigating microbial translocation and reducing the risk of opportunistic infections—our empirical data suggest that these theoretical benefits may have limited practical significance in the daily lives of PLWH.[31,32]

We found that elevated ALT levels were associated with nut consumption. However, the underlying mechanism remains unclear. It is worth noting that, despite the apparent trend toward increased ALT, the mean ALT values in both the high and low nut consumption groups remained within the normal reference range. The lack of significant changes in lipid parameters between the high- and low-legume consumption groups at 24 weeks is noteworthy. While the high-legume group demonstrated a significant increase in HDL-C levels, this observed elevation cannot be definitively attributed to legume consumption, as ART itself has been documented to elevate HDL-C concentrations.[33,34] Therefore, the specific effect of legumes consumption on HDL-C modulation in PLWH remains inconclusive.[33] This null finding could be due to several factors. First, the effects of the diet could be masked by ART-induced dyslipidemia, as evidenced by the 40% prevalence of hypertriglyceridemia in our cohort.[35] Additionally, the duration of the intervention may have been insufficient to detect meaningful changes in lipid levels. Finally, the variability in legumes types and

**Table 3** Characteristics of HIV Patients with Low or High Coffee Consumption Group

| Characteristics | Low Coffee Consumption Group N =234 | High Coffee Consumption Group N = 42 | P value |
|---|---|---|---|
| **Gender** | | | 0.625 |
| **Male** | 225 (95.3) | 42 (95.5) | |
| **Female** | 9 (3.8) | 1 (2.3) | |
| **Age, years** | 31.40±8.26 | 31.23±9.21 | 0.904 |
| **Tobacco smoking** | | | 0.090 |
| **Active** | 49 (20.8) | 14 (31.8) | |
| **Non-active** | 181 (76.7) | 28 (63.6) | |
| **Alcohol drinking** | | | 0.334 |
| **Active** | 46(19.5) | 11(25.0) | |
| **Non-active** | 174(73.7) | 31 (70.5) | |
| **WBC**, $10^9$/L | 5.55±1.57 | 5.65±1.56 | 0.720 |
| **HGB**, g/L | 145.77±17.13 | 142.95±17.11 | 0.333 |
| **PLT**, $10^9$/L | 221.54±60.11 | 202.40±54.58 | 0.055 |
| **ALT**, U/L | 25.21±21.02 | 24.64±17.05 | 0.870 |
| **AST**, U/L | 23.18±13.51 | 23.29±11.43 | 0.961 |
| **ALB**, g/L | 45.63±4.85 | 45.60±5.12 | 0.970 |
| **CR**, μmol/L | 78.13±13.53 | 78.05±11.23 | 0.973 |
| **CD4**+T cells counts, cells/μL | 299.95±179.51 | 301.36±194.85 | 0.962 |
| **CD8**+T cells counts, cells/μL | 1067.60±522.84 | 981.14±447.17 | 0.305 |

**Abbreviations**: WBC, white blood cells count; HGB, hemoglobin; PLT, platelets count; ALT, alanine aminotransferase; AST, aspartic aminotransferase; ALB, albumin; CR, creatinine.

preparation methods could have contributed to the lack of observed effects. Large prospective studies, such as the Data Collection on Adverse Events of Anti-HIV Drugs (DAD) study, have shown that prolonged ART exposure increases cardiovascular risk.[33,36] Specifically, there are 3.0 myocardial infarctions per 1000 person-years. These findings highlight the importance of dietary interventions to mitigate the iatrogenic effects of ART.[37]

High coffee consumers exhibited lower CAP values, suggesting a potential association between coffee consumption and reduced hepatic steatosis. This finding aligns with evidence that coffee polyphenols, such as chlorogenic acid, mitigate hepatic lipid accumulation through the erythroid-2-related factor 2 antioxidant pathway and NLRP3 inflammasome activation.[38] While the AST to platelet ratio index remains a practical first-line tool for fibrosis screening (AUROC = 0.77–0.83 for significant fibrosis or cirrhosis), its accuracy may be compromised in people living with HIV due to HIV- and antiretroviral therapy-associated thrombocytopenia, underscoring the need for validation through imaging or elastography.[39]

