



## **On-Farm Food Safety: Aquaponics**

Jim Hollyer, Clyde Tamaru, Allen Riggs, RuthEllen Klinger-Bowen, Robert Howerton, Darren Okimoto,  
Luisa Castro, Tetsuzan 'Benny' Ron, B. K. 'Kai' Fox, Vanessa Troegner, and Glenn Martinez

**A**quaponics is a food production system that uses nutrient-rich water from fish culture to irrigate and fertilize plants. After the plants have absorbed the nutrients, the water is recirculated to the fish rearing tanks. This combination of aquaculture and hydroponics recycles both water and nutrients, resulting in an efficient use of resources. However, when food plants are grown in the presence of fish culture effluent, food safety considerations become very important.

### **Why do you need to consider food safety?**

While the American consumer enjoys one of the safest supplies of fresh produce in the world, outbreaks of foodborne illnesses, associated with both domestic and imported fresh fruits and vegetables, have increased. In 1997 the U.S. Food and Drug Administration (FDA) published the Food Code<sup>1</sup> to provide guidance based on basic principles and practices associated with minimizing microbial food safety.

The Food and Drug Administration's (FDA's) 2005 Food Code states that foodborne diseases cause an estimated 76 million illnesses, 325,000 hospitalizations, and 5000 deaths in the United States each year, and the annual cost reaches between \$10 and \$83 billion, in terms of pain and suffering, reduced productivity, and estimated medical costs.<sup>2</sup> Loss of consumer confidence negatively impacts the agricultural community long after an illness outbreak. Everyone who sells food, regardless of the amount, has both an ethical and legal obligation to ensure that the food is safe.<sup>3</sup> Aquaponics producers, therefore, must become aware of the food safety risk factors that

might exist for their operation and should maintain the highest level of adherence to *good agricultural practices* (GAPs).<sup>4</sup>

### **How do you benefit from using GAPs?**

This publication presents practical information that has been tested by experienced farmers. These farmers are often generous in sharing knowledge of their best practices to help you improve practices on your own farm. From a business perspective, when you use good agricultural practices you

- spend less time and money making mistakes
- reduce your business risk of liability (when you start selling produce, you become a commercial provider, with certain responsibilities)
- have a higher probability of keeping a customer that may require an on-farm food safety certification
- improve chances that customers will feel justified in paying a higher price for your produce.

### **Good practices on aquaponics farms**

One of the most important principles of aquaponics systems is their reliance on beneficial bacteria. You might want to learn how these bacteria function in the

---

(<sup>1</sup><http://www.cfsan.fda.gov/~dms/foodcode.html#get05>; <sup>2</sup><http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodCode/default.htm> and <http://www.cdc.gov/ncidod/eid/Vol15no5/pdf/mead.pdf>; <sup>3</sup><http://www.ctahr.hawaii.edu/oc/freepubs/pdf/FST-32.pdf>; <sup>4</sup><http://www.sfc.ucdavis.edu/pubs/articles/foodsafetybeginsonthefarm.pdf>)

conversion of ammonia to nitrate via the nitrogen cycle.<sup>5</sup> Unfortunately, the mention of “bacteria” often conjures up thoughts of “germs,” so we need to distinguish between helpful microbes and the pathogens that can harm us. Both in nature and in aquaculture, fish excrete ammonia from their gills as part of their waste-elimination metabolism. The ammonia is then converted into nitrite and then to nitrate by beneficial bacteria (such as *Nitrosomonas* and *Nitrobacter* species). When plant roots find nitrate in the solution around their roots, it is taken up and converted into amino acids, the building blocks of proteins.

