Use of Hydrogen Peroxide in Finfish Aquaculture

Roy P. E. Yanong

**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 U.S. Food and Drug Administration (FDA) recently 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 \( \text{H}_2\text{O}_2 \). 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® (Eka Chemicals, Marietta, Georgia), is available at a strength of 35% weight/weight (e.g., 35% active ingredient). 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?

In 2007, 35% PEROX-AID® (Eka Chemicals, 
Marietta, Georgia) was approved by the FDA for 
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), and (3) 
freshwater-reared coolwater finfish and channel 
catfish due to external columnaris (Flavobacterium 
columnare) disease. 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® (35%) is currently 
available in 55-gallon drums.

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.

A summary of the FDA-approved label dosage 
rates for hydrogen peroxide is located in Table 1.

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.

\[
\text{ml of 35% PEROX-AID} = \frac{\text{treatment concentration (mg/L)}}{396,100} \times \frac{\text{system volume (L)}}{1000} \times 35 \times \frac{\text{mg}}{\text{L}}
\]

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:

\[
\text{ml of 35% PEROX-AID} = \frac{500 \text{ mg/L}}{396,100} \times 150 \times \frac{1000 \text{ ml}}{\text{L}} = 189.3 \text{ mL of 35% PEROX-AID}
\]

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.
Table 1. FDA-approved dosages for 35% PEROX-AID® (35% weight/weight hydrogen peroxide)

<table>
<thead>
<tr>
<th>Fish Species and Life Stage</th>
<th>Target Disease Organism</th>
<th>Dosage Rate</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>All freshwater-reared cold- and coolwater finfish eggs</td>
<td>Saprolegnia</td>
<td>500–1000 mg/L</td>
<td>15 minutes</td>
<td>Once per day or on alternate days until hatch</td>
</tr>
<tr>
<td>All freshwater-reared warmwater finfish eggs</td>
<td>Saprolegnia</td>
<td>750–1000 mg/L</td>
<td>15 minutes</td>
<td>Once per day or on alternate days until hatch</td>
</tr>
<tr>
<td>Freshwater-reared salmonids</td>
<td>Bacterial gill disease (<a href="#">Flavobacterium branchiophilum</a>)</td>
<td>100 mg/L in continuous flow or static bath</td>
<td>30 minutes</td>
<td>Once every other day for three treatments</td>
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<td>Freshwater-reared salmonids</td>
<td>Bacterial gill disease (<a href="#">Flavobacterium branchiophilum</a>)</td>
<td>50–100 mg/L in continuous flow or static bath</td>
<td>60 minutes</td>
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</tr>
<tr>
<td>Freshwater-reared coolwater finfish fingerlings and adults</td>
<td>Columnaris (<a href="#">Flavobacterium columnare</a>)</td>
<td>50–75 mg/L in continuous flow or static bath</td>
<td>60 minutes</td>
<td>Once every other day for three treatments</td>
</tr>
<tr>
<td>Freshwater-reared coolwater finfish fry</td>
<td>Columnaris (<a href="#">Flavobacterium columnare</a>)</td>
<td>50 mg/L in continuous flow or static bath</td>
<td>60 minutes</td>
<td>Once every other day for three treatments</td>
</tr>
<tr>
<td>Channel catfish fingerlings and adults</td>
<td>Columnaris (<a href="#">Flavobacterium columnare</a>)</td>
<td>50–75 mg/L in continuous flow or static bath</td>
<td>60 minutes</td>
<td>Once every other day for three treatments</td>
</tr>
<tr>
<td>Channel catfish fry</td>
<td>Columnaris (<a href="#">Flavobacterium columnare</a>)</td>
<td>50 mg/L in continuous flow or static bath</td>
<td>60 minutes</td>
<td>Once every other day for three treatments</td>
</tr>
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</table>

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) ([http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfdocs/cfcr/CFRSearch.cfm?CFRPart=530](http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcr/CFRSearch.cfm?CFRPart=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 2. As for approved uses and species, follow label instructions and contact the appropriate regulatory authorities regarding discharge of treated water.

21 CFR 530:

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.

Table 2. Unapproved, experimental uses documented in infected food fish species or for pathogen alone

<table>
<thead>
<tr>
<th>Fish Species and Life Stage</th>
<th>Target Disease Organism</th>
<th>Dosage Rate</th>
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</thead>
<tbody>
<tr>
<td>Rainbow trout Juveniles (Rach et al. 2000)</td>
<td>Ambiphrya (sessile ciliated protistan) Gyrodactylus (monogenean)</td>
<td>170, 280, or 560 mg/L static bath</td>
<td>30 minutes</td>
<td>Once</td>
<td>Rach et al. 2000</td>
</tr>
<tr>
<td>Pacific threadfin (Polydactylus sexfilis) juveniles</td>
<td>Amyloodinium (dinoflagellate)</td>
<td>75–100 mg/L lab tank trial static bath</td>
<td>30 minutes</td>
<td>Once</td>
<td>Montgomery-Brock et al. 2001</td>
</tr>
<tr>
<td>Pacific threadfin (Polydactylus sexfilis) juveniles</td>
<td>Amyloodinium (dinoflagellate)</td>
<td>75 mg/L field tank trial</td>
<td>30 minutes</td>
<td>Two treatments, six days apart</td>
<td>Montgomery-Brock et al. 2001</td>
</tr>
<tr>
<td>No fish host</td>
<td>Uronema (ciliated protistan)</td>
<td>250 or 500 mg/L static bath</td>
<td>60 minutes</td>
<td>Once</td>
<td>Crosbie and Munday 1999</td>
</tr>
<tr>
<td>Kingfish (Seriola lalandi) juveniles</td>
<td>Zeuxapta seriola (monogenean)</td>
<td>300 mg/L static bath</td>
<td>10 minutes</td>
<td>Once</td>
<td>Mansell et al. 2005</td>
</tr>
<tr>
<td>No fish host</td>
<td>Tenacibaculum maritimum (bacteria)</td>
<td>30–240 mg/L</td>
<td>30 minutes</td>
<td>Once</td>
<td>Avendano-Herrera et al. 2006</td>
</tr>
</tbody>
</table>

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) (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcr/CFRSearch.cfm?CFRPart=530) are followed. Producers should work closely with a veterinarian when considering use of any drugs.

In freshwater ornamental aquaculture, husbandry practices often logistically favor 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.
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 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 (Hyphostomus 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 Web site for links to product information including...
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Summary

Hydrogen peroxide (35% PEROX-AID ®) is an aquaculture drug that has recently been approved by FDA for 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*), and 3) freshwater-reared coolwater finfish and channel catfish due to external columnaris (*Flavobacterium columnare*) disease.

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.

References


MSDS:
Western Chemical, Inc. website. Hydrogen Peroxide label, MSDS, and additional information available at: