Color formation and color stability in meat and meat products


Meat color

Important indicator in relation to meat quality

Consumers often use color as an indicator for the quality of the meat.

Color-giving compounds in meat:

95 % myoglobin

5 % hemoglobin

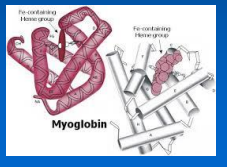
Myoglobin

– "composed" protein

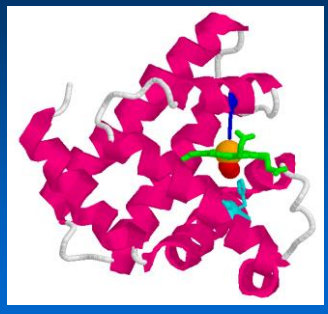
– Consists of a typical amino-acid protein chain

- and -

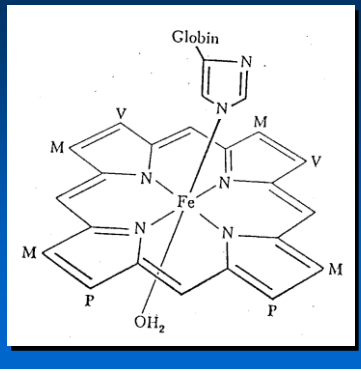
A not protein part (hemegroup)



Myoglobin structure



Heme-molecule structure



Heme group:

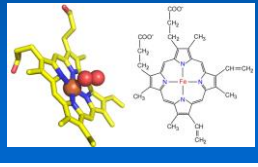
– Responsible for all the color reactions

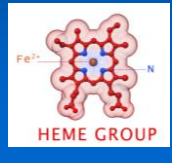
Protein part:

– Color less - ***but*** -

Is of great importance for the stability of the heme group and affects the color indirectly

– Free heme is oxidized very easily into brown pigments

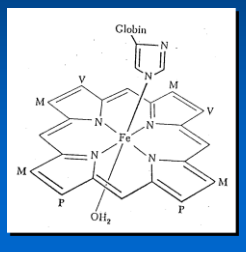




Heme group is connected to a protein molecule by the amino acid called; histidine (5th binding spot of the iron-ion)

6th binding spot is available for other atoms or molecules such as:

- Water
- Oxygen
- Carbon monoxide
- Nitrogen oxide
- Etcetera (things that affects the meat color)



What determines the color of meat?

1. Concentration of myoglobin

White poultry meat	0.05	mg/g
Chicken leg meat	1.8-2.0	mg/g
Turkey leg meat	2.5-3.0	mg/g
Pig, calf	1.0-3.0	mg/g
Cattle	4.0-10.0	mg/g
Meat older catle	15.0-20.0	mg/g
Whale	40	mg/g

The amount of myoglobin depends on:

- Species
  - Cattle contains more myoglobin than pork
- Race
- Age
  - Concentration of myoglobin pigment is decreasing during aging of animals
- Sexes
  - Meat of male animals most commonly contains more pigment than meat from female animals
- Specific function of the muscle
  - Muscles who have to work harder contain more myoglobin
- Variation of muscles

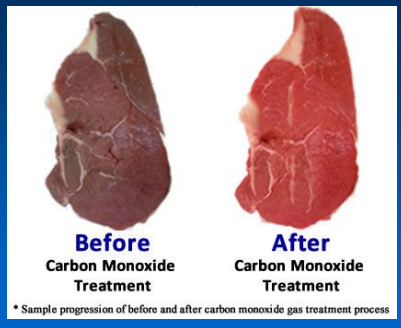
Salmon cut: Two toned meat

2. Chemical aspects

- Responsible for the color of fresh meat are:
  - myoglobin - Fe^{++}
    H_20 connected to the 6th binding place of the heme group
    - Color: purple red
  - oxymyoglobin - Fe^{++}
    oxygen connected to the 6th binding place of the heme group
    - Color: bright red or cherry red
  - metmyoglobin - Fe^{+++}
    OH connected to the 6th binding place of the heme group
    - Color: brown red

Conclusion: oxidation state of $Fe^{(2+ \text{ of } 3+)}$ And the connecected molecules which are present (O_2 etc.) determine the color of the meat

Bonds	Compound	Color	Name
Fe++ Ferrous (covalent)	$:H_2O$	Purple	Reduced myoglobin
	$:O_2$	Red	Oxymyoglobin
	:NO	Cured pink	Nitric oxide myoglobin
	:CO	Red	Carboxymyoglobin
Fe^{+++} Ferric (ionic)	−CN	Red	Cyanmetmyoglobin
	−OH	Brown	Metmyoglobin
	−SH	Green	Sulfmyoglobin
	$-H_2O_2$	Green	Choleglobin

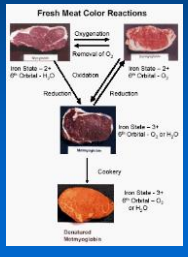


* Sample progression of before and after carbon monoxide gas treatment process

The reducing capacity of muscles ensures that iron-ion is converted from Fe^{+++} in Fe^{++} and so improves the fresh color

- This conversion depends on the availability of reducing enzymes
- Fresh meat *lives !!!*

  It uses $O_2 \rightarrow CO_2$ to evoke energy for releasing enzymes and so keeping the reducing capacity intact



