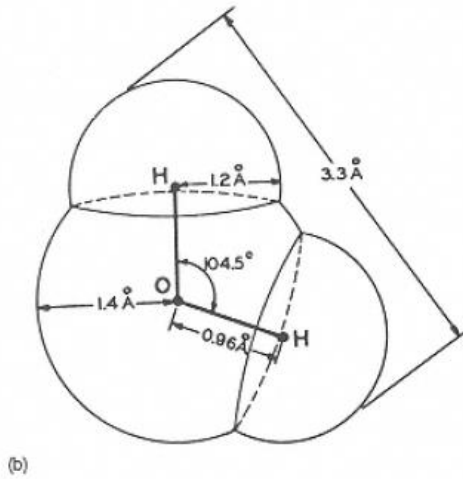
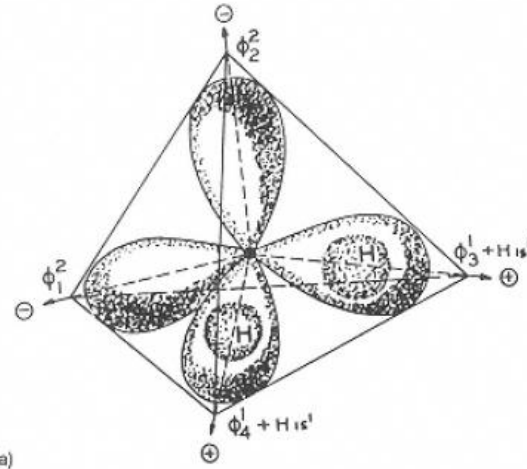


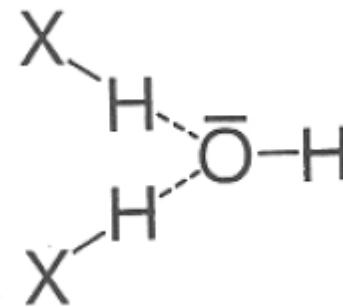
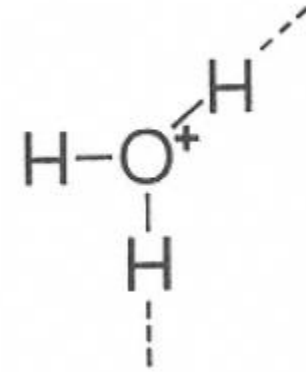
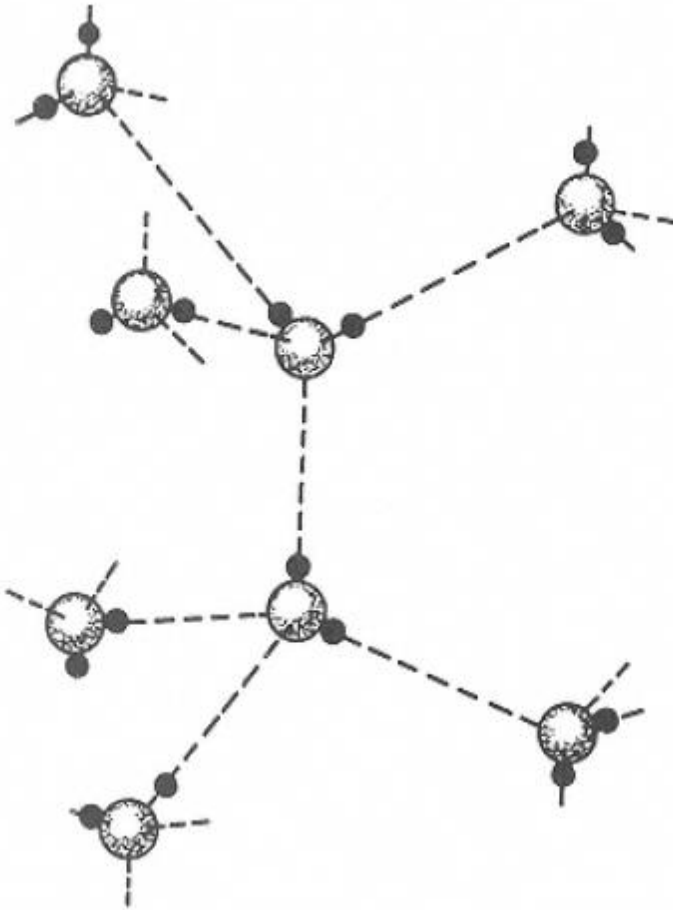
# Νερό

Food	Water content (%)
<b>Meat</b>	
Pork, raw, composite of lean cuts	53–60
Beef, raw, retail cuts	50–70
Chicken, all classes, raw meat without skin	74
Fish, muscle proteins	65–81
<b>Fruit</b>	
Berries, cherries, pears	80–85
Apples, peaches, oranges, grapefruit	90–90
Rhubarb, strawberries, tomatos	90–95
<b>Vegetables</b>	
Avocado, bananas, peas (green)	74–80
Beets, broccoli, carrots, potatoes	85–90
Asparagus, beans (green), cabbage, cauliflower, lettuce	90–95

