IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Review On Lactobacillus Acidophilus

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Abstract

Lactobacillus acidophilus is one of the most extensively studied species of lactic acid bacteria (LAB), recognized for its probiotic properties and health-promoting effects. It is a Gram-positive, non-spore-forming, homofermentative bacterium that naturally inhabits the human gastrointestinal tract, oral cavity, and vagina. Due to its acid tolerance and ability to produce lactic acid, L. acidophilus plays a vital role in maintaining microbial balance, inhibiting pathogens, and enhancing host immunity. This review provides a detailed overview of its taxonomy, morphology, physiology, genome structure, mechanisms of probiotic action, and applications in food, pharmaceutical, and biotechnology sectors. Additionally, current challenges and future research perspectives are discussed.

1. Introduction

Probiotics are defined as "live microorganisms which, when administered in adequate amounts, confer a health benefit on the host" (FAO/WHO, 2002). Among probiotic microorganisms, Lactobacillus acidophilus has gained prominence due to its beneficial effects on gut health, immunity, and overall well-being.

First isolated from the human intestine by Moro in 1900, L. acidophilus is a key component of the intestinal microbiota and is widely used in fermented dairy products and dietary supplements. It survives harsh gastrointestinal conditions and contributes to host health through production of antimicrobial compounds, competition with pathogens, and modulation of the immune system.

Recent genomic analyses have led to reclassification within the Lactobacillus genus (Zheng et al., 2020). Despite nomenclature changes, L. acidophilus remains one of the most commercially important and scientifically validated probiotic species.

3. Morphology and Physiological Characteristics

Shape and Structure: Rod-shaped, Gram-positive, non-spore-forming, non-motile.
Cell Wall: Rich in peptidoglycan and teichoic acids, conferring acid resistance.
Metabolism: Homofermentative—produces lactic acid as the major end product of carbohydrate metabolism.
Temperature Range: Optimum growth at 37–42℃.
pH Tolerance: Grows well at pH 4.0–6.0, showing remarkable acid tolerance.
Oxygen Requirement: Facultative anaerobe or microaerophilic.
This organism ferments glucose and other carbohydrates, producing lactic acid that lowers pH and inhibits the growth of spoilage and pathogenic microorganisms.

4. Genomic Insights

The complete genome of L. acidophilus NCFM (2.0 Mbp, GC content 34.7%) has been sequenced, revealing genes responsible for:

Carbohydrate metabolism (glycosidases, permeases)

Acid and bile tolerance (chaperones, efflux pumps)

Adhesion to intestinal cells (mucus-binding proteins)

Bacteriocin production

Stress response and immune modulation

Plasmids in L. acidophilus often carry genes for antimicrobial production and adhesion factors, crucial for its probiotic activity.

5. Mechanisms of Probiotic Action

a. Competitive Exclusion of Pathogens

L. acidophilus adheres to mucosal surfaces, preventing colonization by harmful microorganisms such as Salmonella, E. coli, and Clostridium difficile.

b. Production of Antimicrobial Substances

Produces lactic acid, hydrogen peroxide, and bacteriocins (acidophilicin, lactacin B) that inhibit pathogenic bacteria and fungi.

c. Enhancement of Gut Barrier Integrity

Stimulates mucin production and tight junction proteins, reducing intestinal permeability.

d. Immunomodulatory Effects

Regulates cytokine production, enhances macrophage and natural killer (NK) cell activity, and modulates T-cell responses.

e. Enzymatic and Metabolic Roles

Assists in lactose digestion, cholesterol assimilation, and vitamin (B12, folate) synthesis.

6. Ecological Distribution

L. acidophilus is commonly found in:

Human and animal gastrointestinal tract

Oral cavity

Vaginal microbiota

Fermented foods (yogurt, kefir, cheese)

Its natural presence in the human body underscores its long-term evolutionary adaptation to mucosal environments.

7. Industrial and Clinical Applications

a. Dairy Industry

Used as a starter culture in yogurt, curd, and fermented milk.

Enhances flavor, texture, and shelf-life.

Reduces lactose intolerance by producing β-galactosidase enzyme.

b. Probiotic Supplements

Incorporated into capsules, tablets, and functional foods.

Used to prevent antibiotic-associated diarrhea, irritable bowel syndrome (IBS), and inflammatory bowel disease (IBD).

c. Veterinary Applications

Improves gut health and growth rate in poultry, pigs, and cattle.

d. Pharmaceutical and Biotechnological Uses

Produces bacteriocins used as natural preservatives.

Converts lactose and other sugars to lactic acid, aiding in bioplastic (PLA) synthesis.

8. Health Benefits

Health Benefit

Mechanism of Action

Example Studies

Gut Health

Restores microbial balance; inhibits pathogens

Helps manage antibiotic-associated diarrhea

Immune System Support

Stimulates cytokines and antibodies

Enhances resistance to infections

Cholesterol Reduction

Deconjugates bile salts; lowers absorption
Demonstrated in animal and human studies
Lactose Intolerance Relief
Produces β-galactosidase enzyme
Reduces symptoms in lactose-intolerant individuals
Anticarcinogenic Potential
Binds carcinogens, reduces tumor risk
Reported in experimental models
Vaginal Health
Maintains low pH and inhibits pathogens
Used in probiotic vaginal capsules

9. Safety and Regulatory Aspects

L. acidophilus has GRAS (Generally Recognized As Safe) status by the U.S. FDA and Qualified Presumption of Safety (QPS) status by EFSA.

It is considered safe for consumption, though strain-specific evaluations are required for probiotic labeling.

10. Challenges and Future Perspectives

Despite its proven efficacy, challenges remain:
Maintaining viability during processing and storage.
Survival through gastric acid and bile.
Strain-specific differences in probiotic effectiveness.
Need for targeted delivery systems (e.g., encapsulation).

Future Directions

Genome editing and synthetic biology for enhanced stability.
Personalized probiotics based on gut microbiome analysis.
Exploration of postbiotics (metabolites of L. acidophilus) for therapeutic use.

11. Conclusion

Lactobacillus acidophilus represents a cornerstone species among probiotics, with extensive applications in food, health, and biotechnology. Its ability to survive harsh conditions, adhere to intestinal mucosa, and confer multifaceted health benefits makes it a valuable microorganism for both industrial and clinical use. Future research focusing on strain optimization, molecular characterization, and targeted probiotic formulations will further enhance its potential in human health management.