

1. REVIEW OF LITERATURE

Medicinal herbs are as old as civilization and throughout history they have been used as popular folk medicine because of their broad-spectrum medicinal properties. The attempt to adopt them in aquaculture is a novel development that got huge attention virtually in every part of the globe, with Asia having the most researched herbs (Bulfon *et al.*, 2015).

Plant extracts have been reported to favor various activities like antistress, growth promotion, appetite stimulation, enhancement of tonicity and immune stimulation, maturation of culture species, aphrodisiaca and anti-pathogen properties in fish and shrimp aquaculture due to active principles such as alkaloids, terpenoids, tannins, saponins, glycosides, flavonoids, phenolics, steroids or essential oils (Citarasu, 2010; Chakraborty and Hancz, 2011).

Plants as growth promoters

Livol (IHF- 1000) is a commercial herbal growth promoter which has been found to significantly improve digestion, thereby leading to better growth, production and health in cultivable fishes (Shadakshari,1993; Unnikrishnan1995; Jayaprakas and Euphrasia,1996).

Gynostemma pentaphyllum is a customary Chinese herbal medicine blend into fish feed caused a raised weight gain and specific growth rate in grass carp *Ctenopharyngodonidella* (Wu *et al.* ,1998). Giresha *et al* (2002) found that *Catla catla* fed on 0.5% livol incorporated diet showed better food conversion efficiency and protein efficiency ratio. They also suggested that livol enhanced the gut digestive enzymes which in turn improved the growth rate and feed conversion ratio. Adding black seed (*Nigella sativa*) at levels 0, 3, 6 and 9 % gave a positive response of growth performance and SGR at low levels of Red tilapia diets (Abdelmonem *et al.* ,2002).

Dietary supplementation with a *Quillaja saponin* mixture improves growth performance and metabolic efficiency in *O.niloticus* and *C.carpio* (Francis *et al.*,2001., 2002a & b). Shalaby *et al* (2006) observed that food intake, specific growth rate and final

weight of Nile tilapia (*Oreochromis niloticus*) increased when garlic was incorporated in the diet.

Olive flounder (*Paralichthys olivaceus*) fed with a herbal mixture of medicated leaven (*Massamedicata fermentata*), hawthorne (*Crataegifructus*), virgate worm wood (*Artemisia capillaris*) and *Cnidium officinale* in the ratio of (2:2:1:1) had higher weight gain than the control fish and showed higher total carcass unsaturated fatty acid content and lower carcass saturated fatty acid content, indicating that feeding with the herbal mixture improves fatty acid utilization (Ji *et al.*, 2007).

A feeding experiment was conducted to assess the impact of the herb, Kaunch (*Mucuna pruriens* Bek.) mixed with conventional diets (rice bran and groundnut oil cake 1:1) of major carp fingerlings in the raising of common carp, *C. carpio* L. fingerlings (Charula *et al.*, 2007). The effect of polyherbal formulation 'Immuplus' on immunity and disease resistance of Indian major carp, *L. rohita* at different stages of growth was studied by (Kumari *et al.*, 2007).

Dietary ginseng herb (Ginsana_ G115) greatly enhanced the growth performance, diet utilization efficiency and haematological indices in the Nile tilapia, *Oreochromis niloticus*, fingerlings (Ashraf and Goda, 2008). The impact of dietary inclusion of medicinal herbs (*Astragalus radix* and *Lonicera japonica*) on the growth performance, proximate body composition, fatty acids profile (whole fish, muscle tissues and viscera) and cytological and histological indicators of the liver and middle intestine of juvenile pikeperch (*Sander lucioperca* L.) and stated that juvenile pike perch (*Sander lucioperca*) fed on diets supplemented with two medicinal herbs (*Astragalus radix* and *Lonicera japonica*) exhibited faster growth than those fed with the control diet (Zakes *et al.*, 2008)

Ephinephelus fed with a diet supplemented with a mixture of methanolic herb extracts (Bermuda grass (*Cynodon dactylon*), Longpepper (*Piper longum*), stonebreaker (*Phyllanthus niruri*), coat buttons (*Tridax procumbens*) and ginger (*Zingiber officinalis*) displayed 41% higher weight than fish fed with the control (Punitha *et al.*, 2008).

