Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(3): 583-589

Received: 23-03-2017
Accepted: 24-04-2017

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A review on role of plant waste products on fish growth, health and production

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Abstract
The purpose of this paper was to summarize the current available knowledge of using plant by-products in fish culture, and their potential to be applied further in aquaculture production because, in recent years, the fish consumption increased and total world production of fish has decreased. Fish constitutes the fastest growing source of food in the developing world. The shift in some countries from extensive to semi-intensive and intensive farming of fish demands that nutritionally complete feeds be provided by the farmer. There is large number of feed additives available to improve fish growth performance but these are very costly. It is preferable that, in the case of commercial aquaculture, the production cost to be reduced. World Health Organization encourages using of medicinal herbs and plants to substitute or minimize the use of chemicals through the global trend to go back to the nature. Various studies have been done on non-conventional raw ingredients and these include host of plants and animals by-products such as sweet potato peels [1], banana peels [2], calabash seed [3], papaya seed [4].

Keywords: Fish, nutrition, food security, plants, growth, health

1. Introduction
The world population is growing at an exponential rate and the need of the hour is to increase the food production with the same rate. World population is expected to grow from the present 6.8 billion to greater than 9 billion by 2050 [5]. The growing need for nutritious and healthy food will increase the demand of fisheries products from inland and marine sources, whose productivity is already highly stressed by excessive fishing pressure, growing organic pollution, toxic contamination, habitat degradation and climate change [6]. The shortage of animal protein intake in developing countries can be satisfied with proper development of aquaculture. Fish feed is the most expensive input in aquaculture operations. Most of the high cost of feed arises from extensive reliance on protein sources such as fish meal and shrimp meal [7]. To overcome the high cost input in feed, it would be economical to utilize plant ingredients which will enhance fish production [8]. Today capture fisheries and aquaculture provide almost 20% and 15% of average per capita intake of animal protein to 3.0 billion and 1.3 billion people respectively [9]. This share exceeds about 50 percent in a few countries. The global evidence on record reveals that fisheries play pivotal role in health and food security [9].
Nutrition of fish is an important consideration in fish health management of farmed finfish and shellfish [9]. The shift in some countries from extensive to semi-intensive and intensive farming of fish demands that nutritionally complete feeds be provided by the farmer. The use of nutritionally inadequate feeds can result in reduced growth and production due to stress, but more seriously, the use of such feeds can result in loss of fish from nutritional deficiency syndromes and/or from mortality brought on by increased susceptibility of nutritionally compromised fish to infectious diseases [10]. In aquaculture, fish feeds costs the maximum expenditure [11] and this is because of using animal protein sources such as fish meal, shrimp mean etc. [7]. If plant sources can be used as a supplement to animal protein sources, it will not only reduce the production cost and also increases the growth and production [12].

2. Phytobiotics
Phytobiotics can be defined as plant derived products added to feed in order to improve the performance of animal [13]. The phytobiotics have a wide variety of properties such as: antioxidant, antimicrobial, anticarcinogenic, analgesic, insecticidal, antiparasitic, anti-coccidial, growth promoters appetite enhancement, stimulant of secretion of bile and digestive enzyme activity etc [14].

The evaluation of phytobiotics in aquaculture is a relatively new area of research showing promising results. Addition of different single herbal extracts (*Massa medicata, Crataegi fructus, Artemisia capillaries, Cnidium officinale*) or a mixture of all the herbs promoted growth and enhanced some non-specific immunity indicators of fish [15].

3. Present status of phytobiotics in aquaculture

In aquaculture one of the most promising methods of strengthening the defense mechanism and disease management is through prophylactic administration of immunostimulants [16]. Recent advancement in immuno-nutrition studies revealed that some nutrients are linked to the immunological status of fish [17]. This has drawn the attention of fish nutritionists to the immunoprotection of fish besides the growth. Yuan and his co-workers [18] fed common carp (*Cyprinus carpio*) diets containing a mixture of *Astragalus membranaceus* (root and stem), *Polygonum multiflorum*, *Isatis tinctoria* and *Glycyrrhiza glabra* (0.5 and 1%) for 30 days and observed that both concentrations significantly increased ($P < 0.05$) macrophage phagocytic activity, respiratory burst and levels of total protein, albumin, globulin and nitric oxide synthetase activity in the serum; no significant difference ($P > 0.05$) was found in superoxide dismutase (SOD), lysozyme activities and triglyceride level. Root extracts of the Chinese herb *Astragalus* contain polysaccharides, organic acids, alkaloids, glucosides and volatile oil as major active components that have been found to enhance immune function in fish [19]. The Astragalus polysaccharide (APS) from *A. membranaceus* is reported to halt reactive oxygen species (ROS) production, stimulate humoral and cellular immunity, and thus possess anticancer and immunostimulating effects [18]. The oriental medicinal herb G. glabra (liquorice) comprises flavonoids and pentacyclic triterpene saponin, including liquiritin, liquiritigenin, isoliquiritigenin, liquiritin apioside, glycyrrhizin and glycyrrhizic acid as major constituents and is reported to have anti-oxidant effects [20].

