Postharvest Handling Insights

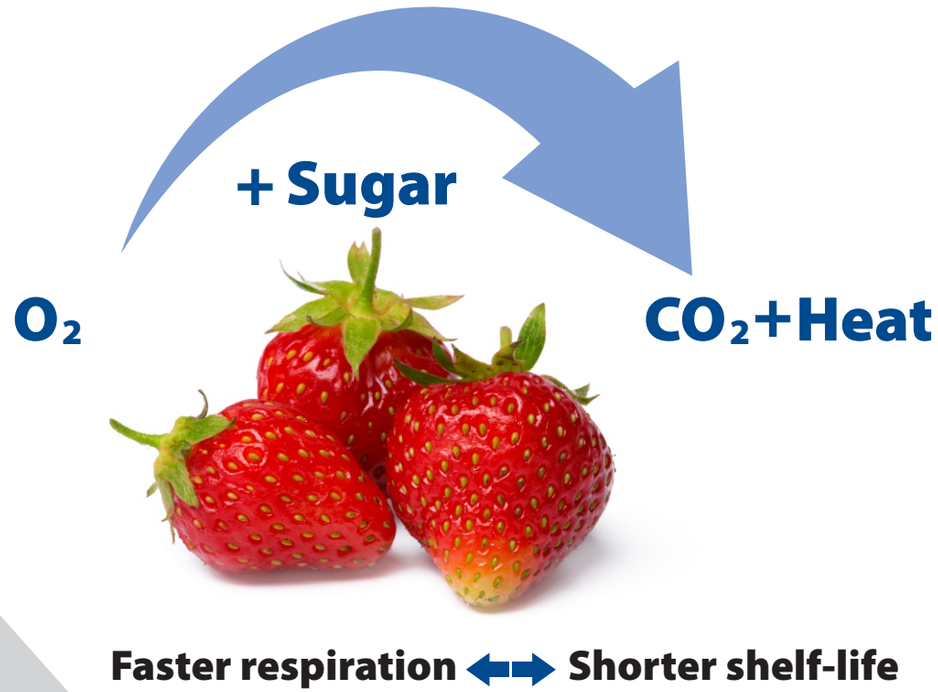
Food Challenge

33% of food is wasted due to mold, bacteria and respiration during post-harvest, packaging, transportation and storage

Biological Factors Involved in Produce Quality and Deterioration

Respiration

- Perishable products are alive
- All life processes (including senescence) require respiration
- When produce is stored, they break down into $C_6H_{12}O_6 + 6O_2 = 6\ CO_2 + 6\ H_2O + Heat$ ↺
- Rate of deterioration $\propto$ Respiration rate



Faster respiration ⟷ Shorter shelf-life

Temperature Effects on Respiration

- As temperature increases, the rate of respiration and associated deterioration increase *exponentially*
- For every 10 °C (18 °F) increase in temperature, the rate of respiration increases 2 fold
- The effect of this increase in respiration is a proportional decrease in shelf-life of the produce
- High temperatures also accelerate water loss, disease growth and defects in appearance

Biological Factors Involved in Produce Quality and Deterioration

Pathological Disorders

Diseases are the greatest cause of postharvest losses in all fresh berries

The best methods for disease control are similar for all fresh berries:

- Prompt cooling
- Storage at the lowest safe temperature
- Preventing physical injury to the fruit
- Reduce moisture loss
- Storage and distribution under high carbon dioxide atmosphere
- Sanitizers as a processing aid in combination with all of the above
- Keep diseased or wounded berries out of packages as rot can spread from diseased to nearby healthy berries (nesting).

Botrytis Rot (Grey Mold). Caused by Botrytis cinerea is a common pathogen on berry fruit. This fungus continues to grow even at 0°C (32°F), however growth is very slow at this temperature.

Rhizopus Rot. Caused by the fungus Rhizopus stolonifer. Spores of this fungus are usually present in the air and are easily spread. This fungus will not grow at temperatures below 5°C (41°F), therefore temperature management is the simplest method of control.

Biological Factors Involved in Produce Quality and Deterioration

Responses to Ethylene

Strawberries, blackberries and raspberries do not respond to ethylene by stimulation of ripening processes.

Blueberries are climacteric fruit and respond to ethylene; but should be harvested near to full ripe as sugar content does not improve after harvest. Removal or management of ethylene found in storage air may reduce the speed of disease development.

Responses to Controlled Atmospheres (CA)

The use of Controlled atmosphere (CA) & Modified atmosphere (MA) packaging during refrigerated storage and shipment of berries is well documented and beneficial. In addition, after transferring from CA/MA to air the beneficial effects continue for several days.

