

# Use of CO in meat/fish

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Funded by



# What piece do you prefer?



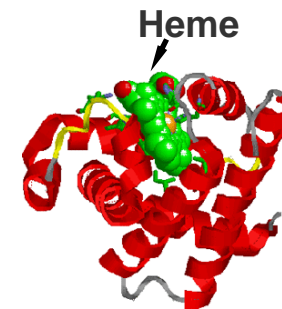
# Importance of muscle color

- Color and appearance is one of the most important quality factors of muscle foods
- The basis and chemistry of muscle color is complex and can be influenced by a variety of factors
  - Species
  - Season
  - Water content
  - Lipid content
  - Spoilage
  - Muscle type
    - White muscle
    - Red muscle
  - Heme content and oxidation state

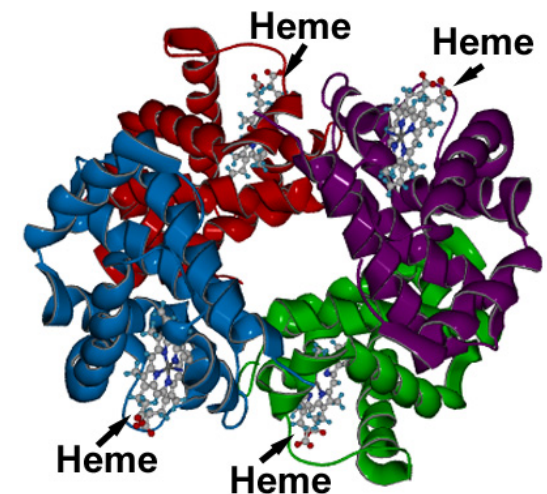


# Red muscle color

- Red color is a positive quality attribute of many fish species and land animals
- Primarily arises from
  - Hemoglobin (Hb)
    - Blood
  - Myoglobin (Mb)
    - Muscle cell
- Both have a heme group that can exist in different oxidation states and bind different gas molecules which dictates the color of these proteins
- The main function of the protein is to transport  $O_2$  and minimize binding to CO

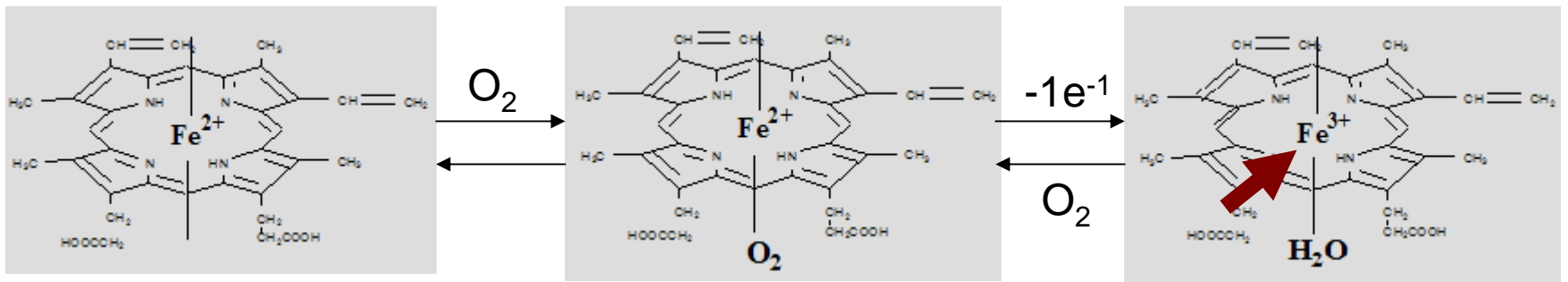


**MYOGLOBIN**



**HEMOGLOBIN**

# The different states of heme of importance for muscle



Deoxy-Hb/Mb  
(fresh muscle interior)



Oxy-Hb/Mb  
(fresh muscle exterior)

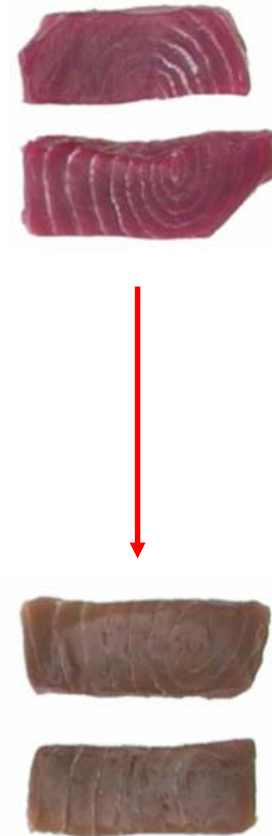


Met-Hb/Mb  
(aged/frozen/cooked muscle)

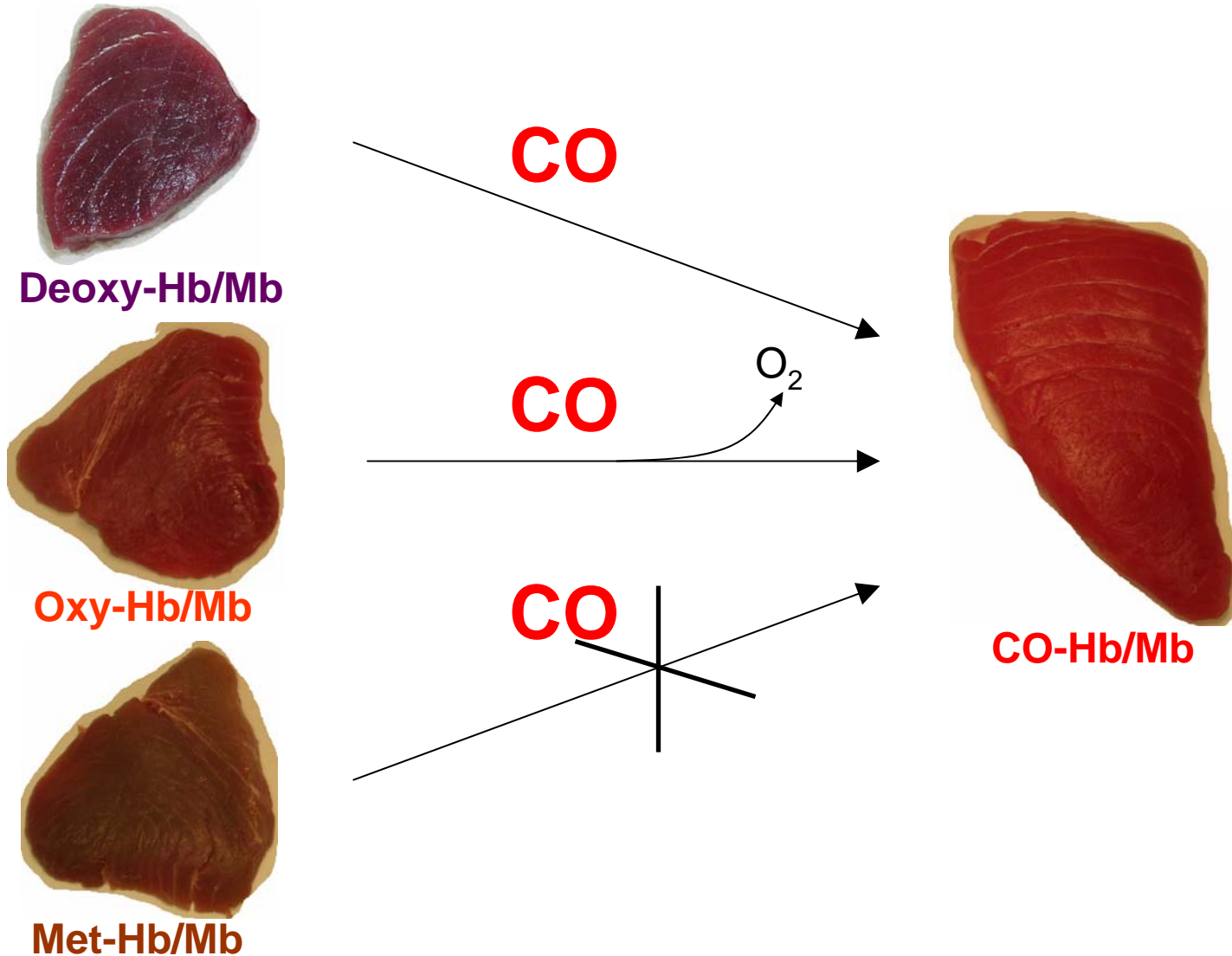


# What promotes browning/oxidation?

- pH
  - Decrease in pH post-mortem
- Temperature
  - High temperatures
  - Frozen storage
- Light
- [O<sub>2</sub>]
- Species and Muscle type
  - Variations in Hb and Mb
    - Quantity
    - Stability
  - Different levels of oxidizing agents



