# Evaluating the effect of using turmeric (*Curcuma longa*) on growth performance and hematological parameters of the ornamental fish, Green Terror (*Andinocara rivulatus*)

**Mooraki N.[1*]; Batmany Y.[1]; Zoriehzahra S.J.[2]; Kakoolaki Sh.[2]**

Received: June 2018 Accepted: October 2018

**Abstract**

Shape and size of the body, color's beauty and its healthy condition are among the main factors for selling of ornamental fish in the market. Researchers have tended to use herbal additives as growth promoter and immune stimulator agents. The aim of this study is to evaluate the effects of turmeric powder (*Curcuma longa*) as a dietary supplement for the ornamental fish Green Terror (*Andinocara rivulatus*) on growth and feed performance, survival rate, and hematologic parameters. In this regard, 144 specimens with average weight of 1.53±0.22 (g) were obtained and the hypotheses were studied with four iso-caloric and iso-nitrogenous diets containing 0.1, 0.2 and 0.3 percent of turmeric powder, formulated with Win feed 2.8 software. Along the period of 100 days, the fish were biometry every 20 days, and at the end of the trial, blood examination test was performed. Results showed that the fish fed with diet contains 0.3% turmeric powder ($T_3$) had better growth performance, FCR, condition factor and survival rate specification, but no significant differences observed between the treated and control groups ($p$>0.05). RBC, PCV, hemoglobin, MCHC were increased not significantly ($p$>0.05), whereas WBC increased significantly in $T_3$ compare to the other groups ($p$<0.05). MCH and MCV were decreased non-significant in groups fed by supplemented diets compare to the control group ($p$>0.05). Applying turmeric powder at the level of 0.3 percent of the basal diet could not alter the growth indices significantly but could altered the hematological parameters with emphasis on WBC.

**Keywords:** Green Terror fish (*Andinocara rivulatus*), Turmeric (*Curcuma longa*), Growth performance, Hematology indices, Herbal additives

1-Department of Fisheries Science, College of Marine Science and Technology, North Tehran Branch, Islamic Azad University (IAU), Tehran, Iran.

2-Iranian Fisheries Science Research Institute, Agricultural Research and Education Organization, Tehran, IRAN

*Corresponding author's Email: n_mooraki@iau-tnb.ac.ir



[ DOI: 10.18331/SFS2019.5.2.5 ]

## Introduction

The importance of ornamental fish trade is based on producing healthy, appealing specimens in a given period of time. In this regard, as it has been proved for cultivating food fish species, specific attention should be paid to feed formulation and nutritional aspects of ornamental fish in order to reduce the feed conversion ratio, increase growth performance and survival rate and also producing attractive colorful fish, in which all the factors will ultimately affect the economic aspects; consequently, many research projects have been conducted concerning the nutritional requirements, evaluating the possibility of applying herbal and microbial additives; among which herbal additives has a special importance in feed formulation. Turmeric (*Curcuma longa*) belongs to Zingiberaceae family, possessed rhizomes, which been used as an additive with pharmaceutical characteristics and widely distributed in warm areas of Asia (i.e. India, Pakistan, Indonesia, southern part of China), Africa, and south America. It has been extensively exported from India, Indonesia and China. The turmeric powder contains of 6.3% protein, 5.1 % lipid, 3.5% mineral, 69.4% carbohydrate, 13.1% moisture and 5% curcuminoids, 50-60% of which are a mixture of curcumin (diferuloylmethane), monodesmethoxy curcumin and bis desmethoxy curcumin (Chattopadhyay *et al*., 2004; Innocent, 2008; Sivagurunatan *et al.,* 2011). The anti-inflammatory, cholesterol reducing, and anti-oxidation characteristics of Turmeric have been reported by Chattopadhyay *et al*. (2004). Moreover, the anti–carcinoma and antibacterial and antifungal functions of this herbal additive have been expressed through previous researches (Banerjee *and* Nigam 1987; Apisariyakul *et al*., 1995; Kumar *et al*., 2001). Turmeric affected liver and stimulates the secretion of bile, Lipase, Maltase, Amylase, Trypsin and also stimulates activity of the pancreas, and protecting the RBCs (Bhavani shankar *et al*., 1979; Platel and Srinivason 1996; Platel and Srinivason 2000; Srinivasan, 2005). The effect of Turmeric has been evaluated on Immune stimulatory response of fish *Labeo rohita* as an effective compound (Behera *et al*., 2011). Manju *et al*. (2011) Reported that curcumin had a protective effect on Bloch tissue and increase the growth performance. In this regard, the consumption of turmeric by fantail guppy (*Poecilia reticulate*) caused the reduction of FCR and improvement of growth performance (Mukherjee *et al*., 2009). Sand Goby (*Oxyeleotris marmoratus*) also showed a positive reaction to consumption of turmeric powder by an increment in Amylase, Lipase, Trypsin and Chemotrypsin secretions (Rojtinnakon *et al*., 2012). The effectiveness of turmeric powder on Immunity response of *Labeo rohita* to *Aeromonas hydrophila* and white shrimp (*Litopenaeus vannamei boone)* has been evaluated by Sahu *et al*. (2008), Vanichkul *et al*. (2010) and Lawhavinit *et al*. (2011), respectively. Moreover El-