The effect of different levels of dried Basil leaves on growth performance body composition and cost beneficial analysis of hybrid Tilapia, *Oreochromis niloticus* X *Oreochromis aureus* was studied by El-Dakar *et al.*, (2008). Incorporation of dried basil leaves in test diets improved significantly ($P < 0.05$) growth rate than the control diet and palatability index increased as DBL level increased and resulted in reduction in feed waste per cent from 33.48% with the control diet to 8.43% diet contained 2% DBL level.

Nile tilapia fed with supplemented diets with dried garlic at 5g/kg diet level is recommended to achieve better growth performance (Abdel-Hakim *et al.*, 2010). Singh *et al* (2011) investigated the effect of different levels of Papain (1%, 2% and 4%) supplemented feed in *Cyprinus carpio* and stated that, supplementation of papain to feed of common carp at a level of 2% resulted in better growth performance.

A 45 day study was undertaken to evaluate the effect of dietary aqueous extract of *Garcinia gummi-guttata* cat fish, on growth performance, basic haematological and biochemical parameters by Prasad and Priyanka (2011). The result showed that significant increase in erythrocyte count, leukocyte, thrombocyte, haemoglobin, PCV and MCHC. *Andrographis paniculata* can be considered as a potential as well as a natural additive to fish feed in commercial aquaculture applications to augment the cellular immunity to control the common disease of fish (Prasad and Mukthiraj, 2011) .

Lee *et al* (2012) investigated the effect of garlic extract on growth, feed utilization, whole body composition of Juvenile sterlet sturgeon (*Acipenser ruthenus*) .They reported that the dietary garlic would improve the growth, feed efficiency ratio and feed utilization and body composition significantly in juvenile sterlet sturgeon.

Sivagurunathan *et al* (2012) found that the fishes fed with Amla (*Phyllanthus emblica*) extract incorporated diet exhibited an increase in specific growth rate and feed conversion rate. Incorporation of amla in the diet might have improved palatability, digestion and absorption of nutrients resulting in improved SGR and FCR, so that amla plays a significant role as growth promoter. Dada (2012) stated the effects of herbal growth promoter as feed additive in fish meal on the performance of Nile tilapia (*Oreochromis niloticus* L.). The efficacy of Aqua booster® and Aqua pro® feed additives as a growth promoter in *C. gariepinus* fingerlings was studied by (Dada and Olugbe, 2012).

An investigation was carried to evaluate the effect of feeding lemon balm (*Melisa officinalis*) and *Aloe vera* on growth performance, haematological parameters of rainbow trout by Farahi *et al* (2012). They reported that increased survival, growth and blood parameters *viz.*, RBC, WBC, Hb, PCV were observed in fishes fed with lemon balm (*Melisa officinalis*) and *Aloe vera*.

Using walnut leaf and onion bulb as a supplementation in plant based diets may be useful in improving feed acceptability and growth performance of cultured *Clarias gariepinus* (Bello *et al* ., 2012). Turnip supplementation tend to increase the growth, food conversion ratio, protein efficiency ratio in the rainbow trout (*Oncorhynchus mykiss*) juveniles (Haliloglu *et al.*, 2012) .

Lee *et al* (2012) studied the supplemental effects of dietary garlic extract on growth of juveniles Sterlet Sturgeon *Acipenser ruthenus*. They observed that 0.5% garlic extract, significantly increased the weight gain, feed efficiency, specific growth rate, protein efficiency ratio, protein and lipid retention efficiency than those fed with control diet.

The ethanolic *Aloe vera* extract has effective influence on growth performance and the *Aloe vera* extract in the diet can perform a growth promoter, appetite stimulator and immunostimulant, reduce stress, reduce food losses and protect fish for better growth of fish (Mahadavi *et al.*, 2013). Megbowon *et al.*, 2013 stated that significant increased weight and growth performance of the ecotype cichlid ($P < 0.01$) was observed in all groups fed on garlic.

El-Marakby *et al* (2014) evaluated the use of dry rocket leaves meal (DRLM); *Eruca sativa* as a natural feed additive on growth performance, feed utilization, body composition and innate immunity of Nile Tilapia, *Oreochromis niloticus*. Four isonitrogenous (30% crude protein) and isocaloric (4.40 Kcal/g) diets were formulated to contain 0.0 (control), 0.5, 1.0 and 1.5% DRLM. He recommended the use of 1% DRLM as a feed additive for Nile tilapia to enhance its growth performance, health and innate immunity.

