

## Use of CO in meat/fish

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Funded by



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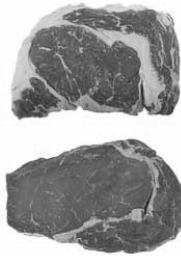
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## What piece do you prefer?



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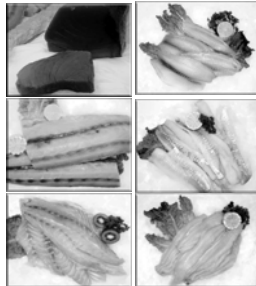
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## Importance of muscle color

- 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



Supremebator.com

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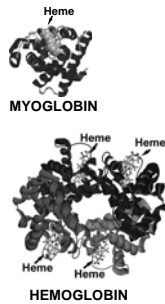
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## Red muscle color

- 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




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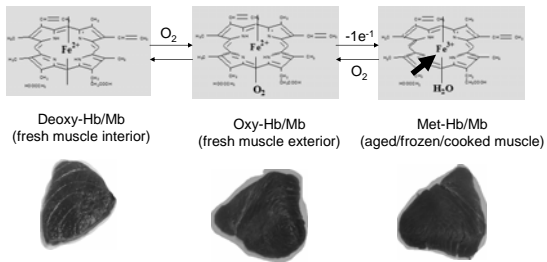
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## The different states of heme of importance for muscle




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## What promotes browning/oxidation?

- pH
  - Decrease in pH post-mortem
- Temperature
  - High temperatures
  - Frozen storage
- Light
- $[O_2]$
- Species and Muscle type
  - Variations in Hb and Mb
    - Quantity
    - Stability
  - Different levels of oxidizing agents




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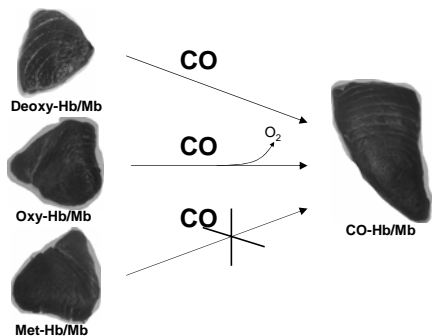
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## Carbon monoxide, heme and color



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## Application

Vacuum



Gassing



24-48 h later



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## 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

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## 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



Local 6 News - CBS

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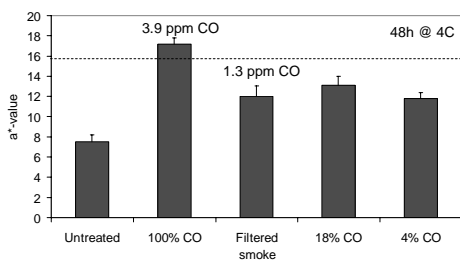
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## Increase in redness – Tuna Effect of treatment



Minolta colorimeter

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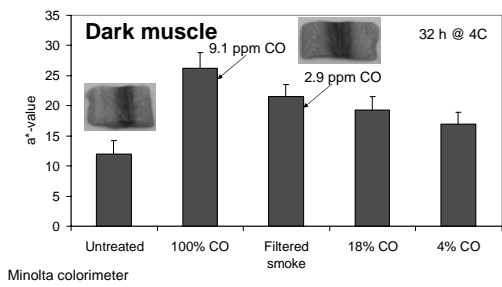
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### Increase in redness - Mahi mahi Effect of treatment




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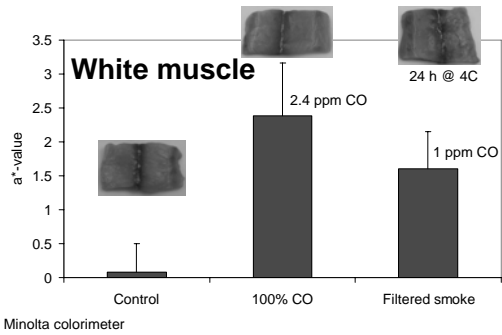
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### Increase in redness - Mahi mahi




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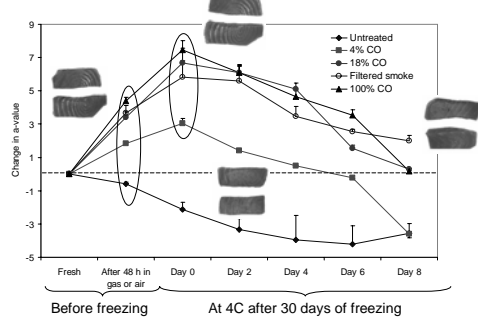
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### Color stability of treated products - Tuna




