# Quality in harvesting and post-harvesting procedures - influence on quality. Fish freshness and quality assessment for sea bass and sea bream

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# Quality in harvesting and post-harvesting procedures – influence on quality. Fish freshness and quality assessment for sea bass and sea bream

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**SUMMARY –** The finfish mariculture industry in the Mediterranean basin has developed astonishingly in the last fifteen years, mostly producing sea bass and sea bream. This rapid development has led to declining prices, thus changing the image of these fish from "prestigious fish" to "common fish". Big supermarket chains have conquered a large part of the fresh fish trade, replacing wholesalers and fishmongers. They ask for continuous and punctual deliveries and a uniform qualitative standard. Assuring high and certified quality will help get through the present difficult period. The HACCP assures one of the primary qualities fish must have as foodstuff: safety. Other qualities are just as important: appearance, shape, brightness, freshness, shelf life, etc. Rearing the fish in clear water and adopting a proper feeding regime, corresponds to accurate farming which can prove fruitless if OSP (Operative Standard Procedures) are not closely followed in harvesting, slaughtering, preparation and transport. Farmed sea bass and bream have many advantages over wild fish: harvest can be predicted in advance, death stress is lower, packing is conducted in a clean and covered area, so the shelf life can be as long as 10 days, compared to 3-5 days for the wild fish. We have to carefully consider what happens during the *rigor mortis* phases and *post mortem* lipid oxidation.

**Key words:** Sea bass, sea bream, quality, standard procedures, harvesting, post harvesting.

**RESUME –** *"La qualité au niveau des procédures de capture et post-capture – influence sur la qualité. Fraîcheur et évaluation de la qualité pour le bar et la daurade". L'aquaculture marine s'est fortement développée dans le bassin méditerranéen durant les quinze dernières années, principalement sur le bar et la daurade. Ce fort développement a conduit à une diminution des prix, transformant ces poissons de haut de gamme en produit de rang inférieur. Les chaînes de supermarchés se sont positionnées de façon décisive sur le marché du poisson frais, prenant ainsi la place des grossistes et des poissonneries. Elles imposent des rythmes de livraisons continus et ponctuels, avec un souci de qualité constante du produit. Cette garantie de qualité devrait se révéler comme un instrument de marketing essentiel pour traverser les difficultés du moment. L'HACCP constitue un gage d'assurance pour tout ce qui relève des aspects sanitaires. D'autres critères de qualité comme l'apparence, la forme, l'éclat, la fraîcheur et la durée de conservation sont tout aussi importants. Elever les poissons en eau propre, selon un régime alimentaire adapté, représente un point d'aboutissement des techniques d'élevage. Cet effort devient inutile si les OSP (Operative Standard Procedures) ne sont pas respectées pendant les phases de capture, d'abattage, de conditionnement ou de transport. Le bar et la daurade d'élevage ont de nombreux avantages : la capture peut être décidée par avance, la mort due au stress est plus faible, l'empaquetage est réalisé en zone aseptisée de telle sorte que la durée de conservation du poisson passe à 10 jours, comparé aux 3-4 jours du poisson sauvage. Il est important d'être particulièrement attentif aux phases de* rigor mortis *et d'oxydation lipidique* post mortem*.*

***Mots-clés :*** *Bar, daurade, qualité, procédures standards, capture, post-capture.*

## Introduction

The finfish mariculture industry in the Mediterranean basin has developed astonishingly in the last fifteen years. Nowadays we estimate that production is over 80,000 tons, mostly sea bream and sea bass. This rapid development has led to declining prices, decreasing more than 60% over the last seven-year period. The image of these fish has changed even if people still realise that they are "healthy", they are no more "prestigious".

Large supermarket chains have conquered a large part of the fresh fish trade, replacing wholesalers and fishmongers.

At the same time, recent EU legislation on farming has obliged many enterprises to invest in their facilities in order to make improvements in quality systems. Therefore we are in a strange situation: farmed fish like bass and bream are (or "should be") more controlled and guaranteed than in the past, but the sale price is much lower.

As producers we cannot hide our concern: global quality must be our target, but it incurs costs and the consumers must be aware of this. A bottle of acceptable quality wine cannot cost less than 1 ECU, and likewise a kilogram of good certified bass cannot cost less than 5 ECU.

Other paper contributions to these proceedings show us marketing strategies to get through the present difficult period. This paper deals with procedures aiming to preserve fish quality during harvesting and post harvesting. These are very delicate operations, because if the work is not done properly, the quality which has taken much effort to achieve, will be severely compromised.