Our study found no significant associations between yogurt consumption and quality of life or mental health parameters. However, higher intake of legumes and coffee was linked to lower social functioning scores on the 36-Item Short Form Health Survey. This association may reflect health-conscious or anxiety-driven dietary adherence rather than any intrinsic nutritional effects. The absence of significant differences across other SF-36 domains or in SDS/SAS measurements implies these dietary patterns exert minimal psychosocial influence. Emerging evidence highlights a bidirectional relationship between psychological well-being and immune function, with depressive symptoms playing a key role in accelerating HIV disease progression. While our study did not identify meaningful associations between dietary patterns and psychosocial outcomes, the need for comprehensive nutritional and lifestyle management in HIV care remains critical.

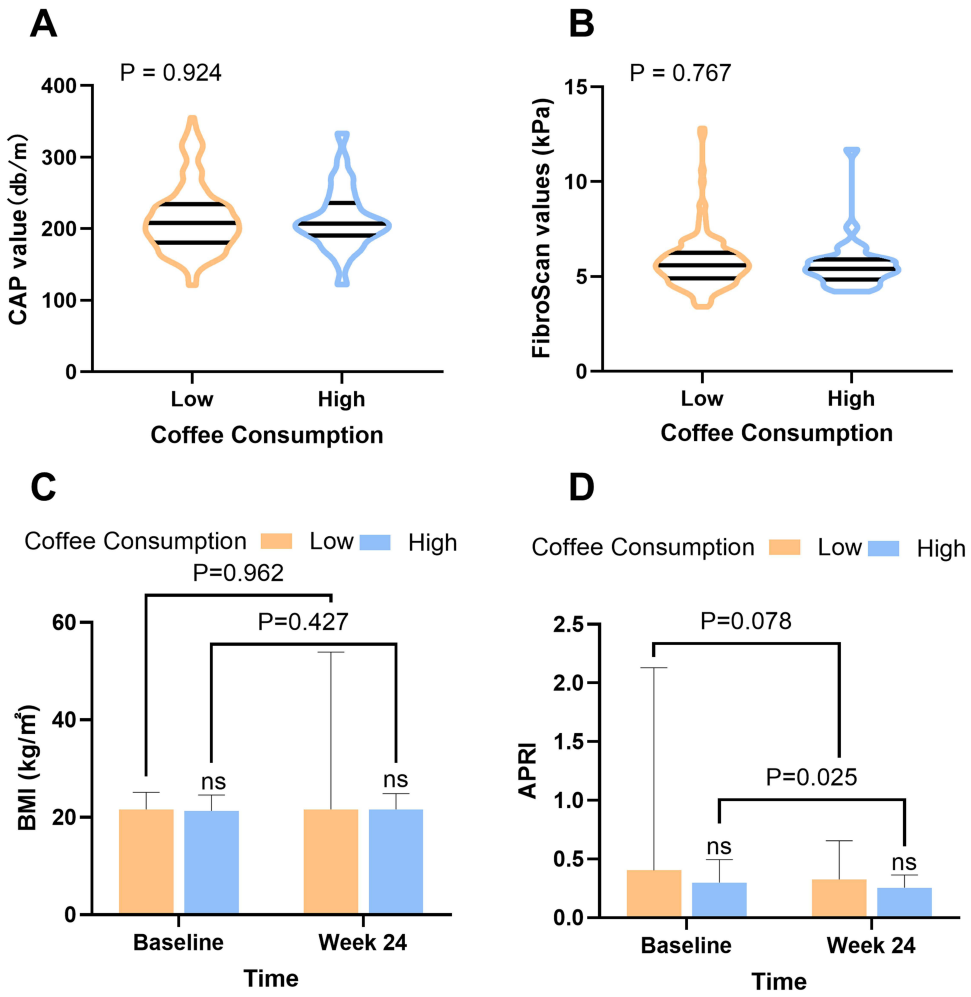


**Figure 3** Changes in Lipid Profiles and Liver Function Indicators from Baseline to 24 Weeks in High and Low Coffee Consumption Groups. (**A**) CAP value in PLWH between the Low and High-Coffee Consumption group. (**B**) Fibroscan value in PLWH between the Low and High-Coffee Consumption group. (**C**) BMI value in PLWH between the Low and High-Coffee Consumption group. (**D**) APRI value in PLWH between the Low and High-Coffee Consumption group. (ns P>0.05 vs Low).
**Abbreviations**: CAP, Controlled Attenuation Parameter; BMI, body mass index; APRI, Aspartate Aminotransferase to Platelet Ratio Index.

This study systematically evaluated the impacts of three dietary patterns on immune function, metabolic comorbidities, and psychosocial well-being among PLWH receiving ART. Several limitations should be acknowledged. First, although we maximized our sample size by enrolling all eligible patients meeting strict inclusion criteria within a defined time frame, resulting in a relatively large cohort of 280 participants, the single-center design and sample size still limit generalizability. Second, despite adjusting for known confounding factors such as age, ART duration, alcohol and tobacco use, residual or unmeasured confounding remains possible. Other lifestyle factors like physical activity, sleep quality, and socioeconomic status were not fully accounted for and may have influenced immune or metabolic outcomes. Third, partial reliance on self-reported dietary data via questionnaires introduces potential recall bias and misclassification, possibly affecting the accuracy of dietary exposure assessment.

Future research should prioritize prospective, multicenter studies with larger and more demographically balanced cohorts to enhance external validity. Incorporating objective dietary biomarkers (eg, urinary polyphenol metabolites or plasma carotenoids), more comprehensive lifestyle assessments, and longitudinal tracking of clinical, metabolic, and psychosocial outcomes will be essential to strengthen causal inference and further clarify the role of specific dietary patterns in the health of PLWH.

