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كلية العلوم

قسم التقنيات الاحيائية الطبية

INDUSTRIAL MICROBIOLOGY

Lec. 2

Microorganisms in Vitamin Production

by

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Lecture: Microorganisms in Vitamin Production

1. Introduction

- **Vitamins** are organic compounds required in trace amounts for normal metabolism, growth, and health.
- They act as **coenzymes or precursors** in vital biochemical reactions.
- Traditionally, vitamins were extracted from **plant or animal sources** or produced **chemically**.
- However, **microbial fermentation** now provides a **sustainable, cost-effective, and scalable** alternative.

Why Use Microorganisms?

- Rapid growth and easy cultivation.
- Genetic manipulability to increase yield.
- Use of inexpensive substrates and waste materials.
- Continuous fermentation is possible.

2. Microbial Producers of Vitamins

2.1 Vitamin B12 (Cobalamin)

- **Producers:**
  - *Propionibacterium freudenreichii*
  - *Pseudomonas denitrificans*
  - *Bacillus megaterium*
- **Importance:**
  - Essential for red blood cell formation and nervous system function.
  - Used in pharmaceuticals and food fortification.

- **Notes:**
  - Only microorganisms can synthesize Vitamin B12 naturally — plants and animals cannot.
  - Industrial processes use **aerobic fermentation** with cobalt as a cofactor.

2.2 Riboflavin (Vitamin B2)

- **Producers:**
  - *Ashbya gossypii* (a filamentous fungus)
  - *Bacillus subtilis* (engineered strains)
- **Process:**
  - Fed-batch fermentation using glucose or vegetable oils as carbon sources.
- **Applications:**
  - Used as a food colorant and nutritional supplement.
- **Advances:**
  - Genetic modification of *B. subtilis* increased riboflavin yield by up to 20-fold.

2.3 Vitamin C (Ascorbic Acid)

- **Microbial Step:**
  - The **Reichstein process** combines microbial and chemical steps.
  - *Gluconobacter oxydans* converts D-sorbitol → L-sorbose → L-ascorbic acid.
- **Applications:**
  - Widely used in the food and pharmaceutical industries as an antioxidant and immune booster.
- **Recent developments:**
  - Attempts to replace the chemical step entirely with microbial co-culture fermentation.

2.4 Vitamin K2 (Menaquinone)

- **Producers:**
  - *Bacillus subtilis* (natto fermentation)
  - *Lactococcus lactis*
- **Applications:**
  - Improves bone and cardiovascular health.
- **Fermentation type:**
  - Solid-state fermentation using soybean substrates (traditional Japanese natto).

2.5 Folic Acid (Vitamin B9)

- **Producers:**
  - *Lactobacillus plantarum*
  - *Streptococcus thermophilus*
- **Applications:**
  - Prevents neural tube defects and anemia.
- **Notes:**
  - Probiotic bacteria engineered to overproduce folate for functional foods.

2.6 Vitamin D2 (Ergocalciferol)

- **Microbial role:**
  - Yeast (*Saccharomyces cerevisiae*) produces **ergosterol**, which is converted to Vitamin D2 upon **UV irradiation**.
- **Applications:**
  - Nutritional fortification in dairy and plant-based milk products.

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3. Fermentation Processes

Fermentation Type	Description	Example
Batch	One-time nutrient supply; simple but limited yield	Vitamin B12
Fed-batch	Nutrients fed gradually to sustain growth	Riboflavin
Continuous	Constant input/output; stable productivity	Folate production

Optimization Factors:

- Carbon & nitrogen sources
- Aeration, pH, temperature
- Metal ions (e.g., cobalt for B12)
- Genetic modification for pathway enhancement

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4. Applications of Microbial Vitamin Production

- **Food industry:** Fortified cereals, dairy, beverages.
- **Pharmaceuticals:** Vitamin supplements, injections.
- **Animal feed:** Poultry and livestock nutrition.
- **Functional foods:** Probiotic strains that produce vitamins in situ.

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5. Advances & Future Prospects

- **Genetic and metabolic engineering** to improve vitamin yields.
- Use of **CRISPR/Cas9** to knock out competing pathways.
- **Synthetic biology** for custom-designed microbial "vitamin factories."
- Transition from **chemical synthesis → full microbial biosynthesis** for sustainability.
- Integration of **multi-vitamin pathways** into single microbial strains.
