
بسم الله الرحمن الرحيم
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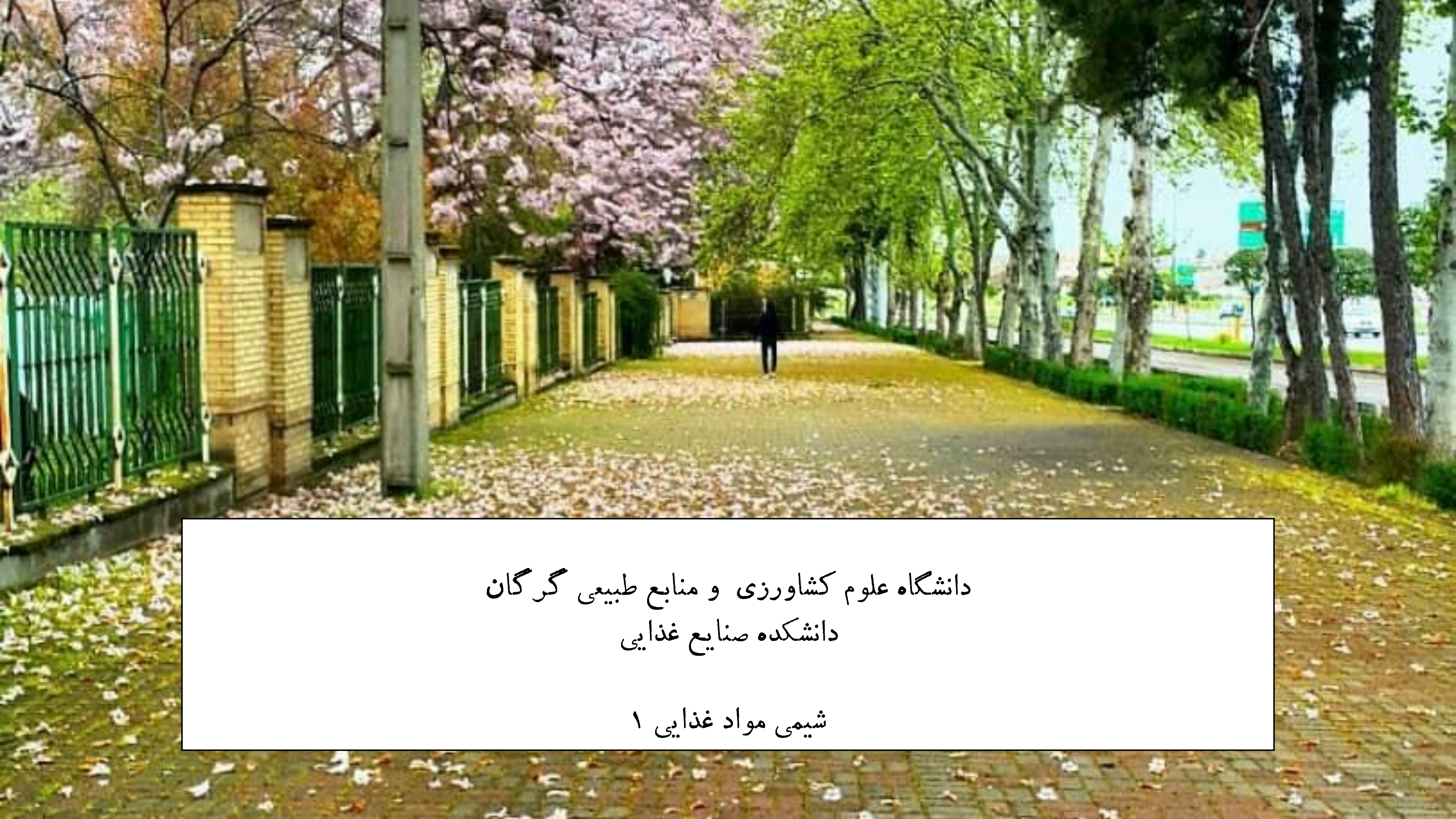
Bismillah al rahman al rahim



دانشگاه علوم کشاورزی و منابع طبیعی گرگان

دانشکده صنایع غذایی

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Ice Formation

- When water freezes, it expands nearly 9%.
- It means that volume of ice is higher than the volume of water at the same weight.
- D = M / V (D: density, M: mass; V: Volume)
- The density of ice is lower than the density of water at the same weight.
- Rearrangement of hydrogen bonds and the large spaces in the ice molecule could be considered as a results of the increase in volume.

