Herb Based Aquaculture: A Suitable Practice for India

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Herb Based Aquaculture: A Suitable Practice for India

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Total Number of **Pages**: 38

Total number of **tables**: 01

Total number of Words in **Abstract**: 164

Number of **Keywords**: 06

Total number of Words in Text (**Excluding Reference**): 2,347

Total number of Words in Text (**Including Reference**): 7,530

ABSTRACT

Unlike other developing sectors aquaculture deals living aquatic organisms under complete human control, which involves risks of pathogens. Researches and commercial use of herbs for growth and therapeutic uses in aquaculture continue to grow at increasing rate, since hormones, antibiotics, vitamins and several other chemicals has lost its appreciation mainly because of resistant development, less-economical, consumer and environmental hazards. India enfolds rich diversity of herbs and forms a good platform for herb based aquaculture practices. A diverse of medicinal plants those are indigenous or cultivated in India are being used extensively in aquaculture worldwide. Among these the present review focuses on *Allium sativum* (A.S.), *Curcuma longa* (C.L), *Zingiber officinale* (Z.O.), *Azadirachta indica* (A.I.), *Ocimum sanctum* (O.S.) and *Allium cepa* (A.C.) owing to its effectiveness and availability.

Key words: *Allium sativum*, *Curcuma longa*, *Zingiber officinale*, *Azadirachta indica*, *Ocimum*

INTRODUCTION

Aquaculture provides a good opportunity for developing countries (Manoj and Vasudevan, 2009) and is the most rapidly developing sector in the world (Harikrishnan *et al*., 2011). Disease due to

pathogens is one of the major problems in aquaculture (Rahman *et al*., 2009). Use of antibiotics in treatment of such disease has led to the development of the resistant strains is rather difficult, non-effective, costly and also involves environmental hazards (Cañada *et al*., 2009). The antibiotics also may reduce the larval growth and inhibit defense mechanisms of the fish larvae accompanied with sensitization reaction and other undesirable side effects (Citarasu, 2009) and some of them have been banned by the Marine Product Export Development Authority of India (MPEDA) (Sanandakumar, 2002).

India is one of the top twelve mega diversity countries in the world. Out of eighteen hot spots of biodiversity identified across the globe, India has two located in Eastern Himalaya and Western Ghats regions containing approximately 3500 and 1600 medicinal plants respectively. Herbal medicines derived from Ashwagandha, Punarnava, Brahmi, Isabgol, Tulsi, Turmeric, Neem, Safed Musli, Amla, Shatavari, Garlic, Senna, Tamala, Nutmeg, Shankhapushpi, etc., have revolutionalized modern herbal therapy in India (Kokate, 2008). India has often been referred to as the "Medicinal Garden of the world'' owing to its rich biodiversity. India represents about 75% of medicinal needs of the third world countries (Johnson, 2002). Three of most ten most widely selling herbal medicines in developed countries, namely preparations of *Allium sativum*, *Aloe barbedensis* and *Panax species* are available in India. Use of medicinal plants have advantages of low/minimum cost, potency and efficiency, enhanced tolerance, more protection, fewer side-effects, complete accessibility, and they are recyclable (Parveen and Shrivastava, 2012).

Oral administration of natural plant products promotes various activities like growth promotion, appetite stimulation, tonic and immunostimulation, and to have antimicrobial properties in some of the aquatic animals due to their bio-active compounds such as phenolics, polyphenols, alkaloids, quinones, terpenoids, lectines and polypeptides and are effective alternatives to antibiotics and other synthetic compounds (Olusola *et al*., 2013). A large number of medicinal plants have been used for therapeutic and growth promoting purposes in aquaculture (Direkbusarakom and Aekpanithanpong, 1992; Tampieri *et al*., 2003, Chitmanat *et al*., 2005; Palavesam *et al*., 2006; Rao *et al*., 2006; Christybapita, 2007; Kumar and Anantharaja, 2007; Ahilan *et al*., 2010; Sharma *et al*., 2010; Harikrishnan *et al*., 2010, 2011; Kolkovski and Kolkovski, 2011; Nargis *et al*., 2011; Prasad and Mukthiraj, 2011; Ravikumar *et al*., 2011;