Medicinal plants Ashwagandha and Shatavari showed increase trend of the body weight of the freshwater fish *Channa punctatus* was stated by (Borkar *et al.*, 2014). Ojha

et al(2013) reported that the growth performance, metabolic enzymes, haematological and immunological parameters were significantly increased in the freshwater fish *Labeorohita* fingerlings fed with *Mucana pruiens* supplemented diet. The application of garlic in on growth performance, flesh quality, antimicrobial activity, as an immunostimulant and antiprotozoal agent in aquaculture (Shakya and Labh, 2014).

The crude extracts of *Cinnamomumcamphora*, *Euphorbia hirta*, *Azadirachta indica*, and *Carica papaya* have significantly increased weight gain (WG), specific growth rate (SGR), feed intake (FI), feed conversion ratio (FCR) among others, in Nile tilapia (Kareem *et al.*, 2016). The use of garlic (*Allium sativum*) meal as a natural feed supplement in diets for European Seabass (*Dicentrarchus labrax*) juveniles was observed by (Irkin and Yigit, 2016).

Gabriel *et al* (2019) investigated the effects of dietary *Aloe vera* polysaccharides on growth performance, feed utilization, haemato-biochemical parameters, and resistance against low water pH in African catfish (*Clarias gariepinus*) fingerlings. Fish were divided into five triplicate groups before being fed feeds supplemented with 0% (control), 0.5%, 1.0%, 2.0%, and 4.0% *A. vera*/kg diet for 8 weeks. Fish fed 1.0% *A. vera*/kg diet had significantly increased ($P\leq 0.05$) growth parameters (i.e., final weight, weight gain, absolute growth rate, and specific growth rate) compared to unsupplemented ones. Among dietary groups, significantly lower feed conversion ratio was presented in fish fed 1.0% followed by those fed 0.5, 2.0%, and 4.0% *A. vera*/kg diet ($P\leq 0.05$). The protein efficiency ratio was significantly higher ($P\leq 0.05$) in fish fed 1.0% *A. vera*/kg diet compared to unsupplemented fish and those fed 4.0% *A. vera*/kg diet, respectively. Dietary *A. vera* polysaccharide crude extracts requirement suitable for growth and feed utilization was estimated to be between 1.76 and 1.79% *A. vera*/kg diet.

Plants as antibacterial agents

Harikrishna *et al.*, 2003 indicated that the aqueous extract of *Azadirachta indica* leaf could effectively control *A. hydrophila* infection in common carp *Cyprinus carpio*.

Muniruzzaman and Chowdhury (2004) stated that onion (*Allium cepa*) was highly effective against *A. hydrophila* and other two fish pathogenic bacteria *Pseudomonas fluorescens* and *Edwardsiella ictaluri*.

Bhuvaneshwari and Balasundaram (2006) stated that the crude ethanol extracts of *Acalypha indica*, *Acorus calamus*, *Coleus aromaticus*, *Heliotropium indicum* and *Indigofera aspalathoides* were screened for invitro antibacterial activity against the growth of the fish pathogenic bacteria, *Aeromonas hydrophila*. The order of potency of the herbs in warding off growth of *Aeromonas hydrophila* invitro was ranked *A. calamus*, *I. aspalathoides*, *C. aromaticus*, *A. indica* and *H. indicum*.

Obi *et al.*, (2007) stated that acetone and hexane extracts of *Pterocarpus angolensis*, *Syzygium cordatum*, and *Zornia milneana* showed inhibitory activity against all *Aeromonas* isolates. Guava and Neem extracts showed higher antimicrobial activity against Gram-negative bacteria such as *A. hydrophila* was reported by Hoque *et al.*, (2007).

Castro *et al.* (2008) found that 31 methanolic extracts of Brazilian plants presented antibacterial activity (agar diffusion assay) against the fish pathogenic bacteria *Streptococcus agalactiae*, *Flavobacterium columnare* and *A. hydrophila*, *F. columnare* being the most susceptible microorganism to most of the tested extracts.

Pachanawan *et al* (2008) stated that among a wide variety of herbs tested against *A. hydrophila* infection in tilapia (*Oreochromis niloticus*), the ethanol extract of *Psidium guajava* was found to have the highest antimicrobial activity. Musa *et al.*, (2008) observed that garlic was active against *A. hydrophila* as well as other many bacteria isolated from fish and shrimp.

