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RESEARCH ARTICLE

TURMERIC AND GINGER AS FEED ADDITIVE: AN OVERVIEW

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ABSTRACT

The main factor that determines the potential of farmed fish is their diet. The cost and quality of fish feed formulation are rising, necessitating further research on alternatives. As a result, additives need to be added to the fish meals. Medicinal herbs and extracts are widely employed in aquaculture and approved due to their anti-inflammatory, anti-oxidative, and growth-promoting qualities. Numerous bioactive components found in herbal essential oils have substantial antibacterial, antioxidant, and immunostimulant properties, which suggest that aquatic animals could benefit from their use. Essential oils can be given to aquatic animals through food, which will enhance their general health and well-being. Medicinal herbs play a major role in the global health systems for both humans and animals, and they are a possible source of medications and nutritional supplements. The purpose of this review is to present information on turmeric and ginger plants that are employed in fish production and health treatment.

INTRODUCTION

Herbs as feed additives play an important role in health and nutrition. Due to rise in antibiotic resistance and its negative impact on human health, there is a growing interest in using herbal feed additives in livestock production. Consumer pressure also exists to eliminate the use of all synthetic substances from animal diets. The rise of antibiotic resistance and its adverse impact on human health has sparked increased interest in herbal feed additives in livestock production. Vaccines are expensive and impractical for widespread use in fish farms, and there is a lack of single vaccine against multiple infections (Harikrishnan et al. 2011; Plant and LaPatra 2011). Therefore, the use of medicinal plants is one of the greatest strategies for boosting immunity of fish (Van Hai 2015) and could be an appropriate alternative to antibiotics (Abarike et al. 2018; Awad and Awaad 2017; Van Hai 2015). Owing to their diverse range of biomolecules, these plants may serve as substitutes for antibiotics and vaccinations, as they enhance immunity in a targeted or non-targeted manner, so fortifying the animal's defences against diseases and outside threats (Vallejos-Vidal et al. 2016). One can include entire plants or only their components, such leaves, roots, seeds, fruits, etc. According to Van Hai (2015), they can be utilised either fresh or as produced herbal extracts using a variety of solvents, including water, methanol, chloroform, ethyl acetate, etc. They have antimicrobial characteristics, the ability to boost growth, improve the immune system, stimulate appetite, and antistress and antipathogen effects in fish have all been extensively documented (Reverter et al. 2014; Van Hai 2015). They can serve as effective alternative to antibiotics, chemicals, vaccines, and other synthetic compounds due to the presence of active compounds such as alkaloid, terpenoid, phenolic, polyphenolic, quinone, lectin, and polypeptide compounds (Chakraborty and Hancz 2011 ; Harikrishnan et al. 2011). As a result, they're used in aquaculture as chemotherapeutics and feed supplements (Chang 2000).

Dügenci et al. (2003) and Yuan et al. (2007) found that fish treated with medicinal herbs had improved immunological parameters. In Nile tilapia (*Oreochromis niloticus*) fed withmistletoe (*Viscum album coloratum*) based diet for 80 days. Mistletoe fed fish had higher lysozyme, respiratory burst, alternative complement, and phagocytic activity, resulting in a 42 percent increase in survivability when challenged with the bacterial pathogen *Aeromonas hydrophila* (Park and Choi 2012). The use of medicinal plants to cure ectoparasites is also

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a viable option. Medicinal plants offer antiparasitic properties when added to water and taken orally, (Fu et al. 2014; Huang et al. 2013; Yi et al. 2012). The effects of pure garlic components allicin and ajoene in aquaculture have been researched, and their immunostimulant potential and efficiency against pathogenic fish parasites *Spironucleus vortens, Ichthyophthirius multifiliis,* and bacteria *A. hydrophila* have been demonstrated (Millet et al. 2011; Nya and Austin 2010 and Tanekhy and Fall 2015). Antiviral and antifungal properties of medicinal plants can help reduce excessive death rates in aquaculture. Several studies have demonstrated that plants like conidinium fruit (*Cnidium monnieri*), magnolia bark (*Magnolia officinalis*), aucklandia root (*Aucklandia lappa*), and common rue (*Ruta graveolens*) have antifungal properties in-vitro (Hashemi et al. 2012; Xue-Gang et al. 2013).

