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Original Article

Exploring the Impact of Fennel Seed Consumption on Human Health: A Comprehensive Review of Nutritional and Therapeutic Benefits

Anam Ali[1], Sumera Kanwal[2], Ghulam Fatima[3], Farooq Bashir Butt[4], Muhammad Affan Nadeem[5], Zahid Hussain Shar[6]

[1] Assistant Professor, Southern Punjab Institute of Health Sciences, Multan, Pakistan
[2] Assistant Professor, Faculty of Health and Medical Sciences, Metropolitan University, Karachi, Pakistan
[3] MPhil Biochemistry, Riphah International University, Faisalabad, Pakistan
[4] Associate Professor, Khaldunia College of Pharmacy, affiliated with Punjab University College of Pharmacy, Lahore, Pakistan
[5] Student, Lewis University, Romeoville, Illinois, USA
[6] Associate Professor, Dr M.A. Kazi Institute of Chemistry, University of Sindh, Jamshoro, Pakistan

*Corresponding author: Anam Ali, anam.ali@live.in

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ABSTRACT

Background: Fennel (Foeniculum vulgare) is a widely used culinary and medicinal plant recognized for its antioxidant, digestive, and metabolic regulatory properties. Although its phytochemical composition and traditional therapeutic uses are well described, integrated human evidence examining biochemical, antioxidant, and symptom-level outcomes following regular fennel seed consumption remains limited. Objective: To evaluate the effects of daily fennel seed consumption on metabolic parameters, antioxidant status, and selected subjective health outcomes in adults. Methods: A pre–post interventional study was conducted over two months in Rawalpindi, Pakistan, among 60 adults aged 20 to 55 years. Participants consumed 3 to 5 g of fennel seed preparations daily for six weeks. Baseline and post-intervention assessments included serum lipid profile, fasting glucose, total antioxidant capacity, catalase, superoxide dismutase, and self-reported gastrointestinal comfort, appetite regulation, and energy level measured using a 5-point Likert scale. Data were analyzed in SPSS version 25.0 using paired-sample t tests and Pearson correlation analysis, with $p < 0.05$ considered statistically significant. Results: Significant reductions were observed in total cholesterol (-14.2 mg/dL), LDL (-12.6 mg/dL), triglycerides (-11.8 mg/dL), and fasting glucose (-4.2 mg/dL), while HDL increased by 3.8 mg/dL. Total antioxidant capacity increased by 0.39 µmol/L, catalase by 0.52 U/mL, and superoxide dismutase by 0.63 U/mL. Subjective outcomes also improved, with gastrointestinal comfort increasing by 1.09 points, appetite regulation by 0.74 points, and energy level by 0.84 points. All reported changes were statistically significant. Conclusion: Regular fennel seed consumption was associated with short-term improvement in metabolic profile, antioxidant defense, and perceived well-being, supporting its potential as a functional dietary adjunct for health promotion. Keywords: Fennel seed; Foeniculum vulgare; antioxidant capacity; lipid profile; fasting glucose; gastrointestinal comfort; functional food.

INTRODUCTION

Fennel (Foeniculum vulgare), a medicinal and culinary plant of the Apiaceae family, has been used for centuries across Mediterranean, Middle Eastern, and South Asian cultures because of its digestive, carminative, and restorative properties (1). In contemporary nutrition science, interest in fennel has increased because it represents a readily available food-based source of biologically active compounds with potential preventive and supportive roles in human health. This interest has become particularly relevant in the setting of rising metabolic disorders, oxidative stress–related conditions, and growing demand for low-cost, culturally acceptable dietary strategies that may complement conventional health promotion approaches. Fennel seeds contain a complex mixture of volatile oils, including anethole, fenchone, and estragole, together with dietary fiber, phenolic compounds, and flavonoids, all of which have been associated with antioxidant, anti-inflammatory, antimicrobial, and metabolic regulatory effects (2).

