An Extensive Review on the Use of Feed Additives Against Fish Diseases and Improvement of Health Status of Fish in Turkish Aquaculture Sector

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Abstract
Aquaculture is the second-fastest-growing sector in the world after informatics and its. Average growth of aquaculture is annually ~8.8% over the last 30 years. Turkey has great potential in terms of fish production and the number of fish farms started to increase rapidly. Fish production in intensive culture conditions has enlarged possible threats of contagious disease outbreaks due to high stocking densities, water quality or environmental gradient, etc., as well as the combination of all these factors together. Depending on animal husbandry situations and organizational conditions, gradation of the aquatic surroundings and outbreaks of bacteriological diseases may well cause production losses around 30-40% in aquaculture facilities. Some fish diseases reported most repeatedly in Turkish aquaculture facilities are Vibriosis, Furunculosis, Streptococcosis, Lactococcosis, Aeromonas septicaemia, Yersiniosis, Photobacteriosis and Flavobacteriosis. Antibiotics, disinfectants and chemotherapeutics used for the prevention and treatment of diseases result in residual antibiotics and chemicals in fish products, microorganisms resistant to antibiotics and damages to the aquatic environment and human health. This situation has led researchers to use alternative feed additives in fish diets such as medicinal plant, herbal extracts, phytochemicals, plant secondary metabolites, immunostimulants and probiotics. This review includes research conducted in Turkey between the years 2001 and 2020, and aims to summarize the findings regarding the use of medicinal plant, herbal extracts, phytochemicals, plant secondary metabolites and immunostimulants in fish feed to prevent and treat diseases, improve immunity, increase disease resistance, and reduce stress in fish towards a better management and best aquaculture practice for the sustainability of the growing aquaculture industry in the region and worldwide.

Introduction
Aquaculture represents one of the most commercially traded products in the world food industry, showing an annual increase of nearly ~8.8% over the last 30 years (FAO, 2018). In Turkey, rainbow trout (Oncorhynchus mykiss) is the most produced species in inland waters, whereas European sea bass (Dicentrarchus labrax) and gilthead sea bream (Sparus aurata) production stands out in the marine environment. As of 2019, trout harvest from freshwater and marine facilities yielded 116.053 and 9.692 tons, respectively, whereas sea bream and sea bass harvest from marine cage farms in Turkey reached around 99.730 and 137.419 tons, respectively (TUIK, 2019).

Fish production in intensive culture conditions has enlarged possible threats of contagious disease outbreaks due to high stocking densities, water quality or environmental gradient, underwater acoustic noise beyond ambient audio level from machines in recirculating systems, etc., as well as the combination of all these factors together. Depending on animal husbandry situations and organizational conditions, gradation of the aquatic surroundings and outbreaks of
bacteriological diseases may well cause production losses around 30-40% in aquaculture facilities. Some fish diseases reported most repeatedly in Turkish aquaculture facilities are *Vibriosis*, *Furunculosis*, *Aeromonas septicemia*, *Streptococcus*, *Lactococcosis*, *Yersiniosis*, *Photobacteriosis* and *Flavobacteriosis*.

Antibiotics and chemotherapeutics are frequently chosen for the control of several infectious diseases in culture systems (Ozturk & Altinok, 2014). There are 41 licenced drugs used in fish farm facilities in Turkey (Yarsan, 2013, Aksit, 2016). Out of these drugs, 15 contain florfenicol, 9 sulfadiazina-trimetoprim, 12 oxytetracycline, 2 enrofloxacin, 2 amoxicillin and 1 oxolinic acid (Yarsan, 2013).

The use of antibiotics and chemotherapeutics in aquaculture facilities is associated with residual complications in the nearby vicinity and the human body, as well as antibiotic-resistant pathogenic strains (Capkin et al., 2017; Yilmaz et al., 2018a). Additionally, resistance may be acquired by genes, which are placed on transportable elements of environmental, human, or other animals (pets)-origin of existing microorganisms that could be transported to the bacteria isolated from fish (Capkin et al., 2015).

