

Importance of herbs in aquaculture; Cinnamon a potent enhancer of growth and immunity in fish, *Ctenopharyngodon idella*

F. Ghafoor*

Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad, Pakistan

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Abstract

Aquaculture practices always strive for the betterment of human lives and for providing cheaper resources for fish production. As fish is the most common food source all over the world, its sustainable production is very important. The use of herbs provides a cheaper way towards the progress of aquaculture. Herbs are used in place of expensive chemicals and growth enhancers. Like others, cinnamon is also a good alternate for growth chemicals. Cinnamon is an aggregate of many related species with different names depending on the environmental conditions of different landmasses. Cinnamon contains many compounds and chemicals which are important for fish growth. Cinnamon when added to fish feed makes the fish fight against stress and grow healthy than before. Cinnamaldehydes, polyphenols, carbohydrates, flavonoids, etc., boost up the immune system of fish and act as an important antioxidant and antibiotic. It fastens the growth rate of fish and enhances the other growth and blood parameters as compared to other aquaculture systems using chemicals.

***Correspondence** F. Ghafoor, University of Agriculture, Faisalabad, Pakistan (e-mail: filzaghafloorjutt111@gmail.com).

Moreover, the use of cinnamon as a growth and immunity promotor is cheap and environmentally friendly compared to other synthetic antibiotics.

Keywords: antibiotic, herb, Cinnamon, Fish, immunity, growth

Introduction

Aquaculture is mostly regarded as the farming or cultivation of aquatic organisms including fish, crustaceans, mollusks, aquatic plants, algae, and many other aquatic organisms (Ferreira, 2007). In aquaculture freshwater and saltwater, populations are reared under perfectly controlled conditions to assure better possibilities for future food production (Hepburn, 2015). Aquaculture is very different from commercial fishing in the respect that it covers a broad range of aquatic organisms. Commercial fishing on the other hand is the rearing of wild fish for food. In aquaculture farming, the rearing processes are somehow changed and modified to increase production (Jhingran, 1987). There are many kinds of aquaculture. Fish farming, oyster farming, shrimp farming, mariculture,

algaculture i.e. seaweed farming, and cultivation of ornamental fish but most of the time the ornamental fish cultivation is not considered in aquaculture (Bengtson, 2003).

The feed is the most important survival need of all organisms, but balanced diet is vital as well. The proper balanced diet should correlate the quantity of feed with its quality. The inexpensive and easy-accessible feed is the basic requirement of any living system. Aquaculture costs are about 40%-50% of the production costs (Rahmawati and Ubaidillah, 2017).

Fish is the cheapest dietary protein source. More than half of the total world population rely on fish as its sole dietary protein source (Ghafoor *et al.*, 2020). For fish to exhibit greater genetic capacity for growth, survival, and reproduction, nutrition is the most crucial factor (Handayani and Widodo, 2010). In the fast and expensive world, there should be another way available for poor farmers to carry out their business and make some profit. Feed additives are minute amounts of some substances for enhancement of growth performance, survival rate and reproduction of the fish stock. The enhancement of growth and quality parameters is the major goal of aquaculture. The living feed additives include the use of probiotics, plants and algae in fish feed. The plant additives can be in the form of leaves, extracts, oils etc. (Ogunkalu, 2019).

Ctenopharyngodon idella, is one of the widely cultured Chinese carp. In 1963, it was introduced in Europe as a biological control agent for aquatic plants there as a cheaper alternate for pond maintenance. Grass carp is

an herbivorous fish which can utilize plant proteins and other compounds to produce top-notch quality meat (Kristan *et al.*, 2018).

The major producers of grass carp are many, but China is top of the list with Bangladesh, Iran, Taiwan and Russian federation as the other producers. Grass carp account for 11% of the world aquaculture production (FAO, 2016). Grass carp is widely found in Pakistan in slow running and standing waters. More than 186 fish species are found from the water bodies of Pakistan. The inland fisheries account for 30 species of high economic value, *Ctenopharyngodon idella* is one of them. Grass carp is one of the exotic fishes introduced in Pakistan in last four decades. Exotic Carps are present abundantly in three provinces in Pakistan viz Sindh, K.P.K and Punjab (Khan *et al.*, 2008).