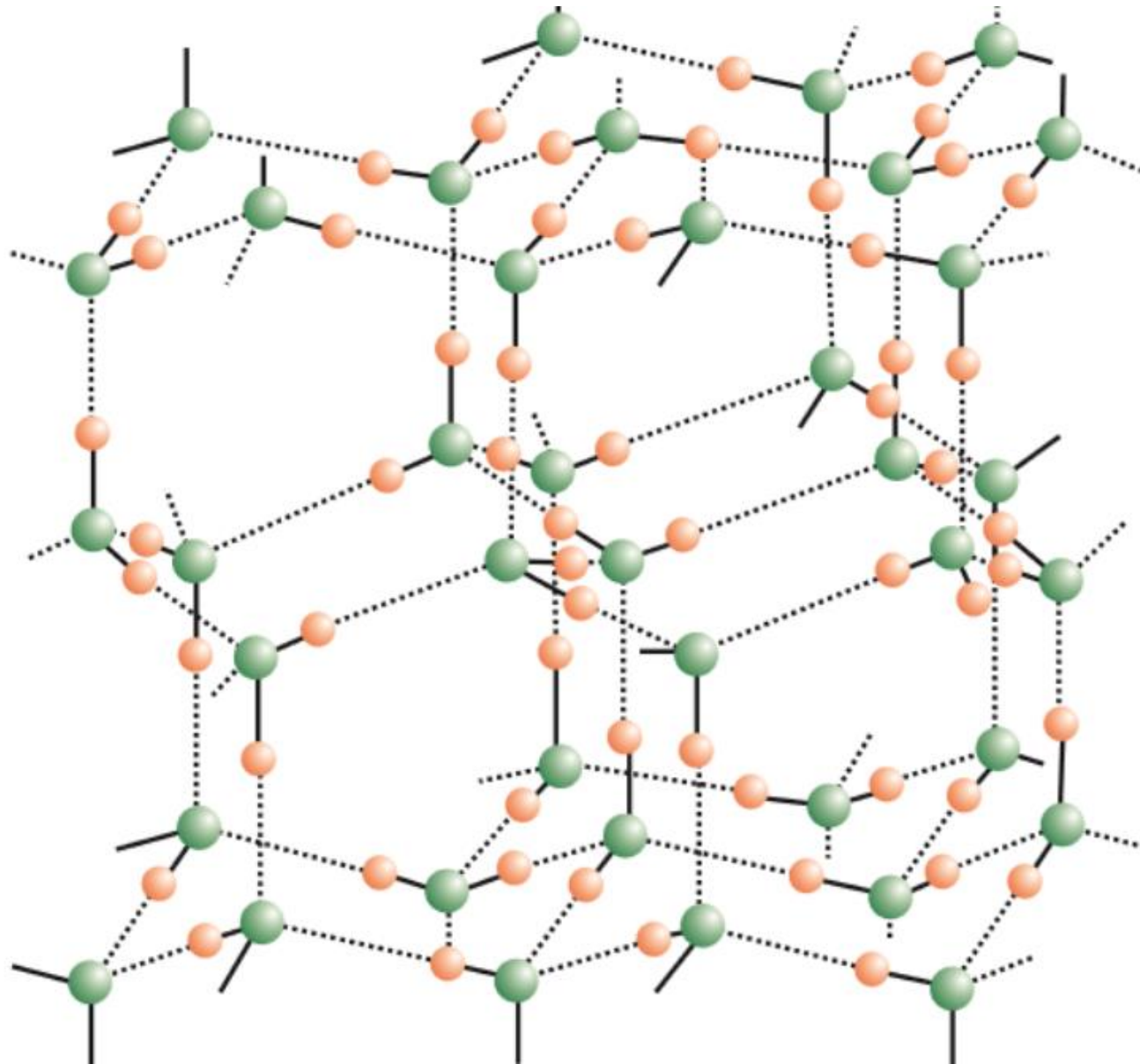
# Νερό



# Νερό: δεσμοί υδρογόνου



# Δομή του πάγου



# Αλληλεπιδράσεις του νερού

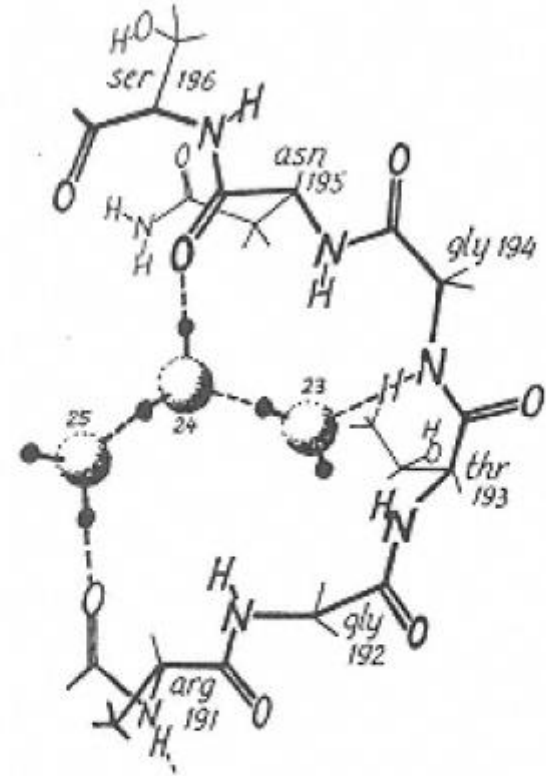
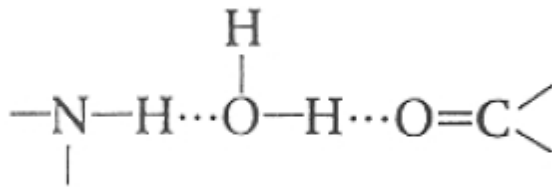
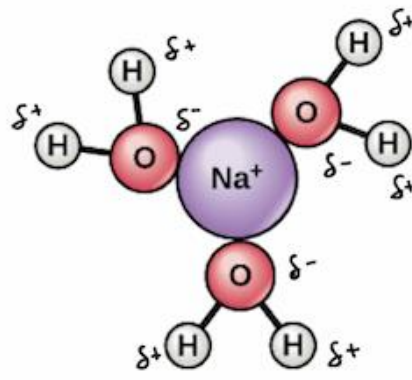
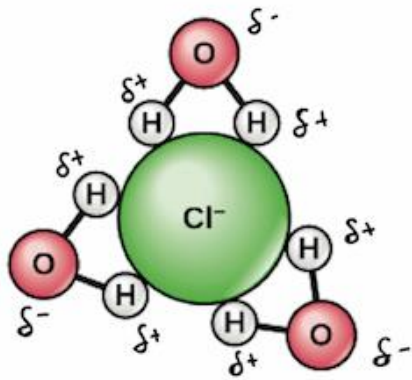


FIGURE 9

Examples of a three-molecule water bridge in papain; 23, 24, and 25 are water molecules.

(From Ref. 4.)

# Νερό και άπολες αλληλεπιδράσεις

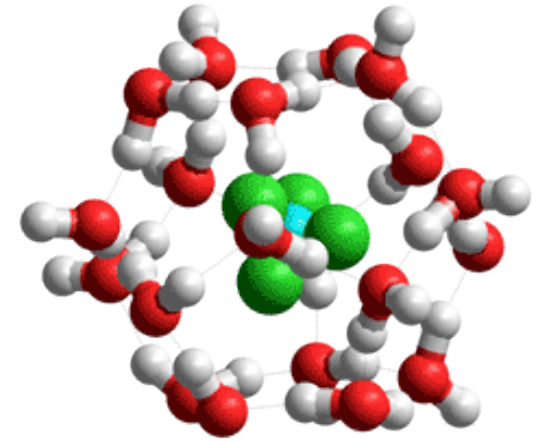
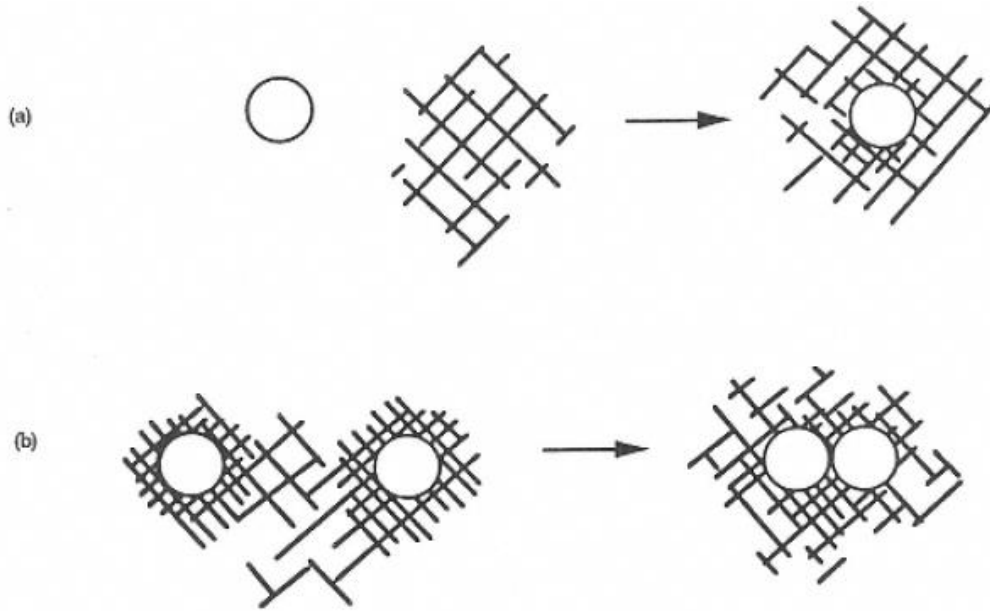
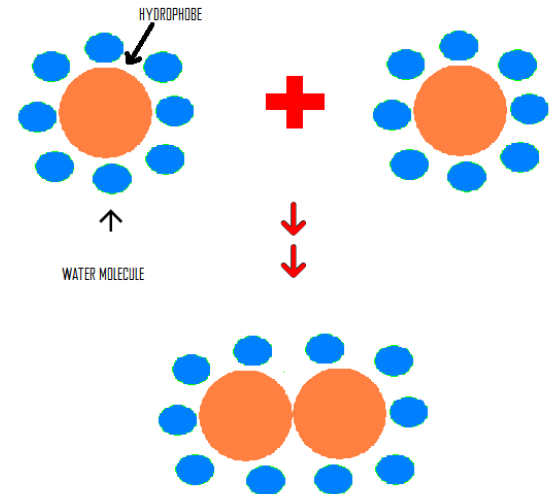


FIGURE 10  
Schematic depiction of (a) hydrophobic hydration and (b) hydrophobic association. Open circles are hydrophobic groups. Hatched areas are water. (Adapted from Ref. 28.)



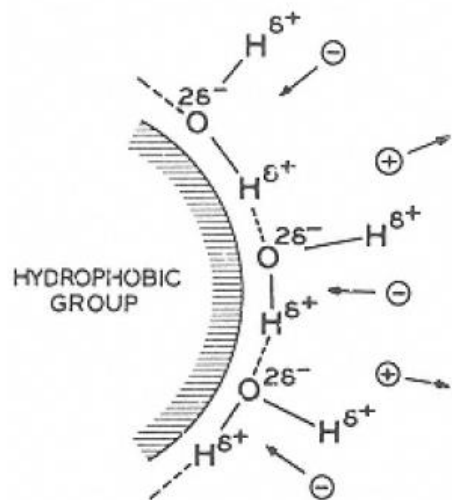


FIGURE 11  
Proposed water orientation at a hydrophobic surface. (Adapted from Ref. 68.)

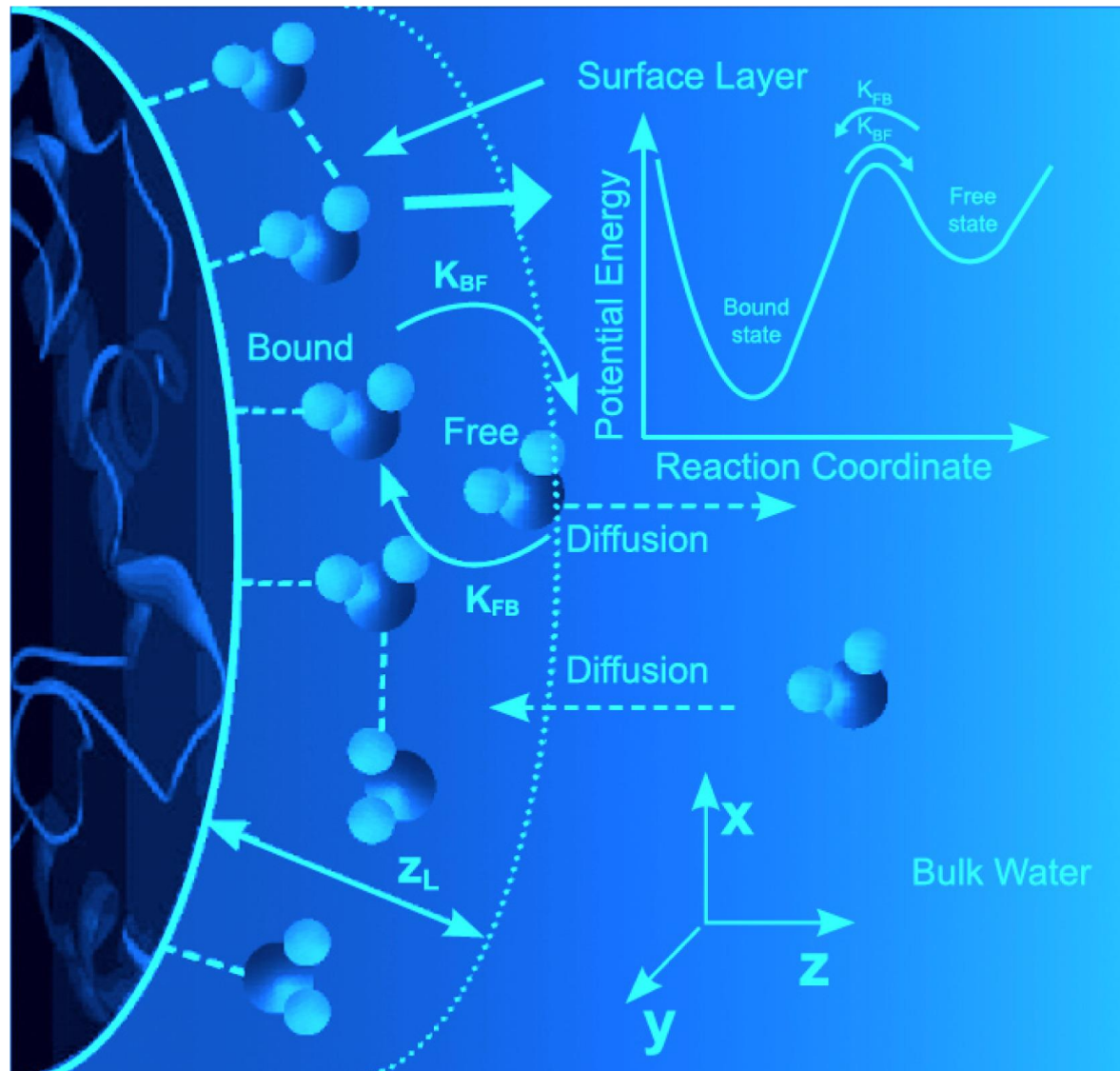
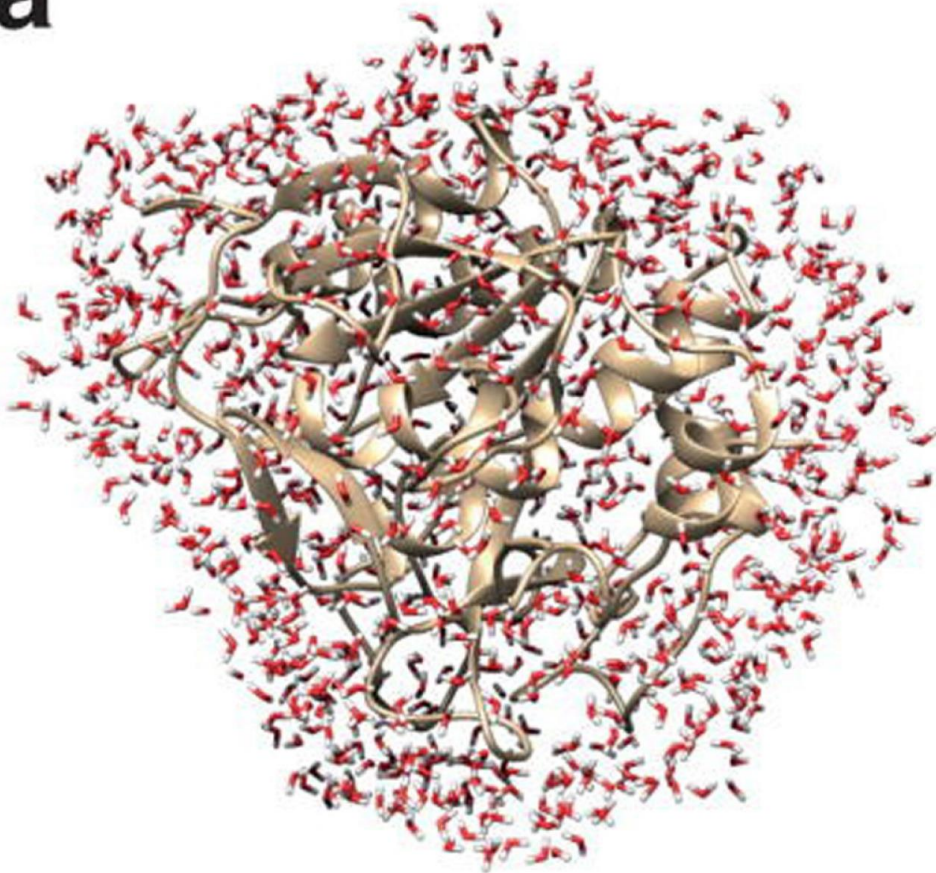


