



# **Fundamental Physics for Food Technology and Innovation (4011106)**

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# **Waves and Vibrations in Food Processing**

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# Overview of topics to be covered:

- A. Understand basic concepts of waves and vibrations
- B. Identify applications of waves in food processing
- C. Explain how ultrasonic waves affect food materials
- D. Recognize the importance of vibration control in food equipment

# Introduction to Waves

- Definition: A wave is a disturbance that transfers energy through matter or space
- Types of waves relevant to food industry:
  - *Mechanical waves (sound, ultrasound)*
  - *Electromagnetic waves (microwave, infrared)*

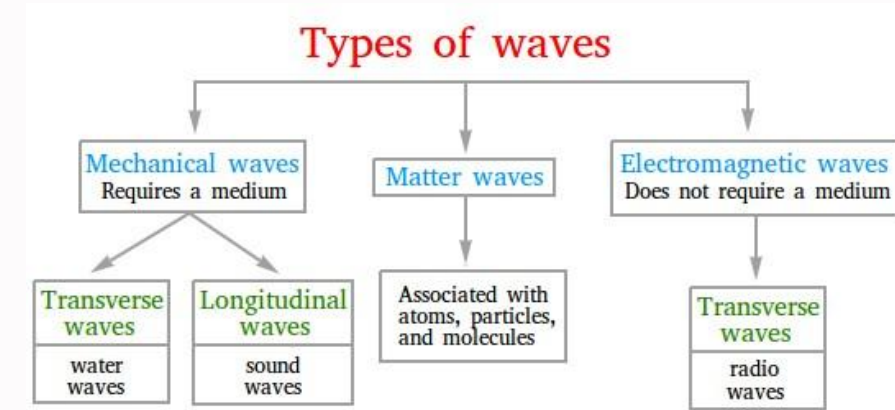


Figure 1: Types of waves physics

# Basic Wave Properties

Key characteristics:

- *Wavelength ( $\lambda$ ): Distance between two consecutive crests*
- *Frequency ( $f$ ): Number of cycles per second*
- *Amplitude ( $A$ ): Maximum displacement from equilibrium*
- *Wave speed ( $v$ ):  $v = \lambda f$*

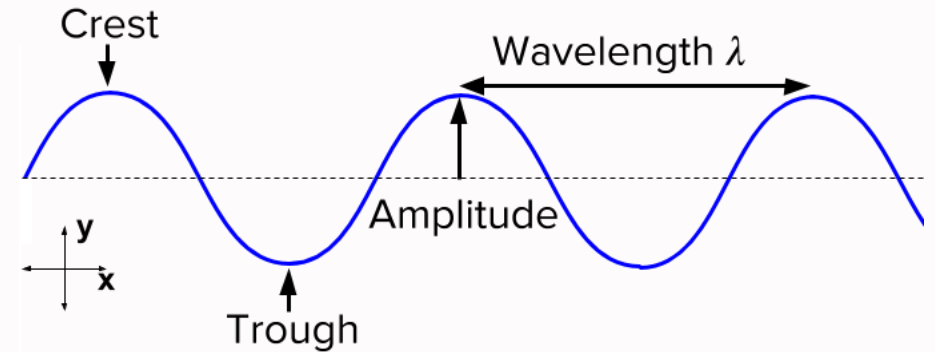


Figure 2: Wave properties diagram

# Applications in Food Industry

## 1. Ultrasonic Processing Homogenization

- *Extraction*
- *Emulsification*

## 2. Quality Control

- *Non-destructive testing*
- *Texture analysis*



Figure 3: Ultrasonic food processing

# Vibrations in Food Processing Equipment

Common applications:

- *Vibratory conveyors*
- *Screening and sorting*
- *Packaging systems*



Figure 4: Vibratory conveyor food



# Wave Energy in Food Processing

Energy transfer principles:

- *Cavitation effects*
- *Heat generation*
- *Mechanical effects on food structure*

