The Off-Flavors Management in the Production of Farmed Sturgeon

36

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Abstract

The rearing of sturgeon from its beginnings faces the problem of earthy taste in caviar and flesh. After a short presentation of the origins of this problem, a certain number of solutions possible in farming are presented, like depuration stocking in pure water or in recirculated systems and caviar selection before sales. Nevertheless, a global thought against this problem is now indispensable for the survival of each sturgeon freshwater fish farm.

Keywords

Sturgeon fish farming • Off-flavors • Depuration • Sensorial asting • Caviar

Introduction

Off-flavor taste problems are numerous in aquaculture, mainly in freshwater.

For centuries, the practice of having earth pond fishes spend several days in clear water basin to decrease the mud taste before slaughter is known. In the north of the Caspian, in the 1980s, beluga (*Huso huso*) and ossetra (*Acipenser gueldenstaedtii*) fisheries in the fall were avoided because of the earthy taste associated with wastewater flowing into the Volga in this period (Gödecken 1986). Sturgeons caught in shallow and stagnant water, with a strong presence of algae, generally tended to give caviar with the same characteristics. Given that caviar from aquaculture production develops in a global current context of strong competition, most producers were forced to put in place arrangements to limit or eliminate these unpleasant tastes. The aims of the present chapter are to briefly update the knowledge on (1) the origin of

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the unpleasant tasting, (2) how this happens, and (3) how to eliminate this inconvenience with a special emphasis on recirculated aquaculture systems (RAS).

36.1 The Origin of the Off-Flavor

It is related to the presence of bacteria, *Actinobacteria* of the genus *Streptomyces* and cyanobacteria, and a wide variety of fungi and molds that produce molecules yielding an unpleasant taste or odor (Berni and Billard 2002) at very low concentrations, of the thousandth of a milligram per liter. The well-known responsible molecules in aquaculture are geosmin and methylisoborneol (MIB), also responsible for the earthy-musty taste in drinking water or wine. This is because soil leaching will allow compounds produced by bacteria and soil fungus to be in the waters of river; coloring of the waters can become an indicator. And this leaching may also have an impact on the most superficial aquifers, from which we can draw clear but contaminated water. Additionally, the heat allows the development of populations of cyanobacteria in the water, even in a very clear lake or river, which will produce these compounds. Finally the bottomof ponds or pools with low water renewal promoting settling, rich in mineral or organic solids, or bottom of pools with clear waters, but with irregularities where uneaten food or feces can be deposited, is also an area for production of these compounds. Indeed, Guttman and van Rijn (2008) showed that particulate organic matter in the presence of abundant oxygen is very favorable to this production environment. Closed recirculated systems in freshwater are prone to provide off-flavor fish flesh, whatever the species reared. Most likely, this is because it has been shown recently that a part of every bacteria population is able to produce the aforementioned molecules responsible for the earthy taste. The mechanical and biological filters are important production areas of these compounds. The quality of a food inducing more or less fragmented feces may have an impact on the amount of geosmin present (Comeau et al. 2013).

36.2 Effect of Off-Flavor

After some hours spent in water containing tens of nanograms per liter of these components, fish absorb through their gills, so their muscles and their eggs are in charge of several hundred ng kg^{-1}, the sensory detection threshold being 200 ng mL^{-1} for the flesh. These molecules are very lipophilic. Tastes obtained in caviar are very varied, (earth, mud, grass, earthy, musty, bitter (green walnuts), cellar, etc.). If within wines 20 of various origins and perfectly identified molecules are clearly responsible for varied tastes parasitic characteristics, such a study has been conducted in caviar or farmed trout flesh (Robin et al. 2006) and concluded that the two aforementioned components are responsible for the earthy-musty taste.