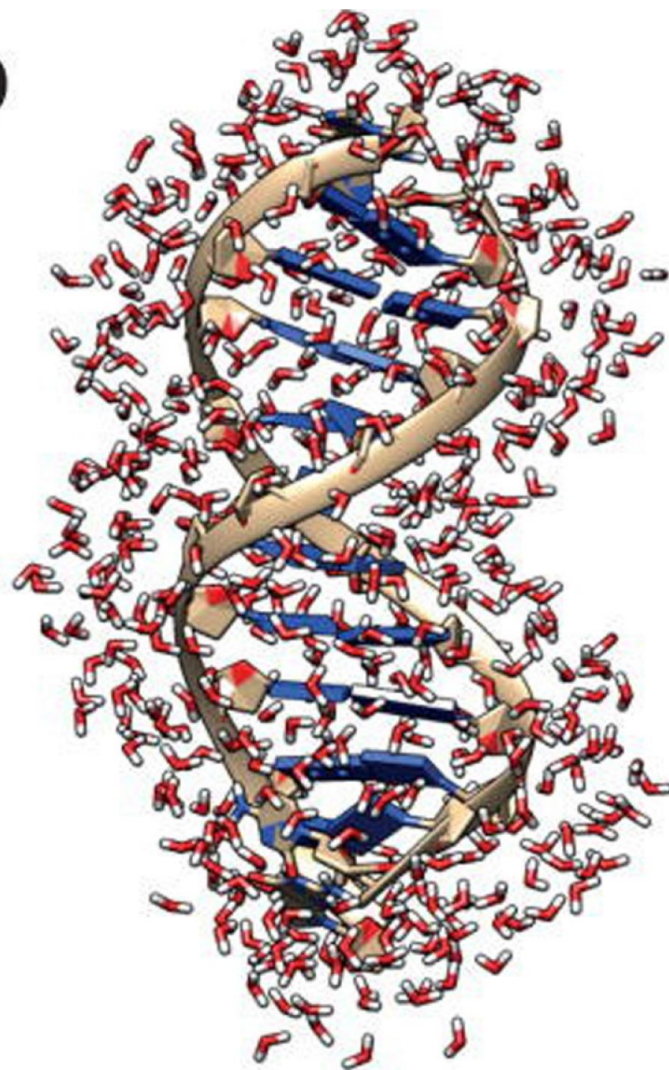
Fig. 5. Schematic representation of the dynamic exchange model describing dynamical equilibrium happening among different types of water molecules surrounding a biomolecule and the corresponding energetic transitions .

Adapted with permission from J. Phys. Chem. B, 107 (2003), 13218–13228. Copyright © 2003 American Chemical Society [61].

**a**

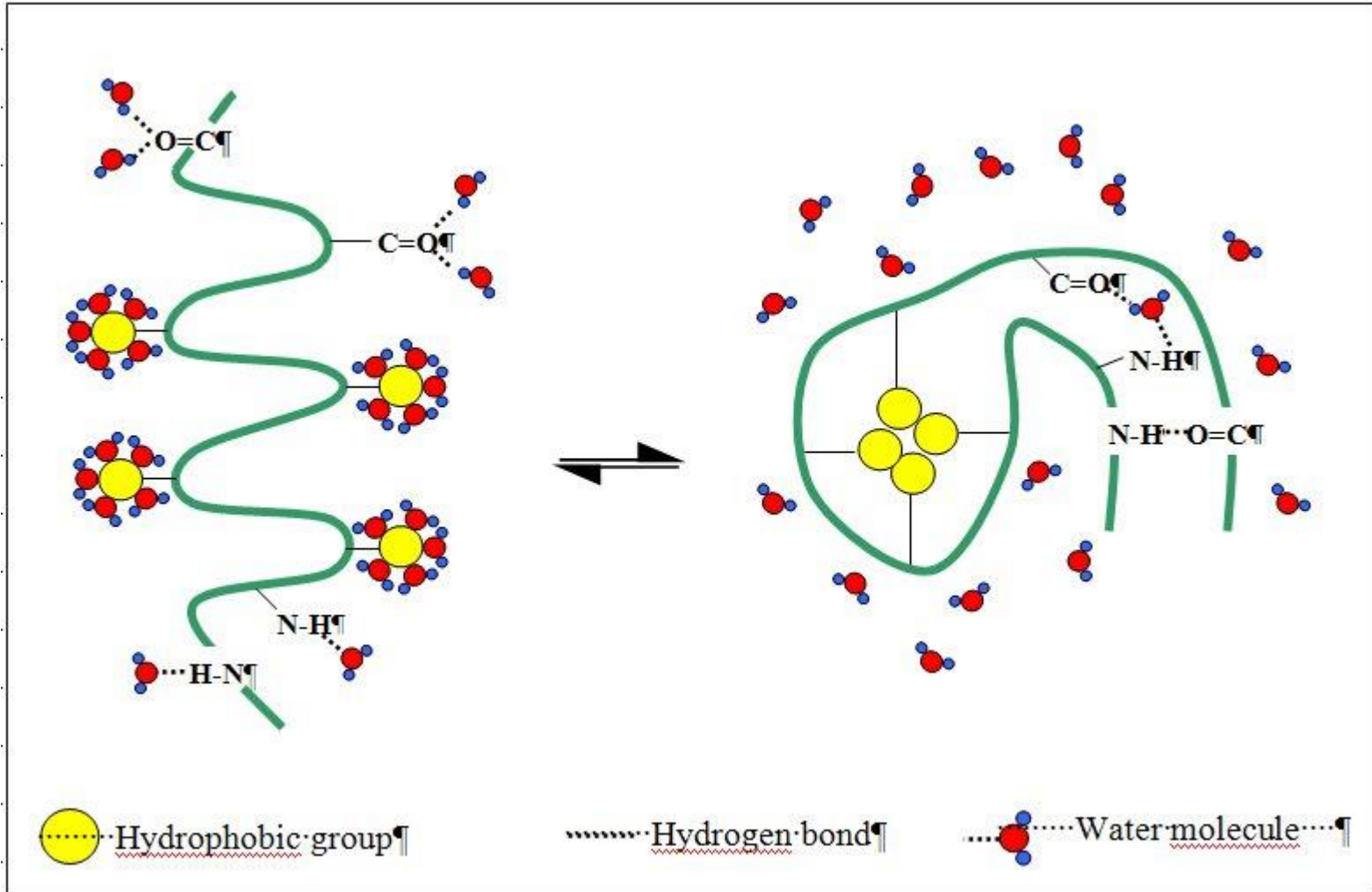


**b**



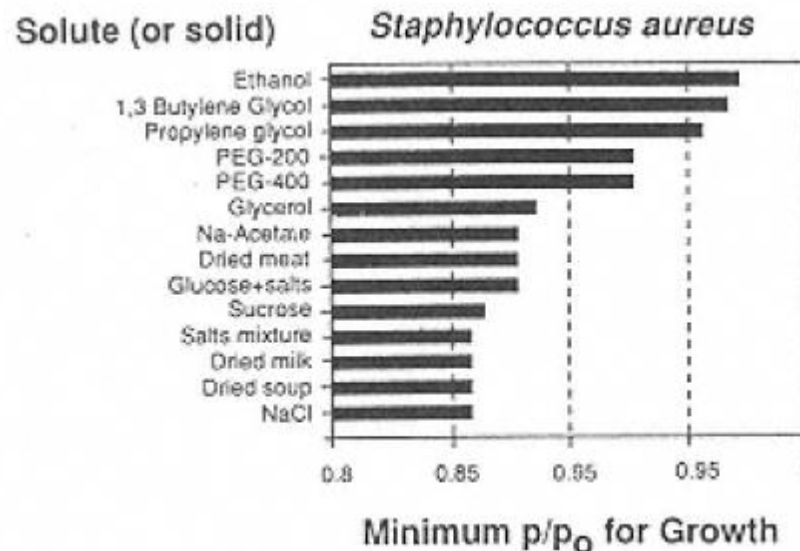


# Υδρόφοβη αλληλεπίδραση



# Ενεργότητα νερού

- Συσχέτιση νερού-ευπάθειας τροφίμων σε αλλοιώσεις (ανάπτυξη μικροοργανισμών – υδρολυτικές αντιδράσεις)
- % νερό όχι αποτελεσματικός δείκτης
- Νερό ισχυρά δεσμευμένο δεν είναι διαθέσιμο ως διαλύτης για την προώθηση διαδικασιών αλλοίωσης
- Ενεργότητα νερού: δείκτης της ισχύος δέσμευσης νερού από τα συστατικά του τροφίμου