Above mentioned detrimental effects have caused global concern in terms of the needs for biologically-safe feeding strategies in fish culture. Hence, fish diets used in aquaculture facilities could be improved with dietary incorporation of immunostimulants, organic acids, herbal extracts, medicinal plant, phytochemicals, plant secondary metabolites, essential oils and probiotics as feed additives. Many reports have documented the effect of β-glucans (Dugenci & Candan, 2001; Sahin & Duman, 2010), levamisole (Ispir & Dorucu, 2005), medicinal plants (Dugenci et al., 2003; Gultepe et al., 2014; Diler et al., 2017a; Akyuz et al., 2018; Almabrok et al., 2018; Amhamed et al., 2018; Diler and Gormez 2019; Yilmaz and Er 2019; Bilgen et al., 2020a; Ontas et al., 2020), plant syrups (Yilmaz et al., 2018b, Yilmaz, 2019c; Yilmaz, 2020), spices (Yilmaz et al., 2013a; Yilmaz et al., 2013c; Yilmaz & Ergun, 2014; Yilmaz et al., 2015a; Yilmaz et al., 2016; Gullu et al., 2016; Altunoglu et al., 2017; Savaşer et al., 2019), natural compounds (Yilmaz et al., 2015b; Acar, 2018a), organic acid (Yilmaz et al., 2019a), mushrooms (Ulukoy et al., 2016), yeast autolysates (Guven and Yalcin 2017), essential and plant oils (Acar et al., 2015; Arslan et al., 2018; Acar, 2018b; Altinterim et al., 2018; Altinterim & Aksu 2019; Acar et al., 2019; Baba et al., 2016b; Kivrak & Didinen 2017; Diler et al., 2017b; Diler et al., 2017c; Yilmaz, 2019b; Kesbic, 2019a; Kesbic, 2019b; Parrino et al., 2019; Gultepe, 2020; Kesbic et al., 2020b), and anthocyanin (Yilmaz 2019d) as effective ones.

This study focuses mainly on the effects of different feed additives on fish, with special reference to hematology, serum biochemistry, nonspecific immunity, antioxidant status, stress responses, disease resistance and immune related gene expression. The results of this review are, therefore, aimed to provide remarkable information for the preparation of a “Standard Feed Additive Inoculation Protocol” and focus on several research gaps in fish production that might help to improve feeding strategies towards “Best Aquaculture Practice” for the sustainability of the growing aquaculture industry in Turkey as well as all around the world, both at laboratory and field levels.

*Aeromonas spp.*

*Aeromonas hydrophila* and *Aeromonas veronii* are among the bacteria that cause motile *Aeromonas septicemia* in fish (Austin & Austin, 2016). *Camellia sinensis* seed powder (Er & Kayis, 2015), *Capparis spinosa* methanolic extract (Bilen et al., 2016a), *Avena sativa* water extract (Baba et al., 2016c), *Zingiber officinalis* powder (Sahan et al., 2016), *Anethum graveolens* and *Lepidium sativum* methanolic extracts (Bilen et al., 2018), *Malva sylvestris* methanolic extract (Bilen et al., 2020b) and *Pleurotus ostreatus* methanolic extract (Bilen et al., 2016b) were administered to fish diets and found to increase protection against *A. hydrophila* (Table 2). Considering these earlier reports in terms of ecological approach (non-melianic extraction) and the best RPS values, *Avena sativa* water extract (Baba et al., 2016a) with a value of 67 RPS and *Camellia sinensis* seed powder (Er & Kayis, 2015) with a value of 100 RPS are remarkable ones.

There was merely one report showing 5 g/kg of caffeic acid supplement diets, adequately improved the enhanced nonspecific immune responses, up-regulated the immune and antioxidant related genes and disease resistance of fish against *A. veronii* (with a value of 57.89 RPS) in Turkey (Yilmaz, 2019a).

Yilmaz et al. (2020a) reported that L-achill and oleuropein improved serum biochemistry parameters and immunological parameters of rainbow trout. Similarly, Yilmaz et al. (2020c) investigated the nonspecific immune responses, health status and effect on growth performance of fish by testing black mulberry syrup in tilapia. The authors confirmed the highest RPS value (68.75%) in the fish fed with black mulberry syrup by 2%.

*Aeromonas salmonicida* are known as the causative agent of furunculosis. Yonar et al. (2019) reported that the curcumin powder administration, especially at 2% and 4%, effectively enhanced the nonspecific immune responses and disease resistance to *A. salmonicida* subspecies *achromogenes* in rainbow trout, and the highest RPS value (76.67%) was determined in the group fed with curcumin powder feed contribution by 2%.

*Streptococcus spp.*

Streptococcal disease is caused by three major species of facultative anaerobic encapsulated Gram-positive streptococci. *Streptococcus iniae, S. agalactiae*...
and *S. dysgalactiae* are in charge of disease in more than 30 freshwater, estuarine and marine fish species worldwide (Lee, 2015). *Streptococcus iniae* is perhaps the most significant because of its virulence across a broad range of hosts, global distribution, economic impact and zoonotic risk (Agnew et al., 2007; Gauthier, 2015).

Yilmaz et al. (2013b) indicated that rosemary, thyme or fenugreek powders increased disease resistance against *Streptococcus iniae* in tilapia fry (Table 3).

