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Original Article

Influence of Probiotic Supplements on Nutrient Absorption and Immune Function in Individuals With Digestive Disorders

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ABSTRACT

Background: Chronic digestive disorders such as irritable bowel syndrome and Crohn's disease are frequently associated with dysbiosis, impaired nutrient status, persistent gastrointestinal symptoms, and inflammatory activation. Probiotics may improve intestinal barrier function, microbial balance, nutrient bioavailability, and immune regulation, but local clinical evidence from Pakistan remains limited. Objective: To evaluate the effect of 8-week probiotic supplementation on nutrient-related biochemical markers, inflammatory indices, and digestive symptom improvement among adults with IBS or Crohn's disease. Methods: This controlled open-label clinical trial included 120 adults recruited from tertiary care hospitals in Islamabad, Pakistan. Participants were allocated to a probiotic group (n=60), receiving multi-strain probiotic supplementation plus standard care, or a control group (n=60), receiving standard care alone. Hemoglobin, vitamin B12, vitamin D, albumin, CRP, ESR, and digestive symptoms were assessed at baseline and week 8. Results: Compared with controls, the probiotic group showed greater improvements in hemoglobin (+0.9 vs +0.3 g/dL), vitamin B12 (+53.2 vs +11.3 pg/mL), vitamin D (+6.4 vs +1.5 ng/mL), albumin (+0.4 vs +0.1 g/dL), CRP (−5.7 vs −1.8 mg/L), and ESR (−8.3 vs −2.3 mm/hr). Moderate-to-marked symptom improvement was higher in the probiotic group than in controls (68.3% vs 31.7%). Conclusion: Probiotic supplementation may provide clinically useful adjunctive benefits for nutritional recovery, inflammatory reduction, and symptom relief in IBS and Crohn's disease, although larger randomized blinded trials are required. Keywords: Probiotics; nutrient absorption; immune function; irritable bowel syndrome; Crohn's disease; inflammation; gut microbiota; Pakistan.

INTRODUCTION

Digestive disorders such as irritable bowel syndrome and Crohn's disease impose a substantial clinical burden because they affect bowel habits, abdominal comfort, dietary tolerance, nutritional status, inflammatory activity, and overall quality of life. Although IBS is classically regarded as a functional bowel disorder and Crohn's disease as a chronic inflammatory bowel disease, both conditions share clinically relevant disturbances in gut microbial balance, intestinal barrier integrity, nutrient handling, and immune signaling. These disturbances may contribute to abdominal pain, bloating, diarrhea or bowel irregularity, fatigue, micronutrient deficiency, and persistent low-grade or systemic inflammation,

making supportive interventions that target gut ecology biologically plausible and clinically important (1–5).

The gut microbiota plays a central role in digestion, vitamin synthesis, epithelial barrier protection, mucosal immunity, and inflammatory regulation. Dysbiosis may impair intestinal permeability, alter short-chain fatty acid production, disturb immune tolerance, and increase inflammatory signaling, thereby worsening both gastrointestinal symptoms and nutritional compromise. Probiotics, defined as live microorganisms that confer health benefits when administered in adequate amounts, may help restore microbial balance through competitive inhibition of pathogenic organisms, enhancement of epithelial barrier function, modulation of cytokine activity, and improvement of nutrient bioavailability (1–5). These mechanisms support the rationale for evaluating probiotics not only as symptom-relieving agents but also as adjunctive interventions capable of improving biochemical indicators of nutrient absorption and immune function.

Clinical evidence for probiotics in IBS is relatively stronger than in Crohn's disease, although findings remain heterogeneous across strains, doses, duration, and patient phenotypes. Randomized trials and systematic reviews have reported that selected Lactobacillus, Bifidobacterium, and multi-strain probiotic formulations may reduce abdominal pain, bloating, stool irregularity, and global IBS symptom severity, while other studies show modest or strain-specific effects (6–16). In Crohn's disease, the evidence is more mixed. Some trials have not demonstrated clear benefit for remission induction or relapse prevention, whereas other studies suggest possible improvements in inflammatory activity, mucosal immune regulation, quality of life, or nutritional status when probiotics are used as adjuncts rather than replacements for standard medical care (17–26). This variability highlights the need for context-specific studies that examine clinically meaningful biochemical and symptomatic outcomes together.

