

Postmortem Changes in Fish and Fishery Products

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ABSTRACT

Fish is a highly nutritious and perishable food commodity, and its quality is greatly influenced by the biochemical and microbiological changes that occur after death. These changes, known as postmortem changes, play a critical role in determining the freshness, texture, flavour, and storage life of fish and fishery products. After death, the cessation of blood circulation and oxygen supply leads to a shift from aerobic to anaerobic metabolism in muscle tissues. This results in the depletion of energy reserves such as ATP, breakdown of glycogen into lactic acid, and subsequent alterations in muscle proteins. The process typically progresses through several stages including pre-rigor, rigor mortis, and post-rigor, followed by autolysis and microbial spoilage. These stages cause significant changes in muscle structure, biochemical composition, and sensory characteristics of fish. Factors such as temperature, handling stress, species, and storage conditions strongly influence the rate of these changes. Understanding postmortem changes is essential for the fish processing industry because proper handling, chilling, and preservation techniques can effectively slow down deterioration and maintain product quality.

INTRODUCTION

What are Postmortem changes in fish????

Postmortem changes in fish refer to the series of physical, biochemical, and microbiological changes that occur in fish tissues after death. Once the fish dies, blood circulation stops and oxygen supply to the muscles ceases, causing a shift from aerobic metabolism to anaerobic metabolism. As a result, the normal physiological processes of the muscle are disrupted and several chemical reactions begin to take place within the fish tissue. These changes involve depletion of energy reserves (ATP), breakdown of glycogen to lactic acid, alterations in muscle proteins, enzymatic degradation, and microbial activity. The process usually progresses through stages such as pre-rigor, rigor mortis, autolysis, and bacterial spoilage, which ultimately determine the texture, flavour, freshness, and shelf life of fish and fishery products (Huss, 1995). Understanding postmortem changes is important in fish processing and preservation, as proper handling, chilling, and storage can slow down these reactions and maintain the quality of fish for a longer period.

Changes in raw fresh fish

- Immediately after death the muscle is totally relaxed and the elastic texture usually persists for some hours, thereafter the muscle will contract.
- When it becomes hard and stiff the whole body becomes inflexible and the fish is in rigor mortis.
- The rate in onset and resolution of rigor varies from species to species and is affected by temperature, handling, size and physical condition of the fish.
- Rigor mortis starts immediately or shortly after death, if the fish is starved and the

glycogen reserves are depleted, or if the fish is stressed during fishing (Balachandran, 2016).

The "Shrinkage" Risk

If fish is filleted before it goes into rigor (pre-Rigor), the muscle has nothing to hold it in place. Once rigor hits, the muscle contracts significantly: Dark Muscle: Can shrink up to 52% of its original length and White Muscle: Can shrink up to 15% of its original length. If filleted too early, you end up with "shortened," tough fillets that look unappealing to the consumer.

State	Cooked Texture	Processing Yield
Pre-Rigor	Very soft and pasty	High risk of shrinkage
In-Rigor	Tough but not dry	Poor (Low yield, gaping issues)
Post-Rigor	Firm and succulent	Excellent (Best for fillets)

1. Pre-Rigor Stage Muscle condition

Immediately after the fish dies, the muscle remains soft, flexible, and elastic. The body can still bend easily and the muscle fibres are relaxed (Germond *et al.*, 2023).

Energy status

At this stage, ATP (Adenosine Triphosphate) is still present in sufficient quantity in the muscle cells. ATP acts as the energy currency that allows muscle contraction and relaxation.

- During life, muscles contract when actin and myosin filaments slide over each other.
- ATP helps separate actin and myosin after contraction, allowing the muscle to relax again.

Because ATP is still available after death, the actin and myosin remain separate, keeping the muscle soft (Hematyar *et al.*, 2024).

Biochemical reactions

After death, oxygen supply stops, so the muscle shifts to anaerobic glycolysis:

- Glycogen → Lactic acid
- This causes a gradual decrease in pH of the muscle (usually from about 7.0 to 6.2–6.5).

Importance in fish processing

Pre-rigor fish is considered extremely fresh and high quality.

