Ecology of Microorganisms: Extremophiles (Acidophiles and Alkatophies)

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Abstract:

The extremophiles are those organisms whose optimal growth conditions are found outside the normal environment. It is now well organized that many parts of the world contains extreme environment such as polar region. Acidic and alkolophilic springs and cold pressurized depths of the ocean are colonized by microbes which are specially adapted to these exceptional environments. Some restricted ranges of microbes have the ability to inhabit it extreme environments. 'Extreme' is defined as the fact that microbes not only survive but actually grow in some of unusual environment on earth. It has stimulated scientific curiosity about the mechanisms permitting the survival and growth in such surroundings. These special organisms might provide a valuable resource for the exploration of new chemical and biotechnological processes. Most of the extremophiles are prokaryotes and archaea. They produce enzymes, antibiotics etc. which have biotechnological importance.

Keywords: Extreme environment, Acidophiles, Alkalophies, pH, Digestibility detergents.

Introduction:

Now it is known that various groups of extremophiles such as acidophiles, alkalophiles, halophiles, thermphiles and hyperthermophiles, Psychrophiles and barophiles are well studied. This article describes the important groups of extremophiles such as acidophiles and alkalophiles only.

1. **Acidophiles**: Microorganisms that live at low pH are called acidophiles. Natural environments on the earth are essentially neutral, having pH between 5 and 9. Only a few microbial species can grow at pH less than 2 or greater than 10. Fungi as a group tend to be more acid tolerant than bacteria. Many fungi grow optimally at pH 5 or below and a few grow well at pH value as low as 2. For example species of Thiobacillus and genera of archaea including sulpolobus and Thermoplasma are acidiophilic.

Figure. 1- Massive Growth of extreme acidophile ferroplasma in Californa mine

Sulphuric acid is produced by the ferroxidans and sulfolobus species oxidize sulphide minerals. The most important factor for obligate acidophily is the cytoplasmic membrane of obligatory acidophilic bacteria which actually dissolves and lyses the cell wall. This suggests that high concentration of H^+ ions are needed for membrane stability.

Highly acidic environment is formed naturally from geochemical activities and from the metabolic activities of certain acidophil themselves. Acidiophiles are also found in the debris left over coal mining. Interestingly, acid -loving extremophiles cannot tolerate great acidity inside their cells, where it would destroy DNA. They survive by keeping the acid out. But defensive molecules provide this protection as well as others that come in contact with the environment must be able to operate in extreme acidity. Indeed extremozymes that is their enzyme providing adaptibilities are able to work at pH below one, more acidic than even vinegar or juice of stomach. Such enzymes have been isolated from the cell wall and underlying cell membrane of some acidophiles.

Figure. 2- The bacterium Thermoplasma acidophilium, that lives in acidic springs. Survives by keeping the acid out

i) **Physiology**: Obligate acidophiles have an optimum pH for growth which remains extremely low that is 1 to 4. To protect the intracellular enzymes and other components from low to medium pH, the organism maintain large pH gradient across the membrane. Special, forms of lipids are present in their membrane which may minimize the leakage of H^+down the pH Value. For instance, the presence of certain fatty acids has been reported to provide special adaptations to growth and survival at extremely low pH Acidophiles maintain the cytoplasmic pH around 6.5. In these organisms, the PH remains generally 1-2 which is lower in comparison to neutrophiles and alkalophiles. In acidophiles the pH is compensated by positive inside electric potential which is opposite to that present in neutrophiles. The reverse electric potential generated by electrogenic K^+ uptake which allows the cells to extrude more H^+ and thus maintain the internal pH.

ii) **Molecular Adaptation**: Most critical factor for obligate acidophily lies in the cytoplasmic membrane. When the pH is raised to neutrality, the cytoplasmic membrane of obligately acidophilic bacteria actually dissolves and the cells lyse. It is suggested that high concentration of hydrogen ion are required for stability of membrane that allows bacteria to survive.

iii) Applications: Potential applications of acid-tolerant extremozymes range from catalysts for the synthesis of compounds in acidic solutions to additives for animal feed which are intended to work in animal stomach. When added to feed, the enzymes improve the digestibility of expensive grains, therefore avoiding the need for more costly food.