Atmospheres of 10 to 20% carbon dioxide and 5 to 10% oxygen reduces the growth of Botrytis cinerea (Grey Mold Rot) and other decay causing organisms, and reduces the respiration and softening rates of all berries.

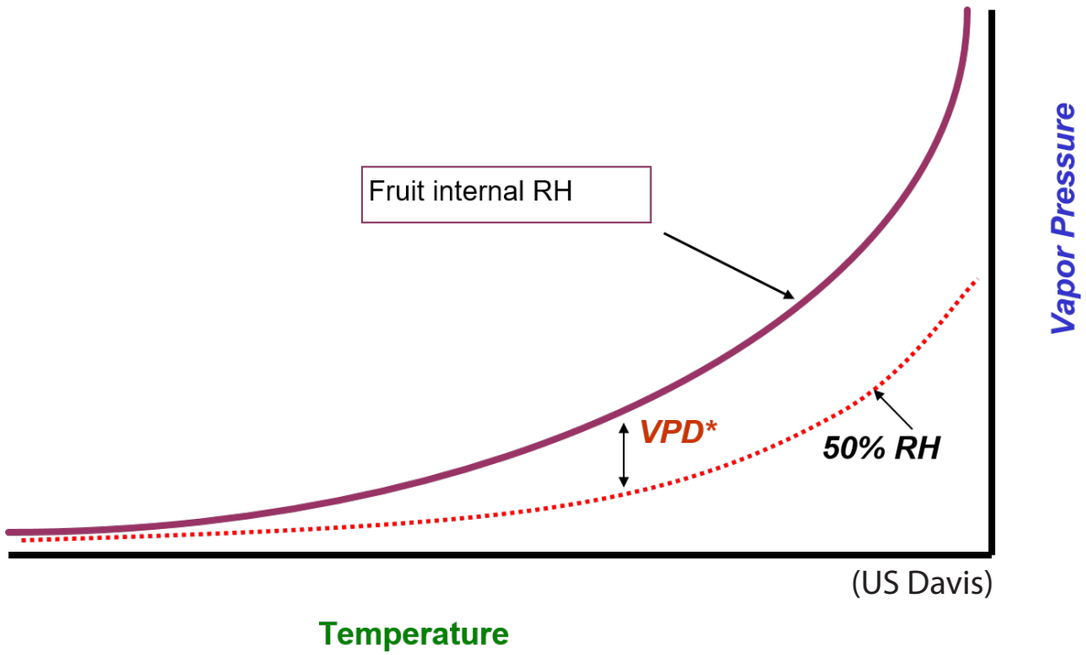
Although 15 to 20% CO_2 + 5 to 10% O_2 is a good basic starter recipe for CA/MA of berries, there are a number of factors required to optimize the outcome. These include known factors such as temperature, maturity, condition, and less known factors such as variety specific responses to CA/MA for blueberries, raspberries, strawberries, and blackberries. Adjusting for factors like varietal differences, storage time, and turn out procedure when using CA/MA atmospheres during storage or transport will help to maintain quality and extend postharvest life.

Whole pallet covers and consumer packages for containment of the modified atmosphere and reducing moisture loss are commonly used. Prompt cooling should always be done before or in conjunction with atmosphere modification.

Postharvest Handling Consideration to Prevent Moisture Loss in Produce

Temperature vs Water Loss

For a given relative humidity, the rate of water loss increases logarithmically with increasing temperature (and VPD)



*Vapor pressure differential

Preventing Water Loss From Produce

Reduce temperature!!
- Cold produce respire less and gives off less moisture
- Cold air also holds less moisture

Increase ambient VP
- Increase the realtive humidity of the ambient air
- Use Plastic Pallet enclosures or bags/packaging

Avoid temperature breaks in the cold chain
- Keeping produce at a constant temperature prevents condensation
- Preventing condensation reduces the development of decay

Key Factors Involved in Produce Quality Balance

Key factors for maintaining quality and shelf life of fresh berry products include:

- Using high **quality raw product**
- Following **strict sanitation procedures**
- **Minimizing** mechanical damage
- Using appropriate **packaging**
- Package with an **appropriate modified atmosphere**
- **Carefully control product temperature!**
  Start reducing toward 0 to 1°C (32 to 34°F)
  immediately after harvest and throughout storage,
  transportation, and distribution.

Cooling Begins in the Field

Prevent heating in the field. Shorten time before cooling begins.

