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Effect of Soaked Almond Consumption on Serum Lipid Profile in Young Adults: A Single-Group Pre–Post Interventional Study

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ABSTRACT: Background: Dyslipidemia is emerging early in the life course among Indian adults and is a modifiable driver of premature atherosclerotic cardiovascular disease (CVD). Almonds are some nutrient-dense tree nut rich in monounsaturated fatty acids (MUFA), soluble fibre, plant sterols and vitamin E, and soaking almonds overnight is a widespread traditional dietary practice in South India. Whether a small, culturally familiar daily portion of soaked almonds is associated with measurable improvement in the lipid profile of young adults has not been well characterized in this setting. Objective: To estimate the change in fasting serum lipid profile after 8 weeks of daily soaked almond consumption in young adults from South India. Methods: This was a single-group pre–post interventional study conducted in the [Department of General Medicine/Biochemistry/Nutrition], [name of tertiary care teaching hospital/institution], [city], [state], South India, during [study period]. Sixty apparently healthy young adults aged 18–30 years consumed 20 g of soaked almonds daily for 8 weeks. Fasting total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG) and non-HDL cholesterol were measured at baseline and week 8 by standard enzymatic methods. Adherence and adverse events were monitored. Paired t-tests, 95% confidence intervals (CI) and Cohen's dz were computed, with $p<0.05$ considered significant. Results: Participants (mean age 24.5 years; 25 men, 35 women) had a mean adherence of 91.6%. All lipid parameters improved significantly at week 8 (all $p<0.001$). TC fell from 194.29±25.57 to 178.14±27.34 mg/dL (−16.15 mg/dL; 95% CI −17.58 to −14.72; dz=−2.92), LDL-C from 120.55±18.57 to 107.44±19.30 mg/dL (−13.11 mg/dL; dz=−2.66), TG from 135.15±26.78 to 115.99±28.21 mg/dL (−19.16 mg/dL; dz=−2.74) and non-HDL cholesterol from 146.97±26.06 to 126.82±27.88 mg/dL (−20.15 mg/dL; dz=−3.52), while HDL-C rose from 47.32±7.08 to 51.32±7.04 mg/dL (+4.00 mg/dL; dz=2.18). Body weight (67.3→66.8 kg) and BMI (23.9→23.7 kg/m²) changed minimally. Only mild adverse effects occurred (12/60, 20%); there were no serious events and no discontinuations. Conclusion: Eight weeks of 20 g/day soaked almond consumption was associated with statistically significant and clinically meaningful improvement of the lipid profile in young South Indian adults, with large effect sizes and negligible weight change.

1. INTRODUCTION

Atherosclerotic cardiovascular disease (CVD) remains the leading cause of death in India, and it manifests roughly a decade earlier in Indians than in Western populations. Dyslipidaemia — characterized by raised total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG) together with low high-density lipoprotein cholesterol (HDL-C) — is a central, modifiable driver of this burden. Of particular concern in South India is the increasingly frequent detection of adverse lipid patterns in young adults, in whom sedentary behavior, refined-carbohydrate- and saturated-fat-rich diets, and rising adiposity converge to produce an Atherogenicity phenotype long before clinical events occur [1,2]. Because the atherosclerotic process begins in early adulthood, the young-adult window is a strategically important opportunity for low-cost, sustainable dietary interventions that can shift the lifetime trajectory of cardiovascular risk.

Non-HDL cholesterol — the cholesterol carried by all Atherogenicity Apo Lipoprotein-B-containing lipoproteins — has gained prominence as a robust marker of cardiovascular risk that does not require a fasting sample and captures risk missed by LDL-C alone. Interventions that simultaneously lower TC, LDL-C, TG and non-HDL cholesterol while raising HDL-C are therefore attractive, especially when they are inexpensive, well tolerated and culturally acceptable.

Tree nuts have been consistently associated with favorable cardio metabolic profiles, and almonds (*Prunus dulcis*) are among the most extensively studied. Almonds are a nutrient-dense functional food: they are rich in monounsaturated fatty acids (MUFA), provide soluble and insoluble dietary fibre, and are a concentrated source of plant sterols, vitamin E (α-tocopherol), magnesium, polyphenols and L-arginine. These bioactive constituents plausibly act through complementary mechanisms — displacement of dietary saturated fat by MUFA, binding of intestinal bile acids and cholesterol by soluble fibre, competitive inhibition of cholesterol absorption by plant sterols, and antioxidant protection of lipoproteins by vitamin E and polyphenols. Randomized trials and meta-analyses have reported that regular almond and mixed-nut intake reduces TC and LDL-C, tends to lower TG and non-HDL cholesterol, and improves endothelial function, generally without promoting weight gain despite the energy density of nuts [3-6].