## Quality concepts

The first quality we must assure is hygiene. Modern sea farms adapt the Hazard Analysis Critical Control Point (HACCP) system to check the safety of the products throughout the whole process, from the broodstock to the market size fish. In future, HACCP monitoring will have to be considered as part of a global quality management system based on ISO 9000 certification.

Large supermarket chains are demanding these systems to be followed, but it seems logical they should pay an extra price to the producers.

Besides hygiene, other quality aspects are just as important: appearance, shape, brightness, freshness, shelf life, and *taste*. All these quality aspects may be affected by many factors, as shown in Fig. 1, including harvesting and post harvesting procedures.

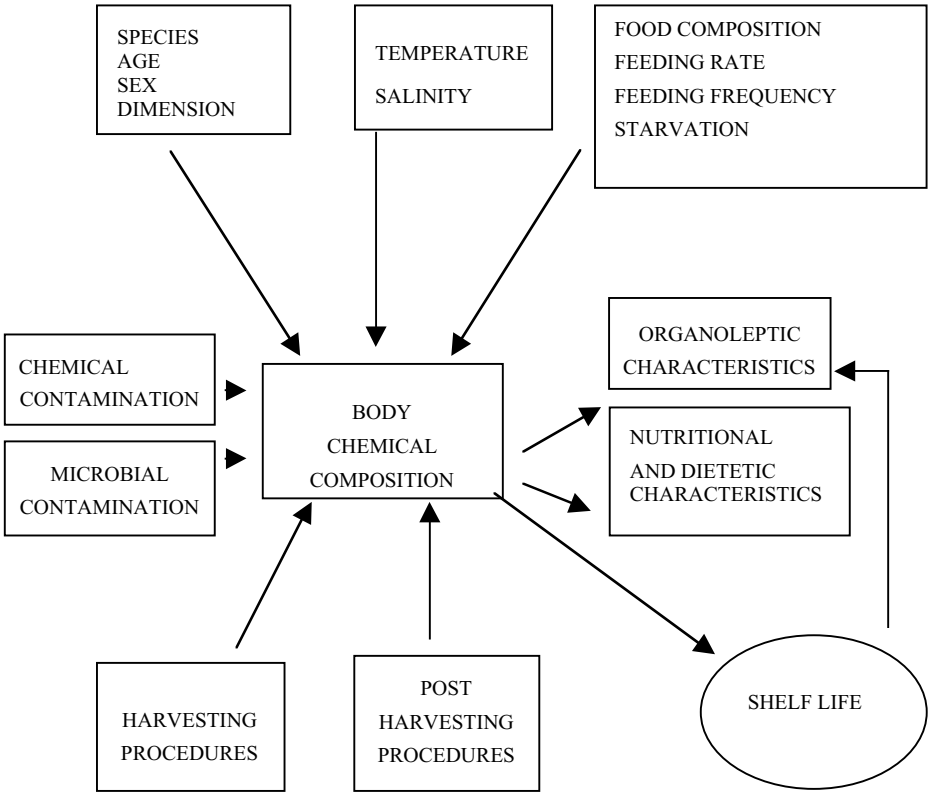


Fig. 1. Factors affecting quality.

Big differences can be detected in fillet yield and fillet composition, not only between different fish

species, but also between individuals of different age, sex or dimension within the same species. Food composition, feeding rate and frequency, widely linked to temperature affect body composition. Chemical and microbial contamination can unfortunately occur, both on live and dead animals. Changes in chemical composition produce different organoleptic, nutritional and dietetic characteristics, and shelf life as well.

Thus we must set operative standard procedures, and follow them closely in harvesting, slaughtering, preparation and transport.

## Harvesting

Two different situations should be considered two different situations: in land culture and sea cage culture.

In the first case great attention must be paid to cleaning the bottom of the tank, particularly before harvesting. Even in the best planned tanks, the water current, produced by water renewal and/or specific devices, is not enough to keep the bottom clean, therefore it is necessary to remove sludge and waste. It is possible to use pumps connected with a siphon, or special self-moving "cleaning car" equipment that can be driven directly in the tank which makes it possible to clean about 300 square meters per hour. The cleaning operation has many advantages: it reduces the oxygen consumption, and the impact of bacterial and parasitic diseases, and last but not least, assures greater hygiene and good organoleptic characteristics for the harvested fish, avoiding undesired materials entering the gills and mouth.

Obviously we have to ensure that the inside of the fish is kept clean. Some days of starvation are required; the period changing according to temperature and feeding rate. At 25°C degrees 24 hours could be enough if the fish is fed properly. At a lower temperature 48-72 hours are necessary. The result must be a gastro-intestinal tract free from feed residuals.