Carp species are eminent all over the world for their fast growth, good performance, high feed conversion ratio, easy cultivation, convenient harvesting and high nutritional value. Grass carp (*C. idella*) is one of the most important carp species from the economic point of view in the subcontinent (Lin *et al.*, 2012). Its contribution is 35% of total carp production in the subcontinent. Due to its taste and good profile of protein and fatty acid, it is of immense importance for human health (Brozova, 2005).

Grass carp (*C. idella*) is tropical fish natural to Chinese freshwater (Du *et al.*, 2006). *C. idella* is primarily herbivorous that feed on naturally occurring aquatic weeds. The fish flourishes very well on intensive or semi-intensive conditions. Also, the fish meat is

responsible for various type of foodstuff for human use. Grass carp a mid-lower layer water column fish. It reaches to extreme length of 2.0m with weight of 45kg at an expected age of 9 years. Grass carp has an average length of 50-70 mm. It is specie of estuary and fresh water. It desires to live in standing water and rivers where adequate vegetation is present (Able and Curran, 2008).

As, the ingredients of the fish meal primarily are the fish products, the dire need of the hour is to get less expensive and much nutritious products. Therefore, expansion of aquaculture emphasis to find out alternative of fish meal for aquafeeds because of its increasing demand, less availability and high price. Plant sources, being effective alternative to the fish meal, are good source of energy and protein, are helpful for the formulation of cost-effective and ecofriendly aquaculture feeds (Hardy, 2010).

The world health organization is promoting the usage of remedial replace or lessens chemical use in aquaculture. (Levic *et al.*, 2008). Immunostimulants, the products to improve feed's nutritional value, can increase specific and non-specific immunity by increasing the resistance for disease (Chakrabarti and Rao, 2006). These immunostimulants produce more fighting bodies against infectious agents by activating the innate defense system resulting in production of anti-microbial particles (Setiawati *et al.*, 2015).

There is a whole market of different feed ingredients of plants and animal sources which claim to enhance the performance of fish

growth. In the process of feed preparation, some chemicals such as antibiotics and hormones are must (Gunawardena *et al.*, 2015). But they cause certain negative side effects. Therefore, the use of chemicals is strongly sentenced at every level to promote the use of herbs or medicinal plants (Cabuk *et al.*, 2003). Because, these agents increase fish immunity and impart less-dangerous impacts on its health and alternatively the human (Baruah *et al.*, 2008).

Growth-stimulants, products of herbs and medicinal plants, are recyclable, low in cost, biodegradable and harmless for environment (Noga, 2011). Supplemented feed is source of essential nutrients for fish that are mandatory for growth, survival, proper functioning and for obtaining other ingredients (Civitello, 2011). Remedial plants or probiotics which are used in feed can increase growth rate and activate the other non-specific immunity functions of fish (Ahmad *et al.*, 2011).

Cinnamomum verum is a notable member of family Lauracea. This species is known for its remedial property, and also for defence effects against various stress conditions (Becerril *et al.*, 2007). Approximately, 49.9% of cinnamon bark is cinnamaldehyde (Wong *et al.*, 2014). Active concentration of cinnamaldehyde may be different in different species based on the environment as well the form used; powder or essential oil (Afifi *et al.*, 2009). Cinnamon also contains bioactive molecules like essential oil, tannins, polyphenol, carbohydrates and flavonoids (Gruenwald *et al.*, 2010).