Turker *et al* (2009) reported that the alcoholic and aqueous extracts of *Nuphar lutea*, *Nymphaea alba*, *Stachys annua*, *Genista lydia*, *Vinca minor*, *Fragaria vesca*, *Filipendula ulmaria* and *Helichrysum plicatum* herbs of Bold (Turkey) have antibacterial activity against *A. hydrophila*, *Yersinia ruckeri*, *Lactococcus garvieae*, and *Enterococcus faecalis* Bacteria isolated from fish. Durairaj *et al.*, (2009) stated that garlic extract was found to be active against three *Aeromonas* species *A. hydrophila*, *A. caviae* and *A. sobria* isolated from seafood.

Ravikumar *et al* (2010) observed that the chloroform extract of *Datura metel* plant has wide range of antimicrobial activity against many fish pathogens. The methanol and aqueous extracts of leaves of six different medicinal plants, *Acalypha indica*, *Aervalanata*,

Phyllanthusamarus, *Phyllanthusemblica*, *Cassia auriculata* and *Caesalpinia pulcherrima* were used in antibacterial studies against *Aeromonashydrophila* and *Xanthomonas campestris* by Britto *et al.*, (2011).

Mydeen and Haniffa (2011) evaluated the antimicrobial activity of medicinal plants on fish pathogen *Aeromonashydrophila* and found that the strongest antibacterial activities were obtained from the aqueous extract of *Azadirachta indica* with the inhibition zone of 18 mm followed by *Solanum tarvum* with an inhibition zone of 11 mm.

The antibacterial activity of extracts prepared from different parts of *Olea europea*, *Mytus communis*, *Thymus vulgaris*, *Rosmarinus officinalis* and *Achillea falcate* that grow in Syria against *A. hydrophila* was studied by Laham and Fadel (2014).

Thagarajan *et al.*, (2014) used the extracts of *Mentha piperita*, *Azadirachta indica*, *Andrographis paniculata*, *Phyllanthus niruri*, *Solanum nigrum*, and *Ruta chalepensis* to control *Aeromonashydrophila*. Vasanthakumar *et al.*, (2015) investigated the antibacterial activity of *Rosa damascena* petal extracts against the fish pathogen *Aeromonashydrophila*.

An investigation was carried out to estimate the antibacterial activity of different concentrations of medicinal plants against common fish pathogen *Aeromonas hydrophila*. The ethanolic extracts of *A. catechu*, *C. papaya*, *E. camaldulensis*, *P. ambonicus* and *O. basilicum* were prepared in different concentrations from 10% ,20%,30%,40% and 50% and antibacterial activity against *A. hydrophila* was performed by following well diffusion assay. Among the extracts *O. basilicum* showed maximum inhibition against *A. hydrophila* by producing 27mm inhibition followed by *E. camaldulensis* 23mm and *A. catechu* 21mm of inhibition at 50% concentration respectively against *A. hydrophila* (Pirakadeaswari *et al.*, 2019).

Plants as immunostimulants

Many herbal plants found to inhibit the bacterial pathogens and activate the immunity (Chansue *et al.*, 2000; and Dugenciet *et al.*, 2003;) at a low concentration and hence its use was very cost effective (Lipton, 2000). The application of herbal plant extracts as a potential therapeutic measure for modulating the immune response in fish was found out by many researchers.

Dey (1997) reported on the use of herbal materials for managing disease and health conditions of fish during sustainable aquaculture practices. Michael *et al.* (1998) treated *Oreochromis niloticus* with the plant extract of *Azadirachta indica* and the antibody production was higher even after the twenty days of heat killed pathogen of *Aeromonas hydrophila*.

The effect of azadiractin derived from *Azadirachta indica* on the humeral and cell mediated immune responses in the fresh water teleost fish, *Oreochromis mossambicus* was studied by Logambal and Michael (2000).

Chansueet *al.*, 2000 stated that the non-specific immune functions such as bacteriolytic activity and leukocyte function were improved by mixtures of chosen Chinese herbs incorporated in shrimp and fish diet. Dietary intake of *O. sanctum* enhanced the antibody response and disease resistance against *A. hydrophila* (Logambalet *al.*, 2000).

Venkatalakshmi and Michael (2001) found that the medicinal plant *Azadirachta indica* enhanced the primary and secondary antibody response of *Oreochromis niloticus* in an inverse dose-dependent mode.