Longer starvation could be used to reduce excessive fat from the use of high-energy diets. Fish flesh contains a high level of PUFA, compared with other meat (pig, cow, lamb and chicken); for this reason fish meat is healthier to eat. Total fat could affect fish flavour and shelf life.

After correct starvation, the fish are ready to be collected. Before starting this operation we must carefully check for the presence of dying or dead fish; these fish could look normal, so they must now be discarded to avoid confusion with healthy ones. Harvest in sea cages is more difficult than in concrete tanks. First of all, weather conditions (waves, wind, current) must be acceptable for worker safety. In the second place, fish must be crowded in a relatively small area of several thousand cubic meters. Then the animals are harvested with dip nets or vacuum pumps, and put in plastic tubs with iced water.

In concrete tanks the operation is easier and possible in all weather conditions. The tanks are generally 1-2 meters deep, and it is often possible to collect the fish without entering the tank: the workers gently push the animals toward the water inlet using a small trawl, then they lift them with a vacuum pump or dip net, and place them in a plastic or stainless steel tank with iced water.

Both in sea cages and in land tanks, care is needed when taking the fish out of the water. This should be a quick operation to prevent the fish from scale loss and to preserve the appearance and brightness of the skin. In extreme cases widespread haemorrhages can be caused.

## Slaughtering

This operation must be considered from different points of view: hygiene, changes in organoleptic characteristics, work efficiency and animal welfare.

Ideal slaughtering should be easy, quick, hygienic, and should cause as little pain as possible. Usually sea bream and sea bass are killed by thermal shock, using iced water (0-4°C). With this method, in a few minutes the fish are chilled from sea temperature (12-28°C) to about 2-3°C; thus

maintaining the organoleptic characteristics. The iced water should be saturated with $CO_2$ which has an anaesthetic power and therefore the fish suffer less stress and are less sensitive to pain.

Recently two Norwegian specialists (Tobiassen and Sorensen, 1999), have reported on the influence of different slaughter methods and dying time in Atlantic salmon and rainbow trout. They tested three killing methods: gill slit, percussion stun and gill slit, pin bolt and gill slit, and these systems preceded by anaesthesia with $CO_2$ for 5 min or Eugenol 70 ppm, for 12 min. After the treatments, they detected: equilibrium, swimming, handling, breathing, eye-roll, prick reaction, electricity reaction. They found percussion stun and Eugenol bath the best method, while $CO_2$ + gill cut did not give a rapid loss of sensibility. Unfortunately Eugenol should be considered as a food additive, so it cannot be used in commercial activities.

Even if there are many differences between cold-water and warm-water farming and the environment (thermal shock is very difficult in cold temperatures, percussion stun is impossible to use with small size bass and bream), it would be interesting to run a similar experiment in our farms, in order to find out more on dying time and stress. Some data about the duration of slaughter and fish, water and ice quantities are reported in Table 1.

Table 1. Sea bass slaughtering† (Source: G. De Nigris, pers. comm.)

| | Time | Water temp. (°C) | Water pH | Body movements |
|---|---|---|---|---|
| Without $CO_2$ | Start | 22 | 7.65 | Detectable on all fish |
| | 5 min | 4 | 7.55 | |
| | 10 min | 2 | 7.35 | Detectable on all fish |
| | 15 min | 2 | 7.15 | |
| | 20 min | 1.5 | 7 | Detectable on few fish |
| | 25 min | 4 | 6.95 | Detectable on few fish |
| | 30 min | 7 | 7 | No movements |
| With $CO_2$ | Start | 22 | 7.60 | Detectable on all fish |
| | 5 min | 6 | 7.10 | |
| | 10 min | 4 | 6.85 | Detectable on few fish |
| | 15 min | 2 | 6.45 | |
| | 20 min | 2 | 6.3 | No movements |
| | 25 min | 4 | 5.95 | |
| | 30 min | 8 | 5.8 | |

†Fish load: 300 kg; Ice load: 80-100 kg; Sea water: 350 kg.

At this moment thermal shock and $CO_2$ seems to be the best way of killing bass and bream. It is recommended to produce ice from drinkable water, to keep the slaughter tanks clean, to use tested detergents and to rinse with clean pure water. It would be better to use iced sea water to kill fish, because fresh water causes the skin to lose its colour.

Usually slaughtering begins near the fattening tanks or cages, and continues during the transport of the tubs with the iced water as far as the packing unit. After slaughter, fish should not remain for more than 30 min in iced water, otherwise it would be impossible to pack them in a curved shape.