# Ενεργότητα νερού

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

where

$a_w$  = water activity

$p$  = partial pressure of water in a food

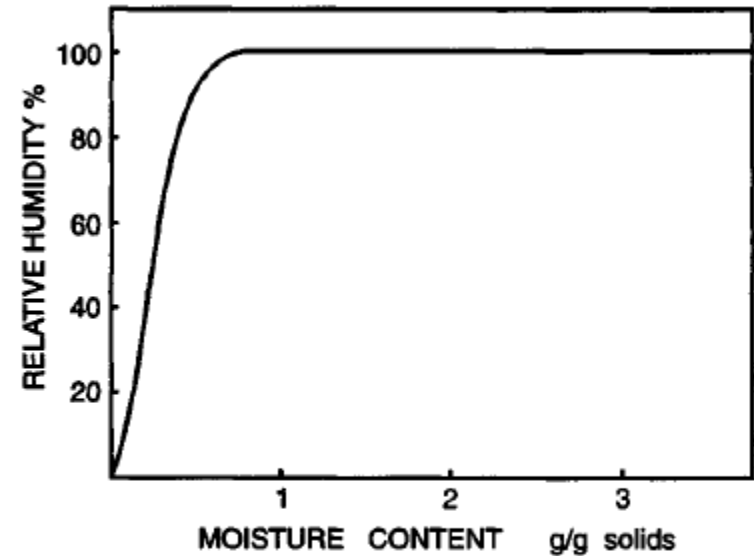
$p_o$  = vapor pressure of water at the same temperature

## Σχετική υγρασία

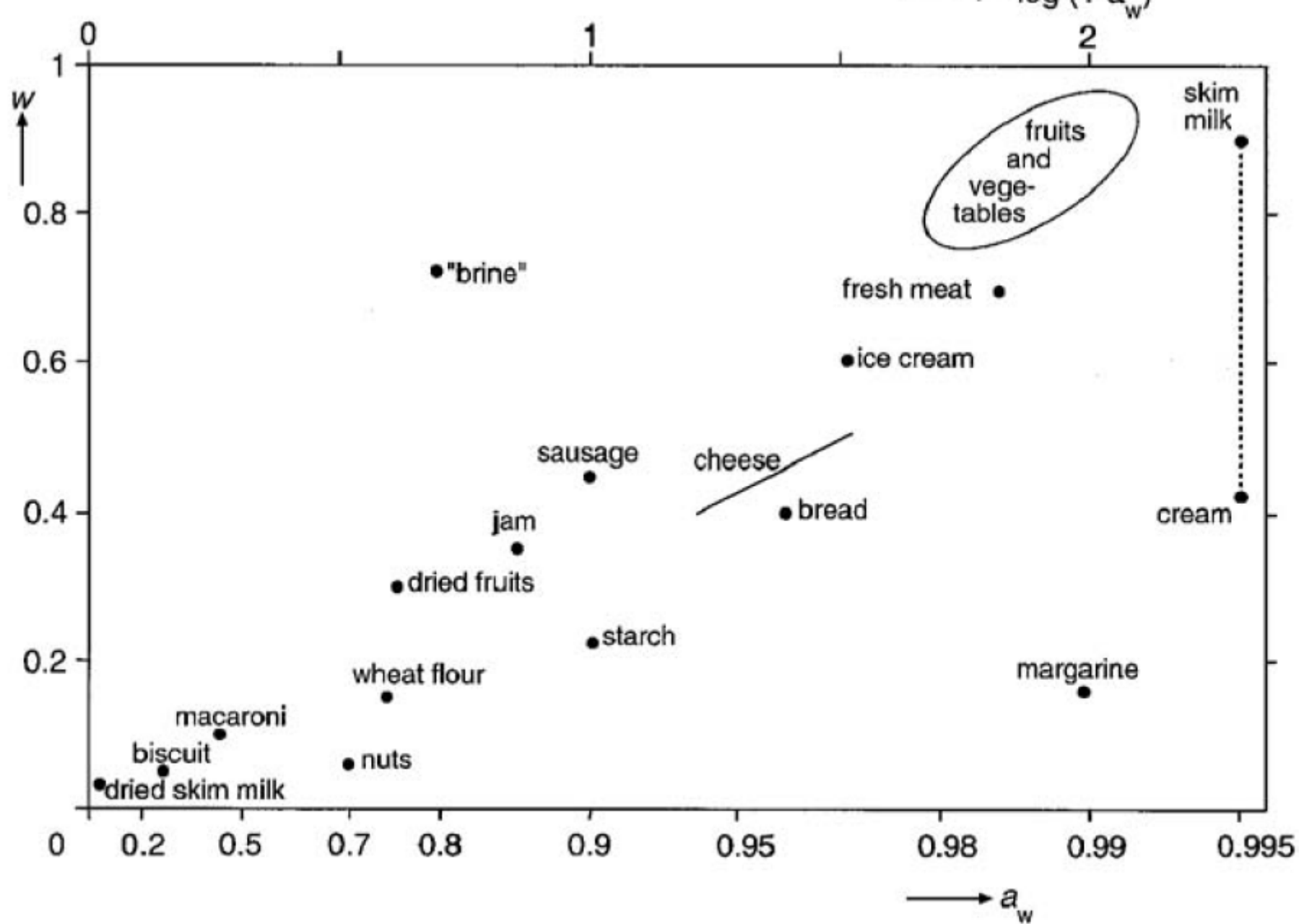
$$ERH = \frac{p^{equ}}{p^{sat}}$$

$p^{equ}$  = partial pressure of water vapor in equilibrium with the food at temperature T and 1 atmosphere total pressure

$p^{sat}$  = the saturation partial pressure of water in air at the same temperature and pressure