Venkatalakshmi and Michael (2001) analyzed the immunostimulatory effect of *Ocimum sanctum* extracts against fish pathogen in *Oreochromis mossambicus*. Sukumaran and Anita (2001) evaluated the immunomodulatory effects of *Azadirachta indica* and *Acalypha indica* extracts in tilapia, *Oreochromis mossambicus* infected with *Pseudomonas fluorescens*.

Nguyen *et al.*, (2002) stated that feeding with *Catharanthus roseus* plant extract enhanced the immune response of *L. rohita*. Balasubramani and Michael (2002) investigated the immunostimulatory effect of the fruit extract of Indian Gooseberry *Phyllanthus emblica* in *Oreochromis mossambicus*. Deva sagayamet *al.*, 2002 evaluated the effectiveness of Indian medicinal plants as an alternative to antibiotics to combat disease problems in fishes.

Application of immunostimulants for modulation of the non specific defense mechanisms in sturgeon hybrid *Acipenser ruthenus* and *A. baerii* was reviewed by Jeney and Jeney (2002).

Dugenciet *al.*, (2003) indicated that the herbs and herbal drugs viz., ginger, nettle and mistletoe were used in adjuvant therapy in rainbow trout through feed and they enhanced phagocytosis and cellular and humoral defense mechanism against fish pathogen. Chitra (2003) found that the plant extracts of *Azadirachta indica* and *Ocimum sanctum* enhanced the primary and secondary antibody titre against heat killed *Aeromonas hydrophila*.

The aqueous extract of *Azadirachta indica* leaf has been tested against *A. hydrophila* infection in common carp *Cyprinus carpio* and this plant could effectively control *A. hydrophila* infection was suggested by (Harikrishna *et al.*, 2003).

Chen *et al.* (2003) reported that plasma lysozyme activity was increased in crucian carp by feeding four Chinese herbs (*Rheum officinale*, *Rogorhispaniculata*, *Isatis indigotica* and *Lonicera japonica*).

Jian and Wu, 2004 noted that in common carp (*Cyprinus carpio*) and large yellow croaker (*Pseudosciaenacrocea*) respiratory burst activity of phagocytic cells and plasma lysozyme activity were significantly increased after feeding with a ration containing a mixture of *Astragalus membranaceus* and *Angelica sinensis*. The immunostimulatory activity of *Coriandrum sativum* has increased proliferation of lymphocytes and the production of interleukin were documented by (John Britto *et al.*, 2004).

Rao *et al.* (2006) reported that superoxide anion production by the blood leucocytes was enhanced in *Labeo rohita* after feeding the fish with *Achyranthes aspera* seed. Chakrabarti and Rao (2006) reported that prophylactic treatment of *Achyranthes aspera* significantly enhanced the specific antibody response and antigen clearance against BSA in *Catla catla*.

Gopalakannan and Arul (2006) identified that the dietary plant extract supplementation enhanced the resistance of *Cyprinus carpio* against *Aeromonas hydrophila*. Aly *et al.* (2006) reported that garlic improves the immune response of *Oreochromis niloticus* through a rapid increase in monocytes and over a longer timeframe enhanced phagocytic activity which affords increased protection against immediate challenge infection.

Kumari *et al* (2007) reported that enhanced antibody response in *Labeorohita* fed with polyherbal formulation „immuplus“ when challenged against *Aeromonashydrophila*. Christyapita *et al* (2007) noted that the aqueous extract (AqE) of *Ecliptaalba* (Bhangra) leaf oral administration as feed supplement in tilapia fish, *Oreochromismossambicus* enhances non-specific immune responses and disease resistance against *Aeromonashydrophilain* infection.

Sahu *et al* (2007a) reported that serum protein, albumin and globulin levels in *L. rohita* fingerlings fed with *Magnifera indica* kernel were higher than control. Since serum proteins include various humoral elements of the non-specific immune system, high concentrations of total serum protein, albumin and globulin might be due to the enhancement of non-specific response of fishes. *Curcuma longa* and *Allium sativum* enriched diets increased the serum bactericidal activity and phagocytosis in rohu *Labeorohita* was determined by (Sahu *et al.*, 2007b).

Seung-Cheo *et al.*, (2007) showed that the addition of different single herbal extracts (*Massa medicata*, *Crataegifructus*, *Artemisia capillaries*, *Cnidium officinale*) or a mixture of all the herbs promoted growth and enhanced some non-specific immunity indicators of red sea bream *Pagrus major*.

