

# Herbal medicine in aquaculture



**W**ith the continued expansion of cultured fish and shellfish species, aquaculture has become a key component of the animal health industry. Aquaculture is the fastest growing industry around the world with around 80 million tones produced annually.

“In the decade to 2015, world aquaculture production will at least double, an average annual growth rate of not less than 7.0 percent per annum, and potentially much more.” (as quoted by State One Stockbroking Ltd in June 2007).

## Antibiotics in aquaculture

Due to the intensification of rearing methods and systems, diseases and pathogens have been an integral part and formidable obstacle to the aquaculture industry worldwide.

Moreover, antibiotic resistance has become a major issue affecting the aquaculture industry.

As early as 1994 it was being reported by the American Society of Microbiology Task Force on Antibiotic Resistance (ASM) that, “the increasing problems associated with infectious diseases in fish, the limited number of drugs available for treatment and prevention of these diseases, and the rapid increase in resistance to these antibiotics represent major challenges for this source of food production worldwide.”

Currently, almost every section in the aquaculture industry from fish, crustaceans and shellfish is using some sort of chemotherapeutic agents including antibiotics and many other chemicals.

The ASM antibiotic resistance task force report targets aquaculture as representing “one of the biggest concerns.”

Both the task force and the FAO (2005) made several points regarding the use of antibiotics:

- Although aquaculture production is

growing rapidly, disease prevention and treatment practices are far from standardized or regulated

- When antibiotics are used in aquaculture, the drugs typically remain in the open environment and may flow out of production facilities into open waterways or sewage systems, where they may also interact with other environmental contaminants
- The antibiotics typically used are also important in treating human disease and infection

Impacts of all these factors on the emergence of antibiotic resistance are unknown, however, we do know the following:

- Studies demonstrate an increase in resistant bacteria in the intestines of fish receiving antibiotic drugs (ASM, 1994 citing Ervik, 1994; Frost and Thwaites, 1998; Threlfall et al., 2000; Tollefson, L. 2000)
- Studies indicate the level of resistant bacteria in the gut of wild fish is affected during antibiotic treatment of farmed fish (ASM, 1994 citing Ervik, 1994)
- A total of 74-100 percent of wild fish in close proximity to treated ponds contained quinolone residues – a group of antibiotics (for example, CIPRO) important in human health (ASM, 1994 citing Ervik, 1994; Hernández Serrano, 2005)
- Prior to medication 0.6-1 percent of the fecal bacteria in wild fish were resistant to oxacillin and oxytetracycline, respectively (ASM, 1994 citing Ervik, 1994)

## Significant progress

European researchers have made significant progress in understanding the mechanisms through which antibiotic resistant bacteria that emerge on fish farms can move to humans.

A team of British and Irish scientists documented the distinct movement of

resistant bacterial pieces of DNA from fish hatcheries into *E. coli* and *Aeromonas* species isolated from patients in hospitals (Rhodes et al. 2000). They concluded that, “Collectively, these findings provide evidence to support the hypothesis that the aquaculture and human compartments of the environment behave as a single interactive compartment.” (Rhodes et al. 2000)

The FAO estimated that nearly 170kg of antibiotics are applied per hectare of salmon harvested in the USA and since cages are placed in natural seawaters, antibiotics and the resultant resistant bacteria are in contact with the environment.

Some countries, such as Norway, utilise natural structures like fjords for salmon farming and for this reason there are concerns about the wastes that collect in fjord bottoms (FAO/NACA/WHO, 1997).

All drugs legally used in aquaculture must be approved by the designated authorities (FDA’s Centre for Veterinary Medicine in the US, APMVA in Australia).

The most common route of delivery of these legal antibiotics to fish occurs through mixing with specially formulated feed.

However, fish do not effectively metabolise antibiotics and will pass them largely unused back into the environment in the faeces. It has been estimated that 75 percent of the antibiotics fed to fish are then put into the water through excretion (Goldburg and Triplett 1997).

Since 2006, the EU has banned completely the use of antibiotics as growth promoters in aquaculture (as well as any other domestic animal). Banning and rejection of seafood imported to US and EU countries due to antibiotic and other chemotherapeutics residues are almost a daily occurrence and yet, currently, there is no alternative solution to antibiotics and other chemotherapeutics.

## Diseases and aquaculture

During the past decade, several outbreaks of diseases devastated the aquaculture industry around the world. The global

shrimp industry suffered major outbreaks in South East Asia and South America due to poor management, as well as, uncontrolled use of antibiotics resulting in resistance developed by pathogens.

Recently, the Chilean salmon industry suffered (and still does) a devastated outbreak of infectious salmon anaemia (ISA) virus that cause loss of hundred of millions of dollars. This outbreak followed another outbreak during 2008-09 of sea lice that again resulted in major losses to the industry. These outbreaks drove the authorities to review and revise the use of chamotherapeutics in this industry.