Turmeric plant, its distribution and composition -Turmeric (*Curcuma longa*) is a perennial subterranean herb in the ginger family Zingiberaceae that has been used as a medicinal herb since ages. Turmeric is a popular home cure for sore throats, fevers, and nausea. It has pointed leaves and funnel-shaped yellow flowers and grows up to 1 m height with a short stem and is primarily found in China, India, and Asia (Wickenberg et al. 2010). Curcumin, turmerone, curcuminoids, turmerone, arturmerone, and zingiberene are antioxidants present in turmeric (Ruby et al. 1995; Selvam et al 1995). Curcumin (75%), demethoxycurcumin (15%), bisdemethoxycurcumin (15%), and volatile oil (10%) are the main curcuminoids found in commercially available natural turmeric (Shehzad et al. 2013). Golding et al.1982 and Chowdhury et al 2008 documented that major compounds of turmeric oil include aromatic (ar)-turmerone (28%),α -turmerone (17%),β-turmerone, curlone (14%), 2-carene (5%), zingiberene (4.37%), sesquiphellandrene (6%), ar-curcumene (3%), and linoleic acid (5%). Wang et al. (2008) isolated a new quinoline alkaloid and seven known bisabolane sesquiterpenes: (1) 2-(2 -methyl-1 -propenyl)-4, 6-dimethyl7-hydroxyquinoline, (2) 2, 5-dihydroxybisabola-3, 10-diene, (3) 4, 5-dihydroxybisabola-2, 10-diene, (4) turmeronol A, (5) bisacurone, (6) bisacurone A, (7) bisacurone B, (8) bisacurone C, (9) dehydrozingerone, and (10) zingerone. The chemical composition of turmeric powder given by various authors has been shown in table 1

Table 1 Chemical composition of turmeric powder given by different scientists.

Item	Imoru et al. (2018)	Ikpeama et al. (2014)	Mane et al. (2018)
Moisture	8.92±0.02	8.91	84.25 ± 0.23
DM	91±0.01		
CF	4.60±0.01	4.87	0.72 ± 0.03
EE	4.60±0.01	6.64	1.08 ± 0.13
CP	9.40±0.02	10.07	1.20 ±0.07
Ash	2.85±0.02	2.76	0.66 ± 0.01
CHO	67.38±0.01	66.76	9.10 ± 0.10
Alkaloid	0.76±0.01	10.04 mg/g	
Saponin	0.45±0.00	1.36mg/g	
Tannin	1.08±0.02	1.87mg/g	
Sterol	0.03±0.01		
Hydrogen cyanide	0.82±0.00		
Flavenoid	0.40±0.01	0.68mg/g	
Phenol	0.08±0.03		
Ca	0.21±0.01	1.67ppm	
P	0.63±0.02	1.07ppm	

Mode of action of Turmeric

Jiang et al. (2019) studied effects of curcumin supplementation on blood biochemical parameters and testicular gene expressions in Hu sheep. They reported that supplementing a low-fat diet with 450 mg and 900 mg curcumin raised serum fatty acids, glutathione peroxidase, IgA, and IgM levels. It was suggested that curcumin supplementation in the diet can improve lipid metabolism, antioxidant capacity, immunological response, and testicular development in Hu sheep.

Konak and Sener (2019) reported curcumin's antioxidant effect on rat blood tissue. Curcumin's antioxidant impact was measured by oral gavage by maize oil at 300mg/kg/day. TAC (Total Antioxidant Capacity) and TOC (Total Oxidant Capacity) levels in blood were found to be greater ($p< 0.05$) in the experimental group than in the control group.

Rezaei-Moghadam et al. (2012) studied the impact of turmeric and carrot seed extracts on serum liver indicators, hepatic lipid peroxidation, antioxidant enzymes, and total antioxidant status in rats. They used gavages to administer Turmeric @ 100, 200 mg/kg b.w and carrot seed extract (CSE) (@ 200, 400 mg/kg b.w.) for a month. The results showed that antioxidant enzymes superoxide dismutase, catalase, and glutathione peroxidase were considerably elevated in the hepatic tissue of treatment groups. Malondialdehyde levels in liver tissue were considerably lower in the turmeric and carrot seed extract fed groups. When compared to the control groups, serum levels of alanine aminotransferase, aspartate aminotransferase, and alkaline phosphatase were considerably lower in the treated groups, although albumin and total protein were significantly higher ($p<0.05$). Park et al. (2013) studies the levels of phenolic compounds, flavanoids, radical scavenging activity and antiobesity were evaluated with cold water (CLC), hot water (CLH), and methanolic (CLM) extracts of turmeric. The CLM showed significantly higher DPPH and ABTS radical scavenging capabilities than water extract (CLC and CLH). The CLM therapy significantly reduces lipid accumulation in 3T3 –L1 cells during adipocyte development. Bastaki et al. (2016) used 1 ml of 4 percent acetic acid intrarectally at 8 cm proximal to the anus for 30 seconds to assess the protective effects of turmeric powder against acetic acid-induced colitis in rats. For a total of seven days, curcuma longa (CL) powder at 1, 10, and 100 mg/kg/day was administered either three days before to or following inflammatory bowel disease. They found that in rats with acetic acid-induced inflammatory bowel illness, turmeric powder increased body weight growth and mean macroscopic and microscopic ulcer scores in the colon. In the colon mucosa, turmeric lowered the levels of IL-23 (interlukin) and MPO (mylo peroxidase). An increase in the average serum glutathione level may help reduce the oxidative stress associated with inflammatory bowel disease. Anna et al. 2011 investigated the anti-inflammatory effect of turmeric