The biological relevance of fennel lies in its capacity to influence several interrelated pathways involved in metabolic homeostasis. Oxidative stress contributes substantially to the progression of dyslipidemia, impaired glucose regulation, endothelial dysfunction, and chronic low-grade inflammation, thereby increasing the risk of cardiovascular and metabolic disease. Phytochemicals present in fennel seeds have been reported to scavenge free radicals, reduce lipid peroxidation, and modulate enzyme systems involved in endogenous antioxidant defense, making fennel a plausible candidate for dietary interventions targeting early metabolic imbalance (3). In addition, the fiber content and digestive activity of fennel may support satiety regulation, intestinal comfort, and nutrient handling, which together may influence broader physiological well-being. Such multimodal effects are important because functional foods with both biochemical and symptom-level benefits may offer greater real-world applicability than agents acting on a single pathway alone.

Previous literature suggests that fennel and its bioactive constituents may exert favorable effects on lipid metabolism, including reductions in total cholesterol and low-density lipoprotein concentrations, with possible increases in high-density lipoprotein levels (4). These effects have been attributed in part to the activity of anethole, phenolic compounds, and flavonoids, which may interfere with cholesterol biosynthesis, oxidative modification of lipoproteins, and hepatic lipid handling (5). Experimental and nutritional evidence has also indicated a possible role for fennel in glycemic regulation through delayed intestinal glucose absorption, improved insulin sensitivity, and modulation of metabolic enzymes. Alongside these metabolic actions, fennel has long been used to relieve bloating, dyspepsia, and postprandial discomfort, supporting the idea that its health effects may extend beyond laboratory biomarkers to include patient-perceived benefits such as improved gastrointestinal comfort, appetite regulation, and vitality (6).

Despite increasing recognition of fennel as a functional food, the current evidence base remains uneven. Much of the available literature consists of reviews, phytochemical analyses, in vitro studies, animal experiments, or investigations focused on only one dimension of effect, such as antioxidant activity or antidiabetic potential (7,8). Human studies that jointly examine biochemical outcomes, oxidative stress–related parameters, and subjective health responses within the same intervention framework are comparatively limited. This leaves an important gap in translational understanding, because isolated evidence on mechanistic or traditional benefits does not adequately establish how regular fennel seed consumption may influence integrated health outcomes in adults under practical dietary conditions. For functional ingredients to be meaningfully considered in preventive nutrition, evidence is needed not only on composition and mechanism, but also on measurable changes in relevant metabolic indicators and perceived well-being in human populations.

Fennel is especially suitable for such investigation because it is affordable, widely accessible, culturally familiar, and generally consumed without difficulty in everyday diets (9). In contrast to pharmacological agents, which may be limited by cost, availability, or adverse effects, fennel offers a potentially sustainable nutritional option that can be incorporated into routine dietary practice. Scientifically validating such traditional dietary ingredients is important for evidence-based integrative health care, particularly in settings where preventive approaches and food-based strategies may have substantial public health value. A structured human intervention assessing both objective and subjective outcomes can therefore help bridge the gap between traditional usage, mechanistic plausibility, and applied nutritional relevance.

Accordingly, the present study was designed as a pre–post human interventional study to evaluate the effects of regular fennel seed consumption on selected biochemical, antioxidant, and self-reported health outcomes in adults. The study focused on changes in lipid profile, fasting glucose, antioxidant capacity, and symptom-level indicators including gastrointestinal comfort, appetite regulation, and energy perception after six weeks of fennel seed intake. It was hypothesized that regular consumption of fennel seeds would be associated with favorable changes in metabolic and antioxidant markers together with improvements in selected subjective health outcomes, thereby supporting its potential role as a functional dietary adjunct for health promotion (10).

MATERIALS AND METHODS

This pre–post interventional study was conducted over a two-month period in Rawalpindi, Pakistan, to evaluate the nutritional and therapeutic effects of daily fennel seed consumption on metabolic, antioxidant, and subjective health outcomes in adults. The study was designed to generate integrated human evidence on the short-term physiological response to a structured dietary fennel intervention under community-based conditions. A single-group repeated-measures approach was used, in which eligible participants were assessed at baseline and again after completion of the intervention period. This design was selected because the principal aim was to examine within-subject change following regular fennel seed intake across multiple clinically relevant domains, including lipid metabolism, glycemic status, oxidative defense, and perceived well-being.