# Carbon monoxide, heme and color



# Application

**Vacuum**



**Gassing**



**24-48 h later**



# The pros and cons

- **Potential problems:**

- Fish can look good but could be of very poor quality
- Can convert a poor product to a good looking product
- Fish can look good but could present an underlying hazard

- **Known benefits:**

- Can hold fish frozen without adverse color change of red muscle

- Several positive claims have been made for these processes

- Research is needed into these claims to understand how these processes influence seafood quality and safety

# Regulatory status

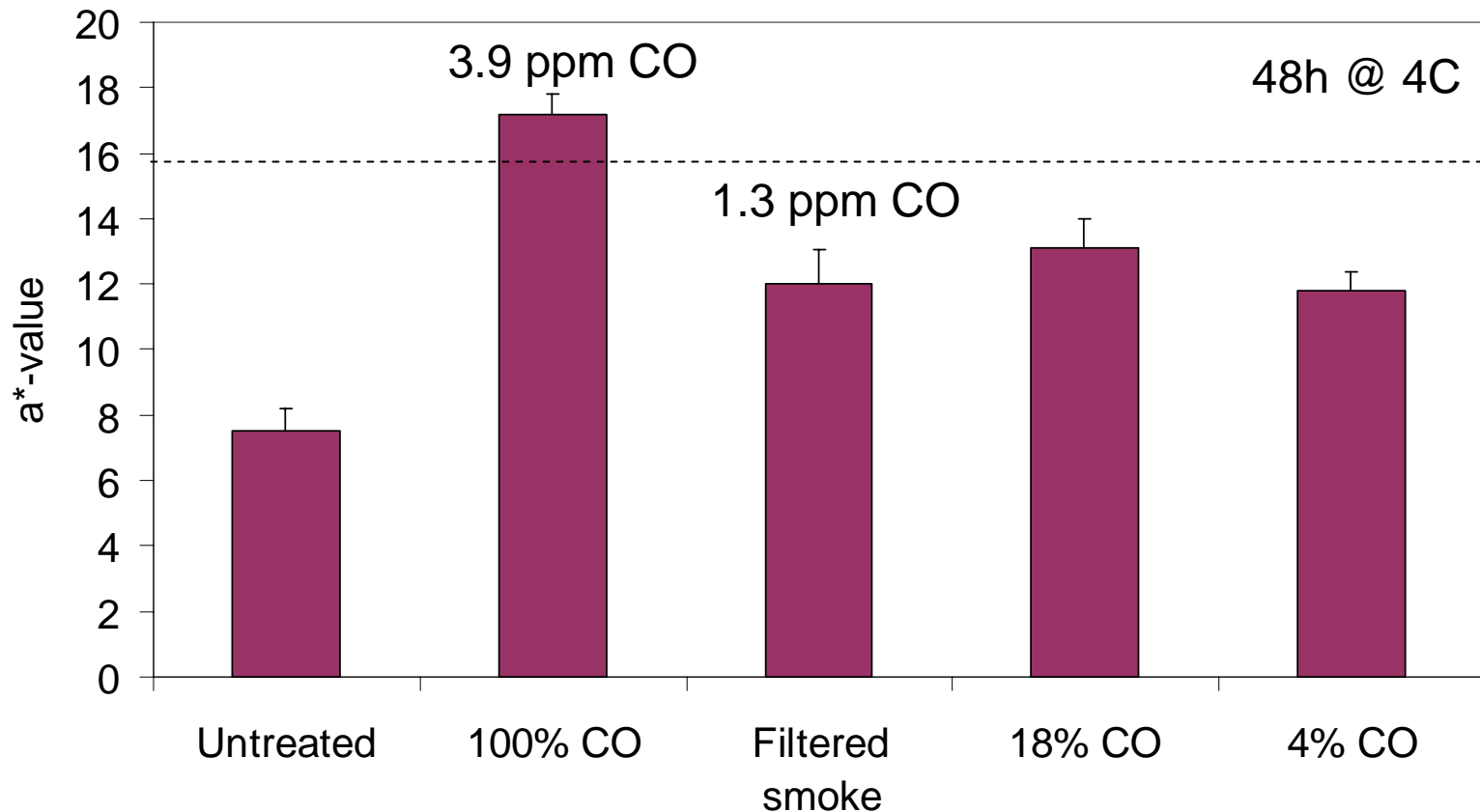
- Red meat and pork: GRAS status
  - 0.4% CO in modified atmosphere packages (MAP)
- Seafood: No clear regulations
  - Product should be labeled appropriately
  - Should only be used on frozen product
  - Many different seafood products treated with CO