Attempts to explain the transfer of these molecules in the fish are as follows according to A. Lautraite (com pers): geosmin and methylisoborneol (MIB) are quite lipophilic (their index lipophilia defined as log (octanol/water) and

abbreviated as log K_{ow} is 3.70 and 3.1, respectively) according to Boardman and Flick (2013), and their solubility in water is thus low (150–194 mg mL^{-1}, respectively). So they easily pass through cell membranes; it is a passive transfer without enzymatic reaction. If the concentration in water is higher than in the blood of fish, the compounds will be absorbed through the gills or the digestive tract, travel in the blood, and set in the fat of myotomes or into the oocytes. Concentration in muscle and fat and in the oocytes will thus be much greater than in water or blood from the fish. This accumulation process will be fast (a few minutes or hours). If you put the fish in the water where the concentration of geosmin and MIB is very low or zero, these compounds will tend to passively diffuse, but very slowly (several days or weeks), from muscle lipids or oocytes to fish blood and then passively diffuse through the gills (or the digestive tract) into the water column.

Preliminary results from E. Schram suggest that Nile tilapia bio-concentrates more geosmin in its ovaries than in its fillets and that the elimination of geosmin from the ovaries is slower than from the fillets. Higher initial geosmin levels combined with a slower elimination increase the time required for geosmin elimination in the depuration phase. This finding is especially relevant for the practice of off-flavor depuration when not only the fillet but also the ovary is of commercial interest, e.g., aquaculture of sturgeons. Off-flavor depuration time should be based on the elimination of geosmin and probably 2-MIB from the ovary rather than the fillet. Using the sensory quality of fillets as indicator for the sensory quality of the ovary may result in the harvest of still off-flavored caviar.

So, the rinsing applied to fish flesh may not be sufficient for the production of caviar.

36.3 How to Get Rid of Off-Flavor?

There are varied ways to both eliminate the off-flavors and earthy tastes and assess the results prior to any marketing decision.

36.3.1 The Rinsing

36.3.1.1 Open Circuit

The best solution is stored in clear water in open circuit, if one has sufficient resource of drilling water (Fig. 36.1), river, or lake bottom devoid of any contamination. The waters of shallow groundwater, river, or closed circuit may be infected without warning, after years without problems. The duration of the depuration is a function of the load in the off-flavor of the fish, the concentration of off-flavor in the rinsing water to be reabsorbed then released by the fish and slow down the process, so the pure water renewal. Also the temperature intervenes directly in affecting metabolism under the rule of Q10. The general rule is at least 2 weeks for lightly loaded fish and up to 6 weeks for heavily loaded fish, at a temperature of 17 °C. There is a wide

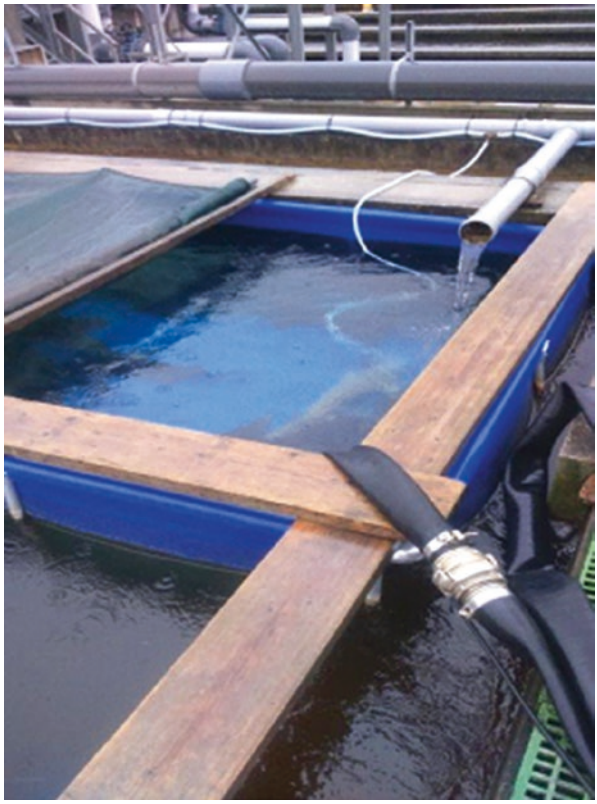

Fig. 36.1 Depuration tank in sturgeon farm supplied with well water inside a concrete basin supplied with colored river water (Esturgeonnière Farm, France) (Photo: Bonpunt)

variability in sturgeon for the concentration of molecules in the oocytes and for the purification speed. Furthermore, caviar batches are often obtained from several females, with only one fish contaminating a batch or more without the dilution effect taking place. We assume that concentrations of geosmin in unpleasant caviar may not be detectable in the flesh of the same fish.

