# RIGOR MORTIES

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## Rigor mortis-

Muscle - Meat CONVERSION involves a series of complex physico-chemical changes.The first and most important change that occurs in muscles is- rigor mortis.

Proteins form the most important solid constituent and consist of myofibrillar, sarcoplasmic and connective tissue proteins. About two-thirds of the proteins are myofibrillar,most important types being actin and myosin which form actomyosin complex after rigor mortis and give rigidity to the muscles. Troponin A, B and T, and tropomyosin are the other proteins present in variable quantities.

Sarcoplasmic proteins which are water soluble include myoglobin, haemoglobin and some glycolytic enzymes.

Occurrence of proper degree of rigor mortis and development of low pH of meat during rigor are desirable characteristics. A low pH of meat inhibits bacterial growth while lactic acid converts connective tissue in gelatin which makes it more tender on cooking.

The phenomenon of rigor mortis is characterized by-

1)Hardening and contraction of all voluntary muscles,

2) Loss in transparency of the surface of the muscle,

3) Stiffening of joints and

4) Slight rise in temperature by 1 - 1.5 °C or more.

# Process of rigor mortis

1. After death/slaughter of an animal, blood supply of the muscles ceases leading to severe deficiency of oxygen, energy and vital elements essential for cellular activity and an anaerobic environment in the muscles is created.

2. During normal glycolysis in presence of oxygen through a series of biochemical changes, the muscle glycogen is converted into adenosine triphosphate (ATP), carbon dioxide and water. However, absence of oxygen favours anaerobic glycolysis and due to action of lactic dehydrogenase glycogen is converted into lactic acid thereby causing drastic reduction in ATP production.

3. The lactic acid formed during the glycolysis goes on accumulating and lowering the pH of muscles. The pH begins to decline from about 7.0 till 5.3 to 5.5. With reduction in pH, ATP content of the muscle starts declining from its pre-rigor concentration of 5.9 micromoles/gm at pH 7.0 - 7.2 to near zero at pH 5.3-5.5.

4. The level of ATP can be maintained for some time by resynthesis from ADP and creatinine phosphate, but the quantity of ATP generated is very low and the overall level falls leading to further reduction in pH due to lactic acid formation.

5. This lowering of pH leads to weakening in the permeability of sarcoplasmic reticulum which results into influx of Ca++ ions in the cell.

6. Ca++ gets bound to troponin and causes conformational changes in the tropomyosin resulting into release of the Mg++ activated ATPase enzyme

7. Due to action of this ATPase enzyme, ATP at actin-combining site on myosin and ATP at myosin combining site on actin are hydrolysed. As a result, myosin and actin interact together to form cross-linkage as actomyosin complex which cannot be dissociated. This actomyosin complex results in inextensibility and toughening of the muscles making them rigid and noncontractile

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This rigidity and toughening to the muscles is termed as rigor mortis. The loss of extensibility due to actomyosin formation proceeds slowly at first (the delay period), then with rapidity (the fast phase) after which it remains at a low level. The onset of rigor mortis is accompanied by lowering of water holding capacity of muscles.

