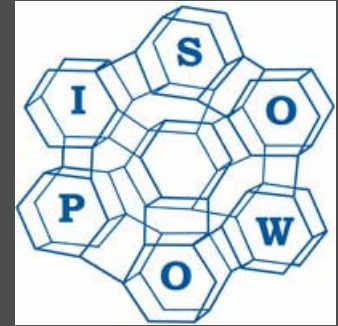


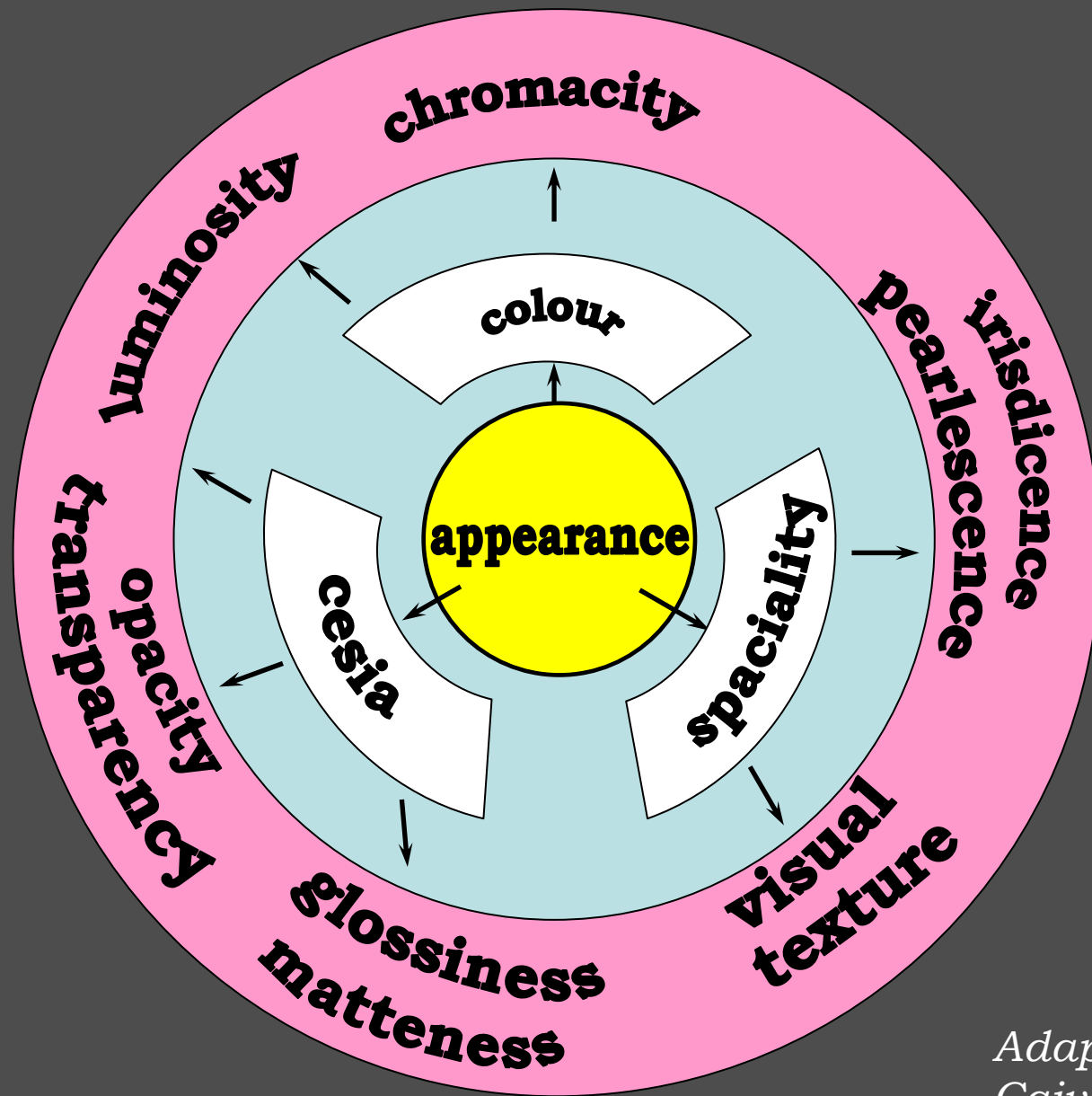
Water, structural changes and food appearance



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*Adapted from
Caivano, 1991*

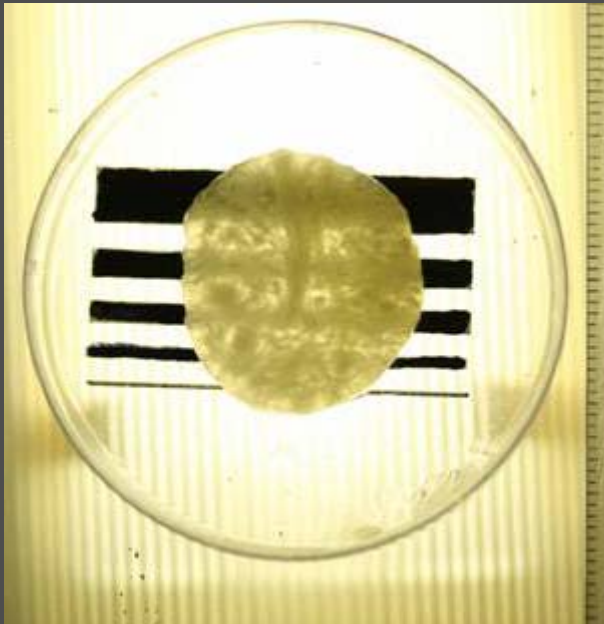
During processing or storage of foods many structural changes occur, which induce changes in color, gloss, transparency and luminosity.

Water is the main component governing those changes!!!

