Edible Films, Coatings & Processing Aids

Mikal E. Saltveit

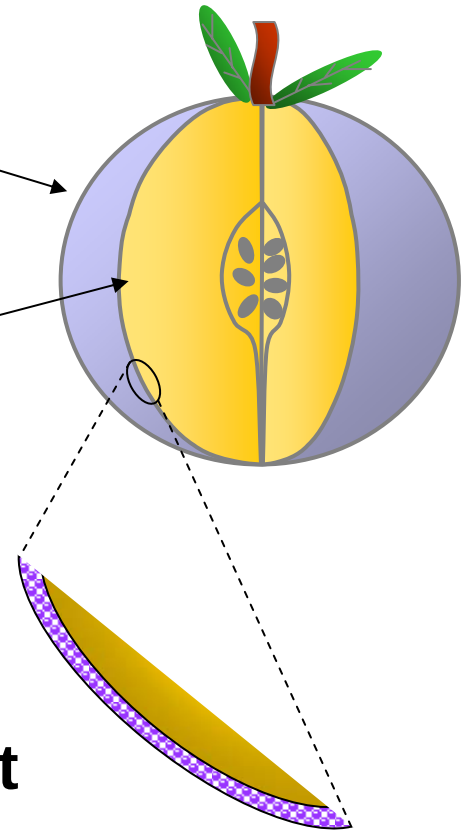
Mann Laboratory, Department of Plant Sciences,
University of California, Davis, CA 95616-8631

Use of Edible Films and Coatings

- Reduce water loss
- Reduce gas diffusion
- Reduce movement of oils and fats (nuts)
- Reduce movement of solutes
- Reduce loss of volatile flavors & aromas
- Improve structural properties (hold it together)
- Incorporate pigments, flavoring, & food additives
- Improve appearance (e.g., gloss)
- Enhance quarantine treatments

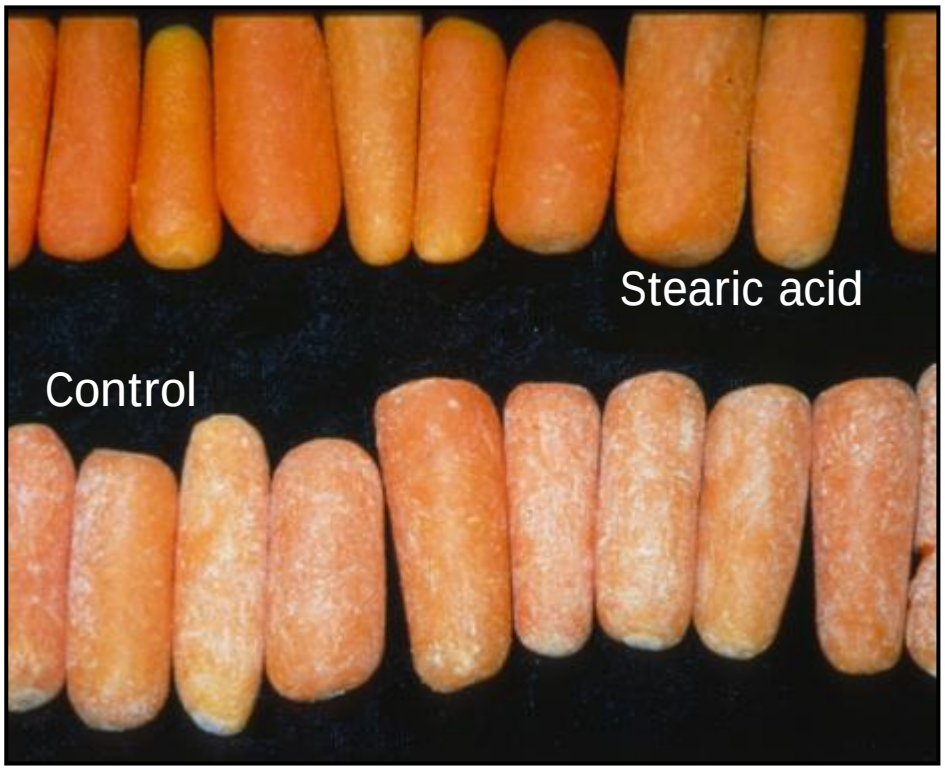
Composition of a Typical Epidermis

- Waxes (Lipids)
- Hydrocolloids Pectins, polysaccharides, proteins)
- Supported by underlying mechanically stable, homogeneous tissue
- Components have a specific order and spatial arrangement