on collagen-induced arthritis. Six groups of 36 male Sprague-Dawley rats (6-8 weeks old) were randomly assigned. One group served as a control, while the other five were inoculated subdermally with 150 g collagen type-II on day 0. For four weeks, all rats with established collagen-induced arthritis and an arthritis score greater than 1 were administered orally betamethasone (0.5 mg/ml/kg body weight) and different dosages of turmeric extract (@ 30, 60, and 110 mg/ml/kg body weight) in olive oil as a carrier. On day 28, therapy with 110 mg/ml/kg CL resulted in a significant mean difference in ESR and radiological score. The mean difference for the ESR, AS and radiological scores of this highest turmeric dose group were found to be insignificant compared to the betamethasone treated group. It was suggested that turmeric extract arrested the degenerative changes in the bone and joints of collagen-induced arthritic rats. Ananda kumar et al. (2014) investigated the anti-inflammatory effects of turmeric extract on acute and chronic inflammation models. In xylene-induced ear edema and carrageenan-induced paw edema models, activity against the acute phase of inflammation was assessed. They found that turmeric extract prevented the production of xylene-induced ear edema at all dose levels ($P \leq 0.05$). In a cotton pellet-induced granuloma model, activity against chronic inflammation was also assessed. Turmeric extract significantly ($P \leq 0.05$) reduced the weight of granuloma tissue on cotton pellets in a dose-dependent manner. It was suggested that turmericextract may be helpful against both acute and chronic inflammation.

Ukaegbu et al. (2016) studied the antibacterial effects in-vitro of crude ethanol and aqueous extracts of Turmeric, Ginger and, Turmeric and Ginger combined were assayed. The well diffusion method was used to measure antibacterial activity. Turmeric showed the lowest antibacterial activity against the *Salmonella enterica* Type typhi and *Pseudomonas aeruginosa* microorganisms tested. The potency of the ethanolic extract was higher than that of the aqueous extract. Plant extracts exhibited the lowest anti-*Salmonella enterica* Type typhi activity and the highest anti-*Pseudomonas aeruginosa* activity. Chloramphenicol, the control, had a stronger effect than the spices alone or in combination. According to Gupta et al. (2015), the antibacterial activity of several fractions extracted from the turmeric rhizome was examined against both clinical isolates and standard strains of *Staphylococcus aureus*. Compared to normal strains, clinical isolates of *Staphylococcus aureus* were found to be more susceptible for different fractions. Test pathogens treated with turmeric extract showed shape deformation and partial cytoplasmic membrane loss under scanning electron microscopy, which resulted in cell rupture. The latter serves as a sign of the turmeric fraction's broad spectrum antibacterial action. Ho et al. (2012) investigated the effects of fermented turmeric (standardised ethanol extract; FTE) on obesity in a mouse model. Mice were given a diet with FTE at 0, 200, or 500 mg/kg body weight for nine weeks. FTE supplementation significantly decreased body weight growth as well as the weights of retroperitoneal and epididymal adipose tissue when compared to the control group. The FTE-200 and FTE-500 groups showed a significant decrease in serum and liver total cholesterol and triglyceride levels when compared to the control group. However, there was an increase in high-density lipoprotein cholesterol levels.