2. **Alkalophiles**: Alkalophiles live in soils laden with carbonates and in Soda lakes, such as those found in the Rift Valley of Africa and West U. S.. The first alkalophilic bacterium was reported in year 1968. Most alkalophilic prokaryotes studied have been aerobic non-marine bacterio and reported as Bacillus Spp. Krawich and Guffout (1989) separated them into two broad categories: Alkali-tolerant organisms (pH 7.0-9.0) which can grow above pH 9.5 and alkalophilic organisms (pH 10.00-12.00). Most of the alkalophilic organisms are aerobic or facultative anaerobic. Some alkaophiles are Bacillus alkalophilus B. Firmus RAB, Bacillus Sp. No. 8-1 and Bacillus Sp No. C-125 which bear flagella and hence are motile. The flagella induced motility is considered by a sodium motive force instead of proton motive force. They are motile at pH 9-10.5 but no motility is seen at pH 8. The Indigo - reducing alkalophilic bacterium (Bacillus Sp.) isolated form indigo ball was used to improve the Indigo fermentation process. Their cell wall contains acidic compounds similar in composition to peptidoglycans.

i. **Physiology**: The cell surface of alkalophiles can maintain the neutral intracellular PH in alkaline environment of pH 10-13. The recommended concentration of NaOH for large scale fermentation is 5.2% depending upon the organisms. The pH should remain 8.5-11. Sodium ions (Na^+) are required for growth, sporulation and also for germination. The presence of sodium ion in the surrounding environment has proved to be essential for effective solute transport through the membranes.

In the Na^+ ion membrane transport system the H^+ is exchanged with Na^+ by Na^+/H^+ antiport system, thus generating a sodium motive force. This drives substrate accompanied by Na^+ ions into the cell. The incorporation of α- aminobutyrate is increased two fold as the external P shifts from 7 to 9, and the presence of Na^+ ions significantly enhance the incorporation. Molecular cloning of DNA fragments conferring alkalophily was isolated and cloned. This fragment is responsible for Na^+/H^+ antiport system in the alkalophily of alkolophilic microorgamisms.

ii. **Molecular Adaption**: Alkalophiles contain unusual diether lipids bonded with glycerol phosphate just like other archaea. In these lipids, long chain, branched hydrocarbons, either of the phytanly or biophytantly type, are present. The intracellular pH remains neutral in order to prevent alkali-labile macromolecules in the Cell. The intracellular pH may by 1-1.5 pH units from neutrality which helps these organisms to survive in highly alkaline external environment.

iii. **Applications**: Some alkalophiles produce hydrolytic enzymes such as alkaline proteases which function well at alkaline pH. These are used as supplements for house hold detergents. For example an alkaline propose called substilisin has been produced from substilis which is used in detergent. The stone washed denim fabric is due to the use of these enzymes. These enzymes soften and fade fabric by degrading cellulose and releasing dyes. (see table I)

Table. 1- Some extremozymes and their applications

S.N.	Extremozymes	Uses
1	Thermozymes	Required for DNA amplification reactions and industrially important product formation.
2	Halozymes	Proteases, alkaline phosphatases lipases and amylases are used in industry for manufacturing of degergents.
3	Acidozymes	Sulphate oxygenase, Thiobacillus dehydrogenase rusticyanine (acid stable e carrier and thromopsin)
4.	Psychozymes	Pectinase, lipase, cellulose, amylase for detergents, food processing (cheese making, meat tendering, lactate hydrolysis, biotransformation's and contact lens cleaning solutions
5.	Alkalozymes	Protease (detergents), amylase (Starch Industry),Cyclomattodextrin, glucanotransferase (chemicals and pharmaceuticals) Pullunaces (detergents), Xylanses (Pulp and paper industry) Pectinases (Paper production)

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