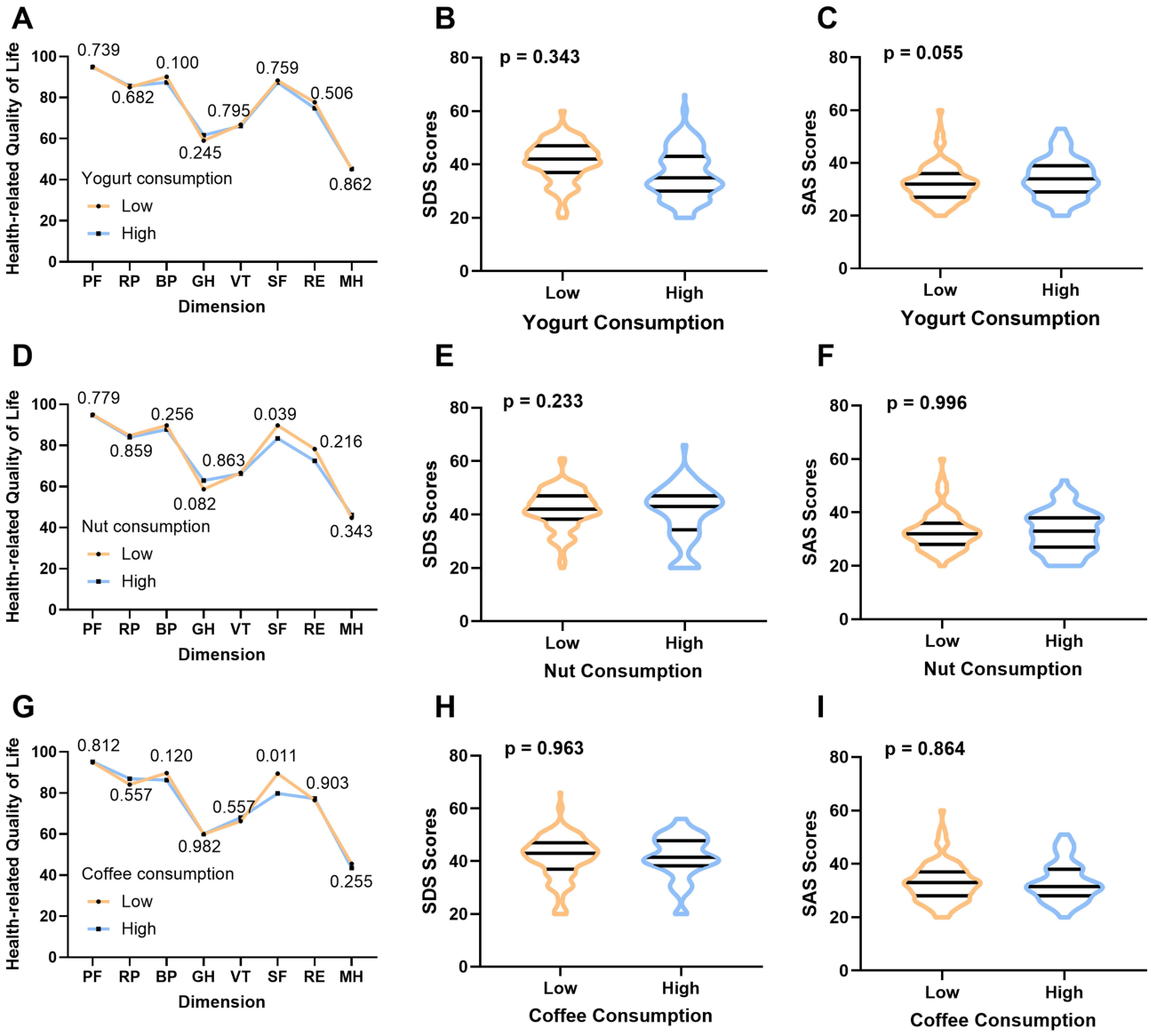


**Figure 4** Correlation of Yogurt, Legumes, and Coffee Consumption with the Physical and Mental Health of HIV Patients. (**A**) Health-related quality of life across different dimensions in relation to yogurt consumption (low and high) at Week 24. (**B**) SDS scores across different yogurt consumption (low and high) at Week 24 (p=0.343). (**C**) SAS scores across different yogurt consumption (low and high) at Week 24 (p=0.055). (**D**) Health-related quality of life across different dimensions in relation to legumes consumption (low and high) at Week 24. (**E**) SDS scores across different legumes consumption (low and high) at Week 24 (p=0.233). (**F**) SAS scores across different legumes consumption (low and high) at Week 24 (p=0.996). (**G**) Health-related quality of life across different dimensions in relation to coffee consumption (low and high) at Week 24. (**H**) SDS scores across different coffee consumption (low and high) at Week 24 (p=0.963). (**I**) SAS scores across different coffee consumption (low and high) at Week 24 (p=0.864).

**Abbreviations**: SDS, self-rating depression scale; SAS, self-rating anxiety scale; PF, physical functioning; RP, role-physical; BP, bodily pain; GH, general health; VT, vitality; SF, social functioning; RE, role-emotional; MH, mental health.

## Conclusion

The study found that, at baseline, yogurt consumption among PLWH was associated with higher CD4+ and CD8+ T-cell counts. However, no significant differences observed after 24 weeks of ART. Moreover, no significant differences in lipid profile were observed between low- and high-legume consumption groups, either at baseline or after 24 weeks of ART. Coffee intake showed limited associations with clinical outcomes, although participants in the high-coffee group exhibited a significant reduction in the APRI. In addition, no significant association was found between dietary patterns and mental health.


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## Abbreviation

ART, antiretroviral therapy; PLWH, people living with HIV; RUTF, ready-to-use therapeutic food; WBC, white blood cells count; HGB, hemoglobin; PLT, platelet count; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALB, albumin; CHOL, cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; VLDL, very low-density lipoprotein; CAP, Controlled Attenuation Parameter; SAS: Self-Rating Anxiety Scale; SDS: Self-Rating Depression Scale.

## Data Sharing Statement

The authors confirm that all relevant data are included in the article, and the materials are available upon reasonable request from the corresponding authors.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare that they have no conflict of interest.

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