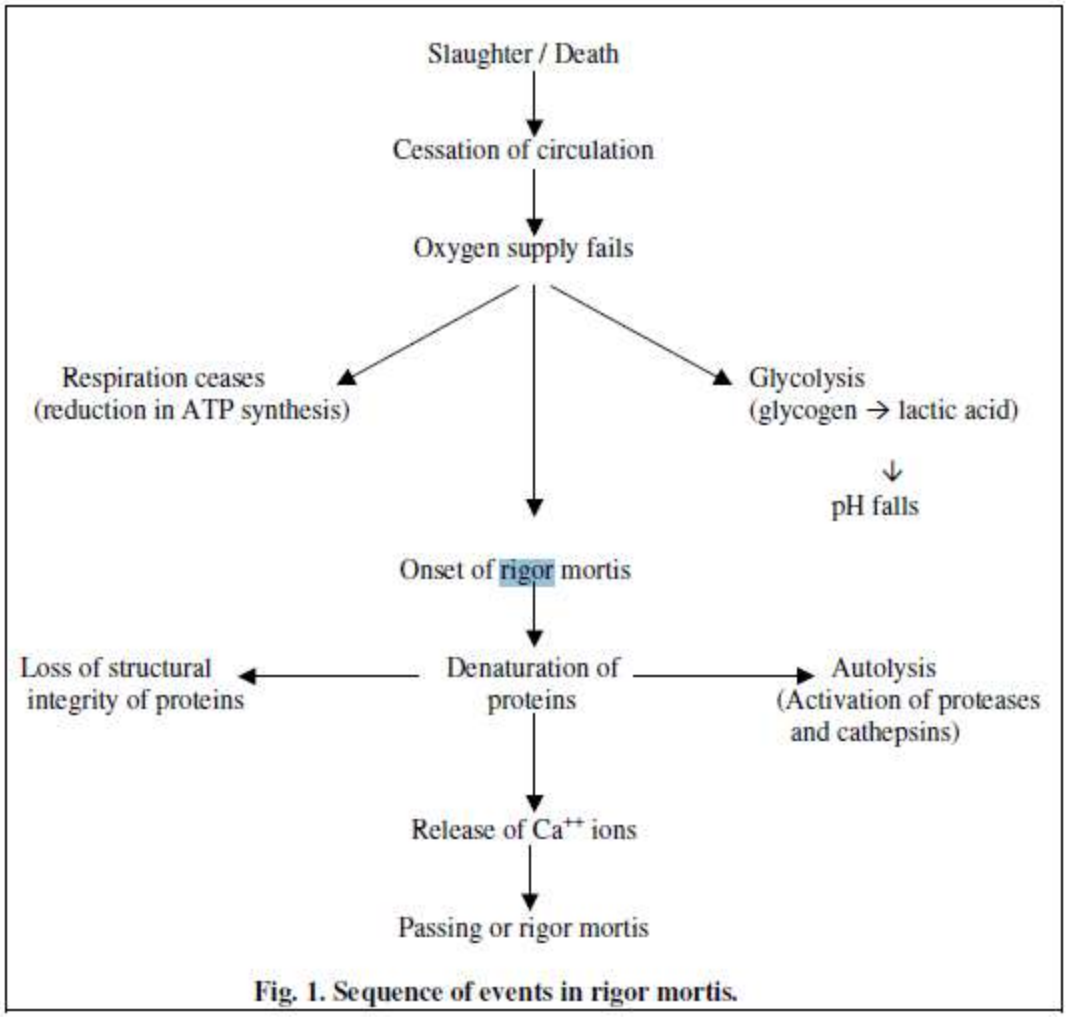


**Fig. 1. Sequence of events in rigor mortis.**

The onset patterns of rigor mortis can be classified as acid rigor which is characterised (in immobilised animals) by a long delay period and a short fast phase and in struggling animals by a drastic curtailment of the delay period;

alkaline rigor which is characterised by a rapid onset of stiffening and by marked shortening of muscles; and intermediate rigor characterised (in starved animals) by a curtailment of the delay period but not of the rapid phase.

•Rigor mortis starts from muscles of head and neck and then extends to rest of the body and finally the legs. In healthy animals it starts after 9-12 hours of slaughter, stays for 20-24 hours and then passes off.

•After 20-24 hours, the rigidity of the muscles cannot be maintained due to lowering of ATP concentration since it is also required to maintain the stromal integrity of the proteins.

•Besides, lowering of pH by lactic acid denatures the proteins that are attacked by proteases and cathepsins of muscles. These all complex activities ultimately increase the pH of meat which results in enhancing impermeability of sarcoplasmic reticulum to Ca++ ions.

•There is increased accumulation of non-bound Ca++ resulting from protein breakdown. These all factors together lead to softening of coagulated muscle fibers and rigor passes off.

•As a general rule, faster the onset of rigor mortis, faster it passes off, and slower the onset of rigor mortis, slower does it pass off.

•Rigor mortis tends to affect the most and properly nourished muscles at first and commences at the head and neck, extending backwards to the body and limbs.

The heart, however, is affected very early in the process - normally within an hour of slaughter.

**Factors affecting rigor mortis.**

## Intrinsic factors

- **Species of animal.**
- **Type of muscle**
- **Amount of glycogen**
- **Initial level of ATP and creatinine phosphate**

## Extrinsic factors

- **Atmospheric temperature**
- **Health and condition of an animal**
- **Administration of drugs-drugs such as sodium salicylate, alcohol and ether tend to encourage the early onset of rigor mortis.**

**Affections induced in meat during rigor mortis.**

***(a) Cold shortening.*** Cold shortening is described as the excessive shortening that occurs in muscles during glycolysis when the temperature of carcass is maintained in the range of 0- 10°C pre-rigor. Exposure of meat to low temperatures immediately after slaughter results in excessive contraction of muscles (may be up to 40%) thereby resulting in pronounced increase in the toughness of meat.

This change usually occurs in more active muscles of legs. Muscles having incomplete development of acidity (pH usually more than 6.7) and high ATP levels are more prone to cold shortening.

Besides, it occurs only in muscles with significant proportions of red muscle fibers, and thus its extent is much less in pig and rabbit muscles. This undesirable change in meat is attributed to release of Ca++ by sarcoplasmic reticulum due to its reduced efficiency in the cold and subsequent calcium activation of ATPase enzyme in rise in intracellular Ca++ levels in the muscles

**b)** ***Thaw rigor / Freezing shortening*** **-** This phenomenon results when the muscle is frozen pre-rigor and subsequently thawed. Massive contractions of muscles occur (up to a 50% of its initial length) when frozen and which upon thawing release substantial amount of drip resulting in tough muscles.

Fine crystals of ice formed inside the cells break the sarcoplasmic reticulum resulting in an abundant release of Ca++ on thawing. Increased concentration of Ca++ produces toughness in muscles on thawing.

# Thank you