Nutrient absorption is a particularly relevant but comparatively underexplored endpoint in probiotic research. Patients with chronic digestive disorders may develop low hemoglobin, vitamin B12 deficiency, vitamin D deficiency, hypoalbuminemia, and other nutritional abnormalities due to inflammation, reduced intake, altered absorption, dysbiosis, or disease-related intestinal dysfunction. Existing literature suggests that probiotics may support micronutrient status and intestinal absorptive capacity through improved microbial metabolism, reduced inflammatory burden, and better epithelial function, but evidence remains inconsistent and population-specific (4,26–28). Evaluating nutritional markers alongside inflammatory indices such as C-reactive protein and erythrocyte sedimentation rate may therefore provide a more clinically complete assessment of probiotic benefit.

In Pakistan, IBS and related gastrointestinal complaints are commonly reported, and local evidence suggests associations with anxiety, bowel habit disturbances, small intestinal bacterial overgrowth, lactose intolerance, and overlapping functional gastrointestinal symptoms (29–34). However, local clinical data evaluating probiotics in patients with chronic digestive disorders remain limited, particularly studies that assess both nutrient-related biochemical markers and immune-inflammatory outcomes within the same trial framework. Differences in diet, microbial background, disease presentation, healthcare access, and baseline nutritional status may influence probiotic response, making locally generated evidence important for clinical decision-making.

Therefore, this controlled clinical trial was conducted in tertiary care hospitals in Islamabad, Pakistan, to evaluate whether 8-week multi-strain probiotic supplementation, given as an adjunct to standard medical care, improves biochemical indicators of nutrient status and reduces inflammatory activity in adults with IBS or Crohn's disease. The primary hypothesis was that patients receiving probiotic supplementation would demonstrate greater improvement in inflammatory status and nutrient-related biochemical markers than patients receiving standard care alone. The study specifically aimed to compare changes in hemoglobin, vitamin B12, vitamin D, albumin, CRP, ESR, and digestive symptom improvement between probiotic and control groups after 8 weeks of follow-up.

MATERIALS AND METHODS

This study was designed as a controlled, open-label, non-randomized clinical trial conducted to evaluate the effect of probiotic supplementation on nutrient-related biochemical markers and immune-inflammatory status among adults with chronic digestive disorders. The design was selected because the study compared an intervention group receiving probiotic supplementation plus routine medical care with a control group receiving routine medical care without probiotic supplementation. The study was conducted in the gastroenterology and internal medicine departments of selected tertiary care hospitals in Islamabad, Pakistan, over a six-month period, which included participant recruitment, baseline assessment, intervention delivery, follow-up monitoring, and final outcome assessment.

The study population consisted of adult male and female patients aged 18–60 years with a clinical diagnosis of irritable bowel syndrome or Crohn's disease and gastrointestinal symptoms persisting for at least three months. Participants were recruited through non-probability purposive sampling from eligible patients presenting to the participating hospital departments during the study period. Patients were included if they were willing to participate, able to provide written informed consent, and available for follow-up during the 8-week intervention period. Pregnant or lactating women, patients with severe hepatic, renal, or cardiac disease, those who had used probiotic supplements during the preceding four weeks, patients with recent gastrointestinal surgery, acute infection, severe systemic illness, or unwillingness to complete follow-up were excluded. Patients receiving immunosuppressive therapy unrelated to Crohn's disease management were also excluded to reduce potential confounding of immune-related outcomes.

A total of 120 eligible participants were enrolled and allocated into two equal groups of 60 participants each. The probiotic group received multi-strain probiotic supplementation in addition to standard medical care, whereas the control group continued standard medical care and dietary advice without probiotic supplementation. Allocation was based on clinical feasibility and study arrangement rather than concealed random assignment; therefore, the study findings were interpreted as controlled interventional evidence rather than as fully blinded randomized trial evidence. Both groups continued their physician-prescribed treatment plans, and participants were advised not to initiate new nutritional supplements, herbal products, or over-the-counter gut-directed preparations during the study period unless clinically prescribed.

