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Anaesthetics Used in Aquaculture

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Introduction

Handling and transit can cause stress in fish, which can lead to immunosuppression, physical harm, or even death. Anaesthetics are used in aquaculture during transportation to prevent physical harm and to slow metabolism (DO consumption and excretion). They are also used to immobilise fish, making them easier to handle during harvesting, sampling, and spawning procedures. An ideal anaesthetic should produce anaesthesia quickly and with as little hyperactivity or stress as possible. It should be simple to use and keep the animal in the desired state. When the anaesthetic is removed, the animal should recover quickly. The anaesthetic should be effective at low dosages, and the toxic dose should be much higher than the effective amount, allowing for a wide margin of safety.

Stages of anesthesia

The majority of anaesthetics have numerous levels or phases of anaesthesia. Stages include sedation, anaesthesia, surgical anaesthesia, and death (Table 1). The dose and length of exposure usually define the stage attained. After getting an anaesthetic (induction), fish may become hyperactive for a few seconds.

Table 1. Stages of anesthesia in fish

Stage	Condition	Behaviour/Response
I	Sedation	Motion & breathing reduced
II	Anesthesia	Partial loss of equilibrium Reactive to touch stimuli
III	Surgical anesthesia	Total loss of equilibrium. No reaction to touch stimuli
IV	Death	Breathing & heart beat stop Overdose - eventual death

Anesthetics used in fish

Only MS-222 is now registered for use on food fish in the United States. Numerous compounds, however, have been studied experimentally, and some are now employed on non-food fish and in research. The following chemicals have been subjected to extensive testing in the United States or other countries. Table 2 summarises the effective dosages of these drugs for several fish species.

ND = not determined. Only MS-222 is approved in the U.S. at the time of this publication.

1.MS-222

Tricaine methane sulfonate is the substance's official name in chemistry. It is offered as Finquel and Tricaine-S. It comes in the form of a white, crystalline powder that can dissolve in water at a concentration of up to 11%. It decreases water's pH, resulting in an acidic environment that might irritate fish and have negative side effects. Baking soda (sodium bicarbonate) can be used as a buffer to raise the stock solution's pH to 7 in order to prevent issues. Even when fish are completely unconscious, handling still causes levels of plasma cortisol, a sign of stress, to rise. This is one of the main downsides of MS-222. Rapid induction can happen in as little as 15 seconds. When submerged in 25–50 mg/L, salmonids become promptly anaesthetized. 10 mg/L is a safe level to keep anaesthesia at. *Ictalurus punctatus*, a species of channel catfish, requires induction times of 3 minutes and doses of 25 to 50 mg/L for sedation and 100 to 250 mg/L for complete anaesthesia. Some species, such as tilapia, require up

Table 2. Dose rates of major anesthetic drugs, evaluated experimentally, for a number of commonly cultured fish species.

Anesthetic	Atlantic Salmon *Salmo salar*	Rainbow Trout *Oncorhynchus mykiss*	Common Carp *Cyprinus carpio*	Channel Cat Fish *Ictalurus punctatus*	Nile Tilapia *Oreochromis niloticus*	Striped bass *Morone saxitallis*
MS-222	40-50 mg/L	40-60 mg/L	100-250 mg/L	50-250 mg/L	100-200 mg/L	100-150 mg/L
Benzocaine	40 mg/L	25-50 mg/L	ND	ND	25-100 mg/L	50-100 mg/L
Quinaldine	25-40 mg/L	ND	10-40 mg/L	25-60 mg/L	25-50 mg/L 25-40 mg/L	25-40 mg/L
2-Phenoxyethanol	100-200 mg/L	100-200 mg/L	400-600 mg/L	ND	400-600 mg/L	ND
Metomidate	2-10 mg/L	5-6 mg/L	ND	4-8 mg/L	ND	7-10 mg/L
Clove oil	10-50 mg/L	40-120 mg/L	40-100 mg/L	100 mg/L	ND	60 mg/L
Aqui-S™	0-50 mg/L	20 mg/L	ND	20-60 mg/L	ND	ND