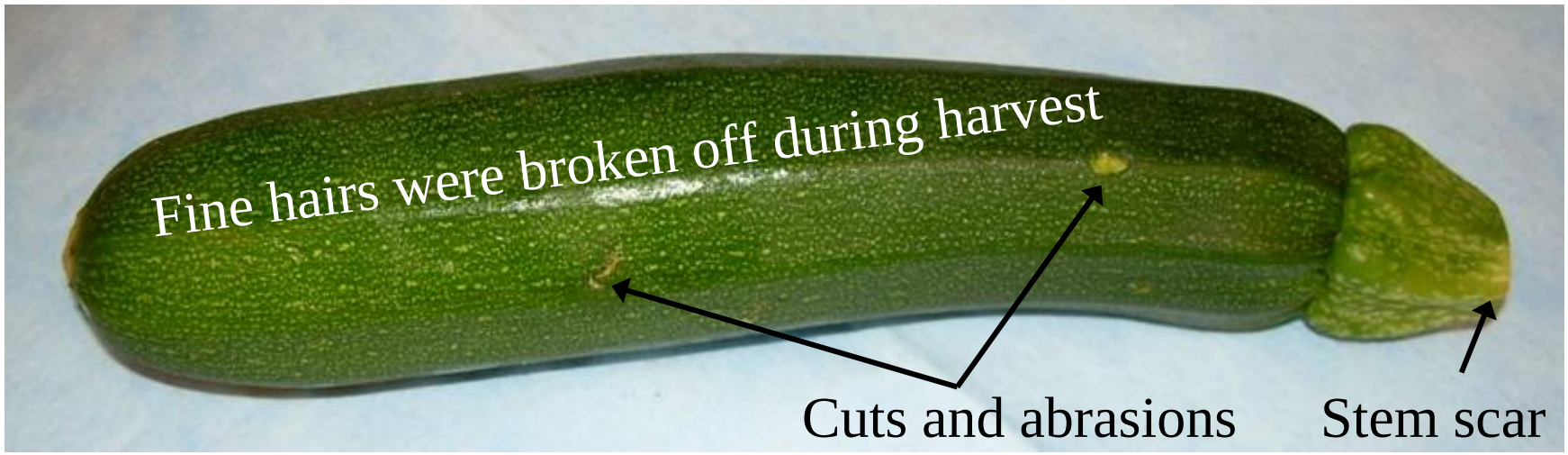
Coatings can reduce physical changes in the fresh-cut product