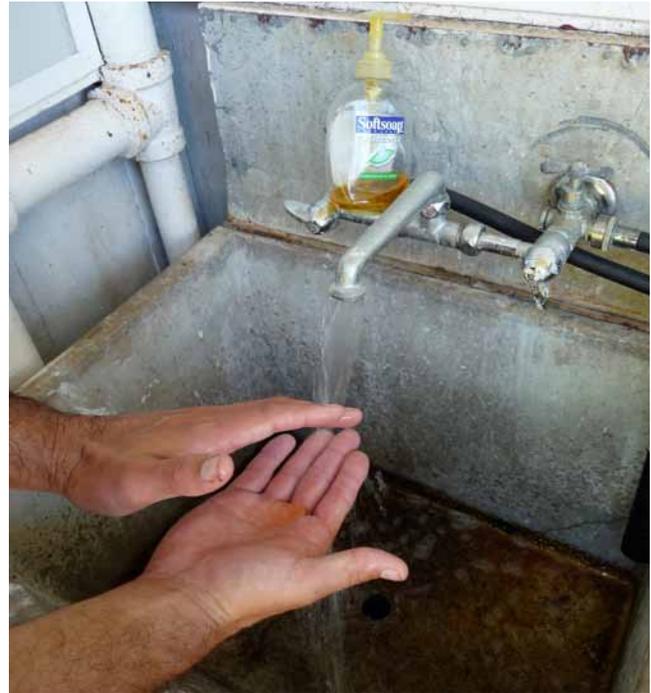
In contrast to the beneficial bacteria that help turn fish waste products into plant food, zoonoses are diseases of animals, caused by bacteria and other organisms, that can be transmitted to humans. Zoonotic pathogens represent a health risk to people contacting the water used in an aquaponic system<sup>6</sup> or to people consuming food that has zoonotic pathogens on them. If the water you are using contains *E. coli*, salmonella, or other pathogens, you must take immediate steps to address potential contamination issues. You need to reduce or eliminate the risk of causing a foodborne illness in someone consuming your produce. By following some simple, basic sanitation procedures, you can significantly minimize this risk. Key areas of consideration include

- human sanitation
- harvesting produce safely
- managing warm-blooded animal feces
- water sources for fish and produce
- zoonoses prevention
- disposing of the system’s waste water.

### Human sanitation

One of the biggest risks to fresh produce safety is our hands, which are in continual contact with the environment. When you harvest produce, be mindful of what you have touched before you touch the food product that you will sell or serve to others. Before harvesting your plant crops, wash your hands using liquid soap, rinse them for at least 20 seconds with potable water, and dry them with single-use paper towels. Wash hands every time after using the bathroom, eating, smoking, petting animals, shaking hands with someone, changing diapers, handling fish, putting your hands into the system’s water, touching your head (mouth, nose, ears, hair), etc.

<sup>5</sup><http://freshaquarium.about.com/cs/biologicalcycle/a/nitrogencycle.htm>; <sup>6</sup><http://www.cdc.gov/ncidod/dpd/animals.htm>



**Wash your hands and all harvesting tools and equipment with soap in potable water.**



**GOOD HARVESTING TECHNIQUE:** With *washed* hands, or washed hands covered with clean disposable gloves, touch *only* the produce when harvesting.



**DO NOT** touch the raft or the water underneath the raft during harvesting. That contaminates your hands or gloves with bacteria, which can then contaminate the produce.



For the same reason, **DON'T** touch the root system or growing cup when harvesting.

### Harvesting produce safely

You need to keep harvest bins, cutting utensils, produce-contact surfaces, and your hands clean, because you touch produce that someone might not wash before putting it into their mouth. The basics of good on-farm food safety practices require

- a toilet within ¼ mile or five minutes walk of the operation
- a sink with potable water, single-use towels, pump hand soap, and a covered trash can
- a first aid kit
- prohibiting smoking, chewing, or eating around the production or packing areas
- sanitizing all harvest tools and bins before each harvest, and keeping all harvest containers off the soil surface
- removing all pest-attracting trash from the farm and setting up a pest control system
- periodically testing fish and produce rinse water for human pathogens
- removing nests of birds or animals and excluding livestock and pets from production and packing areas
- covering all packing materials so that they don't get contaminated by insect or rodent droppings
- having an appropriate and well maintained refrigerator (if required)
- not harvesting produce that has fecal material or pest damage, because of the possibility that pathogens are left on the produce
- rinsing produce only in potable water (never aquaponic system water or other irrigation water)
- not cutting produce into a salad mix or other seemingly "read-to-eat" product for sale (of any amount) unless your facility has been approved by the Hawai'i Department of Health
- labeling all your produce bags with your farm name, address, phone number, the product name, date and location of harvest, and a statement advising consumers to "rinse before eating or serving."

