

# Study on the Evolution of Rigor Mortis in Batches of Fish\*

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*Two methods were employed to obtain information regarding the setting, permanence and resolution of rigor mortis in batches of fish.*

*It was found that by determination of the percentage of the fully flexible specimens, the method of visual and tactile estimation of body rigidity is the most suitable for the determination of the rigor mortis evolution.*

*It was also observed that the changes in the reduced viscosity of the high ionic strength muscle extract of a pooled sample, permit to track the rigor mortis.*

*The rigor mortis characteristics of some fishes from the patagonian shelf were studied by the methods described above.*

## 1. Introduction

The period of setting, permanence and resolution, as well as the intensity of the rigor mortis, are important factors to establish appropriate conditions for fish handling and processing.

It is commonly accepted that a delay in the development of the rigor mortis increases the conservability of the fresh fish; nevertheless this asseveration has been questioned (1). From the practical point of view, in relation with processing on board for the preparation of frozen fish or fillets, it is important to know the length of time that the fish remains in rigor. For the processing on land and the consumption of fresh fish it is important to determine if the prolongation of the state of rigor in a particular species maintains its initial quality for a longer period.

Different methods have been proposed for the determination of the rigor mortis stage, that is pre rigor, full rigor and post rigor by measurement of changes of different parameters such as visual and tactile estimation of body rigidity (2) and strength needed to produce certain deformation (3, 4). Since the dielectric properties of the muscle change during the rigor mortis stage, measurements with the Fishtester V were also considered by Lupin *et al.* (5). After an exhaustive evaluation of these methods in our laboratory it was found that the visual and tactile estimation of the percentage of the fully flexible specimens of a sample of sixteen specimens from the same catch gave reproducible results to establish the rigor mortis stage.

It was also observed in our laboratory that the changes in the reduced viscosity of the high ionic strength muscle extract

allows to track, rigor mortis and the results showed a good coincidence with those obtained by the visual and tactile evaluation method.

Since most of the information on the characteristics of rigor mortis already available, is for species from the Northern Hemisphere, it was considered of interest to investigate the evolution of rigor mortis in species of the South-west Atlantic.

The results obtained with Hake (*Merluccius hubbsi*), Tail Hake (*Macruronus magellanicus*) Patagonian Blue Whiting (*Micromesistius australis*) Grenadier (*Macrourus whitsoni*) Sea Bream (*Sparus pagrus*) and Anchovy (*Engraulis anchoita*) are presented here.

## 2. Material and Methods

### 2.1. Source of material

The material was obtained from experimental captures performed by the research vessel "Walther Herwig" in the period from August to September 1978. A bottom net was pulled during half an hour at an average rate of nine to ten kilometers per hour.

Specimens from different places of the pile were taken immediately after the opening of the net, boxed with ice and stored at around 0°C.

### 2.2. Determination of the rigor mortis

Periodically samples of sixteen specimens from the same catch were visually and tactically examined and then discarded. The number of fully rigid, fully flexible and partially flexible specimens were determined in each sample. Results were expressed as the percentage of each type from the total sample.

### 2.3. Viscosity measurement

Reduced viscosity of high ionic strength muscle extract dur-

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ing the period of setting, permanence and resolution of rigor mortis was measured as described previously (6); washing of the pellet with distilled water was eliminated to speed up and simplify the procedure. Each viscosity measurement was done by quadruplicate, on a pooled sample obtained from sixteen fish each time.

### 3. Results

#### 3.1. Percentage of rigid, flexible and partially flexible specimens during the evolution of rigor in hake

The percentage of fully rigid, fully flexible and partially flexible specimens from the visual and tactile evaluation of Hake during the rigor mortis are represented in Fig. 1.

As can be observed when the curve for the fully rigid specimens decays the number of fully flexible specimens still remains at zero. The curve for the partially flexible specimens presents two peaks, one in early rigor and another very wide one which extends almost to the complete resolution of the rigor according to the curve for the fully flexible; the maximum values never reach hundred per cent.

The same type of curves were obtained with other species analysed. Although a dispersion was observed in different runs for the behaviour of fully rigid (7) and partially flexible specimens, fully flexible fish gave similar results for all the runs.

Thus it was considered that the curve for the fully flexible specimens best expresses in a qualitative and quantitative manner, the evolution of the rigor mortis and it was decided to adopt the determination of the percentage of the fully flexible specimens as the method to follow the evolution of the rigor mortis.

From the point of view of fish processing, the fully flexible curve also gives a practical information because as it is known, problems can arise in filleting and handling when partially or fully rigid fish is mechanical or even hand processed.