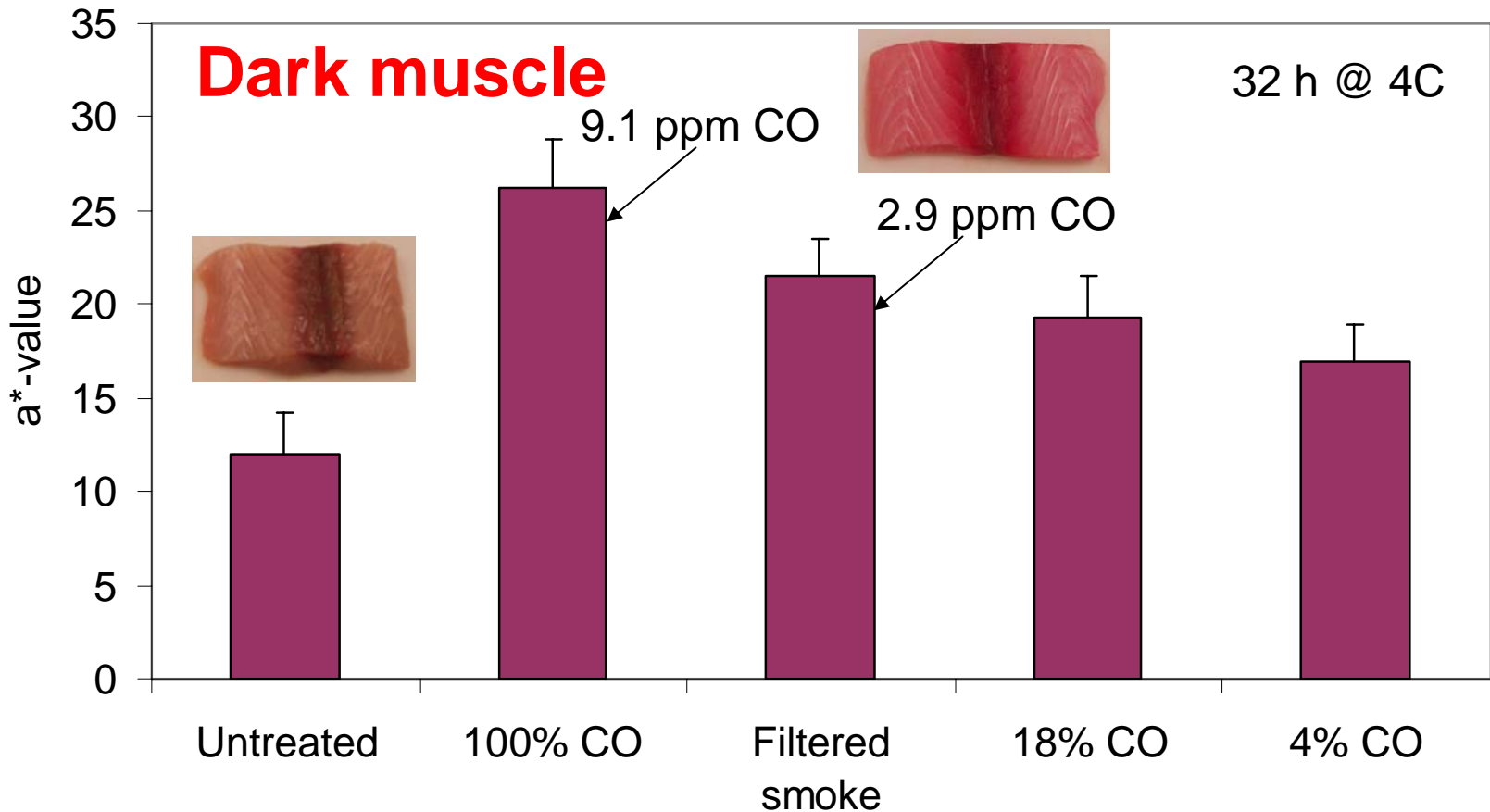
# Increase in redness – Tuna

## Effect of treatment



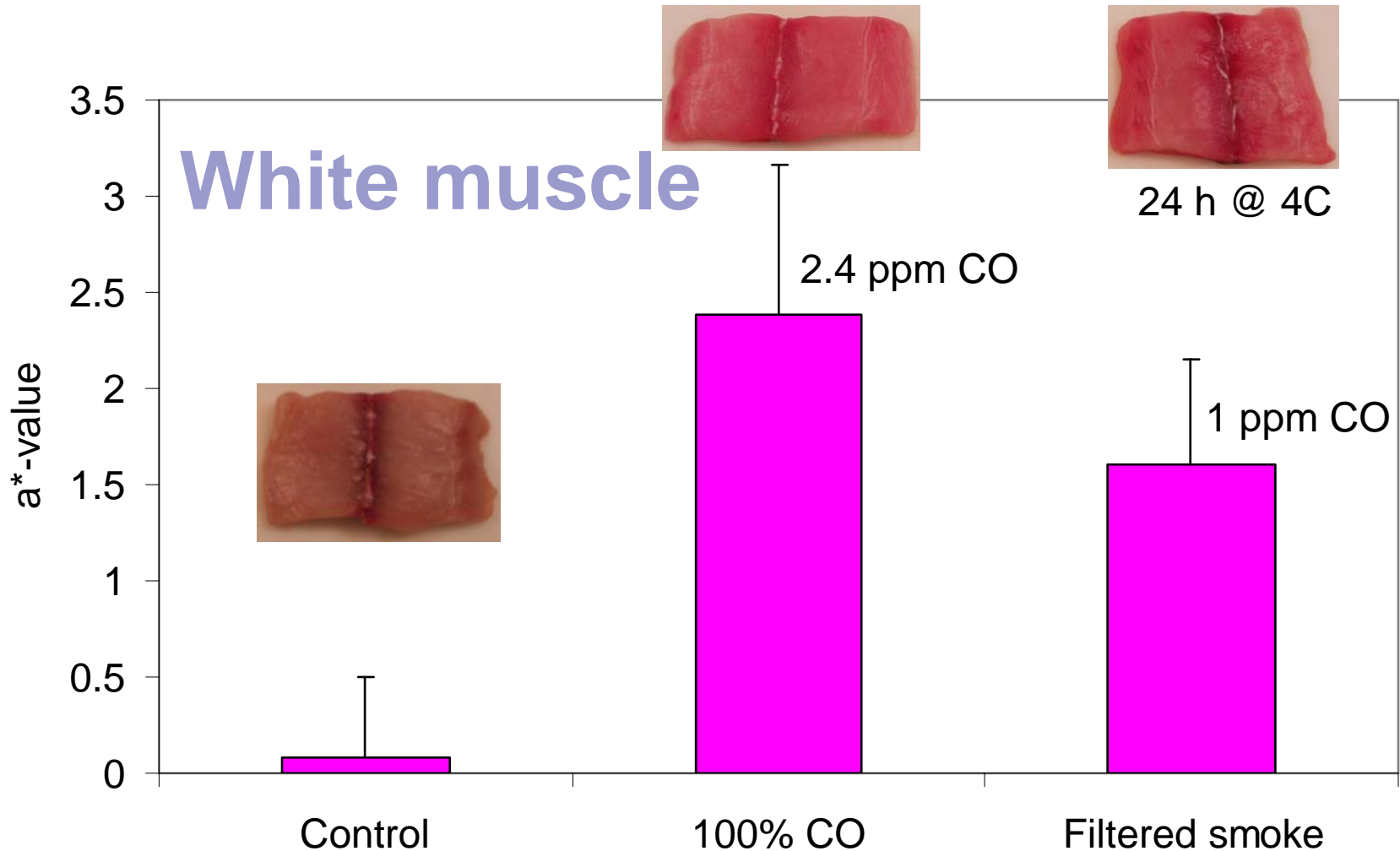
# Increase in redness - Mahi mahi

## Effect of treatment



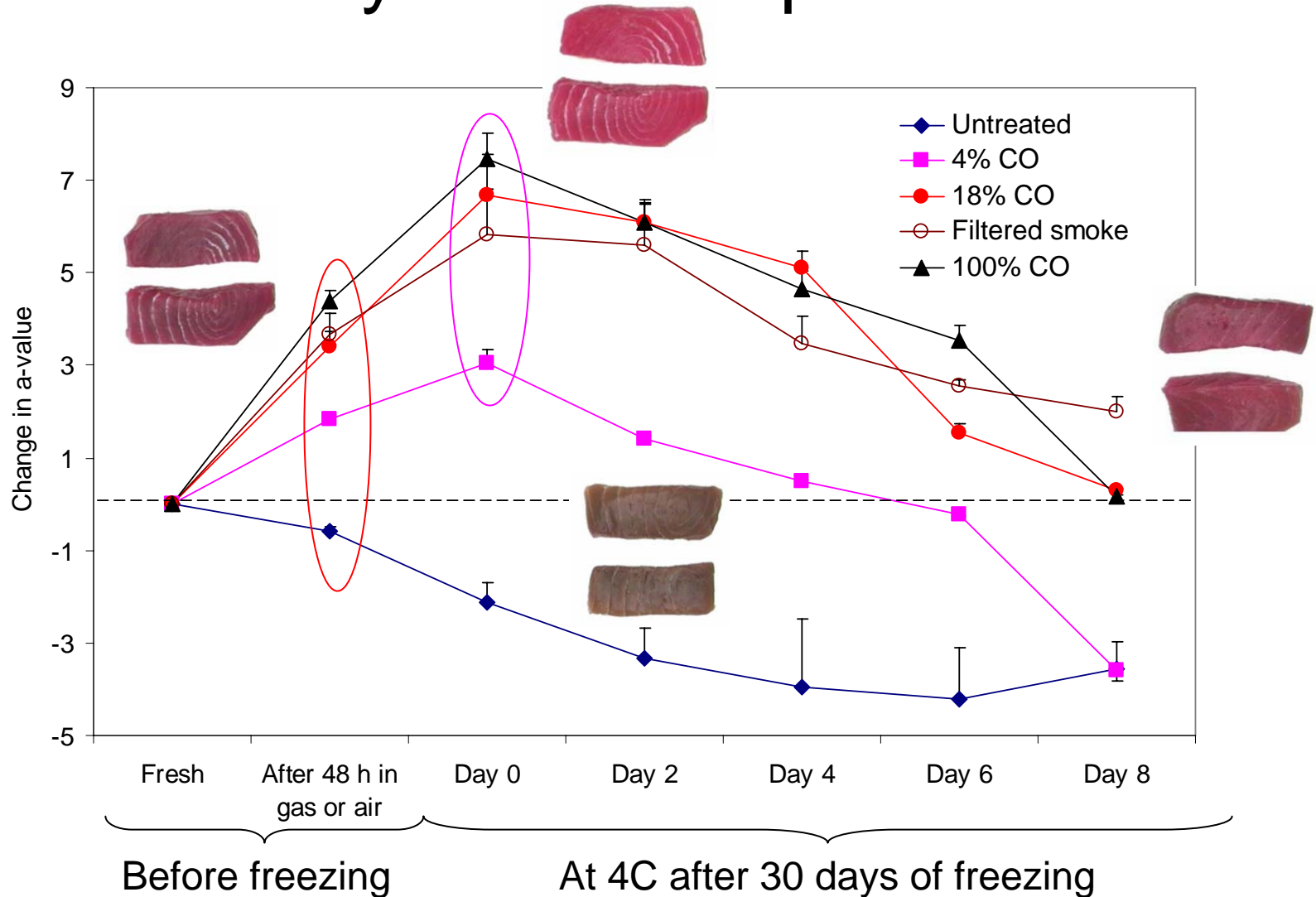
Minolta colorimeter

# Increase in redness - Mahi mahi



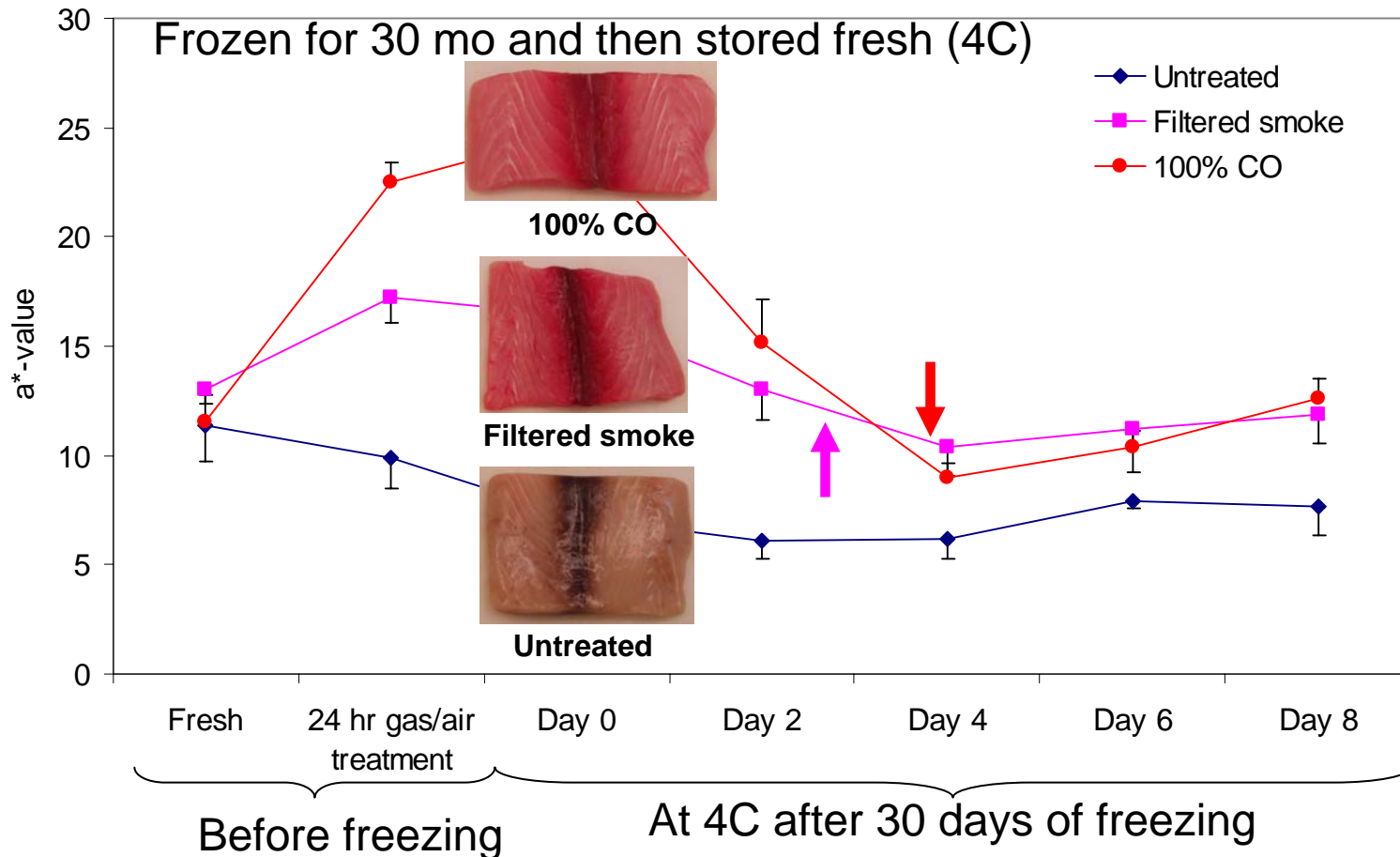
Minolta colorimeter

# Color stability of treated products - Tuna



# Color stability of treated products – Mahi mahi

## Dark muscle



# Color as an indicator of treatment?



