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Use of Hydrogen Peroxide in Finfish Aquaculture[1]

Roy P. E. Yanong[2]

Introduction

Hydrogen peroxide is commonly used as a disinfectant for cleaning wounds in people. Hydrogen peroxide has also been used in aquaculture as an immersion (bath) treatment against many different disease-causing organisms, including external parasites, bacteria, and fungi, on different species and life-stages of fish. The US Food and Drug Administration (FDA) has approved a hydrogen-peroxide-based aquaculture product, which has spurred greater interest in its use.

What is hydrogen peroxide?

Hydrogen peroxide is the chemical compound H_2O_2. Hydrogen peroxide is a highly reactive, strong oxidizing and bleaching (whitening) agent that is classified as corrosive at concentrations higher than 20%. Hydrogen peroxide has numerous non-medical and medical uses because of these properties. When added to water, hydrogen peroxide breaks down into oxygen and water over time, and the formation of these by-products is one reason that hydrogen peroxide is considered to be relatively safe for the environment. Hydrogen peroxide's highly reactive nature, similar in some respects to the reactivity of potassium permanganate, makes it ideal for use in aquaculture against numerous external fish-disease-causing organisms, but with similar concerns regarding toxicity. The FDA-approved product, 35% PEROX-AID® (Western Chemical, Syndel USA, Ferndale, WA), is available at a strength of 35% weight/weight (e.g., 35% active ingredient). For comparison, over-the-counter products used for human health are typically sold at 3% active ingredient.

How stable is hydrogen peroxide in water?

A number of different elements, enzymes, and compounds, as well as light, heat, and high pH, all accelerate the degradation of hydrogen peroxide. It is important to understand the stability of hydrogen peroxide in water because toxicity can result from improper use and excessive exposure.

At 15°C (~59°F) and 20°C (~68°F), initial hydrogen peroxide concentrations of 10 and 100 mg/L in tank culture water were not measurable after 2–3 days in the presence of aeration and/or organic matter. Under static water conditions with no aeration or organic matter, concentrations were halved by day 6 and undetectable by day 10 (Tort et al. 2003).

Another study tested the stability of hydrogen peroxide during tank trials with ornamental fish and in earthen ponds without fish (Russo et al. 2007). In the tank trials, groups of 17–25 fish were placed into separate, static systems consisting of a glass aquarium containing 32 liters (~8.5 gallons) of water and aeration. Beginning concentrations of hydrogen peroxide ranged from 1.2–26.9 mg/L. The hydrogen peroxide concentration was tested 1 hour and 24 hours after the initial dose was added. After 1 hour, concentrations did not vary significantly from starting concentrations in all tanks. However, after 24 hours, concentrations in all tanks had decreased to 0.4–0.8 mg/L (Russo et al. 2007).

In the same study, two earthen ponds with initial hydrogen peroxide concentrations of 6.46 and 13.60 mg/L, respectively, had concentrations of 1–2 mg/L after 24 hours (Russo et al. 2007).

Hydrogen peroxide appears to degrade relatively rapidly in the presence of organic material and aeration; however, species sensitivities and starting concentrations will also determine its toxicity to fish.

Is hydrogen peroxide legal for use in aquaculture?

The product 35% PEROX-AID® (previously manufactured by Eka Chemicals, Marietta, GA, currently Syndel USA, Ferndale, WA) is approved by the FDA for the following uses (as per 35% PEROX-AID® insert):

FOR FRESHWATER-REARED FINFISH EGGS - for the control of mortality in freshwater-reared finfish eggs due to saprolegniasis (fungi of the family Saprolegniaceae). (Author's note: *This includes* Saprolegnia *and other related water molds*.)

FOR FRESHWATER-REARED COLDWATER FINFISH – for the control of mortality in freshwater-reared coldwater finfish (all life stages) due to saprolegniasis associated with the fungi in the family Saprolegniaceae.