In another study, cumin can be used as a feed additive as an immunostimulant during feeding of Mozambique tilapia (*Oreochromis mossambicus*) and it can be recommended as an alternative to antibiotics to control streptococcal disease in tilapia culture (Yilmaz et al., 2012; Yilmaz et al., 2013c).

A different study revealed that the management of 400 mg/kg *Tribulus terrestris* extract, which are rich in flavonoids in a diet for Mozambique tilapia fry for 45 days and they improved disease resistance against *S. iniae* (Yilmaz et al., 2014).

Similarly, Yilmaz and Ergun (2014) stated that pimenta can be used as a substitute to antibiotics in the control of streptococcal disease in tilapia culture. The highest survival rate (80%) was recorded in 10 g/kg pimenta powder fed fish, and the lowest survival rate (38%) was recorded in fish fed the control feed. Acar et al. (2015) reported that the highest RPS value (51.92) was found in the fish fed 1% sweet orange peel (*Citrus sinensis*). In addition, a plenty of studies have been reported on the use of feed additive against *Streptococcus* spp. infection (Table 3).

**Vibrio anguillarum**

Disases that are caused by *Vibrio* spp. are known to influence a wide range of wild and farmed fish species around the world, with reports in marine and brackish water environments, as well as in freshwater conditions (Woo & Bruno, 2017; Gudding et al., 2014). *V. anguillarum* affects more than 50 diverse saltwater and freshwater fish species worldwide (Frans et al., 2011). Increased disease resistance against *V. anguillarum* was found in rainbow trout, gilthead seabream and European seabass when fed diets supplemented with *Vaccinium myrtillus*, *Glycyrrhiza glabra*, *Echinacea angustifolia* (Terzioglu & Diler, 2016), *Salvia officinalis*, *Origanum vulgare* (Diler et al., 2017c), and *Artemisia vulgaris* (Diler et al., 2018a), respectively (Table 4). Among these studies, the best RPS value with 66.67% at the end of experimental infection with *V. anguillarum* was detected in fish fed diets containing *Coriunus coggyria* leaf powder (Bilen et al., 2013).

**Yersinia ruckeri**

Infection with *Yersinia ruckeri*, a member of the family Enterobacteriaceae causes Yersiniosis in fish. The term "yersiniosis" is identical with enteric redmouth disease (ERM), a disease of fish caused by overt infection with *Y. ruckeri*.

ERM was first reported in the late 1950s when it was affecting rainbow trout in the Hagerman Valley of Idaho (Woo & Bruno, 2017). *Yersiniosis* is now endemic across all the major salmonid farming areas of the world (Horne & Barnes, 1999).

Gulec et al. (2013) reported that dietary supplementation with thyme and fennel oils increased disease resistance in rainbow trout against *Y. ruckeri* (Table 5).

The oral administration of trans-cinnamic acid for 60 days in rainbow trout diet enhanced the haematological, serum biochemical and non-specific immune responses, improved immune-related gene expression as well as increased disease resistance (with a value of 50 RPS) against *Y. ruckeri* (Yilmaz & Ergun, 2018).

Similarly, the highest RPS value (42.09%) was detected in the group with 20% rosehip (*Rosa canina*) added (Sahan et al., 2017). It was observed that olive leaf ethanolic extract (Baba et al., 2018), pomegranate seed oil (Acar et al., 2018) and orange peel (Gultepe, 2020) reduced mortality in rainbow trout after challenge with *Y. ruckeri* (Table 5).

**Lactococcus garvieae**

In 1985, the genus *Lactococcus* was reported as a separate genus from *Streptococcus*. The original isolation of the *L. garvieae* was made from bovine mastitis (Schleifer et al., 1985; Teixeira et al., 1996; Collins et al., 1983).

The disease was described as a hyperacute systemic disease in rainbow trout (Eldar & Ghiotto, 1999). It can be separated into 3-distinct groups, based on RAPD analysis: Spanish, Portuguese, English and Turkish isolates formed one group, French and Italian formed a second, whilst Japanese formed a distinct third group (Ravelo et al., 2003).

Baba et al. (2017) examined the effects of argan oil, achieved from *Argania spinosa*, on pre- and post-challenge immuno-haematological and biochemical responses of the Nile tilapia (*Oreochromis niloticus*). For this purpose, the fish were comprising fed diets of 0, 0.5%, 1% or 2% argan oil for 45 days and then, fish were challenged with *L. garvieae*. The highest RPS of 52.0% against *L. garvieae* were recorded in the fish fed on argan oil at 1% (Baba et al., 2017).

