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Efficacy of Probiotics to Combat Anemia among Adolescent Girls

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Abstract

Anemia remains a significant public health concern among adolescent girls, adversely affecting their growth, development, and overall well-being. Recent research has explored the potential role of probiotics in managing anemia by enhancing iron absorption and improving gut health. This review synthesizes current evidence on the efficacy of probiotics in addressing anemia among adolescent girls, focusing on their impact on hemoglobin levels and iron metabolism. The highlighted mechanisms through which probiotics influence anemia include modulation of the gut microbiota, reduction of intestinal inflammation, and enhancement of nutrient bioavailability. Studies have demonstrated that probiotics, when used as an adjunct to iron therapy, can significantly improve hematological parameters while minimizing gastrointestinal side effects associated with iron supplementation. Strain-specific effects, such as those of Lactobacillus and Bifidobacterium species, are particularly noteworthy in optimizing iron uptake. Despite promising findings, variations in study design, probiotic strains, dosage, and duration warrant further investigation to establish standardized guidelines. This review underscores the potential of probiotics as a complementary strategy for managing anemia among adolescent girls and emphasizes the need for well-designed clinical trials to validate their long-term efficacy and safety.

Keywords:*Anemia, Adolescent Girls, Gut Microbiota, Haemoglobin, Iron Deficiency, Probiotics.*

1. INTRODUCTION

Anemia is characterized by a condition in which the number of crimson platelets (RBCs) and their oxygen-conveying capacity are inadequate to meet the body's physiologic needs **(Chaparro M, et al., 2019)**. Globally, pallor is the most widely recognized dietary issue influencing around 2 billion of the population,

significantly affecting human well-being and financial and social development.(GetachewMengistu, et al, 2019).Anemia is a significant general medical issue and is regularly overlooked in both created and developing countries (Fekede Weldekidan et al., 2018).The prevalence of iron deficiency is assessed to be 40% around the world. Over 89% of this weight happened in creating countries (Gonete, K.A., et al., 2018). Adolescence is considered a healthfully basic time of life who are defenseless against both large-scale and micronutrient lacks. Iron requirements peak during the juvenile period because of quick development and expansion in blood volume(Kelemu Fentie et al., 20120). Furthermore, prebiotics stimulate the absorption of iron in the proximal colon as well as the duodenum by producing short-chain fatty acids in the colon (Bougle, D.,et al., 2002).Thus, absorption of iron is enhanced in the presence of fermentable food involved in the growth of bacteria, leading to the production of short-chain fatty acids such as propionic acid (Rusu, I.et al, 2020).Eating food processed from animal liver and animal sources during pregnancy is the safest and most effective method of iron supplementation. Food fortification with iron is the other well-known approach to treating anemia in women of reproductive age (Owais, A., et al.,2021).The addition of vitamins and minerals through fortification helps to improve food quality and nutritional value. Equally, studies have shown that prebiotics such as galacto oligosaccharides and inulin might play an important role in enhancing iron absorption in anemic subjects (Sundberg, M. 2011)

2. PREVALENCE OF ANEMIA AMONG ADOLESCENT GIRLS

Anemia is a prevalent health issue among adolescent girls, particularly in developing countries, due to increased iron demands during puberty and inadequate dietary intake of iron-rich foods. According to WHO reports, nearly 50% of anemia cases in this population are linked to nutritional deficiencies (WHO, 2021). For instance, a study by (Nguyen et al. 2020) highlighted that iron deficiency anemia accounts for 75% of anemia cases among adolescent girls in Southeast Asia. Similarly, (Gupta et al. 2019)noted a 54% prevalence rate of anemia among school-going adolescent girls in India, attributing it to poor dietary diversity and menstrual blood loss. Moreover, (Osunkentomi and Salami 2021)emphasized that socioeconomic factors and lack of awareness exacerbate the prevalence of anemia in low-income communities. These studies underscore the urgent need for targeted interventions, such as dietary supplementation and probiotic use, to address the anemia burden effectively.

3. ROLE OF GUT MICROBIOTA IN IRON ABSORPTION

Micronutrients are elements classified as vitamins and minerals. Optimal concentrations can function as co-factors and coenzymes and participate in metabolic activity in biochemical processes. Its concentrations depend on the metabolic activity and the life cycle stage, as well as specific dietary habits and infectious processes (Akram, M., et al., 2020). An inappropriate pool of micronutrients in the individual may lead to a deficiency, increasing the risk of certain diseases, and may lead to other micronutrient deficiencies. This nutritional lack may go unnoticed, and the signs and symptoms usually appear only in the advanced stages of the disease, such as anemia, pellagra, beriberi, and others (Hans, K.B., et al., 2018).The gastrointestinal mucosa, the gut microbiota are also the first line of protection against pathogens. It contributes to the reinforcement of the integrity of the intestinal epithelium and better absorption of micronutrients knowledge of this two-way relationship between micronutrients and gut microbiota bacteria, with a focus on iron, zinc, vitamin A, and folate (vitamin B9), as these deficiencies are public health concerns in a global context (Frank, T., et al., 2023).