FOR FRESHWATER-REARED SALMONIDS – a) for the control of mortality in freshwater-reared salmonids due to bacterial gill disease (*Flavobacterium branchiophilum*), and b) for the treatment and control of *Gyrodactylus* spp. in freshwater-reared salmonids.

FOR FRESHWATER-REARED COOLWATER FINFISH – a) for the control of mortality in freshwater-reared coolwater finfish due to external columnaris disease associated with *Flavobacterium columnare* and b) for the control of mortality in freshwater-reared coolwater finfish fingerlings and adults due to saprolegniasis associated with the fungi in the family Saprolegniaceae.

FOR FRESHWATER-REARED WARMWATER FINFISH – a) for the control of mortality in freshwater-reared warmwater finfish due to external columnaris disease associated with *Flavobacterium columnare* and b) for the control of mortality in freshwater-reared warmwater finfish fingerlings and adults due to saprolegniasis associated with the fungi in the family Saprolegniaceae.

No withdrawal period is required when used according to labeling for food fish species.

No other forms of hydrogen peroxide, including those sold for human use, are approved for use with fish.

What quantities are available?

35% PEROX-AID® (weight/weight) is currently available in 55-gallon drums and 5-gallon carboys.

What are the approved dosage rates for 35% PEROX-AID® use?

Producers should test any treatment using hydrogen peroxide for safety and efficacy. Test on a small number of fish before treating the entire lot.

Summaries of the FDA-approved label uses, dosages and durations for 35% PEROX-AID are located in Tables 1–4.

How do I calculate the volume of hydrogen peroxide to add to my system?

Use the following formula to calculate how much 35% PEROX-AID® should be added to a system for treatment. NOTE: This formula will not work for hydrogen peroxide products that are not 35% active ingredient. Furthermore, use of non-approved products is illegal. Work with an aquatic veterinarian or other fish health specialist to make sure you are using 35% PEROX-AID® properly.

The following formula can be used to determine the volume (in milliliters [= mL] of 35% PEROX-AID® required for a given treatment concentration and system volume.

$$\frac{(\frac{mg}{L})}{396{,}100\,\frac{mg}{L}} \times \ (L) \times 1000\,\frac{mL}{L} = \_\_mL\ of\ 35\%\ PEROX-AID®$$

Equation 1.

NOTE: There are 396,100 mg of hydrogen peroxide per L of 35% PEROX-AID®.

NOTE: There are 1000 mL in 1 L. The liters are converted to milliliters to allow for easier measuring of the 35% PEROX-AID® liquid for treatment.

For example, if you need to use a treatment concentration of 500 mg/L and will treat 150 liters of water in a closed system, then:

$$\frac{500(\frac{mg}{L})}{396{,}100\,\frac{mg}{L}} \times \ 150\ (L) \times 1000\,\frac{mL}{L} = 189.3\ mL\ of\ 35\%\ PEROX-AID®$$

Equation 2.

Static or closed-system treatments are the most common aquaculture systems used in Florida. If you are treating a raceway type or any other type of system, contact an aquatic veterinarian or other fish health specialist to determine proper dosing protocol.

Can hydrogen peroxide be used on other warmwater finfish species intended for human consumption and for other indications not on the label?

A veterinarian can prescribe 35% PEROX-AID® for an extralabel use provided that all the provisions in Title 21 Code of Federal Regulations Part 530 (21 CFR 530) (https://www.ecfr.gov/current/title-21/chapter-I/subchapter-E/part-530) are followed. In brief, the client must be working with a veterinarian within the context of a valid veterinarian-client-patient relationship (see description below), and there must be no residues that pose a public health risk. Research using food fish species is much more common in the literature, and biotests will most likely be required to determine the best dose and treatment time for specific disease problems. A summary of unapproved doses and indications used by researchers

in foodfish species is outlined in Table 5. As for approved uses and species, follow label instructions and contact the appropriate regulatory authorities regarding discharge of treated water.

