Lecture 02

Determination of Moisture Content

Drying & Storage Engineering

(PFE-304)

Moisture content determination

There are several methods for determination of moisture content of agricultural products. For determination of moisture content of a particular product, the choice of method depends on many factors, they are

(1) the form in which water is present in the product,
(2) the relative amount of water present,
(3) the rapidity of determination,
(4) accuracy of method,
(5) product's nature whether easily oxidised , and
(6) the cost of equipment used.

Determination of Moisture: Methods

1. Drying Methods
   - Air oven/ Oven drying methods
2. Distillation method
3. Chemical Methods
   - Karl Fisher
   - Gas production
4. Physical Methods

Drying Methods

- These methods rely on measuring the mass of water in a known mass of sample.
- The moisture content is determined by measuring the mass of a food before and after the water is removed by drying.

- Basic Principle

  Water has a lower boiling point than the other major components within foods such as lipids, protein and carbohydrate.

Air oven method

(i) When the moisture content of grains is upto 13%, 2-3 grams representative ground samples of grains are placed in an air-oven. The temperature of the oven is set at 130°C and the samples are kept in oven for 1-2 hours. Afterwards, the samples are taken out and placed in a desiccator to cool down. The drop in the weight of grain is measured based on its initial weight.

Air oven method

(ii) 25 to 30 grams of unground representative samples of grains are taken and placed in an air-oven at 100°C temperature. The samples are kept in it for 72 to 96 hours. Afterwards, the samples are taken out from oven placed in a desiccator to cool down to room temperature. Moisture content of samples is measured based on drop in weight from initial weight of sample.


UWE
AXM
0.0 g
MODE
OFF
TARE
ON
ZERO


NOVA

EXAMPLE

S. No.	Test 1	Test 2	Test 3
MASS OF MOISTURE BOX (g)	**22.05**	**17.10**	**19.05**
INITIAL MASS OF SAMPLE WITH M.B.(g)	**45.35**	**39.90**	**40.90**
FINAL MASS OF SAMPLE WITH M.B.(g)	**43.95**	**38.20**	**39.60**

Calculate the moisture content of the wet basis and dry basis of the following table.

Calculations

SR .NO. (1)	MASS OF MOISTURE BOX (g) (2)	INITIAL MASS OF SAMPLE WITH M.B.(g) (3)	FINAL MASS OF SAMPLE WITH M.B.(g) (4)	MASS OF WATER IN SAMPLE (5) (3-4)	TOTAL MASS OF SAMPLE (6) (3-2)	MASS OF SOLID (7) (6-5)
1	22.05	43.95	45.95	1.4	23.3	21.9
2	17.10	39.90	38.20	1.7	22.8	21.1
3	19.05	40.90	39.60	1.3	21.85	20.5

Calculation:

M.C. on weight basis for sample (1).

$$\text{M.C.(wb)} = \frac{\text{Mass of water}}{\text{Mass of sample}} \times 100$$

$$= \frac{1.4}{23.3} \times 100$$

$$= 6\%$$

$$\text{M.C.(wb)} = \frac{\text{Mass of water}}{\text{Mass of sample}}$$

$$= \frac{1.4}{23.3}$$

$$= 0.06$$

1. M.C. on weight basis

sample (2). M.C.(wb)= $\frac{\text{Mass of water}}{\text{Mass of sample}}$ X100

$= \frac{1.7}{22.8}$ X100

=7.45%

M.C.(wb) = $\frac{\text{Mass of water}}{\text{Mass of sample}}$

$= \frac{1.7}{22.8}$

= 0.07

1. M.C. on weight basis

sample (3). $M.C.(wb) = \frac{\text{Mass of water}}{\text{Mass of sample}} \times 100$