Potential causes of transparency/opacity changes

- 1. Filling pores with water or syrup.**
- 2. Starch gelatination.**
- 3. Appearance of particles (crystals/bubbles).**

Opacity increase of apple disks due to freeze-drying



Blanched apple disk



Freeze-dried apple disk

Transparency increase due to hydration of freeze-dried apple

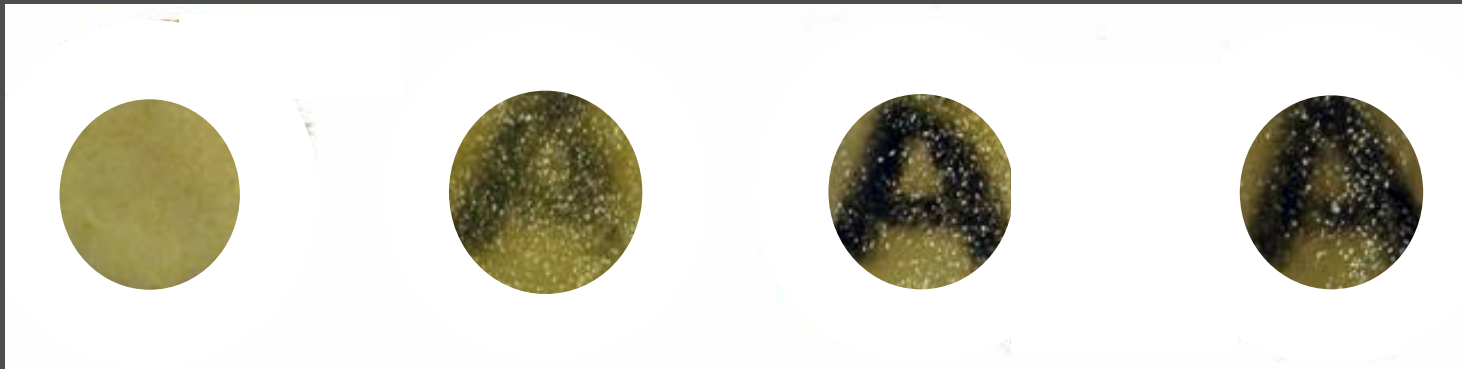
imbibition time

0'

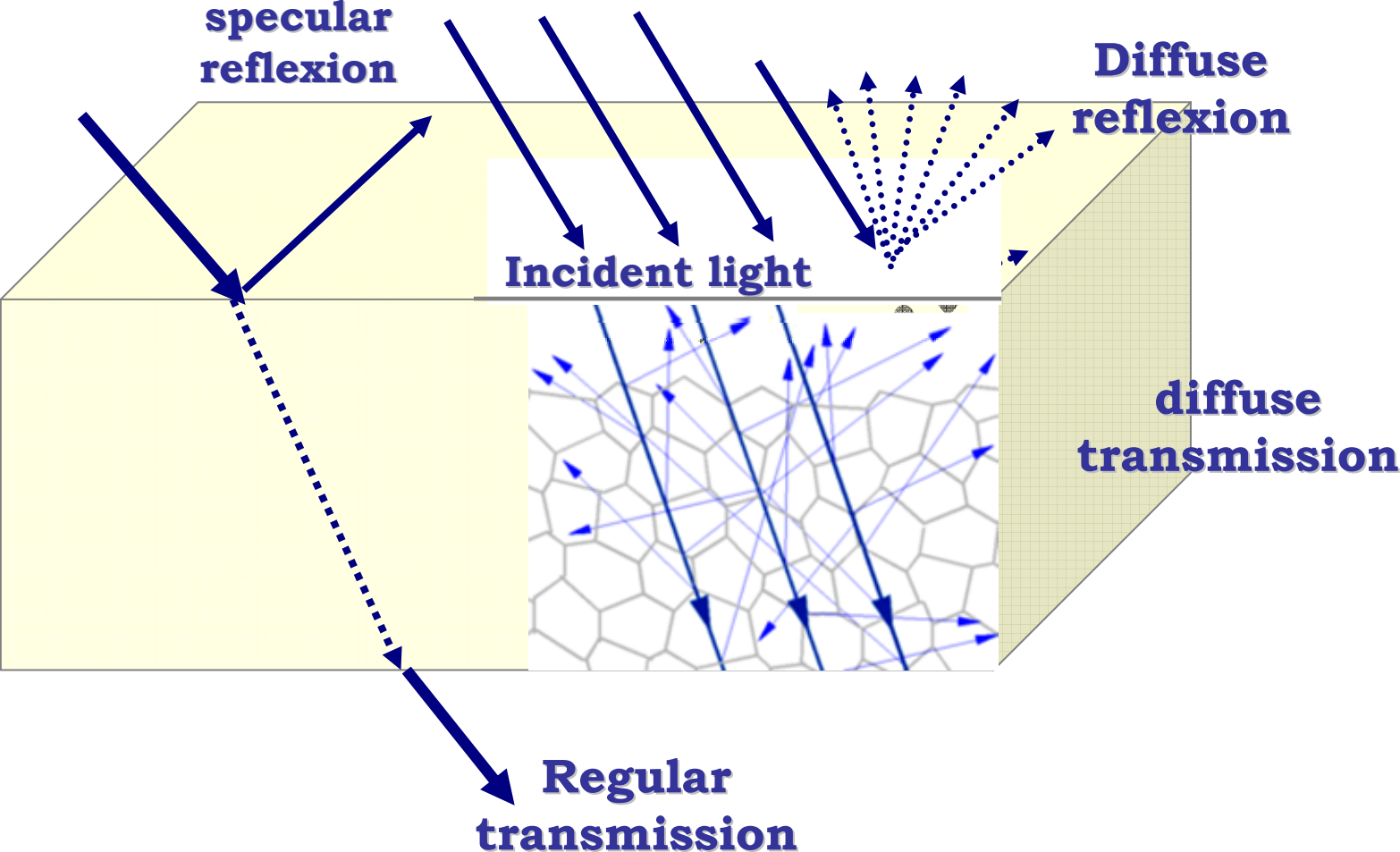
1'

3'

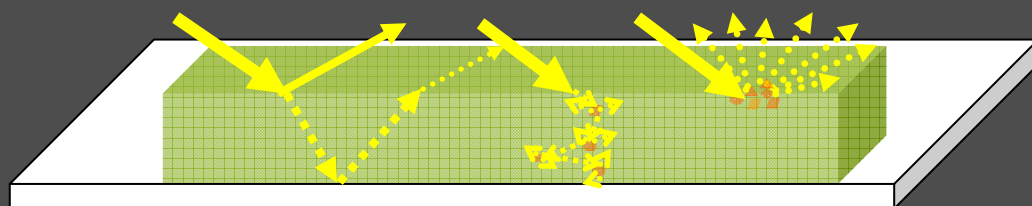
5'



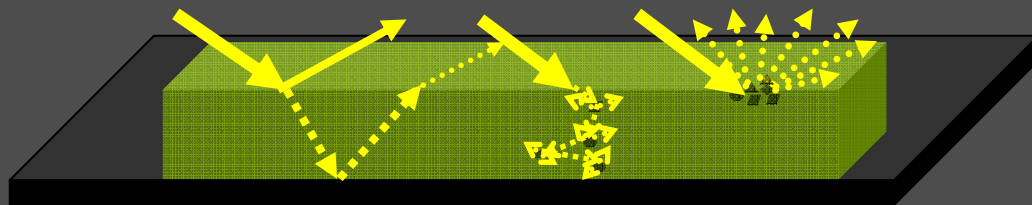
Light diffusion is the result of multiple reflexions and refractions at optical interfaces.



