Target atmospheres

Produce	Temp (C)	O_2 (%)	CO_2 (%)	Comments
Blueberry	**0-5**	**5-10**	**8-15**	Reduces water loss and decay

Target atmospheres from https://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/

Packaging Calculations

Oxygen transmission rate = Film O_2 Permeability

Thickness of plastic

O_2 in atmosphere (21% – target O_2 in bag) (from research)

$$OTR = RR \bullet t \bullet W/A \bullet (air\ O_{2atm} - target\ O_{2pkg})$$

Respiration rate (consumption of O_2) at the storage temperature

= MAP is **temperature specific**

Measure or from tables

Weight in bag (kg)

Surface area of bag or lid

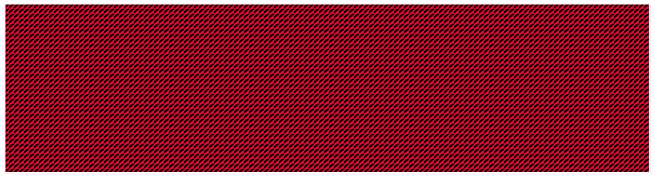
width x height

(x 2 for bag)

Plastic films

Structures	Characteristics
Monolayer	One resin one single layer film
Engineered polymers	Different resins blended to make a monolayer film
Laminated	Different film layers are joined by adhesives or molten polymers
Coextruded	Multiple film layers are incorporated into a single structure during manufacturing

LDPE-EVA Blend



LDPE-EVA Coextrusion

LDPE-EVA Lamination

Selected plastic films

Material	OTR	Characteristics
LDPE low density polyethylene	450-500	Most commonly used in packaging Good stiffness and clarity
EVA ethyl vinyl acetate	600-900	Available as a copolymer in LDPE (2 to 28%) Increase in EVA = decrease in stiffness + increase OTR Clarity increases to about 6% EVA
PP polypropylene	300	Used commonly in core layers of co-extrusions Good stiffness
BOPP Bi-Axially Oriented PP	80-260	Used as the outer layer in many produce laminations Excellent stiffness and clarity.
PET or PETE Polyethylene-terapthalate polyester	5	Can be used in lidding material in combination with micro-perforation or high breathability patches. PET alone is a good oxygen barrier film May be coated for various seal applications

OTR units = cc/100 in^2/ mil/atm/day !!!

Perforated Materials

Macroperforated

- Holes visible to the naked eye
- Reduce water loss without modifying O_2 and CO_2
- Prevents produce from going anaerobic

Microperforated

- Holes of 40-200 um; not visible to the naked eye
- Usually made by laser
- Useful for products with a high respiration rate
- Low-mod O_2 with a mod-high CO_2
- i.e. cannot have low O_2 and low CO_2
- Note: O_2 + CO_2 = about 21%
- High RH

Packaging to reduce water loss

Options

- Packaging with macroperforations
- Package liners – folded not sealed
- Shrivel sheets
- Clamshells

Reduce water loss but don’t change atmospheres

Additional topics

- Sustainability
- Recycling
- Compostability
- Marketing and branding
- Condensation
- High water vapor transmission rates (WVTR)
- Anti-fog
- …

Measuring gases in the MAP

- Mocon O2/CO2 analyzer

Hypobaric storage

Hypobaric storage

- Cold storage with partial (10 kPa)
- Reduce ethylene
- Reduce respiration rate
- Usually vent with water saturated air
- Commercial system - cylindrical drums

RipeLocker
PROLONGING FRESH

Coating agents

Same challenges as MAP

- Hard to achieve right atmosphere if retailed at ambient – usually only reduce water loss
- Lose the ‘bloom’ (waxy layer)

• Apeel, Mori, Decco etc

Ethylene

- Keep ethylene sources away from sensitive products

  Sources: Vehicles, floor polishers, forklifts, decaying produce, exhaust from ripening rooms etc.

- Avoid mixed loads of ethylene producers/ethylene responders

  Blueberry – low production and low sensitivity

Low production High sensitivity	Moderate to high production Low sensitivity
kiwifruit, mature-green tomato, watermelon, plantain	ripe tomato, feijoa, fig
spinach, brassica vegetables, herbs	

Ethylene production is not related to sensitivity

1-MCP (ethylene action inhibitor)

- Needs registration !!
- Firmer blueberries especially with some cultivars
- Not a wow effect

Suppliers:

- AgroFresh
- Pace
- Jansen
- Hazel Tech
- Verdant etc.