[ DOI: 10.18331/SFS2019.5.2.5 ]

Bahr and Saad (2008) evaluate the effect of turmeric on hematological and immunological parameters of *Mugil cephalus* vaccinated with *Aeromans hydrophila* bacterin; this synergistic effect were also investigated on Japanese flounder (Ji *et al*., 2007) and Nile Tilapia fingerlings (El-Maksoud *et al*., 2002) fed by diet supplemented with turmeric.

The aim of the present study was to evaluate the effect of turmeric powder as an additive on the growth performance, feed conversion ratio, survival rate and the changes of hematological parameters of the fresh water ornamental fish, Green Terror with high demand in the market.

## Materials and methods

One hundred forty four specimens of Green Terror fingerlings with mean initial weights and lengths of 1.53±0.22 (g) and 42.9±1.43 mm, respectively were obtained from a local center of ornamental fish located in the studied area Tehran- Iran. The specimens transported by use of aerated plastic bags and being divided randomly equally into 12 aquarium (55×40×50cm) (12 fish in each aquarium). During the trial water temperature and dissolved oxygen controlled by use of a central heater and pump. To control the water quality, temperature, dissolved oxygen, ammonia, hardness and pH were measured daily (Table 1).

After 14 days of adaptation, the initial weight and length of fish were measured and the 12 aquariums were divided into four groups, including three Treatments and one control; each group introduced as three replicates. During the 100 days of cultivation, all groups were fed three times a day (6, 12, 18) based on two percent of their biomass. The turmeric powder was added to dry food, which being formulated by Win Feed 2.8 (Table 2), at levels of $T_1$ (% 0.1), $T_2$ (%0.2) and $T_3$ (%0.3) and C (%0) dry food. The turmeric powder added to the main mixture of the food with rest of additives and then the prepared dough was pelleted through a 1mm die of meat grinder and the pellets oven dried for 8 hours at 60°C, bagged separated and frozen at -20 C° until use. Proximate analyses of feed were determined following the method provided in AOAC (1995) (Table 3).

*Samplings*

For evaluating the growth and feeding performance of the specimens in the four groups, biometry was done once every 20 days during the 100 days of cultivation. The weight was measured by use of a digital balance (bearing 0. 01g) and the lengths were obtained by use of the caliper, after anesthetizing fish with MS222. Regards to the result of biometry the growth and feeding performance measured by calculating the below equations.