$= \frac{1.3}{21.85} \times 100$

$= 5.9\%$

$M.C.(wb) = \frac{\text{Mass of water}}{\text{Mass of sample}}$

$= \frac{1.3}{21.85}$

$= 0.05$

Average M.C. (wb)=

$$\frac{6+7.45+5.9}{3}$$

$$=6.45\%$$

Average M.C. (wb)=

$$\frac{0.06+0.07+0.05}{3}$$

$$=0.06$$

2. M.C. on Dry basis

sample (1). M.C.(db)= $\frac{\text{Mass of water}}{\text{Mass of sample}}$ X100

$= \frac{1.4}{21.9}$ X100

=6.3%

M.C.(wb) = $\frac{\text{Mass of water}}{\text{Mass of sample}}$

$= \frac{1.4}{21.9}$

= 0.06

2. M.C. on Dry basis

sample (2). M.C.(wb)= $\frac{\text{Mass of water}}{\text{Mass of sample}} \times 100$

$= \frac{1.7}{21.7} \times 100$

$= 8.0\%$

M.C.(wb) = $\frac{\text{Mass of water}}{\text{Mass of sample}}$

$= \frac{1.7}{21.7}$

$= 0.08$

2. M.C. on Dry basis

sample (3). M.C.(wb)= $\frac{\text{Mass of water}}{\text{Mass of sample}}$ X100

$= \frac{1.3}{20.55}$ X100

=6.3%

M.C.(wb) = $\frac{\text{Mass of water}}{\text{Mass of sample}}$

$= \frac{1.3}{20.55}$

= 0.06

Average M.C. (db)=

$$\frac{6.3+8.0+6.3}{3}$$

$$= 6.8\%$$

Average M.C. (db)=

$$\frac{0.06+0.08+0.06}{3}$$

$$= 0.06$$

1.M.C.(wb) = 6.4%

2.M.C.(wb) = 0.06

3.M.C.(db) = 6.8%

4.M.C.(db) = 0.06

Total solid content

- Sometimes, moisture content is also reported as "total solid"
- Total solid is a measure of the amount of material remaining after all the water has been evaporated
- Advantages
  - Cheap, easy to use, many samples can be analyzed simultaneously
- Disadvantages
  - Destructive, time consuming

- Total solids contents of food can be calculated using one of the equations below:

  - % Total solids (wt/wt) = $\frac{\text{wt of dry sample}}{\text{wt of wet sample}} \times 100$

Types of Oven

1. Convection Oven
   - Greatest temperature variations - because hot air slowly circulated with out the aid of fan, air movement is obstructed further by pans placed in the oven

Forced Draft Oven

- The least temperature differential across the interior (< 1°C). Air is circulated by a fan that forces air movement throughout the oven cavity

- Drying period 0.75 – 24 hr, depending on food sample and its pretreatment

VACUUM OVEN

- Drying under reduced pressure (25 – 100mm Hg).
- Able to obtain a more complete removal of water and volatiles without decomposition within a 3 – 6 hr

Microwave Oven

Weighed samples are placed in a microwave oven for a specified time and power-level and their dried mass is weighed.

- In microwave oven, water evaporation is due to absorption of microwave energy, which causes them to become thermally excited.
- Advantage
  - simple
- Disadvantage:
  - Care must be taken to standardize the drying procedure and ensure that the microwave energy is applied evenly across the sample.

INFRARED LAMP DRYING

Principle of drying: Similar to microwave oven

Advantages: rapid and inexpensive

- This is because the IR energy penetrates into the sample

To produce consistent results

- one must control the distanc between the sample and IR lamp
- The dimensions of the samples

Not officially recognized due to difficult in standardization of procedure.