4. Integration of plants with fisheries

4.1 Basic principle

Integrated fish farming is a system of producing fish in combination with other agricultural/livestock farming operations centred on the fish pond [21]. The farming sub-systems e.g. fish, crop and livestock are linked to each other in such a way that the by-products/wastes from one sub-system become the valuable inputs to another sub-system and thus ensures total utilization of land and water resources of the farm resulting in maximum and diversified farm output with minimum financial and labour costs [21]. It also enables effective utilization of available farming space for maximizing production. The rising cost of protein rich fish food and chemical fertilizers as well as the general concern for energy conservation have created awareness in the utilization of rice and other crop fields and livestock wastes for fish culture [21]. Fish culture in combination with agriculture or livestock is a unique and lucrative venture and provides a higher farm income, makes available a cheap source of protein for the rural population, increases productivity on small land-holdings and increases the supply of feeds for the farm livestock [21]. The scope of integrated farming is considerably wide.

4.2 Criteria of Fish Species Selection for Integrated Fish Culture

(A) Prominent features

i. Rapid growth potential
ii. Having cellulose digesting enzymes
iii. Ability to use natural food efficiently
iv. Acceptance to artificial feed of low conversion value
v. Hardy in nature
vi. Accept all provided/available food
vii. Enhances mineral bioavailability from food in the meal
viii. Compatible to other species
ix. Should fetch good price

(B) Fish species

Table 1: Fish species suitable for integrated fish farming [21]

Common Name	Scientific Name
Plant-Eaters (Herbivores)	
Chinese grass carp	*Ctenopharyngodon idella*
Large gourami	*Osphronemus goramy*
Snakeskin gourami	*Trichigaster pectoralis*
Tilapia	*Tilapia rendalli*
Zill's tilapia	*Tilapia zillii*
Chinese 'Wuchang' bream	*Megalobrama amblycephala*
Omnivores (Eat Small Plants And Animals)	
Barb species	*Puntius spp*
Catfish species	*Clarias spp., Pangasius spp.*
Chinese mud carp	*Cirrhinus molitorella*
Climbing perch	*Anabas testudineus*
Common carp	*Cyprinus carpio*
Crucian carp	*Carassius carassius*
Mrigal carp	*Cirrhinus mrigala*
Tilapia species	*Oreochromis spp., Sarotherodon spp., Tilapia spp.)*

4.3 Importance of plants for human 'Health & Wealth' as well as for fisheries

- It serves the major purpose of providing cheap feedstuffs and organic manure for the fish ponds, thereby reducing the cost and need for providing compounded fish feeds and chemical fertilizers.
- By reducing the cost of fertilizers and feedstuffs the overall cost of fish production is reduced and profits increased.
- The overall income is increased by adding vegetable farming which supplement the income from fish farming.
- By producing grain, vegetables, fruits and fish the community becomes self-sufficient in regard to food and this contributes to a high degree of self-reliance.
- The silt from the ponds which is used to fertilize crop, increases the yield of crops at a lower cost and the need to buy chemical fertilizer is greatly reduced. It is estimated that about one third of all the fertilizer required for farming in the country comes from fish ponds.
- There are no side effects of using plants in aqua-feed because they are natural products which cause no harmful effects to both fish and human beings.
- It increases resistance power of fish because some plants are having medicinal value which increases the immunity.
- The next main advantage is that this practice is eco-friendly as is having no adverse effect on the environment. It is truly organic & natural way of treatment because no chemicals are used
- Locally available resources/plants are used. So by

adopting integrated fish farming practice the farmer can economically use the easily and locally available resources.

- Un-used area in the form of dykes are used for cultivation by which the farmer get double benefit that is by selling the fruits or vegetables grown on the dykes and using the vegetation waste in the fish feed which increases the growth of fish as well.