In South India, soaking almonds overnight and consuming them peeled in the morning is a deeply rooted traditional practice, commonly recommended within families as a "brain and heart" tonic. Soaking softens the seed coat, is believed locally to improve digestibility and palatability, and lowers the barrier to daily consumption of a modest portion. Despite this cultural familiarity, there is limited region-specific evidence quantifying the effect of a small, habitual daily portion of soaked almonds on the lipid profile of young South Indian adults. Most available trials have used larger doses (28–56 g/day), were conducted in Western or specific clinical populations, and rarely reflect the soaked-almond practice typical of South India [7,8].

Against this background, we conducted a single-group pre–post interventional study to estimate the change in fasting serum lipid profile — TC, LDL-C, HDL-C, TG and non-HDL cholesterol — after 8 weeks of daily consumption of 20 g of soaked almonds in young adults from South India. Our objective was pragmatic and hypothesis-generating: to characterize the direction and magnitude of lipid change achievable with a low-cost, culturally embedded dietary practice, and thereby to inform the design of a future randomized controlled trial. We explicitly frame the study as uncontrolled and therefore incapable of establishing causation [6,9,10].

2. MATERIALS AND METHODS

2.1 Study design and setting

This was a single-group, pre–post (single-arm) nutritional interventional study conducted in the Department of General Medicine/Biochemistry/Nutrition, name of tertiary care teaching hospital/institution], South India, during [v no 4521]. Each participant served as their own control, with fasting lipid measurements obtained at baseline and after 8 weeks of intervention.

2.2 Participants

Apparently healthy young adults aged 18–30 years were eligible. Inclusion criteria were age 18–30 years and absence of diagnosed cardiovascular disease or current lipid-lowering therapy. Exclusion criteria were known nut allergy, pregnancy or lactation, current use of lipid-lowering medication, major chronic illness (including diabetes mellitus, renal, hepatic or thyroid disease), and concurrent participation in another dietary intervention. A total of 60 participants were enrolled and all completed the study.

The sample size of 60 was chosen to provide stable descriptive summaries and an adequate demonstration of paired within-participant comparisons; with N=60 (df=59), the design has substantial power to detect moderate-to-large within-person changes in lipid parameters.

2.3 Intervention

Participants consumed 20 g of raw almonds per day, soaked overnight in potable water for 8–10 hours and consumed peeled on an empty stomach in the morning, for 8 consecutive weeks. The 20 g portion (approximately 15–16 almonds) was chosen to reflect the modest daily quantity typical of the traditional South Indian soaking practice and to be affordable and sustainable. Participants were counselled to maintain their usual diet and physical activity throughout the study and not to add other nuts or lipid-lowering supplements. Almonds were provided in pre-weighed weekly portions to standardise the dose.

2.4 Adherence and tolerability monitoring

Adherence was assessed by participant diaries and weekly counts of returned/unconsumed almonds and expressed as the percentage of prescribed doses consumed. Adverse effects were solicited at each weekly contact using a structured checklist and recorded as none, mild, moderate or severe, together with the nature of the event.

2.5 Outcome measurements

The primary outcomes were the fasting serum lipid parameters: TC, LDL-C, HDL-C, TG and non-HDL cholesterol. After a 10–12 hour overnight fast, venous blood was collected at baseline and at week 8. TC, HDL-C and TG were measured by standard enzymatic colorimetric methods on an automated clinical chemistry analyser; LDL-C was derived using the Friedewald equation where applicable, and non-HDL cholesterol was calculated as TC minus HDL-C. Secondary outcomes were body weight and body mass index (BMI), measured with calibrated instruments using standardised technique, together with adherence and tolerability.

2.6 Statistical analysis

Continuous variables are summarised as mean ± standard deviation (SD). Within-participant change from baseline to week 8 for each lipid and anthropometric parameter was assessed using the paired t-test (df=59). For each outcome we report the mean difference with its two-sided 95% confidence interval (CI) and the standardised within-person effect size, Cohen's dz. Effect sizes were interpreted using conventional thresholds (≈0.2 small, 0.5 medium, 0.8 large). The paired-test assumption of approximately normally distributed change scores was considered reasonable. A two-sided p-value <0.05 was regarded as statistically significant. Analyses were performed using standard statistical software.