21 CFR 530 (i):

A valid veterinarian-client-patient relationship is one in which:
(1) A veterinarian has assumed the responsibility for making medical judgments regarding the health of (an) animal(s) and the need for medical treatment, and the client (the owner of the animal or animals or other caretaker) has agreed to follow the instructions of the veterinarian;
(2) There is sufficient knowledge of the animal(s) by the veterinarian to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s); and
(3) The practicing veterinarian is readily available for follow-up in case of adverse reactions or failure of the regimen of therapy. Such a relationship can exist only when the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of examination of the animal(s) and/or by medically appropriate and timely visits to the premises where the animal(s) are kept.

Can hydrogen peroxide be used in ornamental finfish species and for other indications?

A veterinarian can prescribe 35% PEROX-AID® for an extralabel use provided that all the provisions in Title 21 Code of Federal Regulations Part 530 (21 CFR 530) (https://www.ecfr.gov/current/title-21/chapter-I/subchapter-E/part-530) are followed. Producers should work closely with a veterinarian when considering use of any drugs.

35% PEROX-AID® can also be used under FDA Investigational New Animal Drug (INAD) #11-669 (see https://www.fws.gov/inad/hydrogen-peroxide-35-perox-aidr-11-669 for more information).

In freshwater ornamental aquaculture, husbandry practices often logistically favor the use of lower doses of drugs for longer time periods. In one study (Russo et al. 2007), results suggested that use of 3.1 mg/L hydrogen peroxide for one hour may be effective for control of external bacteria, and use of 6.5 mg/L or more for one hour may be effective for control of external flagellates, including the parasite *Ichthyobodo* sp., in swordtails (*Xiphophorus hellerii*). *Trichodina* sp. and *Gyrodactylus* sp., however, did not appear to be controlled with this regimen. As for approved uses and species, follow label instructions and contact the appropriate regulatory authorities regarding discharge of treated water. See Table 5 for experimental (off label) uses, doses, and durations in various species of fish.

Are there any target animal safety concerns with use of hydrogen peroxide?

As with any aquaculture drug or chemical, improper use may potentially lead to ineffectiveness of treatment. Underdosing, toxicity from overdosing, and pathogen tolerance or resistance (the disease-causing organism may become tolerant or resistant to treatment) are some of the potential problems that could render treatment ineffective. Some species of fish have been shown to be very sensitive (see *Are any species known to be sensitive to hydrogen peroxide?* below). For species not listed on the 35% PEROX-AID® label, test a small subset of fish before treating the entire diseased population. Species differences, differences in fish age and size, as well as differences in water quality parameters and other factors may alter hydrogen peroxide efficacy and fish toxicity.

Reduced growth rate has been reported in fish treated with high doses of hydrogen peroxide (Speare et al. 1999). In addition, damage to the gills has been reported in some species when hydrogen peroxide has been administered at high or lethal concentrations. For instance, at 22°C, there were 50% mortalities after 3 hours in channel catfish exposed to 238 mg/L and bluegill exposed to 460 mg/L (Rach et al. 1997; Speare et al. 1999). Rach et al. (1997) also noted that early life stages of rainbow trout, i.e., sac and swim-up fry, were much more tolerant of high concentrations of hydrogen peroxide (greater than 1132 mg/L) than larger, older fish. This may be due to differences in gill function and gill anatomy among fish of different ages and sizes.

Mansell et al. (2005) observed significant changes in several blood parameters (lactate, osmolality, and pH) in kingfish following hydrogen peroxide treatment, but overall, there were fewer changes after treatment than were observed during peak infection with the monogenean parasite being treated.

Are any species known to be sensitive to hydrogen peroxide?

Several species of fish are known to be sensitive to hydrogen peroxide, and the use of the chemical may be toxic to those species. 35% PEROX-AID® is not recommended for use on northern pike or paddlefish and should be used with caution on walleye because these fish have been shown to be sensitive to the drug (35% PEROX-AID® label).