Effect of cinnamon on fish blood parameters in lipid metabolism is limited. It is reported that dietary cinnamon supplementation increases metabolism and blood circulation (Kucukbay *et al.*, 2006). *Cinnamomum verum* is also used as taste-enhancer in meal. It has wide medicinal properties and is used widely in Chinese traditional medicine (Brahmachari *et al.*, 2009). It also shows anti-bacterial, diuretic, anthelmintic and anti-bacterial effects in human and other animals such as fish (Jakhetia *et al.*, 2010). Moreover, it is also an antioxidant (Shan *et al.*, 2009), antimicrobial and anti-inflammatory in nature (Lee *et al.*, 2005; Matan *et al.*, 2006). Oil obtained from cinnamon contains cinnamaldehyde which is under investigation for its effects for human diseases. These diseases include cancer and dyspepsia (Kwon *et al.*, 1996).

It is an attractive way to improve feeding, health, productivity and growth performance of a fish by using herbal medicines. Herbal medicines like cinnamon enhance feed quality and impart a therapeutic impact on the fish population (NRC, 2011). These are cost-effective too and are imperative to be used in fisheries sustainable fish production and ecologically friendly aquaculture. *Cinnamomum zeylanicum* is a well-known herbal spice in human society since ancient times as it is remedy of many diseases (Nugroho, 2016).

As far as nano-particle form of cinnamon is concerned, it also exhibits variety of improvements in fish system. The ability of nanoparticles to remain in blood stream of fish

for a greater period make these particles readily available for fish use for longer time span. Nano particles are thought to be beneficial in improving the feed characteristics. These enhanced feed characteristics in turn account for enhanced fish performance, improved health and better immunity (Abdel-Tawwab *et al.*, 2018).

Cinnamon is abundant in polyphenols and cinnamaldehyde which are essential for the improvement in blood glucose metabolism and breakdown of fatty acids (Khan *et al.*, 2016). High density lipoproteins level was also enhanced by the bioactive compounds present in cinnamon leading to lowering of cholesterol and triglycerides level. Prominently, polyphenols are a source of mimetic insulin which activate and stimulate glucose metabolism. Cinnamaldehyde shows antioxidant activity and provokes the activation of IGF (insulin-like growth factor) which accelerates the protein and collagen biosynthesis, thereby increasing the protein deposition in the body to build strong muscles (Setiawati *et al.*, 2016).

Growth rate and survival rate as well as immunity can be improved by addition of medicinal plants to fish feed. Flavour and storage ability of feed is also improved with added spices. Cinnamon leaf extract, cinnamon bark oil and cinnamon powder is known for significant increase in energy utilization, PER, SGR, APU, FCR, PER, FER and protein retention in fish. Cinnamon exhibits various biological activities i.e. antioxidant, antiallergic, antidiabetic and antimicrobial (Begum *et al.*, 2018).

Cinnamon in fish farming

Some important literature regarding the use of cinnamon as a feed additive in different fish species given by various scientists is as under.

Kanghear *et al.* (2005) reported the improved immunity and growth performance in sex-reversed tilapia by administration of bark oil of cinnamon *Cinnamomum zeylanicum*. When the bark oil extract was analyzed by mass spectrometer as well as by gas chromatography, it showed to be composed of cinnamaldehyde C_9H_8O (83.1%), coumarin $C_9H_6O_2$ (12.6%) and also cinnamic acid $C_9H_8O_2$ (2.2%). The cinnamon diet was given to tilapia for 8 weeks. Four diet concentrations were formulated that show 0 ppm, 250 ppm, 500 ppm, and 1000 ppm of the leaves extract. Different diet concentration groups showed different enhancements of qualities as; best feed conversion ratio was observed in 250 ppm group. Fish fed with 250 ppm also showed the most stimulated immunity responses as compared to other groups. But on the other hand, the higher concentrations of 1000 ppm caused atrophy and degenerations in cells leading to abnormal hepatic cells.