3. RESULTS

3.1 Baseline characteristics

Sixty young adults completed the 8-week intervention. The mean age was 24.5 (SD 3.7) years, and the cohort comprised 25 men (41.7%) and 35 women (58.3%). Baseline anthropometry was in the normal-to-upper-normal range (mean weight 67.3 kg; mean BMI 23.9 kg/m²), and mean adherence to the prescribed soaked-almond regimen was high at 91.6%. Baseline characteristics are summarised in Table 1.

Table 1. Baseline characteristics of participants (N = 60).

Characteristic	Value
Sample size, n	60
Mean age, years (SD)	24.5 (3.7)
Sex, male, n (%)	25 (41.7)
Sex, female, n (%)	35 (58.3)
Mean body weight, kg	67.3
Mean BMI, kg/m²	23.9
Intervention	Soaked almonds 20 g/day for 8 weeks
Mean adherence, %	91.6
Completed study, n (%)	60 (100)

3.2 Changes in serum lipid profile

All five lipid parameters changed significantly and in a cardioprotective direction between baseline and week 8, with every comparison reaching $p<0.001$ and all effect sizes in the large range (Table 2). TC decreased by 16.15 mg/dL (from 194.29±25.57 to 178.14±27.34 mg/dL; 95% CI of change −17.58 to −14.72; t=−22.63; dz=−2.92), and LDL-C decreased by 13.11 mg/dL (from 120.55±18.57 to 107.44±19.30 mg/dL; 95% CI −14.38 to −11.84; t=−20.63; dz=−2.66). TG fell by 19.16 mg/dL (from 135.15±26.78 to 115.99±28.21 mg/dL; 95% CI −20.96 to −17.35; t=−21.24; dz=−2.74), and non-HDL cholesterol showed the largest absolute and standardised change, falling by 20.15 mg/dL (from 146.97±26.06 to 126.82±27.88 mg/dL; 95% CI −21.63 to −18.67; t=−27.27; dz=−3.52). In contrast, HDL-C rose by 4.00 mg/dL (from 47.32±7.08 to 51.32±7.04 mg/dL; 95% CI +3.53 to +4.48; t=16.90; dz=2.18).

Table 2. Pre–post changes in serum lipid profile (paired t-test, df = 59).

Outcome	Pre (mean ± SD)	Post (mean ± SD)	Mean difference	95% CI	t	p-value	Cohen's dz
Total cholesterol (mg/dL)	194.29 ± 25.57	178.14 ± 27.34	−16.15	−17.58 to −14.72	−22.63	<0.001	−2.92
LDL cholesterol (mg/dL)	120.55 ± 18.57	107.44 ± 19.30	−13.11	−14.38 to −11.84	−20.63	<0.001	−2.66
HDL cholesterol (mg/dL)	47.32 ± 7.08	51.32 ± 7.04	+4.00	+3.53 to +4.48	16.90	<0.001	2.18
Triglycerides (mg/dL)	135.15 ± 26.78	115.99 ± 28.21	−19.16	−20.96 to −17.35	−21.24	<0.001	−2.74
Non-HDL cholesterol (mg/dL)	146.97 ± 26.06	126.82 ± 27.88	−20.15	−21.63 to −18.67	−27.27	<0.001	−3.52

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Expressed as relative change, the reductions corresponded to approximately −8.3% for TC, −10.9% for LDL-C, −14.2% for TG and −13.7% for non-HDL cholesterol, alongside an increase of approximately +8.5% in HDL-C. The absolute pre-versus-post concentrations, with SD error bars, are displayed in Figure 1, and the mean percent change per parameter — showing HDL-C rising while all other parameters fell — is displayed in Figure 2.