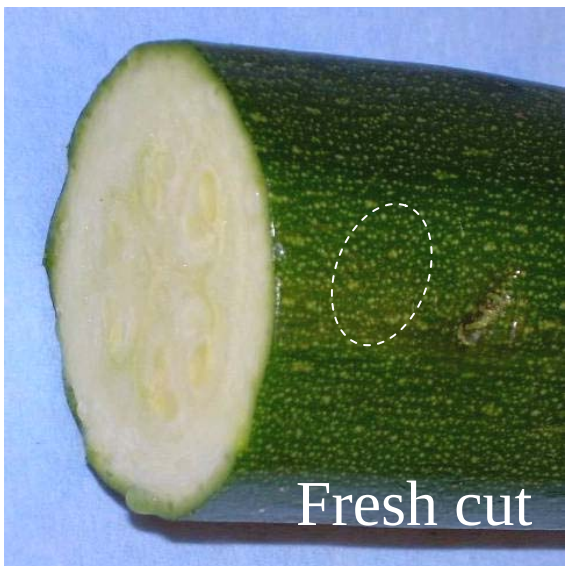
Development of white blush



Development of flared ends

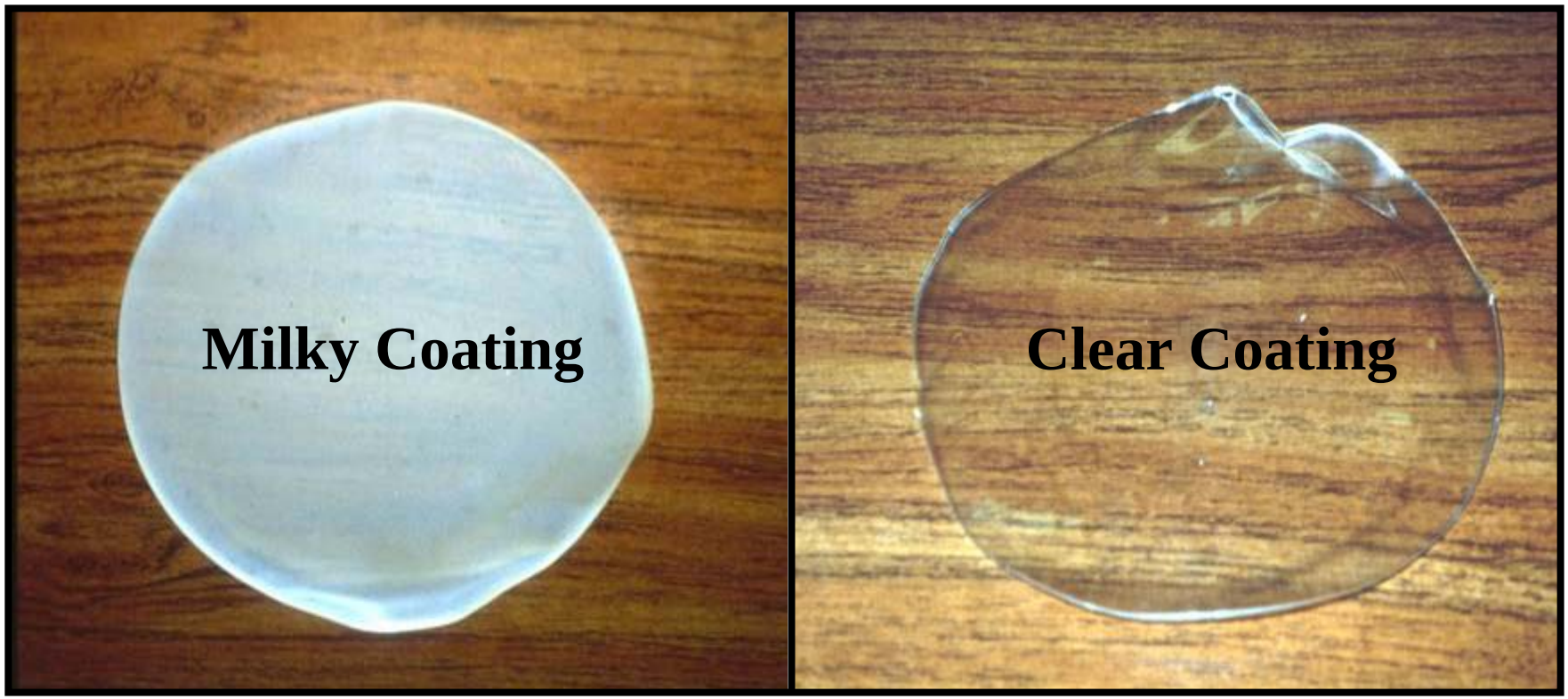
Sites of Water Loss





Water loss

Coatings can be milky or clear



Types of Edible Films & Coatings

- Hydrocolloids
- Lipids
- Composites

Composition of Hydrocolloids

Water based colloidal mixtures of proteins and/or polysaccharides

- ***Proteins***
  - **Casein, gelatin, wheat gluten**
  - **Corn, soy and whey protein**
- ***Polysaccharides***
  - **Cellulose derivatives**
  - **Alginates, Pectins, Starches**

Properties of Hydrocolloids

- Poor resistance to water vapor
- Barriers to oxygen & carbon dioxide
- Mechanical strength
- Water soluble (i.e., *hydrophilic*)
- Water insoluble (i.e., *hydrophobic*)

Examples of Lipids

- Waxes
- Fatty acids
- Acetylated monoglycerides
- Sucrose fatty acid esters
- Shellac

Properties of Lipid Coatings

- **Barriers to water vapor**
- **Coatings add gloss**
- **Lack structural strength & durability**
- **Require supporting matrix**
- **Many lipids exist in crystalline form**

Crystalline Lipids

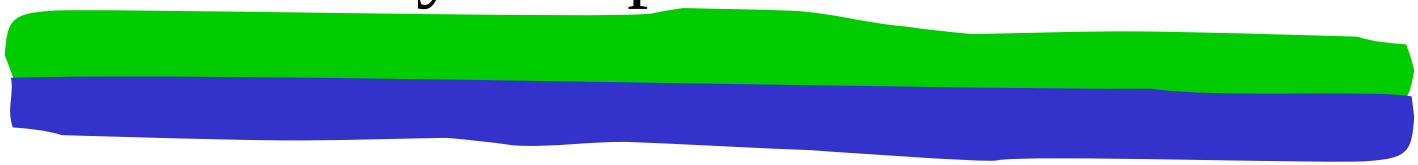
- **Many lipids exist in crystalline form**
- **Crystals are impervious to gases & water vapor**
- **Packing and orientation of the crystals determine film properties**
- **Liquid lipids have less resistance to gases & water vapor than crystalline lipids**

Structure of Composites

- ***Bilayers***
  - **One layer deposited over another**
- ***Conglomerates***
  - **A mixture of several components in one layer**

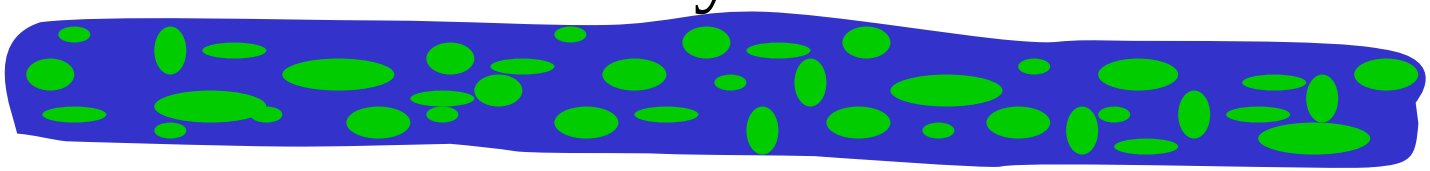
Bilayer

One layer deposited over another

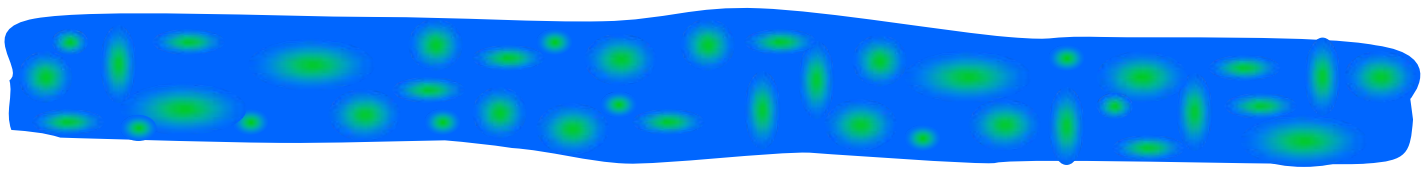


Conglomerate

A mixture of several components in one layer



Components distinct



Components intermixing

Properties of Composites

- **Combine advantages of components**
- **Lessen disadvantages of components**

- ***Example***
  - **Lipids provide a barrier to water vapor movement**
  - **Hydrocolloids provide the supporting matrix**
- ***Example***
  - **Films of casein and acetylated monoglycerides are effective barriers to water loss in fruits and vegetables**

Film Additives

- Modify mechanical properties of the film
- Cause significant changes in barrier properties