Effect of turmeric

Effect on growth of fish

Abdel Tawwab and Abbass (2017) studied the effect of turmeric powder, in common carp. For 10 weeks, fry were fed 0.0 basal feed, 1.0, 2.0, or 5.0 g turmeric/kg diet twice daily until satiated. The growth permoting effect of turmeric powder was studied and it was reported that when dietary turmeric powder levels increased fish growth and innate immunity was significantly with the increased levels of turmeric powder supplementation. It was concluded that turmeric powder supplementation was promising immunostimulant which could improve fish performance and prevent infection from *Aeromonas hydrophilla* when supplementation at level of 2g/kg. The impact of turmeric powder on the growth and feed efficiency, survival rate, and hematologic parameters of the ornamental fish Green Terror (*Andinocara rivulatus*) was documented by Batmany et al. (2019). Four iso-caloric and iso-nitrogenous meals containing 0.1, 0.2, and 0.3 percent turmeric powder were made for 114 specimens, with an average weight of 1.53±0.22 (g). The fish fed a diet containing 0.3% powdered turmeric showed no discernible change in behaviour, according to the results. Curcumin was incorporated into Gilthead seabream diets at rates of 0, 1.5, 2, 2.5, and 3% for 150 days, according to research by Ashry et al. (2021). The ultimate body weight, weight increase, specific growth rate, and feed conversion ratio of fish treated with curcumin were all markedly improved in a dose-dependent manner. The fish with the best growth outcomes were those fed a diet supplemented with 3% curcumin. The dangerous bacteria (*Vibrio spp*. and *Faecal coliform*) in the intestines of Gilthead seabream fed a diet containing curcumin were shown to have decreased in activity in a dose-dependent way. Sahu et al. (2008) studied the effect of dietary dosages of turmeric on immune response and disease resistance against the opportunistic pathogens *Aeromonas hydrophila* in *Labeo rohita* fingerlings. Four dosages of turmeric at 0.1, 0.5, 1.0 and 5.0 per kg feed were given for 60 days to the fingerlings of *L. rohita. D*ifferent biochemical, haematological, enzymatic and immunological parameters of fish were evaluated after every 20 days. Fish were exposed to *A. hydrophila* after 60 days. The mortality (%) was recorded on the tenth day post challenge. Most of the immune parameters were found to be significantly higher on 60 days of turmeric at 1.0 g/per kg of feed. Feeding of turmeric might have maintained long-term protection in fish by elevating the nonspecific immune system such as Nitroblue tetrazolium (NBT), lysozyme and serum bactericidal activity.

Effect on body composition of fish

Mahmoud et al. (2014) studied the effect of dietary supplementation of turmeric on Nile tilapia. By using 180 Nile tilapia fish in a three-month growth trial. Three treatment groups of fish were used. The first group, T1, was given a basal diet without any turmeric supplementation. The second group T2 had a 0.25 and the third groupT3 was given a turmeric powder supplemented diet of 0.50 percent. The growth performance was not significantly affected, there was a trend toward better growth as the level of turmeric supplementation was increased. However, a significant increase in feed consumption in T3 was observed when compared to T1 and T2.Turmeric supplementation had an effect on the body composition of fish. When compared to T1, T3 had numerically higher crude protein content. The ether extract content of the fish

declined significantly as the turmeric supplementation amount increased; with T1 having the highest ether extract content and T3 is having the lowest.

Effect on biochemical and hematological parameters of fish

Abdel-Rahman et al. (2020) investigated the effect of turmeric powder (TP), and clove bud powder (CBP) in the diet on Nile tilapia. Fish of weight 27.56 ± 0.15 g were randomly allocated into four groups in triplicates. The first (control) group was fed basal without any feed additives. The second and third groups were fed on a basal diet enriched with 0.5% TP and 3% CBP, respectively, and the fourth group was fed on a basal diet enriched with a mixture of TP and CBP for 6 weeks. After the 6 weeks of feeding, fish were intraperitoneally injected with *P. mirabilis,* and mortalities were recorded up to 14 days. Supplementation of the basal diet with TP @ .5%, CBP @ 3%, TP + CBP. The results demonstrate that all groups fed TP and/or CBP supplemented meals had significantly improved growth metrics as compared to the control group. Fish fed a dietary TP+CBP mixture followed by TP then CBP showed significant increases in lysozyme activity, nitric oxide, total protein, particularly total globulin, and the hepatic level of antioxidant enzymes catalase, superoxide dismutase activities, and reduced glutathione content before and after bacterial challenge compared to control fish. Zare et al. (2019) studied the effects of *Curcuma longa L*. affected the haematological factors of *Huso huso*. Fish were divided into three groups: curcumin, control (+), and control (-). They were injected curcumin extract intraperitoneally after a week of adaptation to the experimental environment. A maximum volume of 0.5 ml of 400 mg/kg bw curcumin extract was used in the curcumin group. 0.5 ml of physiological serum was kept in the control (+) and control (-) without injection to ensure that the fish experimental conditions were correct. At 0, 3, 6, 9, and 12 days after the injection, blood was drawn. The result showed that the curcumin group had more red blood cells, white blood cells, hematocrit, haemoglobin, and blood indices like MCV, MCH, and MCHC than both the control groups. The findings of this study revealed that use of curcumin beluga has a significantly improved the haematological parameters. Abdel Rahman et al. (2020) investigated the effect of turmeric powder (TP), and clove bud powder (CBP) in the diet on Nile tilapia. Fish of weight 27.56 ± 0.15 g were randomly allocated into four groups in triplicates. The first (control) group was fed basal without any feed additives. The second and third groups were fed on a basal diet enriched with 0.5% TP and 3% CBP, respectively, and the fourth group was fed on a basal diet enriched with a mixture of TP and CBP for 6 weeks. After the 6 weeks of feeding, fish were intraperitoneally injected with *P. mirabilis,* and mortalities were recorded up to 14 days. Supplementation of the basal diet with

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Curcumin was incorporated into Gilthead seabream diets at rates of 0, 1.5, 2, 2.5, and 3% for 150 days, according to research by Ashry et al. (2021). The findings demonstrated that, with the notable exception of hematocrit, haemoglobin, red blood cells, and white blood cells, which were all significantly raised by dietary curcumin, haematological indices were within the usual range for healthy fish. In comparison to the control, dietary curcumin clearly increased phagocytic activity. Blood urea nitrogen, total cholesterol, alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, and other biochemical blood metabolites linked to liver function were all within normal ranges.