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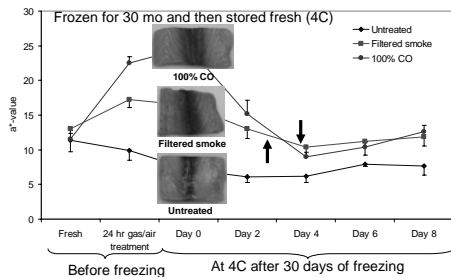
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## Color stability of treated products – Mahi mahi

### Dark muscle




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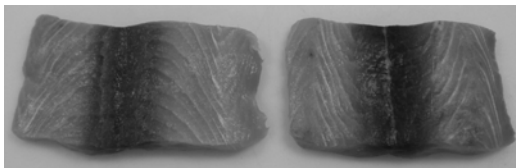
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## Color as an indicator of treatment?



**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)

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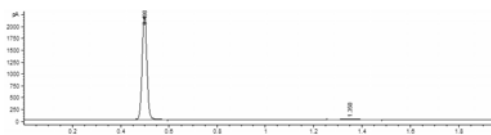
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## How do we detect treated products?

- Quantitative analysis
  - Gas chromatography
    - CO converted to methane (CH<sub>4</sub>) and quantified with an FID detector
    - Good sensitivity
    - Expensive and somewhat tedious method




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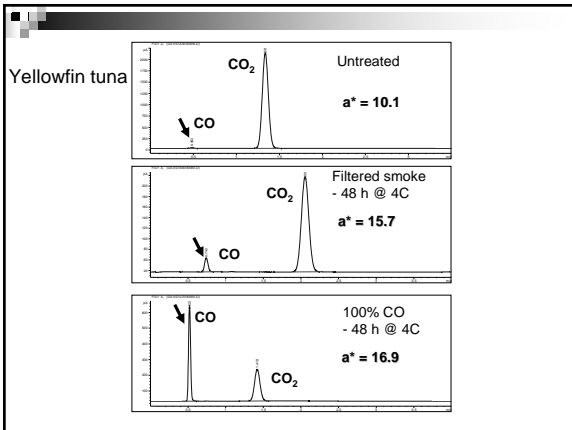
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### Developments with rapid detection techniques

**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

The graph plots Absorbance (y-axis, 0.0 to 1.1) against Wavelength (nm) (x-axis, 300 to 600). Two curves are shown: Oxy-Hb (solid line) and CO-Hb (dashed line). The Oxy-Hb curve has a peak at approximately 414 nm, while the CO-Hb curve has a peak at approximately 425 nm.

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

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### 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

The photograph shows a person using a syringe to draw liquid from a vial into a CO detection tube. To the right, two detection tubes are shown side-by-side for comparison. The left tube is labeled '100% CO treated' and shows a dark color change, while the right tube is labeled 'Untreated' and remains clear.

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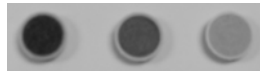
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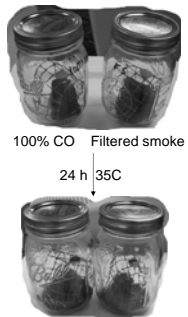
## Developments with rapid detection techniques

### 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

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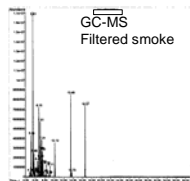
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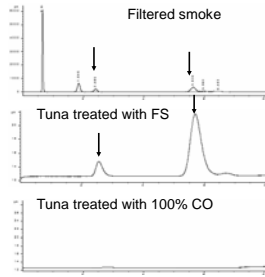
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## Smoke vs. CO treated?