to 100 mg/L. Salmonids shouldn't typically be exposed to levels higher than 100 mg/L, and warm-water fish shouldn't typically be exposed to levels higher than 250 mg/L. Normal recovery is quick, and equilibrium should return in just a few minutes. If recovery takes more than 10 minutes, either too much anaesthetic is being administered or the exposure time is too long. MS-222 has a wide margin of safety in fish. The effective concentration in trout, for example, is 40 mg/L, whereas the maximum safe value is 63 mg/L. As the temperature rises, the safety margin shrinks and appears to be smaller for smaller fish. The medication is more effective in warm, soft water.MS-222 is eliminated in fish pee in less than 24 hours, and tissue levels fall to near zero in the same time frame. It is legal to use on food fish in the United States and the United Kingdom, but it was recently outlawed in Canada. The FDA requires a 21-day withdrawal period for MS-222, making it impracticable as an anaesthetic for fish en route to market.

Benzocaine

A white crystal known as benzocaine, also known as ethyl amino benzoate, is chemically comparable to MS-222. However, benzocaine must first be dissolved in ethanol or acetone because it is virtually completely insoluble in water. Preparing a stock solution in ethanol or acetone (often 100 g/L) that will last for more than a year when sealed in a dark bottle is the normal procedure. Because benzocaine has a pH of 7 in solution, it has a neutral effect and has a milder initial stress response than un buffered MS-222. Similar to tricaine, benzocaine is effective at dosages between 25 and 100 mg/L. The safety margin for benzocaine is reasonable, albeit it seems to be smaller at higher temperatures. More than 15 minutes of exposure are not safe. Water hardness or pH have no impact on its effectiveness. It is fat-soluble, similar to MS-222, and recovery durations may be slowed down in older fish or pregnant females. FDA has not approved benzocaine for use on food fish in the United States.

Quinaldine

Before being combined with water, quinaldine must first be dissolved in acetone or alcohol due to its low water solubility. Despite being a powerful anaesthetic, it irritates fish, has a foul smell, and is carcinogenic. Quinaldine is a common method for obtaining tropical fish for the aquarium sector, as well as in the bait and sport fish industries, because to its inexpensive cost. Quinaldine sulfonate, a powder that is water soluble and pale yellow, is more expensive than quinaldine or MS-222.Quinaldine solutions are acidic, therefore sodium bicarbonate is typically used as a buffer. Mild muscle spasms could occur during induction, which lasts 1 to 4 minutes. Recovery is frequently quick. Depending on the species, quinaldine solutions' effective treatment concentrations range from 15 to 60 mg/L. When exposed to 15 mg/L, grass carp (*Ctenopharyngodon idella*) experience balance loss within 5 minutes. But to totally anaesthetize tilapia, quinaldine doses of 50 to 1,000 mg/L were needed. Because some reflex response is typically retained, quinaldine may not deliver the profound anaesthesia required for surgery. Although quinaldine has been used at higher doses (150 mg/L) during surgical operations, it is not typically advised. Full quinaldine anaesthesia typically prevents fish from stopping their gill breathing, which reduces their susceptibility to asphyxia from respiratory arrest compared to MS-222 Quinidine's potency is generally stronger in warm and hard water. For usage on food fish in the United States, quinolone has not been given FDA approval.

2-Phenoxyethanol

Oily and opaque, 2-phenoxyethanol is a liquid. This medication is easily soluble in ethanol but just slightly soluble in water. The solution is helpful during surgery since it is antibacterial and fungicidal. It is reasonably priced and keeps working for at least three days when diluted. With a reasonably wide margin of safety, 2-phenoxyethanol has been shown to have a variety of effects, from mild drowsiness to surgical anaesthesia, at concentrations between 100 and 600 mg/L. Lower concentrations of 100 to 200 mg/L are thought to be safe for protracted sedation, such as during transport, while concentrations of 300 to 400 mg/L are effective for quick treatments. For usage on fish used as food in the United States, 2-phenoxyethanol is not FDA-approved.