Verma *et al*., 2012; Chakrabarthi *et al*., 2012; Park and Choi, 2012). Indian medicinal plants are a rich source of immune-enhancing substances in fish (Galina *et al*., 2009). Database of Garlic, Turmeric, Ginger, Neem, Tulsi and Onion has been presented by Joy *et al*., (1998). The bioactive compounds in *Allium sativum Curcuma longa*, *Zingiber officinale*, *Azadirachta indica*, *Ocimum sanctum* and *Allium cepa*, cited from literature is presented in Table-1.

Garlic-*Allium sativum* (A.S.)

The name ‘‘*Allium sativum*’’ is derived from the Celtic word ‘‘all’’, meaning burning or stinging, and the Latin ‘‘*sativum*’’meaning planted or cultivated (Mahady *et al*., 2001). Garlic is a member of the family Liliaceae (Omar and Al-Wabel, 2010). The medicinal properties of garlic are derived from two major classes of flavonoid and organosulfur constituents (Bozin *et al*., 2008). The bulbs of A.S. contains an acrid volatile oil (0.25%), propyl disulphide which is a powerful germicide (Anawer, 2001). Garlic possesses higher nutritive value than any other bulbous crops (Sood *et al*., 2003) its extracts have known to increase glutathione peroxidase activity (Pedraza-Chaverrí *et al*., 2001) and rich in seleno-compounds (Whanger, 2002; Obioha *et al*., 2009). Selenium plays an important role in glutathione peroxidase activity (Rao, 2003; Liu *et al*., 2007; Saxena and Jaiswal, 2007). Antioxidants in garlic extract, such as the organosulfur compounds, protect against oxidative damage, thus, lower the risk of injury to vital molecules and may help prevent the onset and progression of disease (Ghosh, 2010).

Reports of A.S usage in aquaculture

In the field of aquaculture A.S has been reported to promote protein synthesis and enhances the uptake of free amino acids in *Clarias lazera* (Al-Salahy, 2002); to promote growth, provide antibacterial effect and enhance blood parameters in *Oreochromis niloticus* (Shalaby *et al*. 2006); as an useful ectoparasiticidal in *Oreochromis niloticus* fingerlings (Olusola *et al*., 2013); to show sensitivity against fish pathogenic bacteria (Muniruzzanian and Chowdhury, 2004); to control *Aeromonas hydrophila* infection in *Oncorhynchus mykiss* (Nya and Austin, 2009).

Turmeric-*Curcuma longa* (C.L.)

C.S. is a member of the family Zingberiaceae (Aggarwal *et al*., 2007) and is extensively used as a spice, food preservative and colouring material in India, China and South East Asia. Curcumin,

a yellow bioactive pigment, is the major component of C.L. (Hatcher *et al*., 2008; Mandal *et al*., 2009).

Reports of C.L. usage in aquaculture

In the field of aquaculture C.L. has been reported as a carotenoid source on pigmentation and growth of *Poecilia reticulate* (Mukherjee *et al*., 2009); to increase serum bactericidal activity and phagocytosis in *Labeo rohita* (Sahu *et al*., 2007);.to exhibit antimicrobial activity in *Oreochromis niloticus* (Rattanachaikunsopon and Phumkhachorn, 2010); to manage bacterial infection in *Clarius gariepinus* (Chakraborty and Chattopadhyay, 1998); to show sensitivity of fish pathogenic bacteria (Muniruzzanian and Chowdhury, 2004). A combination of A.S., C.S. and A.I. is reported to resist disease in *Catla catla* (Olusola *et al*., 2013). It has been reported that, natural curcumin and its analogue inhibits lipid peroxidation in *Anabas testudineus* (Manju *et al*., 2008, 2009).

Ginger-*Zingiber officinale* (Z.O.)

