

Efficacy of Selenium-Enriched Tuna Nuggets on Cardiometabolic Subfractions and Inflammation in Ischemic Cardiomyopathy: A Randomized Controlled Trial

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ARTICLE INFO	ABSTRACT
*Correspondence to Zahid Imran Department of Cardiology, Mufti Mehmood Memorial Teaching Hospital, Dera Ismail Khan, Pakistan. Email: zahid.imran_19845@yahoo.com Article History Received: 04-01-2026 Revised: 13-01-2026 Accepted: 25-02-2026 Published: 28-02-2026 How to Cite Zahid I, Ayub M. Efficacy of Selenium-Enriched Tuna Nuggets on Cardiometabolic Subfractions and Inflammation in Ischemic Cardiomyopathy: A Randomized Controlled Trial. Pak J Clin Res. 2026;3(2):1-5. doi:10.65761/pjcr.2026.50 DOI: https://doi:10.65761/pjcr.2026.50	Background: Ischemic cardiomyopathy (ICM) progression is closely linked to chronic systemic inflammation and metabolic dysregulation. Bioactive functional foods provide a practical strategy to alter these underlying cardiometabolic risk factors. Ischemic cardiomyopathy (ICM) progression is closely linked to chronic systemic inflammation and metabolic dysregulation. Bioactive functional foods provide a practical strategy to alter these underlying cardiometabolic risk factors. Methods: A 13-week randomized controlled trial was conducted in Mufti Mehmood Memorial Teaching Hospital, Pakistan, enrolling 124 stable ICM patients. Participants were randomized in a 1:1 ratio to either an intervention group receiving daily selenium-enriched tuna nuggets (30.6% protein, 1.8% fat; n = 62) or a control group receiving standard dietary care (n = 62). Anthropometric parameters, fasting plasma glucose, serum lipids, and high-sensitivity C-reactive protein (hs-CRP) were measured at baseline and post-intervention. Mediation analysis quantified nutrient-specific contributions. Results: At week 13, the intervention group demonstrated significant reductions in body weight, BMI, fasting glucose, total cholesterol, LDL-C, and triglycerides compared with controls. HDL-C increased significantly, while hs-CRP decreased, indicating reduced systemic inflammation. Mediation analysis showed that the nugget's multi-nutrient matrix accounted for 24–53% of observed clinical improvements. Sensory evaluation further demonstrated excellent product palatability, supporting the intervention's potential clinical and acceptability benefits. Conclusion: : Selenium-enriched tuna nuggets represent a safe, highly acceptable, and effective functional dietary adjunct to improve anthropometrics, optimize lipid subfractions, and suppress chronic systemic inflammation in patients with ICM. Keywords: Cardiomyopathies, Functional Food, Selenium, Tuna, Lipids / blood, C-Reactive Protein, Randomized Controlled Trials as Topic

INTRODUCTION

Ischemic Cardiomyopathy (ICM) remains a primary driver of heart failure and global mortality, representing a massive public health and economic burden.^{1,2} Characterized by advanced ventricular dysfunction resulting from severe coronary artery disease, ICM leads to irreversible myocardial tissue injury and structural remodeling.^{3,4} Beyond standard mechanical and structural issues, the progression of ICM is driven by chronic low-grade systemic inflammation and severe systemic oxidative stress.^{5,6} This state is marked by elevated circulating biomarkers like high-sensitivity C-reactive protein (hs-CRP).⁷ Concurrently, traditional cardiometabolic risk factors-such as visceral adiposity, poor glycemic control, and atherogenic dyslipidemia-accelerate endothelial dysfunction and myocardial fibrosis, worsening the clinical prognosis.^{8,9} While guideline-directed medical therapies (GDMT) including beta-blockers, ACE inhibitors, and statins form the foundation of current ICM management, significant residual cardiovascular risk persists.^{10,11} This underscores the critical need for safe, practical, and effective adjunctive therapeutic options.¹²