In India, Marine Product Export Development Authority (MPEDA) has instructed the hatcheries operators and farmers not to use antibiotics such as chloramphenicol, nitrofurans and all their derivatives, as well as many other antibiotic groups.

However, sulfadimethoxine, sulfabromomethazine and sulfaethoxyrpyridine, floroquinolones and glycopeptides, which are presently used in hatcheries and farms, are still approved for use in aquaculture (Sanandakumar, 2002).

Considering the overall misuse of antibiotics in all areas - human medicine, veterinary medicine, animal production and plant protection – FAO, in 2005, published 'The responsible use of antibiotics in aquaculture' to raise awareness of the antibiotic resistance problem in fish farming and related sectors.

The document focuses on antibiotics misuse and the concomitant threat of resistance development, which is a seen as a public health concern affecting the population worldwide.

In its opening statement the authors stated that, "Antibiotic resistance as a phenomenon is, in itself, not surprising. Nor is it new. It is however, newly worrying because it is accumulating and accelerating, while the

world's tools for combating it decrease in power and number."

Diseases and pathogens are part of every intensive culture.

In aquaculture 'natural mortality' of 10-25 percent is considered to be normal in grow-out systems.

Marine finfish larvae (such as sea bream, sea bass, yellowtail kingfish, etc) survival in intensive hatcheries is 5-15 percent (Kolkovski, personal comment). These low survival rates are usually the result of combined factors such as, environmental conditions, non-specific pathogens, larvae susceptibility and low immune system development.

In fact, this situation is true to most marine and fresh water organisms reared in intensive systems.

In many cases, and although banned in most countries, to combat this problem, antibiotics are used as growth promoters and/or specifically against bacteria infection (Hernández Serrano, 2005). For example, in many hatcheries, fish juveniles are supplemented with antibiotics several days prior and few days after transferred to sea cages.

## Alternative therapy

Low immune system and responses may result in very high mortalities due to specific pathogens that antibiotics are helpless against. For example, White Spot Syndrome Virus (WSSV) is one of the most devastating viruses in the shrimp industry. It has caused the collapse of the shrimp industry in many countries both in South America and South East Asia (FAO, 2006).

Phytotherapy such as the use of herbal extracts in herbal medicine for humans is known for thousands of years. In some countries such as China, India, SEA and some countries in South and Central America phytotherapy considered mainstream while in Western medicine,

naturopathy and herbal medicine are more and more acknowledged.

Different medicinal plants and herbs and/or combinations of them known to have properties such as anti-bacteria, anti-fungal, physiological systems (immune system, digestive system,) supporting, hormonal balancing and many other properties.

Strategies for prophylaxis and control of WSSV include improvement of environmental conditions, stocking of specific pathogen free (SPF) shrimp post-larvae and enhancement of disease resistance by using immuno-stimulants.

Immuno stimulants are substances, which enhance the non-specific defense mechanism and provide resistance against pathogenic organisms (Citarasu et al., 2006).

There are many scientific publications looking at different mechanisms and ways to enhance the specific and non-specific immune systems in fish and crustaceans. Many plant-derived compounds have been found to have non-specific immuno-stimulating effects in animals, of which more than a dozen have been evaluated in fish and shrimp (Citarasu et al. 2002, 2006, Sakai, 1999).

Many herbs and plants have been used for millennia as home remedies in many cultures around the world for both human and animals. Some of these remedies have potent anti-viral as well as anti-bacterial and anti-fungal properties.

These natural plant products have been reported to have various properties such as anti-stress, growth promoters, appetisers, tonic and immuno-stimulants.

Moreover, these substances also possess other valuable properties; they are non-toxic, biodegradable and biocompatible. No herbal-resistance immunity has been found by any pathogen to date.

Although the properties of herbs and plants are well known, documented, and in use in human herbal medicine around the world, currently very few commercial remedy

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**Table 1:** The use of herbal extracts in shrimp broodstock diets

Botanical name	Family	Distribution	Useful parts	Biological effect in aquaculture	Reference
<i>Cinnamomum zeylanicum</i>	Lauraceae	India, Sri Lanka	Bark	Endocrine system, Growth promoter	Punitha, 2003
<i>Elettaria cardomomum</i>	Scitamineaceae	India, Burma, Sri Lanka	Dried ripe seeds	Endocrine system, Growth promoter	Punitha, 2003
<i>Eugenia caryophyllata</i>	Myrtaceae	India, Sri Lanka	Fruits and dried flower buds	Endocrine system, Growth promoter	Punitha, 2003
<i>Mesua ferrea</i>	Guttiferae	India, Burma, Andaman, Nicobar Islands	Flowe buds, seeds and bark	Endocrine system, Growth promoter	Punitha, 2003
<i>Asparagus racemous</i>	Liliaceae	India	Leaves and Root	Endocrine system	Devi, 1995
<i>Mucuna pruriens</i>	Papilionaceae	Tropics	Seeds, roots and legumes	Endocrine system	Babu and Marian, 2001
<i>Witania somnifera</i>	Solanaceae	India	Root and leaves	Endocrine system	Babu, 1999; Citrasu, 2008

exists for use in large-scale aquaculture in the world.