5. Functions of natural plant products

- Growth promotion
- Anti-stress
- Appetite stimulation
- Immuno-stimulation
- Antimicrobial properties
- Wound healing
- Aphrodisiac
- Color enhancing

Table 2: Main herbal plant extracts and their multiple therapeutic properties in aquaculture [22]

English name	Scientific name	Useful part	Active substances	Therapeutic properties
Aromatic Species				
Nutmeg	*Myristica flagrans*	Seed	Sabinene	Digestion stimulant, antidiarrhotic
Cinnamon	*Cinnamomum zeylanicum*	Bark	Ammameldehyde	Appetite and digestion stimulant, antiseptic
Clove	*Syzygium aromaticum*	Cloves	Eugenol	Appetite and digestion
Cardamom	*Elettaria caramomum*	Seed	Cinook	Appetite and digestion stimulant
Pungent Species				
Capsicum	*Capsicum annum longum*	Fruit	Capsaicin	Antidiarrhoic, stimulant tonic, anti-inflammatory
Ginger	*Zingiber officinale*	Rhizom	Zingerole	Gastric Stimulant
Pepper	*Piper nigrum*	Gruit	Piperine	Digestion stimulant
Aromatic Herbs And Spices				
Garlic	*Allium tuberosum*	Bulb	Allicin	Digestions stimulant, antiseptic
Rosemary	*Aniba rosaeodora*	Leaves	Cineole	Digestion stimulant, antiseptic, antioxidant
Thyme	*Thymus vulgaris*	Whole plant	Thymol	Digestion stimulant, antiseptic, antioxidant
Sage	*Salvia apiana*	Leaves	Cineole	Digestion stimulant
Peppermint	*Mentha piperita*	Leaves	Menthol	Appetitie and digestion stimulant, antiseptic
Neem	*Azadirachta indica*	Leaves, bark	Azadirachtin, salanin numbin	Antiviral, antiseptic, fungicidal

5.1 Anti- Stress

Rutin has improved the biochemical, immunological and haematological parameters in *Litopenaeus vannamei* during the stress conditions by *V. alginolyticus* **[23].**

5.2 Growth Promotion

Miguel *et al.* [24] conducted study on the dietary efficiency of protein concentrate from cowpea seed, as an ingredient for practical diets of tilapia fry. No mortalities related to the dietary plant protein were recorded and concluded that cowpea seed protein concentrate is a potential ingredient for use in feeding tilapia.

Duckweed and water spinach can be used as a supplement to poly-culture fish although fish gained better with the supplement of duckweed **[25].** Varying levels of sweet potato (*Ipomea batatas*) peels on growth, feed utilization and some biochemical responses of the cichlid (O*reochromis niloticus*). Analysis of the results revealed that *Oreochromis niloticus* could tolerate up to 15% level of inclusion of sweet potato peel. The significance of research finding is that sweet potato peels can be incorporated into fish feeds in order to reduce the cost associated with production of farmed fish [26]. Same findings were observed by Adewolu [27] in tilapia fingerlings and by Faramarzi *et al.* [1] in Cyprinus carpio.

Mohd din *et al*. [28] studied the effect of mushroom supplementation as a prebiotic compound in super worm based diet on growth performance of red tilapia fingerlings. There was increase in SGR, FCR and PER level and survival was up to 93.33%. 10% supplementation level of MSM as a prebiotic for tilapia could be used in the insect-based diet, *Zophobas morio*. The utilisation of mellon shell as dietary energy source in the diet of nile tilapia (*Oreochromis niloticus*) increases the growth [29]. Mellon shell meal inclusion in the diet of Tilapia up to 75% can be effectively utilized by the *Oreochromis niloticus*. The specific growth rate, protein intake, protein efficiency ratio, gross feed conversion efficiency, feed efficiency, mean feed intake, survival rate, and percentage weight gain increases as the level of dietary cowpea (*vigna unguiculata*) hull meal increased. The replacement of maize meal by cowpea hull meal diet within 50% to 100% level enhances growth performance of *C. gariepinus* fry [30].