As long as the meat is fresh enough to keep Fe^{++} reduced, the color is acceptable (purplish red)

– When the meat gets older, the reducing capacity is decreasing and the forming of metmyoglobin (brown-red) dominates

Relation between the formation of metmyoglobin and the meat color	
% metmyoglobin related to the total amount of meat color pigment	Meat color
< 30 % 30 - 50 % 50 – 60 % 60 – 70 % > 70 %	Intensive Cherry red Red Brown red Red-brown Brown

Relation between oxygen pressure and the kind of appearance of myoglobin in fresh meat

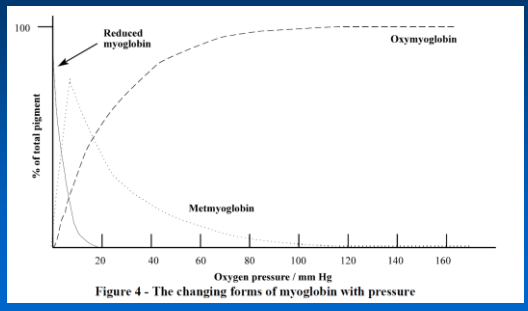
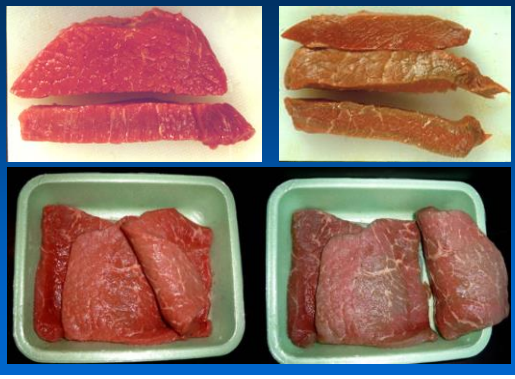
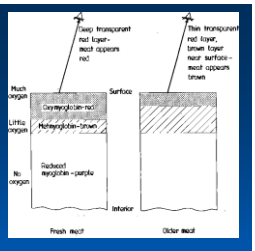


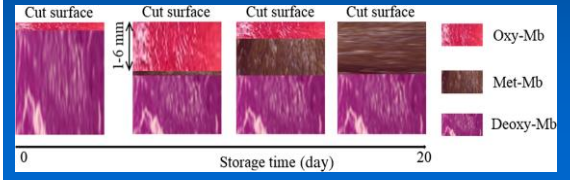
Figure 4 - The changing forms of myoglobin with pressure

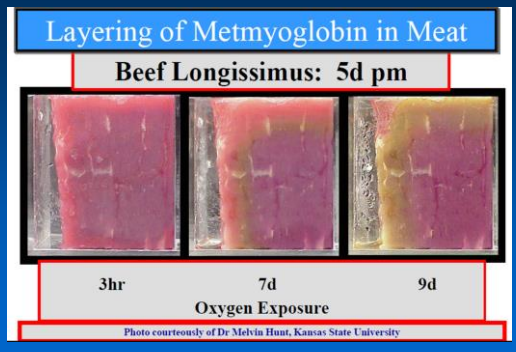
Aging of meat



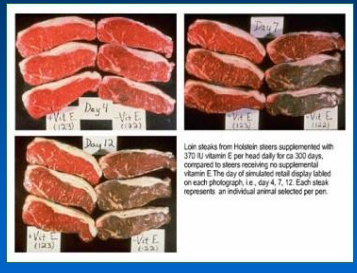
Aging of meat







Influence of vitamin E (added to the feed of Holstein steers) on the color stability of meat parts (loin steaks)

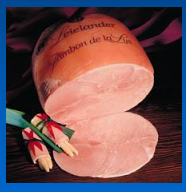


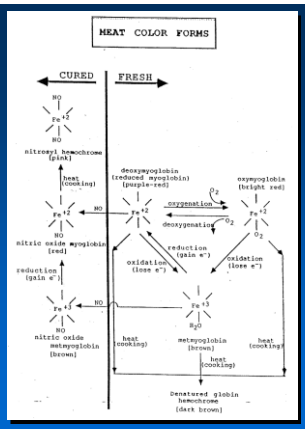
Color of meats

– Examples of raw meat products with nitrite

Color of meats

– Examples of cooked (cured) meat products with nitrite



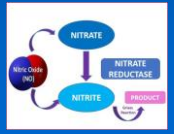


⟶ Maximum color forming

Provide a sufficient amount of nitrite - NO_2^-

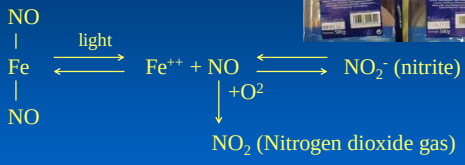
– NO_2^- + reducing enzyms → NO (slow)
– 2 NO_2^- + $2H^+$(acid) → 2HONO → NO + NO_3^- + $2H^+$
– NO_2^- + Fe^{++} (heme) → Fe^{+++} + NO

These three natural reactions of nitrite in meat are very important as NO sources for the formation of the meat color



The color of heated meat products (with nitrite) isn't stable

Particularly in the presence of light and oxygen



That's why vacuum systems and the density of light is essential for the retention of the meat color

The change of color due to heating