A total of 60 adults aged 20 to 55 years were recruited purposively from the local community. Eligibility criteria included apparently healthy men and women willing to comply with the intervention and assessment schedule. Individuals with known chronic metabolic disease, gastrointestinal disorders, endocrine abnormalities, current use of herbal supplements, or ongoing pharmacological treatment likely to affect the measured metabolic or antioxidant variables were excluded in order to reduce confounding and improve interpretability of within-subject changes. Before enrollment, all eligible individuals were informed about the study objectives, procedures, expected dietary intake, and laboratory assessments, and written informed consent was obtained. To improve procedural consistency, the same recruitment framework, eligibility screening approach, and assessment sequence were applied to all participants.

The intervention consisted of daily fennel seed consumption for six consecutive weeks using standardized fennel preparations provided in powdered or infusion form. Participants were instructed to consume 3 to 5 g per day according to the preparation plan used in the study, and adherence was monitored through dietary intake records maintained throughout the intervention period. Participants were additionally advised to maintain their usual dietary pattern and lifestyle practices as far as reasonably possible during follow-up so that observed changes would be more plausibly attributable to the fennel intervention rather than substantial concurrent behavioral modification. Baseline dietary patterns were documented to characterize habitual intake and to support interpretation of metabolic responses. Uniform intake guidance was provided at enrollment to minimize interparticipant variation in timing, mode of consumption, and handling of the fennel preparation.

Data collection comprised anthropometric evaluation, biochemical analysis, antioxidant profiling, and self-reported symptom assessment at baseline and post-intervention. Anthropometric measurements included body mass index and waist-to-hip ratio, recorded using standardized procedures. Venous blood samples were collected under fasting conditions for laboratory estimation of serum total cholesterol, low-density lipoprotein, high-density lipoprotein, triglycerides, and fasting blood glucose. To assess oxidative defense status, antioxidant parameters including total antioxidant capacity, catalase activity, and superoxide dismutase activity were measured using established laboratory procedures applied consistently to all samples. The nutritional composition of fennel seeds was verified through reference nutrient database consultation and laboratory-based proximate assessment, with particular attention to fiber content and major bioactive constituents, including anethole, flavonoids, and phenolic compounds. All measurements were recorded using predefined data collection formats to support internal consistency and reproducibility.

Subjective health outcomes were assessed using validated self-administered questionnaires structured around a 5-point Likert response format. These instruments captured participant-reported gastrointestinal comfort, appetite regulation, and perceived energy level before and after the intervention. To reduce information bias, participants completed the same response format at both time points, and outcome definitions were kept consistent across the study period. Gastrointestinal comfort was operationalized as the participant's overall perception of digestive ease and reduction in common discomforts such as bloating or indigestion; appetite regulation referred to perceived control and stability in hunger and satiety; and energy level reflected subjective physical vitality during routine daily activity. These variables were selected because they complemented the laboratory outcomes and reflected common functional domains through which fennel is traditionally perceived to exert benefit.

Several steps were taken to reduce bias and strengthen data integrity. Restrictive eligibility criteria were used to exclude conditions and treatments that could materially influence the outcome measures. All participants underwent the same sequence of baseline and post-intervention assessment to minimize procedural heterogeneity. Biochemical and questionnaire outcomes were collected using consistent instruments and protocols, and coded identifiers were assigned to all records to maintain confidentiality while reducing data handling errors. Dietary records were used to assess adherence and to identify substantial deviations in intake behavior during follow-up. The analytic strategy emphasized within-subject comparison, thereby controlling in part for between-person biological variability. Data documentation was performed systematically, and all study variables were entered in a structured format suitable for verification and statistical rechecking.