Moisture Analyzer

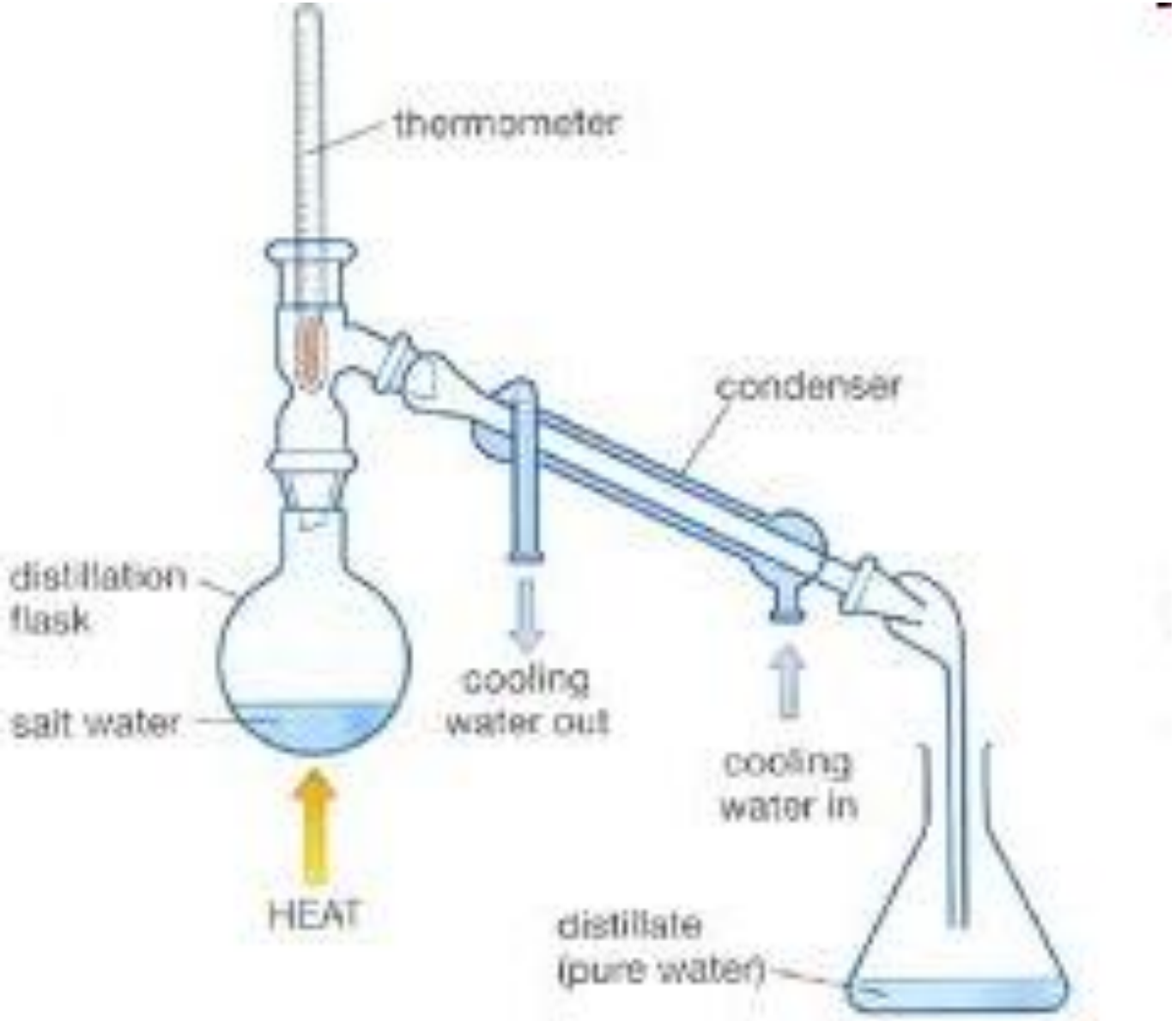
- Using a digital balance, the test sample is placed on an aluminum pan and the constant temperature is applied to the test sample.

- Instrument automatically weighs and calculates the % of moisture or solids

Distillation Methods

- Direct measurement of the amount of water removed from a food sample by evaporation
- Involve co-distilling the moisture in a food sample with a high boiling point solvent that is immiscible in water, collecting the mixture that distills off and then measuring the volume of water

Distillation Methods



- Advantages:
  - Suitable for low moisture foods and foods containing volatile oils such as herbs and spices
  - Cheap, easy to set up and operate
- Disadvantage:
  - Destructive, time consuming, involve flammable solvent, not applicable for some types of foods