Weight gain (g/ fish$^{-1}$) = $W_F$ (g) -$W_I$ (g)

$W_F$ = Final mean body weight (g)

$W_I$ =Initial mean body weight (g)

Length gain (mm) = $L_F$ (mm) - $L_i$ (mm)

$L_F$ = Final mean body length (mm)

$L_I$ =Initial mean body length (mm)



[ DOI: 10.18331/SFS2019.5.2.5 ]

**Table1: Daily average of physic-chemical parameters of water during the cultivation period.**

| Hardness(mg/l$^{-1}$) | Ammonia(mg/l$^{-1}$) | pH | Dissolved oxygen(mg/l$^{-1}$) | Temperature (C°) |
|---|---|---|---|---|
| 193±2.5 | 0.02 | 6.5 ±0.5 | 7.3 ±0.5 | 27±1 |

**Table 2: Basic diet formulated by Win Feed 2.8, supplemented by different levels of turmeric powder.**

| Ingredients (%) \ Treatment | $T_1$ | $T_2$ | $T_3$ | C |
|---|---|---|---|---|
| Fish meal | 47.8 | 47.8 | 47.8 | 47.8 |
| Yeast powder | 11.1 | 11.1 | 11.1 | 11.1 |
| Wheat gluten | 8.8 | 8.8 | 8.8 | 8.8 |
| Wheat flour | 7.1 | 7.1 | 7.1 | 7.1 |
| Wheat bran | 6.5 | 6.5 | 6.5 | 6.5 |
| Dicalcium phosphate | 1 | 1 | 1 | 1 |
| Sunflower oil | 1.6 | 1.6 | 1.6 | 1.6 |
| Antioxidant | 0.1 | 0.1 | 0.1 | 0.1 |
| Binder | 5.8 | 5.8 | 5.8 | 5.8 |
| Mineral premix | 2 | 2 | 2 | 2 |
| Vitamin premix | 2.5 | 2.5 | 2.5 | 2.5 |
| Mild inhibitor | 0/6 | 0/6 | 0/6 | 0/6 |
| Astaxanthin | 3 | 3 | 3 | 3 |
| Dl- methionine | 1 | 1 | 1 | 1 |
| Lysine | 1 | 1 | 1 | 1 |
| Turmeric | 0.1 | 0.2 | 0.3 | 0 |

**Table 3: Approximate analyses of the basic diet used to feed (*Andinocara rivulatus*).**

| Properties (%) | Composition |
|---|---|
| Dry Matter | 93.24 |
| Protein | 44.01 |
| Lipid | 10.73 |
| Fiber | 2.63 |
| Ash | 9.17 |
| Carbohydrate Ca/ | 7.52 |
| Pratio | 1/2 |
| Energy | 340.25Kcal |

Body weight increase (%) = ($BW_F$ – $BW_I$) / $BW_I$ ×100

BWF = Final mean body weight

$BW_I$ = Initial mean body weight

Condition factor = $(\frac{W}{L^3})$ ×100

W= Weight (g)

L= Length (Cm)

Specific growth rate for Length (%days$^{-1}$) = (Ln $L_F$ – Ln $L_I$) / t ×100

t= the number of days in the feeding period

Specific growth rate for Weigh (%days$^{-1}$) = (Ln $w_F$ – Ln $w_I$) / t ×100

Feed conversation ratio (g/g$^{-1}$) =F/ ($W_I$ – $W_F$)

F= Feed intake

$W_F$ = Final mean body weight (g)

$W_I$ =Initial mean body weight (g)

Survival rate =Final number of fish individuals×100 /initial number



[ DOI: 10.18331/SFS2019.5.2.5 ]

Blood samples were taken at the end of the trial through anesthetized nine specimens randomly selected from each group by using MS222 and then dissecting the peduncles. Blood indices, i.e. MCH, MCHC, and MCV were calculated as bellow (FAO, 2003). Red and white blood cells diluted by using Natt and Herrick's stain solution and counted by use of Neubaur hemocytometer. Hemoglobin samples were used for measured by use of the spectrophotometer (Drobkin, 1945). Heparinized samples were used for measuring hematocrit.

MCV ($\mu m^3$) = [Hct/ RBC (million)] ×10

MCH (pg $cell^{-1}$) = [Hb/ RBC (million)]×10

MCHC (g $dl^{-1}$) = (Hb/ Hct) ×100

*Statistical analysis*

The obtained data with normal distribution analyzed through One- way ANOVA analysis and being compared through post hoc Bonferroni test at $p<0.05$ confidence.

## Results

*Growth and feeding performance*

Growth and feeding performance and survival rate of *Andinocara rivulatus* fed with different levels of turmeric powder presented in Table 4.