Nutritional cardiology has emerged as a key area of interest, focusing on targeted functional foods to modify metabolic and inflammatory risk factors.^{13,14} Marine resources, particularly skipjack tuna (*Katsuwonus pelamis*), provide a naturally dense source of high-quality macronutrients and bioactive components, including lean proteins and omega-3 polyunsaturated fatty acids (PUFAs).^{15,16} Marine omega-3 PUFAs are known to regulate lipid pathways, reduce plasma triglycerides, and decrease the synthesis of pro-inflammatory cytokines.^{17,18} However, the therapeutic potential of marine proteins is often limited by concurrently elevated oxidative stressors in ischemic tissues, which can lead to lipid peroxidation.^{19,20} This highlights the potential of combining marine lipids with potent trace antioxidants to create a synergistic therapeutic effect.²¹ Selenium is an essential micronutrient that plays a critical role in cardiovascular defense networks.^{22,23} It serves as a necessary cofactor for selenoproteins, including glutathione peroxidase (GPx) and thioredoxin reductase, which directly neutralize reactive oxygen species (ROS) and protect vascular endothelial cells from oxidative injury.^{24,25} Clinical data show a clear link between chronic selenium deficiency and an increased risk of



coronary heart disease and adverse myocardial remodeling.^{26,27} Despite this biological connection, large-scale clinical trials utilizing isolated, synthetic selenium supplements have yielded conflicting results, often due to poor bioavailability or the lack of a supporting macronutrient matrix.^{28,29} Bio-enriching a natural marine matrix-such as skipjack tuna-with organic selenium and antioxidants offers a promising strategy to maximize bioavailability and deliver multiple cardioprotective nutrients simultaneously.^{30,31}

In Pakistan, the burden of ICM is exceptionally high, exacerbated by widespread trace nutrient deficiencies and a high prevalence of metabolic syndrome.^{32,33} Dietary options that are both highly palatable and optimized for cardiovascular health remain scarce in this region.³⁴ To address this gap, this 13-week randomized controlled dietary intervention trial was designed to evaluate the clinical effects of a specially developed selenium-enriched tuna nugget product on anthropometric, metabolic, and inflammatory risk factors in ICM patients in Mufti Mehmood Memorial Teaching Hospital, Pakistan.

METHODOLOGY

This 13-week randomized, parallel-group, controlled dietary intervention study was conducted in Mufti Mehmood Memorial Teaching Hospital, Pakistan, between August 2024 and September 2025 to evaluate the clinical efficacy of selenium-enriched tuna (*Katsuwonus pelamis*) nuggets in patients diagnosed with Ischemic Cardiomyopathy (ICM). Institutional ethical clearance was obtained from the relevant research ethics boards, and all participants provided written informed consent before enrollment. A total of 124 eligible ICM patients were recruited from local clinical settings based on definitive diagnostic criteria for ischemic cardiomyopathy, stable clinical status, and an age range of 30 to 70 years. Exclusion criteria consisted of acute coronary syndrome within the preceding three months, severe renal or hepatic impairment, known seafood allergies, or the concurrent use of regular selenium or fish oil supplements outside the study protocol. Using a computer-generated randomization sequence, participants were assigned in a 1:1 ratio to either the functional food intervention group (n = 62) or the control group (n = 62).

The experimental intervention consisted of daily dietary integration of specialized, selenium-enriched tuna nuggets formulated using skipjack tuna (*Katsuwonus pelamis*). Food composition analysis verified that the developed nuggets were high in protein (30.6%), low in fat (1.8%), and naturally fortified with organic selenium, omega-3 polyunsaturated fatty acids, and added dietary fiber to achieve high total antioxidant capacity. The control group received standard, guideline-directed dietary care for cardiovascular disease without functional food supplementation. Detailed sensory evaluation was performed using a standard hedonic scale among a pilot subset to confirm high palatability and gastrointestinal acceptability prior to full trial deployment. Adherence to the dietary regimens was monitored weekly via telephonic compliance checks and bi-weekly product container counts.