36.3.1.2 Recirculated Circuit

With the objective of eliminating the unpleasant earthy taste, two routes have been tested or used successfully. The first one is to avoid the presence of the producers of these molecules in circuit, avoiding the presence of rotating filters, biological filters, fluidized beds (Fig. 36.2), and areas rich in organic matter, so a peculiar circuit devoted to the depuration has to be installed.

Even if fish are not fed during this period, the off-flavor compounds released by the fish purifications will come and infect the others. The second route is to eliminate these molecules from the circuit regularly. Among the existing treatments, the treatment with peroxide could be effective enough to ensure sustainable levels in the fish (Davidson et al. 2014). However, a similar weekly treatment applied on sturgeon females has caused oogenesis disturbances or atresia which then has to be currently avoided. An alternative treatment is using the ozonation. The ozone

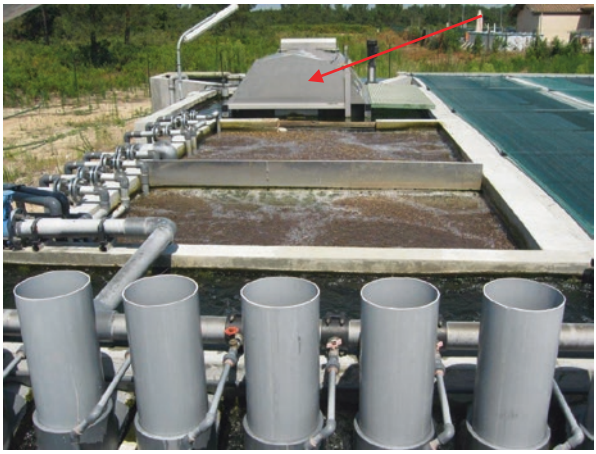

Fig. 36.2 Water treatment devices in sturgeon farm (Nurseteich Farm, France). *Red arrow* shows the rotative filter (mechanical filter) (Photo: Mauduit)

treatment, being effective only with lethal concentrations to the fish, may be done very carefully. The renewal of water purification basin must be totally devoid of off-flavor components. All the outflow of the basin must pass through an ozone generator and then directed to a very large buffer tank for a sufficient period in order to lower both the levels of residual ozone and oxidant molecules acceptable for fish. The required volume of this buffer basin will likely be very large, between two and four times that of the depuration basin. In order to avoid any risk of poisoning fish by these oxidant molecules of which the level will change with the time, it is needed to follow continuously the redox potential at the inflow of the rearing tanks in order to adapt the ozone generator production. Instead of using peroxide or ozone, activated carbon or zeolite could be used as trapping component in filters (Boardman and Flick 2013). Additionally, the search for a bacterial reactor able to consume these compounds might be envisaged as illustrated by Hebrew University of Jerusalem.

36.3.2 Sorting Before Slaughter

It is to taste the oocytes[1] obtained by biopsy at the time of the selection of females ready to produce caviar.

36.3.3 Selection After Salting

It should be noted that caviar production batches from the same batch of fish will have different off-flavor intensities. Some lots with low intensity can see disappear in three weeks the taste of earth and be sold after a tasting of verification. Others

[1] In this chapter, the expression of oocytes corresponds to the biological wording of ovarian follicles (editor's note).

will have to wait several months for storage and regular verification. Still others will have to be permanently decommissioned.

It is worthy to note that the reliable detection of off-flavor requires several people of the production laboratory are entrained for tasting the caviar, tasting facility with grids and blind tests confirming the choice of candidates. This can easily be obtained by taking advantage of the sensorial method described by Cardinal (Chap. 35). Given the availability of a more and more important number of actors on the caviar market with different origins (species, rearing conditions, etc.), the absence of interference taste becomes an essential condition of marketing.

Conclusion

Although the effect of the scarcity of luxurious caviar hinders the objectivity of neophyte tasters, professional buyers know how to detect caviar defects, which give essential control to breeders of this problem parasite taste. However, it does not seem desirable to achieve a uniform product that is bland and tasteless, and farmers may be able to 1 day promote their circuit, rinsing the presence of bacteria and producing a pleasant aroma.

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