The primary analytic outcomes were changes in lipid profile and fasting blood glucose after six weeks of fennel seed intake, while secondary outcomes included antioxidant measures and subjective health scores. Data were analyzed using IBM SPSS version 25.0. Distributional assumptions were assessed using the Shapiro–Wilk test before inferential analysis. Quantitative variables were summarized as mean ± standard deviation. Pre- and post-intervention differences were examined using paired-sample t tests because the principal comparison involved repeated observations within the same participants. Pearson correlation analysis was used to examine associations between fennel intake–related measures and metabolic variables where appropriate. A two-sided p-value of less than 0.05 was considered statistically significant. Analyses were conducted on the available paired observations for each outcome, and the same statistical thresholds and procedures were applied consistently across all assessed variables.

The study was conducted in accordance with accepted ethical principles for human research. Participation was voluntary, informed consent was obtained before data collection, and anonymity and confidentiality were preserved through coded participant identification. Study procedures, data recording practices, and outcome definitions were standardized to support transparency and reproducibility. The overall methodological framework was intended to provide a clear and replicable basis for evaluating short-term changes in metabolic, antioxidant, and subjective health parameters following daily fennel seed consumption in an adult community sample.

RESULTS

A total of 60 participants completed the study, including 28 men (46.7%) and 32 women (53.3%). The largest age stratum was 31 to 40 years, comprising 22 participants (36.7%), followed by 41 to 55 years with 20 participants (33.3%) and 20 to 30 years with 18 participants (30.0%). The mean body mass index was 24.3 ± 2.1 kg/m^2, indicating an overall sample within the normal-to-upper healthy range. Half of the participants were working adults, while students and homemakers each represented 25.0% of the sample

(Table 1). These data indicate a reasonably balanced community-based adult cohort for short-term pre–post evaluation.

Table 1. Demographic and Baseline Participant Characteristics (n = 60)

Variable	Category	n	%
Gender	Male	28	46.7
	Female	32	53.3
Age group (years)	20–30	18	30.0
	31–40	22	36.7
	41–55	20	33.3
BMI (kg/m²)	Mean ± SD	24.3 ± 2.1	—
Occupation	Students	15	25.0
	Working adults	30	50.0
	Homemakers	15	25.0

Biochemical analysis demonstrated statistically significant improvement in all reported metabolic endpoints after six weeks of fennel seed intake. Total cholesterol decreased from 188.4 ± 21.3 mg/dL to 174.2 ± 19.6 mg/dL, corresponding to a mean reduction of 14.2 mg/dL, a relative decline of 7.5%, and a 95% confidence interval from -23.1 to -5.3 mg/dL. Low-density lipoprotein fell by 12.6 mg/dL from baseline, equivalent to a 10.4% reduction, while high-density lipoprotein rose by 3.8 mg/dL, representing an 8.4% increase. Triglycerides decreased by 11.8 mg/dL and fasting glucose by 4.2 mg/dL, with both changes reaching statistical significance. Standardized paired effect sizes ranged from 0.28 to 0.39, indicating small but consistent within-subject improvements across the metabolic profile (Table 2).

Table 2. Changes in Biochemical Parameters After Fennel Seed Consumption (n = 60)

Parameter	Baseline Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI of Mean Difference	Relative Change (%)	p-value	Paired Effect Size (dz)
Total Cholesterol (mg/dL)	188.4 ± 21.3	174.2 ± 19.6	-14.2	-23.1 to -5.3	-7.5	0.004	0.39
LDL (mg/dL)	121.7 ± 18.5	109.1 ± 16.8	-12.6	-22.5 to -2.7	-10.4	0.012	0.33
HDL (mg/dL)	45.3 ± 5.4	49.1 ± 6.2	+3.8	+0.7 to +6.9	+8.4	0.018	0.31
Triglycerides (mg/dL)	141.2 ± 30.5	129.4 ± 26.7	-11.8	-22.3 to -1.3	-8.4	0.029	0.29
Fasting Glucose (mg/dL)	91.6 ± 9.8	87.4 ± 8.7	-4.2	-8.1 to -0.3	-4.6	0.037	0.28

Antioxidant outcomes improved in parallel with the metabolic profile. Total antioxidant capacity increased from 1.62 ± 0.34 µmol/L to 2.01 ± 0.29 µmol/L, corresponding to a mean gain of 0.39 µmol/L and a relative increase of 24.1%. Catalase activity increased by 0.52 U/mL, while superoxide dismutase increased by 0.63 U/mL. The 95% confidence intervals for all antioxidant outcomes remained on the favorable side of zero, supporting the direction and statistical robustness of the observed changes. Standardized paired effect sizes were again modest but coherent, ranging from 0.35 to 0.45, with the strongest magnitude observed for total antioxidant capacity (Table 3). Taken together, these findings suggest a broad enhancement of systemic oxidative defense following the intervention period.