Dorojan *et al.* [31] studied the influence of some phytobiotics (thyme, seabuckthorn) on growth performance of stellate sturgeon (*A. stellatus, pallas*, 1771) in an industrial recirculating aquaculture system. The phytobiotics used, thyme (*Thymus vulgaris*) and seabuckthorn (*Hippophae rhamnoides*), have been embedded in fodder, by using gelatin, having a concentration of 2%/ kg fodder. *Alterna Storioni* feed-48% crude protein was used. As a conclusion, it can be said that the two types of phytobiotics (thyme, seabuckthorn), administered in a concentration of 2%/kg fodder, have influenced the growth performance of stellate Gaber *et al.* [32] observed the effect of partially replacing corn meal by wet date on growth performance in nile tilapia (*oreochromis niloticus*) fingerlings, diets supplemented with digestarom concluded that diet containing 30% of WD with 0.03% D exhibited the highest net profit and would seem to be the most desirable level of WD and Digestarom.

5.3 Appetite-Stimulation

Another possible mode of action of phytogenic bioactive compounds on growth performance of farm animals could be their effects on the activities of digestive enzymes. The dietary supplementation of fructooligosaccharides improved daily body weight gain of animals by increasing the activities of amylase and protease. Furthermore, a study with these animals indicated that feeding a diet containing a commercial blend of essential oils (CRINAR) in combination with lactic acid induced a significant increase in activities of digestive enzymes of the pancreas and intestinal mucosa of animals, leading to a significant increase in growth [33].

The use of hot spices from peppers & cinnamon has been demonstrated to stimulate salivation. The increase in enzyme production can result in improvements in digestibility & availability of nutrients from feedstuffs [34].

5.4 Immunity Stimulation

The immune systems of fish and higher vertebrates are similar and both have two integral components. First component is the innate, natural or nonspecific defense system formed by a series of cellular and humoral components, and second is the adaptive, acquired or specific immune system characterized by the humoral immune response through the production of antibodies and by the cellular immune response which is mediated by T-lymphocytes, capable of reacting specifically with antigens. In aquaculture one of the most promising methods strengthening of the defence mechanism disease management is through prophylactic administration of immune-stimulants. In fish, the immunostimulants are known to increase certain aspects of innate immunity.

Table 3: Use of herbal phytochemicals as immunostimulants in fish culture [35]

Medicinal plant	Major phytochemical	*Species*	Dose & length of administrati-on	Results	References
Astragalus radix, root extract	Astragalus polysaccharide	*O. niloticus*	0.1,0.5,1.0% 4 weeks	↑Leucocytic phagogocytosis ↑Lysozyme activity →Repiratory burst activity	[36]
Astragalus membranaceus root extract and *Lonicera japonica* flower extract	Astragalus polysaccharide and chlorogenic acid	*O. niloticus*	0.1 % 4 weeks	↑Leucocytic phagogocytosis →Total protein, total immunoglobulin ↑Repiratory burst activity	[37]
Ganoderma lucidum extract	polysaccharide	*C. carpio*	0.5%- 5 weeks	↑Leucocytic phagogocytosis ↑Lysozyme activity ↑Repiratory burst activity	[38, 39]
Allium sativum	Alliin,allicin, ajoene, ally propyl disulphide, ally trisulphide, S-ally cystein, vinyldithiins, S-allymercaptocystein	*L. rohita*	0.1. 0.5, 1.0% 60 days	↑Superoxide anion production ↑Lysozyme activity ↑Serum bactericidal activity, serum protein, serum albumin	[40]
Withania somnifer root extract	Alkaliods, withanolids with a glucose at carbon 27, steroidal lactones, saponins containing an additional acyl group	*L. rohita*	1.0, 2.0, 3.0g/kg 42 days	↑Nitroblue tetrazolium level ↑Phagocytic cell activity ↑Lysozyme actibvity ↑Total immunoglobulin level	[41]
Sibarian ginseng *Eleutherococcus senticosus* residuum extract	Lignin, iridoid glycoside	*P. olivaceus*	3.0% 8 weeks	↑Non-specific immunity	[42]

Symbols represent an increase (↑) or no effect (→) on the specified response.

5.5 Anti-Microbial

Some bioactive substances from plants, like most antimicrobial agents, exert their effects by modulating the cellular membrane of microbes [43]. *In vitro* studies of (Kamel 2001) indicate that the minimum inhibitory concentration (MIC50) and minimum bactericidal concentration (MBC50) are linked to the level of active substance and purity of the plant extract. Furthermore, a strong increase in hydrophobicity of the microbial species in the presence of some plant extracts may influence the surface characteristics of microbial cells and thereby affect the virulence properties of the microbes [43]. This may be an important antimicrobial mechanism of some plant extracts. This concept may have implications for the gut, in which adhesion of microbes to intestinal mucosal cells is of vital importance for some pathogenic microflora and is strongly influenced by the hydrophobic surface properties of microbial cells [43, 44]. Various essential oil mixtures, which contain natural polyphenolic compounds or flavonoids as major active ingredients, have been identified as potential antimicrobial and antioxidant agents [45]. Thus, supplementation of broiler diets with essential oil mixtures can create a healthier gut microflora, aiding optimum digestion and improving bird performance [46]. Citarasu *et al*. [47] showed effects from including a combination of methanolic plant extracts in the diet of black tiger shrimp (*Penaeus monodon*) on survival and viral load during White Spot Syndrome Virus (WSSV) infection.