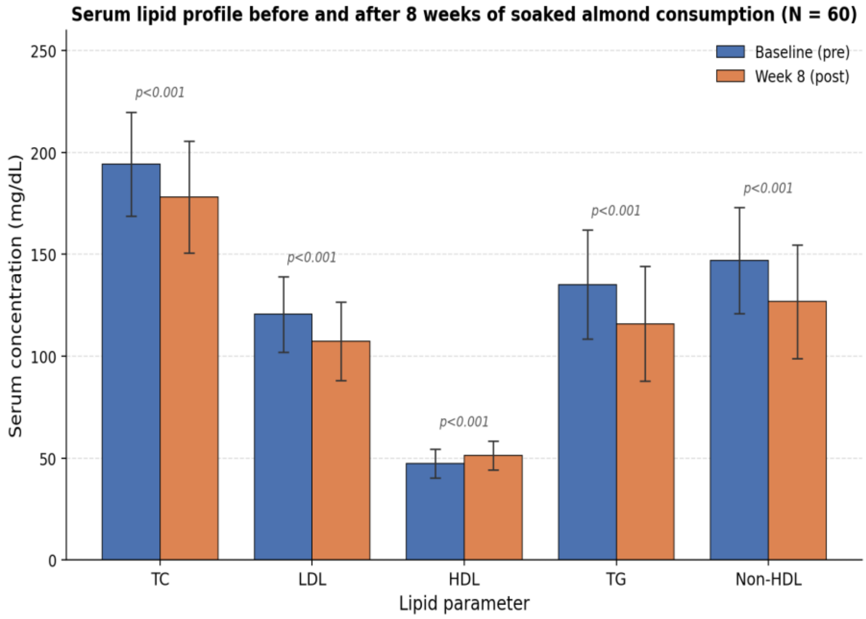

Figure 1. Mean serum lipid concentrations (total cholesterol, LDL-C, HDL-C, triglycerides and non-HDL cholesterol) at baseline and at week 8, with SD error bars. All pre–post comparisons were significant at p<0.001.

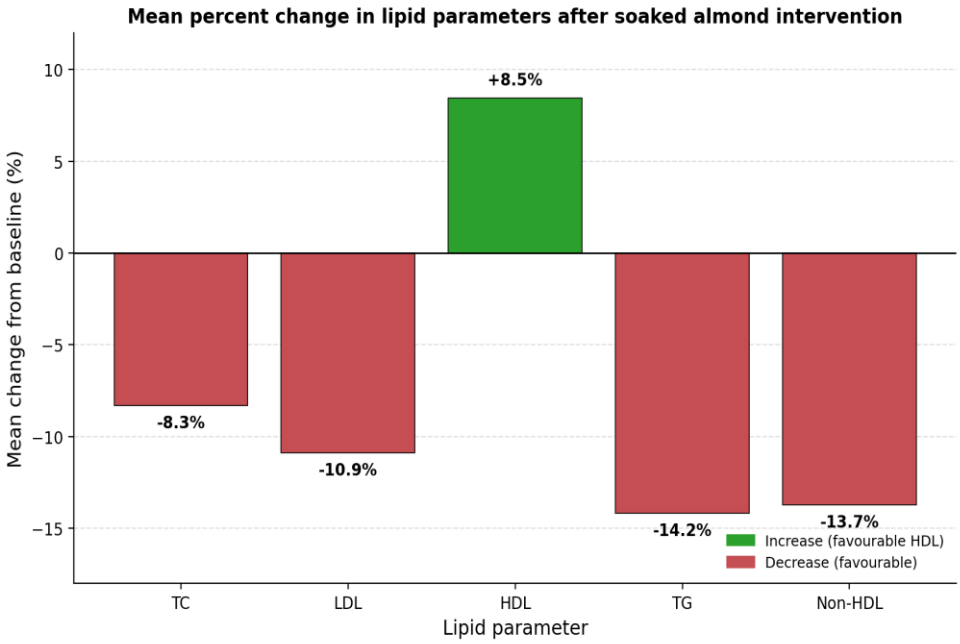

Figure 2. Mean percent change from baseline in each lipid parameter. HDL-C increased (favourable), whereas total cholesterol, LDL-C, triglycerides and non-HDL cholesterol decreased (favourable).

3.3 Anthropometric changes

Body weight and BMI changed minimally over the 8 weeks despite daily consumption of an energy-dense nut, indicating that the lipid improvements were not driven by weight loss (Table 3). Mean weight decreased from 67.3 to 66.8 kg and mean BMI from 23.9 to 23.7 kg/m².

Table 3. Anthropometric measurements at baseline and week 8.

Parameter	Pre	Post	Change
Body weight (kg)	67.3	66.8	−0.5
BMI (kg/m²)	23.9	23.7	−0.2

3.4 Adherence and adverse events

Mean adherence was 91.6%, and all 60 participants completed the study with no discontinuations. Adverse effects were reported by 12 of 60 participants (20%) and were exclusively mild and self-limiting: mild bloating (n=5), mild gastrointestinal discomfort (n=4) and transient fullness (n=3). No moderate or serious adverse events occurred, and no participant withdrew because of adverse effects (Table 4).

Table 4. Adverse events reported during the intervention (N = 60).