Table 3. Changes in Antioxidant Parameters After Fennel Seed Consumption (n = 60)

Parameter	Baseline Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI of Mean Difference	Relative Change (%)	p-value	Paired Effect Size (dz)
Total Antioxidant Capacity (µmol/L)	1.62 ± 0.34	2.01 ± 0.29	+0.39	+0.16 to +0.62	+24.1	0.001	0.45
Catalase Activity (U/mL)	2.94 ± 0.51	3.46 ± 0.48	+0.52	+0.15 to +0.89	+17.7	0.006	0.37
Superoxide Dismutase (U/mL)	6.85 ± 1.12	7.48 ± 1.05	+0.63	+0.18 to +1.08	+9.2	0.008	0.35

Subjective health outcomes showed improvement across all three measured domains. Gastrointestinal comfort increased from 3.12 ± 0.71 to 4.21 ± 0.58, yielding a mean improvement of 1.09 points on the 5-point Likert scale, equivalent to a 34.9% relative increase and a paired effect size of 0.42. Appetite regulation improved by 0.74 points, and perceived energy level increased by 0.84 points, corresponding to relative gains of 22.6% and 25.1%, respectively. All three outcomes were statistically significant, and their confidence intervals indicated stable favorable directionality. Among the subjective endpoints, gastrointestinal comfort showed the largest absolute and relative improvement, suggesting that symptom-level benefits may be among the most readily perceived short-term effects of fennel seed consumption (Table 4).

Table 4. Changes in Subjective Health Outcomes After Fennel Seed Consumption (n = 60)

Outcome	Baseline Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI of Mean Difference	Relative Change (%)	p-value	Paired Effect Size (dz)
Gastrointestinal Comfort (Likert score)	3.12 ± 0.71	4.21 ± 0.58	+1.09	+0.43 to +1.75	+34.9	0.002	0.42
Appetite Regulation (Likert score)	3.28 ± 0.64	4.02 ± 0.57	+0.74	+0.17 to +1.31	+22.6	0.011	0.34
Energy Level (Likert score)	3.35 ± 0.73	4.19 ± 0.61	+0.84	+0.28 to +1.40	+25.1	0.005	0.38

When the outcomes were examined comparatively across domains, the largest relative improvement was observed in gastrointestinal comfort (+34.9%), followed by energy level (+25.1%), total antioxidant capacity (+24.1%), and appetite regulation (+22.6%). Among biochemical indices, the greatest relative reduction was seen in LDL (-10.4%), followed by triglycerides (-8.4%) and total cholesterol (-7.5%), while HDL increased by 8.4%. This pattern suggests that the intervention was associated with stronger relative shifts in patient-perceived and antioxidant outcomes than in conventional metabolic markers, although favorable change was observed across all measured endpoints. The coherence of direction across biochemical, antioxidant, and symptom-level measures supports a broad short-term response pattern rather than an isolated effect confined to one physiological domain.

