FDE 449
Physical properties of Foods

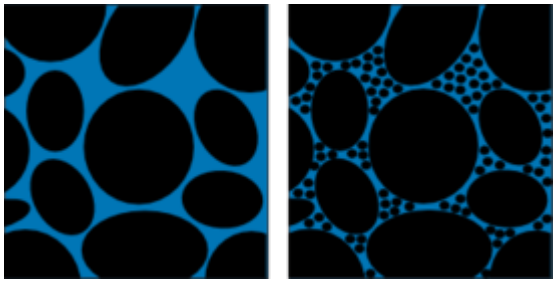
Size, shape and volume

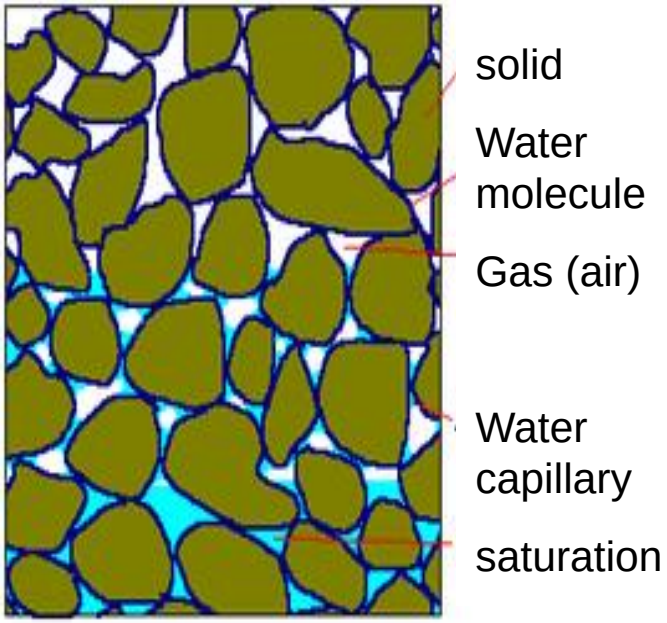
Size and shape

- important physical properties in food separation, classification and quality control.
- important in the flow of liquid foods and in heat and mass transfer calculations.
- Sieve analysis is used to calculate the average particle diameter of granular food and to calculate the specific surface area.

Porosity

- **Porosity is a physical property that reveals the texture and quality of dry and semi-dry foods.**