Adverse event	n	%
None	48	80.0
Mild bloating	5	8.3
Mild gastrointestinal discomfort	4	6.7
Transient fullness	3	5.0
Any adverse event	12	20.0
Serious adverse events	0	0.0
Discontinuations	0	0.0

4. DISCUSSION

In this single-group pre–post interventional study of young South Indian adults, 8 weeks of consuming a modest 20 g/day portion of soaked almonds was associated with statistically significant and clinically meaningful improvement across the entire lipid profile: TC, LDL-C, TG and non-HDL cholesterol all decreased, HDL-C increased, and every comparison showed a large standardised effect size. Importantly, these changes occurred with negligible change in body weight and BMI and with excellent tolerability and adherence [11]. The pattern — a coordinated fall in atherogenic lipids together with a rise in HDL-C — is precisely the direction of change associated with reduced cardiovascular risk, and it is consistent with the broader almond and nut literature.

4.1 Magnitude and clinical relevance

The observed reductions are of a magnitude that would be considered clinically relevant if reproduced in a controlled setting. An LDL-C reduction of about 13 mg/dL (≈11%) and a non-HDL cholesterol reduction of about 20 mg/dL (≈14%) approach the lower end of what is achievable with dietary intervention and are meaningful given that even modest, sustained LDL-C lowering over decades translates into substantial lifetime risk reduction when begun early. The largest effect was seen for non-HDL cholesterol ($dz=-3.52$), a marker that integrates the cholesterol content of all apolipoprotein-B-containing particles and is increasingly recommended as a primary target and residual-risk indicator. The concurrent HDL-C increase of 4 mg/dL is notable because HDL-C is often resistant to dietary manipulation; a rise of this size is at the favorable end of what nut interventions typically achieve [12,13].

4.2 Plausible mechanisms

Several bioactive constituents of almonds provide a coherent mechanistic rationale for the observed lipid changes. Almond MUFA, when displacing dietary saturated fat and refined carbohydrate, lower LDL-C and TG and can modestly raise HDL-C. Soluble fibre in the almond matrix binds intestinal bile acids and cholesterol, increasing faecal sterol excretion and up-regulating hepatic LDL-receptor activity, while the poorly digestible cell-wall matrix reduces the metabolisable energy actually absorbed from almonds — helping to explain the negligible weight change despite added energy intake. Plant sterols compete with cholesterol for micellar incorporation and reduce intestinal cholesterol absorption, and vitamin E (α-tocopherol) together with polyphenols provides antioxidant protection that limits LDL oxidation and supports endothelial function. These mechanisms are supported by randomized trials and meta-analyses reporting that almond and nut consumption lowers TC and LDL-C and improves vascular function [9,14,15]. Network meta-analysis of tree nuts indicates that almonds are among the more effective nuts for LDL-C lowering [13], and comprehensive reviews confirm consistent, if modest, LDL-C and non-HDL cholesterol reductions across nut types [2,16].

4.3 Consistency with prior literature

Our findings align in direction with a substantial body of interventional evidence. Randomized controlled trials in adults with elevated LDL-C have shown that daily almond consumption reduces LDL-C and non-HDL cholesterol and favorably alters abdominal adiposity without net weight gain [8,17], and the ATTIS trial demonstrated LDL-C lowering and improved endothelial function with whole-almond snacking [9,18]. In young adults specifically, substituting almonds for a high-carbohydrate snack over 8 weeks improved cardio metabolic markers [19], and free-living healthy adults showed favorable lipid and body-composition trajectories with daily almond intake [20].

4.4 HDL rise, non-HDL fall and weight neutrality

Three features of our results deserve emphasis. First, the rise in HDL-C is clinically encouraging because dietary interventions frequently fail to move HDL-C. Second, the pronounced fall in non-HDL cholesterol suggests a broad reduction in Atherogenicity particle burden rather than an isolated LDL-C effect [21]. Third, the weight neutrality — indeed a trivial mean reduction — is consistent with the well-documented phenomenon that the energy from whole almonds is incompletely absorbed and that nut consumption tends not to cause weight gain.

4.5 South Indian dietary context and implications

Soaked almonds are an inexpensive, widely available and culturally embedded food in South India, and the 20 g/day portion studied here is affordable and easy to sustain. If the direction and magnitude of effect observed here were confirmed in a controlled trial, incorporating a small daily portion of soaked almonds could represent a low-cost, scalable, food-based strategy to support early lipid management in young South Indian adults — a group in whom primordial and primary prevention offer the greatest lifetime return [16,22-24].

5.CONCLUSION

In this single-group pre–post interventional study from South India, 8 weeks of consuming 20 g/day of soaked almonds was associated with significant, clinically meaningful and internally consistent improvement in the serum lipid profile of young adults — reductions in total cholesterol, LDL-C, triglycerides and non-HDL cholesterol together with an increase in HDL-C, all with large effect sizes and with negligible change in body weight — plausibly reflecting the MUFA, soluble fibre, plant sterol and vitamin E content of almonds.

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