Ahmad *et al.* (2011) studied the enhanced growth performance, feed utilization, immunity and body composition in Nile tilapia from cinnamon feed. Four experimental diets were prepared containing 0.5%, 1% and 1.5% cinnamon and one with no added cinnamon. The diet with 1.0% cinnamon showed improved growth parameters like feed efficiency ratio, energy utilization, apparent

protein utilization, SGR, protein efficacy rate and feed conversion rate. Whole-body composition was not as affected by any of the experimental diets. Blood parameters were also improved by cinnamon supplementation. The diet containing 1% cinnamon enhanced hemoglobin, total lipid, RBCs, total protein and hematocrit level and alleviated level of creatinine, AST, ALT and glucose. 1% cinnamon supplemented diet also reduced feed cost by 10% and resulted in FCR improvement.

Roozy *et al.* (2013) determined the effect of cinnamon powder on growth, blood glucose and survival rate of green terror *Andinocara rivulatus*. It was seen that diet quality affected the growth performance, disease resistance capability and costs of feed production in aquaculture. Cinnamon was used for fewer harmful effects on fish growth and survival. The effect of cinnamon on growth and blood parameters was the main purpose of the study. 180 fish were gathered in 15 tanks and fed cinnamon powder supplemented feed for 98 days. The average weight was 1g and the initial length of fish was 38 mm. The experiment consisted of 5 treatments in three replicates each. Experimental diets included control, 0.1%, 0.2%, 0.3% and 1% cinnamon powder supplemented in fish feed. The survival rate and blood parameters were determined. There was an observable difference in blood contents of control and 1% cinnamon group fish in WBCs and blood glucose. It was concluded that fish fed with 1% cinnamon showed significant growth than all others.

Setiawati *et al.* (2014) reported the effect of cinnamon leaves supplementation in the diet of patin i.e. *Pangasius hypophthalmus* on nutrient value and growth performance. Fish with 7.2g initial average weight were selected for an experiment with four treatments in three replicates. Fish were fed with 0%, 0.5%, 1% and 1.5% cinnamon leaf in feed for a period of 30 days. Fish density per aquarium of 50 x 40 x 35 cm was 10 fish/aquarium. It was observed that SGR, feed consumption and survival rate of fish were independent of increasing levels of cinnamon leaves. However, there was significant increase in feed digestibility and feed efficiency as compared to control.

Setiawati *et al.* (2015) reported the role of cinnamon in enhanced growth performance and improved meat quality of striped catfish at different feeding periods. 20 fish with 21g average weight were selected for the experiment. *Cinnamomum burmanni* leaves at levels 0%, 0.5%, 1% and 1.5% were given to catfish for 60 days. Fish were fed three times a day to satiation. It was observed that there was no prominent difference between fish fed at 0, 0.5 or 1% cinnamon level. But these three levels showed a higher growth rate than cinnamon 1.5% level. However, from the 41st day the growth decreased significantly than control group. It was concluded that fish grew best at 0.5% cinnamon feed supplementation for higher growth rate, better meat quality, good texture, high protein content of meat and improved feed efficiency.

Rolin *et al.* (2015) reported the enhanced growth performance of *P.hypophthalmus* *sauvage* by the addition of *Cinnamomum*

burmannii leaves extract in fish diet. The extracts were given to fish in different doses to check the most appropriate dosage of *C.burmannii* leaves extract to be used in diet. The experiment consisted of five treatments in three replications each. The laves extract was added to diet at the dose of 0.5 gm/kg, 1 gm/kg, 2 gm/kg and 4 gm/kg of diet. Catfish were reared in glass aquaria, 160 liters volume each, and the fish count was 30 fish per aquarium for a period of 60 days. The maximum protein retention and feed efficacy was observed when 1 g/kg diet of cinnamon leaves extract was administered.

El-Houseiny *et al.* (2015) examine the effect of cinnamon and oxytetracycline supplemented feed on performance, immunity and pathology of *Ctenopharyngodon idella*. Cinnamon and oxytetracycline were added in diet as a control strategy against infections and diseases. The experiment consisted of 90 *Ctenopharyngodon idella* with two treatments in three replicates. The initial average weight of fish was 24.5g. The treatments consisted of 0.5% cinnamon and 0.5% oxytetracycline levels. The experiment was carried out for 2 months and a 15-day post-observation period. The results showed that 0.5% cinnamon level was responsible for enhanced growth, improved final body weight, increased immunity and good body gain %age in comparison with oxytetracycline level.