Divyaganaeshwari *et al.*, (2008) reported that the extract of *Solanum trilobatum* leaves enhanced the specific and non-specific immune response against *A. hydrophila* in *Oreochromismossambicus*. Aly *et al* (2008) stated that *Echinacaecan* act as a growth enhancer, immune stimulant and disease control agent in fish. It is recommended as a means of improving Tilapia aquaculture production under certain conditions.

Ardo *et al.*, (2008) indicated that feeds containing *A. membraneaus* and *L. japonica* extracts significantly reduced mortality of *O. niloticus* followed by experimental infection with *A. hydrophila*. Choi *et al.*, (2008) stated that Dietary Korean mistletoe enhances cellular non-specific immune responses and survival of Japanese eel (*Anguilla japonica*).

Nya and Austin (2009) used garlic at an inclusion level of 0.5 and 1.0 mg/g feed to control an *Aeromonashydrophilain* infection in rainbow trout (*Oncorhynchus mykiss*). Suresh and Amolkumar (2009) evaluated the immunomodulatory activity of an extract of

Andrographolides from *Andrographispaniculata*. The effect of using dried Fenugreek seeds as natural feed additives on growth performance, feed utilization, whole-body composition and entropathogenic *Aeromonashydrophila*-challenge of monsex Nile tilapia *O. niloticus* (L.) fingerlings was studied by (Abdel *et al.*, 2009).

Immanuel *et al.* (2009) worked on the effect of supplementing diets containing the acetone extract of four medicinal plants viz., *Cynodondactylon*, *Aeglemarmelos*, *Withaniasominifera* and *Zingiberofficinale* on non-specific immune response of *Oreochromismossambicus* and reported that enhancement in Leucocrit value, phagocytic index and lysozyme activity in plant extract treated groups.

Soltaniet *al* (2010) studied the effects of essential oil derived from the plant *Zatariamultiflora* on innate immune responses of common carp, *Cyprinuscarpio*. They reported that the essential oil had immunostimulatory effects on the immunological factors such as antibody titre and total white blood cells.

Many plants reduce the oxidative stress produced during adverse environmental conditions. They neutralize the free radicals that are oxygen derived and are important in innate and acquired immunity of the organism (Devi *et al.*, 2011).

Kaleeswaranet *al.*, (2010) observed that the ethanolic extract of plant *Cynodondactylonis* very effective immunostimulant in *Catlacatla* against *A. hydrophilain* infection and he suggested that this plant extract could develop or induce the specific antibody in fish against the antigen, especially at the higher (5%) concentration.

Harikrishananet *al.* (2010) found that the enhancement in phagocytic activity, respiratory burst activity, hemolytic component and lysozyme activity in *Paralichthysolivaca* treated with mixed herbal diet of *Punicagranatum*, *Dalmatian*, *Chrysanthemum* and mastic leaved prickly ash, *Zanthoxylumschinifolium*.

Mohamad and Abasali (2010) investigated the effect of *Inulahelenium*, *Tussilagofarfara*, *Brassica nigro*, *Echinaeaceapurpurea* and *Chelidoniummajuse* extracts supplemented diet on immunity and resistance to *Aeromonashydrophilain* common carp (*Cyprinuscarpio*) and reported significant increase in respiratoryburst activity, serum bactericidal activity, serum proteins and other haematological parameters.

Thanikachalamet *al* (2010) stated that the embedding of garlic peel in feed enhances the haematological parameters even at a low level (0.5%) incorporation and

makes *Clariasgariepinus*, fingerlings, highly immunopotent and more resistant to infection by *A. hydrophila*.

Innocent *et al.* (2011a) stated that increase in lymphocyte count was noted in *Coriandrumsativum* incorporated diet. Remarkable increase in Hb from 6.2 to 8 g % and serum protein level from 0.4 to 0.5 g % was observed in experimental fishes. The immunostimulant administered *Catlacatlawhen* challenged with *Aeromonashydrophilashowed* a decrease in Total Erythrocyte Count and an increase in Total Leucocyte Count. Increase in lymphocytes was also noted.

Immuno stimulant effect of the dietary intake of some medicinal plants extracts on fingerlings of *Labeorohitawere* investigated by Nargiset *al.*, (2011). Fingerlings were fed with diets containing aqueous extract of Nishinda (*Vitexnegundo*) and garlic (*Aliumsativum*). For immune stimulatory food additives caused a good result compared to the control group.