In a further study with rainbow trout, the effects of the addition of olive pomace oil to assess the antioxidant activity and disease resistance were investigated (Yilmaz et al., 2020b). It was determined that the group fed with on 4% olive pomace oil had the highest RPS (43.86%) (Yilmaz et al., 2020b). Moreover, rainbow trout were fed the different doeses of *O. onites* essential oil (0.125, 1.5, 2.5 and 3.0 mL/kg) for 90 days, and 3.0 mL/kg diet showed no mortality after challenged
with *L. garvieae* (Diler et al., 2017b).

Similarly, RPS values 55% was reported in study against *L. garvieae* in rainbow trout fed 2% supplemented *Lentinula edodes* (medicinal mushroom) water extract (Baba et al., 2015) (Table 6).

### Edwardsiella tarda

The Edwardsiella (family Enterobacteriaceae) was initially recognized as a new genus of the Enterobacteriaceae in the mid-1960s, and characterized 37 isolates recovered from open wounds, blood, urine and faeces of humans and animals (Ewing et al., 1965).

*E. tarda* has mainly been considered a warm-water, opportunistic fish pathogen. Environmental variables such as high temperature, poor water quality and high organic content contribute to the harshness of infections (Woo & Capriano, 2017). *E. tarda* has also been reported from intensively reared rainbow trout in the Czech Republic (Rehulka et al., 2012). Diseased fish were anorexic and lethargic, having internal hyperaemia and petechial haemorrhages on the liver, with chronic lymphocytic portal hepatitis, focal necrosis, steatosis, dilation of the blood sinuses and activation of sinusoidal cells (Woo & Cipriano, 2017).

Baba et al. (2016b) investigated the effects of citrus lemon peel essential oil on the antioxidant activity and disease resistance (*E. tarda*) of tilapia. The highest RPS value (54.20%) was detected in the group with 0.5% citrus lemon peel essential oil added.

In another study, the effects of the addition of olive leaf ethanolic extract on *C. carpio* feeds on some blood parameters of fish, immune related genes and disease resistance (*E. tarda*) were investigated (Zemheri-Navruz et al., 2019). It was determined that the group with 1% olive leaf extract added had the highest RPS (43.75%). Similarly, the highest survival rate of carp infected with *E. tarda* was found in groups with dill (1 g/kg) and garden cress (2 g/kg) feed additive (Bilen et al., 2018).

### Plesiomonas shigelloides, Mycobacterium salmoniphilum and Spironucleus salmonis

Blackberry syrup (Yilmaz 2019c), *Rosa canina* powder (Duman & Sahin, 2018) and *Artemisia campestris* ethanolic extract (Diler et al., 2018b) were incorporated to fish diets and identified to increase protection against *Plesiomonas shigelloides*, *Mycobacterium salmoniphilum* and *Spironucleus salmonis*, respectively (Table 8). Duman and Sahin (2018) found the highest RPS value as 47.61% in the group with 15% *Rosa canina* powder addition. Diler et al. (2018b) determined the highest RPS value as 87.50% in the 1 g/kg *A. campestris* (L) ethanol extract incorporation group, which determined the *in vivo* antiparasitic activity of *Artemisia campestris* (L) plant ethanol extract on *Spironucleosis* (Hexamitiasis) infections seen in rainbow trout.

### Conclusion and Perspectives

Until recent years, antibiotics have been used as a feed additive that encouraged development in fish feed quality, and the use of antibiotics as a substance that promotes development has been banned in EU countries including Turkey. Many products considered as alternatives to antibiotics have been investigated. Result from intensive research challenges provide strong and reliable evidences that medicinal plants, herbal extracts, phytochemicals, plant secondary metabolites, immunostimulants, probiotics etc., are available in place of antibiotics in the fish diets. The positive effects of these additives especially killing pathogenic microorganisms stands in their strong ability of developing in the digestive organs, inhibiting the development of toxins in feed, increasing the activity of digestive enzymes, strengthening the immune system and, as a result, improving the growth performance and disease resistance of fish.

The exponential increase of the aquaculture industry is undeniable. As a result of the growing pressure from intensive production, environmental load from biogenic wastes such as organic waste and inorganic nutrients is likely to increase remarkably in the near future. Hence, using alternative feed additives with higher nutrient utilization efficiency might help to reduce waste load into the environment that in terms may support best aquaculture practice in long run.

As a result of this review, important information has been presented regarding the use of medicinal and aromatic plants as fish feed additives. Fish feed producers may encounter difficulties in accessing to medicinal or aromatic plants. In Turkey, there is a wide variety of medicinal and aromatic plants, a good source of feed additives with significantly strong antimicrobial and antioxidant effects. Approximately 6% of the world’s medicinal and aromatic plants are naturally grown in Turkey and the production of 72 different kinds of medicinal and aromatic plants such as thyme, rosemary, garlic, sumac, ginger, turmeric, mint, etc is supported by the Turkish Agriculture and Rural Development Support Institution.