Translucent materials- Kubelka-Munk theory

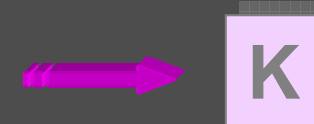


White background

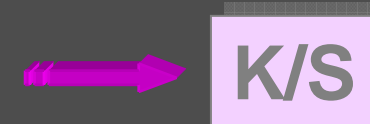


Black ground

Absorption coefficient



Scattering coefficient



Transparency increase due to storage above T_g

Matrix: PVP (polyvinylpyrrolidone)

11% R.H.



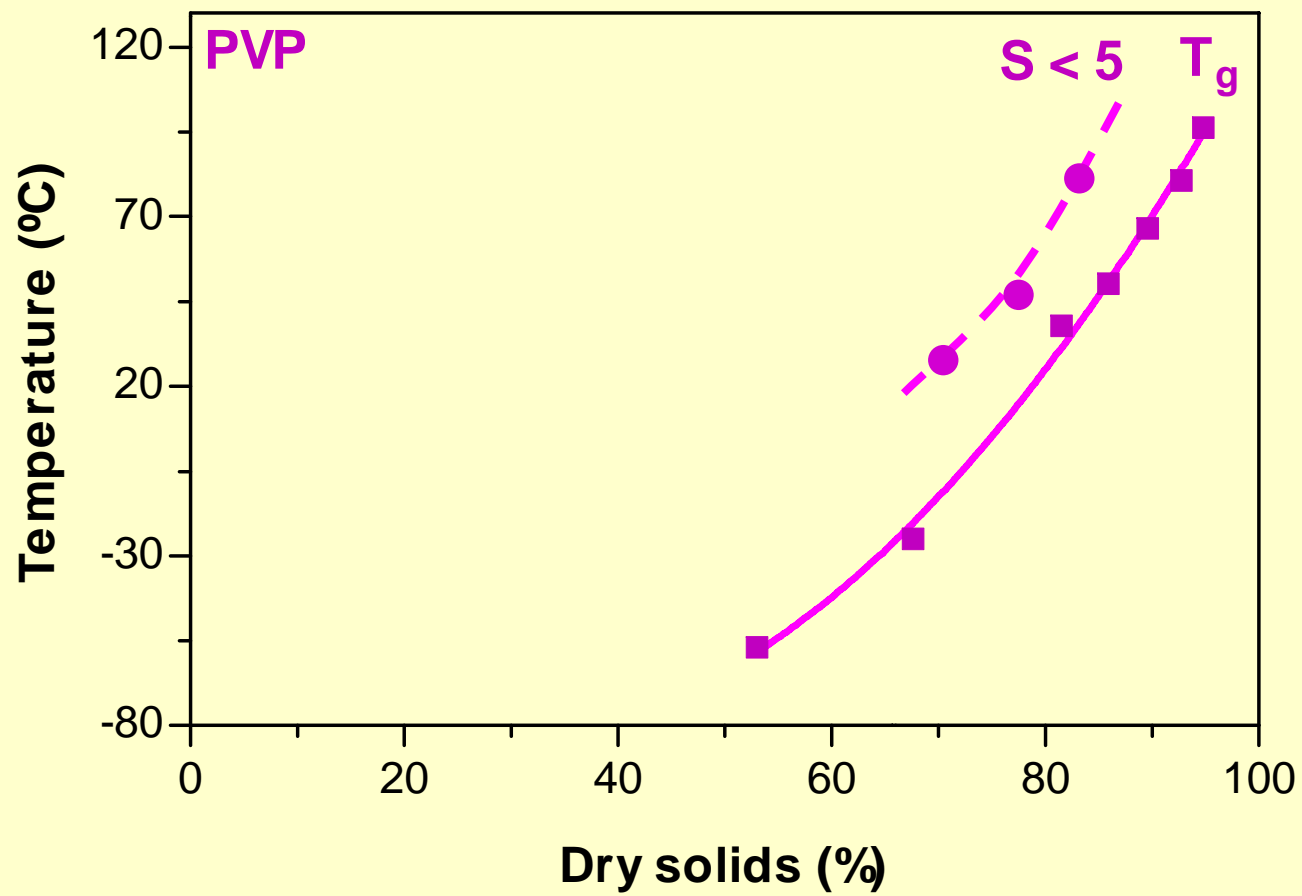
84% R.H.



Acevedo, 2006

Transparency increase above T_g

PVP: polyvinylpyrrolidone

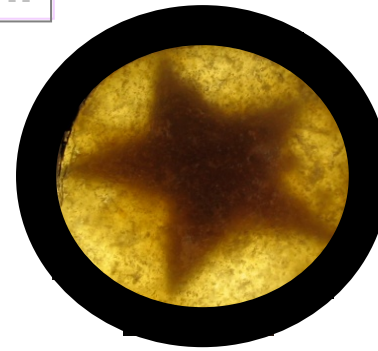


**2 mm
thickness**

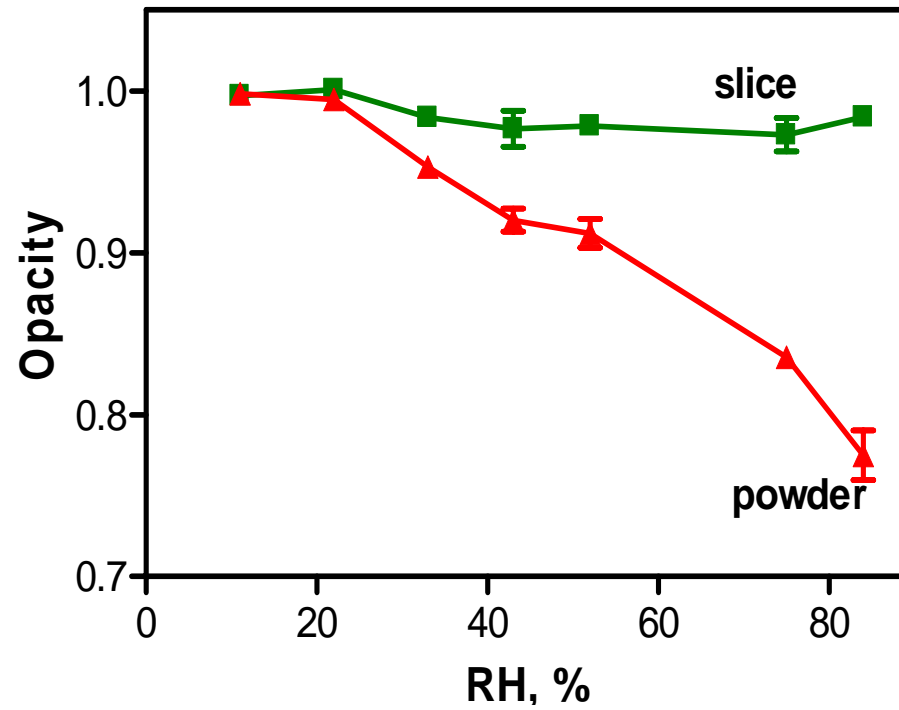
84% R.H.



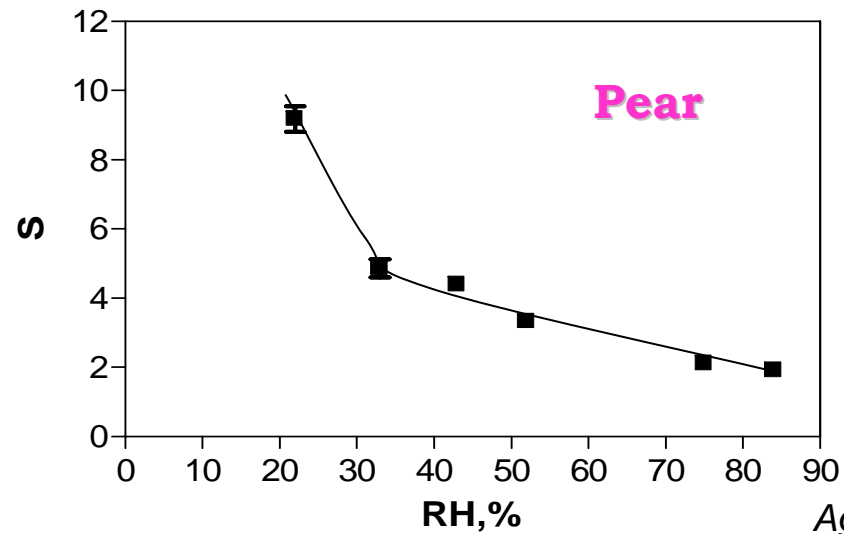
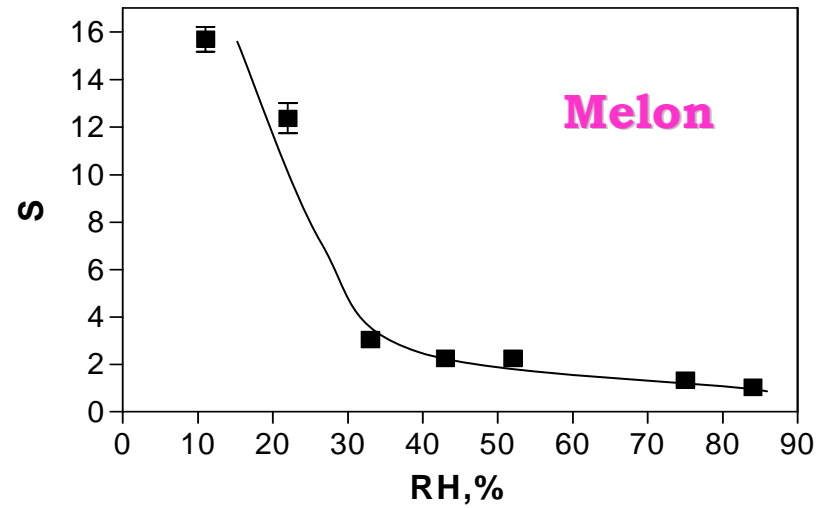
**Sliced dry melon
(opaque)**



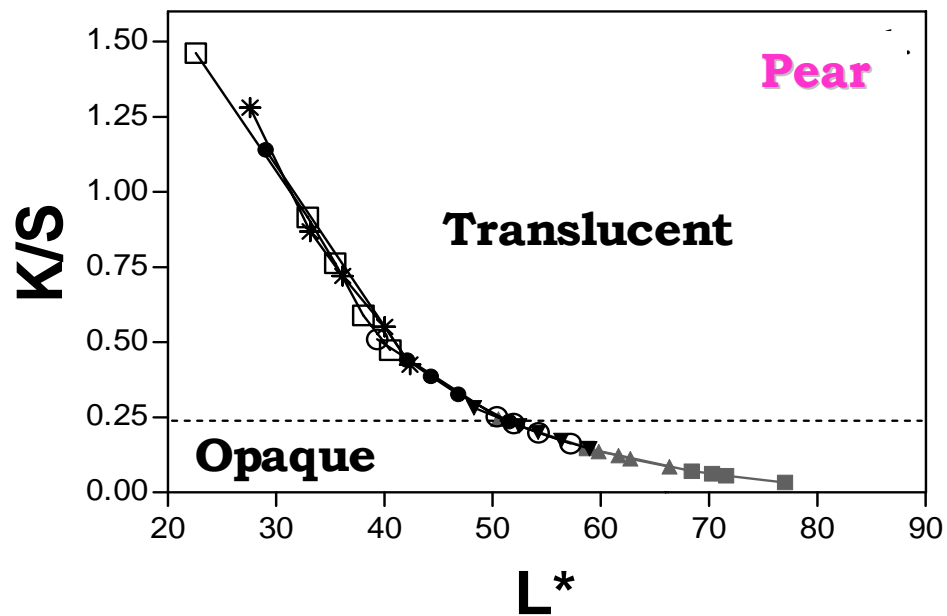
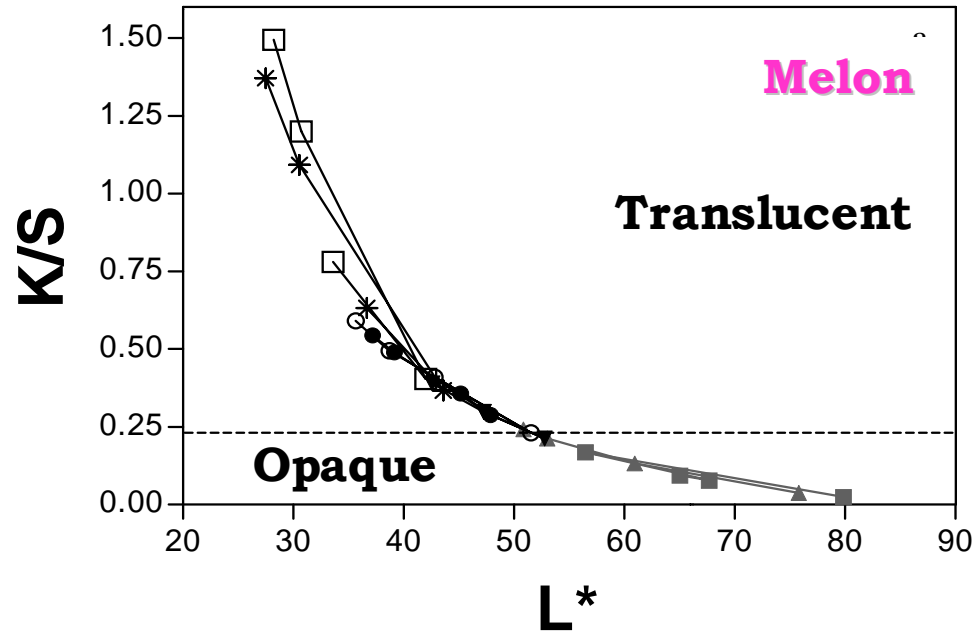
**Powdered dry melon
(translucent)**