Z.O. is one of the members of the family Zingiberaceae (Fakim, 2006) and is one of the most highly consumed dietary spices in the world known in Western societies for its antiemetic and carminative uses (Janet *et al*., 2009). Regular intake of ginger in diet can protect against oxidative tissue damage (Nirmala *et al*., 2007).

Reports of Z.O. usage in aquaculture

In the field of aquaculture Z.O. has been reported to increase extracellular activity of phagocytic cells in blood in *Oncorhynchus mykiss* (Dugenci *et al*., 2003); to increase the phagocytic capability of cells in rainbow trout (Yin *et al*. 2008); to enhance phagocytosis and extracellular burst activity of the blood leukocytes (Galina *et al*., 2009); to improve digestive enzyme activity, nutrition and feed indices in *Penaeus monodon* fed with Z.O. enriched *Artemia* (Venketramalingam *et al*., 2007).

Neem-*Azadirachta indica* (A.I.)

A.I. is a member of the family Meliaceae (Kashif and Ullah, 2013) and is native to the Indian sub-continent (Gajalakshmi, 2002) and has been used extensively in Asian and African subcontinent because of its medicinal properties (Srivastava and Prakash, 2006). Almost every part of A.I. tree has been known to possess a wide range of pharmacological properties (Farah *et*

al., 2006; Van Wyk and Wink, 2004). In recent years A.I. has attracted global attention due to its potential as a source of natural drugs (Kumar, 2002; Gajalakshmi and Abbasi, 2004) because of the presence of triterpenoids, steroids, carotenoids, ketones and phenolic compounds (Jacobson, 1990), Azadirachtin A, B, D, H, I, Desacetylnimbin, Azadiradione, Nimbin, Salanin, Azadirone, Nimbolin, Nimbinene, Nimbolide (Harikrishnan *et al.*, 2003; Sadeghian and Mortazaienezhad, 2007). Neem Gum is a rich source of protein (Kashif and Ullah, 2013).

Reports of A.I. usage in aquaculture

In the field of aquaculture A.I. has been reported to enhanced primary and secondary antibody response in *Oreochromis mossambicus* (Logambal and Michael 2000, 2001); to control fish predators in macroinvertebrates (Dunkel and Ricilards, 1998); as alternative for the control of parasites and predators such as dragon-fly larvae in *Prochilodus lineatus* (Martinez, 2002); to assess acute lethal and sublethal effects on *Prochilodus lineatus* (Winkaler *et al*., 2007); to possess antibacterial effect in *Channa striatus* (Abdul Kader Mydeen and Haniffa, 2011); to exhibit antibacterial activity in ornamental fishes (Ravikumar *et al*. 2011); to exhibit antiviral properties in cultured shrimp (Banerjee *et al*., 2013); to produce disease resistant fry of *Catla catla* (Rao *et al*., 2004); for assessment of 72-hr Median Lethal concentration in *Cyprinus carpio* Juvenile (Davoodi, 2012); for assessment of growth in *Tilapia zilli*, when exposed to sublethal concentrations (Omoregie and Okpanachi, 1992); for assessment of acute toxicity in *Tilapia zilli* (Omoregie and Okpanachi, 1997); as an effective inhibitory agent of reproduction in *Tilapia zillii* (Jegedel and Fagbenro, 2008)

Tulsi-*Ocimum sanctum* (O.S.)

O.S. is a member of the family Lamiaceae (Prakash, and Gupta, 2005; Sethi, and Anjana, 2004) and is a holy plant common to India (Kashaw *et al*., 2011). Oleanolic acid, Eugenol, Carvacrol, Linalool and caryophyllene (Kuhn, 2007; Kashif and Ullah, 2013) sufficient quantity of antioxidants and fixed oil (Suanarunsawat *et al*., 2010) are the principle bioactive compounds in O.S.

Table-1. Bioactive compounds in *Allium sativum Curcuma longa, Zingiber officinale, Azadirachta indica, Ocimum sanctum* and *Allium cepa* cited from literature.