- Gas chromatography
  - Extraction of volatile components
  - GC-FID detection
  - GC-MS detection to focus in on specific compounds



GC-MS  
Filtered smoke



Tuna treated with FS

Tuna treated with 100% CO

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## Microbial consequences

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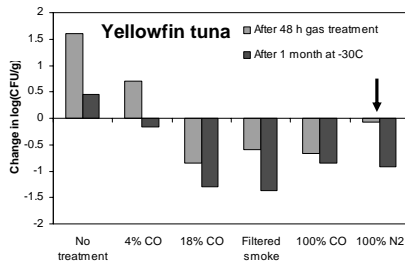
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## CO/FS treatment reduces the numbers of aerobic bacteria in tuna




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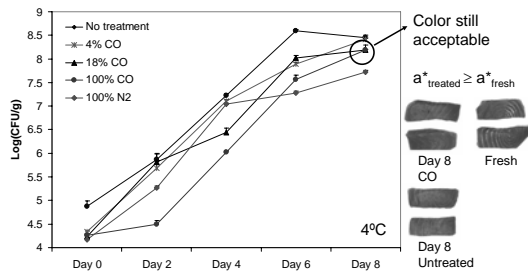
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## Microbial growth in Yellowfin tuna after frozen storage




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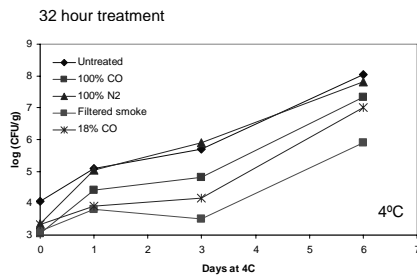
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## Microbial growth in fresh tuna after treatment




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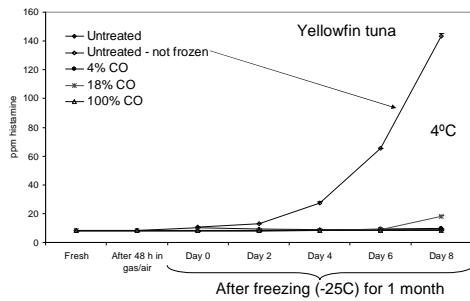
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## Histamine production in treated tuna




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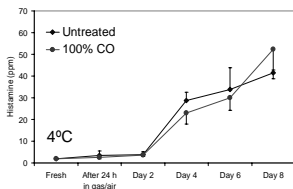
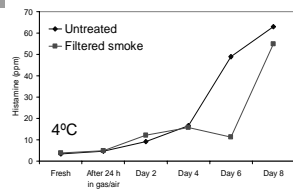
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## Histamine formation in mahi mahi treated with CO or FS




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## Other quality factors

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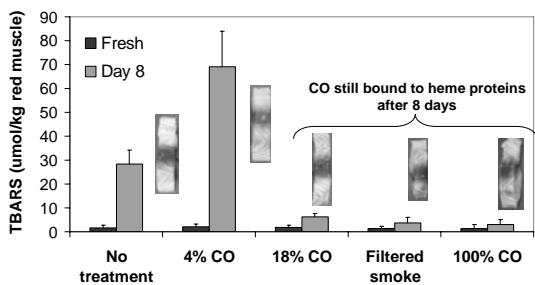
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### Lipid oxidation in mahi mahi




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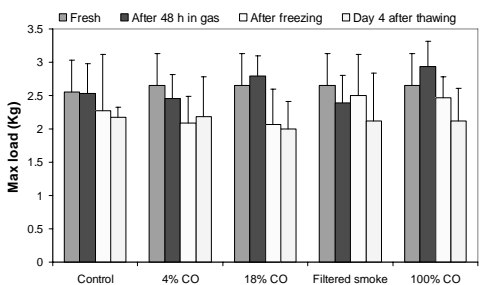
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### Firmness (compression test)




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Can you abuse this process?

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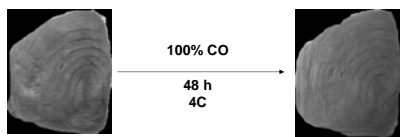
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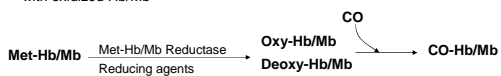
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If a trace of reduced Hb/Mb is in the product or the species has an active reducing system then it is possible to convert a brown product to a "fresh" appearing product



Previously frozen tuna with oxidized Hb/Mb



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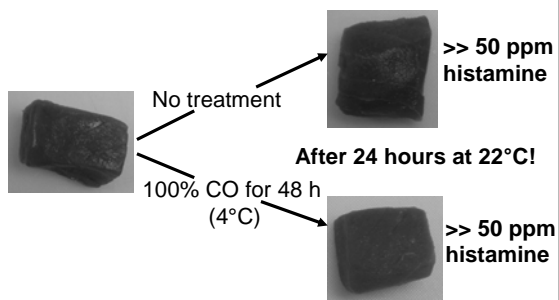
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### Histamine risk?



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