Tolerances of different concentrations of hydrogen peroxide by five species of ornamental fish, representing five different families, were tested at 1 hour and 24 hours (Russo et al. 2007). Blue gourami (*Trichogaster trichopterus*) did not tolerate any of the concentrations tested for 1 hour (11.4–15.9 mg/L) or for 24 hours (3.3–6.0 mg/L). Likewise, the suckermouth catfish *(Hypostomus plecostomus*) did not tolerate even relatively low doses at 1 hour (6.6–21.9 mg/L); no tests were run on suckermouth catfish for 24 hours. Hydrogen peroxide at these concentrations may not be suitable for use in these two species; however, additional testing in different water quality conditions or in different types of systems is warranted.

By contrast, for 1-hour exposure times, serpae tetras *(Hyphessobryconis eques*) tolerated 17.0 mg/L; tiger barbs (*Puntius tetrazona*), 10.0 mg/L; and swordtails, 20.2 mg/L. For 24-hour exposure times, serpae tetras tolerated 5.6 mg/L; tiger barbs, 5.0 mg/L; and swordtails, 5.4 mg/L (Russo et al. 2007).

As a general rule, hydrogen peroxide should not be used for treatment in combination with other chemicals.

Are there any human safety concerns with use of hydrogen peroxide?

As with other strong oxidizers, common sense and appropriate precautions, as described on the label and material safety data sheet (MSDS), should be followed, including use of personal protective equipment. Irritation and chemical burns and associated damage may result from eye or skin contact, inhalation, or ingestion. Always read the label and MSDS carefully. (See the following website for links to product information for 35% PEROX-AID®, including MSDS: https://syndel.com/product/35-perox-aid/).

Summary

Hydrogen peroxide (35% PEROX-AID®) is an aquaculture drug approved by FDA for the control of mortality in 1) freshwater-reared finfish eggs due to saprolegniasis (a common water mold), 2) freshwater-reared salmonids due to bacterial gill disease (*Flavobacterium branchiophilum*), 3) freshwater-reared coolwater and warmwater finfish fingerling and adults due to *Flavobacterium columnare*, and 4) freshwater-reared coolwater and warmwater finfish fry due to *Flavobacterium columnare*, as well as for 5) the treatment and control of *Gyrodactylus* spp. in freshwater-reared salmonids.

35% PEROX-AID® may be used in an extralabel manner, i.e., for other species and for other indications, as long as FDA regulations with regard to extralabel use are followed. Most importantly, a valid veterinary-client-patient relationship is required, and, if used in foodfish, no tissue residues that may be harmful to public health should result. In addition to those listed above, hydrogen peroxide has been used to control a number of other disease-causing organisms, including various protistans and monogenean parasites.

Before use, consultation with a veterinarian or other fish health professional is strongly recommended. Dosages for species or indications other than those on the label may vary. Effectiveness and safety tests should be run on a small group of fish from the affected population (i.e., a biotest) before the entire population is treated.

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Table 1.FDA-approved uses and dosages/durations for 35% PEROX-AID® (35% hydrogen peroxide, weight/weight) for the control of mortality due to **saprolegniasis** associated with fungi in the family Saprolegniaceae (an initial bioassay on a small number is recommended prior to treatment of the entire group)

Fish Species and Life Stage	**Dosage (as H_2O_2)**	**Duration**	**Frequency**
All freshwater-reared cold- and coolwater finfish eggs	500–1000 mg/L	15 minutes	In continuous flow water supply of finfish egg incubation units **once per day or on alternate days until hatch**
All freshwater-reared warmwater finfish eggs	750–1000 mg/L	15 minutes	In continuous flow water supply of finfish egg incubation units **once per day or on alternate days until hatch**
Freshwater-reared coldwater finfish including salmonids (all life stages) Freshwater-reared coolwater finfish fingerling and adults Freshwater-reared warmwater finfish fingerling and adults	75 mg/L	60 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**