Components of Film Additives

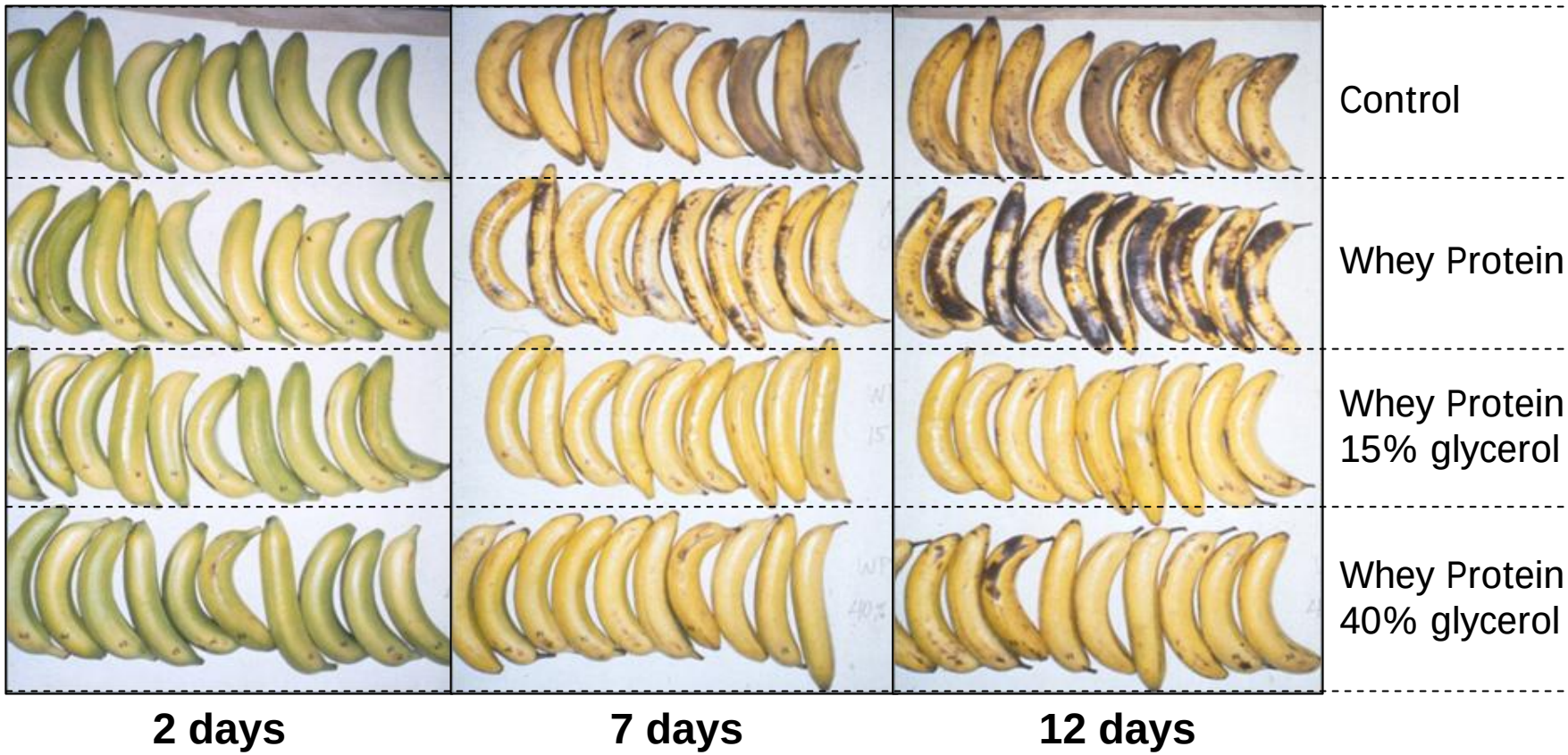
- **Antimicrobial compounds**
- **Antioxidants**
- **Flavor and aroma compounds**
- **Pigments**
- **Preservatives**
- **Vitamins**

Types of Film Additives

- ***Emulsifers*** keep the components in solution.
- ***Surfactants*** reduce the surface tension of the film formulation to achieve uniform coverage.
- ***Plasticizers*** modify mechanical properties
  - Water, relative humidity
  - Glycerol, polyethylene glycol
  - Acetylated monoglycerides, sucrose