Medicinal plant	***Bioactive compounds***	***Biological activities***	***References***
Allium sativum	C-glutamyl-S-allyl-L-cysteine, Allicin, Diallyl Sulphide (DAS), Diallyl Disulfide (DADS), Diallyl Trisulfide (DATS) and Ajoene	1. Antimicrobial	Harris *et al.*, 2001; Sood *et al*., 2003; Banerjee and Maulik, 2002.
		2. Antiproliferative and Antiplatelet	Rao and White, 1985; Daoud, 1992; Wiseman, 1994.
		3. Hypocholesterolemic / Antihyperlipidemic	Eliat *et al*., 1995; Dehkordi *et al*., 2009.
		4. Detoxification of xenobiotics	Nordberg, 1984.
		5. Hepatoprotection	Augusti, 1996; Nakagawa *et al*., 1989.
		6. Antioxidant	Banerjee and Maulik, 2002; Griffiths *et al.*, 2002; Nuutila *et al*., 2003; Marzouki *et al*., 2005; El-Demerdash *et al*., 2005.
		7. Antihypertensive	Foushee *et al.*, 1982.
		8. Hypoglycemic	Jain and Vyas, 1975.
		9. Antithrombotic	Bordia *et al*., 1996.
		10.Anticarcinogenic	Al-Salahy, 2002.
Curcuma	Curcumin	1. Antimicrobial	Chattopadhyay *et al*., 2004; Mohammadi *et al*., 2005; Menon and Sudheer, 2007; Si *et al*., 2007; Di Mario *et al*., 2007; Rai *et al*., 2008; Hatcher *et al*., 2008.
		2. Anti-inflammatory	Punithavathi *et al*., 2000; Siddiqui *et al*., 2006; Jurenka, 2009.
		3. Antioxidant	Mohammadi *et al*., 2005; Menon and

longa			Sudheer, 2007.
		4. Anticancer	LoTempio *et al*., 2005.
		5. Antidiabetic,	Aggarwal *et al*., 2007.
		6. Antiallergic	Suzuki *et al*., 2005.
		7. Antiprotozoal	Reddy *et al*., 2005.
		8. Prevent lipid peroxidation	Shukla *et al*., 2003; Stankovic, 2004.
		9. Hepatoprotective	Marotta *et al*., 2003; Joanna *et al*., 2010.
		10. Hypoglycemic	Rao *et al*., 1970; Chattopadhyay *et al*., 2004.
		11. Hypolipemic	Blasiak *et al*., 1999; Chattopadhyay *et al*., 2004.
Zingiber officinale	Gingerol, shogaols, Zingerone/vanillylacetone, paradol and curcuminoids	1. Antimicrobial	Jagetia *et al*., 2003; Ficker *et al*. 2003 a, b; Ajith *et al*., 2007, 2008.
		2. Antioxidant	Sirat *et al*., 1996; Kim *et al*., 2007.
		3. Improvement of digestive functions	Haksar *et al*., 2006; Mahmoud *et al*., 2008.
		4. Reduced lipid peroxidation	Bernd *et al*., 1997.
		5. Anti-inflammatory, Antipyretic, Hypoglycemic, Hepatoprotective, Diuretic, Hypocholesterolemic	Langner *et al*., 1998; Kamtchouing *et al*., 2002; Ezz *et al*., 2011.
		6.Antihypertensive activities	Ghayur and Gilani, 2005.
		7. Stomachic, Laxative, Gastric emptying enhancer, Appetizer,	Ghayur and Gilani, 2005.