4. MECHANISMS OF PROBIOTICS IN ENHANCING IRON BIOAVAILABILITY

Probiotics have been demonstrated to improve the bioavailability of iron via mechanisms like the modulation of gut microbiota, the generation of organic acids, and the diminishing effects of phyticacid(Patel et al., 2020).Probiotics have demonstrated the ability to improve iron bioavailability through several mechanisms, such as the modulation of gut

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microbiota, the production of organic acids, and the mitigation of phytic acid effects. For example, Lactobacillus plantarum 299v has been shown to notably enhance iron absorption in humans (Tussing-Humphreys et al., 2019).There is strong research data that some probiotics, such as Lactobacillus acidophilus and Bifidobacteriumlongum improve iron absorption and influence the course of anemia. Furthermore, prebiotics, including galactooligosaccharides (GOS) and fructooligosaccharides (FOS), increase iron bioavailability and decrease its destructive effect on the intestinal microbiota. In addition, multiple postbiotics, which are probiotic metabolites, including vitamins, short-chain fatty acids (SCFA), and tryptophan, are involved in the regulation of intestinal absorption and may influence iron status in humans (ZuzannaZakrzewska et al., 2022).Probiotics also act as anti-microbial agents by producing substances,short-chain fatty acids (SCFA), organic acids, and hydrogen peroxide (Ahire et al., 2021).

5. POTENTIAL BENEFITS OF PROBIOTICS IN ADOLESCENT HEALTH

Beneficial effects attributed to probiotics include improvement of intestinal health, enhancement of the immune response, reduction of serum cholesterol, and cancer prevention. There is substantial evidence to support probiotic use in the treatment of acute diarrhoeal diseases, prevention of antibiotic-associated diarrhea, and improvement of lactose metabolism, but there is insufficient evidence to recommend them for use in other clinical conditions(Kechagia, M.,et al, 2013).

The health benefits of probiotics are associated with preventing and reducing many diseases, i.e., allergic diseases, cancer, hypercholesterolemia, lactose intolerance, inflammatory bowel disease, diarrhea, and irritable bowel syndrome (Grom et al., 2020).

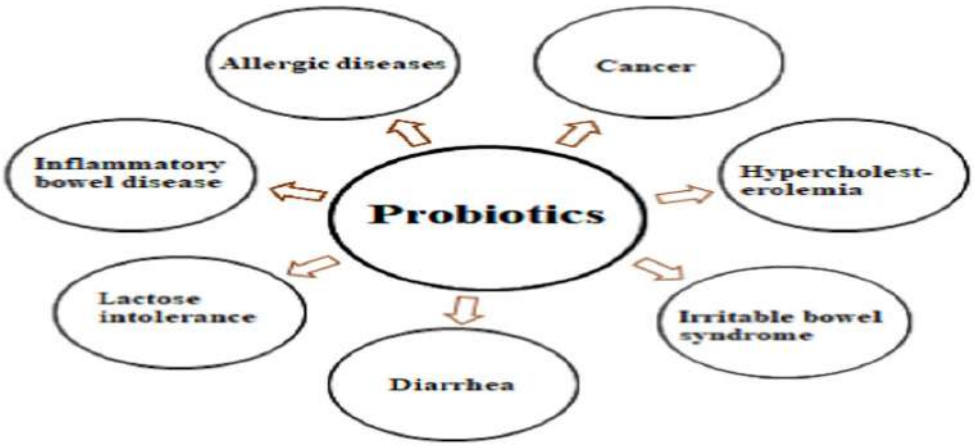

Fig-1 : Potential Benefits of Probiotics in Adolescent Health
(Sources:https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1216674/ful)