Bananas coated with Whey Protein & Glycerol

Held at 20 °C

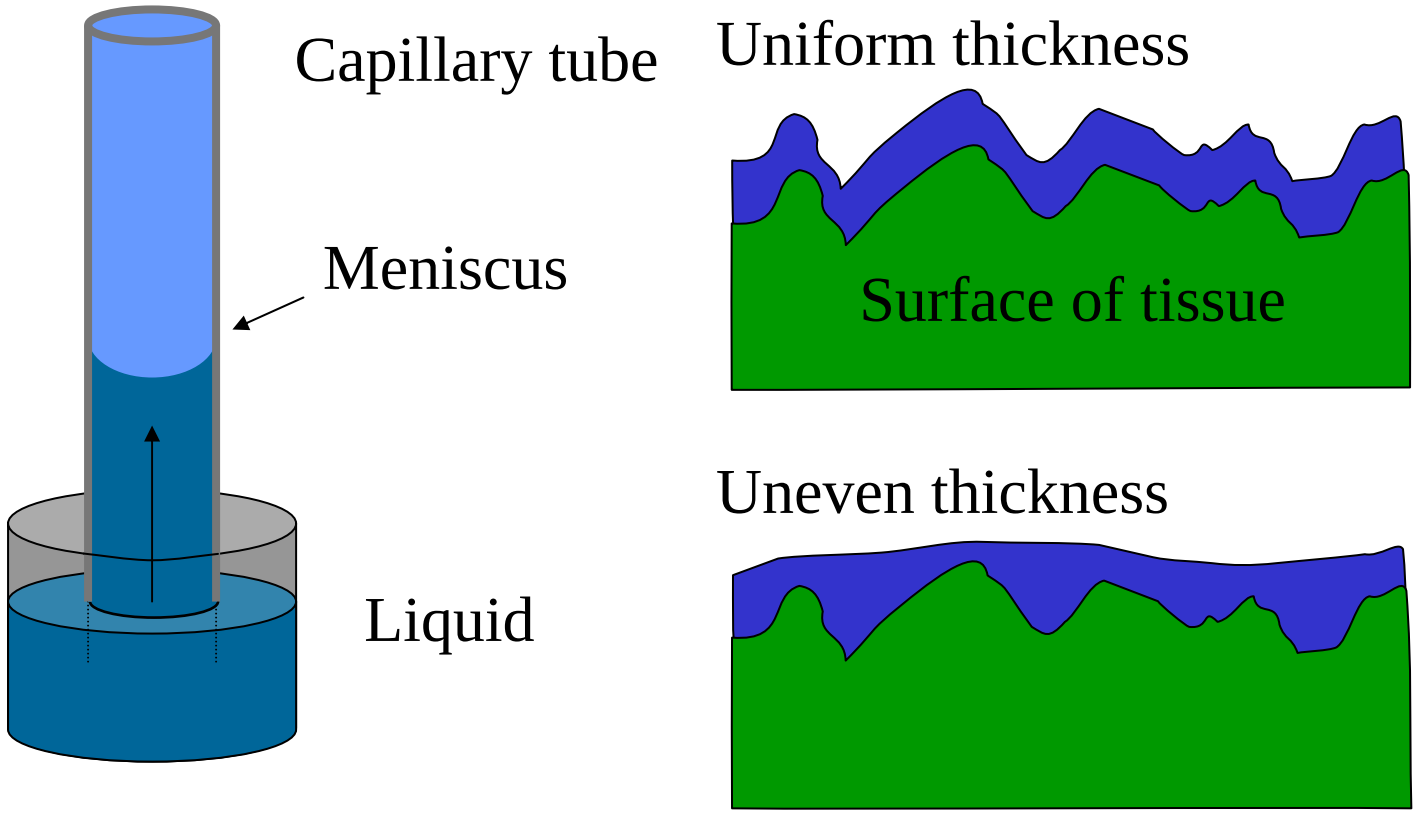


Application of Films & Coatings

- **Methods of application**
  - **Dip, spray, foam, Drip, Brush, Casting**
- **The hydrophobic nature of most fruit and vegetable cuticles makes it difficult to apply uniform coatings and films.**
- **Emulsifers, surfactants, and plasticizers are often needed for uniform coverage.**

Application of Coatings

Surface Tension and Film Thickness



Some Commercial Edible Coatings

- **NutreSeal** contains modified cellulose polymers
- **Nutri-Save** contains carboxymethyl chitosan
- **Pro-long** is based on sucrose polyesters of fatty acids and sodium salts of carboxy-methyl cellulose
- **Sealgum** and **Spraygum** are based on gum acacia & gelatin
- **Semperfresh** is similar to Pro-long, but with more short-chain unsaturated fatty acids esters
- **Shellac** is a resin secreted by an insect
- **Waxes** are long-chain fatty acids like beeswax, paraffin, & carnauda.

Effects of Edible Coatings

- **Reduces water loss**
- **Protects against contamination**
- **Reduces gas diffusion**
- **Establishes modified atmosphere**