In the light of this information, feed companies are encouraged to benefit from medicinal and aromatic plants, which are abundant in Turkey, easily accessible at affordable prices, and whose effectiveness on fish health and welfare has been proven by intensive scientific studies.

### Ethical Statement

No ethical statement required.

### Funding Information

No funding required.
Table 1. The role of beneficial feed ingredients supplemented to fish feed in Turkey at laboratory and field levels

| Additives | Fish species | Initial body weight | Stocking density (kg/m³) | Doses and supplementation duration | Results | References |
|-----------|-------------|---------------------|--------------------------|-----------------------------------|---------|------------|
| Extracts, powders, organic acids | O. mykiss | 10.14±0.06 g | 0.72 | 0.025, 0.05 and 0.1%, 60 days | NSIRs ↑ | Kurvak & Didinnen (2017) |
| Viscum album, Urtica dioica and Zingiber officinale (aqueous extract) | O. mykiss | 10.45±0.06 g | 2.33 | 5 and 10 mL/kg, 60 days | HS ↑, AS ↑ | Yilmaz (2019b) |
| Thymus vulgaris, Rosmarinus officinalis and Trigonella foenum graecum L. (powders) | O. mykiss | 3.07±0.15 g | 2.30 | 5 and 10 mL/kg, 60 days | HS ↑ | Kesbic (2019a) |
| Tribulus terrestris (extract) | O. mykiss | 10.68±0.35 g | 1.60 | 1, 2, 4, 6%, 60 days | HS ↑ | Kesbic (2019b) |
| Pimenta dioica (powder) | O. mykiss | 10.14±0.06 g | 0.72 | 0.025, 0.05 and 0.1%, 60 days | NSIRs ↑ | Kurvak & Didinnen (2017) |
| Carvacrol | O. mykiss | 10.79±0.57 g | 0.44 | 1, 3, 5 g/kg, 60 days | HS ↑ and NSIRs ↑ | Gultepe et al. (2014) |
| Artemisia vulgaris (powder and ethanolic extract) | O. mykiss | 21 g | 1.10 | Powder: 0.1, 0.5, 1, 2% | AS ↑ | Diler et al. (2017a) |
| Black cumin (methanolic extract) | O. mykiss | 15.02±0.1 g | 1.00 | 0.1 and 0.5 kg/kg, 30 days | NSIRs ↑ | Altunoglu et al. (2017) |
| Tilia tomentosa (methanolic extract) | C. carpio | 4.35±0.16 g | 0.15 | 0.01, 0.05, 0.1%, 45 days | NSIRs ↑ | Almabrook et al. (2018) |
| Chenopodium album (methanolic extract) | C. carpio | 2.4±0.1 g | 0.87 | 0.5, 0.1, 1 g/kg, 45 days | NSIRs ↑ | Amhamed et al. (2018) |
| Propolis (ethanolic extract) | O. mossambicus | 19.53±0.16 g | 6.17 | 2 and 4 g/kg, 60 days | NSIRs ↑ | Akyüz et al. (2018) |
| Cherry laurel (laurocerasus officinalis Roem.) leaf extract | O. mykiss | 6.05±0.03 g | 0.045 | 1, 5, 10, 15 g/kg, 52 days | SR ↑, AS ↑ | Akyüz et al. (2018) |
| root powder | O. mykiss | 108.7±17.0 g | 3.74 | 250, 500, 750, 1500 g/kg, 60 days | AGER ↑, AS ↑, HS ↑ | Yilmaz et al. (2019a) |
| Cinnamic acid | O. mykiss | 17.4±0.08 g | 2.45 | 250, 500, 750, 1500 g/kg, 60 days | AGER ↑, AS ↑, HS ↑ | Yilmaz et al. (2019a) |
| Tribulus terrestris | O. mykiss | 10.14±0.06 g | 0.72 | 0.025, 0.05 and 0.1%, 60 days | NSIRs ↑ | Kurvak & Didinnen (2017) |
| Fig and rosemary extract | O. mykiss | 12.47±0.15 g | 0.34 | 0.5, 1, 2 g/kg, 60 days | HS ↑ | Yilmaz & Er (2019) |
| Melissa officinalis (extract) | O. mykiss | 12.04±0.1 g | 0.35 | 0.1, 0.5, 1 g/kg, 75 days | HS ↑, NSIRs ↑ | Bilgen et al. (2020a) |
| Crocus cancellatus subsp. mazziacianus (Herbert) Mathew extract | D. labrax | 130±3.5 g | 10.7 | No information available | 0.5 mg/fish, 2 mg/fish | NSIRs ↑ | Öntas et al. (2020) |
| Fruits and Plants Syrups | O. mossambicus | 30.70±1.58 g | 6.57 | 0.625, 1.25, 2.5, 5%, 60 days | HS ↑ and NSIRs ↑ | Yilmaz et al. (2018b) |
| Carob syrup | O. niloticus | 3.68±0.092 g | 0.78 | 0.625, 1.25, 2.5, 5%, 60 days | NSIRs ↑, HS ↑, IRGER ↑, AGER ↑ and AMS ↑ | Yilmaz (2020) |
| Carob syrup | O. niloticus | 3.68±0.092 g | 0.78 | 0.625, 1.25, 2.5, 5%, 60 days | NSIRs ↑, HS ↑ | Yilmaz et al. (2018b) |
| Fruit pigments | O. niloticus | 8.24±0.64 g | 1.76 | 20, 40, 80, 160 mg/kg, 60 days | IRGER ↑, AGER ↑, AS ↑, NSIRs ↑ and AMS ↓ | Yilmaz (2019d) |
| Anthocyanin | O. niloticus | 8.24±0.64 g | 1.76 | 20, 40, 80, 160 mg/kg, 60 days | IRGER ↑, AGER ↑, AS ↑, NSIRs ↑ and AMS ↓ | Yilmaz (2019d) |
| Essential oils and plant oils | O. mykiss | 10.14±0.06 g | 0.72 | 0.025, 0.05 and 0.1%, 60 days | NSIRs ↑ | Kurvak & Didinnen (2017) |
| Rosmarinus officinalis | O. mykiss | 10.14±0.06 g | 0.72 | 0.025, 0.05 and 0.1%, 60 days | NSIRs ↑ | Kurvak & Didinnen (2017) |
| Lavandula stoechas (oil) | C. carpio | 10.88±0.90 g | 2.33 | 5 and 10 g/kg, 60 days | HS ↑ | Yilmaz (2019b) |
| Juniper berry (oil) | C. carpio | 3.07±0.15 g | 2.30 | 5 and 10 mL/kg, 60 days | HS ↑ | Kesbic (2019a) |
| Cinnamon (oil) | O. mykiss | 10.68±0.35 g | 1.60 | 1, 2, 4, 6%, 60 days | HS ↑ | Kesbic (2019b) |
| Hot pepper (oil) | O. mykiss | ~7 g | 0.15 | 1, 2, 4, 6%, 60 days | HS ↑ | Yilmaz et al. (2015a) |
| Hypericum perforatum (oil) | C. carpio | 3.07±0.02 g | 2.30 | 5 and 10 g/kg, 60 days | HS ↑ | Akyüz et al. (2018) |
| Vitis vinifera seed (oil) | O. mykiss | 30 g | 1.2 | 250, 500, 1000 mg/kg, 60 days | HS ↑, AS ↑ and SR ↑ | Aslan et al. (2018) |
| Green tea (Camellia sinensis) (oil) | O. mykiss | 76.2±0.75 g | 2% | 0.25, 0.5, 1%, 42 days | NSIRs ↑ | Almintirim & Akșu (2019) |
| Allium sativum Linne, Allium tuncelianum Kollman oils | O. mykiss | 39.0±1.64 g | 9.75 | 2% | NSIRs ↑, NBT ↓ | Almintirim & Akșu (2019) |