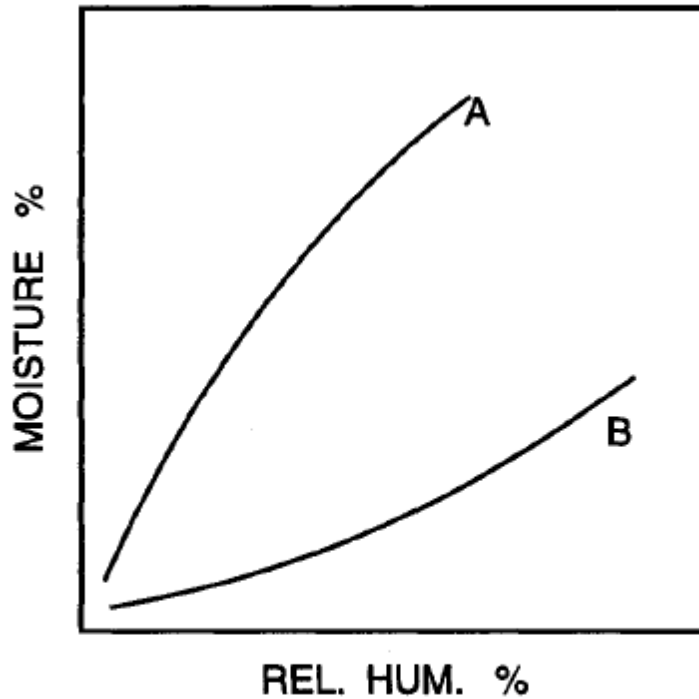


**Figure 1-6** Water Activity in Foods at Different Moisture Contents

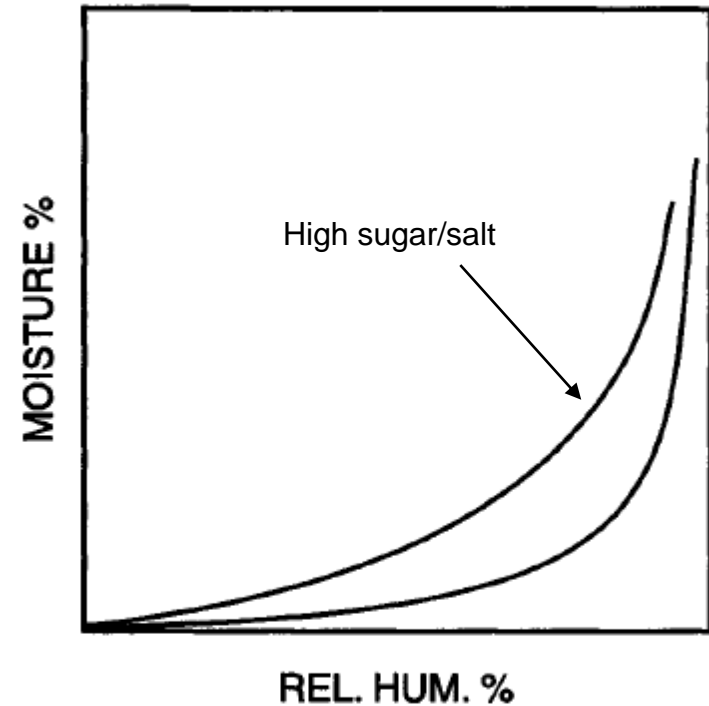


**FIGURE 8.2** Approximate water activity ( $a_w$ ) of some foods versus mass fraction of water ( $w$ )

# Νερό

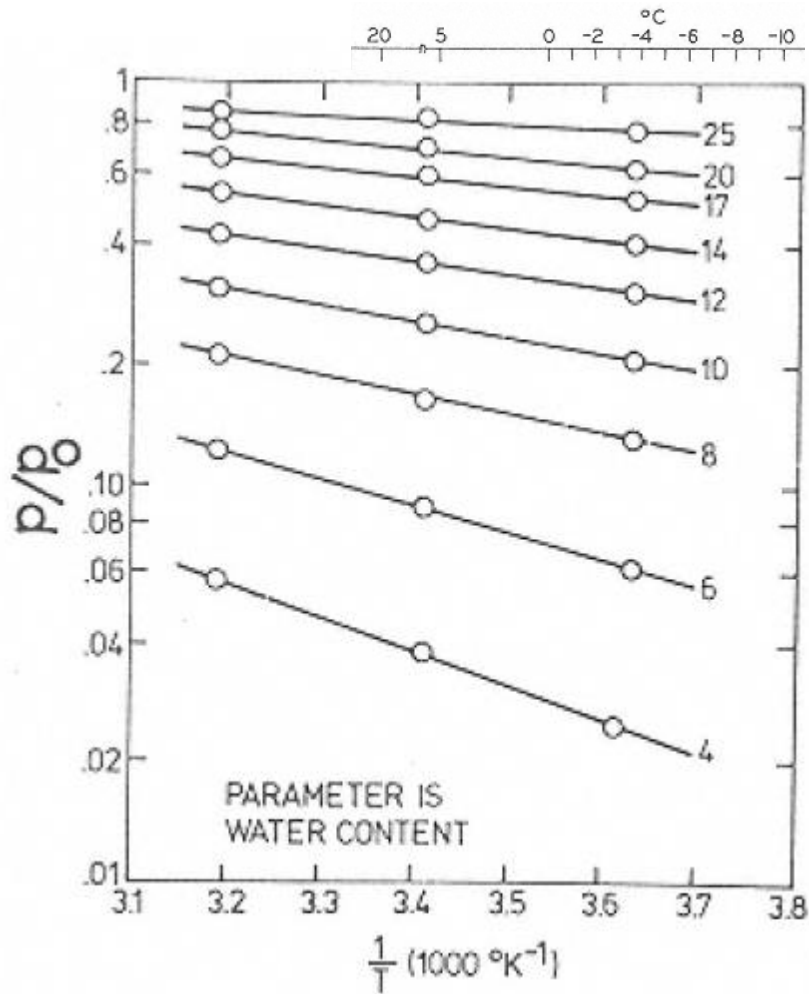


**Figure 1-8** Sorption Isotherms of Hygroscopic Product (A) and Nonhygroscopic Product (B)



**Figure 1-9** Sorption Isotherms for Foods with High Sugar or Salt Content; Low Capillary Adsorption

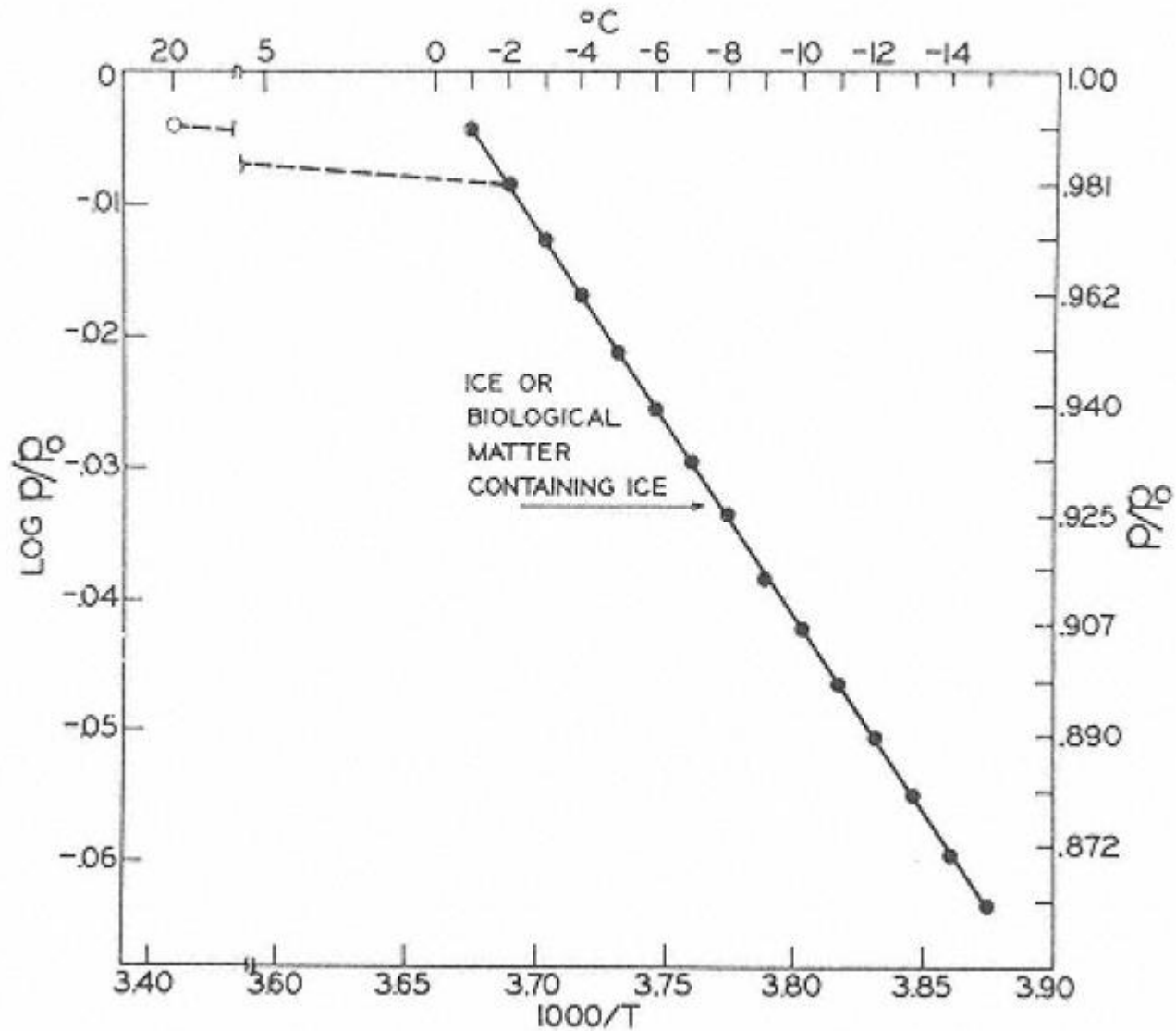
# Νερό



$$\frac{d \ln a_w}{d(1/T)} = \frac{-\Delta H}{R}$$

Άμυλο πατάτας

# Κατεψυγμένες τροφές



# Νερό

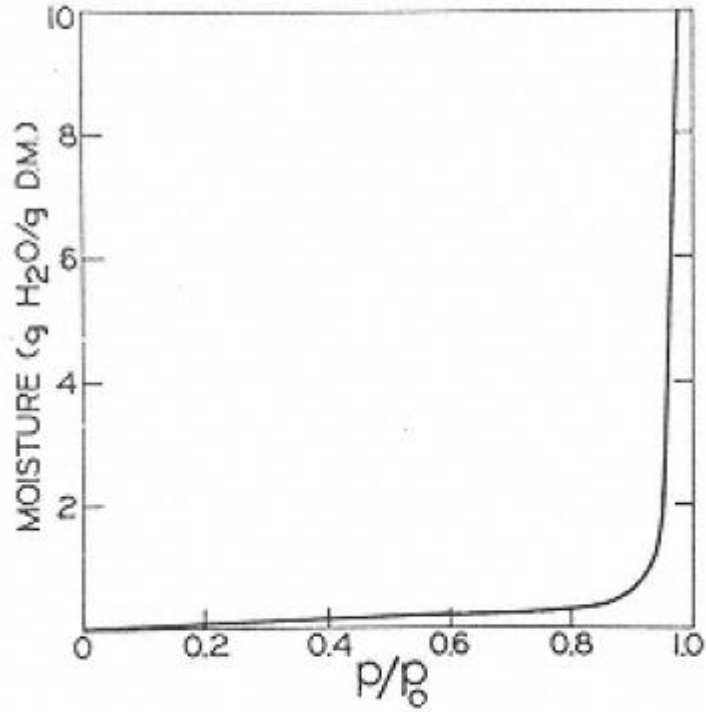
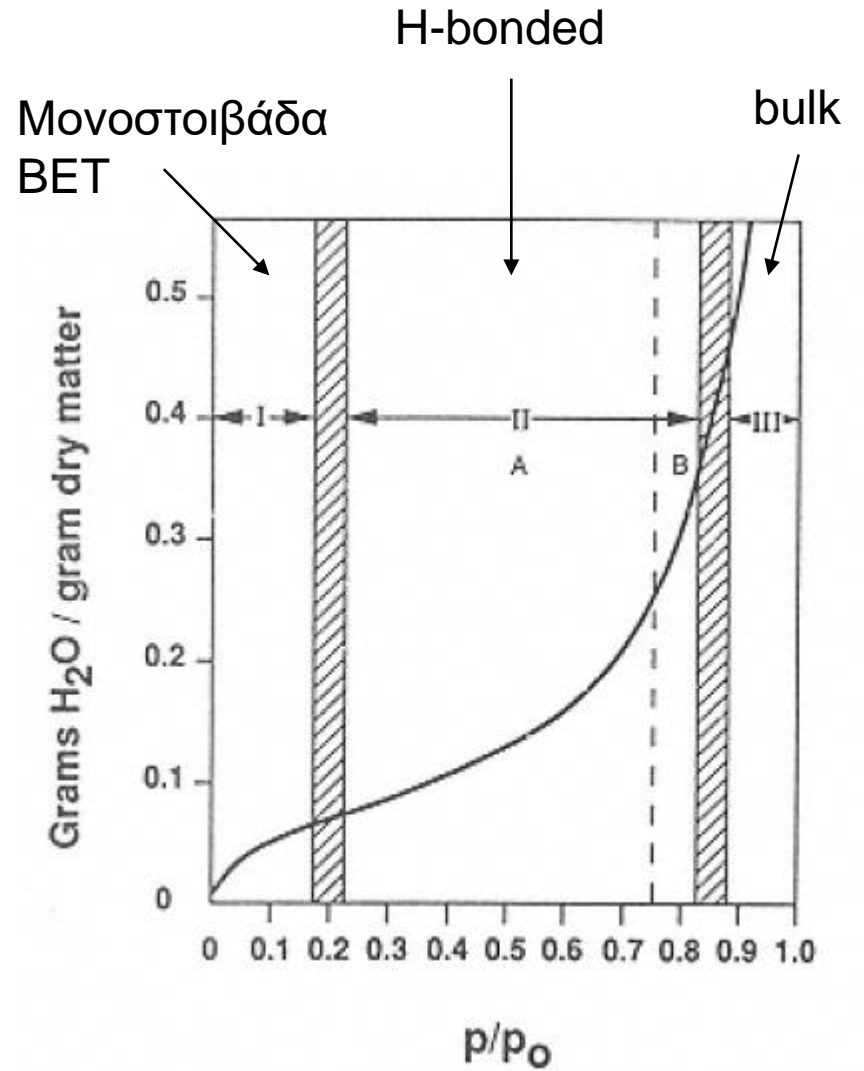