**$a^*=16.4$**

Untreated mahi mahi  
steak after 8 days at 4C  
(spoiled)

**$a^*=15.7$**

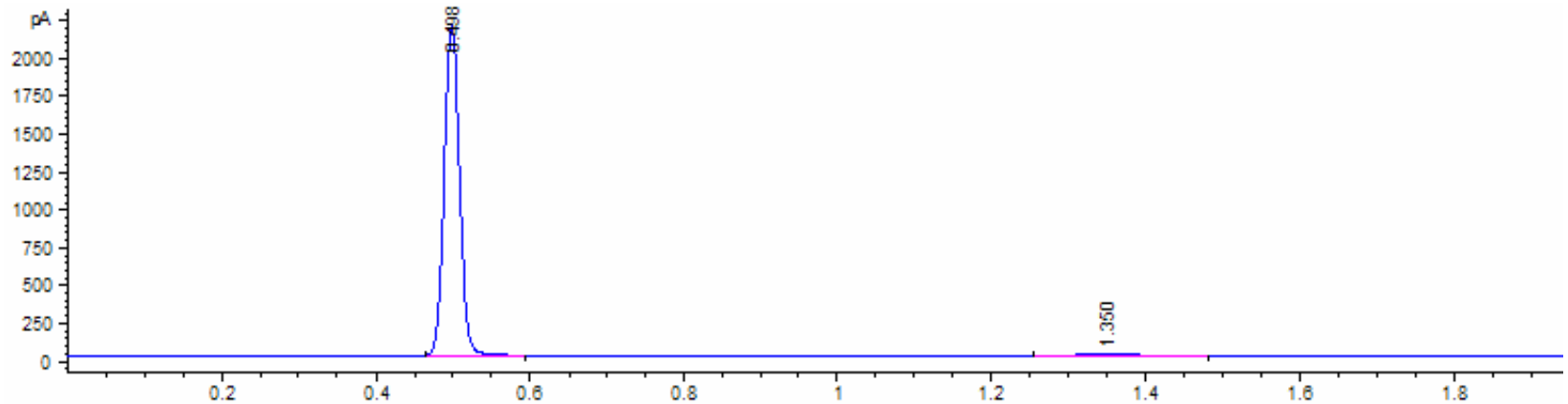
100% CO treated (24 h) mahi mahi  
steak after 8 day at 4C (post gassing)  
(spoiled)

# How do we detect treated products?

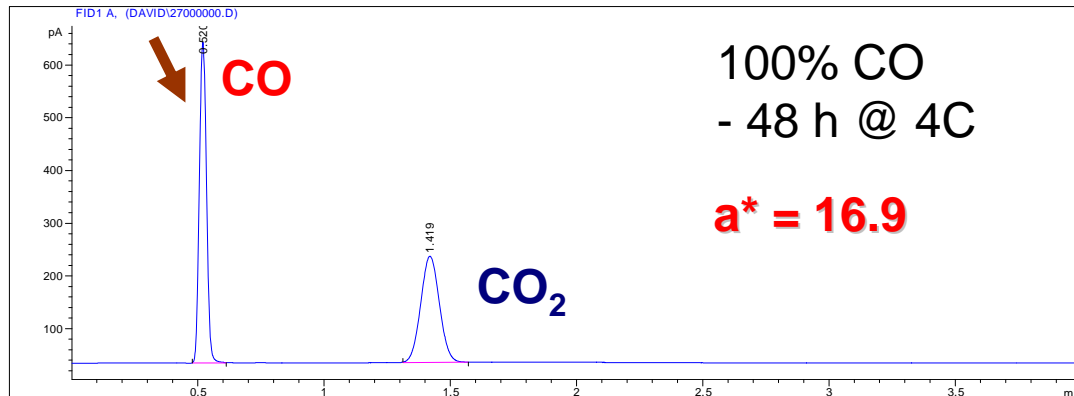
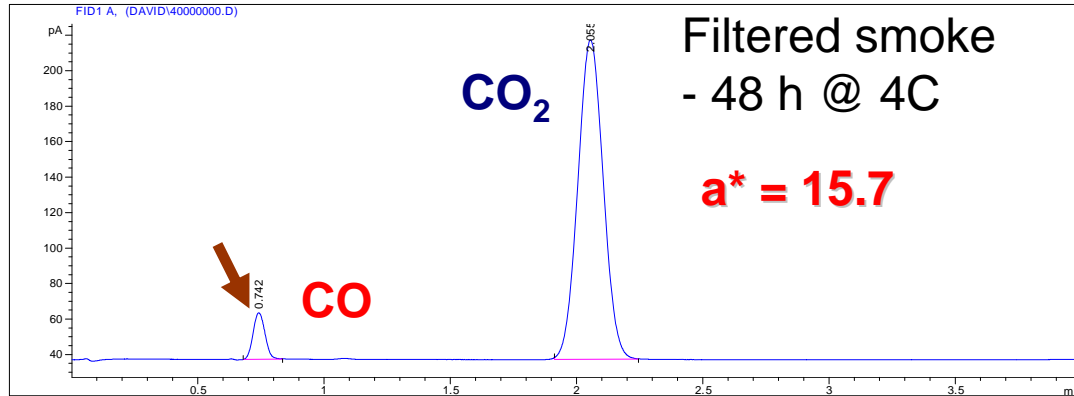
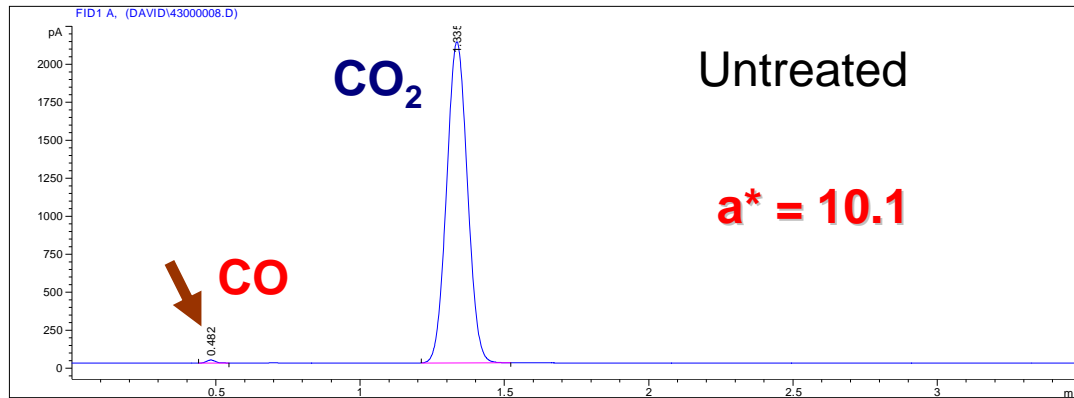
- Quantitative analysis

