Rigor Mortis in Fish

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Rigor Mortis

During harvest aquatic animals experience high activity levels
- Metabolism speeds up
- Oxygen demand increases
- The animal struggles trying to escape and survive

Harvest stress can greatly affect quality
- Bruising or other physical injuries
- Removal of slime coat
- Handling conditions post mortem

Rigor Mortis (Latin ‘the stiffness of death’) is one of the most drastic changes that occur in the muscle soon after death
Rigor Mortis

Rigor Mortis is characterized by a succession of muscle contractions.

Rigor can cause changes in muscle quality:
- Shortening (shrinkage of fish fillet)
- Gaping (the individual flakes of muscle come apart giving the fillet a broken and ragged appearance)
- Drip loss (loss of water from fish fillet)
- Shortening and drip loss lead to tougher texture

Determining the optimal conditions for muscle to pass through rigor state with minimum quality loss is important.
Rigor Mortis

Gulf of Mexico
Sturgeon
pre- or post-rigor

Gulf of Mexico
Sturgeon in rigor
Post-Mortem Changes

Changes that occur in fish muscle after death and prior to processing

Rigor Mortis

- First notable change in fish is rigor
- Rigor is a physiological reaction to death
- Muscle path:
  limp/elastic ---> stiff/hard ---> limp/elastic
  (pre-rigor)   (rigor)    (post-rigor)
Post-Mortem Changes

Onset, duration and resolution of rigor in fish muscle depends on many factors…

- Amount of struggle in net/on deck fish underwent right before death
- Killing method
- Handling practices after harvest
- Elapsed time between harvest and chilling of the catch
- Temperature muscle undergo rigor mortis (holding temperature prior to processing)
- Fish species
- Fish size
- Starvation prior to harvest
- Sexual maturity
- Overall condition of the animal at harvest (heath)
- Processing of fish pre-rigor, in-rigor or post-rigor
Post-Mortem Changes

Noticeable changes in muscle quality that may occur in fish due to rigor:

- Odor changes: Off-odors may develop during short-term or long-term storage of fish muscle depending on the condition fish was left to undergo rigor. This is normally cause by degradation due to enzymes or bacteria.
- Color changes: Pigments may degrade or partially degrade
  - E.g. Fading of orange color is salmon muscle, development of black spots in shrimp
- Texture changes: If muscle contractions are strong then either muscle gaping (ripping of muscle structure near bones) or muscle toughening (drip-loss, or water loss) can occur
Fish Muscle

Three types:
- striated (voluntary)
- smooth (involuntary) – e.g. stomach walls
- cardiac (heart muscle)

Mostly interested in the striated or voluntary muscle that makes up the flesh of the fish. Smooth muscle is used in the edible portion of some mollusks.

Top view of fish muscle in bony fish.
Source: Lagler et al., 1977
Fish Muscle


Two types of striated muscle found in fish - **white meat and dark meat**

- Dark meat (also called swimming meat) lies just under the skin
  - Shape and amount depends on the species
  - Fish that live on the bottom of the ocean have very little or no dark meat
  - Fish swimming near the surface have higher amounts
  - Used for continuous movement

- **White meat used for quick bursts of energy, such as fleeing predators**
Dark vs. White Muscle

Distribution and amounts of dark muscle are different among fish species as shown in Figure below.

(a) Herring
(b) Mackerel
(c) Tuna
(d) Haddock
(e) Cod
(f) Whiting (Hake)

Source: Love, 1988
Fish Muscle Structure

Fish muscle is a made of one cell deep W-shaped segments (muscle fiber). A single muscle is formed by several bundles of fibers held together by connective tissue (collagen).

Connective tissue is distributed in sheathes between muscle fibers (works as a “cement” or “glue”). It holds the muscle fibers together.

Lateral view of myotome pattern in bony fish muscle. Source: Lagler et al., 1977

Top view of myotome pattern in bony fish muscle. Source: Lagler et al., 1977
Muscle Structure: Fish vs. Warm-Blooded Animals

- Amount of collagen in the fish body is relatively LOW compared to mammals and birds.
- Collagen is one of the main components of skin, cartilage, ligaments, tendons, etc.…
- Collagen is one of the responsible compounds for skin strength and elasticity – its degradation leads to wrinkles (aging).
Muscle Structure: Fish vs. Warm-Blooded Animals

- In fish muscle, collagen provides only a weak network of connective tissue.
- In warm-blooded animals, collagen provides a strong network of connective tissue.
- This is why when fish muscle is cooked, it ‘flakes’, and it is much more TENDER than muscle of warm-blooded animals.