Metomidate

Human medicine has made considerable use of methomide. Without the usual stress of a raised heart rate, it anaesthetizes fish. Compared to MS-222, induction is quick—1 to 2 minutes—and recovery is also quicker. At dosages as low as 2 to 6 mg/L, it anaesthetizes salmonids; small doses are equally efficient in catfish. Salmonids that have evolved to life in the sea are said to be more susceptible to the effects of methomide than freshwater fingerlings or parr. Red drum Sciaenops ocellatus and larval goldfish *Carassius auratus* have both been found to induce insufficient anaesthesia and high mortalities. Metomidate is not frequently used and has not been given U.S. approval for use on food fish.

Clove oil

Clove oil has long been used as a food flavour and as an anaesthetic in human dentistry. While clove oil mostly comprises eugenol (70 to 90% of the weight), it also contains a variety of other chemicals that give the oil its distinctive flavour and aroma. At 40 to 120 mg/L, it works well as an anaesthetic on carp (*Cyprinus carpio*). A sedative effect of 2 to 5 mg/L was adequate to transfer rainbow trout *Oncorhynchus mykiss*, while doses of 40 to 60 mg/L for 3 to 6 minutes effectively anaesthetized the fish for surgery. Higher doses and longer exposure times result in longer recovery times. At concentrations of 100–200 mg/L, clove oil is also a powerful anaesthetic for crustaceans. Compared to MS-222, clove oil has a much higher margin of safety but also requires a longer recovery period. Clove oil's main benefits are that it is affordable and easy to deal with. Fish intended for human consumption cannot be treated with clove oil in the United States.

Aqui-S™

An anaesthetic for fish called Aqui-S™ was just recently created by the Seafood Research Laboratory in New Zealand. This substance contains roughly 50% polylobate 80 and 50% eugenol. For the majority of fish species, a dosage of 20 mg/L is effective, and since the drug inhibits cortisol, induction is said to be "stress free". Aqui-S™ was found to be an efficient anaesthetic on freshwater prawns, according to a recent study, but only at considerably higher concentrations of 100 to 200 mg/L (S. Coyle and J. Tidwell, unpublished data). In Australia and New Zealand, Aqui- S™ is currently permitted with no waiting period for use on fish intended for human consumption. It has no withdrawal time and is currently going through the New Animal Drug Approval procedure for usage in the United States. The "rested harvest" of commercial fish species, where minimal stress induction enhances product colour, texture, and appearance, is where it is most frequently utilised. Aqui- S™ would be a useful tool to utilise while shipping live food fish to market if it were approved

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for usage in the United States with the zero-withdrawal time.

Non-chemical methods

Hypothermia

Fish will become immobile or tranquillized as the water temperature is lowered. Lower water temperatures also boost the water's ability to carry more oxygen while decreasing fish activity and oxygen consumption. Ice can be used to cool water, or it can be refrigerated. Rapid chilling might induce thermal shock; thus gradual cooling is advised. The main application of this method has been in transportation. When cooled to 0 °C, adult Atlantic salmon (*Salmo salar*) can be transported over great distances. Carp previously acclimated to 23 °C can be kept in an apparent anaesthetic state for 5 hours at 4 °C without risk of mortality, though lower temperatures are harmful. On crustaceans, hypothermia is frequently applied during transit. According to unpublished findings from S. Coyle and J. Tidwell, market-size freshwater prawns can be carried at high densities (100 to 200 mg/L) when the water is chilled to 16 to 18 °C. The safety margin for immobilising fish by lowering water temperature is frequently quite tiny, and deaths happen if the temperature is decreased too quickly or too drastically. As a result, it is important to closely monitor the cooling rate and maintain the desired temperature. The general rule is that you shouldn't lower the water's temperature by more than 1 °C every 15 minutes. To decrease the amount of anaesthetic needed, decrease oxygen use, and lengthen the period the fish are anaesthetized, hypothermia is frequently employed in conjunction with chemical anaesthesia.

