

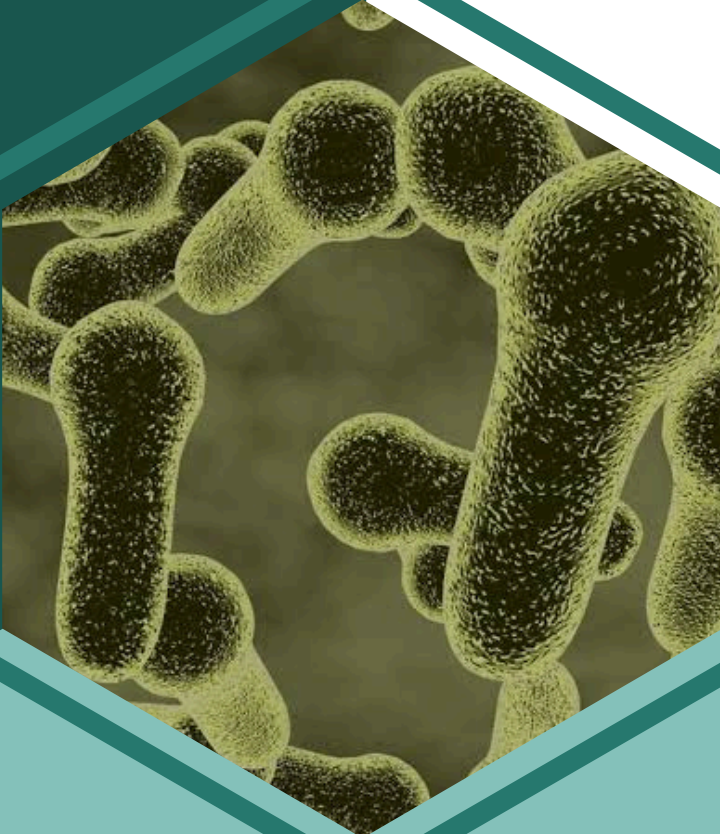


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A Call for Bioprospecting: Potential Industrial and Environmental Applications of *Bacillus acidicola* in Ethiopia



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A Call for Bioprospecting: Potential Industrial and Environmental Applications of *Bacillus acidicola* in Ethiopia

Genetic Resource Access and Benefit Sharing Research LEO

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1. Background

1.1. Ethiopian ABS Laws

Ethiopia has domestic laws governing access to genetic resources, community knowledge, and community rights, namely Proclamation No. 482/2006 and Regulation No. 169/2009. Ethiopia is also a signatory to the Nagoya Protocol. Because they establish national sovereignty over biological resources, these laws are fundamental for bioprospecting. These laws guarantee that the discovery of a commercially valuable trait in an organism like *Bacillus acidicola* results in just and equitable benefit-sharing with local communities by requiring researchers and companies to obtain Prior Informed Consent (PIC) and establish Mutually Agreed Terms (MAT). This framework promotes industrial innovation while providing incentives for the preservation of Ethiopia's distinctive microbial diversity.

1.2. Purpose/Objective

This call seeks to increase the bio-prospecting of *Bacillus acidicola* strains. Local strains with unique thermo-acidophilic characteristics that is found in Ethiopia due to the diverse soil chemistry, which can provide better efficiency for biotechnology than international varieties (Tadesse & Martín-Pinto, 2024).

1.3. Overview of the Organism

- **Scientific Name:** *Bacillus acidicola*
- **Common Name:** Acidophilic Bacillus
- **Classification: Kingdom:** Bacteria
 - **Phylum:** Firmicutes
 - **Class:** Bacilli
 - **Order:** Bacillales
 - **Family:** Bacillaceae
 - **Genus:** *Bacillus*
 - **Species:** *Bacillus acidicol*

2. Biology of the Organism

2.1. Morphological Characteristics

The cells of *B. acidicola* are generally 0.5-0.8 μm wide and 2.0-4.0 μm long. A characteristic feature is the formation of ellipsoidal endospores, usually subterminal. These spores allow the bacterium to persist in dormant form in conditions of extreme desiccation or lack of nutrients (Albert *et al.*, 2005).

2.2. Physiological Traits

Unlike the “type species” *B. subtilis*, *B. acidicola* has developed a specialized cell membrane that maintains internal pH homeostasis while thriving in acidic external environments. It is a facultative anaerobe, meaning it can generate energy using either oxygen respiration or fermentation. It grows best at temperatures between 25 and 30 $^{\circ}\text{C}$, although some strains are psychrotolerant (cold-tolerant) (Madigan *et al.*, 2021).

2.3. Genomic Attributes

Genomic analyses of *B. acidicola* have revealed the presence of genes encoding acid-stable amylases and proteases. These enzymes are structurally stable at low pH. This is a very valuable property in industrial fermentations where organic acids are produced as by-products (Sharma & Satyanarayana, 2013).

3. Distribution of the Organism

3.1. Geographical Presence in Ethiopia

While microalgae like *Chlorella* dominate Ethiopian lakes, *Bacillus acidicola* is found in more specialized terrestrial and aquatic niches:

- **Acidic Highlands:** Indigenous strains have been isolated from the acidic, red-clay soils (Nitisols) found in the southwestern highlands of Ethiopia, particularly in regions like Jimma and Wollega (Muleta *et al.*, 2007).
- **Wetlands:** The organism thrives in the decaying organic matter of Ethiopian wetlands, where the decomposition process naturally lowers the pH (Muleta *et al.*, 2007).
- **Rhizosphere Interactions:** Strains are frequently collected from the rhizosphere (root zone) of acid-tolerant crops like coffee and tea, where they may assist in nutrient cycling under low-pH conditions (Muleta *et al.*, 2007).