#### 3.2. Evolution of rigor in other species

The results obtained with Tail Hake (*Macruronus magellanicus*), Patagonian Blue Whiting (*Micromesistius australis*), Grenadier (*Macrourus whitsoni*) are presented in Fig. 2 and those of Sea Bream (*Sparus pagrus*) and Anchovy (*Engraulis anchoita*), in Fig. 3. As can be observed in Fig. 2 the setting of rigor mortis for Tail Hake takes around ten hours like in the case of Hake similarly rigor mortis lasts about thirty hours for both species, however the time for resolution has not been completed after eighty hours. The behaviour of the Patagonian Blue Whiting in setting, permanence and resolution correspond to that of Hake. Grenadier has a totally different behaviour since it gets into rigor not before thirty hours and remains in this condition for more than four days, as can be seen in the Fig. 2. Sea Bream and Anchovy behave as shown in Fig. 3.

It is necessary to point out that the rigor mortis evolution could vary from that described here, due mainly to seasonal changes in fish and catch or handling procedures. However the proposed methods can be used to obtain profiles of rigor mortis evolution in different situations.

#### 3.3. Effect of temperature on the evolution of rigor in Hake

It is known that an increase in storage temperature diminishes the rigor mortis period. A comparative assay was performed with Hake of the same catch, storing one sample at 0°C and another one at room temperature (10–11°C). The results obtained are shown in Fig. 4. The similarity in the time for setting was interpreted as being a consequence of the time that took the fish to reach 0°C when it was stored in

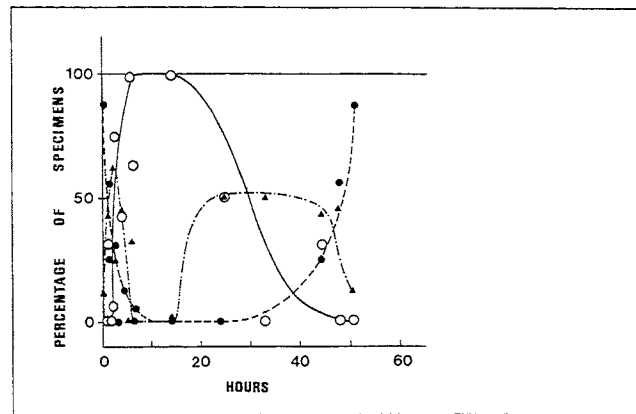


Fig. 1 Evolution of the rigor mortis in Hake. Percentage of fully rigid specimens (—○—), fully flexible specimens (—●—), partially flexible specimens (—▲—)

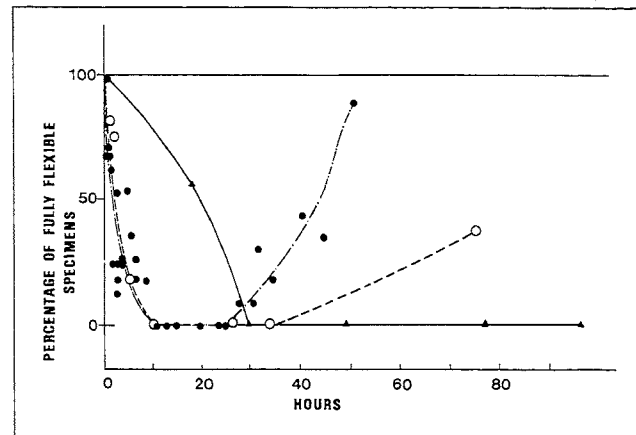


Fig. 2 Evolution of the rigor mortis in Tail Hake (---○---), Patagonian Blue Whiting (---●---), and Grenadier (—▲—)

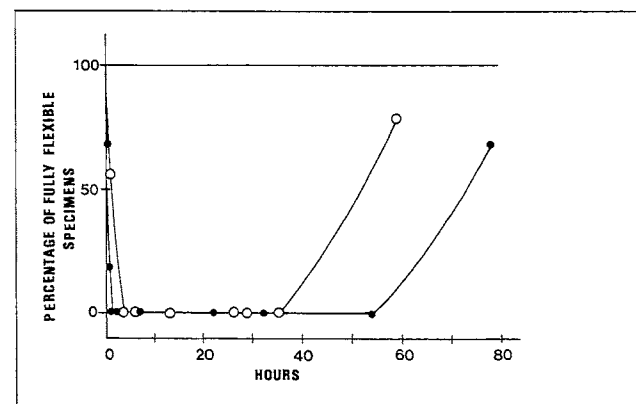


Fig. 3 Evolution of the rigor mortis in Sea Bream (—○—), and Anchovy (—●—)

ice (the initial temperature was the same). However, the proposed method seems appropriate to distinguish the existing difference in the length of rigor mortis.