The effect of freezing on food quality

The main effect is mechanical damage of cell wall.

According to this damage, some other problems may arise from food to food.

- Destabilization of emulsions
- Increase in toughness of fish flesh
- Loss of textural integrity
- Softening in vegetable tissues
- Increase in drip loss in meat

Water Activity and Relative Vapor Pressure

- It has long been recognized that a relationship, although imperfect, exists between the water content of food and its perishability.
- Concentration and dehydration processes are conducted primarily for the purpose of decreasing the water content of a food, simultaneously increasing the concentration of solutes and thereby decreasing perishability.
- However, it has also been observed that various types of food with the same water content differ significantly in perishability.

- Peanut oil, 0.6%, slowly spoiling
- White sugar, 2.0%, unstable
- Potato starch, 20%, stable



- Thus, water content alone is not a reliable indicator of perishability.
- This situation is attributable, in part, to differences in the intensity with which water associates with nonaqueous constituents—water engaged in strong associations is less able to support degradative activities, such as growth of microorganisms and hydrolytic chemical reactions, than is weakly associated water.

- The term “water activity” (aw) was developed to account for the intensity with which water associates with various nonaqueous constituents.

  Food stability, safety, and other properties can be predicted far more reliably from aw than from water content.

Definition and Measurement

The notion of substance “activity” was rigorously derived from the **laws of equilibrium thermodynamics** by G. N. Lewis, and its application to foods was pioneered by Scott.

It is sufficient here to state that $$aw = f/f0$$

f is the fugacity of the solvent (fugacity being the escaping tendency of a solvent from solution)
$f0$ is the fugacity of the pure solvent

At low pressures (e.g., ambient), the difference between $f/f0$ and p/p0 is less than 1%, so defining aw in terms of p/p0 is clearly justifiable

$$aw = p/p0$$

This equality is based on the assumptions of solution ideality and the existence of thermodynamic equilibrium

With foods, both assumptions are generally violated. Consequently, Equation must be taken as an approximation and the proper expression is

$$aw \sim p/p0$$

Because p/p0 is the measured term and sometimes does not equal aw, it is more accurate to use the term p/p0 rather than aw.

Relative vapor pressure” (RVP)

RVP is related to percent equilibrium relative humidity (ERH) of the product environment as follows:

$$RVP = p/p0 = \%ERH/100$$

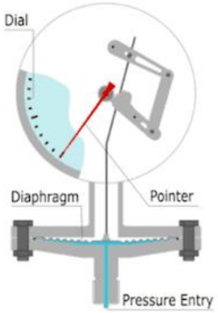
RVP is an intrinsic property of the sample whereas ERH is a property of the atmosphere in equilibrium with the sample

The Equation relationship is an equality only if equilibrium has been established between the product and its environment

- Water availability
- $a_W = P/P_o \quad (0 \leq a_W \leq 1)$
- $a_W = \%ERH/100$ (Equilibrium Relative Humidity)

The RVP of a small sample can be determined by placing it in a closed chamber for a time sufficient to achieve apparent equilibrium (constant weight) and then measuring either pressure or relative humidity in the chamber.

Various types of instruments are available for measuring pressure (manometers) and relative humidity (electric hygrometers, dew-point instruments).



Measurement :

Gravimetric method

Hygrometric and manometric methods

If one desires to adjust a small sample to a specific RVP, this can be done by placing it in closed chamber at constant temperature, maintaining sample atmosphere at constant relative humidity by means of an appropriate saturated salt solution, and storing it until constant sample weight is achieved.

Glycerol solutions and sulphuric acid–water mixtures for control of relative humidity at 25 °C.

