

RIGOR MORTIS IN FISH THE PHENOMENON AND ITS SIGNIFICANCE

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INTRODUCTION

Literally the term 'rigor mortis' means 'death-stiffening'. This phenomenon occurs in the bodies of all animals, closely following their death. In the case of fish, the stiffening starts from the head region after a certain interval after death and gradually spreads through the body to the caudal region. It attains a peak after some time, maintains the maximum stiffness for some more time and then slowly resolves in the above order. The course of rigor mortis depends upon several factors such as the species and size of fish, type of death i.e. whether slaughtered immediately after catch or struggled and physically exhausted before a natural death, temperature at which held etc. A survey of the existing literature on the subject shows widely varying and rather confusing/conflicting data on these aspects; however, some broad generalisations can be made as follows. Duration of rigor is shorter in fish than in mammals, starting generally 1-7 hours after death and attaining the peak in 5-22 hours, with total duration extending over 30-120 hours in the case

of slaughtered fish kept in ice. It lasts longer in fish which has struggled less prior to death and refrigerated immediately thereafter. In this respect, fishes killed by a stunning blow on the head or electrocuted immediately after catch keep better than those which have undergone a natural death after suffocation and prolonged struggling and wriggling, onset of rigor occurring later, growing more intense and lasting longer in the former compared to the latter. Low temperatures of storage prolong the rigor considerably. It lasts longer in smaller fish than in larger ones. Wide variations are observed among various species of fishes in the matter of on-set, attaining maximum intensity, duration and resolution of rigor.

CHANGES OCCURRING DURING RIGOR MORTIS

A contraction of the skeletal muscle occurs during rigor mortis resulting in stiffening due to biochemical and physiological changes taking place in the dying muscle. The glycogen present in the tissues gets oxidised to lactic acid. Creatine phosphate in the muscle breaks down with release of

phosphoric acid which causes rapid contraction of the muscle, the lactic acid controlling the duration of the contracted condition. The stiffening is largely attributed to two of the major protein fractions of the muscle viz; actin and myosin combine together to give actomyosin. Both the acids mentioned above contribute to a rapid lowering of the pH value of the tissue fluids. The solubility of the proteins in sodium chloride solution is considerably reduced during rigor accompanied by damage to the colloidal nature of the muscle proteins. This is often referred to as 'denaturation' of the proteins. Adenosine triphosphate (ATP) breaks down stepwise to adenosine diphosphate (ADP), adenosine monophosphate (AMP) and inosine monophosphate (IMP), the last one especially imparting a characteristic and attractive flavour to the muscle. The real cause of rigor mortis is supposed to be the disappearance of ATP which appeared to be complete within 6 to 8 hours at 25°C in carp muscle, marketing its on-set. Electrical resistance of the muscle fluids show a rapid decline through pre-rigor, rigor and immediate post-rigor periods.

The muscle of newly killed fish is either neutral or slightly alkaline. During rigor, the pH gradually falls to 6.2 to 6.5 due to release of lactic and phosphoric acids. The ultimate pH values during rigor mortis in had-dock, whiting etc lie in the range 6.2 to 6.6, which may occur in a period of two days at 0°C. The fall is much more steep in the case of mammalian muscle, reaching as low as 5.5. If the fish struggles hard before death, a drastic depletion of glycogen content occurs with corresponding increase in

lactic acid content and consequent fall in pH value to even 5.53. In such cases rigor is initiated earlier and lasts shorter. The more the glycogen content of the muscle at death, the later rigor sets in and the longer it lasts.

RESOLUTION OF RIGOR

A gradual vanishing of the stiffness takes place after the course of rigor is gone through, accompanied by an increase in pH and the pace of autolytic changes, ending up in tenderisation of the muscle. This is followed by breakdown of proteins with appearance of ammonia, rapid spoilage changes ensuing thereafter. The flesh becomes softer, easily stripped off from the backbone and exudes juice under lightest pressure. It loses elasticity and retains finger indentations.