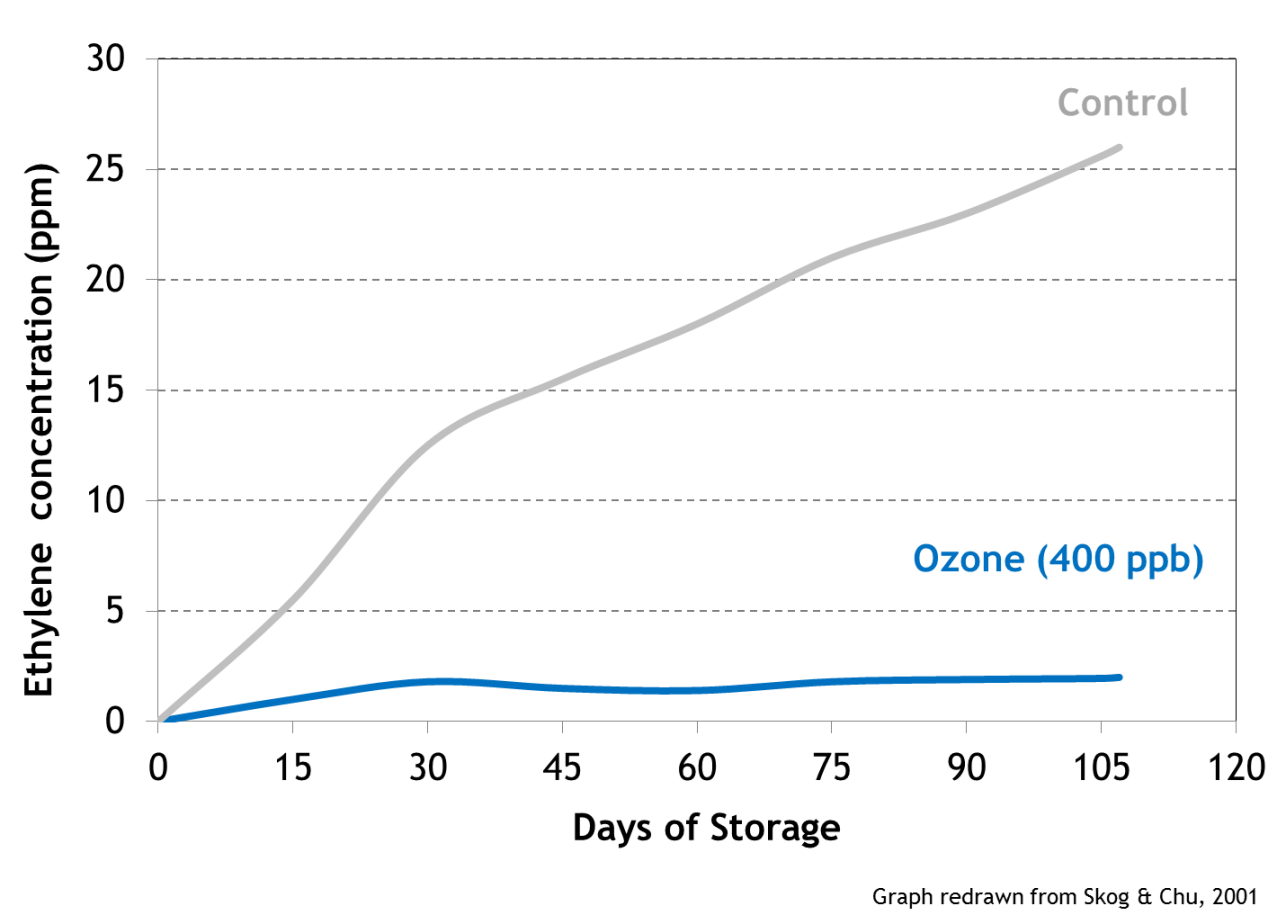
4. Ethylene removal

1. **Ventilation**
   - One air exchange per hour
   - Cheapest method even when considering cooling (or heating) costs

2. **Oxidizers -** Oxidize ethylene to CO_2 and water e.g.
   - Ozone
   - Potassium permanganate ($KMnO_4$)
   - Photocatalytic oxidation

3. **Sorbents** -Direct sorption of ethylene e.g.
   - Activated carbon,
   - Clays,
   - Zeolites
   - Palladium based products