Chemical Methods

- Moisture is determined by the reactions between water and certain chemical reagents
- A chemical reagent is added to the food that reacts specifically with water to produce a measurable change in the properties of the system, *e.g.,* mass, volume, pressure, pH, color, conductivity.
- Type of chemical method commonly used:
  - Karl Fischer Titration
  - Gas production Methods

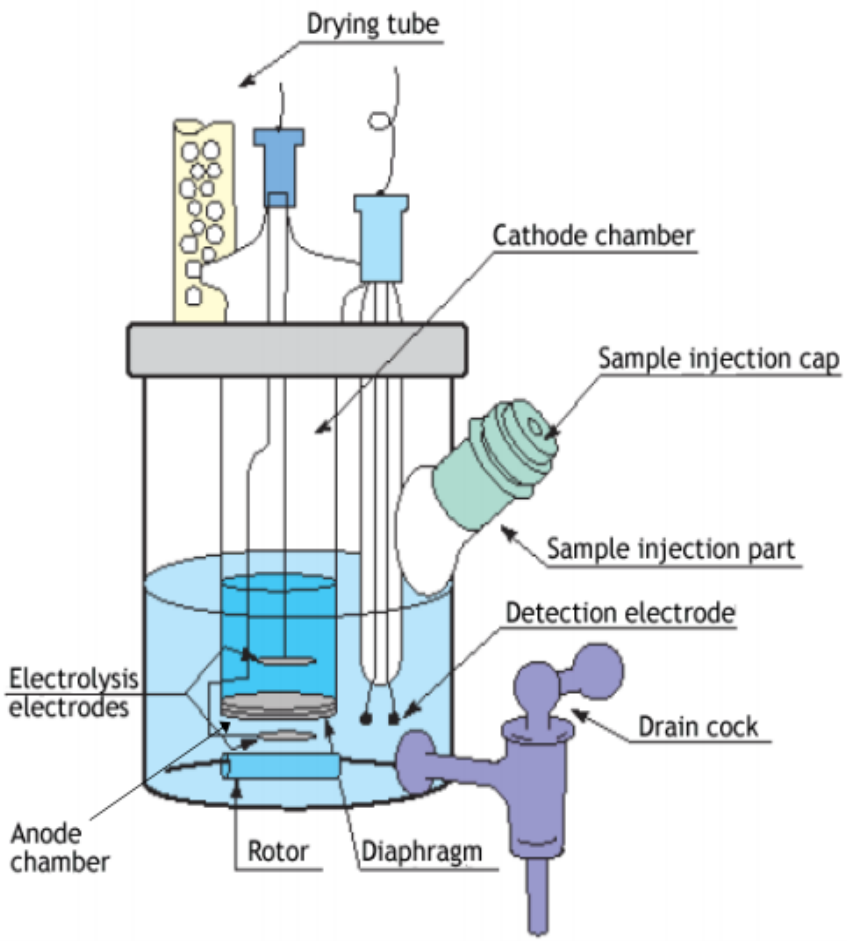
KARL-FISCHER TITRATION

- Determine the low moisture foods (*e.g.* dried fruits and vegetables, confectionary, coffee, oils and fats) or low moisture food high in sugar or protein.

- It is based on the following reaction:

$$2H_2O + SO_2 + I_2 \rightarrow H_2SO_4 + 2HI$$

KARL-FISCHER TITRATION



- Water and iodine are consumed in a 1:1 mole ratio in the KF reaction
- Once the reaction consumes all of the water present, the presence of excess iodine is detected by the indicator electrode
- Percent water is calculated based on the $[I_2]$ in the Karl Fischer titrating reagent (i.e. titer) an the amount of KF reagent consumed

Gas Production Methods

- Commercial instruments are also available that utilize specific reactions between chemical reagents and water that lead to the production of a gas

Gas Production Methods

- When a food sample is mixed with powdered calcium carbide, the amount of acetylene gas produced is related to the moisture content.