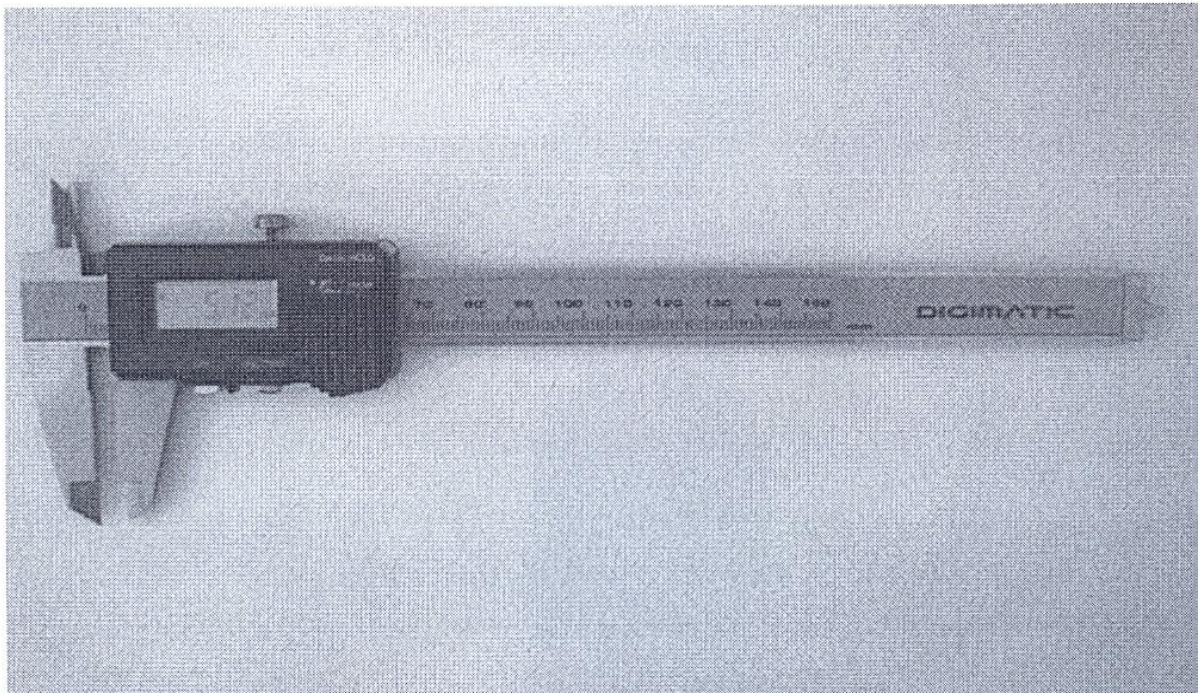


Size

- Size is used to separate solid foods from the impurities they contain.
- in the classification of fruits and vegetables, it is used to evaluate the quality of food.
- It is necessary to know the size of the food in the flow of liquids, heat and mass transfer calculations.

Micrometer

- It is easy to determine the size of particles with a regular shape.
- However, the size of irregular particles is expressed according to some rules.

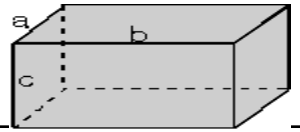
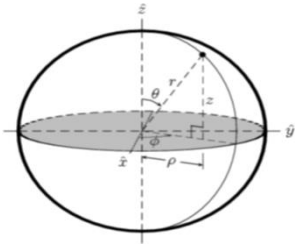
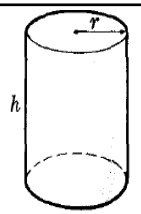
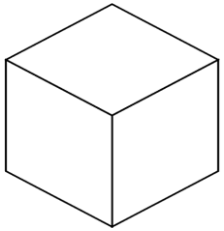


Micrometer

Shape

- The shape of the food is important in heat and mass transfer calculations, separating foreign materials from solid foods, classifying fruits and vegetables, and evaluating the quality of food.

Volume and surface areas of commonly used geometric shapes

Geometric shape	Volume, V	Surface area, A	Shape
Rectangular prism	$V = a\ b\ c$	$A = 2(ab + bc + ca)$	
Sphere	$V=4/3\ \prod r^3$ veya $1/6\prod D^3$	$A = 4\prod r^2$	
Cylinder	$V = \prod r^2\ L$	$A = 2\prod r\ L$	Hacim = $Ah = \pi r^2 h$ Yüzey alanı = $2\pi rh$ 
Cube	$V = a^3$	$A = 6a^2$	

Example

- Calculate the volume and area of a potato croquette with a diameter of 1 cm and a height of 5 cm.