#### 3.4. Changes in the viscosity of the muscle extract during evolution of rigor

Since rigor mortis implicates (8, 9) the occurrence of changes in the content of the actomyosin complex and according to studies carried out in our laboratory (10) the formation or dissociation of the complex can be determined by measurement of the reduced viscosity of the high ionic strength mus-

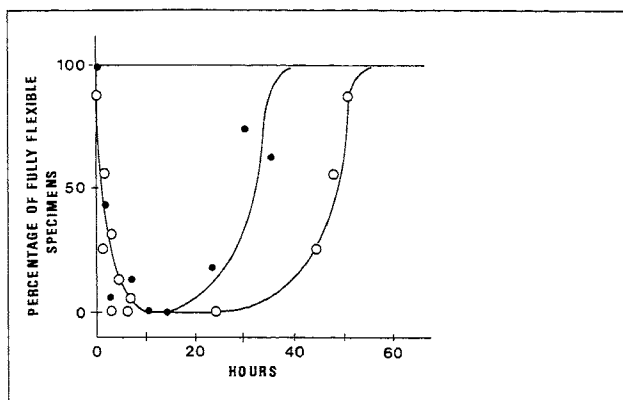


Fig. 4 Effect of temperature on the rigor mortis in Hake Storage in ice (—○—) and at room temperature (—●—)

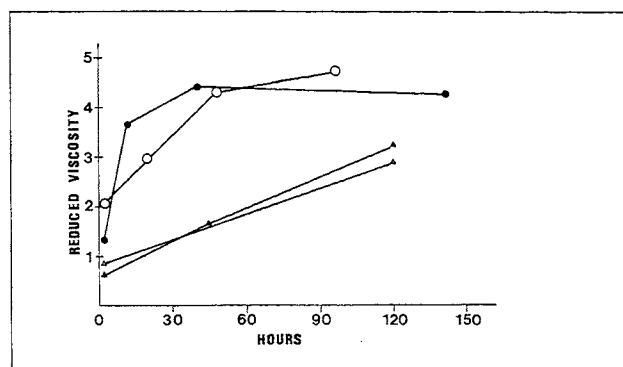


Fig. 5 Reduced viscosity of the high ionic strength muscle extract during the development of rigor mortis. Hake (—○—) Patagonian Blue Whiting (—●—) Tail Hake (—▲—) and Grenadier (—△—)

cle extract, it was decided to investigate the changes of viscosity along the rigor mortis period. The results of the reduced viscosity measurement of different species are represented in Fig. 5. As can be seen in the case of Hake and Patagonian Blue Whiting respectively the reduced viscosity of the muscle extract keeps increasing until the resolution of the rigor mortis is completed and then is stabilized. A similar phenomena occurs with Tail Hake and Grenadier, since after twenty hours Tail Hake is still in full rigor and Grenadier is in this stage after a hundred hours.

The measurements of viscosity can be performed on board, in the first fifteen minutes after the sampling. The extracts can be frozen stored the determination of protein and calculation of reduced viscosity on land. Protein extracts can not be stored for determination of viscosity as it was observed in our laboratory because changes occur in the viscosity even during the frozen storage of the extracts.

#### 4. Discussion

##### 4.1. Visual and tactile estimation of rigor

The results presented here seem to indicate that with the introduction of some modifications, the method early proposed by CUTTING (2) to evaluate the development of the rigor mortis in fishes, is the most sensible and reproducible.

The modifications consisted in determining only the number of fully flexible units from a significant sample and the use of a different sample in each periodical evaluation to avoid repetitive pressing and bending of the specimens.

##### 4.2. Viscosity changes during rigor evolution

The finding that the reduced viscosity of the high ionic strength muscle extract increased continually since slaughtering until the fish reached post rigor, makes it possible to follow the development of the rigor mortis by measurement of the reduced viscosity of the extract. A good concordance with the result obtained with the method of visual and tactile evaluation was found. Studies from our laboratory (10) have shown that the maximal value of the viscosity of the extract of either Hake or Patagonian Blue Whiting correspond to a value of 4.7 which is similar to that for purified actomyosin from Hake. This observation would indicate that either the amount of actomyosin increases until the beginning of the resolution of the rigor mortis, or that the amount of actomyosin extracted is lower in full rigor than after the rigor is over. In favor of the last assumption is the observation made by NIKKILA and LINKO (11) who have shown that the amount of extractable actomyosin is lower in the rigor than in the post rigor stage. Further work will be necessary to elucidate the problem.

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