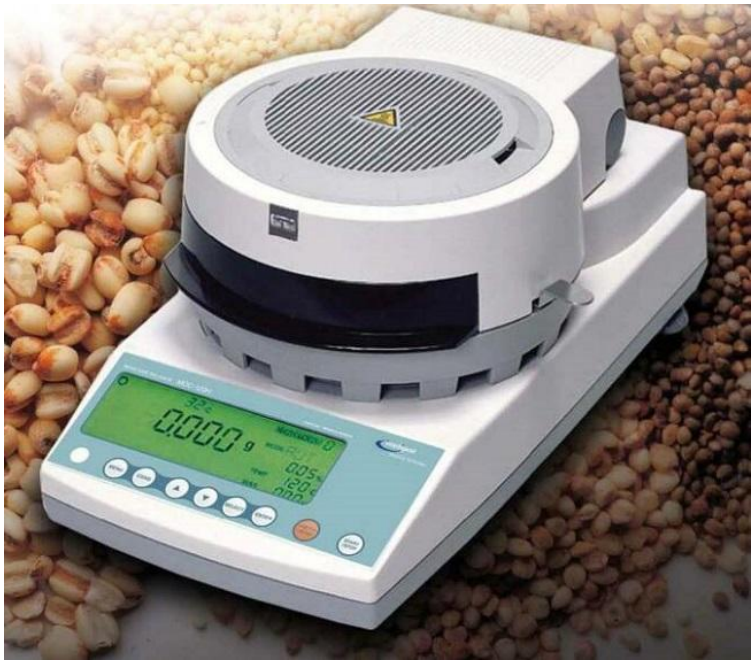
$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$$

- The amount of gas produced can be measured by
  1. The volume of the gas produced
  2. The decrease in the mass of the sample after the gas is released
  3. The increase in pressure of a closed vessel containing the reactants