Table 2. FDA-approved uses and dosages/durations for 35% PEROX-AID® (35% hydrogen peroxide, weight/weight) for the control of mortality due to **bacterial gill disease** associated with *Flavobacterium branchiophilum*

Fish Species and Life Stage	**Dosage (as H_2O_2)**	**Duration**	**Frequency**
Freshwater-reared salmonids (treatment option 1)	100 mg/L	30 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**
Freshwater-reared salmonids (treatment option 2)	50–100 mg/L	60 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**

Table 3.FDA-approved uses and dosages/durations for 35% PEROX-AID® (35% hydrogen peroxide, weight/weight) for the treatment and control of *Gyrodactylus* **spp.**

Fish Species and Life Stage	**Dosage (as H_2O_2)**	**Duration**	**Frequency**
Freshwater-reared salmonids (treatment option 1)	100 mg/L	30 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**
Freshwater-reared salmonids (treatment option 2)	50 mg/L	60 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**

Table 4. FDA-approved uses and dosages/durations for 35% PEROX-AID® (35% hydrogen peroxide, weight/weight) for the control of mortality due to **external columnaris disease** associated with *Flavobacterium columnare*

Fish Species and Life Stage	**Dosage (as H_2O_2)**	**Duration**	**Frequency**
Freshwater-reared coolwater and warmwater finfish fingerling and adults	50–75 mg/L	60 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**

Fish Species and Life Stage	Dosage (as H_2O_2)	Duration	Frequency
Freshwater-reared coolwater and warmwater finfish fry	50 mg/L	60 minutes	In continuous flow water supply or as a static bath in finfish culture units **once per day on alternate days for three treatments**

Table 5. Unapproved, experimental uses and doses documented in other fish species or for pathogen alone (i.e., no fish host).

Fish Species and Life Stage	Target Disease Organism	Dosage Rate	Duration	Frequency	Reference
Rainbow trout juveniles	*Ambiphrya* (sessile ciliated protistan), *Gyrodactylus* (monogenean)	170, 280, or 560 mg/L static bath	30 minutes	Once	Rach et al. 2000
Pacific threadfin (*Polydactylus sexfilis*) juveniles	*Amyloodinium* (dinoflagellate)	75–100 mg/L lab tank trial static bath	30 minutes	Once	Montgomery-Brock et al. 2001
Pacific threadfin (*Polydactylus sexfilis*) juveniles	*Amyloodinium* (dinoflagellate)	75 mg/L field tank trial	30 minutes	Two treatments, six days apart	Montgomery-Brock et al. 2001
No fish host	*Uronema* (ciliated protistan)	250 or 500 mg/L static bath	60 minutes	Once	Crosbie and Munday 1999
No fish host	*Philasterides dicentrarchi*	300 mg/L	150 minutes	Once	Steverding 2022
Yellow perch and Fathead minnow	*Gyrodactylus* spp.	50 or 75 mg/L	60 minutes	Once	Tuttle-Lau et al. 2023
Kingfish (*Seriola lalandi*) juveniles	*Zeuxapta seriolae* (monogenean)	300 mg/L static bath	10 minutes	Once	Mansell et al. 2005
Greater amberjack (*Seriola dumerili*) juveniles	*Benedenia seriolae, Neobenedenia girellae, Zeuxapta japónica* (monogeneans)	75 mg/L	30 minutes	Once	Hirazawa et al. 2016
No fish host	*Tenacibaculum maritimum* (bacteria)	30–240 mg/L	30 minutes	Once	Avendano-Herrera et al. 2006

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[2] Roy P. Yanong, professor and Extension veterinarian, School of Forest, Fisheries, and Geomatics Sciences, Fisheries and Aquatic Sciences Program, UF/IFAS Tropical Aquaculture Laboratory; UF/IFAS Extension, Gainesville, FL 32611.