Ginger plant, its distribution and composition

Ginger (*Zingiber officinale* Roscoe), which belongs to the Zingiberaceae family and the Zingiber genus, has been commonly used as a spice and herbal medicine for a long time (Han et al. 2013). Ginger is a plant native to the Indo-Malayan region that has been grown in India since prehistoric times. It is currently grown over most of the tropical and temperate world. India, China, Australia, the East Indies, the West Indies, Mexico, Jamaica, North Africa, and West Africa are the world's leading ginger producers. Many bioactive components in ginger, such as phenolic and terpene compounds, have been found. The phenolic chemicals responsible for ginger's different bioactivities are gingerols, shogaols, and paradols (Stoner 2013). Ginger has a lot of active ingredients such phenolic and terpene chemicals (Prasad and Tyagi 2015). Ginger's phenolic constituents include gingerols, shogaols, and paradols. Quercetin, zingerone, gingerenone-A, and 6-dehydrogingerdione are only a few of the phenolic chemicals found in ginger (Ji et al. 2017; Schadich et al.2016). Furthermore, ginger contains various terpene components, including -bisabolene, -curcumene, zingiberene, -farnesene, and -sesquiphellandrene, which are considered the major constituents of ginger essential oils (Yeh et al.2014). In addition to these, ginger contains polysaccharides, lipids, organic acids, and raw fibres (Prasad and Tyagi 2015; Yeh et al., 2014)

The presence of crude fiber (10.36%), ash (6.57%), ether extract (6.48%), nitrogen free extract (64.82%), and crude protein (10.36%) was revealed by proximate biochemical findings (5.45 percent). Zinc (Zn), manganese (Mn), copper (Cu), calcium (Ca), iron (Fe), sodium (Na), phosphorus (P), and potassium (K) were the most abundant mineral elements. (Ogbuewu et al., 2014)

Mechanism of action of ginger

Antioxidant effect

Kulkarni and Deshpande (2016) reported that ginger had an effective anti-inflammatory and antioxidant property with anti-TB therapy in human subject as it possesses strong free radical scavenging property. In an investigation by Afshari

et al. (2007), 250 ± 20 g Wistar rats were given 60 mg/kg of streptozotocin. Rats were split into three groups (n = 8): non-diabetic, diabetic treated with ginger powder, and diabetic not treated. The group of diabetics who received ginger treatment included 5% of it in their daily diet. Malondialdehyde, a biomarker of lipid peroxidation in red blood cells, and plasma antioxidant capacity were evaluated using the FRAP method. MDA levels were seen to be considerably lower in the ginger-treated diabetic rats compared to the other groups ($P < 0.01$). Rats given ginger treatment had a higher plasma antioxidant capacity than the first two groups. The group that received ginger treatment also had fewer diabetes-related nephropathies. This study so demonstrated that ginger increases plasma antioxidant capacity, decreases lipid peroxidation, and reduces renal nephropathy. According to a study by Thomson et al., 2002 mice given a low dose of ginger (50 mg/kg) orally or intraperitoneally did not significantly lower their serum thromboxane-B2 levels in comparison to mice given saline. However, at this dosage, oral ginger significantly decreased serum PGE2 levels. When given orally or intraperitonially, high dosages of ginger (500 mg/kg) were effective in considerably decreasing serum PGE2. However, rats fed 500 mg/kg of ginger orally but not intraperitoneally (IP) had considerably lower levels of thromboxane-B2. When a greater dose of ginger (500 mg/kg) was given, there was a noticeable drop in blood cholesterol. When ginger was given intraperitoneally (IP), a notable drop in blood cholesterol was seen at a low dosage of 50 mg/kg. On the other hand, no appreciable variations in serum triglyceride levels were noted. These findings suggest that ginger may have applications as an antithrombotic, anti-inflammatory, and cholesterol-lowering medication. Tjendraputra et al. (2001) studied oleoresin principles of ginger and their analogues for cyclooxygenase-2 (COX-2) inhibition in the intact cell. These compounds showed a structure and concentration dependent inhibition of the enzyme, with IC50 values varying from 1–25 μM. Constituents of Ginger paradol and shogaol, along with two synthetic analogues, 3-hydroxy-1-(4-hydroxy-3-methoxyphenyl) decane and 5-hydroxy-1-(4-hydroxy-3-methoxyphenyl) dodecane lead to strong inhibitory effects on COX-2 enzyme activity.

Im et al. (2021) examined the ginger-cinnamon mixture's anti-inflammatory properties in mice whose intestinal inflammation was brought on by dextran sulphate sodium (DSS). In order to cause intestinal inflammation, the treatment mice were given either ginger extract (GE), cinnamon subcritical water extract (CSWE), low GE + CSWE (GCL), or high GE + CSWE (GCH) for 21 days. For the last seven days, they were also given water containing 5% DSS. In comparison to the control group, the GCH group displayed higher body weight, blocked intestinal shortening, and decreased DAI (disease activity index), although the histological score of intestinal inflammation was the same. Additionally, it decreased the levels of mRNA for tumour necrosis factor-α, IL-6, and interleukin (IL)-1β and MPO (myeloperoxidase) activity. Thus, it was demonstrated that the ginger-cinnamon combination is good for gut health and reduces intestinal inflammation. Habib et al. (2008) studied anticancer effect of ginger where he used male Wistar rats and divided them into 5 groups on the basis of diet into control which were given normal rat chow and several other groups of mice who were fer olive oil, ginger extract (100mg/kg body weight), choline-deficient diet + 0.1% ethionine to induce liver cancer and, choline-deficient diet + ginger extract (100mg/kg body weight) respectively. Tissue samples were after eight weeks were fixed and checked by immunohistochemistry staining for NFκB (Nuclear factor κB) and TNF-α (Tumour Necrosis factor). Thus it was concluded that ginger extract reduced expression of NFκB and TNF-α in rats with liver cancer the expression of NFκB was significantly reduced and it may also act as an anti-cancer and anti-inflammatory agent as it inactivated NFκB through the suppression of the pro-inflammatory TNF-α. Ofongo-Abule and Ohimain (2015) Used aqueous extracts of fresh ginger to study its antimicrobial activity. The microbial population of (*Lactobacillus*, *Salmonella, E. coli* and coliforms) in the crop, ileum and caecum of the birds were determined 7 days before and 7 days after the administration of the fresh ginger extract. *Salmonella* population before administration of ginger was highest in crop @ 1.852 Log cfu/g and decreased after ginger feeding @ 1.744.

Log cfu/g at the ileum and 1.710 Log cfu/g at the caecum. *E. coli* also showed same pattern of decline in microbial population. Administration of aqueous ginger extract resulted in a significant decline of all microbial species compared to the control ($P<0.05$). Hence, ginger can be used for the control of infection in broiler GIT due to microbial load. Al-Amin et al. (2006) investigated ginger's hypoglycemic effects in rats. Rats with diabetes caused by streptozotocin (STZ) received an aqueous solution of ginger extract intraperitoneally once a day at a dose of 500 mg/kg for seven weeks. At a dose of 500 mg/kg, it was discovered that raw ginger dramatically reduced the levels of triacylglycerol, cholesterol, and blood glucose in diabetic rats treated with ginger as opposed to the control group. Urine protein levels were also lowered by the ginger therapy. The diabetic rats treated with ginger not only had hypoglycemia effects but also displayed decreased urine production and water consumption. This shown that raw ginger can effectively reverse diabetic proteinuria in diabetic rats and has hypoglycemic and hypocholesterolemic effects. Iranloye et al. (2011) investigated *Zingiber officinale's* anti-oxidant and anti-diabetic properties in male rats with insulin-resistant diabetes created by alloxan. Oral administration of 500 mg/ml of ginger aqueous extract was given to rats that were both insulin-resistant and diabetic due to alloxan for a duration of 4 weeks. In insulin-resistant and alloxan-induced diabetic rats, ginger was observed to lower fasting blood glucose and malonydealdehyde levels in comparison to the control group. This study clearly shows that dietary ginger has hypoglycaemic effect and enhances insulin synthesis in male rats. Vishwakarma et al. (2002) prepared the benzene fraction of a petroleum ether extract containing anticonvulsant principles of dried rhizomes of ginger. They were screened for antiemetic and anxiolytic activity. BF exhibited antiemetic activity by blocking lithium sulphate-induced conditioned place aversion. These results suggested that the fraction has antiemetic, anticonvulsant and anxiolytic activity. Sharma et al. (1997) studied antiemetic activity of ginger acetone, 50% ethanolic and aqueous extracts of ginger were investigated for against emesis induced by 3 mg/kg cisplatin in healthy mongrel dogs. Aqueous extract @ 25, 50, 100 and 200 mg/kg when supplemented once a day. was found to be ineffective against cisplatin emesis while acetone and 50% ethanolic extract at same dose showed significant protection. Also, acetone extract

was better than

ethanolic extract. However, both were not much effective when compared to 5-HT3 receptors antagonist granisetron. Nor the ginger extract was found to be effective against apomorphine-induced emesis suggest that ginger could be an effective and cheap antiemetic adjunct to cancer chemotherapy. This suggests that ginger can be used as effective and cheap antiemetic along with cancer chemotherapy.

Effect of ginger

Effect on growth and FCR

Lamin et al. (2018) studied the effect of graded levels of dietary ginger supplementation on the growth and nutrient utilisation of *Cyprinus carpio* fingerlings over a 45-day period. Following a completely randomised design (CRD), fish of uniform size (average weight 6.0-6.5 g) were divided into six experimental groups in triplicates. Six diets having different ginger concentrations were Control T1 (0%), T2 (0.2%), T3 (0.4%), T4 (0.6%), T5 (0.8%), T6 (1%) diet, respectively. The application of this herb, at 0.8 percent in the diet of koi carps proved to be an effective tool for koi fish to achieve long-term performance and thus increase their population production. Treatment with ginger improved nutrient utilisation, as evidenced by increased weight gain, the Specific growth rate (SGR), the Protein efficiency ratio (PER), and the Feed efficiency ratio (FER). Sukumaran et al. (2016) studied the effects of ginger as a feeding supplement on *Labeo rohita*'s growth, skin mucus immune parameters, and cytokine-related gene expression, as well as its susceptibility to *Aeromonas hydrophila* infection, in this study. Fish (average weight: 12.3 g) were fed diets containing six different concentrations of dried ginger (0 percent [basal diet], 0.2 percent [G2], 0.4 percent [G4], 0.6 percent [G6], 0.8 percent [G8], and 1.0 percent [G10]). The findings suggested that dietary supplements of ginger (@ 0.8 percent can help *L. rohita* grow faster, have better skin mucus immune parameters, and have stronger immunity. It was suggested that ginger was a promising aquaculture food additive for carps. Hassanin et al. (2014) studied the effect of supplementation of ginger as feed additive in the diets of *Oreochromis niloticus* on growth performance. The fingerlings (b.w + 30g) were fed @ 5% of body weight for 10 weeks 0, 0.1, 0.2, 0.3, 0.5 and 1 %. The results showed that the ginger had a significant ($P < 0.05$) increase in total final body weight, body gain, body gain percent, specific growth rate and improved values of FCR than those fed the control diets. The average daily feed intake wasn't significantly ($P > 0.05$) different amongst the groups.

Najem et al. (2020) studied the effect of ginger supplementation @ 0, 1, 1.5, 2 % for 35 days as a feed additive on growth performance in common carp (35g). the fingerlings receiving ginger supplementation @ 1.5%and 2% showed significantly higher weight gain, RGR. The fingerling receiving ginger @ 2 % showed significantly better feed conversion feed efficiency. The fingerlings which were offered ginger powder @ 1.5 and 2% showed significantly lower PER. There was no significant difference in Total protein, albumin and triglyceride. However, globulin showed increase and cholesterol decreased in 2% ginger supplementation compared to control. Mahmoud et al. (2019) determined the effects of garlic and ginger powder on Nile tilapia fingerlings' growth performance, supplementation of basal diet (C) was done with ginger @ 1.5 % and garlic @ 1.5%. The result showed that there were significant ($p \leq 0.05$) decrease in body weight gain and specific growth Nile tilapia fish fed diets supplemented with garlic and ginger powder compared to the control group. Also, there was feed conversion ratio deteriorated in experimental group in comparison to control group.