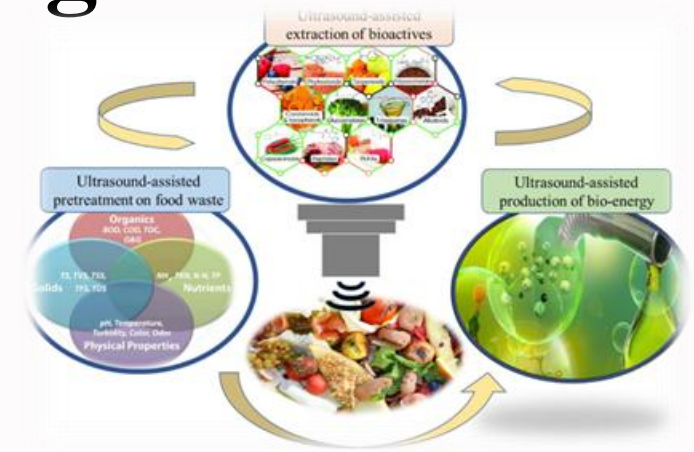


Figure 5: Ultrasonic cavitation food\



# Case Study: Ultrasonic Cutting

## Benefits:

- *Clean cuts for soft foods*
- *Reduced product waste*
- *Improved efficiency*



Figure 6: Ultrasonic food cutting

# Standing Waves in Food Processing Equipment

## Key Concepts:

- *Formation of standing waves*
- *Resonance frequency*
- *Impact on equipment performance and maintenance*
- *Prevention of equipment damage*

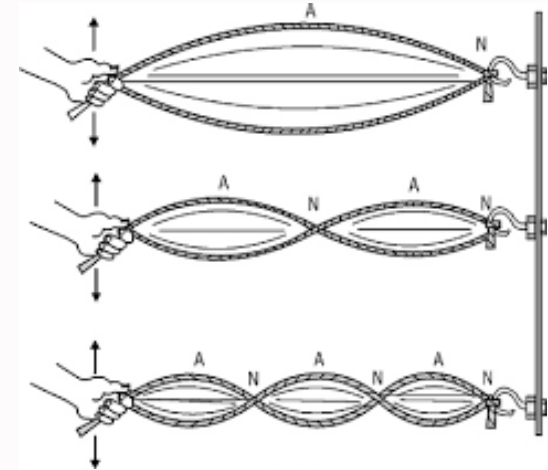


Figure 7: Standing waves physics

# Acoustic Methods in Food Quality Assessment

## Applications:

- *Texture analysis through sound waves*
- *Ripeness determination in fruits*
- *Internal structure analysis*
- *Defect detection in packaged products*

Equation: Acoustic velocity ( $v$ ) =  $\sqrt{E/\rho}$

where:

- $E$  = *elastic modulus*
- $\rho$  = *density of medium*

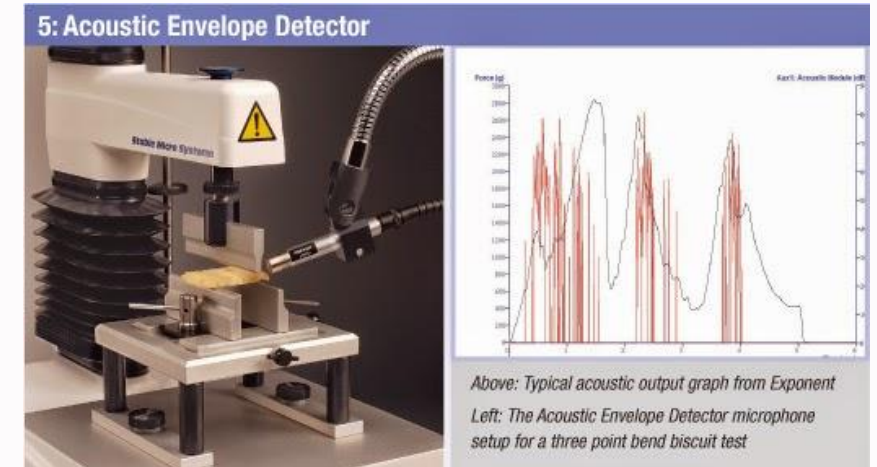


Figure 8: Acoustic food testing

# Modern Industrial Applications

## Emerging Technologies:

### 1. Power Ultrasound

- *Microbial inactivation*
- *Enhanced extraction*
- *Improved crystallization*

### 2. Acoustic Drying

- *Reduced drying time*
- *Energy efficiency*
- *Product quality preservation*



Figure 9: Power ultrasound food

# Safety Considerations in Wave Applications

Important Factors:

- *Frequency exposure limits*
- *Equipment maintenance schedules*
- *Operator safety guidelines*
- *Quality control parameters*



Figure 10: Industrial safety equipment





# References.

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3. CRC Press. Zhang, H. (2021). Ultrasound: Science and Technology. Academic Press.

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