		Antiemetic, Antidyspepsic. Antidiarrheal and Anticolic agent	
Azadirachta indica	Azadirachtin A, B, D, H, I, Desacetylnimbin, Azadiradione, Nimbin, Salanin, Azadirone, Nimbolin, Nimbinene, Nimbolide	1. Antimicrobial	Parida *et al*., 2002; Biswas *et al*., 2002; Das *et al*., 2002; Harikrishnan *et al*., 2003; Chitmanat *et al*., 2005; Ramesh *et al*., 2011; Kashif and Ullah, 2013; Banerjee *et al*., 2013.
		2. Antioxidant	Grover and Rao, 1977; Sethi *et al*., 2004.
		3. Antidiabetic	Kashaw *et al*., 2011.
		4. Antipyretic and Anti-inflammatory	Deni, 1996; Chattopadhyay, 1998.
		5. Analgesic	Dahanukar, 2000.
		6. Hepatoprotective	Obioha *et al*., 2009, Kashaw *et al*., 2011.
		7. Anti-dermatophytic	Dahanukar, 2000.
		8. Immunumodulatory	Sadekar *et al*., 1998.
Ocimum sanctum	Oleanolic acid, Eugenol, Carvacrol, Linalool and caryophyllene	1. Antimicrobial	Logambal *et al*., 2000; Rochfort *et al*., 2008; Olusola *et al*., 2013.
		2. Anti-inflammatory	Singh and Majumdar, 1997; Singh, 1999; Dahanukar, 2000.
		3. Anti-allergic activity	Godhwani, 1988.
		4. Hypoglycemic and Hypolipidemic effect	Rai *et al*., 1997; Dahanukar, 2000; Suanarunsawat *et al*., 2010.
		5. Hepatoprotective	Casalino *et al*., 2002; Kashaw *et al*., 2011.
		6. Antioxidant	Sethi *et al*., 2004; Suanarunsawat *et al*., 2010.

		7. Analgesic	Singh and Majumdar, 1995.
		8. Antistress	Sembulingam *et al*., 1997.
Allium cepa	Saponins, phenols, N-cynnamic amides, S-methylcysteine, Sulphoxide, organosulphur compounds and flavonoids	1. Antimicrobial	Griffiths, 2002; Rochfort *et al*.,2008; Saganuwan, 2010; Olusola *et al*., 2013.
		2. Hypoglycemia	Hassanein and Al-Salahy, 2000; Al-Salahy, 2002; Mantawy and Mahmoud, 2002; El-Demerdash, 2005.
		3. Hypolipidemic	Hassanein and Al-Salahy, 2000.
		4. Antioxidant	Afzal *et al*., 2000; Gorinstein *et al*., 2009.
		5. Hepatoprotective	Afzal *et al*., 2000; Obioha *et al*., 2009.
		6. Immunostimulatory and detoxification of xenobiotics	Obioha *et al*., 2009.

Reports of O.S. usage in aquaculture

In the field of aquaculture O.S. has been reported to increase energy utilization, weight gain and survival rate against the control group in *Macrobrachium rosenbergii* P.L. (Bhavan *et al*., 2011); to improve the survival, growth and moulting efficiencies in *Penaeus monodon*, P.L. fed with O.S. enriched *Artemia* (Citarasu, 2009); to promote growth, anti-stress, immunostimulation, and anti-bacterial properties in *Penaeus* larviculture (Citarasu *et al*., 2002); to enhance immune response in *Oreochromis mossambicus* (Hemapriya, 1997; Logambal *et al*., 2000; Venkatalakshmi and Michael, 2001).

Onion-*Allium cepa* (A.C.)

A.C. is a member of the family Liliaceae (Fakim, 2006) and is one of the oldest cultivated plants with their origin in central Asia (Afzal *et al*., 2000). Apart from culinary purposes, A.C. has received considerable attention for their functional health benefits (Obioha *et al*., 2009). Organic disulfides and sulfoxides are the principle bioactive compounds in A.C. (Lukes 1971; Vaidya *et al*., 2009)

Reports of A.C. usage in aquaculture

In the field of aquaculture A.C. has been reported to prevent bacterial infection in *Penaeus monodon* (Citarasu, 2009); to exhibit antimicrobial activity in *Clarias gariepinus* (Bello *et al*., 2013; 2012a); to increase growth rate in *Clarias gariepinus* (Bello *et al*., 2012 b); to promote glycogenesis, lipogenesis in *Clarias lazera* (Al-Salahy, 2002).

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