Baseline data were collected using a structured data collection form prepared for the study. The form recorded demographic characteristics, age, sex, weight, height, body mass index, disease type, disease duration, medication history, dietary pattern, digestive symptoms, and relevant clinical findings. A brief clinical examination was performed by the treating physician or trained research team member. Nutrient-related biochemical markers were measured as indirect indicators of nutrient status and absorption, including hemoglobin, vitamin B12, vitamin D, albumin, serum iron, ferritin, folate, and calcium where available. Immune-inflammatory status was assessed using C-reactive protein, erythrocyte sedimentation rate, total white blood cell count, and selected cytokine markers where testing facilities permitted. Digestive symptoms, including abdominal pain, bloating, stool irregularity, appetite change, weakness, and fatigue, were recorded at baseline and follow-up using patient-reported clinical assessment.

The intervention consisted of 8 weeks of oral multi-strain probiotic supplementation containing clinically used beneficial bacterial strains, mainly from Lactobacillus and Bifidobacterium groups. Participants were instructed to take the supplement regularly after meals according to manufacturer guidance and clinical safety standards while continuing standard medical treatment. Treatment adherence was supported through follow-up visits and telephone reminders. Participants were asked about missed doses, side effects, and general tolerance of supplementation, and compliance was checked through verbal reporting and review of returned supplement packs where feasible. Any adverse

symptoms, including bloating, abdominal discomfort, or intolerance, were documented during follow-up.

The primary outcome was change in immune-inflammatory status from baseline to 8 weeks, assessed mainly through CRP and ESR levels. Secondary outcomes included changes in nutrient-related biochemical markers, particularly hemoglobin, vitamin B12, vitamin D, and albumin, as well as patient-reported improvement in abdominal pain, bloating, bowel irregularity, appetite, and weakness. Baseline comparability between groups was assessed using demographic, clinical, nutritional, and inflammatory variables. Potential confounding was addressed by applying the same eligibility criteria to both groups, collecting baseline disease and nutritional profiles, maintaining comparable follow-up timing, advising participants not to start additional supplements during the study period, and using consistent laboratory methods for baseline and final assessments.

At the end of the 8-week intervention period, all baseline clinical and laboratory assessments were repeated using the same procedures. Improvement in nutrient-related status was evaluated through within-group and between-group changes in biochemical markers. Improvement in immune-inflammatory status was evaluated through reductions in CRP and ESR and changes in inflammation-related symptoms. Participants who missed follow-up assessments or had incomplete laboratory data were excluded from variable-specific analysis for the affected outcome, while available data were retained for descriptive reporting.

Data were entered and analyzed using SPSS. Quantitative variables, including age, body mass index, hemoglobin, vitamin levels, albumin, CRP, and ESR, were summarized as mean and standard deviation. Categorical variables, including sex, disease type, symptom improvement category, and adverse effects, were summarized as frequency and percentage. Within-group baseline-to-week-8 comparisons were performed using paired sample tests for continuous variables. Between-group comparisons were performed using independent sample tests for continuous variables and chi-square tests for categorical variables where appropriate. Statistical significance was set at $p<0.05$. The analysis plan prioritized comparison of baseline and post-intervention changes between probiotic and control groups, with clinical interpretation based on direction, magnitude, and consistency of biochemical and symptomatic changes rather than p-values alone.

Ethical approval was obtained from the relevant institutional ethical review committee of the participating hospitals before data collection. Permission was obtained from hospital administration, and written informed consent was taken from all participants before enrollment. Participants were informed about the study purpose, procedures, potential benefits, possible discomforts, confidentiality protections, and their right to withdraw at any stage without affecting their routine medical care. Data confidentiality was maintained by using coded study forms instead of personal identifiers. Data quality was ensured through daily review of forms for completeness, standardized laboratory procedures, consistent baseline and follow-up assessment methods, and clear participant instructions to reduce reporting and measurement error.