FIGURE 18

Schematic moisture sorption isotherm encompassing a broad range of moisture contents.





# BET monolayer equation

$$\frac{a_w}{m(1 - a_w)} = \frac{1}{m_1 c} + \frac{C - 1}{m_1 c} a_w$$

$$m_1 = \frac{1}{0.6 + 10.7} = 0.088 \text{ g H}_2\text{O/g dry matter}$$

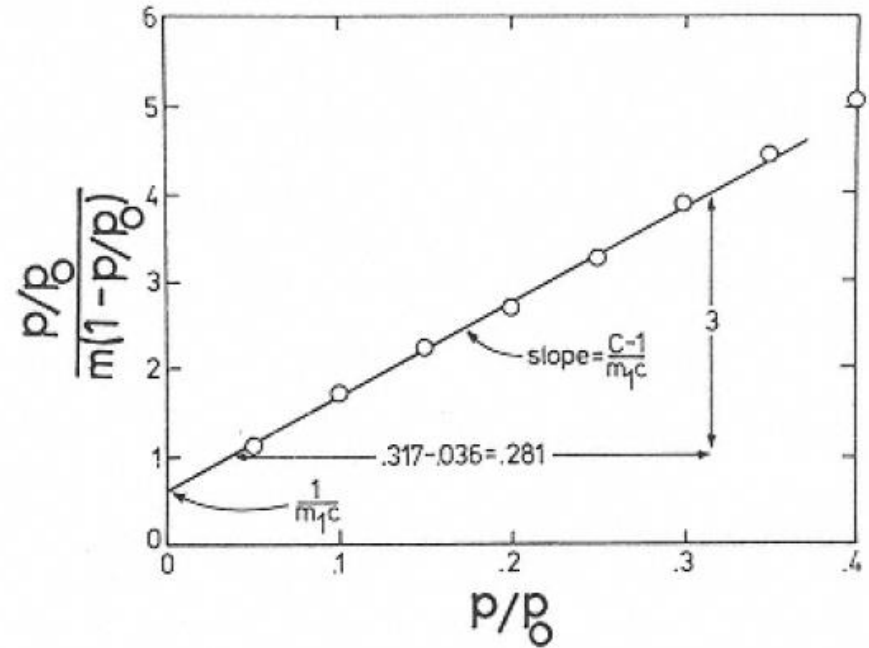


FIGURE 24

BET plot for native potato starch (resorption data, 20°C). (Data from Ref. 125.)

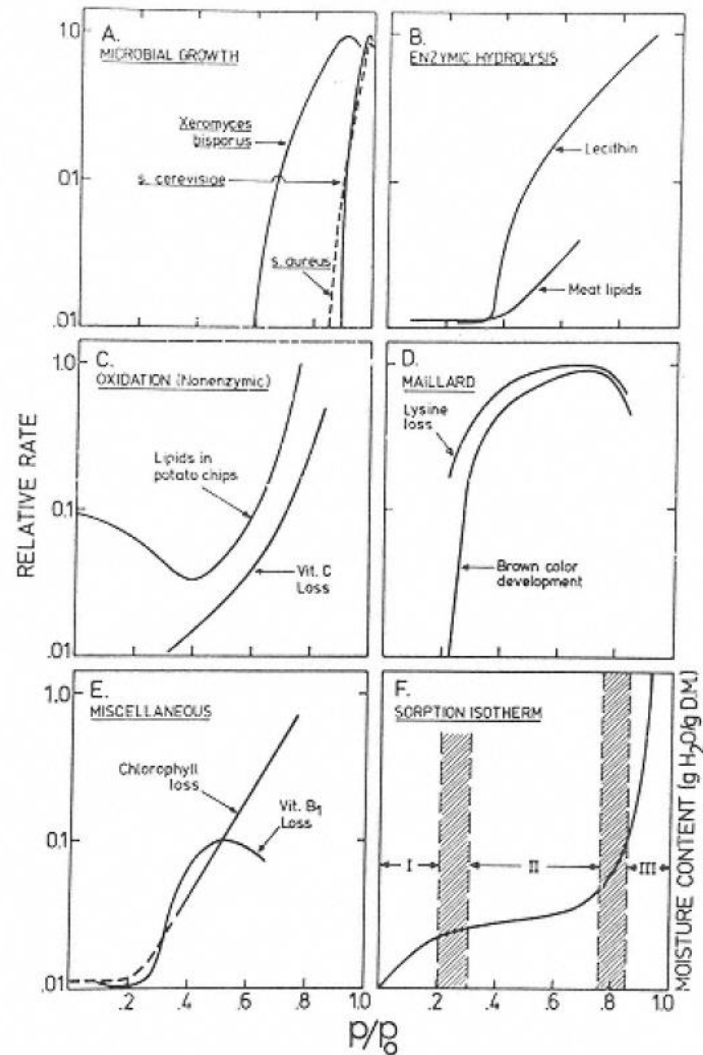


FIGURE 23

Relationships among relative water vapor pressure, food stability and sorption isotherms. (A) Microbial growth versus  $p/p_0$ . (B) Enzymic hydrolysis versus  $p/p_0$ . (C) Oxidation (nonenzymic) versus  $p/p_0$ . (D) Maillard browning versus  $p/p_0$ . (E) Miscellaneous reaction rates versus  $p/p_0$ . (F) Water content versus  $p/p_0$ . All ordinates are "relative rate" except for F. Data from various sources.

# Φαινόμενο υστέρησης

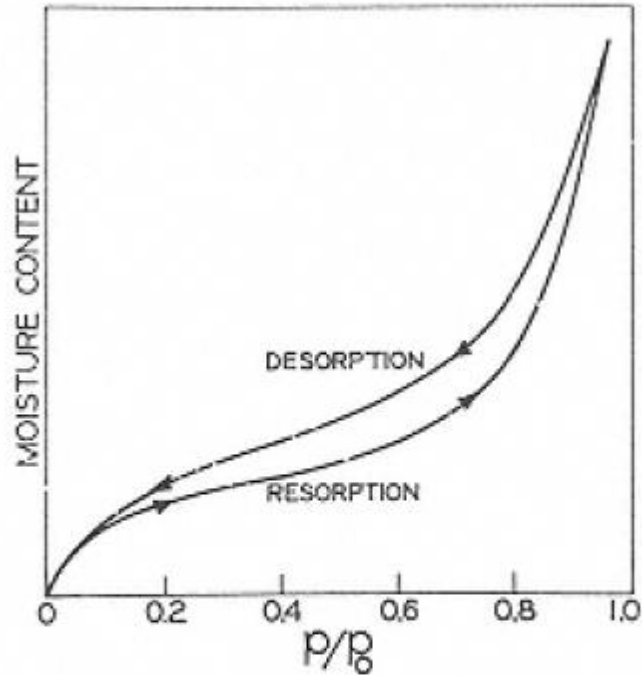
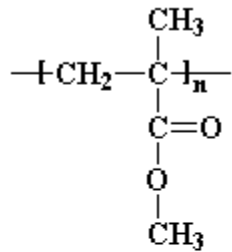


FIGURE 22  
Hysteresis of moisture sorption  
isotherm.

# Μοριακή κινητικότητα και τρόφιμα

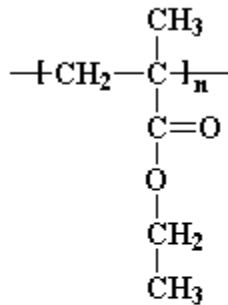
- Διαδικασίες που ελέγχονται από τη διάχυση πολύ σημαντικές στα τρόφιμα
- Ξήρανση και πάγωμα επιδρούν σημαντικά στην «κατάσταση» ενός τροφίμου
- Παρεμπόδιση της μοριακής κινητικότητας σταματά διαδικασίες αποικοδόμησης, αλλοίωσης.