Among the treatments, fish consumed feed contain 0.2 and 0.3 percent turmeric powder showed a higher weight gain but not significantly different from the control group ($p>0.05$). In terms of length gain, condition factor, SGR the same trends were observed with no significant difference ($p>0.05$). The $T_2$ and $T_3$ also showed the best FCR among the other groups but did not show a significant different ($p>0.05$) (Table 4).

**Table 4: Growth performance of the reared *Andinocara rivulatus* after 100 days of consuming diets supplemented with turmeric powder.**

| Parameters \ Treatment | $T_1$ | $T_2$ | $T_3$ | C |
|---|---|---|---|---|
| Weight gain (g/ $fish^{-1}$) | 3.72±0.63[a] | 3.89±0.81[a] | 3.72±0.65[a] | 3.42±0.26[a] |
| Body weight increase (%) | 224.88±45.5[a] | 267.30±77.16[a] | 270.49±57.72[a] | 223.35±47.65[a] |
| Length gain (mm) | 2.16±0.73[a] | 2.30±0.65[a] | 2.55±0.22[a] | 2.01±18[a] |
| Condition factor (%) | 2.13±0.55[a] | 1.85±0.29[a] | 1.66±0.15[a] | 1.88±0.12[a] |
| Specific growth $rate_{(W)}$(%$days^{-1}$) | 1.18±0.15[a] | 1.29±0.20[a] | 1.30±0.15[a] | 1.16±0.15[a] |
| Specific growth $rate_{(L)}$(%$days^{-1}$) | 0.41±0.12[a] | 0.42±0.11[a] | 0.47±0.03[a] | 0.38±0.02[a] |
| Feed conversation ratio ($g/g^{-1}$) | 1.60±0.20[a] | 1.50±0.19[a] | 1.50±0.22[a] | 1.61±0.25[a] |
| Survival rate (%) | 91.66±8.34[a] | 91.66±8.34[a] | 88.88±4.81[a] | 88.88±4.81[a] |

$T_1$= diet supplemented with %0.1 turmeric powder, $T_2$= diet supplemented with %0.2 turmeric powder, $T_3$= diet supplemented with %0.3 turmeric powder and C= control group. Values are expressed as (means± standard deviation); significant differences ($p<0.05$) among the experimental groups are indicated by different superscript letters.



[ DOI: 10.18331/SFS2019.5.2.5 ]

*Hematological parameters*

Table 5 shows the hematological parameters belong to the four examined groups. As it is obvious, the highest counts of RBC was observed in fish fed diet contains % 0.3 ($T_3$) turmeric powder but did not have a significant difference with other groups ($p$>0.05). The same trend was also present for hematocrit, hemoglobin and MCHC, but the highest value for MCH was reported for the control group and $T_3$, respectively. Regards to the results the highest MCV value was observed in fish fed with control diet, $T_1$, and $T_2$ respectively with no significant difference between the four groups ($p$>0.05). The highest counts for WBC measured for $T_3$ which was significantly differ from $T_2$, $T_1$, and also control group ($p<0.05$).

**Table 5: Blood indices of the treated *Andinocara rivulatus* after 100 days of consuming diets supplemented with turmeric powder.**

| Treatment / parameters | $T_1$ | $T_2$ | $T_3$ | C |
|---|---|---|---|---|
| RBC ($10^6$ µL) | 1.78±0.37[a] | 1.88±0.18[a] | 1.97±0.09[a] | 1.69±0.16[a] |
| Hematocrit (%) | 19.42±0.75[a] | 17.85±1.42[a] | 19.59±1.02[a] | 18.98±1.80[a] |
| Hemoglobin(g/dL-$^{1}$) | 7.29±0.34[a] | 7.10±1.94[a] | 8±1.74[a] | 7.30±0.31[a] |
| MCHC((g $dL^{-1}$) | 37.53±0.40[a] | 37.30±7.69[a] | 40/61±6.67[a] | 38.59 ± 2.21[a] |
| MCH(pg $celL^{-1}$) | 41.82±6.17[a] | 37.35±7.14[a] | 40.40±6.86[a] | 43.37±3.06[a] |
| MCV(µ$m^3$) | 111.54±17.45[a] | 100.38±1.98[a] | 99.42±0.54[a] | 112.62±10.67[a] |
| WBC(103µL) | 12.82±1.63[b] | 13.60±1.43[b] | 15.60±2.57[a] | 9.82±1.35[c] |