RESULTS

A total of 120 participants were analyzed, with 60 participants in the probiotic group and 60 in the control group. Baseline characteristics were comparable across groups, including age, sex distribution, disease type, BMI, nutritional markers, and inflammatory markers, indicating acceptable group similarity before intervention. The probiotic group had a mean age of 34.8 ± 9.6 years compared with 35.6 ± 10.1 years in the control group, and IBS was present in 63.3% and 60.0% of participants, respectively. Baseline hemoglobin, vitamin B12, vitamin D, albumin, CRP, and ESR values were also closely aligned between groups, supporting fair comparison of post-intervention outcomes.

Table 1. Baseline Characteristics of Study Participants

Variable	Probiotic Group (n=60)	Control Group (n=60)
Mean age, years	34.8 ± 9.6	35.6 ± 10.1
Male, n (%)	25 (41.7%)	27 (45.0%)
Female, n (%)	35 (58.3%)	33 (55.0%)
IBS, n (%)	38 (63.3%)	36 (60.0%)
Crohn's disease, n (%)	22 (36.7%)	24 (40.0%)
BMI, kg/m²	22.4 ± 3.1	22.7 ± 3.4
Hemoglobin, g/dL	11.2 ± 1.4	11.3 ± 1.5
Vitamin B12, pg/mL	278.5 ± 65.4	281.2 ± 67.1
Vitamin D, ng/mL	19.4 ± 6.2	19.8 ± 5.9
Albumin, g/dL	3.5 ± 0.4	3.5 ± 0.5
CRP, mg/L	14.8 ± 5.2	15.0 ± 5.0
ESR, mm/hr	28.6 ± 8.4	29.1 ± 8.0

After 8 weeks, the probiotic group showed greater improvement across nutritional and inflammatory outcomes than the control group. Hemoglobin increased by 0.9 g/dL in the probiotic group compared with 0.3 g/dL in controls, producing a net improvement of 0.6 g/dL.

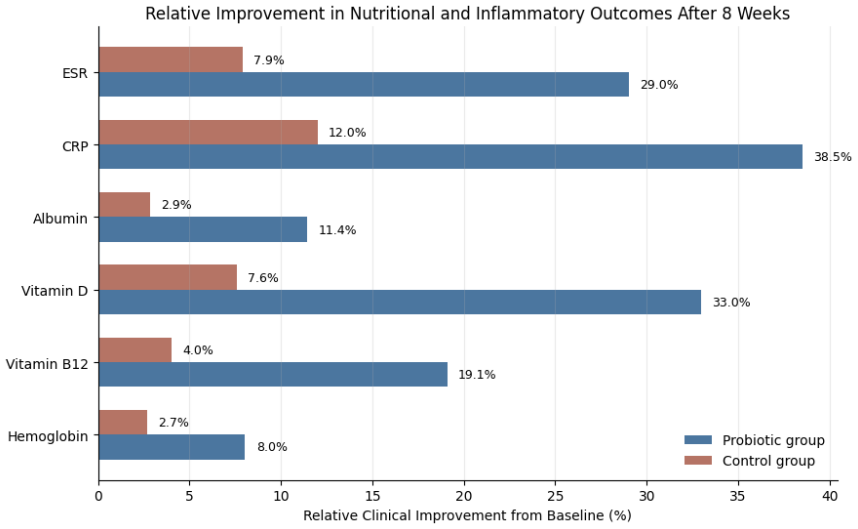

Figure 1 Relative Improvement in Nutritional and Inflammatory Outcomes After 8 Weeks

Vitamin B12 increased by 53.2 pg/mL versus 11.3 pg/mL, vitamin D increased by 6.4 ng/mL versus 1.5 ng/mL, and albumin increased by 0.4 g/dL versus 0.1 g/dL. Inflammatory markers also declined more substantially in the probiotic group, with CRP decreasing by 5.7 mg/L compared with 1.8 mg/L in controls, and ESR decreasing by 8.3 mm/hr compared with 2.3 mm/hr. Week-8 between-group comparisons showed statistically significant differences for hemoglobin, vitamin B12, vitamin D, albumin, CRP, and ESR.