(a) As antibacterial agents

Shrimp fed with 25 ppm turmeric extract showed significantly better resistance against *V. harveyi* [48]. Among a wide variety of herbs tested against *Aeromonas hydrophila* infection in tilapia (*Oreochromis niloticus*), the ethanol extract of *Psidium guajava* was found to have the highest antimicrobial activity [49].

The dietary administration to *Pangasius* catfish of a synergistic blend of botanical extracts with antibacterial and anti-parasitic activities resulted in improved growth and feed conversion, reduced incidence of monogenean gill parasites and improved disease resistance against two important bacterial pathogens (*Edwardsiella ictaluri* and *Aeromonas hydrophila*) in an experimental infection trial [22].

(b) As antiviral agents

Successfully controlled salmonid rhabdovirus, VHSV by the plant extract derived from Olive tree leaf *(Olea europaea)* and its major compound, oleuropein [50].

Citarasu *et al*. [47] showed effects from including a combination of methanolic plant extracts in the diet of black tiger shrimp (*Penaeus monodon*) on survival and viral load during White Spot Syndrome Virus (WSSV) infection.

(c) As antifungal agent

Successfully controlled the pathogens, *Aspergillus flavus* by

the ethanol & methanol extracts from Tulsi through *in vitro* Indian almond leaves, *T. catatppa*, extract can reduce the fungal infection in tilapia eggs [51].

5.6 Aphrodisiac
Reprotism and asparagus in combination with 5% ricebran promoted the reproduction and other related parameters in *Artemia franciscana* [52].

5.7 Color Enhancing
Red colour extracted from red sandal wood *(Pterocarpus santalinus)* when incorporated in tilapia feed is found to increase the acceptability of the feed. It imparted a pink colour to the whole fish as well as to the fish flesh. The fishes fed with coloured feed showed increased feed intake and growth rate [53].

Joseph *et al*. [54] studied the effect four botanical additives (*H. rosasinensis, Rosa indica, Ixora coccinea and Crossandra infundibuliformiss*) on the growth and body colouration of an ornamental fish of red sword tail Xiphophorus hellerei (Heckel) concluded that the percentage of colour pigments obtained in adult fish were maximum in I. coccinea one percent level then remaining flowers peal showed another highest pigment production was R. indica, H. rosasinensis and C. infundibuliformiss. Natural pigment substances have an impact on coloration of cichlid and the groups did not exhibit any distinctions in feed conversion and growth rates. Therefore, it was determined that these pigment sources have an effect on the colour of cichlid fish. Body carotenoid increases by the dietary supplements and increased linearly with the increase of marigold flower meal and beetroot meal. Inexpensive and readily available natural carotenoid sources such as marigold flower and beetroot meals can be incorporated into diets for *S. richardsonii* to enhance pigmentation and ornamental value Jha *et al.* [55].

6. Conclusion
Natural plant products present a viable supplement in the fish feed for better growth, health and production. Herbal products in the aquacultural operations, that have the characteristics as growth promoting ability, tonic to improve the immune system, act as appetite stimulators, increase feed consumption, induce maturation, have antimicrobial as well as of anti-stress characteristics that will be immense use in the culture of fishes. Use of plants may lead to a way for better co-ordination of fisheries with horticulture and establishing a better relationship between agriculture and aquaculture and can achieve a goal of augmented aquaculture production in an eco-friendly, cost effective and sustainable manner.

7. Acknowledgement
Authors would like to thank their advisor Dr. Amita Saxena, Professor, Department of Fisheries Resource Management, CFSc., Pantnagar for their valuable support and motivation for writing articles to develop a habit of publication writing and also to improve the writing skills.