Electro-anesthesia

Utilising electricity is another option to chemical anaesthesia. Electro-fishing has long utilised square waves in the form of chopped direct current (DC) and alternating current (AC). Seawater is more conductive than fish, hence electro-anesthesia is ineffective in it. The quickest way for electrons to travel through freshwater is through the fish because they are more conductive than the water. Low-voltage DC causes fish to become immobile, although this only works while the fish are really in the electrical field. If the current suddenly ceases, the fish will almost certainly swim away. This method does not actually create true anaesthesia; it only immobilises. Short-term anaesthesia is produced by AC current, and the effects are not reversed by cutting off the supply. Fish of all sizes are affected more quickly than fish of all sizes, and the duration of anaesthesia rises with fish body length. Anaesthesia was demonstrated to last for less than a minute at voltages of 110 to 115; higher voltages (220 to 240) are preferred and can result in a loss of sensitivity to touch stimuli for up to five minutes. Electrical stimulation causes erratic muscle reactions that can be fatal or disfiguring. When using electricity, the main worry is for both the operator's and the animal's safety. Electro-anesthesia presents unique challenges because it is dangerous to use electricity near bodies of water. To approach an acceptable level of safety, numerous electrical safety measures and stringent operating guidelines are necessary.

Transportation and anesthesia

Handling, grading, and transportation can all result in a lot of stress. When loading fish for transport, it could be desirable to put them to sleep and/or add ice to the water in the tanks to lower metabolic activity. Fish stocks can be transported in quantity with the help of sedation, especially when doing so over long distances and in areas with a lot of fish. The management of handling stress, mechanical shock, heat stress, and water quality are the main issues with transporting aquatic animals. Fish shouldn't be sedated too much since if they are, the water quality will quickly deteriorate and the fish would suffocate at the bottom of the hauling tank due to very high densities Other than CO_2, no chemical anaesthetics have been licenced for use on fish intended for human consumption in the United States. Therefore, the only approved methods of sedation for delivering live food fish to markets are carbon dioxide and hypothermia.

Conclusion

Animals that are calmed by anaesthetics gradually lose their mobility, equilibrium, consciousness, and reflex response. Anaesthetics can be chemical or physical. Anaesthesia is useful in fishing and aquaculture to lessen stress brought on by handling and shipping. Before doing any large-scale anaesthetizing, experimental dosages should be tested on a small number of non-critical animals because several factors can alter how effective anaesthetic treatments are. Governmental organisations control the manufacture, sale, and use of chemicals to protect public health and the environment. The FDA in the US controls the application of chemicals to food fish. Currently, MS-222, which calls for a 21-day withdrawal period, is the only chemical anaesthetic that the FDA has approved for use on food fish. Users are recommended to routinely check with their local Extension professionals for updated information since these rules are subject to change.

References

Dupree, H. K. and J. V. Huner. 1984. Third report to the fish farmers: The status of warmwater fish farming and progress in fish farming research. U.S. Fish and Wildlife Service, Washington, D.C.

Marking, L. L. and F. P. Meyer. 1985. Are better anesthetics needed in fisheries? Fisheries 10(6): 2-5.

Peak, S. 1980. Sodium bicarbonate and clove oil as potential anesthetics for non-salmonid fishes. North American Journal of Fisheries Management 18(4): 919-924.

Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler and J. Leonard. 1982. Fish Hatchery Management. U.S. Fish and Wildlife Service, Washington, D.C.

Ross, L. G. and B. Ross. 1999. Anaesthetic and Sedative Techniques for Aquatic Animals. Blackwell Science, Inc., Malden, MA.159 pp

Shawn D. Coyle, Robert M. Durborow and James H. Tidwell.2004. Anesthetics in Aquaculture. Southern Regional Aquaculture Centre.