FDE 418
FOOD QUALITY CONTROL
LESSON-11

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Food Rheology

- ✓ The study of deformation and flow of the raw materials, the intermediate products and the final products of the food industry
- ✓ Foods are complex materials structurally and rheologically
  - ✓ in many cases, they consist of mixtures of solids as well as fluid structural components





Food Rheology

- ✓ The rheological characteristics of a food system;
  - ✓ Dependent on the *composition or the ingredients*
  - ✓ Related to *density, porosity and moisture content* of the material





The areas where rheological data are needed in the food industry

- ✓ Applications in the fields of food acceptability, food processing and food handling
- ✓ Process engineering calculations involving a wide range of equipment;
  - ➢ such as pipelines, pumps, extruders, mixers, coaters, heat exchangers, homogenizers and on line viscometers
- ✓ Determining ingredient functionality in product development
- ✓ Intermediate or final product quality control
- ✓ Shelf-life testing

Why to measure rheological properties of foods

- ✓ Flow behavior is responsive to properties such as molecular weight and molecular weight distribution
- ✓ Useful in following the course of a chemical reaction
- ✓ The study of chemical, mechanical and thermal treatments

Viscosity

- ✓ The resistance to deformation and flow
- ✓ Measure of internal friction of a fluid
  - ✓ Stress: force per unit area
  - ✓ Strain: deformation (amount of deformation divided by original length)
- ✓ Different fluids deform at different rates under the same shear stress

Units of viscosity

- The English unit for VISCOSITY ➔ *"Poise"* or OR
  "centipoise" (cp) = g/cm.s

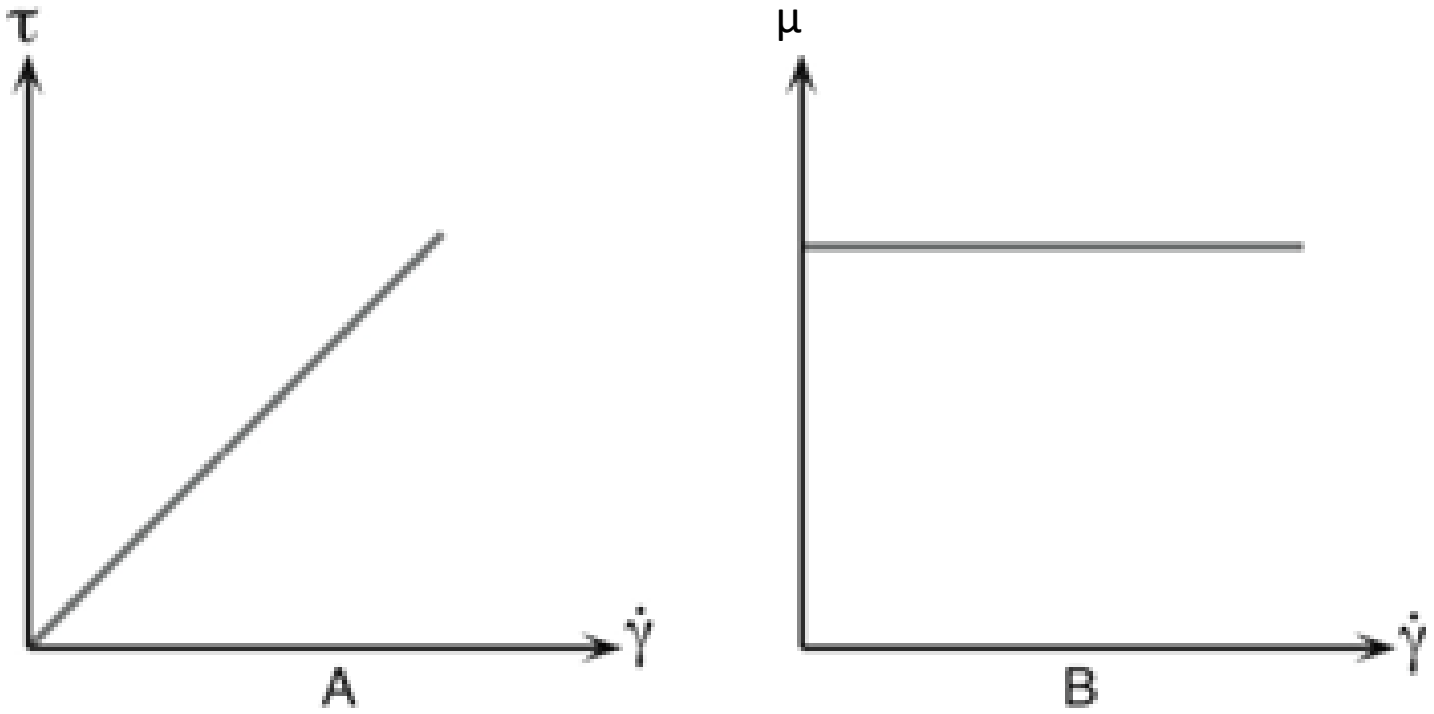
- The SI UNIT for VISCOSITY ➔ Pa.s ($N.s/m^2$ OR kg/m.s)

Rheological Classification of Foods

- **Newtonian fluids**: linear proportionality between the shearing tensor and the shearing rate

- **Non-Newtonian fluids**: any different relation between the shearing stress and the shearing rate

Newtonian (Newtonian Law of Flow)



A: the relationship between shear stress and shear rate

B: relationship between the viscosity and shear rate. The fluid's viscosity remains constant as the shear rate is varied.

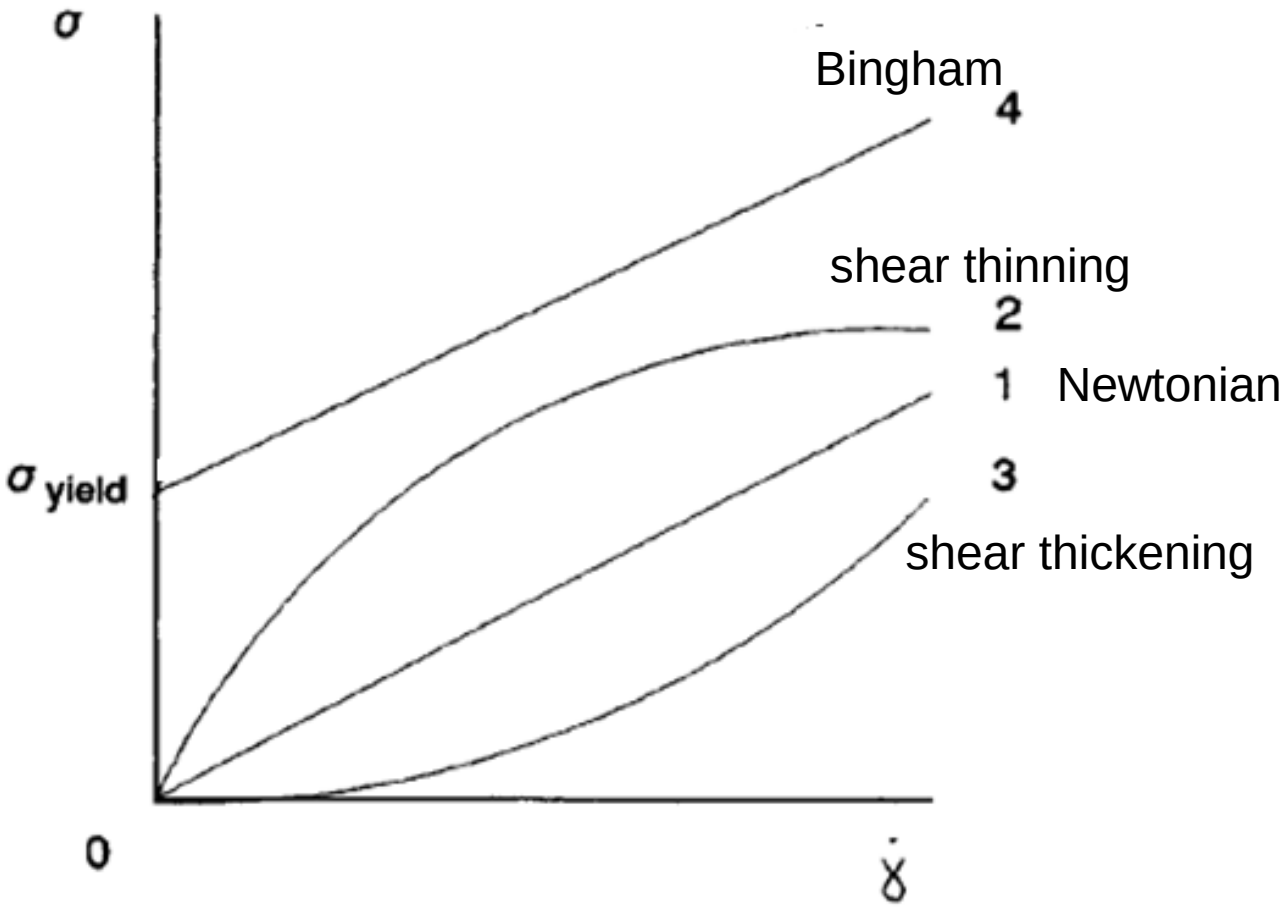
Newtonian (Newtonian Law of Flow)