Setiawati *et al.* (2016) reported the comparison of diet containing cinnamon leaf powder and cinnamon leaf extract. Floating cages were used to rear catfish for 60 days. *Pangasianodon hypophthalmus* cages were fed

diet supplemented with either cinnamon leaf powder or extract at different doses. The administered doses were 0% leaf extract, 0.1% leaf extract along with 1% leaf powder. Fish were fed the supplemented diet two times a day and at the rate of 3% of average body weight. Both the supplemented feed increased the growth performance of fish and feed efficacy as well as the protein retention rate as compare to the control group. After 60 days, the fish blood was also analyzed which showed the significant increase in HDL by 41% and decrease in liver fat by 38% in fish fed with leaf extract of cinnamon. It was found that 0.1% leaf extract level and 1% leaf powder level was effective in enhancement of growth performance.

Dos Santos *et al.* (2016) investigated the effect of dietary supplementation with cinnamon leaves on growth performance and strength mechanism of Nile tilapia. Cinnamon essential oil and powder were added to diet. Total 330 male tilapia stocked with average body weight 66.08 g in aquaria with capacity of 100 liters each. Fishes were fed two times a day for 70 days with diets containing cinnamon powder at different levels 0.05%, 0.1%, 0.15%, 0.2% of cinnamon oil with three replicates. After the trial period, fish were tested for growth performance and strength. Fish were stressed and blood sample of fish were collected for glucose, cortisol, hematocrit, and lysozyme activity. A cinnamon diet supplemented level 0.5% and 0.15% increased fish growth performance and immune response.

Dedi *et al.* (2016) examined the improved growth performance and enhanced flesh

quality of *Cyprinus carpio* by supplementing the fish feed with cinnamon leaf. The experiment contained four treatments in three replicates. The experimental supplemental diet showed 0 %, 0.25%, 0.5% and 1% cinnamon respectively. The initial body weight of fish was recorded as 7.9 ± 1.41 g. Each aquarium was the size of 50x40x35cm with ten fish. It was observed that the diet supplemented with all levels of cinnamon were insignificant for fish growth and survival values. But a reduction in feed efficiency was observed with supplemental diet. The lipid content was decreased with cinnamon. Also, the flesh quality and texture were seemed affected. As the feed supplementation with cinnamon level was increased, the flesh showed more compactness as well as sweetness. It was concluded that cinnamon was helpful in improvement of fish flesh.

Al-Ashaab *et al.* (2017) reported the effect of cinnamon and anise on growth performance and physiological parameters of indicia and common carp. The experiment consisted of nine treatments in two replicates. For this purpose, 18 sixty-liter capacity aquariums were used with 5 fish each. The dimensions of aquarium were 60cm × 30cm × 30cm. 90 fish were distributed in aquarium. The nine experimental treatments included control, 5% anise, 1% cinnamon, 5% anise + 1% cinnamon, 2.5% anise, 2.5% cinnamon, 5% anise + 2.5% cinnamon, 2.5% anise + 1% cinnamon and 2.5% anise + 2.5% cinnamon. The results showed that 1% cinnamon and 2.5% anise + 1% cinnamon were most significant in terms of weight gain, specific

growth rate, relative growth rate and white blood cell content. Red blood cell level was not affected at all. PCV% was highest for increased levels of anise. Hemoglobin content was enhanced in 2.5% anise level. It was suggested that 1% cinnamon and 2.5% anise +1% cinnamon was best for enhanced growth rate and physiological characters of common carp.

Amiri and Bahrekazemi (2017) evaluated the comparative effect of cinnamon, quail-A and levamisole on growth and hematological parameters of marmalade cichlid fish. Fish were divided into four groups; one control and other three containing 0.2% levamisole, 1% cinnamon and 0.5% quail-A for a period of 60 days. The highest fish weight gain was recorded in levamisole group but at the same time levamisole resulted in lowest FCR in comparison with other groups. The cinnamon supplemented feed showed the greater number of WBCs production as compared to control or other treatments. Cinnamon treatment showed the highest level of neutrophils and lymphocytes which are the representatives of immune system.

Rahmawati and Ubaidillah (2017) evaluated the growth rate and survival of *Oreochromis nilotica* by supplementation of diet with cinnamon leaves. The effect of different doses was estimated to check the maximum growth performance of tilapia. Twelve aquaria were used for the experiment in a 30-day feeding trial. Fish were randomly selected and introduced randomly to the water aquaria following the complete randomized design with three treatments in three

replications. The treatment comprised of different levels of cinnamon leaves supplemented at 0%, 0.25% 0.5% and 1% levels. After the trial period it was seen that survival rate was 100% in all treatments, but the 0.25% level showed the most significant growth rate and feed conversion rate enhancement.

Asghar (2017) evaluated the changes in blood parameters and histological properties of *Catla catla* on administration of *Cinnamomum zeylancium* and microelement selenium. The fish were exposed to zinc oxide nanoparticles stress. The trial consisted of a control group with stress factor but no added cinnamon and selenium and, an experimental group with administered cinnamon and selenium in presence of zinc oxide. The initial average weight and length of fish were 55g and 25cm, respectively. Fish were fed with cinnamon and selenium supplemented diet for a period of 28 days. Six experimental treatments with five replicates each were 0 mg/L, 10 mg/L, 20 mg/L, 40 mg/L, 60 mg/L and 80mg/L of ZnO nanoparticles. Blood and tissue were sampled every 7 days. The results showed a significant difference between cinnamon +selenium supplementation and control group. With increasing levels of ZnO the RBCs level also increased. Other blood parameters were also different for both groups. Moreover, the oxidative anxiety caused by zinc oxide was ameliorated by cinnamon and selenium because of phenolic and flavonoid contents.

Abdel-Tawwab *et al.* (2018) reported the effect of Nanoparticles of cinnamon CNP in the enhancement of growth performance,

native immunity and enzyme activity concerning *C. idella*. CNP enriched diet was given to fish in and order of 0.0 g to 10 g CNP/kg in different concentration treatment. Trial was carried out for 8 weeks and fish were different feeds two times a day. The experimental treatments were 0 g/kg, 0.25 g/kg, 0.5 g/kg, 1 g/kg, 3 g/kg, 5 g/kg and the last 10 g/kg. It was observed that with increasing levels of cinnamon nanoparticles, the growth, performance, survival and immunity increased as compared to control group. Crude protein content was also elevated in CNP group than the control group. Further CNP application was responsible for and increased immunity to infections against *Aeromonas hydrophila* which caused high mortality in control group. It was assumed that the CNP/kg concentration of 3.0-10 gram CNP/kg was effective in inducing immune system and improving growth performance of fish.

Stoyanova *et al.* (2018) assessed the accelerating growth performance, enhanced feed conversion rate and survival rate of *Cyprinus carpio*, in a re-circulation system. There were two groups i.e. experimental and control group comprising of two replications of eight fish per group. The average weight of carp in control group was recorded 866g and likewise, in experimental group was 869g. The average weight gain was higher by 18.98% for experimental group supplemented with cinnamon diet as compared to control group with no added cinnamon. The economic efficiency coefficient was also higher by 4.61% in experimental group as compared to control.

Kristan *et al.* (2018) reported the comparative growth rate and survival rates of juvenile *C. idella* in ponds and recirculation chambers for the overwintering period. The study also estimated the production economics of grass carp. *C. idella* fingerlings were distributed randomly in three ponds of 1500m² each and five RAS connected tanks 350L each. Fish were observed for 165 days, after which the survival and growth of fish were measured in both systems. RAS group showed 97.8% survival rate as compared to pond system with 10.9% survival rate. Also, the profit rate was higher in RAS system.