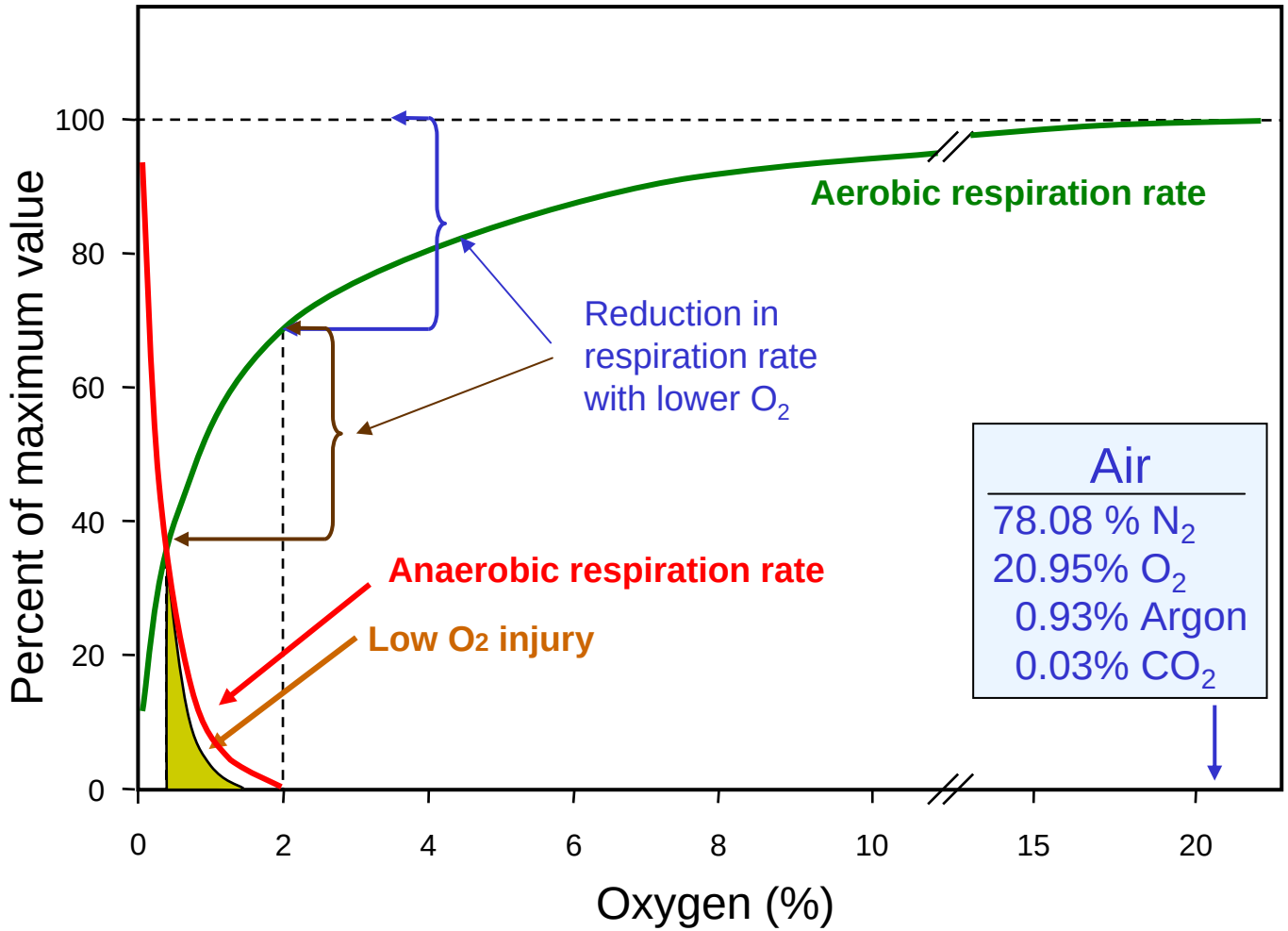
Benefits of Modified Atmosphere

- Retards respiration
- Prolongs market life
- Reduces chilling injury
- Combats disorders
- Controls diseases
- Eliminates pests

Diffusion of Gases

- **Carbon dioxide dissolves and diffuses through water 20-times faster than oxygen.**
  - $CO_2 + H_2O \leftrightarrow H_2CO_3$
- **Gases diffuse through air ~10,000-times faster than through a similar thickness of water.**
  - **A 0.1 mm film of water equals 1 meter of air.**
- **Liquid water can also move by mass flow to the surface and evaporate through natural openings and microscopic cracks.**

Effect of oxygen level on respiration

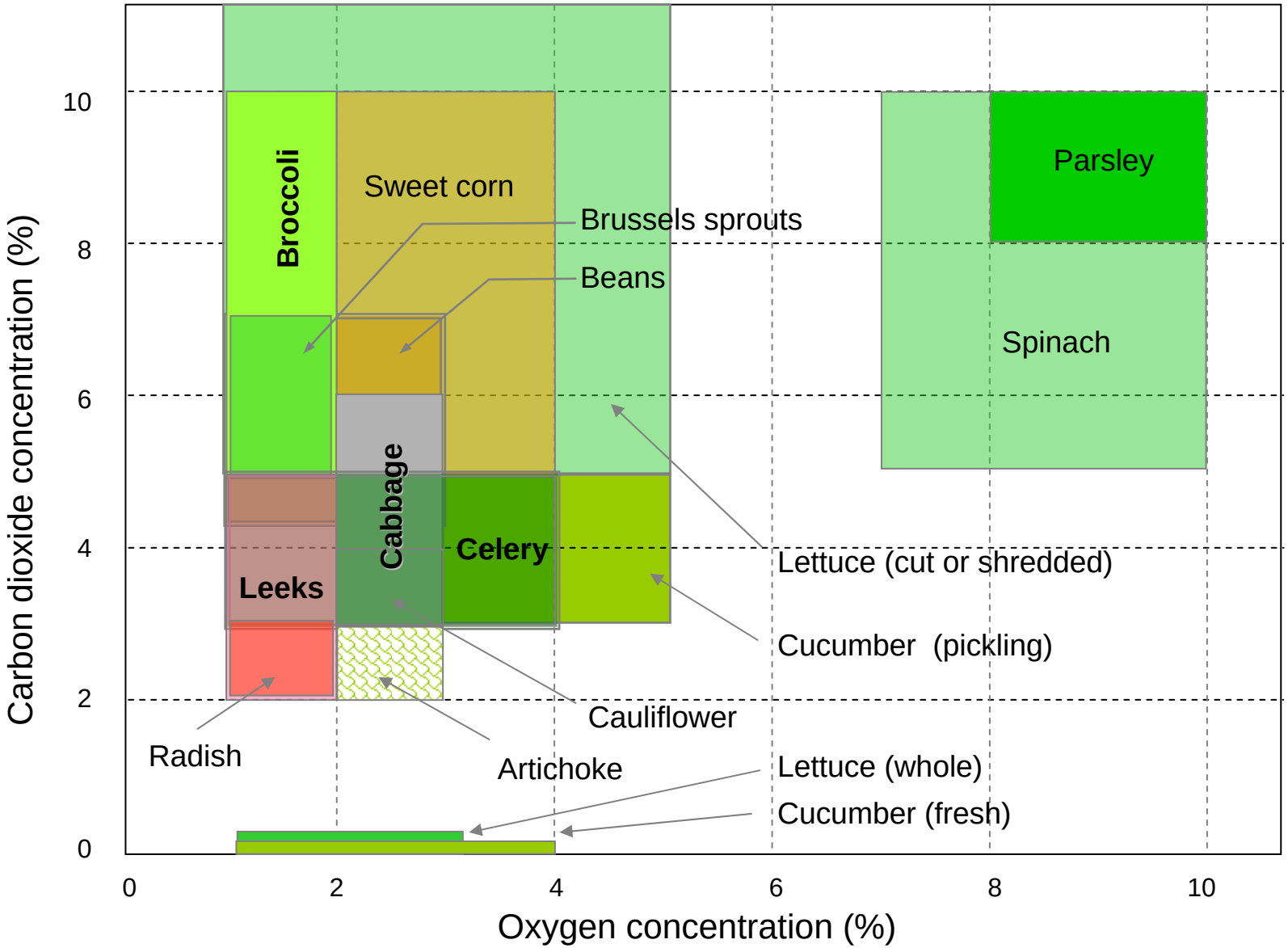


Modified Atmospheres

- **It is *easy to modify* the internal atmosphere within fruits and vegetables with films and coatings.**