Temperature management

Insures best product quality
Longest shelf life
Reduces microbial growth
Required for MA packaging

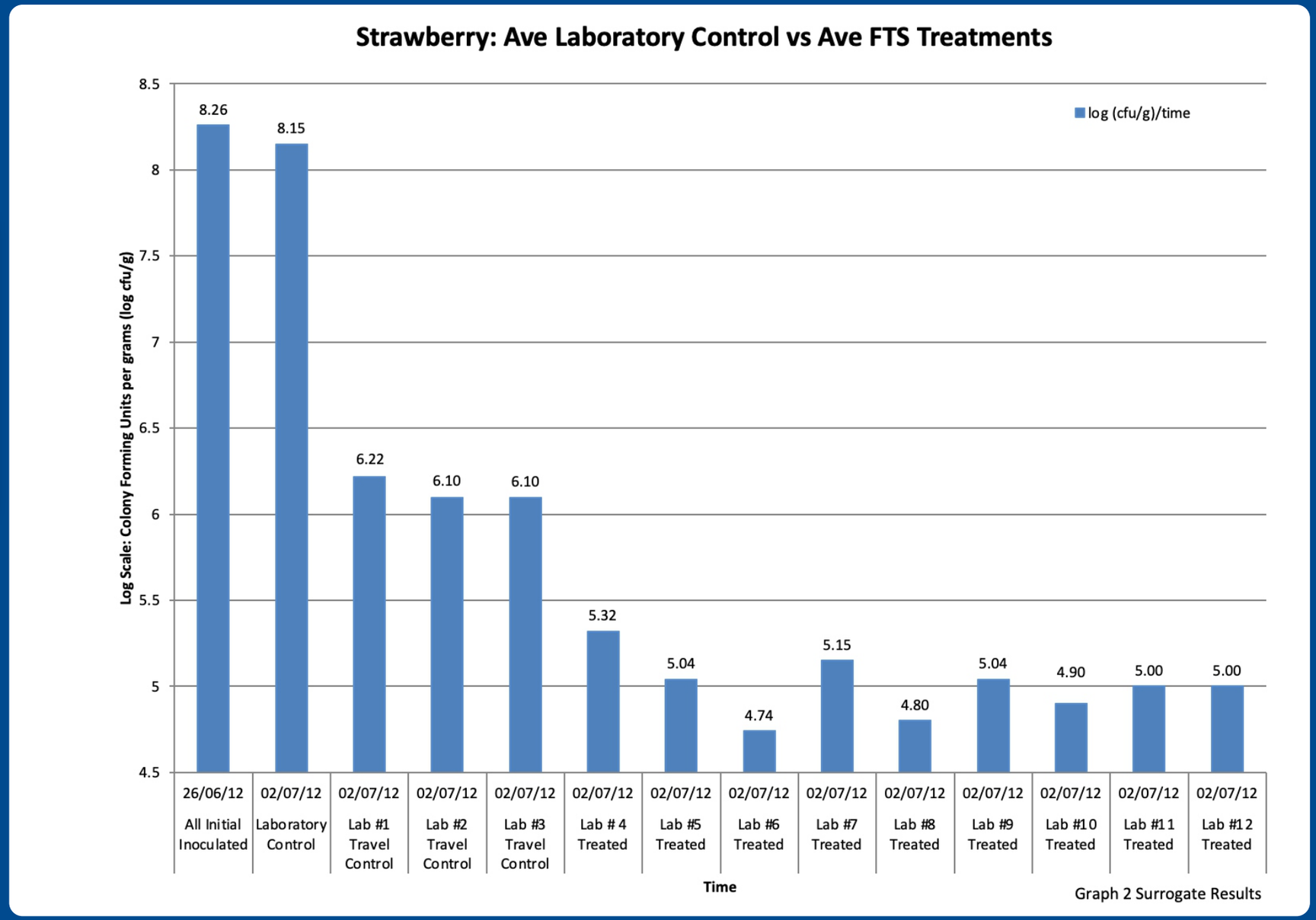
Understanding How to use Sanitizers with your Process

Fresh ProTech Plus Sanitizers:

- **Better and safer berries are achieved by slowing respiration, reducing decay and microbial growth, and preventing moisture loss.**
- **Fresh ProTech is OMRI approved for Organic produce, the sanitizers we use are USDA and FDA approved for food.**
- **Fresh ProTech Plus is "ACTIVE" not "passive" it cleans the air and surfaces of berries, attacking mold, spoilage organisms, ethylene, and even pathogens which means better safer products**