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### Table 1 Continued

| Additives                              | Fish species     | Initial body weight (g) | Stocking density (kg/m³) | Doses and supplementation duration | Results                           | References                      |
|----------------------------------------|------------------|-------------------------|--------------------------|------------------------------------|-----------------------------------|---------------------------------|
| Bergamot peel oil                      | *D. labrax*      | 5.10±0.05 g            | 2.04                     | 0.5, 1, 2%, 60 days                | NSIRs ↑                           | Acar et al. (2019)              |
| O. niloticus                           | 2.57±0.06 g      | 2.45                    |                           | 0.5, 1, 2%, 60 days                | NSIRs ↑ and HS ↑                  | Kesbic et al. (2020a)           |
| Monterey cypress Leaf essential oil    | *C. carpio*      | 7.86±0.15 g            | 1.96                     | 0.5, 0.75, 1%, 60 days             | HS ↑                              | Kesbic et al. (2020b)           |
| Mushrooms                              |                  |                         |                          |                                    |                                   |                                 |
| Lentilule edodes (water extract)       | *O. mykiss*      | 56.2±6.6 g             | 11.94                    | 1 and 2%, 6 weeks                  | Reduce lipid in liver              | Ulukoy et al. (2016)            |
| Yeast autolysates                      |                  |                         |                          |                                    |                                   |                                 |
| Saccharomyces cerevisiae               | *O. mykiss*      | 35 g                    | 0.7                      | 0.1 and 0.2%, 8 weeks              | NSIRs ↑ and HS ↑                  | Guven & Yalcın (2017)           |
| β-glucans                              | *O. mykiss*      | 54 g                    | 1.59                     | 0.1 and 1%, 3 weeks                | NSIRs ↑                           | Dugenci & Candan (2001)         |
| β-1,3/1,6 glucan                       | *O. niloticus*   | 25.6±0.03 g            | 0.3                      | 0.1 and 0.5%, 2 weeks              | NSIRs ↑                           | Sahan & Duman (2010)            |
| Levamisole                             | *O. mykiss*      | 99.4 and 216.0 g       | 6.27 and 13.64           | 5 mg/kg fish (intraperitonally), 14 days | NSIRs ↑                           | Ispir & Dorucu (2005)           |