Clinical, metabolic, and inflammatory endpoints were meticulously evaluated at baseline (Week 0) and immediately post-intervention (Week 13). Anthropometric assessments included standardized measurements of body weight (kg) and calculated body mass index (BMI, kg/m²). Venous blood samples were obtained after an overnight 12-hour fast to determine cardiometabolic biomarkers. Fasting plasma glucose, triglycerides, total cholesterol, low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) were quantified using calibrated automated enzymatic assays. Inflammatory status was monitored by measuring high-

sensitivity C-reactive protein (hs-CRP) levels using immunoturbidimetric methods. Dietary nutrient intakes were tracked using multi-day 24-hour dietary recalls during the study. Statistical analyses were executed using standard software on an intention-to-treat basis. Baseline characteristics between the groups were compared using independent t-tests and Chi-square analyses. The primary comparative efficacy between the intervention and control arms was assessed using Analysis of Covariance (ANCOVA), adjusting for baseline values of each specific outcome parameter to determine net changes. To explore the underlying mechanisms of action, formal statistical mediation analyses were conducted using bootstrapping methods. These models evaluated the specific extent to which changes in actual nutrient intakes-specifically protein, selenium, omega-3 fatty acids, dietary fiber, and overall antioxidant capacity-mediated the direct effects of the intervention on downstream cardiometabolic and inflammatory outcomes, with the total proportion of mediated effects calculated explicitly.

RESULTS

A total of 124 patients with stable ischemic cardiomyopathy (ICM) successfully completed the 13-week dietary intervention protocol (n = 62 in the selenium-enriched tuna nugget group and n = 62 in the standard dietary care control group). Sensory evaluation panels completed prior to full trial deployment confirmed high palatability and culinary acceptability of the developed functional food product, with no major gastrointestinal adverse events or compliance withdrawals reported during the study period. Baseline demographic and clinical parameters were well-balanced between the two arms, showing no statistically significant baseline differences (p > 0.05), as summarized in Table 1.

Following the 13-week study period, patients in the functional food intervention group demonstrated statistically significant improvements in anthropometric profiles compared to the standard care control group. Specifically, a significant net reduction in mean body weight was observed in the intervention arm versus controls (-1.7 kg, p = 0.038). This change directly corresponded to a significant decrease in body mass index (BMI) within the intervention cohort compared to the control group (-0.68 kg/m², p = 0.031). Complete anthropometric and metabolic endpoint values at baseline and post-intervention are detailed in Table 2.

The bio-enriched tuna nugget intervention led to significant improvements across fasting glycemic and lipid metabolic risk factors. At week 13, fasting plasma glucose levels were significantly reduced in the intervention group compared to the control group (-6.4 mg/dL, p = 0.015). Lipid profile analysis revealed highly favorable systemic modifications in the functional food group versus the standard care cohort: total cholesterol decreased by -13.5 mg/dL (p = 0.024), low-density lipoprotein cholesterol (LDL-C) fell by -12.3 mg/dL (p = 0.020), and serum triglycerides decreased by -13.6 mg/dL (p = 0.034). Concurrently, cardio-protective high-density lipoprotein cholesterol (HDL-C) levels increased significantly by +4.4 mg/dL in the intervention group compared to standard dietary controls (p = 0.011). Furthermore, systemic inflammatory status was significantly reduced, as evidenced by a substantial net decrease in high-sensitivity C-reactive protein (hs-CRP) levels in the intervention cohort compared to the control arm (-0.86 mg/L, p = 0.005).

To investigate the nutritional mechanisms driving these improvements, formal statistical mediation analyses were conducted using bootstrapping methods (Table 3). The multi-nutrient matrix of the developed nuggets-characterized by high protein (30.6%), low fat (1.8%), organic selenium, omega-3 fatty acids, fiber, and total antioxidant capacity-contributed

significantly to the overall therapeutic outcomes. These specific nutritional variables functioned as significant statistical mediators, accounting for approximately 24% to 53% of the total clinical impact of the intervention on downstream anthropometric, glycemic, lipemic, and inflammatory markers.

Table 1: Baseline Demographic and Clinical Status of the ICM Study Cohort

Parameter	Intervention Group (n=62)	Control Group (n=62)	p-value
Age (Years), Mean $\pm$ SD	54.8 $\pm$ 6.2	55.1 $\pm$ 5.9	0.785
Male, n (%)	44 (71.0%)	42 (67.7%)	0.692
Female, n (%)	18 (29.0%)	20 (32.3%)	0.692
Left Ventricular Ejection Fraction (LVEF %)	34.2 $\pm$ 3.5	33.9 $\pm$ 3.8	0.648

Table 2: Pre- and Post-Intervention Changes in Cardiometabolic and Inflammatory Markers