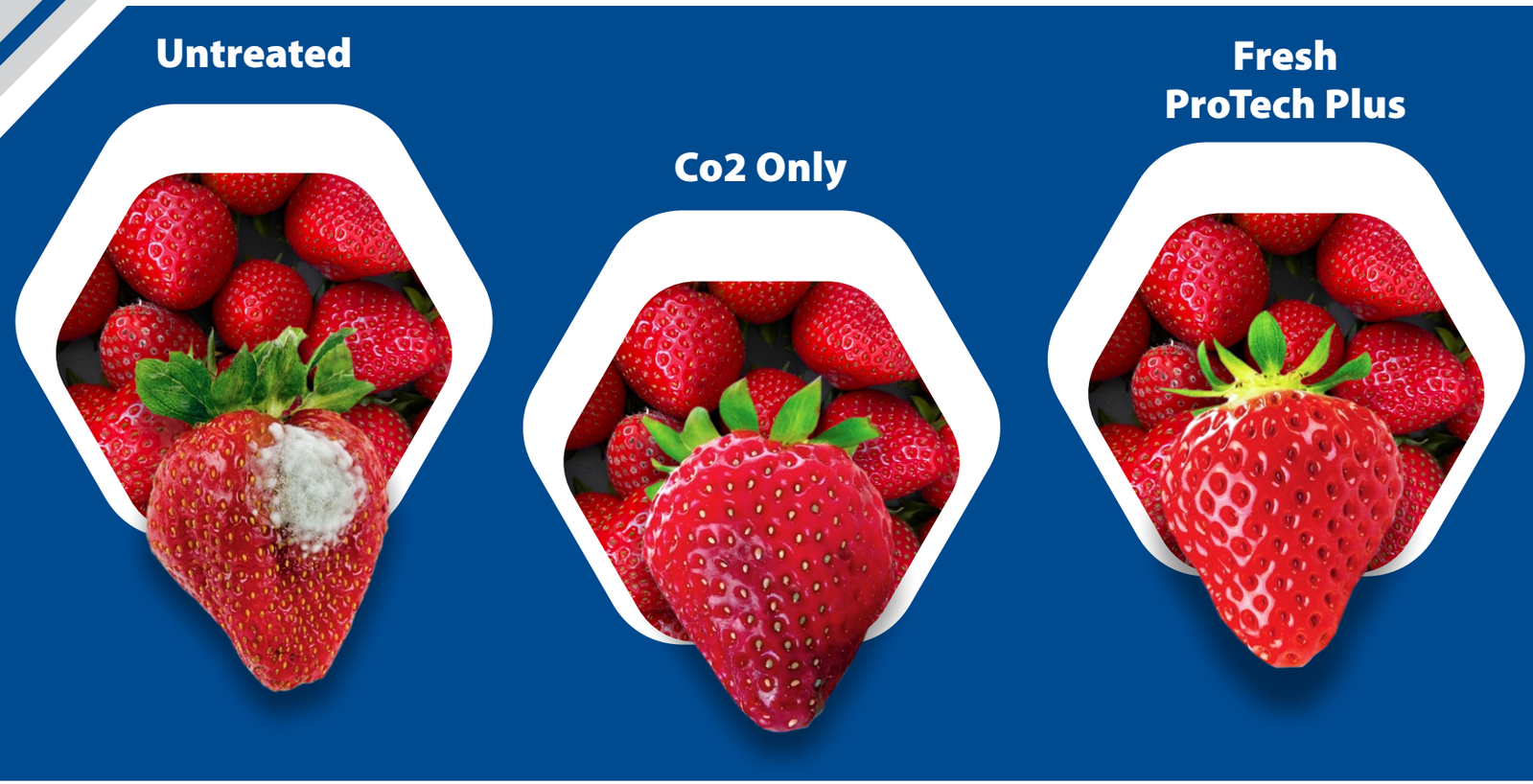
Understanding How to use Sanitizers with your Process

In replicated trials Fresh ProTech Plus is proven to be 30 X better than NO treatment and >10 X better than CO2 alone in reducing e-coli & microbial growth



Graph 2 Surrogate Results

Innovative MAP Treatments on Strawberries



Fresh ProTech Plus is an **innovative process** that combines **modified atmosphere packaging**, a proven science-based solution for protecting perishable products, and a highly effective sanitizer treatment.