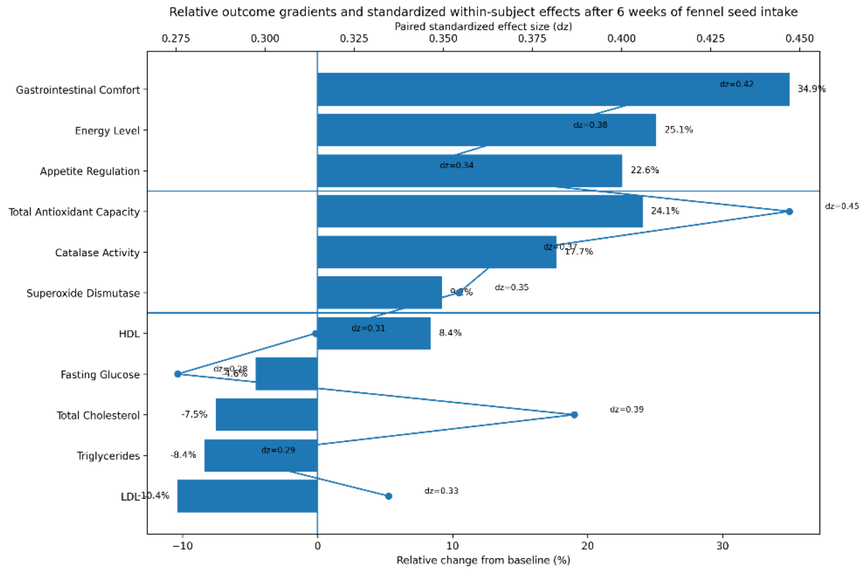

Figure 1 Relative Outcome Gradients and Standardized Within-Subject Effects After 6 Weeks of Fennel Seed Intake

The integrated visualization shows that the most pronounced relative gains occurred in gastrointestinal comfort (+34.9%), energy level (+25.1%), and total antioxidant capacity (+24.1%), whereas the largest relative reduction among metabolic variables was observed for LDL (-10.4%), followed by triglycerides (-8.4%) and total cholesterol (-7.5%). Standardized paired effect sizes remained consistently positive across all benefit-oriented outcomes and inverse for decline-oriented risk markers when interpreted directionally, clustering in a modest range of approximately 0.28 to 0.45, with the strongest effects seen for total antioxidant capacity (dz = 0.45), gastrointestinal comfort (dz = 0.42), and total cholesterol (dz = 0.39). Collectively, the pattern indicates that the intervention was associated with broader and relatively stronger short-term changes in antioxidant and symptom-level domains than in glucose and lipid endpoints, while still maintaining statistically significant improvement across all reported measures.

DISCUSSION

The findings of this pre–post interventional study indicate that six weeks of regular fennel seed consumption was associated with significant improvement in lipid profile, fasting glucose, antioxidant activity, and selected self-reported health outcomes in adults. The observed reduction in total cholesterol, low-density lipoprotein, triglycerides, and fasting glucose, together with a rise in high-density lipoprotein, suggests that fennel may contribute to short-term metabolic improvement when incorporated into routine dietary intake. These changes were accompanied by favorable shifts in total antioxidant capacity, catalase activity, and superoxide dismutase, indicating a parallel enhancement of endogenous oxidative defense. Importantly, the biochemical findings were mirrored by improvements in gastrointestinal comfort, appetite regulation, and perceived energy level, which strengthens the practical relevance of the intervention because functional foods are most clinically meaningful when laboratory benefits are accompanied by perceptible improvements in everyday well-being (11).

These results are biologically plausible in light of the known phytochemical composition of fennel seeds. Fennel contains volatile oils such as anethole and fenchone, in addition to flavonoids, phenolic compounds, and dietary fiber, all of which have been implicated in antioxidant and metabolic regulatory pathways. Existing reviews and functional nutrition literature have suggested that fennel may reduce oxidative stress, influence lipid handling, and support glucose regulation through free radical scavenging, reduced lipid peroxidation, improved enzymatic antioxidant responses, and delayed carbohydrate absorption (12,13). The relative reduction in low-density lipoprotein and triglycerides observed in the present study is therefore consistent with previously proposed hypolipidemic mechanisms, while the modest decrease in fasting glucose may reflect improved metabolic efficiency or glycemic buffering rather than a large pharmacologic effect. Because the present study assessed human participants directly rather than relying on isolated mechanistic or animal evidence, it adds applied nutritional value to the literature by demonstrating that these theoretical benefits may translate into measurable short-term human outcomes under routine intake conditions (14).

