



Starter cultures produce a number of antimicrobial compounds during the preparation of fermented milk products. These antimicrobial compounds are very effective against many Gram positive bacteria and exhibit therapeutic properties. Fermented milks with therapeutic properties possess ability to fight against intestinal pathogens. The effect is exerted by LAB through production of several antimicrobial compounds/creating unfavourable conditions for other bacteria. The primary compounds responsible for such effects are:

Organic acids (Lactic acid, acetic acid, propionic acid), Hydrogen ion concentration (pH), Low oxidation reduction potential, H₂O₂ and CO₂, Aroma compounds- (diacetyl, acetaldehyde), Fatty acids, Bacteriocins

Organic acids:

- Lactic acid is the major metabolite of LAB fermentation. At low pH it is found in its undissociate form and is toxic to many microorganisms.**
- Acetic acid and propionic acid are more antimicrobial than lactic acid due to higher pKa values.**
- The antimicrobial effect of organic acid lies in the reduction of pH as well as the undissociate forms of molecules.**
- The low external pH causes acidification of cell cytoplasm, while the undissociate form of molecule may cause alteration in the cell membrane permeability, collapsing the electrochemical proton gradient that results in disruption of substrate transfer system.**

H₂O₂ and CO₂ :

- **Some lactobacilli are known to produce H₂O₂ in the presence of flavoprotein oxidase or NADH peroxidase from glycerol, under aerobic conditions.**
- **The antimicrobial activity of H₂O₂ results from the oxidation of -SH groups causing denaturation of number of enzymes and from the peroxidation of membrane lipids thus the increased membrane permeability.**
- **H₂O₂ also acts as a precursor for the production of bactericidal free radicals such as superoxide O₂⁻, hydroxides -OH that can damage DNA.**
- ***Lactobacillus* sp. and *Lactococcus* sp. can produce H₂O₂ while CO₂ is mainly produced by heterofermentative LAB.**

Aroma compounds:

- **Diacetyl produced by LAB inhibits the growth of Gram negative bacteria by reacting with the arginine binding protein, thus affecting arginine utilization and finally interfere with protein synthesis.**
- **Acetaldehyde can also be toxic to many bacteria and it is converted to H₂O₂ in the presence of xanthine oxidase or glucose oxidase activities.**

Fatty acids:

- **Under certain conditions, some *Lactobacillus* and lactococci possessing lipolytic activity may produce significant amount of fatty acids.**
- **The unsaturated fatty acids are active against many Gram +ve bacteria and antimicrobial action may be due to the undissociated molecule.**

Bacteriocins:

- These are proteinaceous compounds produced by bacteria which are inhibitory to many bacterial species.
- LAB produces bacteriocins and other antibiotic like proteinaceous substances. These substances are active against many spoilage and pathogenic microorganisms.
- Production of such compounds is encoded by plasmid.
- Nisin has a narrow spectrum anti-bacterial activity and does not inhibit Gram -ve bacteria, yeast, or fungi. Closely relative organisms like *L. lactis* subsp. *cremoris* are more sensitive. It is effective against spore formers.

Species	Compound
<i>Lactococcus lactis</i> subsp <i>lactis</i>	Nisin
<i>Lactococcus lactis</i> subsp <i>cremoris</i>	Diplococcin
<i>Lb. reuteri</i>	Reuterin (non-protein)
<i>Lb. acidophilus</i>	Acidolin Acidophilin Lactocidin
<i>Lb. brevis</i>	Lactobacillin Lactobrevin
<i>Lb .bulgaricus</i>	Bulgaricin
<i>Lb .fermenti</i>	Bacteriocin
<i>Lb. helveticus</i>	Lactacin 27 Helveticin J
<i>Lb. plantarum</i>	Lactolin
<i>Pediococcus acidolactici</i>	Pediocin Bacteriocin
<i>S. thermophilus</i>	Unnamed

Types of Interactions Among Starter Cultures

Neutrality: In this type of association, two organisms living in a close proximity are not affected by each other. This may exist between two organisms whose growth requirements are quite different and hence affect neither kind as there will be no competition between these two for nutrients.

Antagonism: When an organism adversely affects the environment of another organism, it is antagonism. Antibiosis is antagonistic association between two organisms in which one is adversely affected. Production of antibiotic or inhibitory substances by one organism that affect the growth or survival of another organism. Lactic acid bacteria produce lactic acid that is inhibitory to spoilage organisms.

Symbiosis: Relationship between two (or more) organisms that live in a close association but not necessarily benefit each other. In the vast majority of symbioses one or both partners gain something positive from the association. A pair of symbionts may be able to live separately, but they almost always do better in the long run by living together.

Mutualism: Each organism benefits from the association but the manner in which benefit is derived varies with exchange of nutrients between two species (Syntrophism) or association results in metabolic end products. The growth association between the two organisms (*S. thermophilus* and *L. bulgaricus*) of the yoghurt starter culture is termed as symbiosis where they grow in association in milk. The acid development is greater when mixed yoghurt cultures of *S. thermophilus* and *L. bulgaricus* bacteria were used as compared with the single strains. Amino acids liberated from casein by proteases produced by *L. bulgaricus*, stimulate the growth of *S. thermophilus*. Acid production by *L. bulgaricus* is enhanced by formate and carbon dioxide produced by *S. thermophilus* (grow faster during early period of incubation).

Commensalism: Relationship between microorganisms in which one organism benefits from the association but the other organism is not affected. Facultative organism grows and produces anaerobic conditions that favour growth of anaerobes. Growth of yeasts in sugar solutions reduce the concentration of sugar thus permitting growth of bacteria.

Type of interaction	Definition	Examples
Competition	Populations of two species are mutually limiting because of their joint dependence on a common factor or factors external to them	<ol style="list-style-type: none"> 1. In Cheddar cheese (high cooking temperature), <i>Lc. lactis</i> subsp. <i>lactis</i> will dominate 2. Competition for nitrogen nutrients will cause <i>Lc. lactis</i> to dominate in culture containing <i>Leu. mesenteroides</i>
Amensalism	Inhibition of other species by removal of essential nutrients or formation of toxic metabolites	<i>Lc. lactis</i> subsp. <i>lactis</i> producing nisin inhibits sensitive strains in mixed cultures
Commensalism	The species which benefits from another does not provide a benefit in return	The prt ⁻ variants might profit from the prt ⁺ variants without providing any benefit in return
Parasitism	One organism feeds or reproduces at the expense of another that is necessarily damaged by the relationship	Phage-resistant strains having low growth rate will have higher populations in the presence of bacteriophage
Mutualism	Both species benefit from co-growth	<i>S. thermophilus</i> and <i>Lb. delbrueckii</i> ssp. <i>bulgaricus</i> in yogurt cultures exchange growth factors