Volume

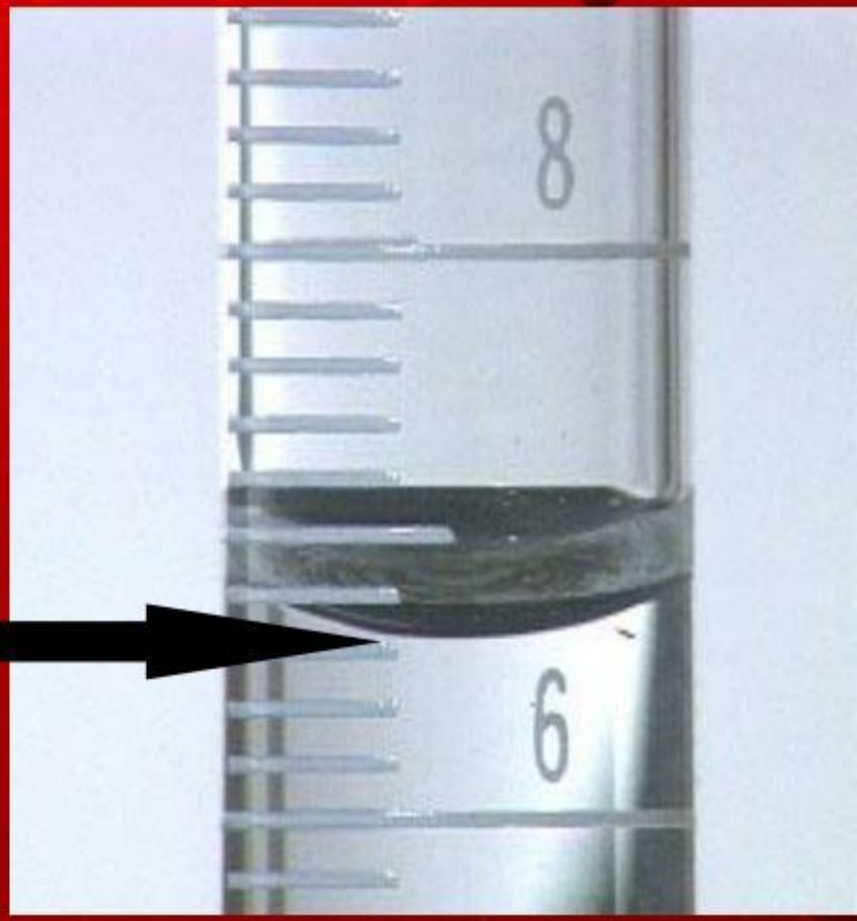
- Volume is the three-dimensional space occupied by an object. Usually the cube of length, i.e. m^3, $inch^3$ or cm^3, is expressed in gallons or liters for liquids.

- The unit of volume in the SI system is m^3.
- The volume of liquids (or gases) are often measured in litres (l) or millilitres (ml)

- Volume is an important quality characteristic in the food industry.

Measuring Liquid Volume

- What is volume?
- Be sure you understand the scale on your graduated cylinder
- How is this scale increasing? What are the increments?
- Read bottom of the curve in the liquid or the "**meniscus**"
- The volume is 6.6 ml

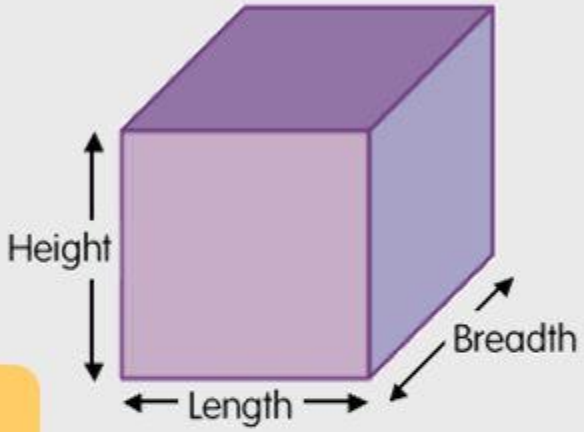


Liquid Volume

- The volume of an object is the amount of space it takes up.
- Liquid volume is measured using a graduated cylinder.
- Liquid volume is measured in milliliters (mL), liters (L), and kiloliters (kL).

Volume Of Solids - *Cube*

- How can you find the volume of a cube?