Physical Methods

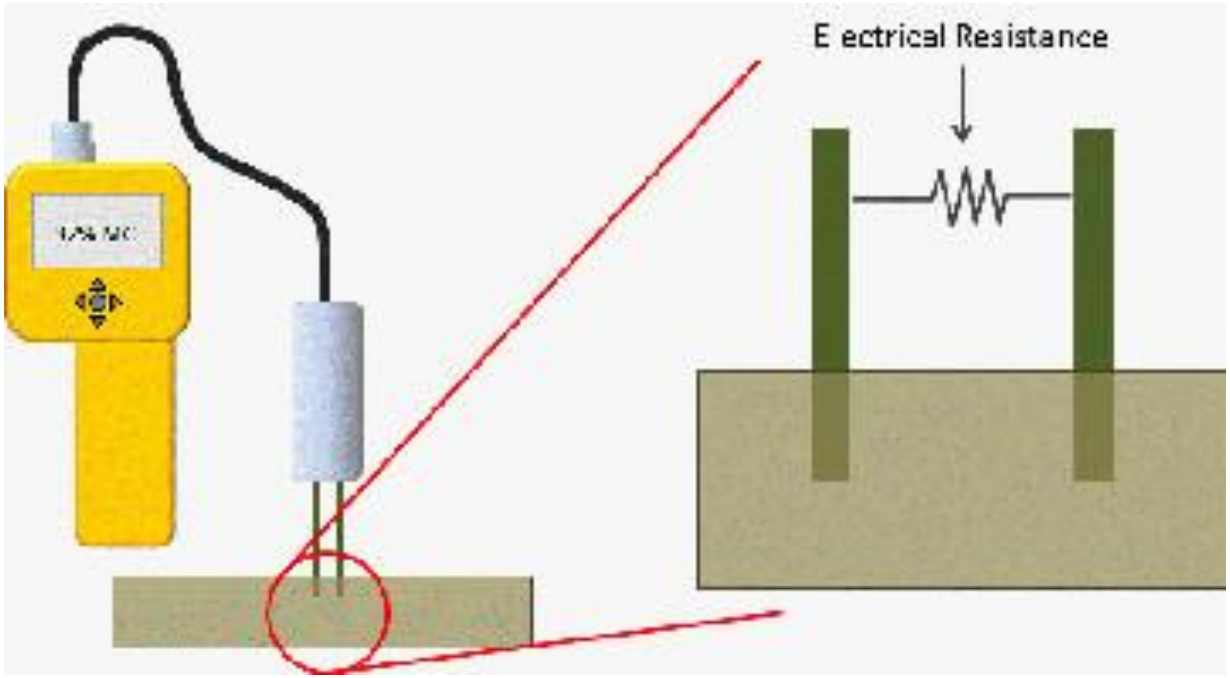
Dielectric Method

- Property: the ability of a substance to store electrical energy
- Moisture is determined by measuring the change in capacitance or resistance to an electric current passed through the sample
- Limited to food contains not more than 30-35% moisture.



Conductivity method

- The conductivity of an electric current increases with the percentage of moisture sample
- Must keep the temperature constant



Hydrometry

- Measuring specific gravity or density
- Best applied to the analysis of solutions consisting of only one component in a medium of water
- Commonly used in beverages, salt brines and sugar solutions
- Example: Pycnometer, hydrometer,

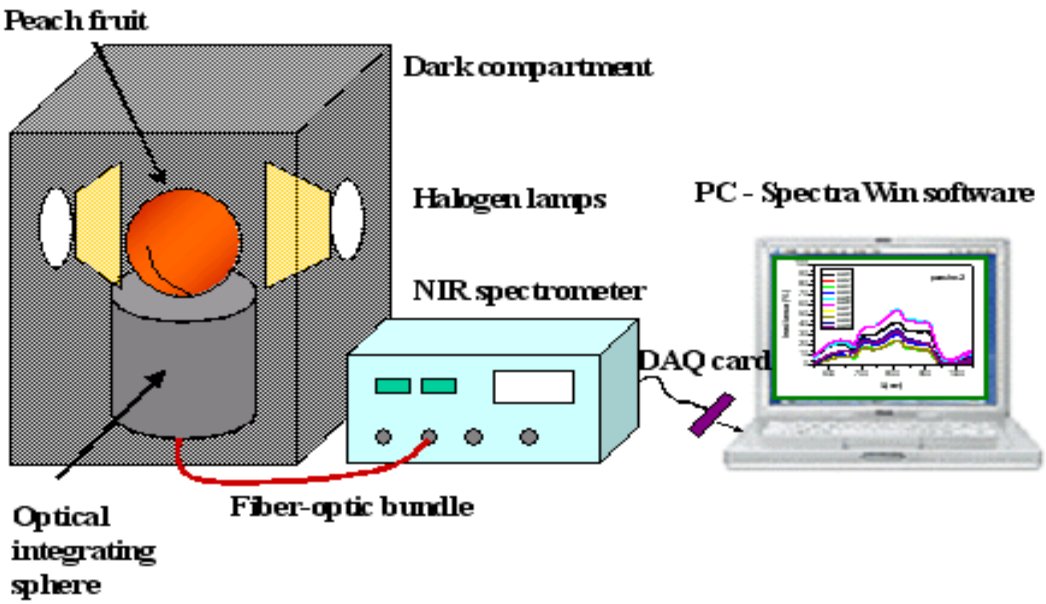
Refractometry

- Determine the soluble solids in fruits and fruit products
- Rapid and accurate methods
- Principle: when a beam of light is passed from one medium to another and the density differs, then the beam is bent or refracted.

Infrared Analysis

Principle:

- Measure absorption of radiation by molecules in foods
- Different functional groups absorb different frequencies of infrared radiation
- For water, near-infrared (NIR) bands (1400-1450, 1920-1950 nm) are characteristic of the –OH stretch of water molecule



Comparison of the Methods

- Oven drying methods: involve the removal of moisture from the sample and then a weight determination of the solids remaining.
- Distillation methods: Involve a separation of the moisture from the solids. The moisture content is calculated directly by volume.
- Chemical Methods: reflected as the amount of titrant used.

Comparison of the Methods

- Dielectric and conductivity methods: electrical properties of water
- Hydrometric methods: based on the relationship between specific gravity and moisture content
- Refractive Index: how water in a sample affects the refraction of light