8. References
1. Faramarzi M, Lashkarboloki M, Kiaalvandi S, Iranshahi F. Influences of different levels of sweet potato peels on growth and feeding parameters and biochemical responses of *Cyprinus carpio (Cyprinidae).* American-Eurasian J Agric. & Environ. Sci. 2012; 12(4):449-455.
2. Benny P, Viswanathan G, Thomas S, Nair A. Investigation of immunostimulatory behaviour of *Musa acuminate* peel extract in *Clarias batrachus*. IIOAB Journal. 1(2):39-43.
3. Mamman T, Ipinjolu JK, Magawata I. Hematological ondices of *Clarias griepinus* (Burchell, 1882) fingerlings fed diet containing graded levels of calabash (*Lagenaria vulgaries*) seed meal. Journal of Biology, Agriculture and Healthcare. 2013; 3:100-104.
4. Ayotunde EO, Offem BO, Bekeh AF. Toxicity of *Carica papaya* Linn: haematological and piscicidal effect on adult catfish (*Clarias gariepinus*). Journal of Fisheries and Aquatic Science. 2011; 6:291-308.
5. UN Population Division/DESA, World population to exceed 9 billion by 2050. Press release, 2015.
6. Maske NS, Satyanarayan S. Effect of special fish feed prepared using potato peels on fresh water fish *Labeo rohita*. Journal of Industrial Pollution Control, 2012.
7. Omoregie E. Utilization and nutrient digestibility of mango seeds and palm Kernel meal by juvenile *Labeo senegalenis* (Antheriniformes: Cyprinidae) Aquaculture Research. 2001; 32:681-687.
8. Omoregie E, Ogbemudia FI. Effect of substituting fish meal with palm karnel on growth amd food utilization of the Nile Tilapia, (*Oreochromis niloticus*). Israeli Journal of Aquaculture. 1993; 43:113-119.
9. FAO. Sustainable fisheries and aquaculture for food security and nutrition: A report by The high level panel of experts on food security and nutrition, 2014.
10. Asimi OA, Sahu NP. Herbs/spices as feed additive in aquaculture. Scientific Journal of Pure and Applied Sciences, 2.
11. Jauncey K, Ross SA. Guide to tilapia feed and feeding. University of Sterling, Scotland, 1982.
12. Schieber A, Stintzing FC, Carle R. By-pruducts of plant food processing as a source of functional compounds-recent developments. Trends in Food Science and Technology. 2001; 12:401-413.
13. Cristea V, Antache A, Grecu I, Docan A. The use of phytobiotics in aquaculture. University of Agricultural Sciences and Veterinary Medicine Iasi, 2012, 57.
14. Denev SA. Ecological alternatives of antibiotic growth promoters in the animal husbandry and Aquaculture. DSc. Thesis, Department of Biochemistry Microbiology, Trakia University, Stara Zagora, Bulgaria, 2008, 294.
15. Yin G, Jeney G, Racz T, Xu P, Jun X, Jeney Z. Effect of two Chinese herbs (*Astragalus radix* and *Scutellaria radix*) on non specific immune response of tilapia, *Oreochromis niloticus*, Aquaculture. 2006; 253:39-47.
16. Raa J, Roerstad G, Ingested R, Robertson B. The use of immunostimulants to increase resistance of aquatic organisms to microbial infections. Asian aquaculture, 1992, 39-50.
17. Kumar S, Sahu NP, Pal AK, Choudhury D, Yengkokpam S, Mukherjee SC. Effect of dietary carbohydrate on haematology, respiratory burst activity and histological changes in *L. rohita* juveniles. Fish and Shellfish Immunology. 2005; 19:331-344.
18. Yuan C, Pan X, Gong Y, Xia A, Wu G, Tang J. Effects of *Astragalus* polysaccharides (APS) on the expression of immune response genes in head kidney, gill and spleen of the common carp, *Cyprinus carpio* L. International Immunopharma. 2008; 8:51-58.
19. Jeney G, Yin G, Ardo L, Jeney Z. The use of immunostimulating herbs in fish. An overview of research. Fish Physiology and Biochemistry 2009; 35:669-676.