AGER=antioxidant gene expression responses; AMS=ammonia stress; AS=antioxidant status; ASS=acidic stress; HS=health status; IM=modulation of intestinal morphology; IRGER=immune related gene expression responses; NSIRs=non-specific immune responses; SR=survival rate

### Table 2. Studies addressing beneficial uses of fish feed additives against *Aeromonas* spp.

| Additives                              | Fish species     | Initial body weight (g) | Stocking density (kg/m³) | Doses and supplementation duration | Results                           | References                      |
|----------------------------------------|------------------|-------------------------|--------------------------|------------------------------------|-----------------------------------|---------------------------------|
| Extracts, powders, organic acids, compounds |                  |                         |                          |                                    |                                   |                                 |
| Camellia sinensis (seed powder)        | *O. mykiss*      | 10±0.12 g               | 4                        | 10%, 10 days                       | DR to *A. hydrophila*             | Er and Kayis (2015)             |
| Capparis spinosa (methanolic extract)  | *O. mykiss*      | 12.0±0.71 g             | 0.80                     | 0.1 and 0.5 g/kg, 30 days          | IRGER ↑, NSIRs ↑ and DR to *A. hydrophila* | Bilen et al. (2016a)           |
| Avena sativa (water extract)           | *C. carpio*      | 9.9±1.52 g              | 3.56                     | 5, 10, 20 g/kg, 60 days            | NSIRs ↑ and DR to *A. hydrophila* | Baba et al. (2016a)            |
| Pleurotus ostreatus (methanolic extract) | *O. mykiss*      | 10.2±0.1 g              | 1.03                     | 0.1 and 0.5 g/kg, 30 days          | NSIRs ↑ and DR to *A. hydrophila* | Bilen et al. (2016b)           |
| Zingiber officinale powder             | *O. niloticus*   | 25.6±0.03 g             | 0.12                     | 0.1, 0.5, 1%, 90 days              | HS ↑, AS ↑ and DR to *A. hydrophila* | Sahan et al. (2016)            |
| Anethum graveolens and Lepidium sativum (methanolic extract) | *C. carpio*      | 3.4±0.1 g               | 1.76                     | 1 and 2 g/kg, 45 days              | NSIRs ↑, and DR to *A. hydrophila* | Bilen et al. (2018)            |
| Caffeic acid                           | *O. niloticus*   | 17.4±0.08 g             | 3.74                     | 1, 5, 10 g/kg, 60 days             | NSIRs ↑, IRGER ↑, AGER ↑, AS ↑, HS ↑ and DR to *A. veronii* | Yilmaz (2019a)                |
| Curcumin (powder)                      | *O. mykiss*      | 31.2±1.17 g             | 1.44                     | 1, 2, 4%, 8 weeks                  | HS ↑, NSIRs ↑, AS ↑ and DR to *Aeromonas salmonicida* subsp. achronomogens | Yonar et al. (2019)            |
| L-allin and Oleuropein                 | *O. mykiss*      | 12.6±0.91 g             | 2.57                     | 10 mg/kg, 60 days                  | HS ↑ and DR to *A. salmonicida*    | Yilmaz et al. (2020a)           |
| Malva sylvestris (Methanolic extract)  | *O. mykiss*      | 54.9±0.03 g             | 3.66                     | 0.1 and 0.5 g/kg, 30 days          | NSIRs ↑, IRGER ↑, DR to *A. hydrophila* | Bilen et al. (2020b)           |

Fruits and Plants Syrups

| Additives                              | Fish species     | Initial body weight (g) | Stocking density (kg/m³) | Doses and supplementation duration | Results                           | References                      |
|----------------------------------------|------------------|-------------------------|--------------------------|------------------------------------|-----------------------------------|---------------------------------|
| Black mulberry syrup                   | *O. niloticus*   | 9.7±0.9 g               | 2.08                     | 0.75, 1.5, 2, 3.0%, 60 days        | NSIRs ↑, HS ↑, IRGER ↑, and DR to *A. veronii* | Yilmaz et al. (2020c)           |