SALIENT FEATURES OF THE PHENOMENON

As mentioned earlier, a hardening of the fish muscle takes place during the course of rigor mortis, which can be felt by touching with the finger. The flesh in pre-rigor fish is soft and flabby and tending to retain (but not retaining) finger indentations. When the rigor is at its maximum, the fish body remains without bending if it is held by the caudal region in a horizontal position. The flesh becomes hard firm and elastic, is not readily stripped off from the backbone and does not readily yield juice under pressure. The acid reaction caused by the release of lactic and phosphoric acids increases the duration of the rigor and simultaneously suppresses the proliferation of micro-organisms responsible for the spoilage of muscle. Flesh and body fluids of newly caught fish are sterile and little or no bacterial activity occurs until the period of rigor mortis

has well passed its maximum (usually a period of 1 to 2 days in the case of fish stored in ice). This latter phenomenon is of utmost importance as far as keeping quality of the fish is concerned. That is to say, the longer the fish remains in rigor, the longer it keeps in good condition. The precautions to be taken for achieving this are many, the most important being the prevention of the fish from struggling before death. In trawling method of fishing, the hauling time should be reduced to the minimum. When once the catch is hauled on board, the fish should be handled very carefully without throwing them around and bruising. The ideal step to be adopted will be to anaesthetise the fish with an electric shock in the net itself. In this respect, fish caught by electrical fishing fares much better than those caught by conventional methods. This principle is also applied in some of the advanced countries in whaling, where an electric shock of sufficient intensity is imparted immediately after the whale is harpooned, preventing it from struggling for long periods as in olden days. In the case of line fishing also, now an electrical device is employed in developed countries by which the fish is subjected to an electric shock as soon as it bites the hook and the line experiences the first jerk which makes an electrical contact. Handling the fish prior to and during rigor should be reduced to the minimum. Temperature of the fish should be brought down as quickly as possible, preferably by applying crushed ice. Fish handled in this manner forms a better raw material for processing than exhausted ones.

SIGNIFICANCE OF THE PHENOMENON TO FISH PROCESSING

If the fish is filleted before the on-set of rigor, the fillets sometimes pass into rigor before reaching chilled or frozen temperature, resulting in severe contractions accompanied by fair losses in weight. In fish frozen pre-rigor, often it occurs during thawing (so called 'thaw-rigor'), which may cause as much as 40% drip loss. However, it has been reported in the case of cod gutted and quick-frozen pre-rigor that it yields a high quality thawed product.

It is a general practice in the case of beef, mutton, pork etc, to hold the butchered, deskinning and cleaned carcasses for varying periods in cold storages before further processing for the purpose of 'age-ing', 'maturing' or 'tenderising'. Resolution of rigor appears to be the significant principle underlying this step. Though much work has been reported on all aspects of rigor mortis as far as the above commodities are concerned, there are comparatively fewer published observations under actual commercial fishing conditions upon the speed with which rigor mortis sets in and its duration in relation to condition of fish at hauling, temperature, species etc. which decisively affect subsequent keeping quality as well as quality of products processed out of them. This is all the more important in a tropical country like India, where unless utmost care is exercised in prompt icing of the hauled fish, the ambient temperatures adversely affect the course of rigor mortis, bringing about spoilage changes very quickly. Informations on the details of time taken for on-set of rigor mortis, attaining its peak, duration and resolution are also important on factory

ships where the harvested fish has to be processed under optimum conditions. It has been observed in the author's laboratory that prawns canned immediately after catch (pre-rigor) were inferior in overall quality to those canned after a certain interval after catch, indicating the obvious influence of the phenomenon of rigor mortis on the quality of the processed product and hence the need for a certain period of maturing for development of the required desirable characteristic flavour and texture. Published literature on the subject shows that in the case of fish frozen pre-rigor, considerable texture and flavour deterioration takes place besides the drip losses and shrinkage that usually accompany such products. Researches on these aspects have not at all been attempted in India. Hence, it will be worthwhile

to make a detailed study of the various aspects of the phenomenon of rigor mortis such as (1) its course ie; on-set, attainment of peak, duration, resolution etc in important species of food fishes and shell fishes under atmospheric/climatic conditions obtaining in the country as well as under refrigerated temperatures after (a) natural death after usual struggling and (b) slaughtering immediately after catch, (2) how it affects/brings about the physical and biochemical changes that generally occur post-mortem in the fish muscle, (3) how it influences their further keeping quality in crushed ice and (4) how the overall organoleptic quality/acceptability of the products turned out from them by the common methods of processing like freezing/canning/dehydration are modified/altered/influenced by it. ●



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