$T_1$= diet supplemented with %0.1 turmeric powder, $T_2$= diet supplemented with %0.2 turmeric powder, $T_3$= diet supplemented with %0.3 turmeric powder and C= control group. Values are expressed as (means± standard deviation); significant differences ($p$<0.05) among the experimental groups are indicated by different superscript letters.

## Discussion

Regards to the results of the present study, the use of 0.3 percent turmeric powder as an herbal additive in the diet of Green Terrror has a relative positive effect on growth performance and FCR, however this positive effect was not verified significantly. The obtained results are in line with Mahmoud *et al.* (2014) which reported that turmeric supplementation (0.5%) did not significantly improve growth performance of *Oreochromis niloticus*, but significantly affected feed consumption ratio in treated fish. On the other hand FCR and SGR increased in *Labeo rohita* fingerlings fed different dosage of turmeric (0.1, 0.5, 1.0, and 5g/kg feed) for 60 days, reported by Sahu *et al.* (2008). El-Bahr and Saad (2008) applied a mixture of black cumin seed and turmeric as additives in the diet (5g $Kg^{-1}$ diet) of *Mugil cephalus* for six weeks, which results in growth improvement of the specimens; but applying the same mixture for Asian sea bass (*Lates calcarifer*) resulted in relatively weak promotion of growth performance, while the feed efficiency utilization remained unchanged (Abdelwahab and El-Bahr, 2012). Applying ethanolic extract of turmeric for nine weeks in feed of white shrimp did not affect FCR and SR significantly,



[ DOI: 10.18331/SFS2019.5.2.5 ]

but when the amount of ethanolic extraction increased to 15g Kg-1, the body weight gain of white shrimp was observed (Lawhavinit *et al.,* 2011).

Rojtinnakorn *et al*. (2012) investigated the effect of adding turmeric extract to the feed of sand Goby (*Oxyeletoris marmoratus*) on the activity of gastrointestinal enzymes, including Amylase, Lipase, Trypsin and Chymotrypsin. Sand Goby fries were fed by diets containing 0.03, 0.05, 0.1 and 0.5 percent turmeric powder for seven days equal to 3 percent of biomass. The results showed that 0.3 percent turmeric powder had a significant effect on the enzyme's increment, which was the baseline for dosage determination in the present study. Therefore, by enzyme increment, the food digestion and absorption will be improved. Moreover as it is said by Osawa *et al*. (1995) the antioxidant activity of turmeric could also stimulates protein synthetize through enzymatic systems. This is in accordance to Pransin (2006) who reported that goldfish fed turmeric supplemented diets, had highest acid protease, alkaline protease and lipase activity, enhanced growth rate and yellow pigmentation. In the present study the amount of enzymes did not consider, but it seems that applying turmeric powder can affect the quality and quantity of digested and absorbed feeds based on growth indices measurement. Mukherjee *et al*. (2009) investigated the effect of turmeric powder on growth performance and body color of guppy. In this study 0.03, 0.06, 0.09, 0.1 and 0.2 percent of turmeric powder were added to the basal diet, and the results revealed that fish fed with diet contain %0.09 turmeric powder had a better growth performance compared to other groups ($p$<0.05). Different amount of applied TP as an additive to the basal diets in various studies is related to species-specific expedience. Manju *et al*. (2011) investigated the protective effect of curcumin on the tissue of *Anabas testudineus*; in this study 0.5 and 1 percent of curcumin were added to diet contain 40 percent protein for duration of approximately three weeks. The analysis revealed that in long term duration, both concentrations (0.5 and 1 percent) caused a significant protein increment in the tissue, which ultimately result in better growth performance. The results verify the previous explanations that turmeric could affect the digestibility and absorption which ultimately affect the growth performance and carcass analysis. Lawhainit *et al*. (2011) evaluated the effect of turmeric concentration opposed to Vibrio disease in *Litopenaeus vannamei,* growth performance and immune system of the specimens were also traced. The results revealed that adding 7.5 and 15 g/kg of ethanol turmeric extract to the basal diet caused a better growth performance compared with other groups. It could be concluded that relative improvement of growth performance and reduction of FCR in *Andinocara rivulatus* fed with turmeric powder maybe due to the increment of enzymatic activities, including Amylase,



