Microbial Degradation of Keratin as a Sole Carbon Source

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Introduction

Keratin, a resilient protein found in hair, nails, feathers, and horns, is known for its durability and resistance to degradation. Its complex structure, characterized by strong disulfide bonds and intricate folding, renders it a challenging substrate for decomposition. However, certain bacteria have evolved the unique ability to use keratin as their sole carbon source, playing a crucial role in natural ecosystems by breaking down this hardy material. The goal of this experiment was to isolate these microbes capable of metabolizing keratin as their sole carbon source.

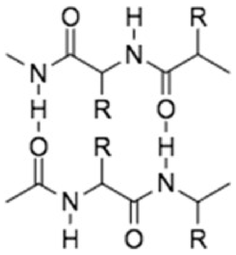


Figure 1. Structure of Keratin, characterized by long chains of amino acids, predominantly featuring cysteine, which forms strong disulfide bonds, contributing to its remarkable durability and resistance

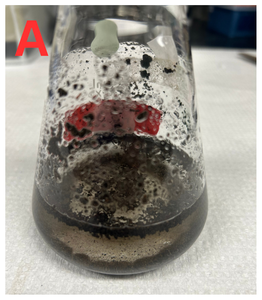
Materials

- 100 mL of base media: 1x FW-Base, 1x potassium phosphate, 1 mM sodium sulfate, 10 mM MOPS buffer pH 7.2, 1x trace element
- 5 mM NH4Cl, 10 mM of Keratin as carbon source
- Powdered keratin
- Innoculum source: Soil taken by the Turtle Pond
- Cultures were grown initially in 100 mL Erlenmeyer flasks, transferred to 10 mL culture tubes, and finally to agar plates.

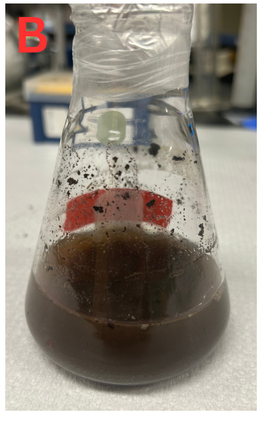
Methods

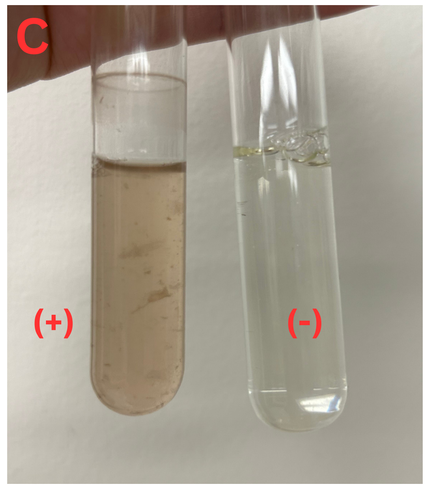
Keratin was introduced as the sole carbon source under the 'No C' condition, with 5 mM NH4Cl and 10 mM of keratin. The medium was prepared with 100 mL of base media. A soil sample was obtained from the turtle pond to inoculate the 100mL liquid culture. First, the culture was grown in a heated shaker at 30 degrees for about a week. The culture was transferred to 10mL culture tubes, with a negative control. After two weeks, clear growth was visible in the (+) culture tube, with no growth in the (-) culture tube.

Results



(A) Initial liquid culture before placed in the heated shaker





(B) Liquid culture of microbes from soil after a week in the heated shaker. Appears cloudy and white, showing signs of growth
(C) White, papery, and light growth clearly visible in the (+) culture tube, suggesting successful degradation and utilization of keratin. No growth in the (-) culture tube, as expected.

Discussion

Upon transfer and growth in the culture tubes, colonies in the (+) tube appeared white and flaky, suggesting successful degradation and utilization of keratin. Negative controls showed no growth, confirming that the observed growth was due to keratin utilization. The growth of microbes also indicated the presence of keratin-degrading enzymes. The white, flaky appearance of colonies could be attributed to the proteinaceous nature of the degraded keratin. We can conclude that the soil taken from the turtle pond provided a good innoculum sourc for keratin.

When searching MetaCyc for pathways involving keratin as a substrate, I found only a few specific pathways. This limited presence suggests that keratin degradation is not a common metabolic process among a broad range of microorganisms. The complexity of keratin's structure, particularly its dense disulfide bonds, makes it a challenging substrate for microbial degradation.

The growth observed on keratin as a carbon source was initially slow, indicating the difficulty microbes face in accessing the nutrients within this complex substrate. Over time, the cultures developed into white, flaky colonies, suggesting successful degradation of keratin. The culturing methods used, such as starting in Erlenmeyer flasks and transferring to smaller culture tubes, had both positive and negative impacts. The initial use of flasks likely provided better aeration, promoting initial microbial activity. However, subsequent transfers might have limited nutrient availability and space, potentially constraining further growth.

Considering the diversity of microbial physiology, a potential adaptation that might enable a microbe to grow on keratin, where others cannot, could be the production of keratinases. These are specialized enzymes capable of breaking down the tough disulfide bonds in keratin, allowing the microbe to access and utilize the amino acids within. Additionally, microbes may possess enhanced protein transport systems or specific metabolic pathways adapted to process the constituent amino acids of keratin more efficiently. These adaptations would be crucial for thriving in environments where keratin is a primary, albeit challenging, nutrient source.