## Preparation

The packing unit should be as close as possible to the fattening unit and should be reached quickly and safely. Usually animals are transported by boat or by forklift truck, then the tubs are unloaded on perforated stainless steel tables, to drain the water from the fish. No means of transport are allowed in the packing room: the fish must be transferred under cover by conveyer belt or hand-driven trolley.

Packing facilities must be registered with the EU authorities and be in accordance with the directives concerning hygiene in fish handling. There must be an entrance for raw material and a separate exit for the processed goods. The packing area must be wide and well illuminated, the walls and floor easily washable. Appropriate nets must keep flying insects or other animals out. All equipment including tubs, conveyors, tables and balances must be made of rust-proof materials, because they must be disinfected and rinsed many times every day with drinkable water. Workers must have health papers and have a medical examination at least every 12 months. Ice, water, equipment, boxes and trucks must be controlled periodically by means of microbiological analysis.

After separating the fish from the iced water, the workers check the animals one by one, rejecting individuals with malformations, wounds or a poor appearance. Fish are graded manually or by automatic grading devices, weighed and placed (either straight or curved) by hand in polystyrene boxes. Then the fish are covered with a cellophane sheet and ice is placed over it. The sheet prevents direct contact between the ice and the fish, so the colour of the skin remains deep and bright for many days.

But what happens to the fish flesh after death?

Muscular tissue of the fish, which is what we eat, undergoes a well-known phenomenon, that we can divide into three periods: *pre rigor* (relaxed status), *rigor* (body stiffness) and *post rigor* (progressive loss of stiffness). The last phase period is characteristic for each species and influenced by the temperature.

For this reason many wholesalers and retailers ask for fish placed "curved" in the boxes. The fish can keep that shape only if it has been placed in the boxes just after death. This is an empirical way to show and detect freshness.

Different experts (Geri *et al*., 1996; Poli, 1999; Mecatti, 1999; Bonelli, 1999) have recently studied and explained very well the biochemical and physicochemical *post mortem* changes, as outlined in Fig. 2.

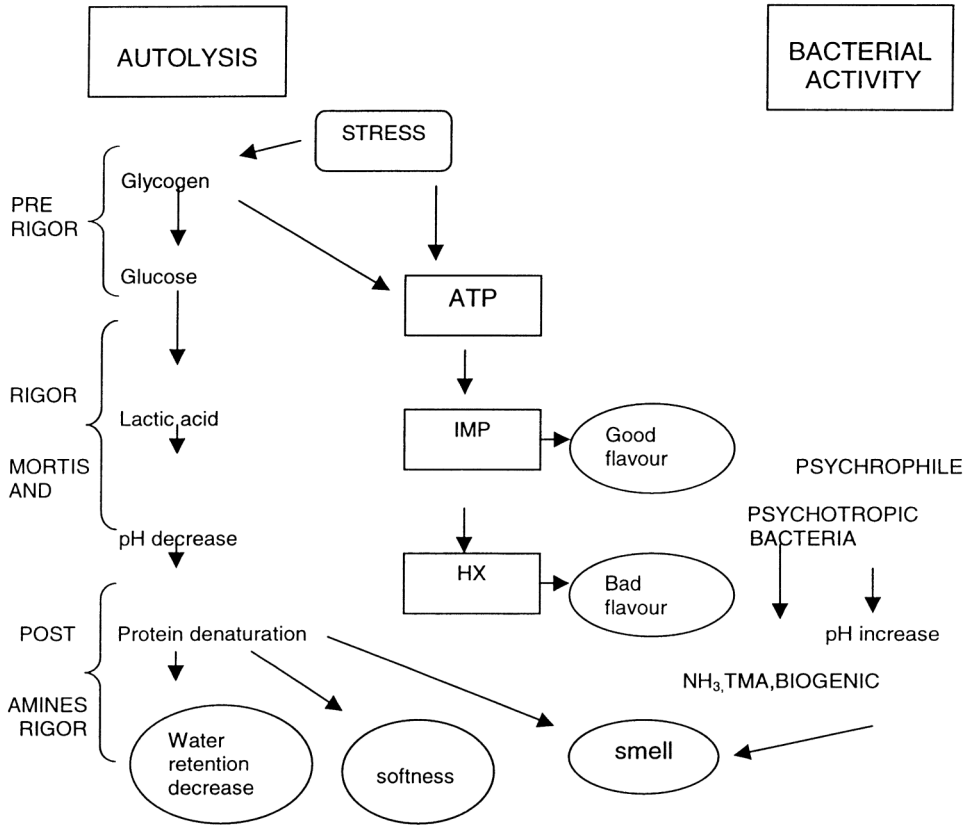


Fig. 2. *Post mortem* muscle alterations (Source: Poli, 1999).