Volume = Length × Breadth × Height

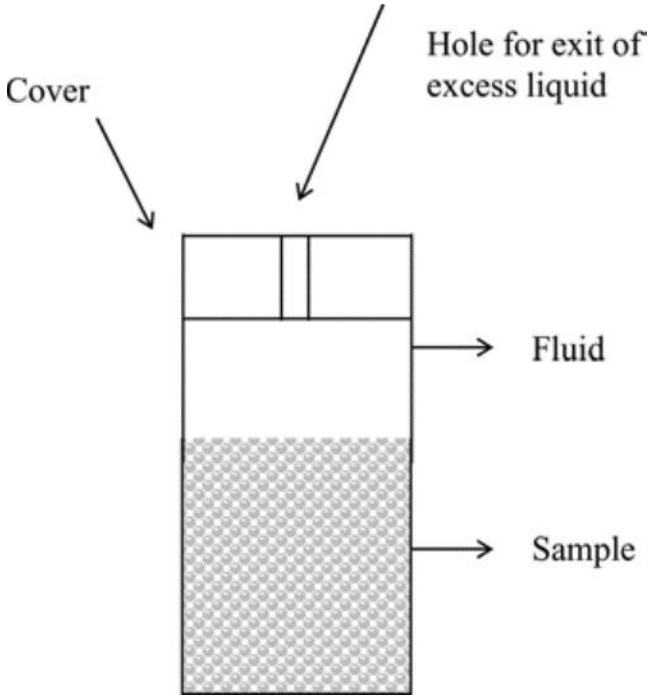
Remember that a cube has the same length, breadth and height.

Liquid, gas, and solid displacement methods

Liquid Displacement Method

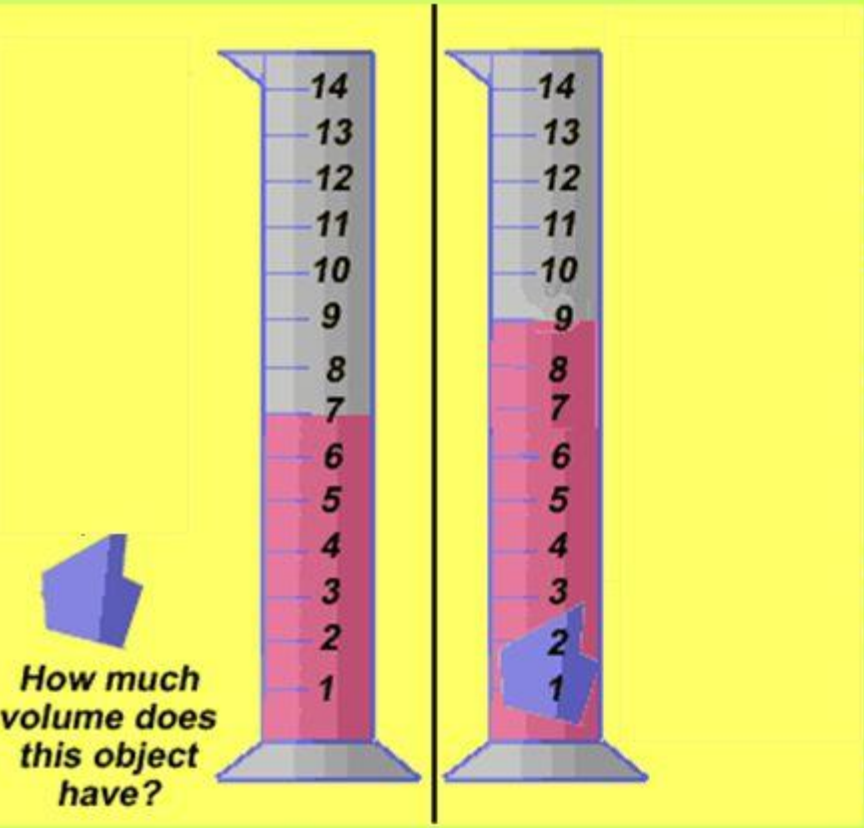
- If the solid sample does not absorb liquid very fast, the liquid displacement method can be used to measure its volume.
- In this method, volume of food materials can be measured by pycnometers (specific gravity bottles) or graduated cylinders.
- The pycnometer has a small hole in the lid that allows liquid to escape as the lid is fitted into the neck of the bottle.

