USING SALT TO TRANSPORT LIVE FISH

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Various chemical additives have been used to transport live fish. With few exceptions, there is little evidence to support claims of any real benefit. Research has shown that anesthetics can produce the same stress response as handling. However, anesthetics are beneficial for calming excitable fish that might injure themselves in transit. Currently, the only additives recommended for food fish transport are food grade salts. Sodium chloride -- table salt -- is the most common. Several other biologically important salts are used also.

Fish and other vertebrates have a unique and common characteristic. The salt content of their blood is almost identical. Vertebrate blood has a salinity of approximately 9 g/l (a 0.9% salt solution) and a pH of 7.4. Approximately 77% of the salt in blood is sodium and chloride. The remainder is made up primarily of bicarbonate, potassium and calcium. Sodium and potassium salts are critical for the normal function of heart, nerve and muscle. An 8 g/l (0.8%) salt solution made with table salt (sodium chloride) would match the sodium content of blood.

Fish blood is brought into close contact (1- or 2-cell separation) with the environment as it flows through the small blood vessels (capillaries) of the gills and skin surface. Salts diffuse from areas of high concentration (blood) to areas of low concentration (fresh water). Therefore, salts (primarily sodium and chloride) are slowly but continuously lost (osmotic leakage) to the environment. The gills and skin are coated with a thin layer of mucus which helps reduce the loss of salts to the surrounding fresh water. Lost salts are replaced by re-absorbing them from the water or during food digestion. Body energy is used to replace salts.

Netting or handling removes some of the protective mucous coating from fish. Transferring and transporting fish to and from ponds and live-haul tanks requires handling and travel which cause stress. Transport stress and loss of mucus increase salt leakage from the blood; placing higher energy demands on fish that are already weakened. Excessive salt loss can cause heart failure as well as nerve and muscle spasms (tetany). The addition of sodium chloride limits or prevents (depending on concentration) the loss of salt during transport.

If fish are placed in a 9 g/l salt solution, no salt loss will occur because the concentrations of the solution and blood match. The addition of salts to transport water stops or minimizes salt loss by reducing or eliminating concentration differences between fish blood and environmental water. This reduces energy demands and diffusion leakage while providing a large supply of environmental salts for re-absorption and replacement of lost blood salts.

In combination with handling stress, salt concentrations 10 g/l (1.0%) or greater could be harmful to fish during live transport. Fish blood is a 9 g/l salt solution, higher concentrations in hauling water cause the loss of water from blood (osmosis) while salts from the transport solution diffuse into the blood. This could cause fish to become dehydrated. A 10 g/l salt solution is approximately 10% higher than blood (9 g/l) and could create a 10% dehydration during transport. It is generally accepted that a 10% dehydration can be lethal to most vertebrates. Therefore, it would be advisable to use transport solutions containing less than 9 g/l salt. An 8 g/l sodium chloride solution matches blood sodium content and is slightly lower than 9 g/l; preventing dehydration and shock by keeping kidneys active and salt loss low.

Traditionally, 0.5 to 2 g/l (0.05 to 0.2%) sodium chloride solutions have been used to reduce stress during fish transport. However, as discussed above, an 8 g/l (0.8%) sodium chloride solution more closely duplicates fish blood. Some of Kentucky's live-haulers use 5 to

8 g/l (0.5 to 0.8%) sodium chloride mixtures and have had excellent success transporting channel catfish and other species. An 8 g/l solution is formulated by dissolving 6.4 lbs of food grade sodium chloride (feed mixing salt or table salt) in each 100 gallons of unloaded water (no fish) or 4 and 3/4 level teaspoons in each gallon (Table 1). It is important to remember that salts are highly corrosive to metal surfaces (e.g. truck beds, chassis and body).

Respiratory carbon dioxide can accumulate in transport water and lowers pH. Bicarbonate alkalinity helps to prevent pH from dropping. Sodium bicarbonate (baking soda) will raise bicarbonate alkalinity and pH.

Channel catfish tolerate salt water with salt concentrations as high as 10 g/l and have been farmed in low salinity lagoons. Striped bass, trout, red drum and several species of tilapia will tolerate a wide range of salinities from sea strength to freshwater. These fish and many others perform well and handle better during live transport when placed in appropriate salt solutions. Some salt- and freshwater species may tolerate very narrow salinity ranges only. If you are considering transport of a fish species for which little is known about salinity tolerance, a 24- to 48-hour bio-assay (test) should be conducted first with a few fish placed in an 8 g/l salt solution; or transport the fish in water most like their preferred environment.

Table 1. Types, concentrations and quantities* of food grade salts used in live fish transport water.

Chemical name	Common name	Concentration	Teaspoons per gallon	Cups per 100 gallons	Pounds per 100 gallons
Sodium chloride	feed mixing or table salt	8 g/l (0.8% salt)	4 3/4	9 3/4	6.4
Calcium sulfate	agricultural gypsum	125-250 mg/l (as $CaCO_3$)	1/4 - 4/10	1/2 - 8/10	0.18-0.36
Sodium bicarbonate	baking soda	100-200 mg/l (as $CaCO_3$)	1/8 - 1/4	1/4 - 1/2	0.14-0.28

* Amounts listed assume a starting concentration of zero (none present). For accuracy, concentrations should be checked before, during and after the addition of each salt. Use level household measures.

Other food grade salts have been used to improve the quality of fish transport water (Table 1). Research has shown calcium hardness helps control leakage of blood salts and is required for their re-absorption. The desired range of calcium hardness is 125-250 mg/l; 250 mg/l calcium hardness equals the calcium concentration in blood. Food grade calcium sulfate (agricultural gypsum) will increase calcium hardness. Also, shipping water should have desirable concentrations of pH (7-8) and bicarbonate alkalinity (100-200 mg/l).