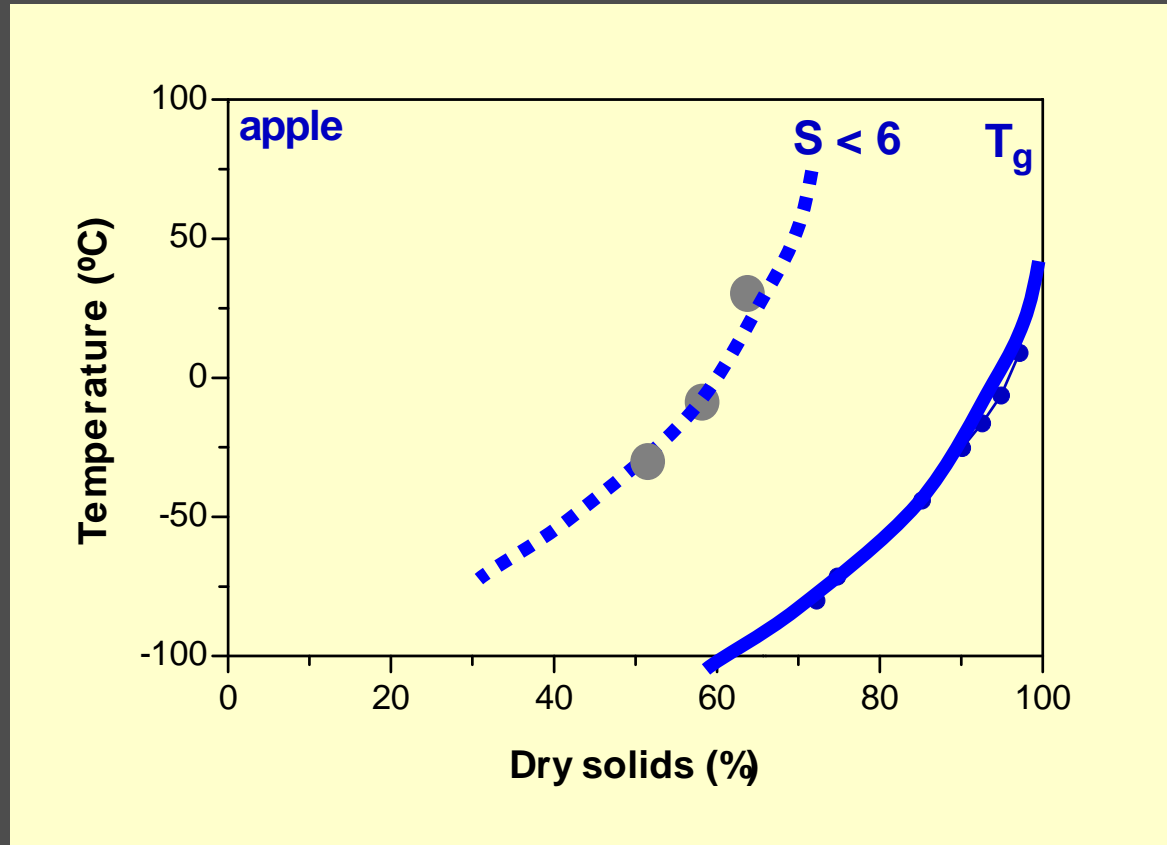
Scattering coefficient vs RH



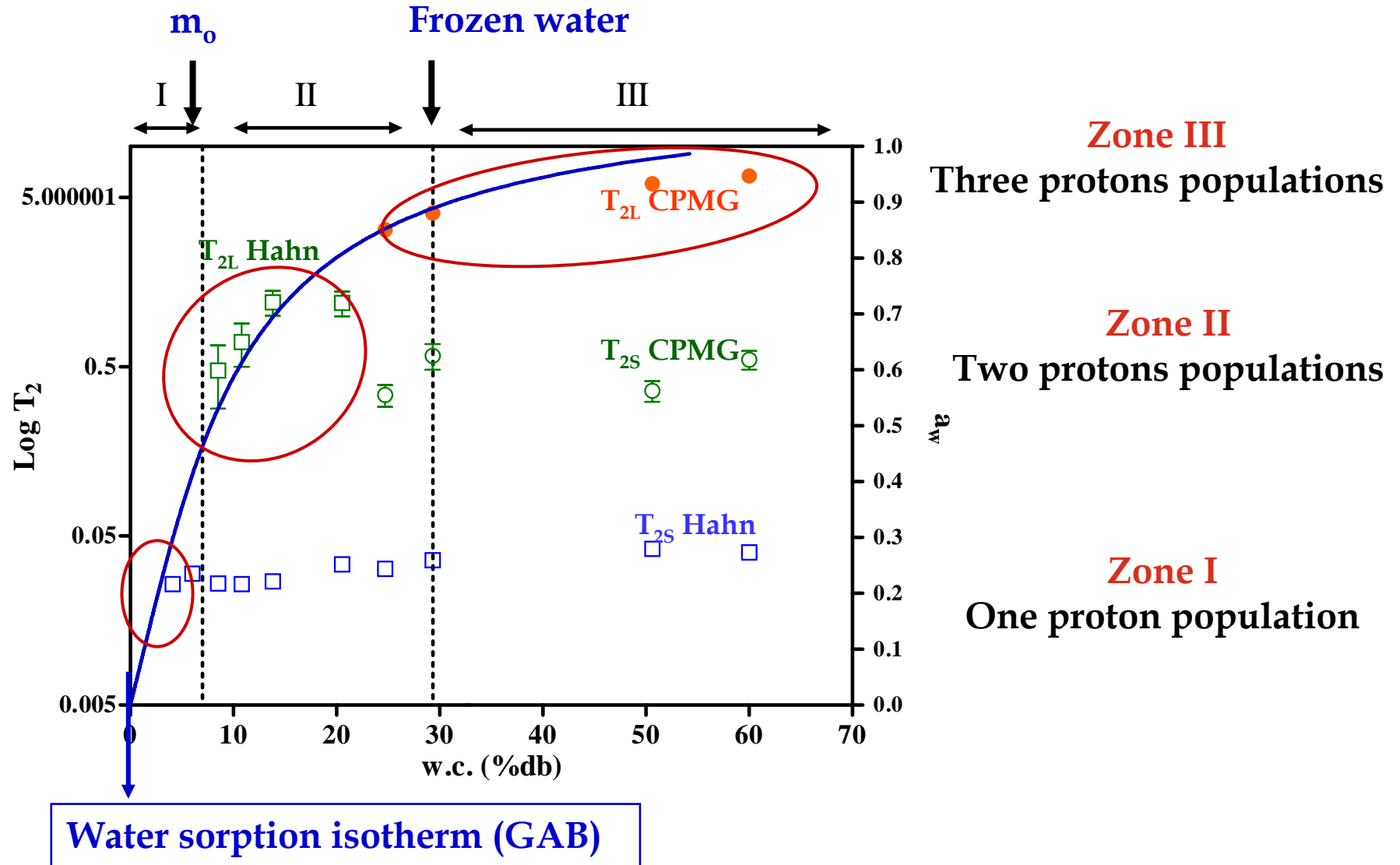
K/S vs L*



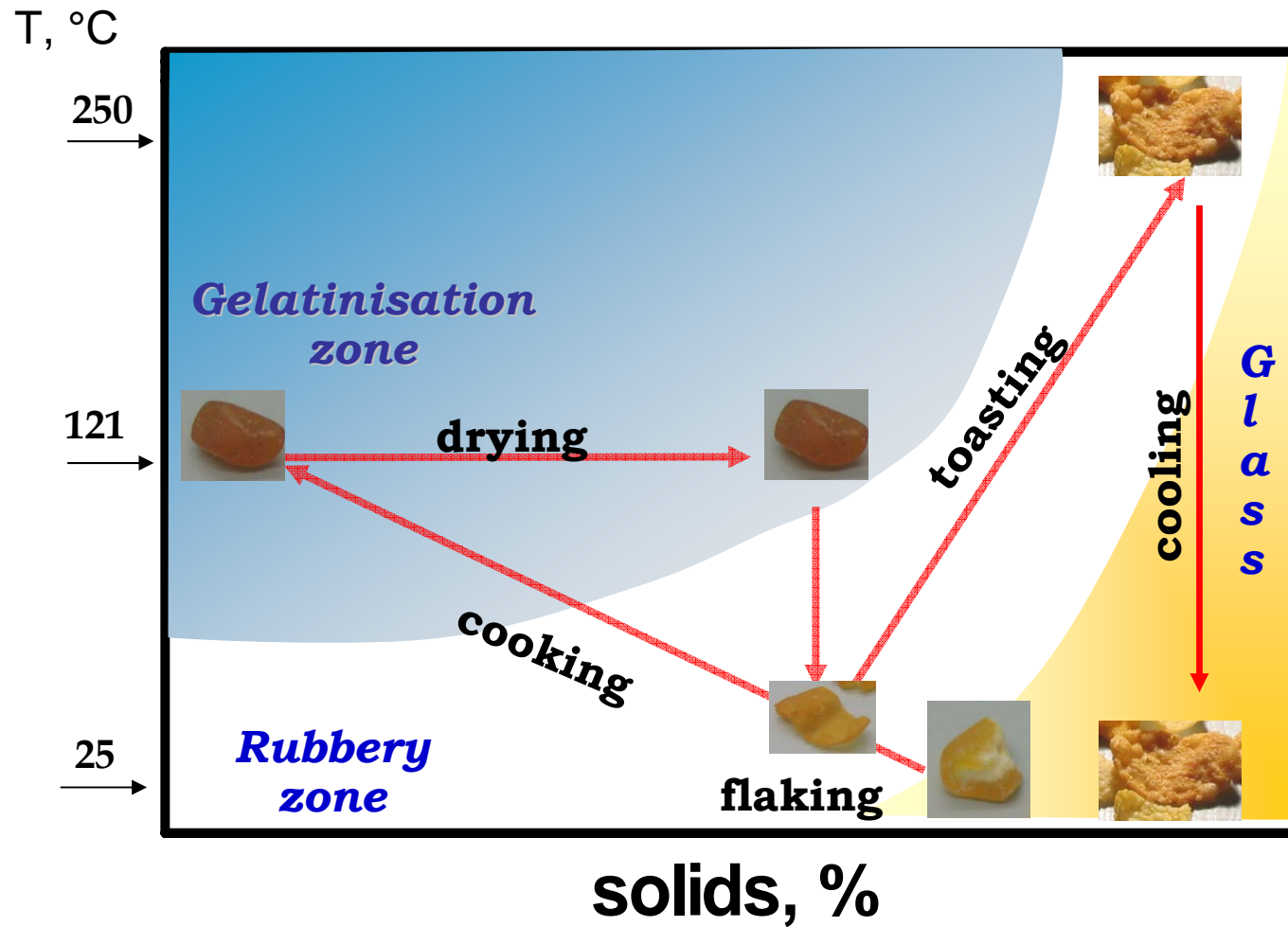
Transparency of powdered apple



Proton mobility $^1\text{H-NMR}$



Corn flakes production in the state diagram