Prasad and Mukthiraj (2011) studied that WBC, thrombocytes, Hb, packed cell volume (PCV), Mean Corpuscular Heamoglobin Concentration (MCHC) were in increased level and, they pointed out increased in the levels of immunity which in turn could be due to the action of *Andrographispaniculata* present in the diets.

Yilmazet *al.*, (2011) suggested that the addition of herbal plants such as thyme, rosemary and fenugreek in fish feed could be considered as feed additives for improving haematological and immune status and for the fish welfare in aquaculture. Bairwaet *al.* (2012) reviewed on fish disease control by several medicinal plants such as *Ocimum sanctum*, *Phyllanthusemblica*, *Azadirachtaindica*, *Solanumtrilobatum*, *Ecliptaalba*, *Zingiberofficinale*, *Allium sativum*, *Camellia sinensis*, *Aloe vera*, *Cynodondactylon*, *Achyranthesaspera*, *Nyctanthesarbortristis*, *Tinosporacordifolia* and *Picrorhizakurooa*.

Kumaret *al* (2012) studied the immunostimulatory and disease resistance properties of *Solanumtorvum* against *Aeromonashydrophila* in *Cyprinuscarpio* and stated that *Solanumtorvum* can used as an first grade immunostimulant in fresh water aquaculture.

Asadiet *al*(2012) stated that oral administration of 1% water cress (*Nasturiumnasaturium*) extract in fish may enhance some haematological and immunological parameters including Hb, MCHC, lysozyme, compliment activity, total protein, globulin levels etc. oral administration of water cress extract may be useful to improve fish immune system.

Sivagurunathanet *al.*, (2012) evaluated that there is significant increase in growth and hematological parameters of *Cirrhinusmrigal* challenged with *Pseudomonas aeruginosa* in fish fed with *Nelumbonucifera* feed. Thus *Nelumbonucifera* in fish feed preparation may be included as growth promoter and immune stimulant.

Park and Choi (2012) observed that Nile tilapia (*O. niloticus*) fed with diets containing different doses of mistletoe (*Viscum album coloratum*) for a period of 80 days displayed an increase in immunological parameters (lysozyme activity, respiratory burst activity, alternative complement activity and phagocytic activity).

Pandeyet *al* (2012a&b) reviewed the immunostimulatory effect of medicinal plants on fishes. The medicinal plants can act as immunostimulant conferring activation of some non-specific immunity and elevation of specific immune response and act as immune booster.

Begum and Navaraj (2012) studied the individual and synergistic effect of two plants extracts (*Solanumtrilobatum* and *Ocimum sanctum*) against *Aeromonashydrophila*. The hematological, biochemical and immunological parameters of fish were investigated at 20, 40 and 60 days of feeding and also on 10th day post-challenge in order to evaluate the immune response and resistance against *A. hydrophil* infection of fish. The serum protein, albumin, globulin, WBC, RBC and hemoglobin content were enhanced ($p < 0.05$) in fish fed herbal diets compared to the control group.

Das *et al.* (2013) demonstrated enhanced super oxide anion production, lysozyme activity, total immunoglobulin in plasma, serum total protein, globulin, total RBC counts, total WBC counts and haemoglobin content ($P < 0.05$) in treatments group compared with control group. Dietary *O. sanctum* extracts of 0.2% showed significantly ($P < 0.05$) higher protection and relative percentage survival (RPS $40.00 \pm 5.773\%$) against *A. hydrophil* infection than the control.

Labeorohitafed with dietary *Phyllanthusamarus* (10g/100ml aqueous extract) for 14 days and observed an increase in total erythrocyte count, haemoglobin concentration, total leucocytes, lymphocytes, monocytes and neutrophils. When these fishes were challenged with *Aeromonashydrophila* significant increase in total erythrocytes, haemoglobin concentration, total leucocytes, lymphocytes and a steady population of monocytes and neutrophils were observed. Thus dietary incorporation of *P.amarus* helps to improve the general health and resistance of the fish (Annalakshmi *et al.*, 2013).

Chinnasamy *et al.* (2013), suggested the protective ability of *Zingiberofficinale* powder mediated through cellular and may be non-cellular immunemechanism, as evident from the enhanced haematological parameters, such as, erythrocytes, leucocytes and haemoglobin, total serum protein, immunological parameters, such as, respiratory burst activity, bactericidal activity, and growth and survival rate against *A. hydrophila*.