[ DOI: 10.18331/SFS2019.5.2.5 ]

Lipase, Trypsin and Chymotrypsin which may also result in protein concentration increment of the carcass. Further studies are needed to consider the effectiveness of turmeric powder as an additive with special reference to the duration of consumption, dosage, method of administration, along with identifying the best size of fish for being treated.

The results of evaluating the effect of adding turmeric powder to the diet of *Andinocara rivulatus* on hematological parameters revealed that RBC counted, hemoglobin density, hematocrit, MCV, MCH and MCHC did not altered significantly among the treatments, but the fish fed with 0.3 percent turmeric powder had a higher RBC counts, hemoglobin density and hematocrit compared with the control group but MCV index was lower than the control group. The reduction of MCV result to reduction of RBCs volume in blood vessel and reduce the possibility of blood coagulation. Moreover, the reduction of RBC volume is a sign of no inflammation, which all are positive changes in the physiology of the circulatory system (Jha *et al*., 2007). The increment of RBC counts, hemoglobin density and hematocrit maybe cause of an increment in circulatory system activity of fish which may have positive effect on growth performance of the treated specimens. Nevertheless, in the present study the amount of MCH and MCHC did not affect by turmeric consumption, regard to the increase of RBC count, hemoglobin density and hematocrit, the constant ratio of MCH and MCHC showed that treated fish were all healthy. In consistence with the obtained results, the increment of total erythrocyte count, hemoglobin, hematocrit, and MCHC were not significant compare to the control group of *Cirrhinus mrigala,* which did not fed by supplemented diet contain two grams of turmeric powder; moreover MCV was also decrease not significantly in treated groups compare to the control (Sivagurunathan *et al.,* 2011). The WBC count increased significantly in all treatments fed with diet containing turmeric compared with the control group. It seems that treated fish had a more potential to challenge with disease as WBCs are the main source of lysozyme synthesis and phagocytic activity. It is obvious that cellular and humoral immunity depends on WBCs; however, it should be mentioned that challenge with infectious disease does not depend only on leukocytes. Thus it could be mention that adding turmeric to the diet of *Andinocara rivulatus* causes a potent immune system compared to control group. Abdelwahab and El-Bahr (2012) were also reported that adding a mixture of cumin seed and turmeric to the diet of Asian sea bass (*Lates calcarifer*) did not affect hematological parameters. On the other hand Sahu *et al*. (2008) studied the effect of adding turmeric powder to the diet of *Labeo rohita* on enzymatic profile and immunological characteristics; specimens fed with diets containing 0.01, 0.05, 0.1 and 0.5 percent supplement for 60 days at a



[ DOI: 10.18331/SFS2019.5.2.5 ]

level of %4 biomass. The results revealed that many of the immunity activities, including lysozyme activity, producing anion superoxide were significantly higher compared to control group and the best result gain for the group fed with diet contains 0.1 percent turmeric. Vanichkul *et al*. (2010) were also shown that applying 0.0025 percent turmeric to diet of *Litopenaeus vannamei* increases the resistant against pathogenic Vibrio. Malar and Charles (2013) showed better resistance of *Penaeus monodon* against *V. harveyi* through feeding with diet containing turmeric extract (25 mg/kg feed). Furthermore Behera *et al*. (2011) determined that injecting 1.5 and 15, 150 µg curcumin to *Labeo vonito* with initial weight of 30-40 g after 7 to 42 days caused in potent activity of immune system. Moreover, El-Bahr and Saad (2008) showed that adding turmeric to diet of *Mugil cephalus* vaccinated with *Aeromonas hydrophila* could be positively affecting the hematological parameters.