Changes of corn grits appearance due to cooking

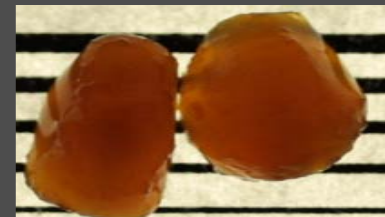
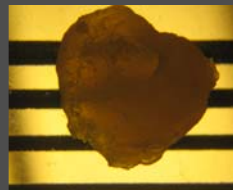
grits

cooked grits

Front-illuminated

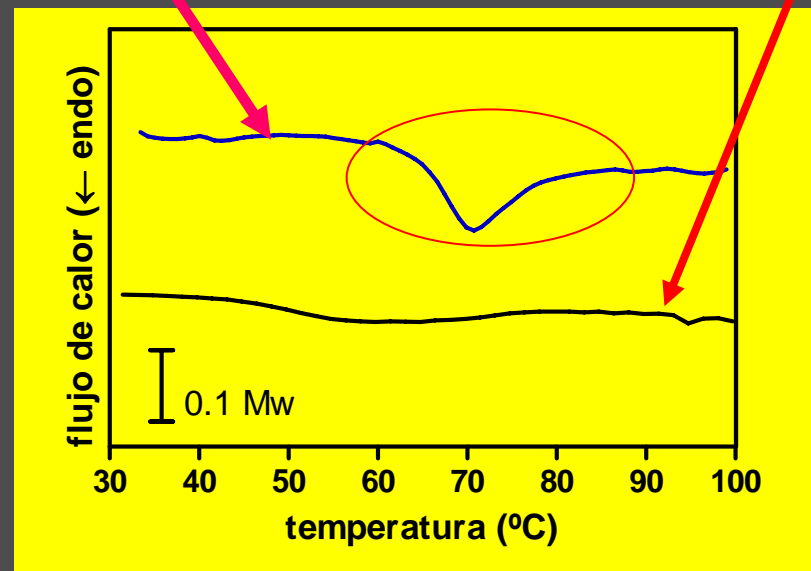


Back-illuminated


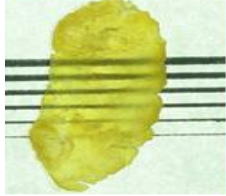
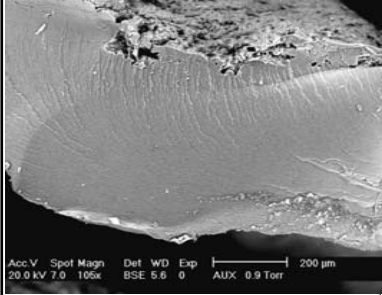