Begum *et al.* (2018) reported the improvement in growth performance by cinnamon supplementation of fish feed in Bloch. The study period was 3 months and fries were stocked at the rate of 20 fry per 60-liter aquarium each. Cinnamon bark powder was used in proportions of 0%, 0.5% and 1% of commercial fish feed. The diet containing 1% cinnamon bark powder showed improved and enhanced growth and survival rate. SGR, ADG and FCR were greater. The low feed conversion ratio was seen in 0.5% supplemented diet. Also, 1% of the supplemented diet showed greater immunity than other diets. It was recommended that cinnamon should be used to maintain a good growth and enhanced immunity of fish culture.

Dairun *et al.* (2018) examined the cinnamon leaves and shrimp head supplementation in the catfish feed. Growth performance was examined for a period of 60 days. Catfish feed was supplemented with cinnamon leaf flour and shrimp head

contents. Fish with initial weight of 207 g/fish were gathered in 12 cages with dimensions of 2×1×1.5 m³. Density of fish was 15/cage. The four experimental diets included a control group, 1% inclusion with cinnamon leaf flour, 45% shrimp head protein source content and, a mixture of cinnamon leaf flour and shrimp head. Feeding was done two times a day at the rate of 3.5% of fish biomass in the cage. It was found that specific growth rate was increased with cinnamon leaf flour and shrimp head. The increase in SGR was 1.67-1.70%/day. Likewise, the feed efficiency was 57% and protein retention 55% as compared to control.

Kesbiç (2019) examined the cinnamon oil *Cinnamomum verum* effects on enhanced growth performance, survival and blood parameters of *Oncorhynchus mykiss* (rainbow trout). The experiment was based on five treatments in 3 replicates. The diets were control with 0 mL/kg oil, 1 mL/kg, 2 mL/kg, 4 mL/kg and 10 mL/kg levels of cinnamon oil in feed. The weight of trout used was 1068g and fish were kept in 100 L aquaria for a period of 60 days. A significant increase in growth and feed utilization was observed in cinnamon oil group as compared to control group. It was examined that cinnamon oil imparted beneficial effect on enhanced RBCs, Hb amount and hematocrit ratio. Moreover, serum glucose level was also observed to decrease because of increased cinnamon oil level. It was concluded that cinnamon oil in 4 mL/kg concentration imparted positive effects on growth performance and blood parameters of rainbow trout.

Altinterim *et al.* (2018) examined the effects of common yarrow, *Cinnamomum zeylanicum*, and rosemary on growth, immunity and blood parameters of common carp *Cyprinus carpio*. The experiment was designed to accommodate 200 common carps for investigation in three replicates. The average initial weight and length of fish was 54g and 15cm, respectively. The trial consisted of 10% common yarrow, 0.5% cinnamon and 5% rosemary hydrosols. The hydrosols were used as a pond or bath agent for fish. Fish were examined on 7th, 14th and 21st day of experimental exposure period. Various blood parameters like RBCs, WBCs, platelets, HCT, Hb, MCH, MCHC and MCV were examined at the end. The control group showed decreased levels of blood contents as compared to experimental group. MCHC level was not affected at all in both groups. Experimental also showed enhanced immunity against pathogens. It was suggested that hydrosols were affected in enhancement of growth, improvement of resistance against diseases and strong defense system with improved blood parameters.

Conclusion

As fish production is directly related to development of a country, feeding innovation should have experimented with different feed ingredients. Cinnamon is helpful in improvement of growth and immunological parameters as compared to expensive and pollution-causing chemicals. Natural herbs are safe for environment and are ecosystem friendly. These can be used without

environmental hazards. Moreover, cinnamon is responsible for production of many expensive substances in fish body. Grass carps are widely used for eradication of excess vegetation in the ponds so their production must be enhanced too. It can provide easy alternate to farmers who wish to maximize their profit. Of all the concentrations of cinnamon presented in literature, 0.5% of cinnamon per 100% feed is recommended for best growth enhancement and immunity system improvement of grass carp.

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