- Gas chromatography

- CO converted to methane ( $\text{CH}_4$ ) and quantified with an FID detector
    - Good sensitivity
    - Expensive and somewhat tedious method



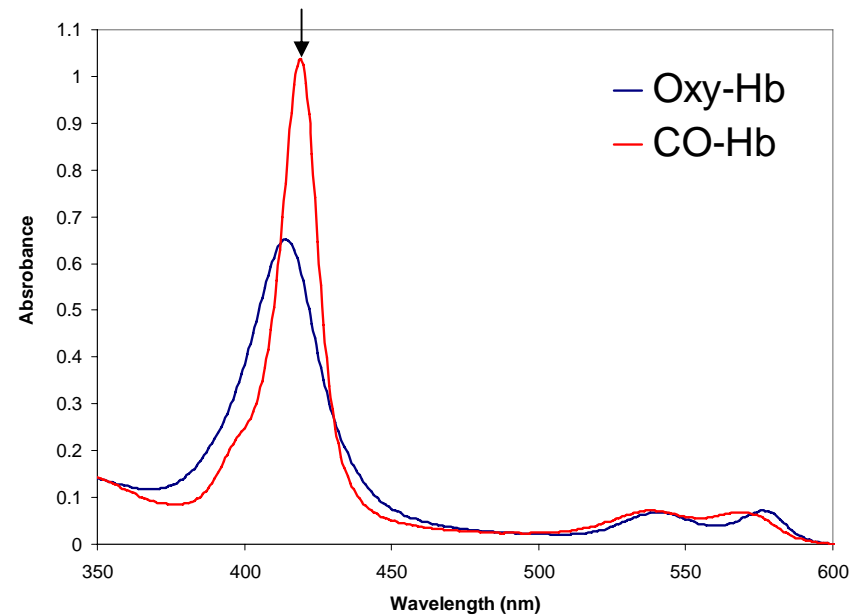
# Yellowfin tuna



# Developments with rapid detection techniques

## Heme protein extraction

- Very simple buffer extraction of heme proteins followed by low speed centrifugation
- 5-10 min procedure
- Follows the shift in heme peak wavelength
- Successfully applied to:
  - Tuna
  - Mahi mahi
  - Tilapia
  - Snapper
  - Grouper
  - Spanish mackerel
  - Salmon



If CO is bound to Hb or Mb: >414nm

# Developments with rapid detection techniques

## ■ Chemical reactions of CO leading to color changes

### A) CO detection tubes

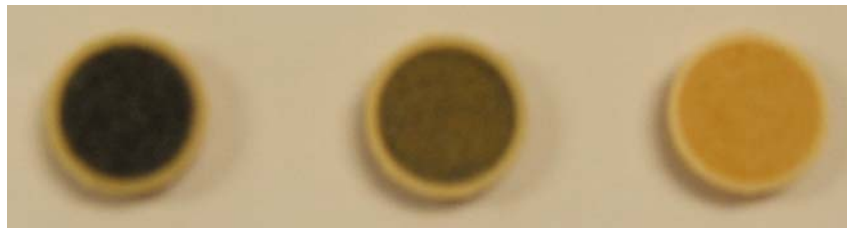
- Simple to use
- “Inexpensive”
- 2-700 ppm range



# Developments with rapid detection techniques

## B) Reducing reactions of CO

- Simple
  - No special instruments needed
- Inexpensive
- Can be relatively sensitive