20. Yin G, Cao L, Xu P, Jeney G, Nakao M, Lu C. Administration of a herbal immunoregulation mixture enhances some immune parameters in carp *(Cyprinus carpio*). Fish Physiology and Biochemistry. 2011; 37:209-216.
21. FAO. Manual on polyculture and integrated fish farming, 1992.
22. Coutteau P, Ceulemans S, Alexander HV. Botanical exracts improve productivity and economics in aquaculture. Nutriad International, 2011, Belgium.
23. Hsieh TJ, Chyi WJ, Hu CY, Li CT, Ching-Ming K, Hsieh SL. Effects of Rutin from Toona sinensis on the immune and physiological responses of white shrimp (*Litopenaeus vannamei*) under *Vibrio alginolyticus* challenge. Fish and Shellfish Immunology 2008; 25(5):581-588.
24. Miguel A, Pacheco ON, Castillo LO, Flores VP, Navarro L, Samano JC. Cowpea *(Vigna unguiculata)* protein concentrate *as* replacement for fish meal in diets for *Tilapia (Oreochromis niloticus)* fry. Aquaculture 1997; 158:107-116.
25. Thy S, Borin K, Vanvuth T, Buntha P, Preston TR. Effect of water spinach and duckweed on fish growth performance in polyculture ponds. Livestock Research for Rural Development, 2008; 20(1).
26. Omoregie E, Igoche L, Ojobe TO, Absalom KV, Onusiriuka BC. Effect of varying levels of sweet potato (*Ipomea batatas)* peels on growth, feed utilization and some biochemical responses of the Cichlid (*Oreochromis niloticus).* African Journal of Food Agriculture, Nutrition and Development. 2009; 9(2).
27. Adewolu MA. Potentials of sweet potato (*Ipomoea batatas)* leaf meal as dietary ingredient for *Tilapia zilli* fingerlings. Pakistan Journal of Nutrition 2008; 7(3):444-449.
28. Mohd din ARJ, Razak SA, Sabaratnam V. Effect of mushroom supplementation as a prebiotic compound in super worm based diet on growth performance of red tilapia fingerlings. Sains Malaysiana 2012; 41(10): 197-1203.
29. Orire AM, Ricketts OA. Utilisation of mellon shell as dietary energy source in the diet of Nile Tilatia (*Oreochromis Niloticus).* International Journal of Engineering and Science. 2013; 2(4):5-11.
30. Falaye AE, Omoike A, Olasebikan OB. Replacement of maize using cowpea (*Vigna unguiculata*) hull meal in practical feeds of african catfish (*Clarias gariepinus*) FRY. International journal of plant, animal and environmental sciences. 2012; 2(3):178-182.
31. Dorojan OG, Cristea V, Ion S, Petrea, SM. The Influence of some phytobiotics (Thyme, Sea buckthorn) on growth performance of stellate sturgeon (*A. stellatus, Pallas*, 1771) in an industrial recirculating aquaculture system. Animal Science and Biotechnologies. 2014; 47(1):205-210.
32. Gaber MM, Labib EH, Omar EA, Zaki MA, Nour AM. Effect of partially replacing corn meal by wet date on growth performance in nile tilapia (*Oreochromis niloticus*) fingerlings, diets supplemented with digestarom. Journal of Geoscience and Environment Protection. 2014; 2:60-67.
33. Jang IS, Ko YH, Yang HY, Ha JS, Kim JY, Kang SY. Influence of essential oil components on growth performance and the functional activity of the pancreas and small intestine in broiler chickens. Asian-Australian Journal of Animal Sciences. 2003, 395-400.
34. Chesson A. Supplementary enzymes to improve the utilization of pig and poultry diets. In: Haresign W, Cole DJA (eds) Recent advances in animal nutrition. Butterworths, London, 1987.
35. Chakraborty SB, Hancz C. Application of phytochemicals as immunostimulant, antipathogenic and antistress agents in finfish culture. Reviews in Aquaculture, 2011; 3(3):103-119.
36. Yin G, Jeney G, Racz T, Pao X, Jeney Z. Effect of two Chinese herbs (*Astragalus radix* and *Scutellaria radix*) on non-specific immune response of tilapia, *Oreochromis niloticus*. Aquaculture. 2006; 253:39-47.
37. Ardo L, Yin G, Xu P, Varadi L, Szigeti G, Jeney Z. Chinese herbs (*Astragalus membranaceus* and *Lonicera japonica*) and boron enhance the non-specific immune response of Nile tilapia (*Oreochromis niloticus*) and resistance against *Aeromonas hydrophila*. Aquaculture. 2008; 275:26-33.
38. Rao YV, Chakrabarti R. Enhanced anti-proteases in *Labeo rohita* fed with diet containing herbal ingredients. Indian Journal of Clinical Biochemistry. 2004; 19:132-134.
39. Rao YV, Chakrabarti R. Stimulation of immunity in Indian major carp *Catla catla* with herbal feed ingredients. Fish and Shellfish Immunology 2005; 18:327-334.
40. Sahu S, Das BK, Mishra BK, Pradhan J, Sarangi N. Effect of *Allium sativum* on the immunity and survival of *Labeo rohita* infected with *Aeromonas hydrophila*. Journal of Applied Ichthyology. 2007; 23:80-86.
41. Sharma A, Deo AD, Riteshkumar ST, Chanu TI, Das A. Effect of *Withania somnifera* (L Dunal) root as a feed additive on immunological parameters and disease resistance to *Aeromonas hydrophila* in *Labeo rohita* (Hamilton) fingerlings. Fish and Shellfish Immunology. 2010; 29:508-512.
42. Won KM, Kim PK, Lee SH, Park SI. Effect of the residum extract of Siberian ginseng *Eleutherococcus senticosus* on non-specific immunity in olive flounder *Paralichthys olivaceus*. Fisheries Science. 2008; 74:635-641.
43. Kamel C. racing modes of action and the roles of plant extracts in non–ruminants. Recent Advances in Animal Nutrition. 2001, 135-150.
44. Pusztai A, Grant G, King TP, Clarke EMW. Chemical Probiosis. (eds. W. Haresign and D.J.A. Cole). Butterworths, London, UK. Advances in Animal Nutrition. 1990, 47-60.
45. Friedman M, Buick R, Elliott CT. Antibacterial activities of naturally occurring compounds against antibiotic-resistant *Bacillus cereus* vegetative cells and spores, *Escherichia coli* and *Staphylococcus aureus*. Journal of Food Protection. 2004; 67:1774-1778.
46. Cruickshank G. Botanical growth enhancers offer natural option for broiler growers. Poultry World 2001; 10:19-22.
47. Citarasu T, Sivaram V, Immanuel G, Rout N, Murugan V. Influence of selected Indian immuno-stimulant herbs against white spot syndrome virus (WSSV) infection in black tiger shrimp, *Penaeus monodon* with reference to haematological, biochemical and immunological changes. Fish and Shellfish Immunology. 2006; 21:372-384.
48. Vanichkul K, Areechon N, Kongkathip N. Application of turmeric (*Curcuma longa* Linn.) extract in black tiger