Nyadjeu et al.(2021) investigated the effects of ginger and garlic as feed supplements on *Clarias gariepinus* fry development, feed utilisation, and whole-body composition. Fry were fed a control basal diet in treatment T0, a basal diet containing 1 % and 2 % ginger in treatments T1 and T2, respectively, and a basal diet supplemented with 1 % and 2 % garlic in treatments T3 and T4, respectively. Following the feeding trial, fish fed 1% garlic had the best growth performance in terms of final weight, weight gain, specific growth rate, and feed conversion ratio. FER and PER were lower as compare to other other treatments. Whole-body composition (moisture, crude protein, crude lipid, ash, and energy) and nutrient retention showed a similar pattern to growth measures. The result suggested that C. *gariepinus* fry fed 1% garlic dietary inclusion level showed improved growth, feed utilisation, and body composition. Abbasi et al. (2017) investigated the effects of different concentrations of ginger powder (0, 0.25, 0.5, 1, 2 g) per 100 g of commercial common carp diet. Except for survival rate, Gain Weight Percent (GW percent), SGR, and NFE contents of fish muscle there were significant differences in all growth parameters and body composition between treatments. The Kruskall-Wallis test showed a significant variation in carbohydrate and body fibre content. The group given the highest dosage of ginger powder in carp commercial food had the best growth performance, protein, lipid, and energy, while the control group had the lowest values for these parameters. In addition, this group had high carbohydrate content and a low fiber content. In the third treatment, there was a higher level of ash. Based on the findings, ginger at larger doses can be an effective treatment for improving the quality and quantity of juvenile Common carp growth and muscle. Jafarinejad et al. (2020) investigated the effects of dietary ginger) on common carp growth. For 56 days, fish were fed four experimental diets containing 0 percent (control diet), 0.5, 2, and 5% ginger powder. When compared to the control diet, fish fed 2 and 5 percent ginger diets showed significant increases in final weight, weight gain, specific growth rate (SGR), and feed conversion ratio (FCR) after 56 days of culture. After 56 days of culture, fish fed 2 and 5% ginger diets had significantly higher numbers of leucocytes (WBC), erythrocytes (RBC), haematocrit, lymphocyte, monocyte, and neutrophils than control diet. The enzyme activity of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPX), as well as malondialdehyde (MDA) levels, were substantially higher in the groups fed 2 and 5% ginger diets. From findings it can be concluded that ginger could help common carp increase their growth, health, and antioxidant capability. The physiological characteristics and growth performance of Huso huso fingerlings fed a diet enriched with herbal plants were examined by Kanani et al. (2014). The diets were 0 g (control), 1.0 g (garlic), and 1.0 g (ginger) /100 g of feed for a duration of 60 days. The specific growth rate, body weight gain, and condition factor were all considerably elevated by the ginger therapy at the conclusion of the trial. On day 30, the ginger group's CF dramatically

dropped compared to the control group. During the trial, the ginger group performed better in terms of growth. After 60 days, BWG rose considerably more in the ginger group compared to the garlic group. At the conclusion of the trial, the fish in the ginger group had a much higher specific growth rate than those in the garlic group. On day 15, the ginger group had the lowest FCR when compared to the garlic and control groups, but there was no statistically significant difference. In summary, the development and physiological parameters of this species seem to benefit from a herbal diet.

Effect of ginger on hematological and biochemical parameters

Şahan et al. (2016) studied the effects of feeding Nile tilapia (*Oreochromis niloticus*) ginger at various ratios for 90 days on their haematological, oxidative stress, and growth parameters, mortality, and RPS (relative percent survival) ratios against *Aeromonas hydrophilla*. Improvement in haematological and oxidative stress indices, as well as the RPS, were attributed to antibacterial and antioxidant properties of ginger against *A. hydrophila* infection in tilapia at higher doses. In rainbow trout (*Oncorhyncus mykiss*), Haghighi and Rohani (2013) assessed the immune-stimulatory effects of dietary powdered ginger at 1%. In comparison to the control group, the powdered ginger rhizome supplementation resulted in a substantial immunostimulatory impact, as well as increases in WBC, hematocrit, RBC count, respiratory burst activity, and lysozyme activity. Arulvasu et al. (2013) investigated the effects of different dietary dosages of ginger powder on the immunological response of Indain major carp (*Catla catla*). Fish were subjected to haematological, biochemical, and immunological tests, which were examined on different days of 30 days feeding study. In 0.001%, 0.05% and 0.1 % ginger supplemented groups, total erythrocyte, leukocyte count, haemoglobin content, and total serum protein were all significantly higher. According to the findings, ginger powder can act as an immunostimulants in *C. catla*. Brum et al. (2018) studied the effect of essential oils of clove basil (*Ocimum gratissimum*) and ginger had any effect on nile tilapia's physiological and immunological parameters. Blood was collected after 35 and 55 days of supplementation (0.5, 1.0, and 1.5 percent) to determine metabolites (glucose, cholesterol, triglycerides, serum total protein, and immunoglobulins) and lysozyme activity. In both sampling times, there were no significant differences in glucose, total serum protein, or immunoglobulin levels. Essential oils were found to be effective in improving the fish's physiological status without over-activating their defence mechanisms.

Growth and feed conversion in fish can be significantly impacted by the addition of turmeric and ginger (turmeric flour, ginger flour, extract, and juice) and has effect on gonad development, survival, feed utilisation efficiency, and digestive enzymes. Although there are instances, where the use of turmeric and ginger have no discernible impact on fish performance. This is impacted when fish food is supplemented with too little feed additive, which prevents the feed from producing the best possible effects. The variation in results could be attributed to various factors such as species of fish, size, age, sex, feeding program, dose of additives, feed formulation, initial body weight of fingerlings/fish and ambient culturing conditions.

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