100% CO    Filtered smoke    Untreated



100% CO    Filtered smoke

24 h | 35C  
↓



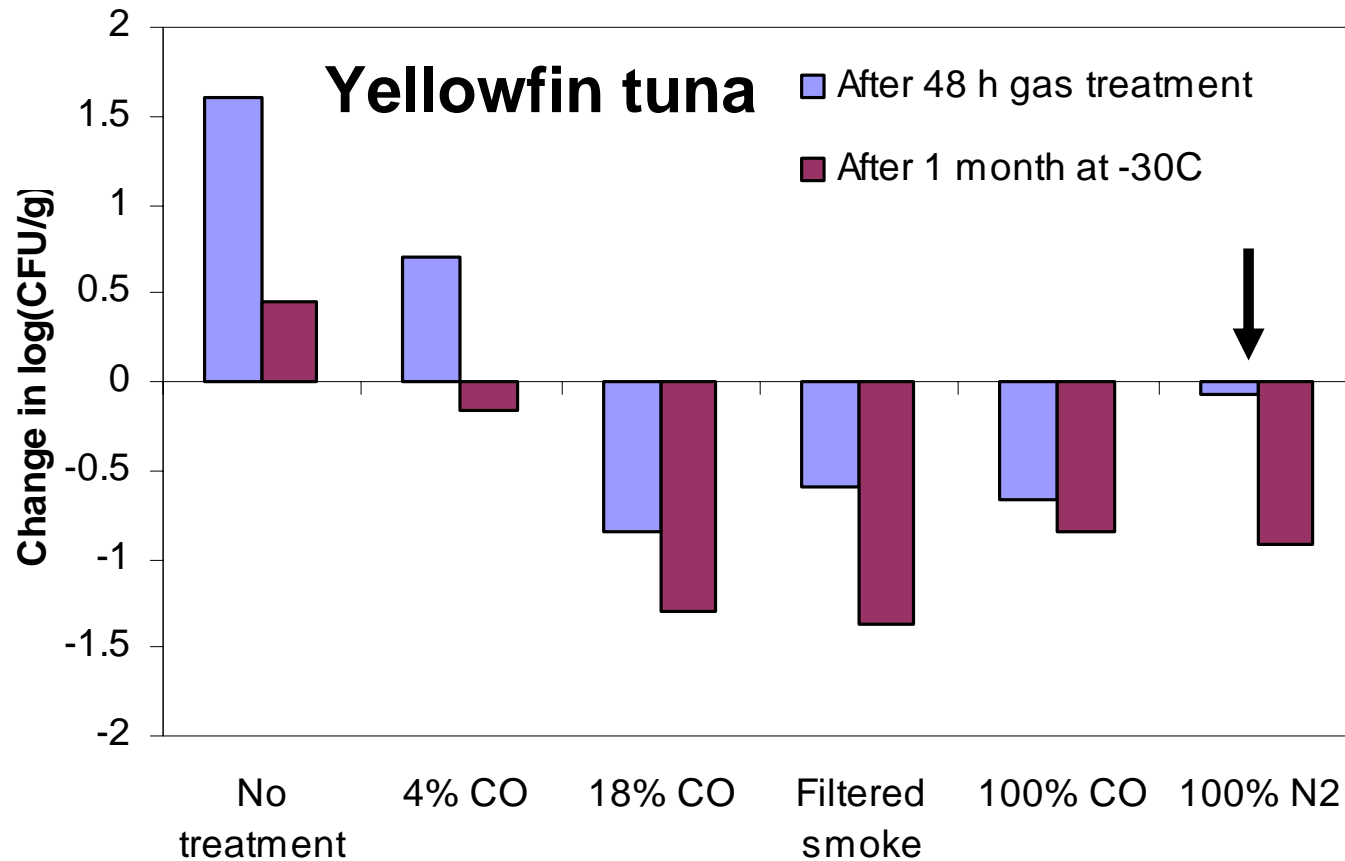
100% CO    Filtered smoke



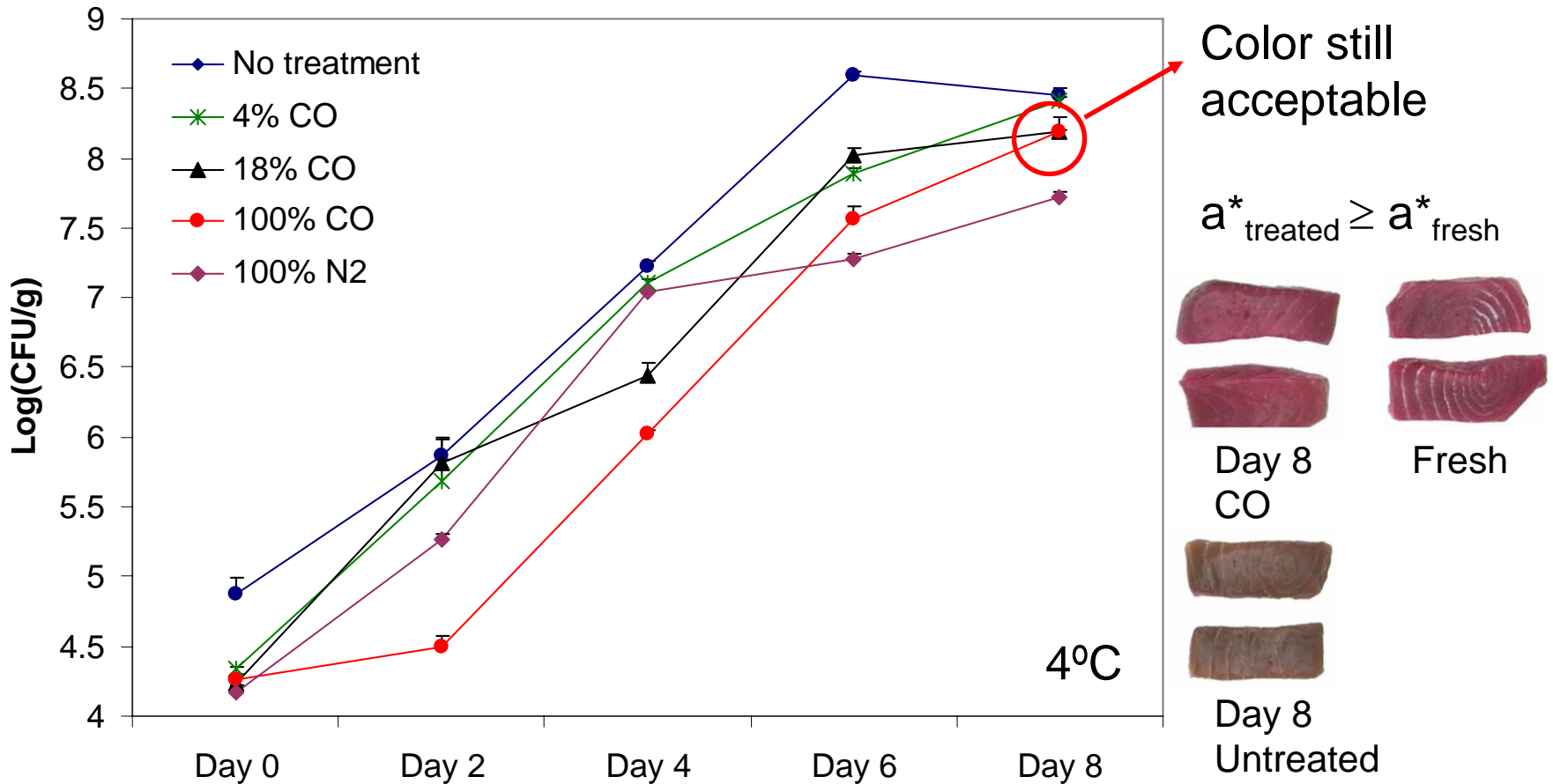


# Microbial consequences

# CO/FS treatment reduces the numbers of aerobic bacteria in tuna

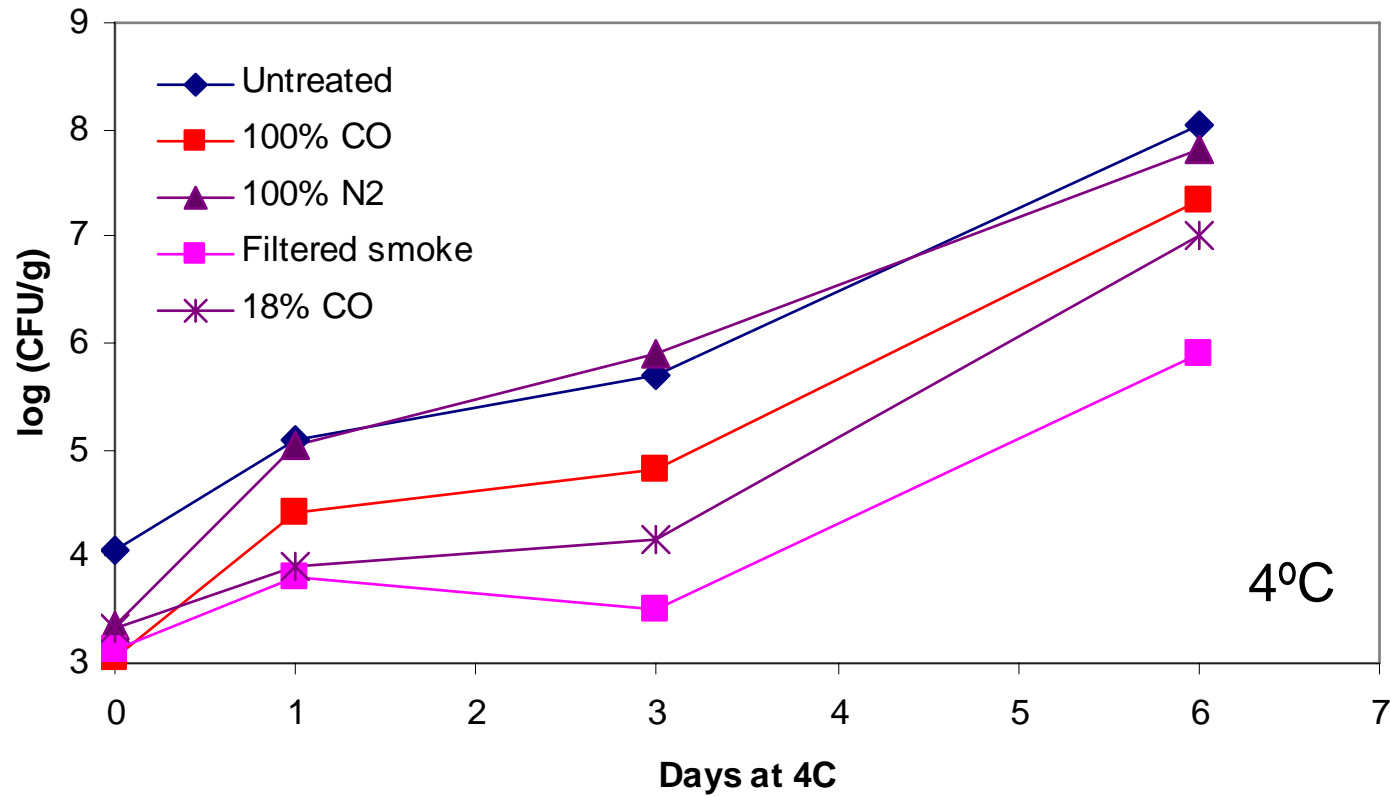