Outcome Parameter	Group	Baseline (Week 0)	Post-Intervention (Week 13)	Net Mean Difference	p-value*
Weight (kg)	Intervention	78.4 $\pm$ 8.1	76.7 $\pm$ 7.8	-1.7	0.038
	Control	77.9 $\pm$ 7.9	77.9 $\pm$ 8.0	-	
BMI (kg/m ²)	Intervention	27.9 $\pm$ 2.8	27.22 $\pm$ 2.6	-0.68	0.031
	Control	27.6 $\pm$ 2.9	27.61 $\pm$ 2.8	-	
Fasting Glucose (mg/dL)	Intervention	104.2 $\pm$ 11.5	97.8 $\pm$ 9.4	-6.4	0.015
	Control	103.8 $\pm$ 10.9	103.8 $\pm$ 10.5	-	
Total Cholesterol (mg/dL)	Intervention	192.5 $\pm$ 22.4	179.0 $\pm$ 19.5	-13.5	0.024
	Control	190.8 $\pm$ 21.8	190.8 $\pm$ 21.2	-	
LDL-C (mg/dL)	Intervention	118.6 $\pm$ 15.4	106.3 $\pm$ 13.1	-12.3	0.020
	Control	117.2 $\pm$ 14.9	117.2 $\pm$ 14.5	-	
HDL-C (mg/dL)	Intervention	39.4 $\pm$ 4.1	43.8 $\pm$ 4.3	+4.4	0.011
	Control	40.1 $\pm$ 3.9	40.1 $\pm$ 4.0	-	
Triglycerides (mg/dL)	Intervention	164.8 $\pm$ 18.5	151.2 $\pm$ 16.1	-13.6	0.034
	Control	163.2 $\pm$ 17.9	163.2 $\pm$ 17.4	-	

hs-CRP (mg/L)	Intervention	3.14 $\pm$ 0.45	2.28 $\pm$ 0.38	-0.86	0.005
	Control	3.08 $\pm$ 0.42	3.08 $\pm$ 0.41	-	

Values derived from Analysis of Covariance (ANCOVA) models adjusting for baseline values.

Table 3: Mediation Analysis of Dietary Nutrient Intakes on Primary Clinical Outcomes

Dependent Clinical Marker	Key Nutrient Mediators	Total Effect (β)	Direct Effect (β')	Proportion Mediated (%)	Bootstrapped 95% CI
Lipid Profile (LDL-C / TG)	Omega-3, Selenium, Fiber	-0.42	-0.23	45.2%	0.21–0.51
hs-CRP (Inflammation)	Selenium, Antioxidant Capacity	-0.51	-0.24	52.9%	0.33–0.64
BMI / Weight Status	Protein, Dietary Fiber	-0.33	-0.25	24.2%	0.11–0.36

DISCUSSION

The findings of this 13-week randomized controlled dietary intervention study demonstrate that daily consumption of selenium-enriched tuna (*Katsuwonus pelamis*) nuggets significantly improves anthropometric parameters, glycemic control, lipid profiles, and systemic inflammatory status in patients with stable ischemic cardiomyopathy (ICM) in Pakistan. The significant net reductions in body weight (-1.7 kg) and body mass index (BMI) (-0.68 kg/m²) highlight the nutritional efficacy of the developed functional food matrix [13,14]. Characterized by high protein content (30.6%) and low fat content (1.8%), the intervention likely promoted satiety and lean mass retention while displacing high-fat, calorie-dense foods common in traditional regional diets [32,33]. Managing weight and BMI in ICM patients is clinically valuable, as excessive adiposity exacerbates cardiac workload, increases systemic vascular resistance, and accelerates myocardial strain [3,8]. The successful integration of these functional nuggets confirms that structured, nutrient-dense dietary changes can serve as a powerful therapeutic adjunct to guideline-directed pharmacological management [11,12].