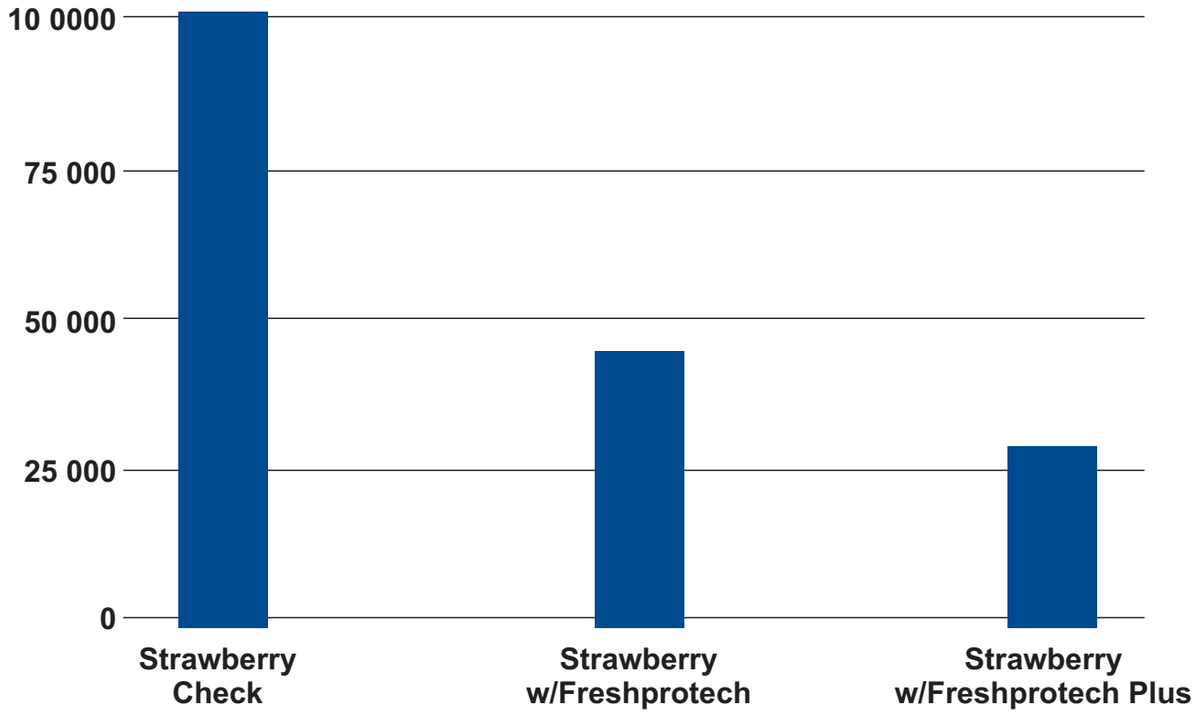
This patented process uses **sanitizers** and **functional treatments** to safely reduce the level of microorganisms on contact, leaving no chemical residue.

Understanding How MA Works

- **Fresh ProTech™ CO_2** treatment is a very effective alternate postharvest technology to Tectrol CO_2 for the establishment of MA
- **Fresh ProTech™ Plus with Sanitizer** is a more effective Modified Atmosphere than CO_2 or N_2 treatments alone
- **Fresh ProTech™ Plus with Ozone** is a more effective Modified Atmosphere than CO_2 treatments alone

Understanding How MA Works

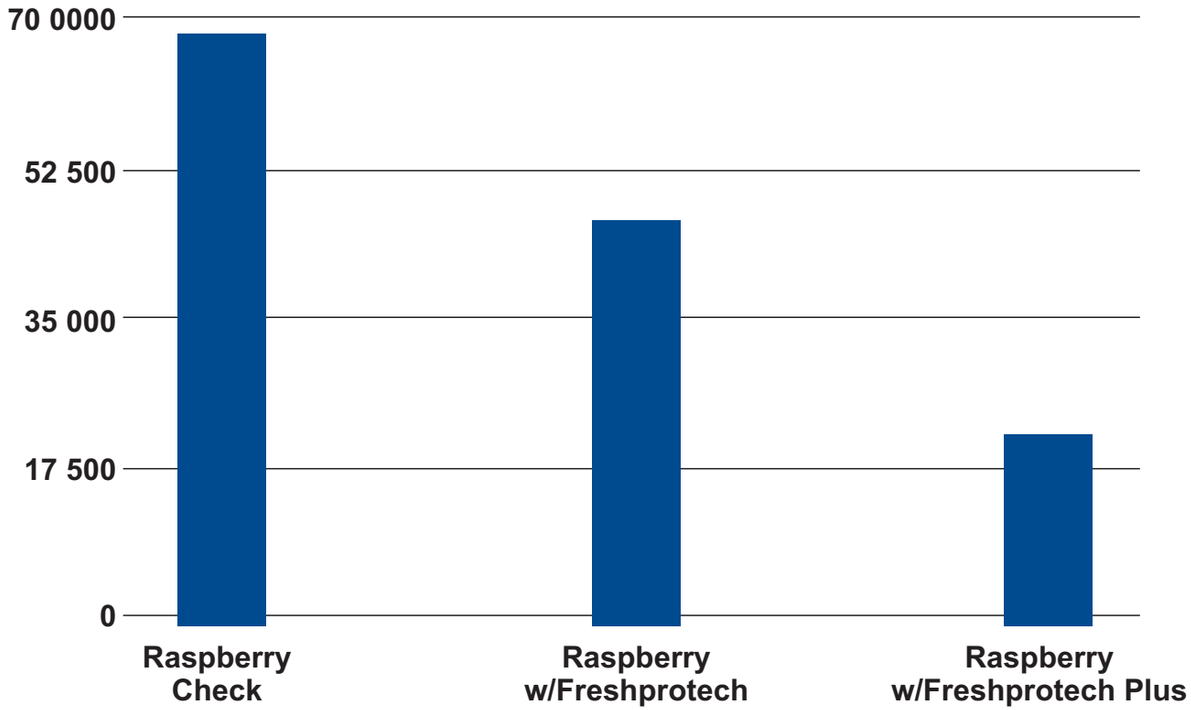
Potential Benefits of MA: Strawberries after
7 Days at 34°F/1.1°C + 2 days at Room Temp. 68°F/20°C