More information on best commercial produce handling practices can be found at <http://www.ctahr.hawaii.edu/adap/FoodSafety/index.htm>.



**Nets help keep this lettuce aquaponics system from contamination by pests and their feces.** Photo: H. Ako



**Using only potable water for your aquaponics system is a good start toward food safety.**



**Take a water sample from the fish tank and have it tested for *E. coli* and other human pathogens.**

### Managing warm-blooded animal feces

It is important to keep warm-blooded animals (birds, dogs, cats, rats, sheep, goats, ducks, cattle, pigs, etc.) away from your commercial produce, because they may contain pathogens harmful to humans. Placing netting over your produce operation will reduce animal-to-plant contact. Keeping your production tanks off the ground will also limit access by animals. Cull any plants soiled with fecal droppings, such as from birds. After all harvested product has been safely removed, remove all contaminated produce and dispose of it where it will not attract additional pests.

### Water sources for fish and produce

Although there are no state or federal regulations about water quality for fish production, it is a best practice to source aquaponic production water only from potable sources (city or well water). Streams, reservoirs, and roof-top rainwater catchment systems can have significant quantities of zoonotic pathogens introduced by domesticated or wild animals (e.g., rats, cats and other pets, livestock, birds), and thus it is best to never use water from these sources in your food production system. For example, salmonella carried by amphibians can contaminate non-potable water used in aquaponics production and wash waters. If catchment rainwater must be used, follow guidelines recommended for keeping the catchment system free of contamination.<sup>7</sup>

At present, there are no national or State of Hawai'i

| Lab No. | Sample Description                          | Total Coliform CFU/100ml | <i>E. coli</i> CFU/100ml |
|---------|---|--------------------------|--------------------------|
| 65      | Water Sample<br>Tank 2<br>04-07-09 11:36    | >2419.2                  | 2.0                      |
| 66      | Water Sample<br>Fish tank<br>04-07-09 11:40 | >2419.2                  | 1.0                      |

**An example of a laboratory report of an analysis of fish culture water from an aquaponics farm. A produce-safe aquaponics production system will have little or no *E. coli* bacteria in the system water. Typically, however, it will have various quantities of coliforms, which are not a good indicator of a food safety risk in an aquaponics system. The counts of *E. coli* are obtained during the test for total coliform, so both results are reported.**

standards for the quality of irrigation water for land-based produce. Water quality standards for agriculture at this time are based on those set for recreational uses (any body of water where human activity occurs).

Based on a statistically sufficient number of samples (generally not less than five samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following: *E. coli* 126 per 100 ml; enterococci 33 per 100 ml.<sup>8</sup>

(<sup>7</sup><http://www.ctahr.hawaii.edu/oc/freepubs/pdf/RM-12.pdf>; <sup>8</sup><http://www.epa.gov/waterscience/beaches/local/statrept.pdf>)



Growing media, such as volcanic cinders, can be sharp and cause cuts that can get infected. It is wise to wear protective, waterproof gloves when digging into the media. This is especially important where youngsters are assisting.



Wear protective gloves when handling fish.

### In your home kitchen

To really grasp the potential risks of diseases caused by food contamination, you can think of your aquaponics farm as though it were your kitchen. This is going to be the case with many small-scale farmers that grow and eat the food produced on their farm. As an aquaponics grower, you will be producing both fish and produce, so you need to be aware of ways to reduce cross-contamination when you consume your products.

(NOTE: This advice is for home kitchens and is not intended to promote commercial processing of fish or produce in the absence of a facility approved for the purpose by the Hawai'i Department of Health.)