- ✓ For a Newtonian fluid, the viscosity depends on;
  - ✓ temperature
  - ✓ chemical composition of the fluid if the fluid is not a pure substance

Non-Newtonian (Newtonian Law of Flow)

- ✓ The Non-Newtonian behaviour is associated with complex internal structure
  - ✓ fluid that has large complex molecules (like a polymer)
  - ✓ fluid that is a heterogeneous solution (like a suspension)

Food Rheology



✓ The Shear Stress as a Function of the Shear Rate T for Various Foods with a "Liquid" Character. (1) Newtonian, (2) shear thinning, (3) shear thickening, (4) Bingham

Rheological Classification of Fluids-NonNewtonian

- ***Time Independent Fluids:*** the relation between shearing stress is non-linear
  - ✓ Bingham
  - ✓ Shear thickening
  - ✓ Pseudoplastic: shear thinning

Rheological Classification of Fluids-NonNewtonian

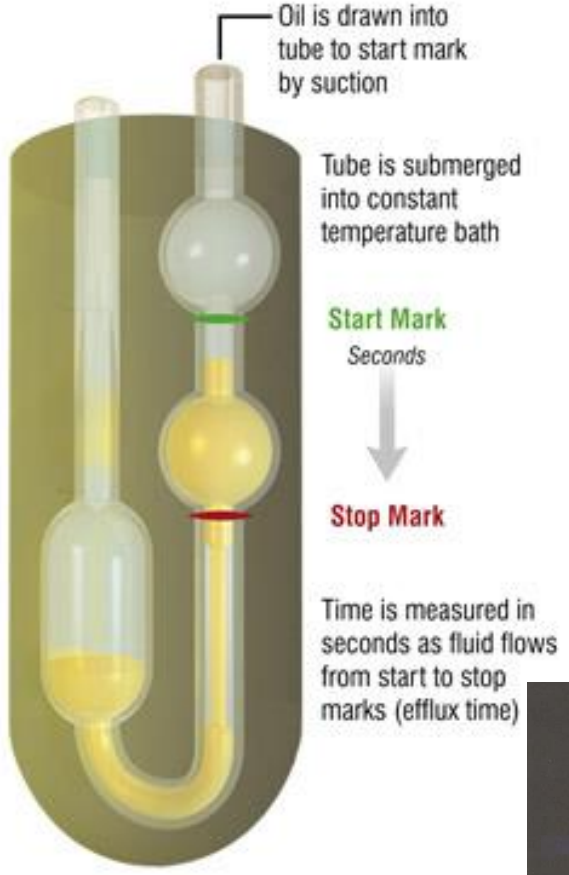
- ***Time Dependent Fluids:*** the shear rate depends on the shearing

  - ✓Thixotropic

  - ✓Reopectic

Basic forms of viscometers

- ✓ Capillary Flow Method
  (The Ostwald-Fenske Viscometer)
- ✓ Falling Ball Method
  (Hoeppler)
- ✓ Rotating Shaft Viscometer
  (BROOKFIELD)



U-shaped Glass Tube Capillary Viscometer
(Ostwald-Fenske Viscometer)

Falling sphere (ball) Viscometer
(Hoeppler Viscometer)

Rotational Type Viscometer

(BROOKFIELD Viscometer)