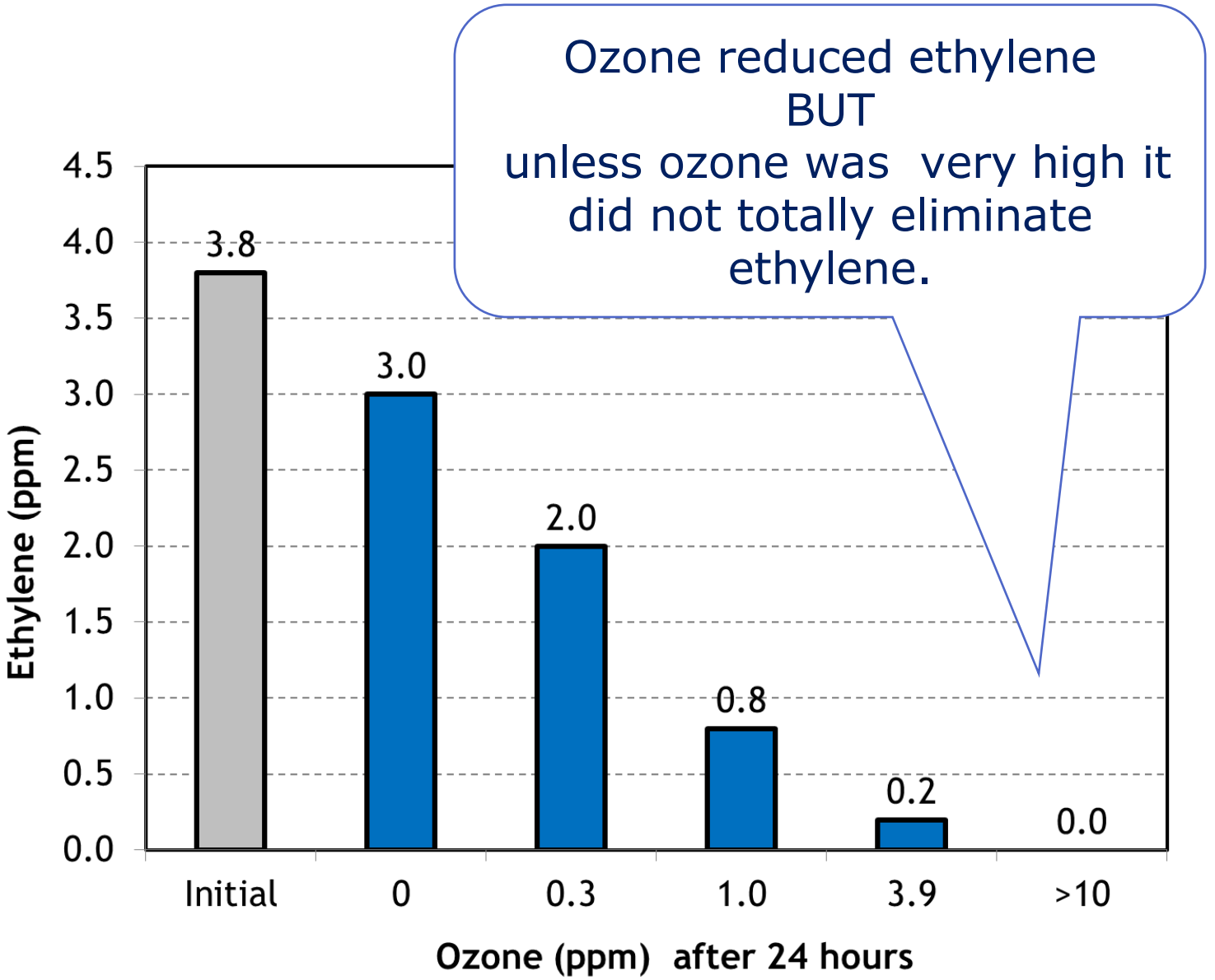
Ozone on Ethylene



Ethylene (ppm or uL/L) in rooms at 1°C containing apples and pears

- left untreated (control)
- exposed to 0.4 ppm ozone (Skog & Chu, 2001).

Ozone on Ethylene



A sealed (59.8 m^3) container at 0°C (32°F) with ethylene 3.8 ppm (3.8 uL/L) and an ozone generator (Palou, Smilanick, Crisosto & Mansour, 2001).

OSHA

TWA = 300 ppb (0.3 ppm)

STEL = 100 ppb (0.1 ppm)

Measuring firmness of blueberry

Hand feel

Mouthfeel

Compression

- Max force (N)
- Rupture point (N)
- Force/deformation (N/mm)

Penetrometer

- Skin break/toughness (N)
- Distance to break (mm or % strain)
- Skin break work energy (J)
- Stiffness (M/mm or N/%)

Texture profile analysis

- Hardness
- Springiness (mm)
- And many more obscure measures

Impact force response (drop test)

- Duration of impact
- Shear force (N/g)
- Laser air puff (kPa/mm)

Versus pome and stuff fruit force (N)

Measuring firmness - Equipment

- **Instron**
- **Ametek force transducer**
- **Portable firmness device**
- **FirmTech**
- **Durometere**
- **Wagner gram dial**
- **Stable Texture analyser**
- **Berry bounce**
- **Laser air-puff**
- **ZwickRoell Texture Analyzer**

TA.XTPlus Texture Analyzer

(Stable Micro Systems, Hamilton, MA, USA)

- Destructive penetration tests
- 2-mm flat cylinder probe (TA-52)
- Data from the force deformation curve,
  - peak force "skin strength" (<1 N or 0.1 kg)
  - Young's modulus "skin elasticity"
  - Deformation at peak force "area under skin strength"

Sulphur dioxide

- SO_2 (fumigation or slow release) reduces decay
- Works well in perforated bags, clamshells, open baskets or with MAP

Control	28% decay
SO_2	7% decay

(Rodriguez & Zoffoli, 2016)

- MRL
- Market acceptance