It is a best sanitary practice in any kitchen to have separate cutting boards for fresh produce and for meat. The following steps are recommended when both produce and meat (including fish) are on the menu:

- Wash cutting boards and knives with soap in hot water before cutting produce. Rinse off all soap under running water for at least 20 seconds and dry as necessary with a single-use paper towel. Cloth dishtowels, once used after laundering, can hold and spread pathogens.
- Pull apart produce as appropriate and rinse it in clean, cool water. Look very carefully for small snails and slugs that might be stuck deep down in the plant. Throw away any product that has snails, slugs or their slime on it as it could have come in contact with the rat lungworm pathogen.
- Cut up the cleaned produce as desired.
- As with vegetables, wash cutting boards and knives with soap in hot water before cutting meats.
- After use, wash and dry the cutting boards as described above.
- Store cutting boards and knives in a way that animals (e.g., cats, geckos, mice) and insects (e.g., cockroaches, ants) cannot contact them.



**Separate produce from meat in your kitchen.**

For more information on food safety in the kitchen, see <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/FN-5.pdf>.

### Zoonoses prevention

Fish are cold-blooded animals whose body temperatures are the same as the water in which they live. Humans are warm-blooded mammals that expend energy to maintain an internal body temperature of 98.6°F regardless of the environmental temperature. This physiological difference is the main reason that cultured aquatic species are not considered high-probability vectors of zoonotic diseases to humans. However, a few fish pathogens can be problematic under certain circumstances. Most of these are bacteria that infect humans through skin punctures made by fish spines during handling, or through open wounds exposed to contaminated water. Humans with healthy immune systems rarely have serious or long-term problems associated with a superficial puncture. However, immune-suppressed individuals should take extra precautions to avoid possible exposure, and if one occurs, they should seek medical attention promptly. Whether you have a fish-only (aquaculture) operation or an aquaponic (fish and produce) production system, the following basic preventive guidelines should be followed when touching the production water:

- Before handling fish or fish system water, cover open wounds to prevent exposure.
- Wear pierce-proof waterproof gloves, boots, waders, and other appropriate personal protective equipment.
- Wash hands with clean water and anti-microbial soap (or waterless hand cleaner) after contact with the system water.
- Report sick fish to an aquatic animal health professional immediately so that disease management recommendations can be implemented.

If an injury occurs while handling fish or working in the system water, immediately wash the area with clean water and anti-microbial soap. A tetanus booster shot is recommended if you have been more than five years without one. Watch for any of the five signs or symptoms of inflammation: heat, redness, swelling, pain or loss of function, and fever or chills. Any indication of infection requires immediate medical attention to avoid further tissue damage or systemic disease development.

### Disposing of system waste water

It is best to apply “used” fish effluent water to soil. Use it to irrigate and fertilize grassy areas, landscape plants, or crops such as papaya and banana. Do not put fish

tank water directly back into a stream, sewer, irrigation ditch, or reservoir, because you might be releasing small fish or other aquatic life forms into that stream or water system, and in so doing you will be violating the U.S. Clean Water Act and Hawai‘i State Regulation S4-71-6.5(g) relative to releasing exotic or non-native species into the environment.

### Summary

Growing fish and plants in an aquaponics system is a novel and attractive idea. Many people are doing it successfully worldwide, using systems that may be ancient or may rely on the latest contemporary materials and technologies. Remember, however, that once you start selling fish or plant produce from an aquaponics system, you step into the realm of commercial responsibility, regardless of the amount of your sales. Follow the advice given above to reduce risks to your personal health and the liability of your commercial operation.