Table 2. Nutritional and Inflammatory Outcomes at Baseline and Week 8

Variable	Probiotic Baseline	Probiotic Week 8	Control Baseline	Control Week 8	Net Difference in Change	Week-8 Mean Difference (95% CI)	Week-8 p-value
Hemoglobin, g/dL	11.2 ± 1.4	12.1 ± 1.3	11.3 ± 1.5	11.6 ± 1.4	+0.6	0.50 (0.01 to 0.99)	0.045
Vitamin B12, pg/mL	278.5 ± 65.4	331.7 ± 61.2	281.2 ± 67.1	292.5 ± 64.8	+41.9	39.20 (16.41 to 61.99)	0.001
Vitamin D, ng/mL	19.4 ± 6.2	25.8 ± 5.9	19.8 ± 5.9	21.3 ± 6.0	+4.9	4.50 (2.35 to 6.65)	<0.001
Albumin, g/dL	3.5 ± 0.4	3.9 ± 0.3	3.5 ± 0.5	3.6 ± 0.4	+0.3	0.30 (0.17 to 0.43)	<0.001
CRP, mg/L	14.8 ± 5.2	9.1 ± 4.3	15.0 ± 5.0	13.2 ± 4.8	−3.9	−4.10 (−5.75 to −2.45)	<0.001
ESR, mm/hr	28.6 ± 8.4	20.3 ± 7.1	29.1 ± 8.0	26.8 ± 7.6	−6.0	−6.50 (−9.16 to −3.84)	<0.001

Symptom improvement was also more frequent in the probiotic group. Moderate-to-marked improvement was reported by 41 of 60 participants (68.3%) in the probiotic group compared with 19 of 60 participants (31.7%) in the control group.

The odds of moderate-to-marked symptom improvement were approximately 4.66 times higher among participants receiving probiotics than among controls.

Table 3. Digestive Symptom Improvement After 8 Weeks

Symptom Response	Probiotic Group (n=60)	Control Group (n=60)	Odds Ratio (95% CI)	p-value
Moderate-to-marked improvement	41 (68.3%)	19 (31.7%)	4.66 (2.16 to 10.05)	<0.001
No/mild improvement	19 (31.7%)	41 (68.3%)	Reference	—

The figure 1 demonstrates that probiotic supplementation produced consistently greater relative clinical improvement than control management across all measured domains. The largest probiotic-associated advantages were observed for CRP, which improved by 38.5% compared with 12.0% in controls, and vitamin D, which improved by 33.0% compared with 7.6%. ESR improved by 29.0% in the probiotic group compared with 7.9% in controls, while vitamin B12 improved by 19.1% versus 4.0%. Nutritional recovery was also evident for albumin and hemoglobin, with relative improvements of 11.4% and 8.0% in the probiotic group compared with 2.9% and 2.7% in controls, respectively.

DISCUSSION

This controlled clinical trial found that 8-week probiotic supplementation, used as an adjunct to standard care, was associated with greater improvement in both nutrient-related biochemical markers and inflammatory indices among adults with IBS or Crohn's disease. Compared with controls, participants receiving probiotics demonstrated larger increases in hemoglobin, vitamin B12, vitamin D, and albumin, together with greater reductions in CRP and ESR. These findings suggest that probiotic supplementation may support gastrointestinal recovery through dual nutritional and immunomodulatory effects, although the non-randomized open-label design means the findings should be interpreted as supportive rather than definitive causal evidence.