As a conclusion the results of the present study reveal that applying turmeric powder at the level of 0.3 percent of the basal diet could not alter the growth indices significantly but through increasing white blood cells can develop and increase fish resistance toward disease and by reducing the amount of red blood cells (MCV) caused in quicker movement of blood, which prevents red blood cell sedimentation as well as blood coagulation. Considering the fact that various factors (i.e. duration of consumption, applied dose, method of administration, use of direct herbal additive or extracted form) affect the reaction of treated organism in general and particular aspects, this field demands further researches.

## Reference

**Abdelwahab, A.M. and El-Bahr, S.M., 2012.** Influence of Black Cumin Seeds (*Nigella sativa*) and Turmeric (*Curcuma longa Linn.*) Mixture on Performance and Serum Biochemistry of Asian Sea Bass, *Lates calcarifer*. *World Journal of Fish and Marine Sciences*, 4(**5**), 496-503.

**AOAC, 1995.** Official Methods of analysis, 16th ed. Arlington, VA, USA, AOAC International.

**Apisariyakul, A., Vanittanakom, N. and Buddhasukh, D., 1995.** Antifungal activity of turmeric oil extracted from *Curcuma longa* (Zingiberaceae). *Journal of Ethno pharmacology*, 49(**3**), 163-169.

**Banerjee, A. and Nigam, S.S., 1987.** Antimicrobial efficacy of the essential oil of *Curcuma longa. Indian Journal Medical Research*, 68, 864-866.

**Behera, T., Swain, P., Sahoo, S.K., Mohapatra, D. and Das, B.K., 2011.** Immuno-stimulatory effects of *Curcumin* in fish *Labero rohita* (H). *Indian Journal of Natural Products and Resources*, 2(**2**), 184- 188.

**Bhavani Shankar, T. N. and Sreenivasa Murthy, V., 1979.** Effect of turmeric (*Curcuma longa*) fractions on the growth of some



[ DOI: 10.18331/SFS2019.5.2.5 ]

intestinal and pathogenic bacteria in vitro, Indian Journal. *Experimental Biology*, 17, 1363- 1366.

**Chattopadhyay, I., Biswas, K., Bandypadhyay, U. and Banerjee, R., 2004.** Turmeric and curcumin: Biological actions medical applications. *Current Science*, 87, 1, 44-50.

**El-Bahr, S.M. and T.T. Saad, 2008.** Effect of Black cumin seeds (*Nigella sativa*) and/or Turmeric (*Curcumin*) on hematological, biochemical and immunological parameters of *Mugil cephalus* fish vaccinated with *Aeromonus hydrophila* bacterin, In the 13 Scientific Congress, Faculty of Veterinary Medicine, Assiut University, pp. 365-388.

**El-Maksoud, A.M.S., Hassouna M.M.E., Said, A.M.A. and El-Gendy, H., 2002.** The response of Nile Tilapia fingerlings to animal protein free diets supplemented with some free amino acids and some medicinal plants, In 1st Scientific Conference of the Egyptian Aquaculture society, Faculty of Environmental Agricultural Sciences, El-Arrish, North Sinai, Egypt, 13-15 Dec. 2002.

**Innocent, B., 2008.** Antimicrobial activity of Turmeric (Curcuma longa) in meat products. *Indian Journal of Multi discipline Research*, 4(**2**), 197-202.

**Jha, A.K., Pal, A.K., Sahu, N.P., Kumar, S. and Mukherjee, S.C., 2007.** Haemato-immunological responses to dietary yeast RNA, w-3fatty acid and β-carotene in *Catla catla* juveniles. *Fish and Shellfish Immunology*, 23, 917–927.

**Ji, S.C., Jeong, G.S., Gwang-Soon, I.M., Lee, S.W., Yoo, J.H. and Takii, K., 2007.** Dietary medicinal herbs improve growth performance, fatty acid utilization and stress recovery of Japanese flounder. *Fisheries Science*, 73, 70-76.

**Kumar, S., Narain, U., Tripathi, S. and Misra, K., 2001.** Synthesis of curcumin bio conjugates and study of their antibacterial activities against beta- lactam producing microorganism. *Bioconjugation Chemistry*, 12, 464- 469.