Graduated cylinder



Pycnometer (specific gravity bottle)

Water Displacement Method



Step 1: Add water to a graduated cylinder and record the amount.

Step 2: Place the object into the graduated cylinder.

Step 3: Record the volume of the water with the object.

Step 4: Find the difference in water volume by subtracting.

Step 5: Convert the liquid volume measurement (mL) to the measurement for solid volume (cm^3).

***** Remember: 1 mL = 1 cm^3**

Liquid displacement method

Liquids that can be used for volume measurement by liquid displacement method:

- should have low surface tension.
- they should not be absorbed at all or very slowly by solid particles.

The most used liquids for this purpose are;

Water
Alcohol
Toluene
tetrachloroethylene

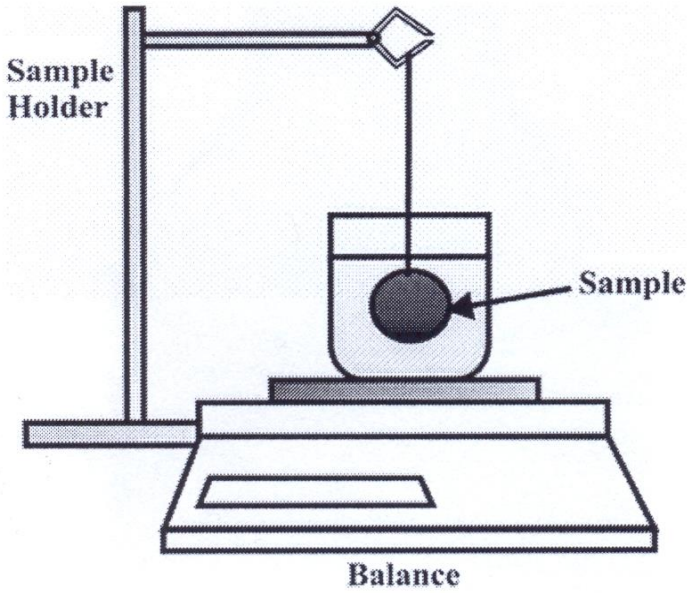
Measuring the volume of large objects

- a platform scale can be used.
- The sample is completely

submerged in liquid such that it does not make contact with the sides or bottom of the beaker.

- Weight of the liquid

displaced by the solid sample is divided by its density.



Measuring the volume of large objects used platform scale

Measuring the volume of large objects

The method is based on the Archimedes principle, which states that a body immersed in a fluid will experience a weight loss in an amount equal to the weight of the fluid it displaces.

That is, the upward buoyancy force exerted on a body immersed in a liquid is equal to the weight of the displaced liquid.