The improvement in hemoglobin, vitamin B12, vitamin D, and albumin is clinically relevant because chronic digestive disorders frequently impair dietary tolerance, intestinal absorption, mucosal integrity, and systemic nutritional status. Probiotics may contribute to improved nutrient status by restoring microbial balance, enhancing epithelial barrier function, reducing inflammatory injury to the gut lining, and supporting microbial metabolism involved in vitamin availability and nutrient handling (1–5,27,28). The observed increase in albumin may also reflect improved inflammatory control and nutritional recovery, particularly in patients with chronic intestinal inflammation. These findings align with previous evidence suggesting that probiotic supplementation may improve micronutrient status and intestinal functional capacity, although the magnitude of benefit varies by strain, dose, host characteristics, and baseline deficiency status (4,26–28).

The reduction in CRP and ESR in the probiotic group supports the potential anti-inflammatory role of selected probiotic strains. Probiotics may modulate mucosal immune activity through cytokine regulation, improved intestinal barrier integrity, competitive suppression of pathogenic organisms, and enhancement of immune tolerance (1–5,10,18,22). In IBS, symptom severity has been linked with altered gut-brain interaction, low-grade inflammation, dysbiosis, and visceral hypersensitivity, and prior trials have shown that selected probiotic formulations can reduce abdominal pain, bloating, and global symptom burden (6–16). In Crohn's disease, the evidence remains less consistent, with some trials showing limited benefit for remission or relapse prevention, while others suggest improvement in inflammatory activity, quality of life, or nutritional status when probiotics are used adjunctively (17–26). The present findings therefore fit best within an adjunctive-care interpretation rather than supporting probiotics as a replacement for established medical therapy.

Symptom improvement was also more frequent among participants receiving probiotics, with moderate-to-marked improvement reported in 68.3% of the probiotic group compared with 31.7% of controls. This difference supports the clinical relevance of the biochemical findings, as reductions in inflammatory burden and improvements in nutrient status may contribute to better bowel comfort, appetite, and

perceived strength. However, patient-reported outcomes may be influenced by expectancy effects, open-label treatment exposure, and subjective variation. Future studies should therefore use validated symptom scales, disease-specific activity indices, and blinded outcome assessment to strengthen interpretability.

The Pakistani context adds importance to these findings. Local studies have reported a meaningful burden of IBS, functional bowel symptoms, anxiety-associated gastrointestinal complaints, small intestinal bacterial overgrowth, and lactose intolerance among Pakistani patients (29–34). Nutritional deficiencies and delayed specialist access may further complicate chronic digestive disorders in routine care. By evaluating both biochemical and symptom-related outcomes, this study contributes locally relevant evidence that probiotics may have practical value as a supportive intervention in tertiary care settings. Nevertheless, treatment decisions should remain individualized, with attention to disease type, baseline nutritional status, strain specificity, safety, and concurrent pharmacological management.

This study has limitations. Allocation was not described as concealed or randomized, and blinding was not applied, which may introduce selection and performance bias. The use of purposive sampling limits generalizability, and the 8-week follow-up period does not establish long-term sustainability of biochemical or symptomatic improvement. The probiotic formulation was described by bacterial groups rather than full strain names and colony-forming units, limiting reproducibility. Direct measures of intestinal permeability, microbiome composition, cytokine signaling, and nutrient uptake were not consistently available. Despite these limitations, the consistency of improvement across nutritional markers, inflammatory indices, and symptoms suggests that further randomized, blinded, adequately powered multicenter trials are justified.

CONCLUSION

Eight-week probiotic supplementation as an adjunct to standard medical care was associated with improved nutrient-related biochemical markers, reduced inflammatory activity, and greater digestive symptom relief among adults with IBS or Crohn's disease. Participants receiving probiotics showed larger improvements in hemoglobin, vitamin B12, vitamin D, albumin, CRP, ESR, and moderate-to-marked symptom response than controls. These findings support the potential role of carefully selected probiotic formulations as supportive therapy in chronic digestive disorders, particularly when nutritional compromise and inflammatory activity coexist. However, because of the open-label non-randomized design, short follow-up, and incomplete strain-level probiotic specification, the results should be confirmed through larger randomized controlled trials with standardized probiotic dosing, validated symptom scoring, microbiome assessment, and longer follow-up.

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