Nahak and Sahu (2014) reported that the plant extract of *Ocimumsantum* may act as a potent immunostimulant in *Clariasbatrachus* Linn. El sayed *et al* (2014) concluded that, using of Echinacea or Ginseng extracts or both as feed additives for Nile tilapia diets for 8 weeks can improve growth performance parameters and stimulate its specific and non specific immune parameters. So addition of Echinacea or Ginseng extracts or both to the Nile tilapia diets can be served as natural alternatives for oxytetracycline as growth promoters, and also they can be used as immunostimulants for Nile tilapia with respect that Echinacea extract is the most potent one of them.

Vijayakumari *et al.*, (2014) investigated the dietary effect of *Ocimumtenuiflorum*, *Zingiberofficinale* and *Allium sepa* (0.5g/100g each) in Catfish (*Mystusmontanus*) fed with for 45 days and analysed growth, haematological and serum biochemical parameters. Specific growth rate, total erythrocytes, haemoglobin, total leucocytes, total serum protein, glucose, cholesterol, magnesium levels, serum amylase, alkaline phosphatase, SGOT, SGPT and GGT have increased in all herbal supplemented fishes (especially in *Z.officinale*) than control. Thus concluded that all the three herbs have immunostimulant potential and among the three herbs *Zingiberofficinale* is more potent.

Pratheepa and Sukumaran (2014) suggested that the plant *Euphorbia hirta* has the immunostimulant activity by stimulating both specific and non-specific immunity at higher concentration against *A. hydrophila* in *Cyprinus carpio*.

Aruldoss *et al.* (2014) investigated the effect of *Cynodon dactylon* on the haematological parameters in the blood of *Oreochromis mossambicus*. The study showed that the RBC count, WBC count, haemoglobin, haematocrit, MCH, MCHC was significantly increased in the treated fishes when compared to control fish.

Haghighi *et al.* (2014) evaluated the effects of *Aloe vera* extract (AE) on various parameters of non-specific immunity responses including respiratory burst activity, phagocytic activity of blood leukocytes, serum lysozyme activity, total plasma protein level and some haematological indices in rainbow trout, *Oncorhynchus mykiss* to develop alternative drug for the prevention or the treatment of diseases in aquaculture.

Suman *et al.*, 2015 examined the effect of *Basella alba* extract treated tilapia which showed higher ($P < 0.05$) weight gain, respiratory burst, phagocytic activity, plasma protein content and plasma lysozyme activity compared to fish fed control diet. The phagocytic and respiratory burst activities of genistein treated fish were significantly higher ($P < 0.05$) compared to the control group.

Narayanan *et al.*, 2016 experimented on the efficiency of aqueous and ethanol leaf extracts of *Psidium guajava* based experimental diets on growth, immune, antioxidant and disease resistance of *Oreochromis mossambicus* challenged with *Aeromonas hydrophila*. He observed a significant enhancement in the biochemical and immunological parameters of fish. The dietary supplementation of *P. guajava* leaf extract powder for 30 days significantly reduced the mortality and increased the disease resistance of *O. mossambicus* following challenge with *A. hydrophila*.

Baba *et al.*, 2016 evaluated the use of *Avena sativa* extract against *Aeromonas hydrophila* and its effect on growth performance, hematological and immunological parameters in common carp (*Cyprinus carpio*). Lysozyme and myeloperoxidase activity, improved in all groups that received feed supplemented with oat extract. Serum glucose and cholesterol decreased while total protein and albumin in fish increased with the use of the diet supplement with oat extract. The hemoglobin level, MHC, MCHC increased in

the blood. They also showed significantly higher relative percentage survival when compared with the control against *A. hydrophila* injection.

Muthu *et al* (2018)studied the modulation of immune response in edible fish against *Aeromonas hydrophila*. The study revealed that the supplementation of *Aegle marmelos* fruit extract have increased WBC and RBC counts and decreased mortality in diseased induced *Catlacatla*.

Sanjana *et al.*, 2019 studied the effect of *Ocimumbasilicum* and *Phyllanthus emblica* on specific immune response of *Cirrhinusmrigala* infected with *Aeromonas hydrophila*. The fishes fed with 5% *Ocimumbasilicum* showed greater effect in terms of survival rate and at 10% it showed better antigen antibody titer.