## Medicinal plants in aquaculture

It is well known and documented that medicinal plants have strong antibacterial effects. Phenolics, polysaccharides, proteoglycans and flavonoids known to play an important role in preventing and/or controlling bacterial infections.

Herbs such as *S. triblobatum*, *A. paniculata* and *P. corylifolia* were found to reduce vibrio in *P. monodon* three time when supplied in enriched *Artemia* (Citrasu et al. 2002, 2009). Many other studies with different species and with different herbal extracts and medicinal plants were published.

Several plant products found to have potent antiviral activity against fish and shrimp viruses.

For example, Direkbusarakom et al. 1996 found that shrimp fed ethanol extract of *Clinacanthus nutans* had 95 percent survival rates when exposed to Yellow head virus (YHV) compared to only 25 percent survival in control group of black tiger shrimp.

Antifungal properties were also found in many plants.

extract of *O. basilicum*. Other herbal extracts are very effective against gills and skin flukes such as *Benedenia seriolae* (Kolkovski, personal comment, Nutrakol Pty Ltd).

Herbal compounds have the ability to inhibit the generation of oxygen anions and scavenge free radical, hence reducing stress effects. Herbal antioxidant effect was demonstrated by Citrasu et al. (2006) when *P. kurroa* (*picrorhiza*) was used as anti-stress compound for black tiger shrimp.

Other herbs such as, *Astragalus membranaceus*, *Portulaca oleracea*, *Flavescent ophora* and *A. paniculata* and many other are know to have specific and none specific anti stress affects.

Medicinal plants are also know to have hormonal boosting affects with some herbs are been used in herbal medicine as natural 'viagra' and in hormonal replacement therapy for menopause woman.

Babu (1999) demonstrated significant increase in fecundity, gonadal weight and reduced intermoult period in *P. monodon* when the shrimp fed maturation diet containing *W.*

*somnifera*, *Mucuna pruita*, *Ferula asafoetida* and *Piper longum* extracts.

Recently, commercial maturation semi-moist diet (NutraFeed, Nutrakol) that included herbal extracts fed to *p. vanamei* resulted in over 40percent increase in total nauplii produced with 44percent reduce in mortality compared to the normal fresh feed

**Table 2:** Herbs, plants and algae incorporated into diets

Plant's Name	Parts used for the extraction
<i>Withania somnifera</i>	Roots and leaves
<i>Mucuna pruriens</i>	Seeds and roots
<i>Myristica malabarica</i>	Seeds
<i>Mimosa pudica</i>	Roots and leaves
<i>Ipomea digitata</i>	Tuberous root
<i>Asparagus racemosa</i>	Leaves, bark and juice
<i>Hygrophila spinosa</i>	Whole herb
<i>Phasedus roxburghii</i>	Seeds
<i>Moringa tinctoria</i>	Inflorescence and gum
<i>Hemidermus indicus</i>	Root

Algae	Parts used
<i>Nannochloropsis oculata</i>	Whole cells
<i>Chlorella salina</i>	Whole cells
<i>Dunaliella salina</i>	Whole cells
<i>Skeletonema costatum</i>	Whole cells
<i>Spirulina salina</i>	Whole cells

and nutritional boosters used (Kolkovski et al., 2010).

## Issues

Although herbal remedies have been in use for human therapy for millennia, there has been relatively little research into the use of medicinal plants in aquaculture.

Standardisation is an issue when whole plant or herb is used during the extraction process. Moreover, in many countries including the EU, US and Australia, the same herbals extracts approved for use in human naturopathy and herbal medicine are treated as drugs when used in aquaculture, forcing the registration of herbal remedies, a process that cost hundreds of thousands or even millions of dollars and can take years.

A review of this legislation should be carried out taking into account the benefits of herbal remedies over currently used chemotherapeutic agents.

Herbals can be used not only as remedies but even more so, as growth promoters, stress resistance boosters and preventatives of infections.

Therefore, the use of herbal extract as feed additives can significantly benefit any organism cultured under intensive condi-

tions. Legislation regarding the addition of herbal extracts, as feed additives need to be reviewed and allowed.

## Conclusion

The development of drug-resistant pathogens has been reported from all areas of aquaculture. Treating microbial infections in fish and crustaceans involves dissolving high quantities of broad-spectrum chemotherapeutic agents in the culture medium or supplying it in the food.

Most of these antibiotics and drugs are

now banned for use in the EU, USA and many other countries.

Natural plant products present a viable alternative to antibiotics and other banned drugs being safer for the reared organism and humans, as well as, the environment.

Authorities should review the current legislation regarding the use of herbal and natural remedies in aquaculture taking the above issues into consideration and allowing more flexibility in the use of herbal medicine in aquaculture.

## Authors

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Nutrakol Pty Ltd is specialized in developing and manufacturing nutritional and natural health solutions for aquaculture.

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