### Resources on aquaponics

- Aquaponics and food safety. Gordon A. Chalmers, DVM. Lethbridge, Alberta. April, 2004.
- The Backyard Aquaponics Magazine. Joel Malcolm. Western Australia. <http://www.byapmagazine.com>.
- Fish: A potential source of bacterial pathogens for human beings. L. Novotny, L. Dvorska, A. Lorencova, V. Beran, and I. Pavlik. *Vet. Med. - Czech*, 49, 2004 (9): 343-358 [www.vri.cz/docs/vetmed/49-9-343.pdf](http://www.vri.cz/docs/vetmed/49-9-343.pdf).
- National Sustainable Agriculture Information Service, <http://attra.ncat.org>.
- Recirculating aquaculture tank production systems: Aquaponics—Integrating fish and plant culture. James E. Rakocy, Michale P. Masser, and Thomas M. Losordo. Southern Regional Aquaculture Center. November 2006 revision. SRAC publication no. 454.
- Tilapia farms guidelines for BAP standards. Global Aquaculture Alliance. 2009. [http://www.aquaculture-recertification.org/index.php?option=com\\_content&task=view&id=105&Itemid=47](http://www.aquaculture-recertification.org/index.php?option=com_content&task=view&id=105&Itemid=47).

**Follow-up contacts**

The following resource persons are available to help you improve your aquaponics production and food safety practices.

***Aquaculture advising***

Clyde S. Tamaru

Aquaculture Specialist, Dept. of Molecular Biosciences and Bioengineering, College of Tropical Agriculture and Human Resources (CTAHR), University of Hawai'i at Mānoa; 1955 East-West Road rm. 218, Honolulu, HI 96822  
808-342-1063; ctamaru@hawaii.edu

Robert Howerton

Aquaculture Specialist, University of Hawai'i Sea Grant College Program, Maui Community College  
310 Ka'ahumanu Avenue, Kahului, HI 96732  
808-268-3246; howerton@hawaii.edu

***Aquatic animal health***

Allen C. Riggs, DVM, MS

Veterinary Medical Officer III, Aquaculture Development Program, Hawai'i Department of Agriculture  
1039 Sand Island Parkway, Honolulu, HI 96819  
808-832-5005; acriggs@hawaiiaquaculture.org

***Site inspections/permitting***

Vernon K. Nakamoto

Invertebrate and Aquatic Biota Specialist, Plant Quarantine, Hawai'i Department of Agriculture  
1849 A'uiki Street, Honolulu, HI 96819  
808-832-0577; Vernon.K.Nakamoto@hawaii.gov

**On-farm food safety coaching**

(Note: these contacts are subject to change.)

**Hawai'i island**

Luisa Castro, CTAHR Educational Specialist  
Hilo, Hawai'i  
808-981-5199 x 250; luisac@hawaii.edu

**Maui County**

Lynn Nakamura-Tengan, CTAHR Extension Educator  
Kahului, Maui  
808-244-3242, ext 233; lynnnaka@hawaii.edu

**O'ahu and Kaua'i**

Jim Hollyer, CTAHR/ADAP Program Manager  
Honolulu, O'ahu  
808-956-9539; hollyer@hawaii.edu

**O'ahu**

Jari Sugano, CTAHR Extension Agent  
Kāne'ohe, O'ahu  
808-247-0421; suganoj@ctahr.hawaii.edu

**The authors**

Of the authors not identified on this page as follow-up contacts or CTAHR food-safety coaches, Vanessa Troegner is with CTAHR's Agricultural Development in the American Pacific Project; Tetsuzan 'Benny' Ron is the Aquaculture Program Coordinator, Office of the Vice Chancellor for Research and Graduate Education, University of Hawai'i at Mānoa; RuthEllen Klinger-Bowen is with the Aquaculture Development Program, Hawai'i Department of Agriculture; Darren Okimoto is with the Sea Grant College Program, University of Hawai'i at Mānoa; B. K. 'Kai' Fox is with the Education Department of UH's Hawai'i Institute of Marine Biology; and Glenn Martinez is the proprietor of Olomana Gardens in Waimānalo, O'ahu.

**Acknowledgments**

Mahalo to Albert Louie, Robert Coffey, and Dr. James Rakocy for review and comment. Funding for the development of this publication came from the Hawai'i Department of Agriculture and the Hawaii Farm Bureau Federation.