Relative humidity	Glycerol (wt. %)	Sulphuric acid (wt. %)
90	34.90	18.5
75	58.61	30.4
65	69.05	36.0
50	80.65	43.4
40	86.30	—
25	—	55.9
10	—	64.8

Salt	ERH
K_2SO_4	0.97
KNO_3	0.94
$NH_4H_2PO_4$	0.93
$KHSO_4$	0.86
$CdCl_2$	0.82
NaCl	0.76
$NaNO_2$	0.66
$Mg(NO_3)_2$	0.54
KCNS	0.47
$MgCl_2$	0.33
CH_3CO_2K	0.20
LiCl	0.12

- **Temperature dependence**

Water activity (a_w)

- It is defined as the ratio of the water vapor pressure of food (P) to that of vapor pressure of pure water (Po) at the same temperature.

$$a_w = \frac{p}{p_o}$$

a_w: water activity
P: partial pressur eof water in a food
P_o: vapor pressure of water at the same temperature

- Water activity ranges from zero (water absent) to 1.0 (pure water).
- Free water is responsible for water activity of any food items.
- Water activity is a measure of how efficiently (the amount of water and the degree of its availability) the water present can take part in a chemical reaction, microbiological growth, and enzyme activity.

Water activity and foods

As the moisture content increases, perishability increases

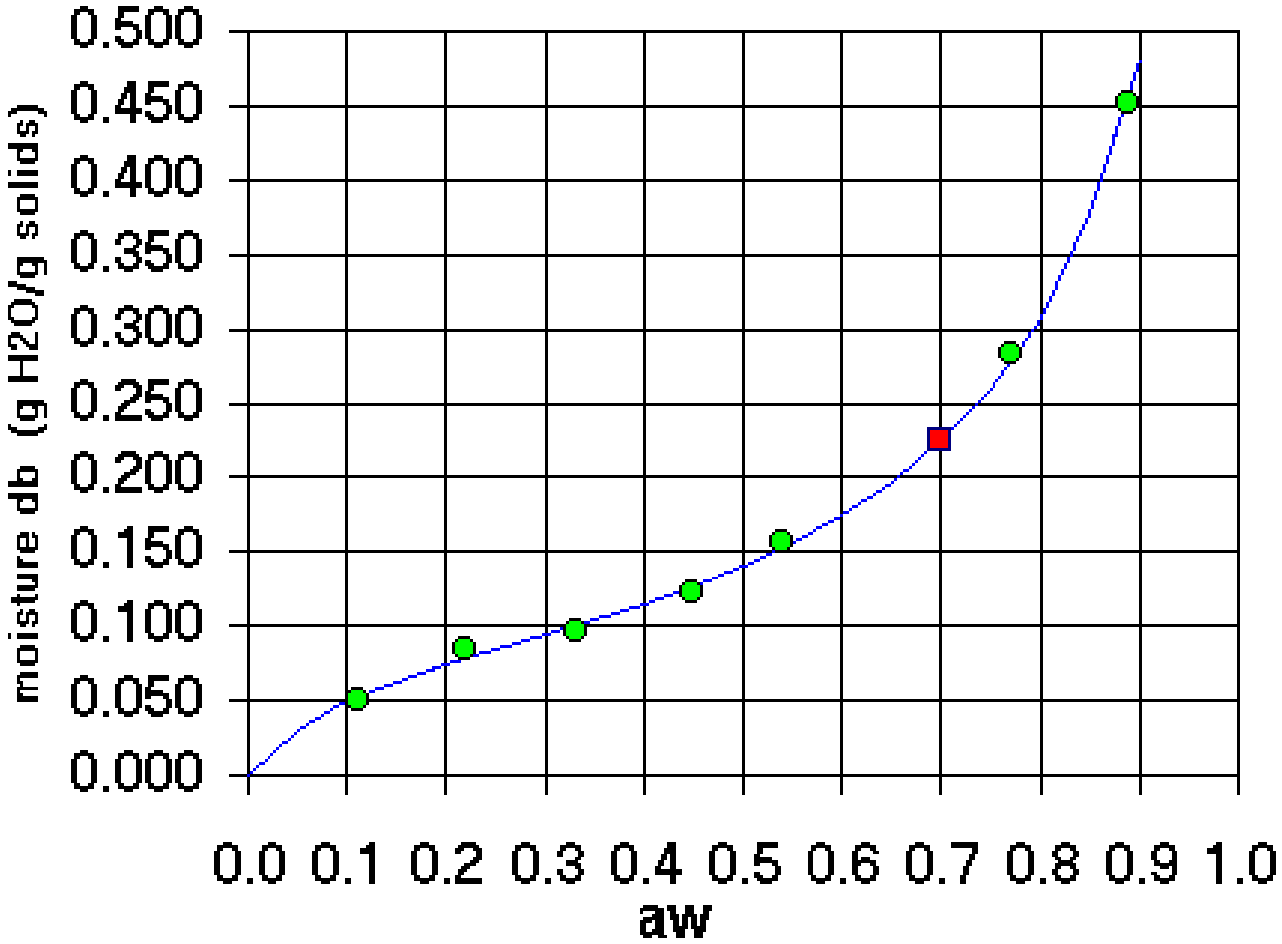
a_w values	Definition of food	Examples
>0.85	Moist foods **(moisture content is >50%)**	Cheese (a_w: 0.90-0.95) Fresh fruits, meat, milk (a_w: 0.95)
0.6-0.85	Intermediate moisture foods **(moisture content is 10-50%)**	Honey (a_w: 0.6-0.65) Jam (a_w: 0.75-0.80) Flour, rice (a_w: 0.80)
<0.6	Low moisture foods **(moisture content is <10%)**	Pasta (a_w: 0.5) Dried vegetables (a_w: 0.3) Crackers, cookies (a_w: 0.2-0.3)

MOISTURE SORPTION ISOTHERM (MSI)

- Definition and zones
- Temperature dependence
- Hysteresis

MOISTURE SORPTION ISOTHERM (MSI)

A plot of water content (expressed as mass of water per unit mass of dry material) of a food versus p/p0 at constant temperature is known as a moisture sorption isotherm (MSI).

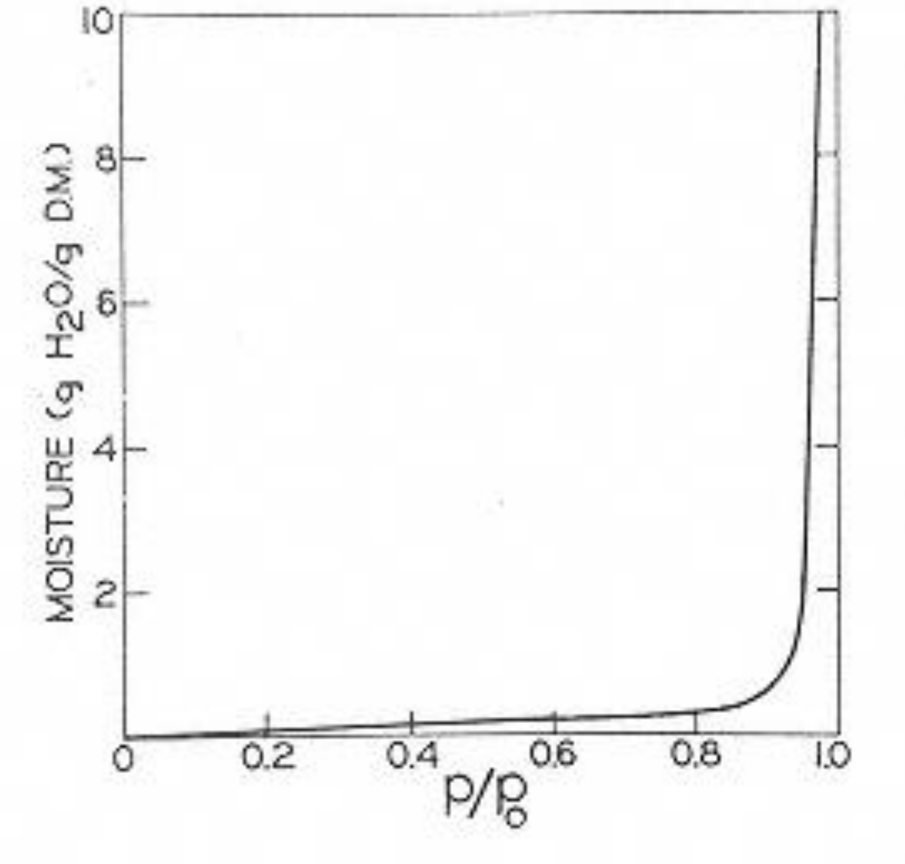


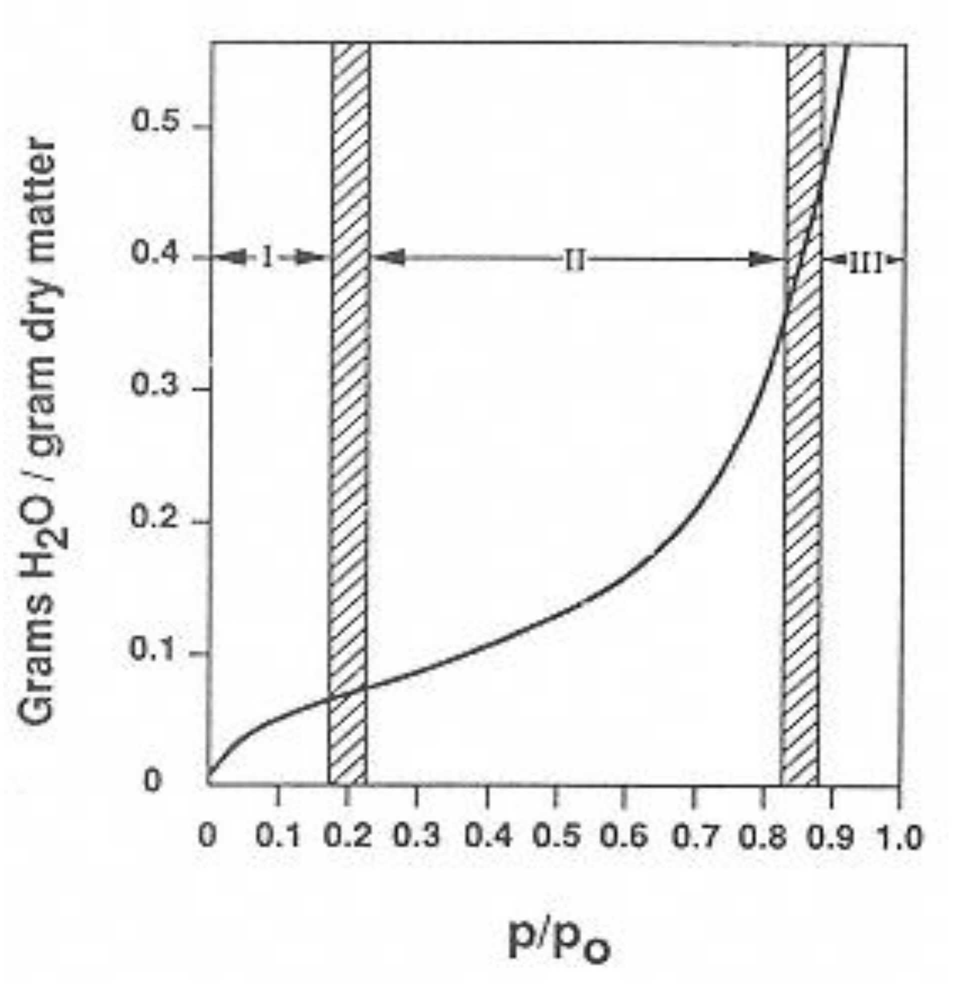
Information derived from MSIs are useful for:

- Concentration and dehydration processes, because the ease or difficulty of water removal is related to RVP
- Formulating food mixtures so as to avoid moisture transfer among the ingredients
- To determine the moisture barrier properties needed in a packaging material,
- To determine what moisture content will curtail growth of microorganisms of interest,
- To predict the chemical and physical stability of food as a function of water content

MOISTURE SORPTION ISOTHERM (MSI)

MSI for a high-moisture food





The shape and position of the isotherm are determined by several factors including sample composition, physical structure of the sample (e.g., crystalline or amorphous), sample pretreatments, temperature, and methodology.

- **The effect of composition on MSI**

  - A type: Hygroscopics
  - B type: Sigmoid-shaped (characteristic of most foods)
  - C type: J-type

  Foods such as fruits, confections, and coffee extract that contain large amounts of sugar and other small, soluble molecules and are not rich in polymeric materials exhibit a J-type isotherm.