$$V_{solid} = G/\rho_{liquid}$$
$$= W_{air} - W_{liquid} / \rho_{liquid}$$

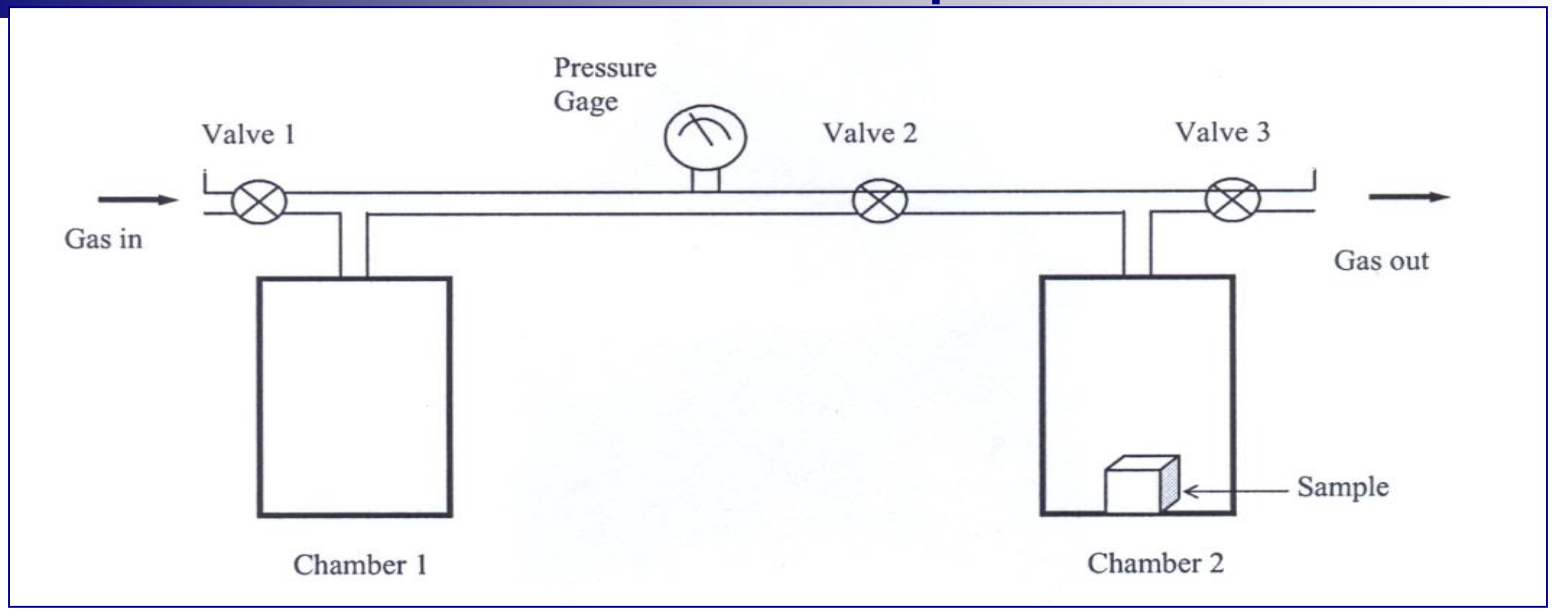
G= the buoyancy force (N)

ρ_{liquid} = the desity of liquid (kg/m^3)

W_{air} = the weight of sample in air (kg)

W_{liquid} = the weight of sample in liquid (kg)

Gas displacement method



Gas comparison picnometer

- Assuming that the gas behaves ideally:

$$P_1 V_1 = n R T_1$$

Where;

P_1 = equilibrium pressure when valve 2 is closed (Pa),

V_1 = volume of the first chamber (m3),

n = moles of gas (kg mol),

R = gas constant (8314.34 J/kg mol K),

T_1 = absolute temperature (K).

Solid displacement method

Volume of irregular solids can be measured by Using:

- Sand
- Glass bead
- Seed (e.g. Rapeseed)

- Rapeseeds are commonly used for determination of volume of baked products such as bread.

- The densities of the seeds are calculated from the measured weight of the seeds and volume of the container.

Volume measurement with rapeseed

- First, the bulk density of rapeseed is calculated.
- For this purpose, rapeseed is homogeneously filled into a glass container of known volume and its surface is smoothed with a ruler.
- Measurements are made one after another until a constant weight is achieved.
- The density of rapeseed is calculated from the measured weight of the seed and the volume of the container.

Volume measurement with rapeseed

- Then, the sample and rapeseeds are placed together in the container.
- The container is tapped and the surface is smoothed with a ruler. Tapping and smoothing are continued until a constant weight is reached between three consecutive measurements.

- The volume of the sample is calculated as follows:

$$W_{seeds} = W_{total} - W_{sample} - W_{container}$$

$$V_{seeds} = \frac{W_{seeds}}{\rho_{seeds}}$$

$$V_{sample} = V_{container} - V_{seeds}$$

W= weight (kg)
V= volume (m^3)
ρ= density (kg/m^3)

Expressions of Volume

- Solid volume (V_s)
- Apparent volume (V_{app})
- Bulk volume (V_{bulk})