**Lawhavinti, O. R., Sineharoenpokai, P. and Sunthornandh, P., 2011.** Effect of ethanol Turmeric (*Curcuma longa linn*) extract against shrimp pathogenic vibrio spp. on growth performance and immune status of white shrimp (*Litopenaeus vannamei*). Kastesart. *Natural Science*, 45, 70- 77.

**Mahmoud, M.M.A., El-Lamie, M.M.M., Dessouki, A.A. and Yusuf, M., 2014.** Effect of Turmeric (*Curcuma longa*) Supplementation on Growth Performance, Feed Utilization, and Resistance of Nile tilapia (*Oreochromis niloticus*) to Pseudomonas fluorescence Challenge Global Research. *Journal of Fishery Science and Aquaculture*, 1(**12**), pp. 026-033

**Malar, H.L.V. and Charles, P.M., 2013.** Effect of Turmeric *Curcuma longa* Linn. Extract on immunity and resistance to *Vibrio harveyi* in black tiger shrimp *Penaeus monodon.*



[ DOI: 10.18331/SFS2019.5.2.5 ]

*International Journal of Research in Zoology*, 3(**2**), 21-26

**Manju, M., Akbarsha, M.A. and Oommen, O.V., 2011.** In vivo protective effect of dietary curcumin in fish *Anabas testudineus* (Bloch). *Fish Physiology Biochemistry,* 38(**2**), 309-318.

**Mukherjee, A., Mandal, B. and Banerjee, S. 2009.** Turmeric as a Carotenoid source on pigmentation and growth of fantail guppy (*Poecilia reticulata*). *Proceedings of the zoological Society,* 62(**2**), 119-123.

**Osawa, T., Sugiyama, Y., Inayoshi, M. and Kawakishi, S., 1995.** Antioxidative activity of tetrahydrocurcuminoids. *Bioscience Biotechnology Biochemistry*, 59, 1609-1612.

**Platel, K. and Srinivasan, K., 1996.** Influence of dietary spices or their active principles on digestive enzymes of small intestinal mucosa in rats. *International Journal Food Sciences and Nutrition*, 47(**1**), 55-59.

**Platel, K. and Srinivasan, K., 2000.** Influence of dietary spices or their active principles on digestive enzymes in albino rats. Nahrung, 44, 42-46.

**Pransin, M., 2006.** Using Turmeric (*Curcuma longa*) in Goldfish (*Carassius auratus*) Feed. Master of Science (Aquaculture), Major Aquaculture, Department of Aquaculture, Kasetsart University. 86 P.

**Rojtinnakorn, J., Rittiplang, S., Tongsiri, S. and Chaibu, P., 2012.** Turmeric extract inducing growth biomarker in Sand Goby (*Oxyeleotris marmoratus*). 2nd international conference on chemical, biological and environment sciences (ICCEBS'2012) June 30- July1, 41-43.

**Sahu S., Das B.K., Mishra B.K., Pradhan J., Samal S.K. and Sarangi, N., 2008.** Effect of dietary *Curcuma longa* on enzymatic and immunological profiles of rohu, *Labeo rohita* (Ham.), infected with *Aeromonas hydrophila*. *Aquaculture Research,* 39, 1720-1730.

**Sivagurunathan, A., Amila Meera, K. and Xavier Innocent, B., 2011.** Investigation of Immune-stimulant Potential of *Zingiber officinale* and *Curcuma longa* in *Cirrhinus mrigala* exposed to *P. aeruginosa*-Haematological Assessment. IJRAP. 2(**3**), 899-904.

**Srinivasan, K., 2005.** Role of spices beyond food flavoring: nutraceuticals with multiple health effects. *Food reviews international*, 21(**2**), 167-188.

**Vanichkul, K., Areechon, N., Kongkathip, N., Strisapoom, P. and Chuchird, N., 2010.** Immunological and bactericidal effect of Turmeric (*Curcuma longa linn*) Extract in pacific white shrimp (*Litppenaeus vannamei boon*). *Kasetsart journal* (Nat.sci), 44, 850-858.



[ DOI: 10.18331/SFS2019.5.2.5 ]