- **It is *difficult to establish and maintain a specific atmosphere* within fruits and vegetables with films and coatings.**

Recommended CA For Selected Vegetables



Variations in Respiration Complicate Designing Modified Atmosphere Packaging

- Modified Atmosphere Packages (MAP) are designed so respiration of the commodity establishes and maintains the desired atmospheric composition of oxygen and carbon dioxide within the package.

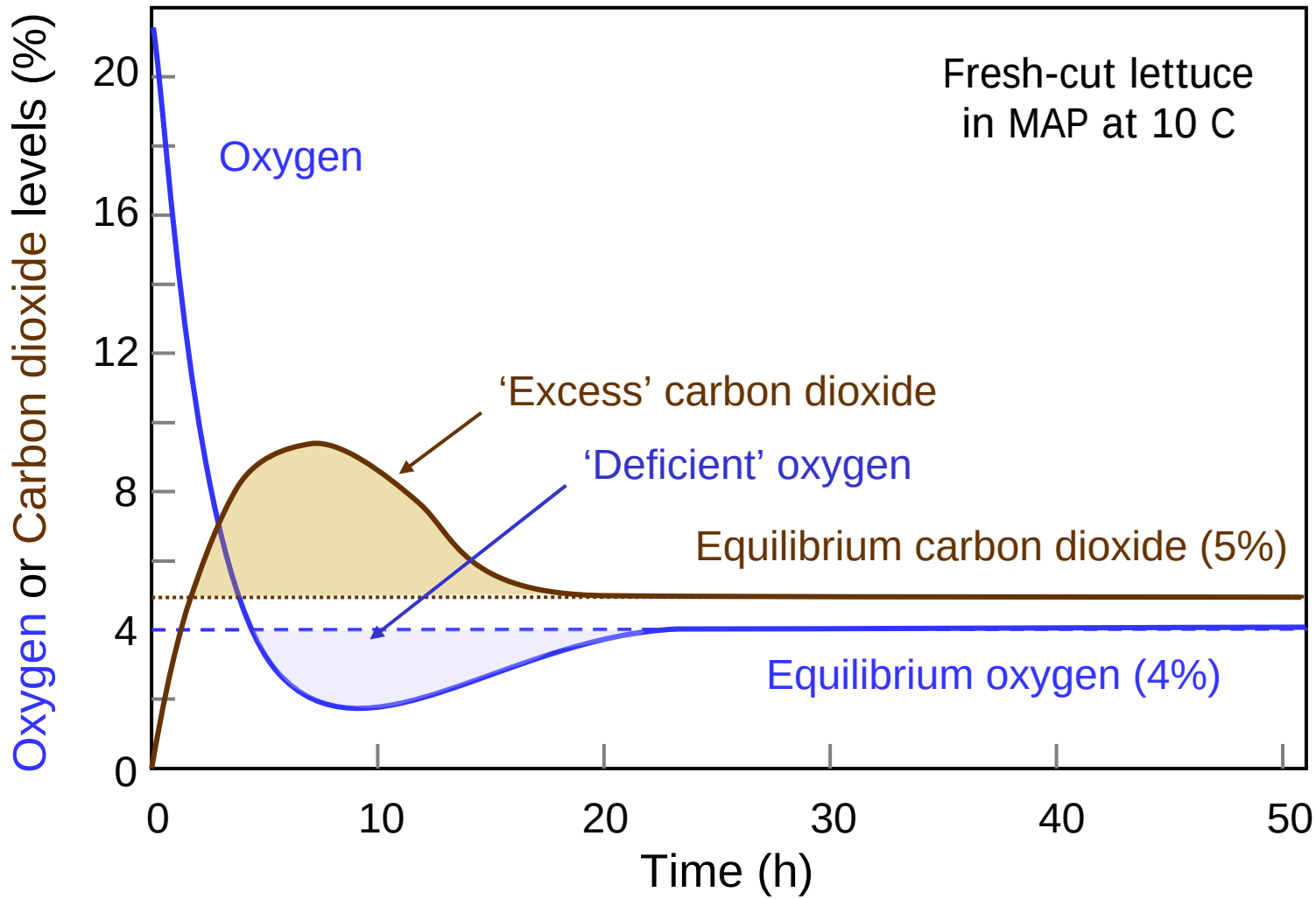
- Plastic films, package dimensions, and product amounts are combined to produce a package that will establish and maintain the desired atmosphere.

- Plastic films that have the correct gas permeability to maintain an establish atmosphere when tissue is respiring at a constant rate will be inadequate to accommodate the large burst of respiration following wounding.

- Oxygen levels may initially decline, and carbon dioxide levels may initially increase to injurious levels before equilibrium is established.

- The rapid increase, and later decline in respiration makes it very difficult to design MAP packages for fresh-cut produce.