shrimp (*Penaeus monodon Fabricius*) culture, In Proceedings of 45th Kasetsart University Annual Conference, Self-sufficient agriculture: Projects initiated by His Majesty the King, 30 Jan- 2 Feb 2007. Kasetsart University, Bangkok, 2007, 212- 220.

49. Pachanawan A, Phumkhachorn P, Rattanachaikunsopon P. Potential of *Psidium guajava* supplemented fish diets in controlling *Aeromonas hydrophila* infection in tilapia (*Oreochromis niloticus*). Journal of Bioscience and Bioengineering. 2008; 106:419-424.
50. Micol V, Caturla N, Perez-Fons L, Mas V, Perez L, Estepa A. The olive leaf extract exhibits antiviral activity against viral haemorrhagic septicaemia rhabdovirus (VHSV). Antiviral Research. 2005; 66(2-3):129-136.
51. Chitmanat C, Tongdonmuan K, Khanom P, Pachontis P, Nunsong W. Antiparasitic, antibacterial, and antifungal activities derived from a terminalia catappa solution against some tilapia (*Oreochromis niloticus*) pathogens. Acta horticulturae, 2005, 678.
52. Devi L. Effect of *Asparagus racemous* to improve the survival and reproductive performance in *Artemia parthenogenetica*. 1995. MPhil Dissertation, Manonmaniam Sundaranar University, Tirunelveli.
53. Mathew PT, Gopakumar K. Effect of Incorporation of Vegetable Colour from Red Sandal (*Pterocarpus santalinus*) on Acceptability, Colour Development and Growth of Tilapia (*Tilapia mossambica*) Central Institute of Fisheries Technology, Kochi, 682, 029.
54. Joseph B, Sujath S, Shalin J, Palavesam A. Influence of Four ornamental flowers on the growth and colouration of orange sword tail Chicilidae fish (*Xiphophorus hellerei*, Heckel, 1940). International Journal of Biological and Medical Research. 2011; 2(3):621-626.
55. Jha GN, Sarma D, Qureshi TA, Akhtar MS. Effect of marigold flower and beetroot meals on growth performance, carcass composition, and total carotenoids of snow trout (*Schizothorax richardsonii)*. The Israeli Journal of Aquaculture. 2012.