$T_g$  = θερμοκρασία υαλώδους μετάπτωσης



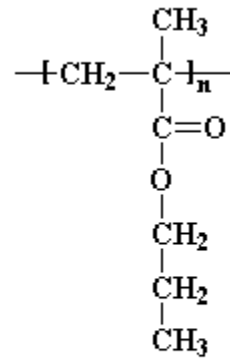
Poly(methyl methacrylate)

$T_g = 100-120 \text{ }^\circ\text{C}$



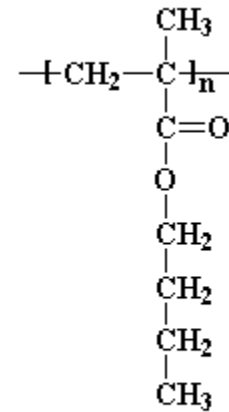
Poly(ethyl methacrylate)

$T_g = 65 \text{ }^\circ\text{C}$



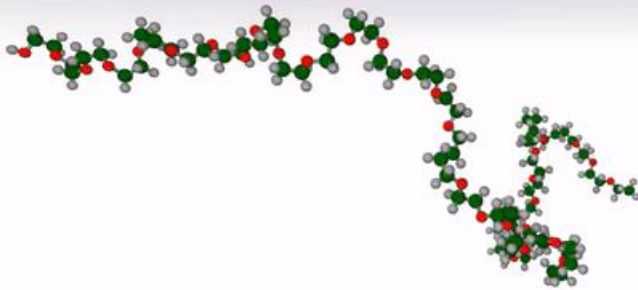
Poly(propyl methacrylate)

$T_g = 35 \text{ }^\circ\text{C}$

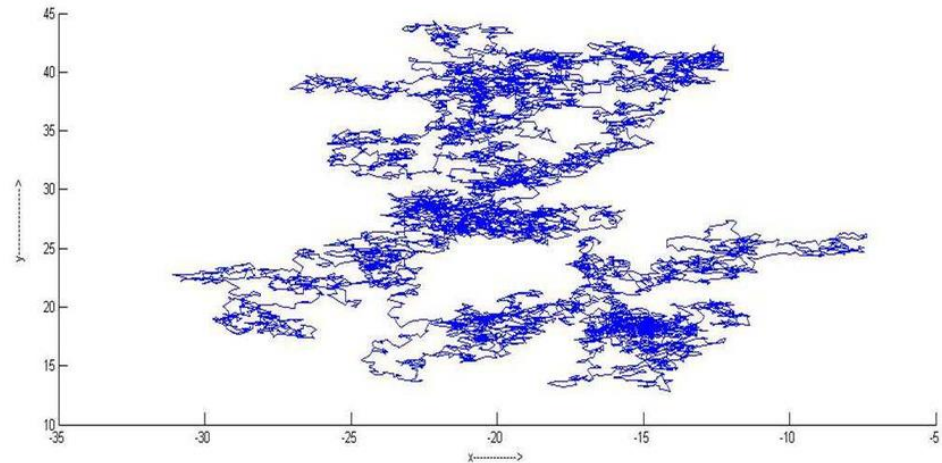


Poly(butyl methacrylate)

$T_g = 20 \text{ }^\circ\text{C}$



$T < T_g$





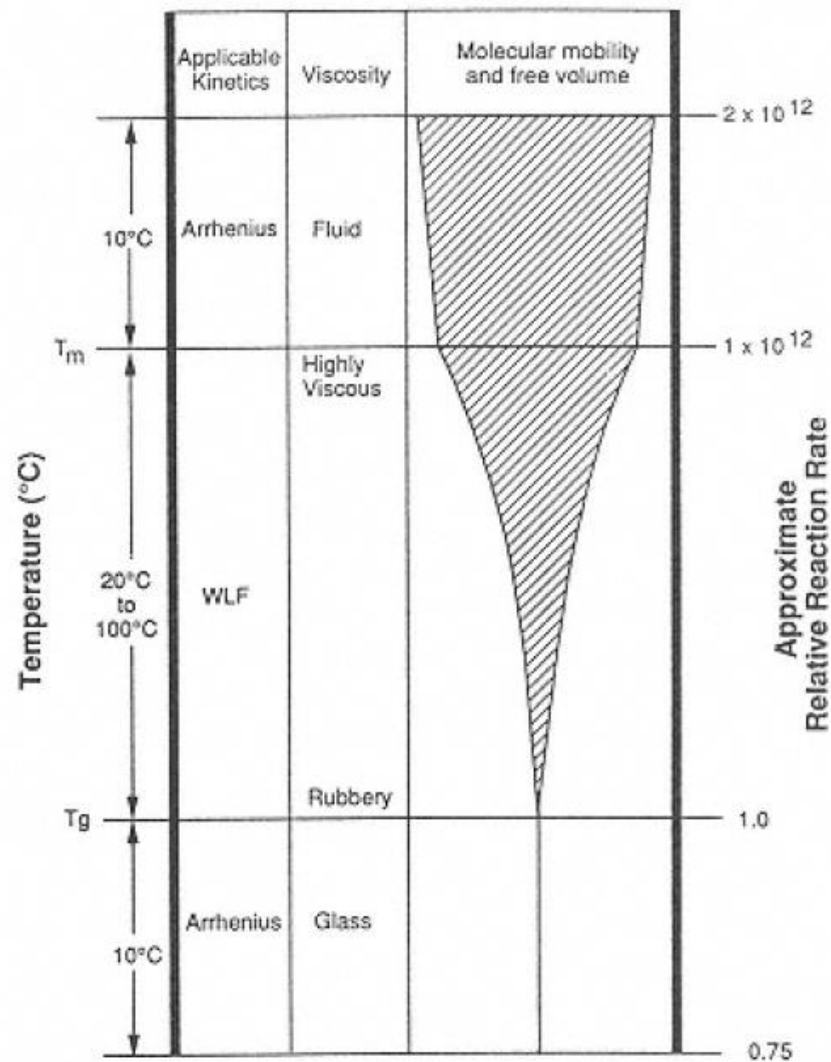
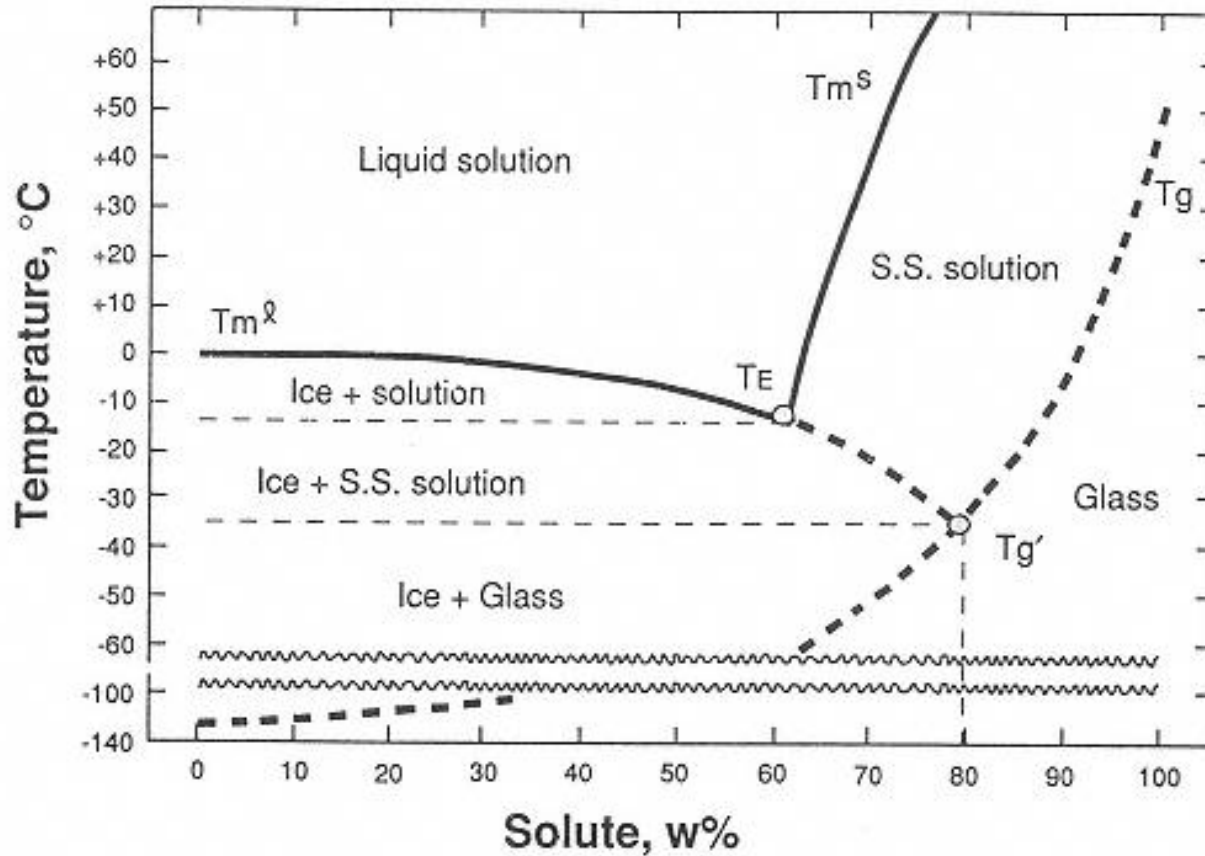


FIGURE 27

Schematic interrelations among temperature, appropriate type of kinetics, viscosity, molecular mobility, free volume, and relative rates of diffusion-dependent events. WLF kinetics based on mean constants. Other terms are defined in legend of Figure 25.