Probiotics could be used as an adjuvant for various types of cancers based on their potential to modulate enteric flora and enhance local and systemic immunity. They prevent the initiation, progression, and metastasis of transplantable or chemically induced tumors(Samanta, 2022).The probiotics inhibit carcinogenesis by inhibiting pathogens through competitive exclusion, increasing short-chain fatty acid production (Chong, 2014), reducing carcinogenic bile salts production, binding carcinogens and mutagens, down-regulating NF-kappa B dependent genes products for cell proliferation (Cox-2, cyclin D1) and cell survivability (Bcl-3, Bcl-xL) and enhancing apoptosis (Konishi et al., 2016). NEC is a serious gastrointestinal condition typically seen in premature infants. Symptoms include abdominal distension, bloody stool, and lethargy. Several studies have demonstrated that

probiotic therapy reduced both the incidence and severity of NEC in a study of very low birth weight infants(Bin-Nun, A., 2005).Probiotic strains have demonstrated advantageous effects, particularly in the context of the prophylaxis of allergic disorders. Generally, the extant scientific literature tends to illustrate the intrinsic complexity associated with allergic syndromes, the specific characteristics and potential variables pertinent to the various probiotic strains evaluated, as well as the constrained comprehension of the mechanisms through which these strains may alleviate and/or neutralize various forms of immune dysfunction observed in allergic diseases (Martinez, R. C. R., et al., 2015)

6. CHALLENGES AND LIMITATIONS IN PROBIOTIC INTERVENTIONS

The challenges and limitations in probiotic interventions are multifaceted, encompassing issues related to safety, efficacy, and technological constraints. Probiotics, while promising as therapeutic agents for gastrointestinal diseases, face significant hurdles that impede their widespread application. These challenges include safety concerns, stress resistance, quantification post-colonization, and the development of effective evaluation models. Additionally, the variability in clinical outcomes and the need for improved delivery systems further complicate their use. Below are the key challenges and limitations identified in the research. Safety is a primary concern, as probiotics must be non-pathogenic and free from adverse effects. The potential for probiotics to cause infections in immunocompromised individuals is a significant limitation(Wolfe et al., 2023).Efficacy varies widely among different strains and formulations, leading to inconsistent clinical outcomes. This variability necessitates more rigorous clinical trials to establish standardized guidelines(Suez et al., 2019).Accurate quantification of probiotics post-colonization is challenging due to the complex nature of the gut microbiome. Advanced techniques like fluorescent labeling are being developed to address this issue(Wolfe et al., 2023).Evaluation models need to be refined to better assess the interactions between probiotics and the host microbiome, as well as their physiological impacts(Suez et al., 2019).There is a need for improved regulation and transparency in the probiotic market to ensure consumer safety and product efficacy. Public awareness about the benefits and limitations of probiotics is also essential(Suez et al.,2019).

While probiotics hold potential as biotherapeutic agents, these challenges highlight the need for continued research and innovation. Addressing these limitations through advanced technologies and regulatory frameworks will be crucial for optimizing the use of probiotics in health interventions.

7. FUTURE DIRECTIONS FOR RESEARCH

Future research on probiotics for adolescent anemia should target key areas for enhanced understanding. Large-scale RCTs are essential to determine long-term impacts on iron metabolism and nutrition. These studies must include varied populations to account for genetic and dietary factors affecting efficacy. Mechanistic studies should investigate specific strains' interactions with gut microbiota to improve iron absorption and mitigate inflammation. Research must also identify optimal probiotic formulations regarding strain, dosage, and duration. Synergistic effects between probiotics and iron-fortified foods should be explored for anemia management strategies. Furthermore, the role of probiotics in non-iron deficiency anemia should be assessed to enhance clinical significance. Longitudinal studies tracking girls from puberty to adulthood could elucidate the long-term benefits and safety. Lastly, evaluating the cost-effectiveness of probiotic interventions in resource-limited settings is crucial for public health policies and anemia prevention. Addressing these gaps will support evidence-based recommendations for incorporating probiotics into adolescent anemia management.

8. CONCLUSION

Probiotics to combat anemia among adolescent girls show promising potential, particularly in enhancing iron absorption, modulating gut microbiota, and reducing inflammation-related anemia. Existing research suggests that specific probiotic strains, such as

Lactobacillus and Bifidobacterium, may improve hemoglobin levels and overall iron status by promoting a more favorable gut environment for nutrient absorption. However, while preliminary studies demonstrate encouraging results, more robust clinical trials with larger sample sizes, diverse populations, and standardized probiotic formulations are needed to establish definitive conclusions on efficacy, dosage, and long-term safety. Additionally, exploring synergistic approaches, such as combining probiotics with iron-fortified diets, could provide holistic and sustainable solutions for anemia management. Integrating probiotics into public health programs, particularly in resource-limited settings, may offer a cost-effective and accessible intervention to reduce the global burden of anemia in adolescent girls. Future research should focus on addressing these gaps to develop evidence-based guidelines for the effective use of probiotics in anemia prevention and treatment.

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