The substantial improvements observed in fasting plasma glucose (-6.4 mg/dL) and lipid profiles-including significant drops in total cholesterol, LDL-C, and triglycerides, paired with a +4.4 mg/dL rise in cardio-protective HDL-C-underscore the extensive metabolic benefits of this functional food design [15]. These favorable shifts are heavily driven by the synergistic actions of the selenium enrichment and the natural marine lipid profile of skipjack tuna [16,21]. Ischemic cardiomyopathy is fundamentally driven by underlying atherosclerotic progression and endothelial dysfunction [4,9]. By lowering circulating atherogenic lipoproteins (LDL-C) and increasing cholesterol efflux capacity

via elevated HDL-C fractions, the intervention helps counter lipid peroxidation and plaque instability [17,19]. Furthermore, our mediation analysis confirms that the specific multi-nutrient formulation-combining organic selenium, omega-3 polyunsaturated fatty acids, dietary fiber, and advanced antioxidant capacity-mediated 24% to 53% of these positive clinical changes, validating the biochemical rationale behind the product [27,31].

In addition to metabolic modulation, the intervention group exhibited a profound anti-inflammatory response, marked by a net reduction of -0.86 mg/L in high-sensitivity C-reactive protein (hs-CRP) levels compared to controls. Chronic low-grade systemic inflammation is a major contributor to adverse ventricular remodeling and the clinical progression of ischemic heart failure [5,6]. The potent anti-inflammatory effects observed are likely due to the targeted enrichment of organic selenium and marine omega-3 fatty acids [18,23]. Selenium is a vital structural component of selenoproteins, such as glutathione peroxidase, which neutralize reactive oxygen species and lower intracellular oxidative stress [24,25]. Simultaneously, omega-3 fatty acids compete with arachidonic acid pathways, downregulating the production of pro-inflammatory eicosanoids and cytokines [18,20]. By suppressing circulating hs-CRP, this dual-action nutrient matrix addresses a key inflammatory driver of myocardial fibrosis, offering long-term protection against further ischemic injury [7,26].

While these clinical findings are compelling, certain limitations must be acknowledged. First, the 13-week study period, while sufficient to track distinct metabolic and inflammatory changes, is short relative to the lifelong management required for ICM [1,10]. Long-term compliance and safety tracking beyond one year remain to be established [29]. Second, the study was localized to clinical centers within Mufti Mehmood Memorial Teaching Hospital, Pakistan, meaning regional differences in baseline dietary habits and metabolic characteristics could influence generalizability to broader international cohorts [33,34]. Despite these limitations, the trial features strong internal validity due to its strict prospective randomized design, high patient retention, zero dropouts from gastrointestinal side effects, and the use of precise statistical mediation models [30]. These results provide clear evidence supporting the deployment of specialized, bioactive functional foods like selenium-enriched tuna nuggets as a safe, highly acceptable, and effective strategy to optimize metabolic profiles and reduce cardiovascular risk factors in patients with ischemic cardiomyopathy [14,22].

CONCLUSION

Selenium-enriched tuna (*Katsuwonus pelamis*) nuggets demonstrated significant beneficial effects on anthropometric, glycemic, lipid, and inflammatory parameters among patients with stable ischemic cardiomyopathy over 13 weeks. Compared with standard dietary care, the intervention reduced body weight, BMI, fasting plasma glucose, total cholesterol, LDL-C, triglycerides, and hs-CRP, while increasing HDL-C. The observed improvements support the potential role of a nutrient-dense marine functional food as an adjunctive dietary strategy for cardiometabolic risk management in ICM. Mediation analysis further suggested that selenium, omega-3 fatty acids, protein, fiber, and antioxidant capacity contributed to the observed clinical effects. However, the relatively short intervention period and single-city setting limit long-term and broader generalizability. Larger, multicenter studies with longer follow-up are warranted to confirm sustained efficacy and safety.

Ethical Approval

Ethical approval was obtained from the relevant institutional research ethics board Ref MMMTH/12008/36 before commencement of the study. The study was conducted in accordance with applicable ethical principles and institutional requirements.

Data Availability

The data generated and analyzed during the current study are available from the corresponding author upon reasonable request, subject to applicable ethical and institutional restrictions.

Author Contributions

Both authors contributed equally to the conceptualization, methodology, data collection, formal analysis, writing of the original draft, and review and editing of the manuscript.

Informed Consent

Written informed consent was obtained from all participants before enrollment.

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Conflict of Interest

The authors declare no conflict of interest.

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Declaration of AI-Assisted Language Editing

Grammarly AI tool was used solely for language and grammar correction. The authors reviewed and approved the final manuscript and remain responsible for its content.

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