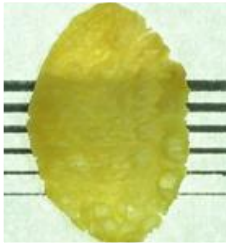
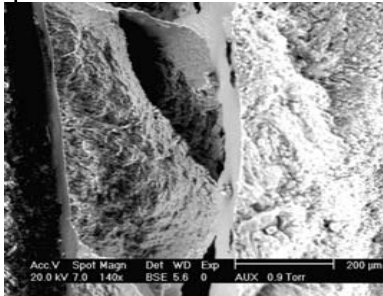


Opacity = 92 %

Opacity = 75 %



Farroni, 2008

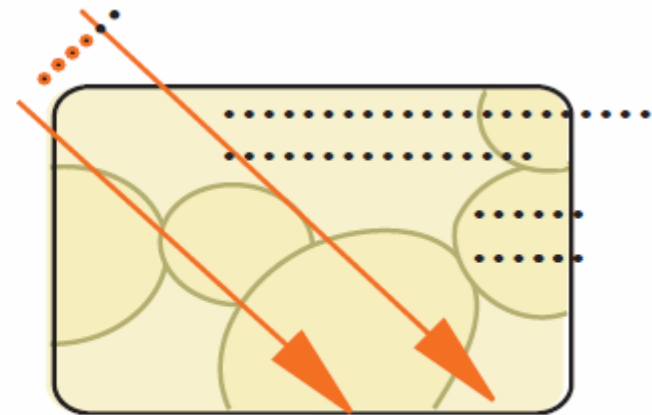
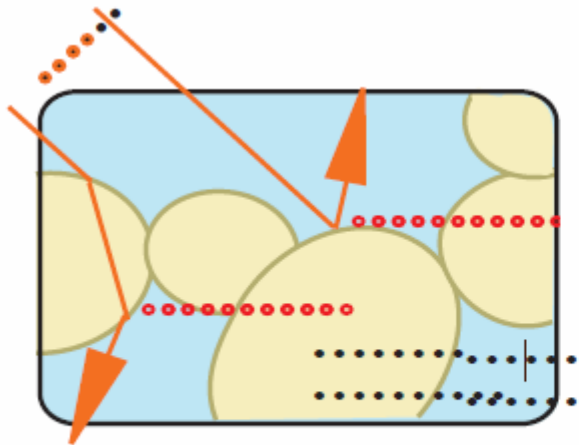
	L*	Retro-illum.	O	SEM images
Flaked 	53		0.69	
Toasted 	63		0.90	