Potential Benefits of MA in Strawberries: Reduction in Mold (CFU/gm)

Understanding How MA Works

Potential Benefits of MA: Raspberries after
7 Days at 34° F/1.1°C + 2 days at Room Temp. 68°F/20°C



Potential Benefits of MA in Raspberries:
Reduction in Mold (CFU/gm)

Understanding How MA Works

Potential Benefits of MA in Asparagus: After 14 Days
Commercial Trails Showed **$166 Savings per Pallet** vs Untreated Asparagus

Un-Treated
Day

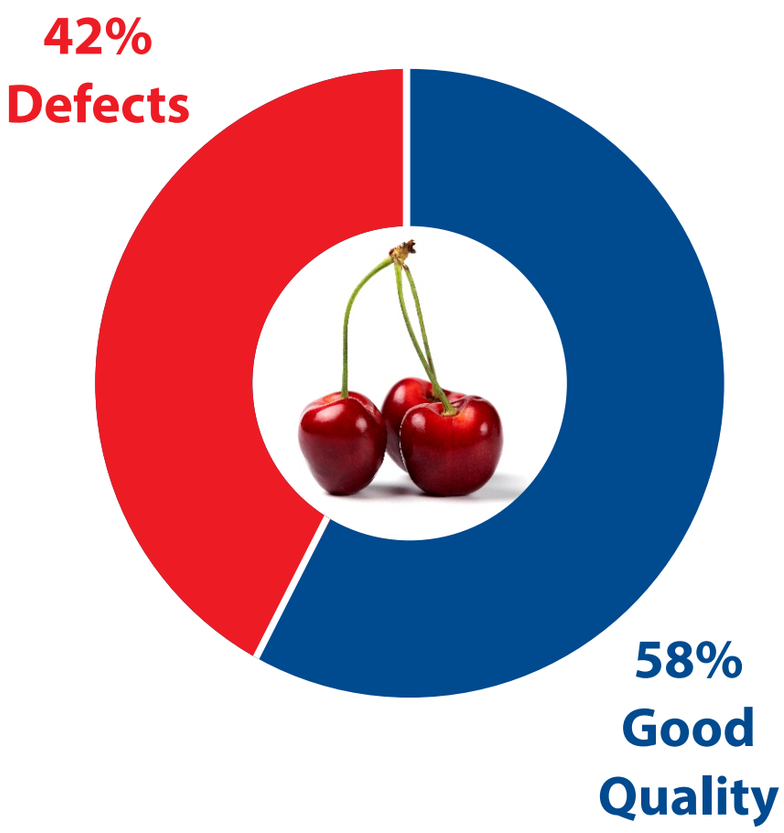
Fresh ProTech
14 Day

Fresh ProTech Plus
14 Day

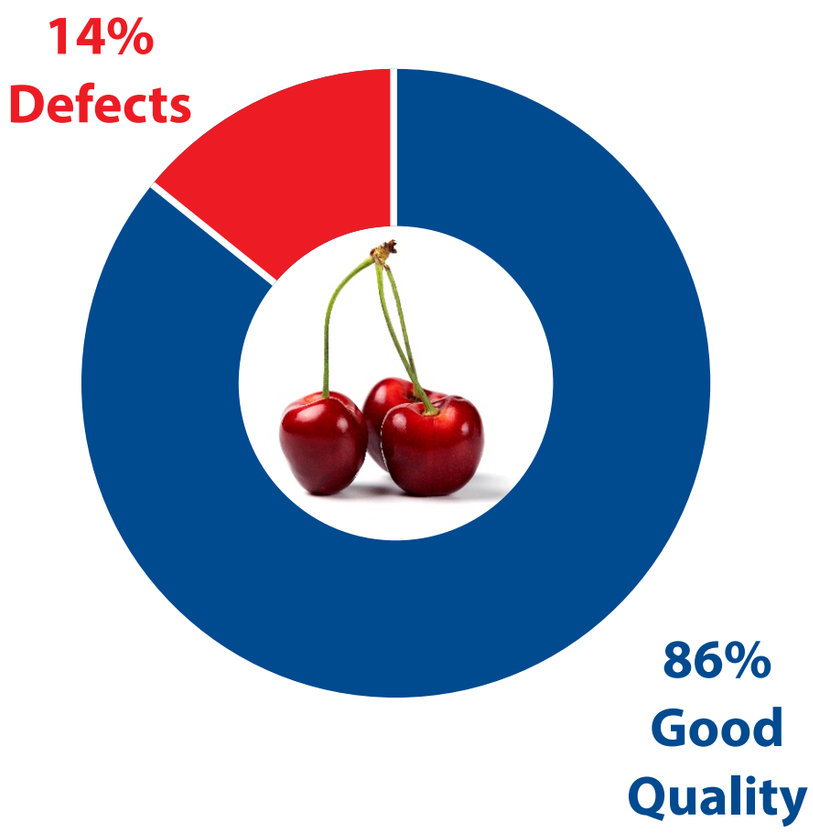
Understanding How MA Works

Potential Benefits of MA: Cherries after 21 Days at 32°- 40°F

Industry Standard



Fresh ProTech



Understanding How MA Works

Potential Benefits of MA: Cherries after 21 Days at 32°- 40°F

With Fresh ProTech

- Brighter Shinny Color
- Fresher Greener Stems
- Still Firm
- Minimum Dehydration
- Zero Decay

14% Defects

Split & Mechanical Damage (No Mold)

Over Ripe & Soft (No Mold)

3 times less Defect

Understanding How MA Works

Potential Benefits of MA: Cherries after 21 Days at 32°- 40°F

Split & Mechanical Damage

Mold

Industry Standard

(No Mold)

Fresh Pro Tech

Over Ripe & Soft

Mold

Industry Standard

(No Mold)

Fresh Pro Tech

Understanding How MA Works

Potential Benefits of MA: Organic Table Grapes after 18 Days

Industry Standard

Fresh ProTech

- **Fresher, greener**, and more **flexible** rachis
- Better **firmness, color**, and **appearance** of fruit
- Elimination of shatter, watery, soft, burst or dehydrated fruit
- More **Homogenous temperature** in each box
- Significant reduction of time for **pre-cooling** and energy cost savings
- Reduced **labor**

Understanding How MA Works

Potential Benefits of MA: Cherry Tomatoes after 21 Days at 50° F

CONTROL
73% of consumer packs with Mold & Decay

Treated With Fresh ProTech Plus

Only 13% of Consumer Packs Had Very Slight Mold/Decay

- **Fresher,** better **appearance and firmness**
- Reduction of **Mold & Decay from 73% to 13%**
- Reduced **Shrivel to 1/6 of control**
- Defects in quality **reduced to 1/8 of control**
- Substantial **reduction of dehydration & weight loss**

Understanding How MA Works

Potential Benefits of MA: Yellow Zucchini after 21 Days

CHECK

WITH LINER BAG

36% With Defects
64% Good Quality