# Microbial growth in **Yellowfin tuna** after frozen storage

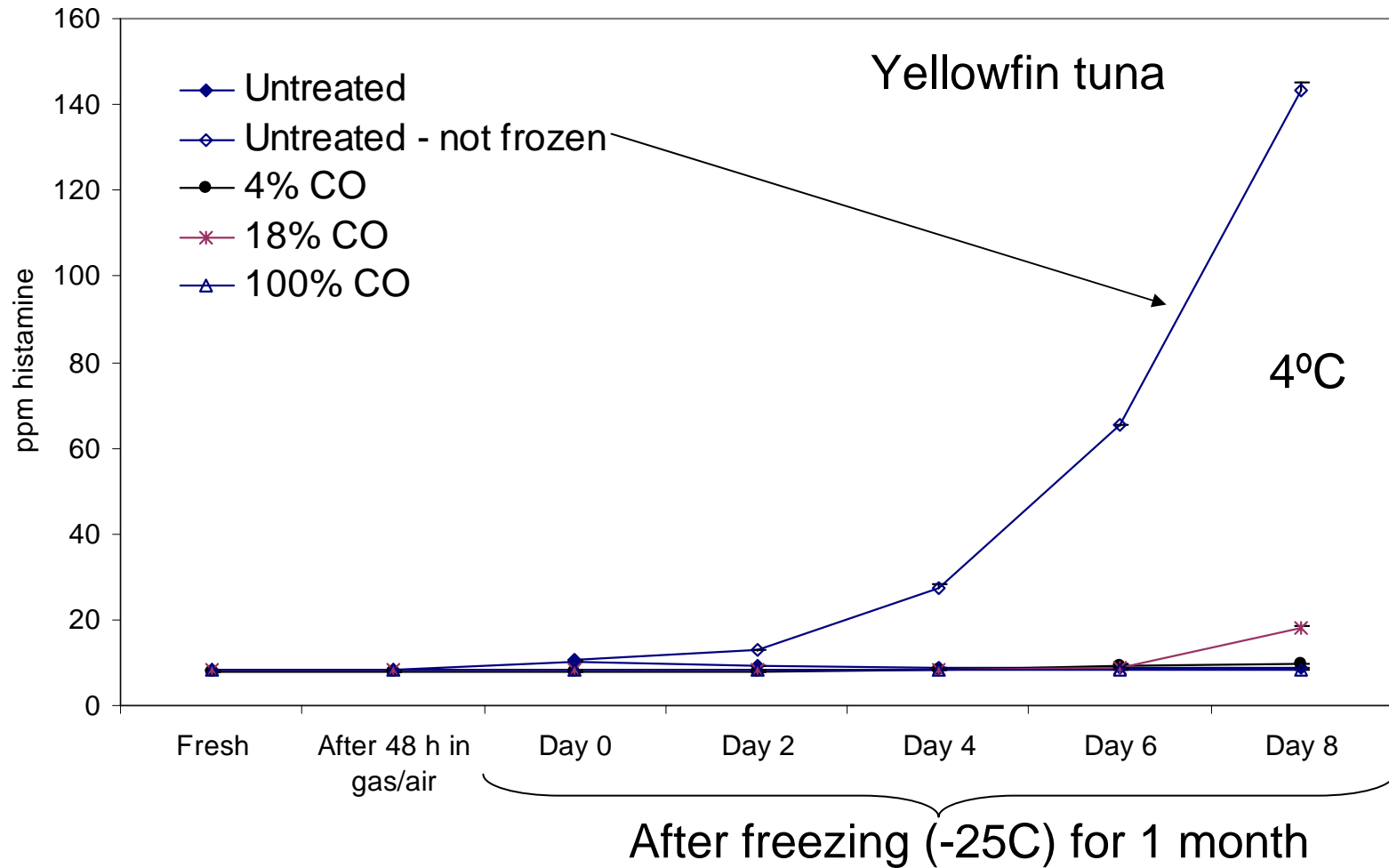


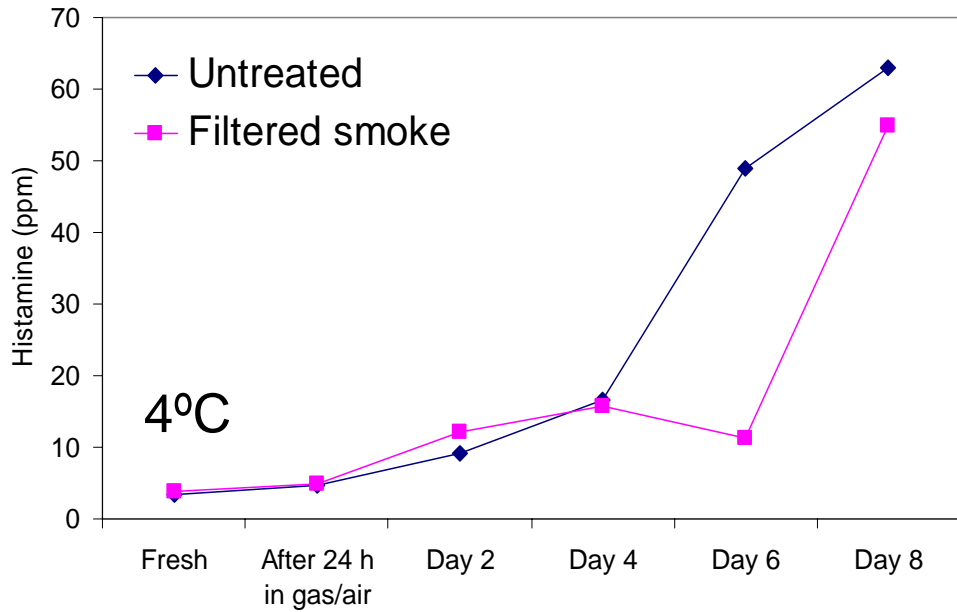
# Microbial growth in fresh tuna after treatment

32 hour treatment

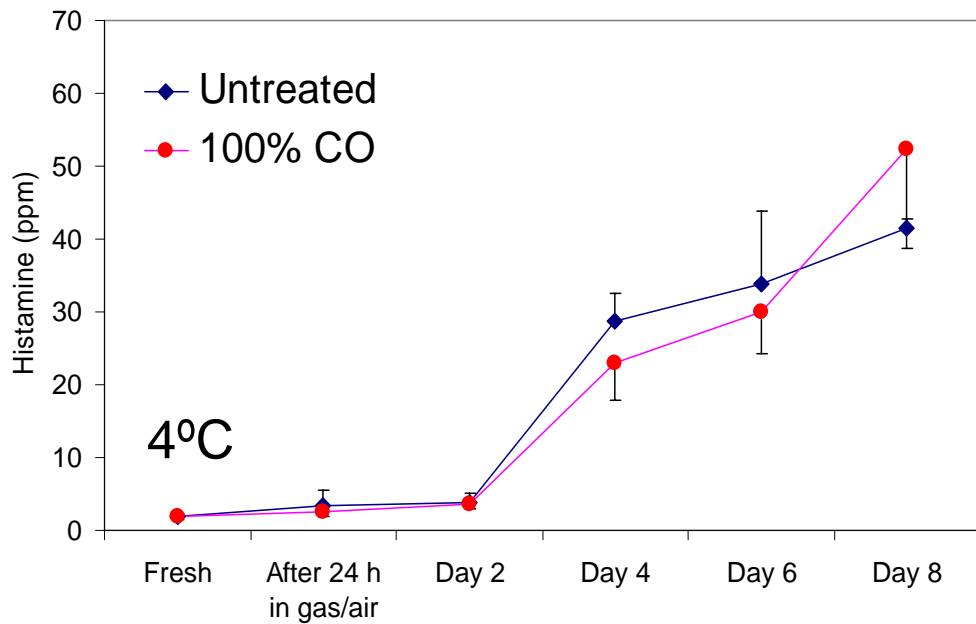


# Histamine production in treated tuna





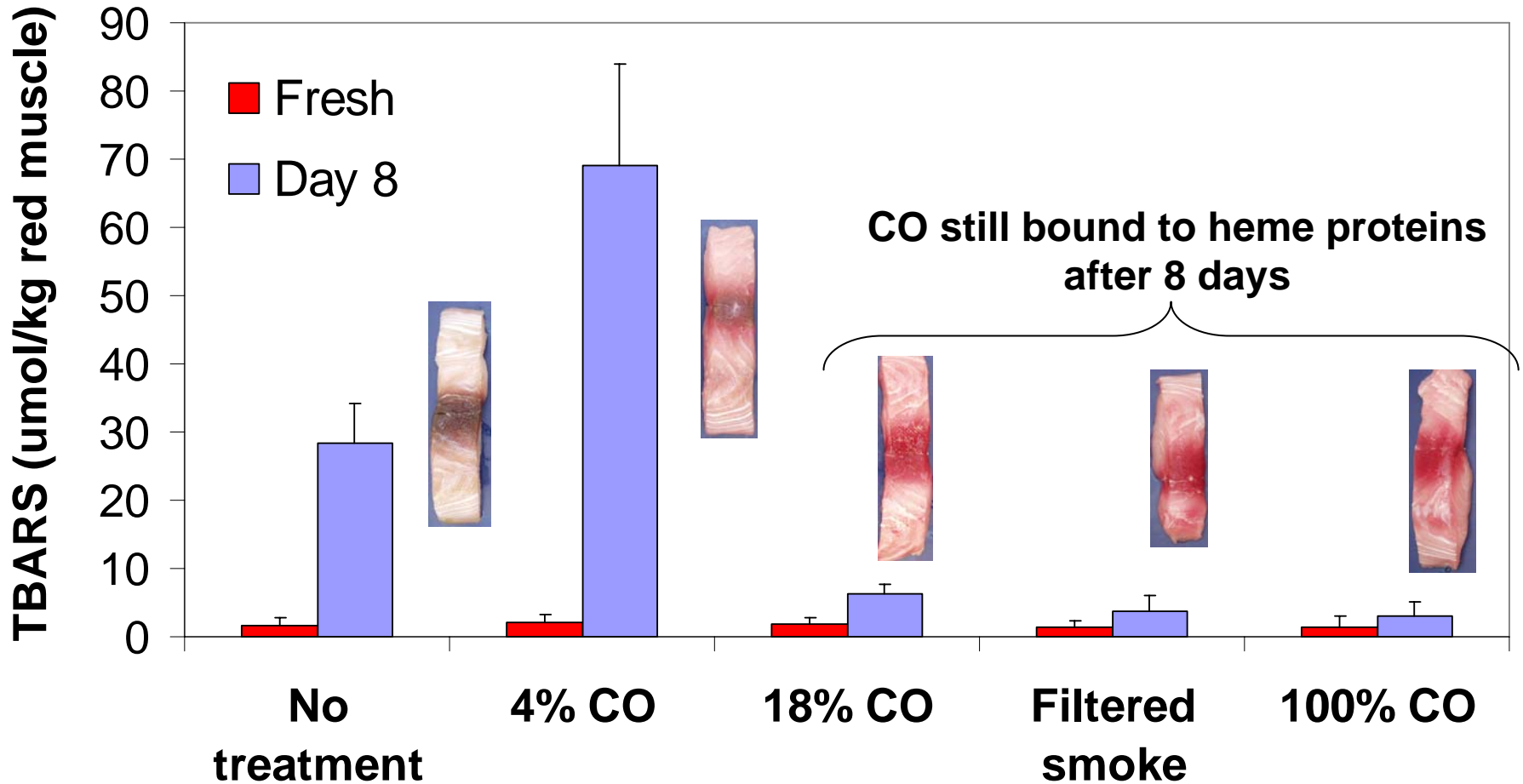
Histamine formation in mahi mahi treated with CO or FS