# Διαγράμματα κατάστασης



$T_g$  = θερμοκρασία υαλώδους μετάπτωσης



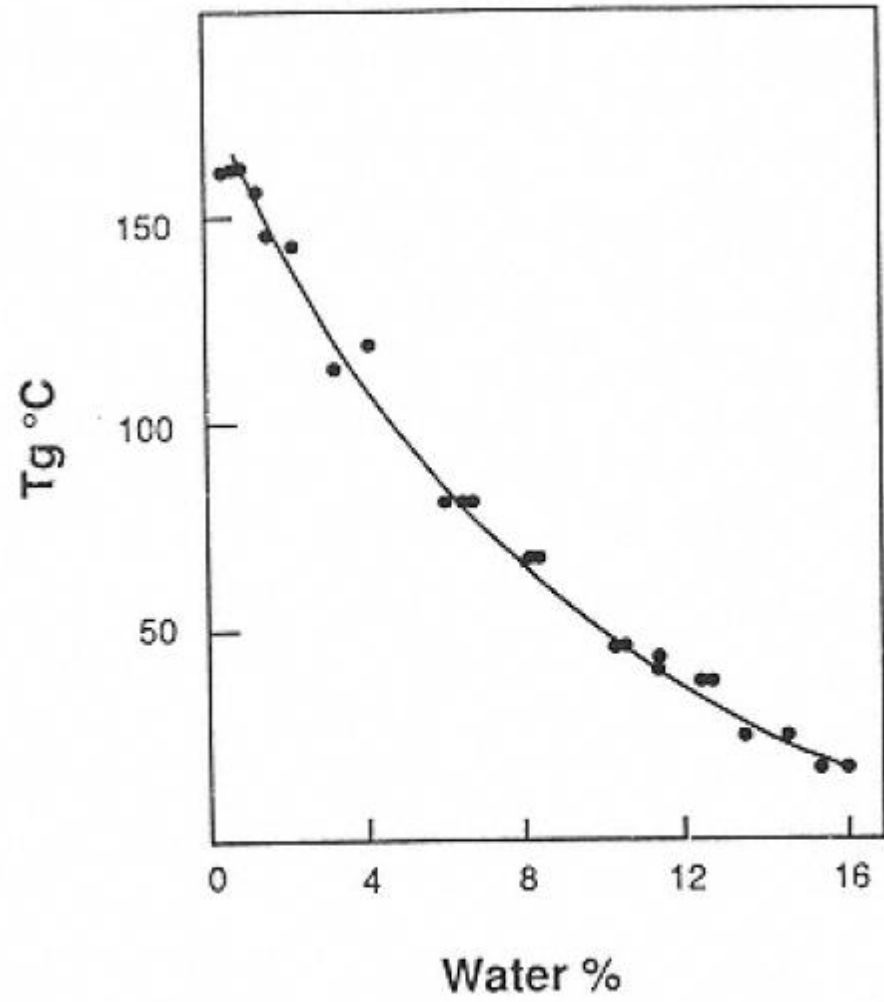


FIGURE 32  
T<sub>g</sub> of wheat gluten as a function of water content.  
(From Ref. 42.)

# Διαγράμματα κατάστασης

- $T < T_g$  (Θερμοκρασία υαλώδους μετάπτωσης)  
Χημικές διαδικασίες που ελέγχονται από τη διάχυση σταματούν.
- Το νερό ενεργεί ως πλαστικοποιητής, κατεβάζοντας την  $T_g$ .

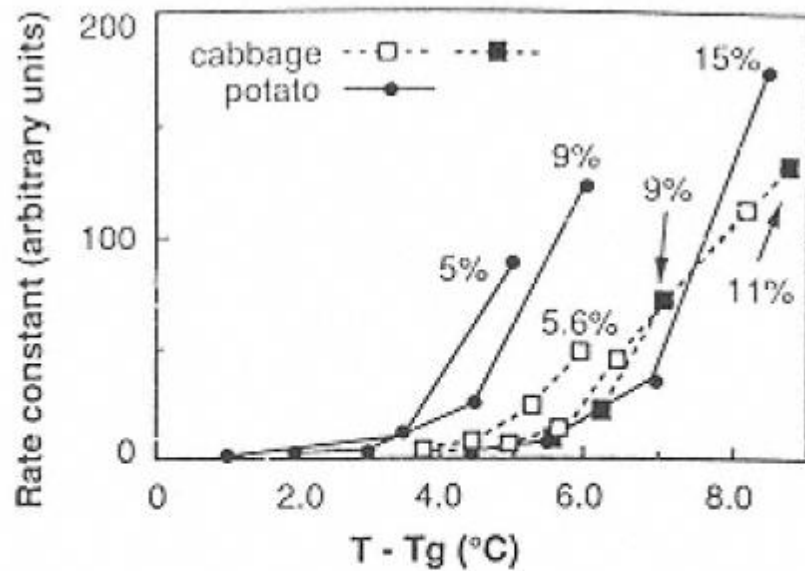


FIGURE 30

Rate of nonenzymatic browning in cabbage and potato as a function of product water content and  $T - T_g$ . (From Ref. 49.)

# Κατάψυξη τροφίμων

- Συγκεντρώνει τα μη-υδατικά συστατικά στο μέρος του τροφίμου που δεν πάγωσε (αλλαγή pH, οξύτητας, ιονικής ισχύος, ιξώδους, κλπ)
- Αυξάνει τον όγκο του νερού κατά 9% (πάγος)

**TABLE 11** Glass Transition ( $T_g'$ ) Values of Foods<sup>a</sup>

Food	$T_g'$ (°C) [ $W_g'$ (wt%)]	Food	$T_g'$ (°C) [ $W_g'$ (wt%)]
<b>Fruit juices</b>		Supermarket "fresh"	-8
Orange (various samples)	-37.5 ± 1.0	Blanched	-10
Pineapple	-37	Potato, Russet Burbank, fresh	-12
Pear	-40	Cauliflower, frozen stalk	-25
Apple	-40	Pea, frozen	-25
Prune	-41	Green bean, frozen	-27
White grape	-42	Broccoli, frozen	
Lemon (various samples)	-43 ± 1.5	Stalk	-27
		Head	-12
<b>Fruits, fresh</b>		Spinach, frozen	-17
Strawberry		<b>Frozen desserts</b>	
Sparkleberry, center	-41	Ice cream, vanilla	
Sparkleberry, edge	-39 and -33	Three commercial brands	-31 to -33 [32-37]
Sparkleberry, intermediate	-38.5 and -33 [7]	Ice milk, vanilla, soft serve	-30 to -31 [28-45]
Other cultivars	-33 and -41 [16-24]	<b>Cheese</b>	
Blueberry		Cheddar	-24
Flesh	-41	Provolone	-13
Skin	-41 and -32	Cream cheese	-33
Peach	-36	<b>Fish</b>	
Banana	-35	Cod muscle <sup>b,c</sup>	-11.7 ± 0.6
Apple		Cod muscle, water insoluble fraction <sup>b,d</sup>	-6.3 ± 0.1
Red Delicious	-42	Mackerel muscle <sup>b,c</sup>	-12.4 ± 0.2
Granny Smith	-41	Mackerel muscle, water insoluble fraction <sup>b,d</sup>	-7.5 ± 0.4
Tomato, fresh, flesh	-41	<b>Beef muscle<sup>b,c</sup></b>	
<b>Vegetables, fresh or frozen</b>			-12.0 ± 0.3
Sweet corn			
Garden fresh, endosperm	-15		

# Μεθοδολογία «εμποδίων»

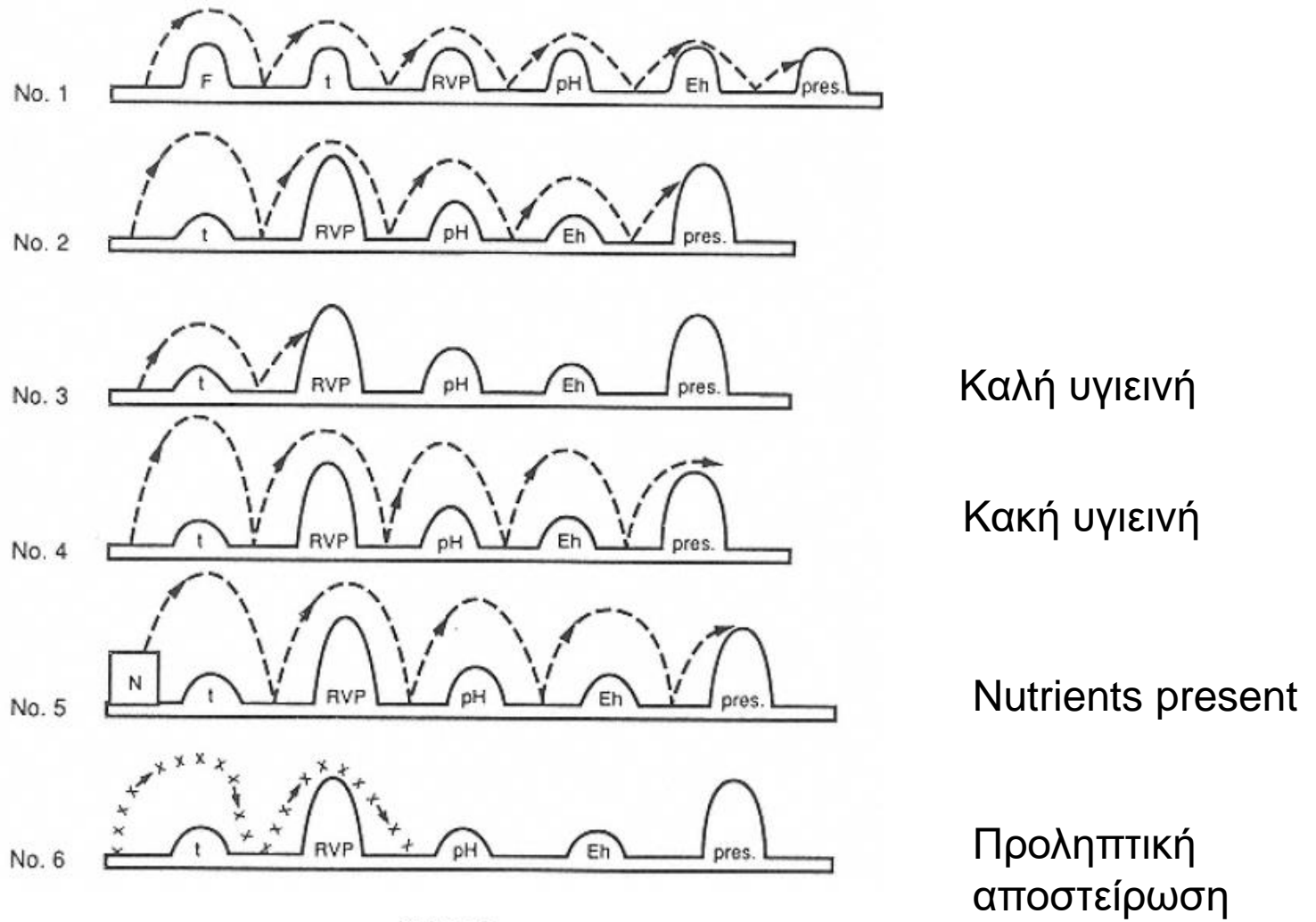


FIGURE 41

The combined methods approach to controlling growth of microorganisms in nonsterilized food. F is heating, t is chilling, RVP is relative vapor pressure, pH is acidification,  $E_h$  is redox potential, pres. is chemical preservative, and N is nutrients. (Adapted from Ref. 58.)