WITH FRESH PRO TECH

16% With Defects
84% Good Quality

2.25 Times LESS Defects

Understanding How MA Works

Potential Benefits of MA: Yellow Zucchini after 21 Days

- **Fresher** and better **appearance** of stem
- Defects in quality **reduced by 50%**
- Substantial **reduction of dehydration**
- More **Homogenous** temperature in each box
- Reduction of time for **pre-cooling by 50% with lower** energy costs
- Reduced **labor**

Check

With
Fresh Protech

With liner bag

Food Challenge and a Real Solution

Challenge

33% of food is wasted due to mold bacteria and respiration during post-harvest, packaging, transportation and storage

Solution

Fresh ProTech TM Modified Atmosphere Packaging (MAP) with Active Sanitizers & Functional Treatments slows the respiration rate, reduces decay and microbial growth, while preventing moisture and weight loss

Retailer Benefits

- Extended produce shelf- life, quality and freshness while increasing the ROI through a significant reduction of labor, packaging materials, quality rejection and shrinkage therefore, representing globally, the most sustainable and proven solution in the industry
- Minimized food safety risks and cross contamination through a reduction of mold, decay and overall produce defects
- Important saving on labor and quality inspections
- Increased consumer satisfaction with repeated purchases due to better quality and appearance, less bruising and waste, fewer claims, along with a clear reduction of greenhouse gas emissions

Shipper Benefits

- Extended produce shelf- life, quality and freshness while increasing the ROI througha a significant reduction of labor, packaging materials, quality rejection and waste, therefore, representing globally, the most sustaninable and proven solution in the industry
- Less vibration and shrinkage/spoilage due to its special patented wrapping system
- Minimized food safety risks and cross contamination through a reduction of mold, decay and overall produce defects
- Important saving on labor (4-6 people per shift vs competitors), energy and quality inspections
- Reduce customer dissatisfaction from fewer quality claims, rejections and adjustments
- Increased consumer satisfaction and repeated purchases due to better quality and appearance, less bruising, waste and complains