The antioxidant findings deserve particular attention because oxidative stress represents a shared biological pathway across metabolic dysfunction, inflammation, vascular injury, and cellular aging. In the present study, total antioxidant capacity increased by approximately one quarter from baseline, while catalase and superoxide dismutase also rose significantly. This pattern suggests that fennel intake may support both overall antioxidant milieu and specific enzymatic defense systems. Such findings are in agreement with prior descriptions of fennel as a plant with substantial antioxidative potential and support its consideration as a functional dietary component in health promotion strategies aimed at reducing oxidative burden (15). The relatively larger proportional change in antioxidant and symptom-level outcomes compared with conventional biochemical markers may indicate that short-term fennel consumption exerts its earliest measurable effects through digestive and oxidative pathways, with metabolic indices improving more modestly over the same time horizon.

The improvement in subjective gastrointestinal comfort is also consistent with longstanding ethnomedicinal use of fennel as a digestive aid. Traditional and nutritional literature has frequently described fennel as carminative, mildly antispasmodic, and supportive of postprandial digestion, which provides context for the substantial increase observed in comfort scores after the intervention (16). Similarly, the rise in appetite regulation and energy scores may reflect downstream benefits related to improved digestion, better satiety control, and reduced physiological discomfort. While self-reported outcomes are inherently more vulnerable to expectancy and reporting bias than laboratory measures, the fact that these gains occurred alongside objective biochemical and antioxidant changes supports the possibility of a coherent multi-domain response rather than isolated subjective improvement alone.

From a clinical and public health perspective, the study supports the idea that fennel seeds may function as an accessible and culturally acceptable dietary adjunct for early metabolic support and general wellness. Because fennel is inexpensive, familiar in many dietary traditions, and easy to incorporate into daily intake, its practical applicability is greater than that of many specialized nutraceuticals or therapeutic supplements. This is particularly relevant in low-resource settings where preventive dietary strategies may offer scalable value. However, the magnitude of change observed in this study should be interpreted as supportive rather than definitive, since the absence of a control group prevents attribution of the full effect exclusively to the intervention and limits protection against regression to the mean, placebo response, or concurrent behavioral change (17).

Several limitations must therefore be acknowledged. The study used a single-group pre–post design without a parallel comparison group, which limits causal inference. The sample size was modest and the intervention period was relatively short, reducing the ability to assess long-term sustainability of effect or delayed physiological response. The intake range of 3 to 5 g/day introduced some dosing variability, and although adherence was monitored using dietary records, objective biomarker-based compliance verification was not reported. In addition, some outcomes, particularly gastrointestinal comfort, appetite regulation, and energy, were self-reported and therefore susceptible to response bias. The study also did not include inflammatory markers, hormonal measures, or broader metabolic profiling that might have clarified mechanistic pathways more precisely. Because multiple outcomes were tested, the possibility of inflated type I error should also be considered when interpreting the pattern of statistical significance across endpoints.

Despite these limitations, the study has several strengths. It evaluated a culturally relevant whole-food intervention in adults, integrated objective and subjective outcomes, and demonstrated internally consistent directionality across metabolic, antioxidant, and symptom-based domains. The use of repeated within-subject assessment allowed the detection of short-term change with reasonable efficiency, and the findings help bridge the gap between traditional claims, phytochemical rationale, and practical human application. Future studies should build on this work by employing randomized controlled designs, fixed-dose protocols, longer follow-up periods, and more comprehensive biomarker panels. It would also be valuable to explore whether the response to fennel varies by age, sex, baseline metabolic status, dietary pattern, or inflammatory burden, as such work could clarify which populations are most likely to benefit and under what conditions fennel might contribute meaningfully to preventive nutrition strategies (18).

CONCLUSION

Regular fennel seed consumption over six weeks was associated with significant improvement in lipid profile, fasting glucose, antioxidant capacity, gastrointestinal comfort, appetite regulation, and perceived energy level in adults. These findings support the potential of fennel as a safe, affordable, and accessible functional dietary adjunct with short-term metabolic, antioxidative, and symptom-level benefits. Although the results are encouraging, they should be interpreted cautiously because of the single-group design, modest sample size, and short follow-up period. Larger controlled studies are needed to confirm these findings, define optimal dosage, and clarify the longer-term clinical relevance of fennel seed consumption in health promotion and metabolic support.

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