Advantages:

- Good water holding capacity
- Better texture and firmness
- Ideal for filleting and processing

However, improper handling can cause gaping, which is the tearing of connective tissue between muscle segments (myotomes).

2. Rigor Mortis Stage

Muscle condition

As ATP becomes depleted, the fish enters rigor mortis, where the muscles become: Hard, Rigid and Inflexible. The body becomes stiff and cannot be bent easily.

Protein changes

When ATP is completely exhausted:

- Actin and myosin permanently bind together
- This forms a stable complex called actomyosin complex.

Because ATP is required to break the actin-myosin bond, the absence of ATP causes the muscle fibres to lock in a contracted state, producing stiffness (Balachandran, 2016).

Energy metabolism (During rigor)

- Glycogen reserves are depleted, Lactic acid accumulates, Muscle pH decreases further.

This pH decline affects protein structure and water-holding capacity, contributing to the firmness of the muscle.

Factors affecting onset of rigor mortis

The time required for rigor mortis to start depends on several factors:

1. Fish species

- Some fish enter rigor quickly (e.g., small pelagic fish)
- Others take longer (large demersal fish)

2. Temperature

- Higher temperatures accelerate biochemical reactions
- Rigor develops faster at warm temperatures

3. Handling stress

- Fish that struggle during capture consume more glycogen
- Less glycogen → faster ATP depletion → earlier rigor onset

4. Fish size

- Smaller fish typically enter rigor faster.

Typical onset time

Rigor mortis may start within 1 to 24 hours after death, depending on the above conditions.

Importance in processing

Processing fish during full rigor is usually avoided because:

- Fillets may become short and tough
- Texture may be less desirable
- Cutting may be more difficult.

3. Post-Rigor Stage

Muscle condition

After some time, the rigid muscle begins to soften again. This stage is called resolution of rigor or post-rigor stage. However, the muscle does not return to the original pre-rigor state.

Protein breakdown

The softening occurs because of enzymatic proteolysis. Natural enzymes present in fish muscle begin to degrade structural proteins (Hematyar *et al.*, 2024).

Important enzymes involved include:

- Cathepsins
- Calpains
- Collagenases

These enzymes break down:

- Connective tissue
- Structural proteins

As a result:

- Muscle fibres weaken
- Tissue structure loosens
- The fish becomes tender and softer

Quality implications

During early post-rigor:

- Fish may develop improved flavour and tenderness
- This stage is sometimes considered ideal for certain processing operations.

However, prolonged enzymatic activity eventually leads to:

- Loss of texture
- Protein degradation
- Spoilage due to microbial growth

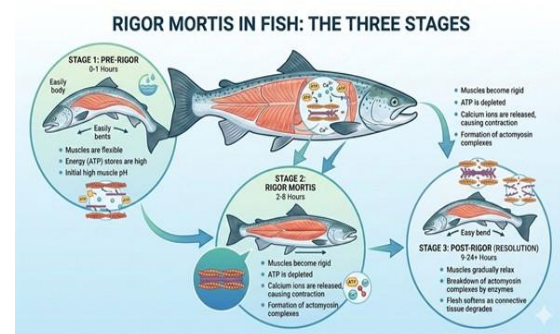
Importance of preservation

To maintain quality during this stage, fish must be:

- Chilled with ice
- Refrigerated
- Frozen

Low temperatures slow down:

- Enzyme activity
- Microbial growth
- Protein degradation



CONCLUSION

Postmortem changes in fish are a series of complex biochemical, physical, and microbiological processes that significantly influence the quality, freshness, and shelf life of fish and fishery products. After death, the

depletion of ATP, onset of rigor mortis, enzymatic autolysis, and microbial activity progressively alter the structure and composition of fish muscle. These changes affect important quality attributes such as texture, flavor, odor, and overall acceptability of the product. The rate and extent of these changes are strongly influenced by factors such as species, handling stress, temperature, and storage conditions. Proper post-harvest handling practices including rapid chilling, hygienic processing, and appropriate preservation techniques are therefore essential to slow down deterioration and maintain fish quality. A clear understanding of postmortem biochemical transformations helps the fish processing industry improve product quality, extend storage life, and ensure safe and high-quality fishery products for consumers.

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