**At high temperature water vapor release
promotes bubble formation ↑ opacity**

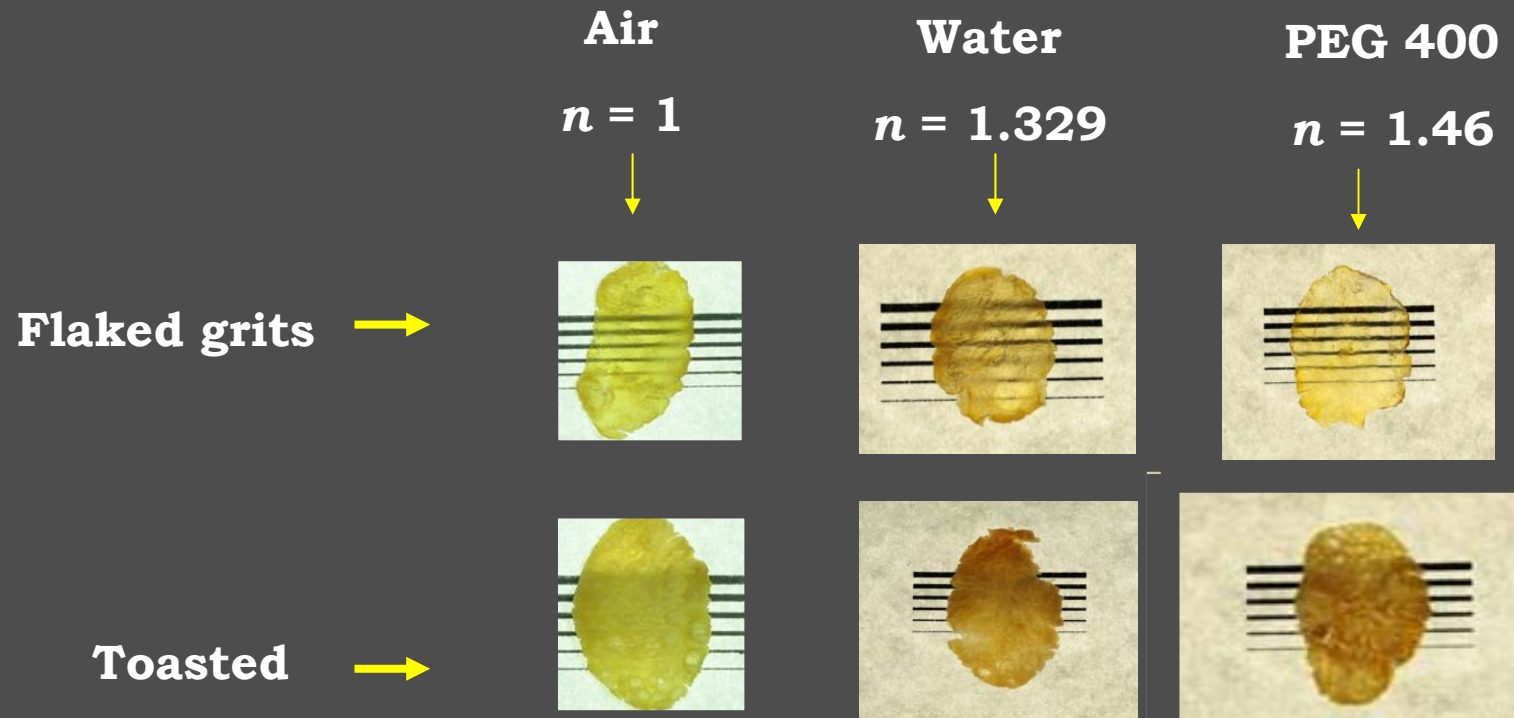
Farroni, 2008

**n mismatching
promotes opacity**

**In porous samples
transparentisation can
be obtained by filling the
pores with n close to
that of the solid material**



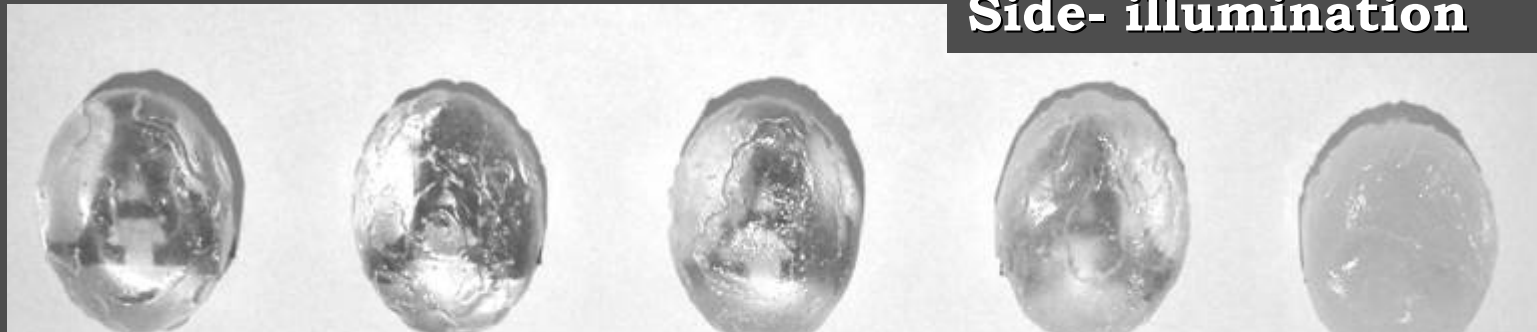
Transparentization of flaked grits and toasted corn-flakes through n matching.



Farroni et al., 2011

Opacity changes in hard candies stored at several R. H.

Side- illumination



R.H.

22%

33%

43%

58%

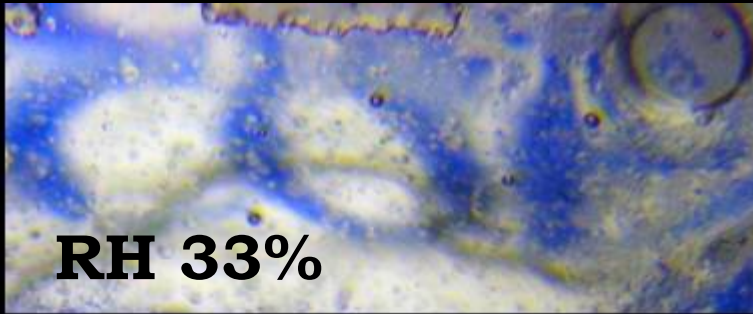
75%

Diffuse retro-illumination

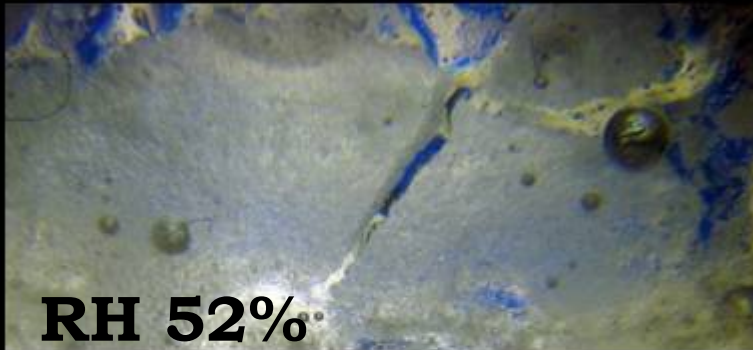


Side and diffuse illumination

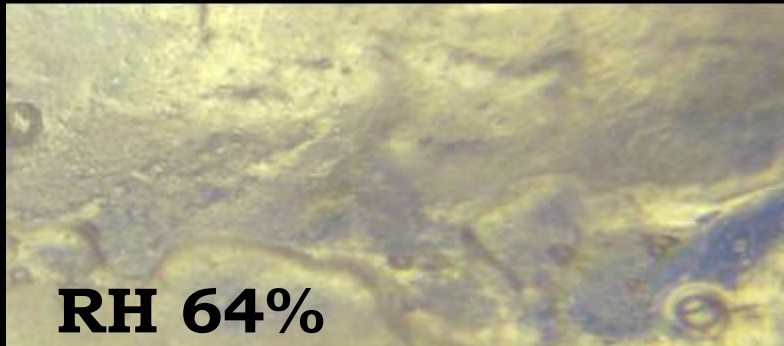




RH 33%

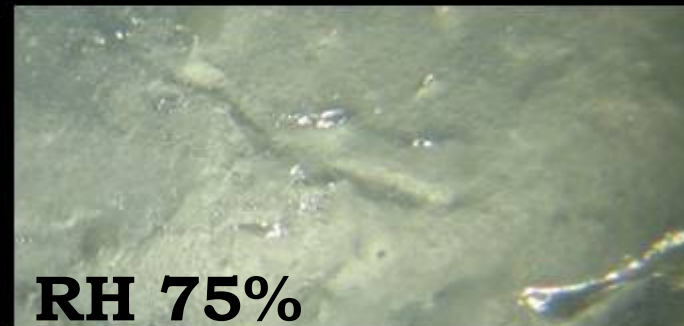


RH 52%

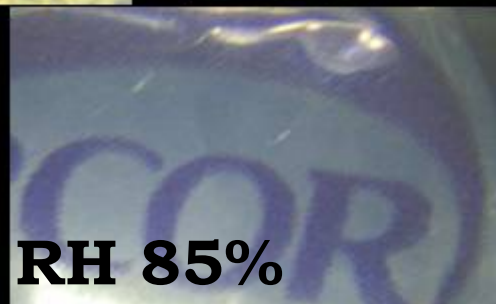


RH 64%

**Opacity changes
due to sugar
crystallisation
in hard candies**



RH 75%



RH 85%

Conclusions

The effects of water on food structure, manifested in food appearance, can be caused by:

- Supramolecular transitions (glass transition, crystallization, gelatinization)**
- Structural changes due to sample compression, bubble formation.**
- Refractive index matching.**

Future perspectives

- **Mathematical development of cesia solids**
- **Better understanding of food optical properties (K-M theory)**
- **Developmento of standarised methods for measuring spatial properties of light in foods**



**Innovative
products
development**



**Tools for
Process control**



Physico-chemical properties of foods
and biomolecule stability group.

Thank you!