Benefits

Retail Price, Cost of Process, Savings

RETAIL		Low Shirink 10%				TIMES	BENEFITS (USD)			
Commodity	Price*	100% Loss	50% Savings	Cost of FTD	Benefits	Cost vs Benefits	Savings per PALLET	Savings per WEEK	Savings per MONTH	Savings per YEAR
Strawberry	3.95	0.40	0.20	0.030	0.168	6	198	118,500	509,550	6,114,600
Blueberry	3.72	0.37	0.19	0.029	0.157	6	195	117,180	503,874	6,046,488
Blackberry	3.93	0.39	0.20	0.030	0.167	6	197	117,900	506,970	6,083,640
Raspberry	4.05	0.41	0.20	0.030	0.173	6	203	121,500	522,450	6,269,400
Cherry	5.01	0.50	0.25	0.026	0.224	6	288	172,845	743,234	8,918,802
		USD per POUND					(20 loads)			

*USDA 2024 Average Annual Retail Price per Lb

Understanding How MA Works

What is Modified Atmosphere?

- Modified Atmosphere (MA) is the establishment of initial conditions leading to the development of an equilibrium atmosphere based on environmental variables.
  The effectiveness of a modified atmosphere can be enhanced by an initial gas treatment using specific gas concentrations.

- Beneficial effects of MA can be obtained only if the product is stored within a specific O_2/CO_2 mix range for that commodity, which is also temperature dependent.
  (i.e. the CO_2 atmosphere target range of 5% to 20% for strawberries held at the recommended storage temperature was effective at reducing decay.

What MA (Modified Atmosphere) Can Do for Produce?

The potential benefits for produce are:

- Retard senescence (slows degradation/product death)
- Maintain nutritional quality
- Inhibit decay development
- Alleviate certain physiological disorders
  - Browning/spotting
- Slow microbial growth

Good quality produce which have been properly cooled will last longer when stored and transported in Fresh ProTech™ Modified Atmospheres

Understanding How MA Works

What MA Cannot Do?

- Make bad quality produce better (produce with significant decay before MA treatment cannot be improved by the MA treatment)
- Substitute for proper temperature management
- Stop the growth of all microbes (decay can be slowed by CO_2 and reduced by Sanitizers, but not completely eliminated)
- Can not substitute for good food safety practices GAP's, GMP's, or worker safety

How many types of MAP (Modified Atmosphere Packaging) exist?

- There are 2 types: Passive and Active Modified Atmosphere Packaging
- Passive MAP is considered when produce is sealed within the package with no modification to the atmosphere. Subsequent respiration of the produce and the gas permeability of the packaging allow an equilibrium - modified atmosphere to be reached. Passive MAP is also called Equilibrium modified atmospheric packaging
- Active MAP is considered when supplemental treatments, additives, and gasses are added to the packaging and/or the packaging performs an additional role, other than as an inert barrier to external influences
- Active Modified Atmosphere Packaging has been developed to correct the deficiencies in passive MAP

Why Should My Company Use Fresh ProTech™ Preservation Solutions vs Other Company's Solutions?

Fresh ProTech™ solutions and systems offer longer produce shelf life and a significant reduction of labor, packaging materials, quality rejections and waste than any other competitor

Additionally, Fresh ProTech™ solutions and systems minimize food safety risks and cross contamination through a reduction of mold, decay and overall produce defects, resulting in increased consumer satisfaction and repeated purchases due to better overall quality and appearance

For additional information, please send us an email to:
info@freshprotech.com or call at XXXXXXXXXXX

Company Facts

Fresh Tech Solutions (FTS) provides packaging, services, equipment, and proprietary technologies that protect, preserve, and enhance perishable products.

FTS is a B2B service provider using license agreements + defined partnerships for the commercialization of its technology, packaging, systems, and services.

FTS is successfully serving the US West Coast Berry Industry. This success was achieved by offering the best MAP technology with a high degree of customer service.

New customer trials are focused on: specific commodities, high potential commercial applications where value can be created for customers and consumers. Trials are limited to customers with market leadership positions.

FTS has more than 50 US & International patents filed and/or granted for the preservation and protection of perishable products, modular systems for treatment & cooling perishables, MAP/CA innovations, as well as unique treatments to enhance the quality and safety of perishables.

FTS has partnered with leading Industrial gas & packaging manufactures and is now offering large scale commercialization of its technologies, products + process offerings.