4. Industrial Application

4.1 Food Industry

B. acidicola is an excellent source of acidophilic α -amylase and glucoamylase. These enzymes are used in the production of high-fructose corn syrup and the clarification of acidic fruit juices (such as lemon or pineapple juice), where standard enzymes would be denatured (Sharma & Satyanarayana, 2013).

4.2 Pharmaceuticals

Species within the genus *Bacillus*, including *Bacillus acidicola*, are known to produce antimicrobial lipopeptides such as surfactins, iturins, and fengycins. These secondary metabolites exhibit broad-spectrum activity against bacteria and fungi and are increasingly investigated for pharmaceutical applications. In particular, their stability and activity under acidic conditions make them promising candidates for targeting acid-tolerant pathogens such as *Helicobacter pylori* infection, which colonizes the human stomach (Cochrane & Vederas, 2016).

4.3 Biotechnology and Biofuels

In the production of bioethanol, biomass is often pre-treated with acid. *B. acidicola* produces cellulases that function efficiently in these acidic pre-treatment liquors, potentially reducing the cost of neutralizing the mixture before fermentation (Archana and Satyanarayana, 2013).

Bacillus acidicola is an acidophilic bacterium primarily used for the production of acid-stable, high-maltose-forming **α -amylase**. This enzyme is particularly valuable in industrial starch processing because it is calcium-independent and functions optimally at acidic pH levels (pH 4.0–5.0) and moderate temperatures (around 60°C) (Archana and Satyanarayana, 2013).

Key Uses and Applications of *B. acidicola* Enzymes

- **Starch Saccharification:** The amylase produced by *B. acidicola* (BAamy) is used for the hydrolysis of raw and soluble starches, specifically designed to liberate maltose, maltotriose, and other malto-oligosaccharides.

- **Baking Industry:** Alpha-amylase from *B. acidicola* has been used to supplement dough, improving the quality of bread.
- **Food and Beverage Industry:** Due to its activity at low pH, the enzyme is useful for industrial processes requiring acidic conditions, such as the production of sweet syrups.
- **Pre-hydrolytic Enzyme:** The enzyme can be used to treat starchy waste (e.g., kitchen refuse) to enhance subsequent anaerobic digestion.

Key Aspects of Cellulase Production by Acidophilic Bacilli

- **Optimal Conditions:** Acid-producing *Bacillus* strains are often cultivated at acidic pH levels (e.g., pH 3.5 to 5.0) to induce high cellulase yields, as seen in related acidophilic thermophilic *Bacillus* species.
- **Agro-Industrial Waste Utilization:** Cellulase produced by *Bacillus* strains, including those adapted to acidic conditions, can utilize agricultural residues such as rice straw, rice bran, and corncobs as carbon sources for fermentation.
- **Enzyme Stability:** Cellulases from acidophilic organisms are typically stable within an acidic range, which is advantageous for specific industrial applications like the clarification of fruit juices or animal feed production.
- **Advantages over Fungi:** Compared to fungi, which are commonly used, bacteria like *Bacillus* generally offer higher growth rates and produce alkaline or acid-stable enzymes that can be more effective for certain catalysts (Kazeem *et al.*, 2016).

4.4 Agriculture

In Ethiopia, soil acidity is a major constraint to crop productivity, particularly in the highland regions. Acid-tolerant plant growth-promoting rhizobacteria, including *Bacillus* species such as *Bacillus acidicola*, have potential as biofertilizers. These bacteria can solubilize insoluble phosphorus in acidic soils, enhancing its availability to plants and reducing dependence on chemical fertilizers (Vessey, 2003).

5. Potential or Known Negative Impacts

The large-scale application of microbial inoculants containing *Bacillus acidicola* may raise ecological and safety concerns. The introduction of high concentrations of exogenous bacteria into soil systems can potentially disrupt native microbial communities and alter ecosystem balance. Additionally, although most *Bacillus* species are considered safe, certain members of the genus, particularly those related to *Bacillus cereus*, can produce toxins and cause food spoilage. Therefore, careful strain selection, risk assessment, and regulatory control are essential when applying such organisms in agricultural or industrial contexts (van Elsas *et al.*, 2003; Stenfors Arnesen *et al.*, 2008).

Conclusion

Bacillus acidicola is an acid-adapted bacterium with promising applications in food processing, agriculture, and biotechnology. Its ability to produce acid-stable enzymes, particularly amylases, makes it valuable for industrial processes operating under low pH conditions. In addition, acid-tolerant *Bacillus* species are well-suited to acidic soil environments, such as those found in parts of the Ethiopian highlands, highlighting their potential for bio-prospecting and sustainable agricultural applications.

The Ethiopian Biodiversity Institute encourages manufacturers and biotechnology companies to explore the industrial potential of *Bacillus acidicola* and other native microbial resources. All bio-prospecting activities should be conducted in accordance with Ethiopia's Access and Benefit-Sharing (ABS) framework, aligned with the Nagoya Protocol, to ensure fair and equitable sharing of benefits. This approach supports sustainable development, promotes responsible innovation, and helps ensure that Ethiopia's microbial resources contribute to local community empowerment and national economic growth.

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