Respiration of Wounded Tissue in MAP



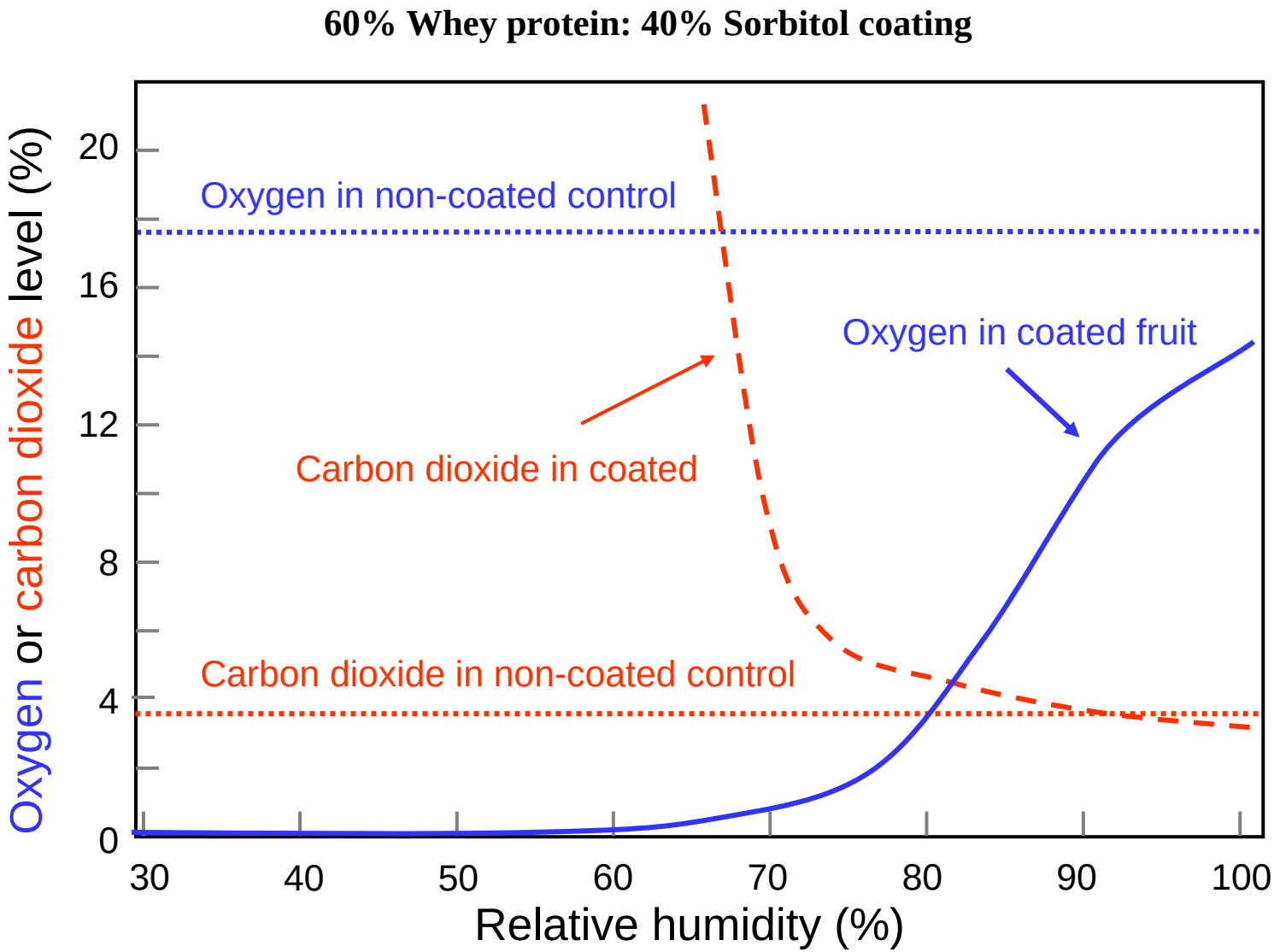
Factors affecting the Establishment & Maintenance of a Modified Atmosphere

- **Permeability of the film**
  - **Temperature, relative humidity**
- **Relative humidity and temperature**
- **Uniformity of coating**
- **Imperfections (cracks, holes, tears)**
- **Respiration of the commodity**
  - **Temperature, relative humidity, O_2, CO_2, ethylene**
  - **Cultivar, culture, stress, disease, disorders**

Difficulties in the Application of Films and Coatings

- **Relative humidity and temperature greatly influences film permeability.**
- **Relative humidity and temperature are insufficiently controlled in wholesale and retail environments.**
- **Freshly cut wet surfaces are difficult for films to adhere to and to uniformly cover.**
- **Physiologically active tissue alters its respiration and metabolism over time.**
- **Physiologically activ tissue may alter its mechanical properties over time.**

Predicted O_2 and CO_2 concentration in fruit



Future of Edible Coatings for Fresh-Cut Produce

- **Great potential, but limited application**
- **Mainly used to control moisture loss & respiration**
- **Used to alter surface appearance**
- **Could be used as a carrier for additives**
- **Main applications are with dry nuts, dried fruits (e.g., raisins) and freeze dried foods.**

Sociological Factors of concern for use of Edible Coatings

- **Food allergies**
  - **(e.g., peanut and milk proteins)**
- **Dietary preference**
  - **(e.g., vegetarian, milk protein)**
- **Religious concerns**
  - **(e.g., pork fat)**
- **Not ‘natural’**
  - **(e.g., coating not from the commodity)**