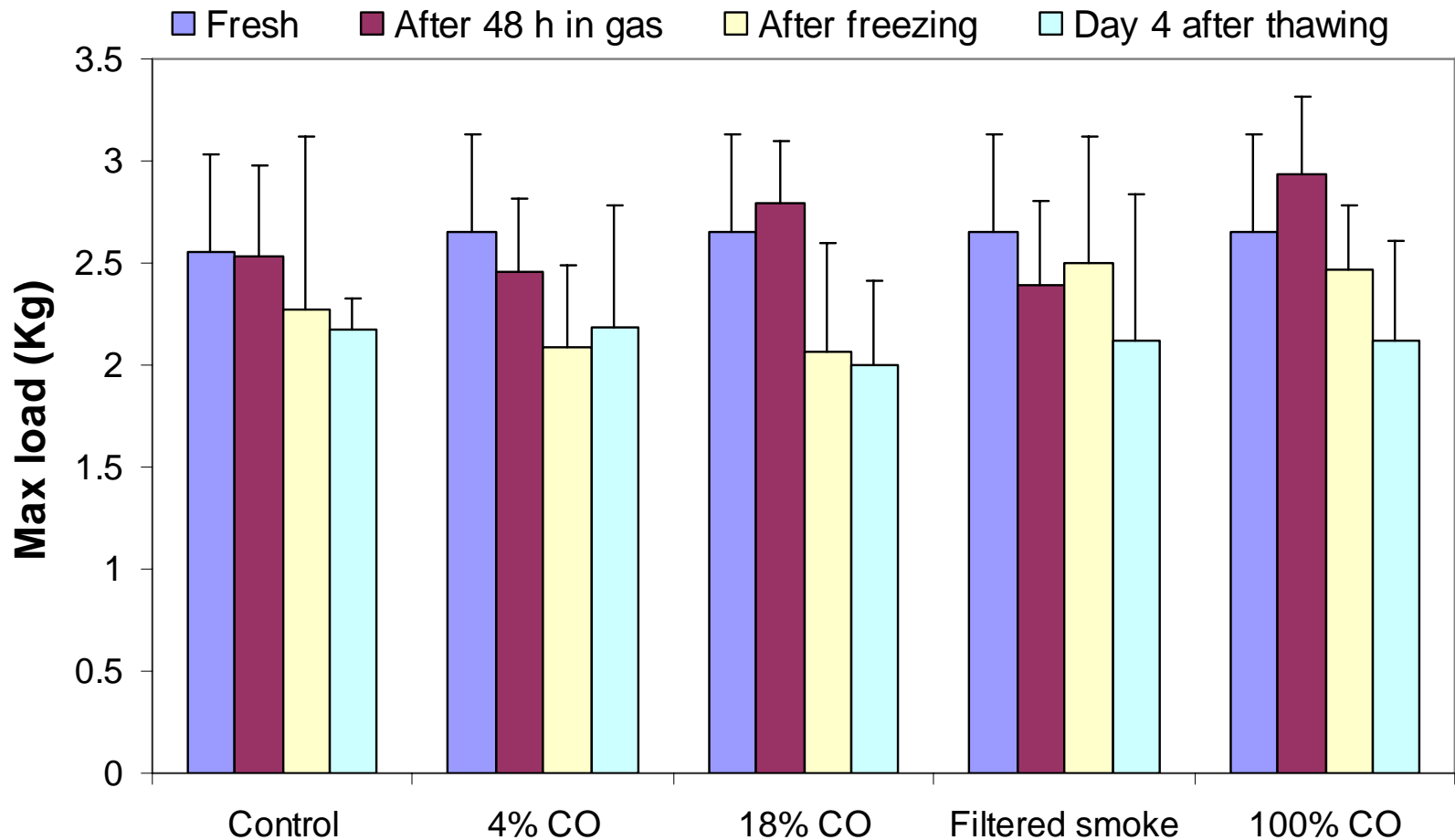


# Other quality factors

# Lipid oxidation in mahi mahi



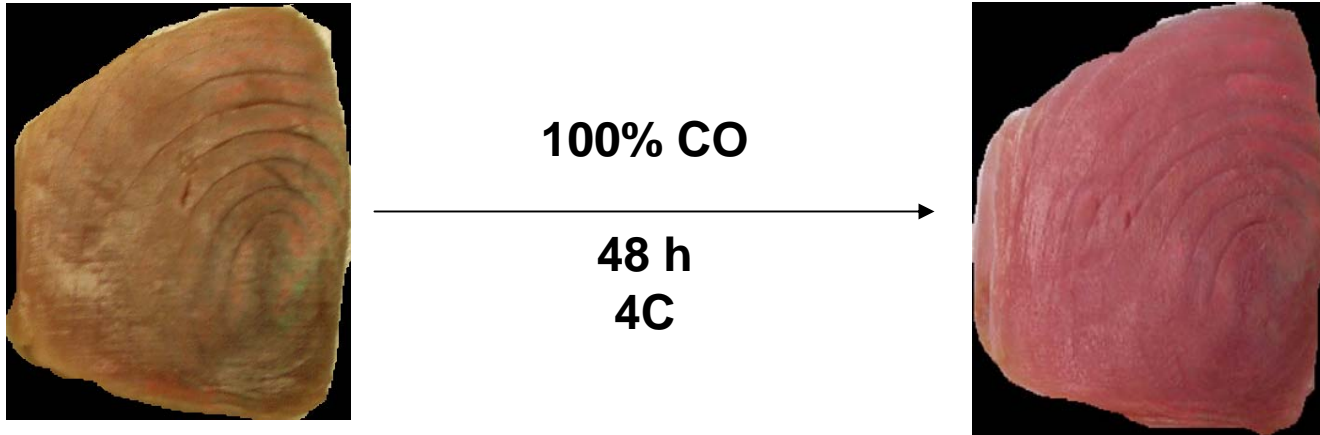
# Firmness (compression test)



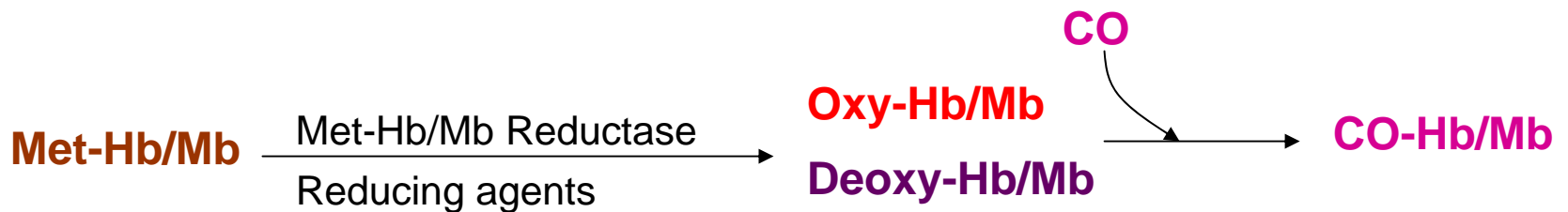


Can you abuse this process?

If a trace of reduced Hb/Mb is in the product or the species has an active reducing system then it is possible to convert a brown product to a “fresh” appearing product



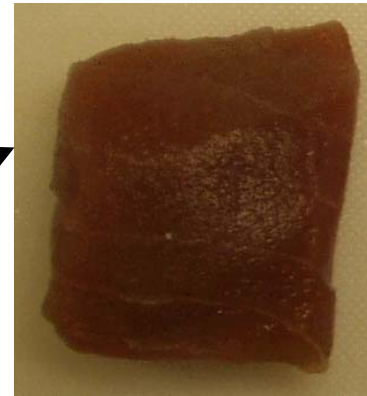
Previously frozen tuna with oxidized Hb/Mb



# Histamine risk?



No treatment



**>> 50 ppm  
histamine**

**After 24 hours at 22°C!**

100% CO for 48 h  
(4°C)



**>> 50 ppm  
histamine**