*Post mortem* modifications are induced by two phenomena: cellular autolysis and bacterial activity. The first one starts soon and the second slightly later. After death, the oxygen does not reach the cells, so they try to survive using energy immediately available (ATP) and anaerobic glycolysis, that produces lactic acid (then the pH value decreases); this happens in the *pre rigor* period, when the fish has relaxed muscles. When the ATP concentration decreases below a certain level, the muscular contraction begins, i.e. the *rigor mortis* period. On one hand the ATP, ADP and AMP levels go down, and on the other the concentration of IMP (inosine-5'-monophosphate) rises; it is this product that gives good flavour to the flesh. When the IMP is degraded to inosine and then to hypoxanthine, the flavour becomes worse. Gradually the *rigor mortis* phase finishes when autolytyc enzymes break the proteinic structure that holds up the muscles, and *post rigor* begins. Denaturation of muscular protein means that the water retention of the meat decreases and it becomes softer. Beyond a certain limit this behaviour becomes negative.

Stress also can influence fish quality and shelf-life. If the animals are stressed before death, two events can occur. In case of acute stress, more lactic acid will be produced, therefore the pH value will decrease dramatically; in case of prolonged stress all the glycogen will be consumed, leading to a high level of pH.

Bacterial degradation generally starts after a long period, and then follows the hydrolytic degradation of the muscles. Psychrophile and psychotropic aerobic, gram negative bacteria, usually living on the fish, begin to multiply and after some days, depending on temperature, substances like ammonia, trimethylamine and biogenic amines produce their characteristic smell.

Nowadays the official fish freshness assessment is tested through a sensorial analysis: this allocates three different classes of freshness (extra, fresh, stale) and one to be rejected, using a pattern of sensorial assessment on skin, eyes, gills, internal organs and so on. This sensorial method is subjective and should be supported by an objective method.

The scientists of Florence University (Geri *et al*., 1996; Mecatti, 1999) tested different instrumental and biochemical methods on sea bass and sea bream coming from two intensive farms in Italy. After slaughtering, whole ungutted fish were kept under different conditions: 18°C, 4°C with or without ice covering, frozen at –20°C for 30 days and deep frozen at –20°C for 90 days, finally four days at 4°C after thawing.

Fillet samples from four fish for each treatment were analysed every 24 hours after slaughter for several days; meanwhile a veterinarian made a sensorial analysis on the same fish, according to the EU pattern. One of the most reliable methods was the K index (Watanabe *et al.,* 1986); this value comes from the determination of some product of ATP degradation: hypoxantine (Hx), inosine (HxR) and inosine-5'-monophosphate (IMP) with the formula { 100 _ ( HxR + Hx) / (IMP + HxR + Hx) }

In Japan if the K index is 20%, fish can be eaten uncooked, if it is between 20 and 40%, it can be eaten cooked, if it is above 40%, fish must be rejected.

At 18°C, the K index was over 40% at 24 hours post mortem with sea bass and at 48 hours with sea bream; at 4°C, the index remained below 20% on the first day after death in sea bass and second day in sea bream.

At 4°C with ice covering, the value was over 20% after 3 days in sea bass and 5 days in sea bream. This last temperature condition kept the K index below 40% (limit of freshness), for nine days in sea bass, and for eleven days in sea bream.

Parallel sensorial analysis of the veterinarian gave the same results, even if some sea bass were found still edible with K index slightly higher than 40%

Other fish freshness markers were proposed: malonic aldehyde (MDA), coming from the oxidation of PUFA (Bonelli, 1996), lipophilic antioxidant (Marco *et al*., 1999), cytochrome P450 (Pretti *et al*., 1999).

These scientific methods under research are of great validity but we also need a simple kit for biochemical determination *in situ*. See Rodríguez *et al*. (this volume).

## Conclusions

Fish processed following the guidelines outlined in this paper will keep their sensorial and nutritional characteristics for at least a week.

Once producers have made the effort to implement these quality procedures, they would also like to receive their profit. For this reason, not *some* farmers but *all of them* must operate with this care, and the competent authorities must oversee it. Hence, it would be very useful to be able to identify the origin, harvest date and expiry date of the product with certainty.

The more information we give to the consumer, the more confidence he will have in our product.

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