AGER=antioxidant gene expression responses; AS=antioxidant status; DR=disease resistance; HS=health status; IRGER=immune related gene expression responses; NSIRs=non-specific immune responses
Table 3. Studies addressing beneficial uses of fish feed additives against *Streptococcus* spp.

| Additives | Fish species | Initial body weight (kg/m³) | Stocking density (kg/m³) | Doses and supplementation duration | Results | References |
|-----------|--------------|-----------------------------|--------------------------|-----------------------------------|----------|------------|
| Extracts, powders | | | | | | |
| *Cuminum cyminum* | *O. mossambicus* | 0.56±0.02 | 0.015 | 0.5, 1, 1.5, 2%, 75 days | DR to S. iniae | Yilmaz et al. (2012) |
| *O. mossambicus* (fry) | | 0.012±0.001 | 0.02 | 0.5, 1, 1.5, 2%, 45 days | DR to S. iniae | Yilmaz et al. (2013c) |
| Thymus vulgaris, Rosmarinus officinalis and Trigonella foenum graecum L. (powders) | *O. mossambicus* (fry) | 0.012±0.001 | 0.02 | 1%, 45 days | DR to S. iniae | Yilmaz et al. (2013b) |
| Tribulus terrestris (extract) | *O. mossambicus* (fry) | 0.0120 | 0.02 | 200, 400, 600, 500 mg/kg, 45 days | PRHD ↓ and DR to S. iniae | Yilmaz et al. (2014) |
| *Pimenta dioica* (powder) | *O. mossambicus* (fry) | 0.012 | 0.02 | 5, 10, 15, 20 g/kg, 50 days | DR to S. iniae | Yilmaz and Ergun (2014) |
| Essential oils | | | | | | |
| Sweet orange peel | *O. mossambicus* | 0.91±0.03 | 0.56 | 0.1, 0.3, 0.5%, 90 days | NSIRs ↑ and DR to S. iniae | Acar et al. (2015) |

DR=disease resistance; NSIRs=non-specific immune responses; PRHD=pathogen related histological damage

Table 4. Studies addressing beneficial uses of fish feed additives against *Vibrio anguillarum*

| Additives | Fish species | Initial body weight (kg/m³) | Stocking density (kg/m³) | Doses and supplementation duration | Results | References |
|-----------|--------------|-----------------------------|--------------------------|-----------------------------------|----------|------------|
| Extracts, powders, essential oil | | | | | | |
| *Cotinus coggygria* leaf powder | *C. carpio* | 4.14±0.08 | 1.81 | 0.5, 1, 1.5 g/kg 4 weeks | NSIRs ↑ and DR to V. anguillarum | Bilen et al. (2013) |
| *Artemisia vulgaris* (powder and ethanolic extract) | *O. mykiss* | 20.48±0.19 g and 20.81±0.04 g | 0.35 and 0.36 | Powder: 0.1, 0.5, 1, 2%  Extract: 250, 1000 mg/kg, 45 days | NSIRs ↑ and DR to V. anguillarum | Diler et al. (2018a) |
| *Vaccinium myrtillus, Glycyrrhize glabra, Echinacea angustifolia and Salvia officinalis* | *O. mykiss* | 15±2 | 1.28 | 0.1 and 1%, 45 days | NSIRs ↑ and DR to V. anguillarum | Terzioglu and Diler (2016) |
| *Cotinus coggygria* and *Malva sylvestris* (methanolic extract) | *S. aurata* and *D. labrax* | 19.92±0.40 g and 18.66±0.86 g | 1.10 and 1.03 | 500, 1000 mg/kg, 60 days | NSIRs ↑ and DR to V. anguillarum | Bilen et al. (2019) |
| *Origanum vulgare L.* essential oil | *O. mykiss* | 26 | 0.45 | 0.125, 1.5, 2.5, 3.0 ml/kg, 90 days | DR to V. anguillarum | Diler et al. (2017c) |

DR=disease resistance; NSIRs=non-specific immune responses;
### Table 5. Studies addressing beneficial uses of fish feed additives against *Yersinia ruckeri*

| Additives                        | Fish species | Initial body weight | Stocking density (kg/m³) | Doses and supplementation duration | Results                                                                 | References                                |
|----------------------------------|--------------|---------------------|--------------------------|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------|
| Extracts, powders, oils          | *O. mykiss*  | 84±1.02 g           | 5.6                      | 10 mL/100 g, 1 week                 | HS ↑ after *Y. ruckeri* infection                                      | Gulec et al. (2013)                       |
| Thyme and Fennel oils            | *O. mykiss*  | 50 to 60 g          | 2.5 to 3                 | 10, 20, 30%, 50 days                | HS ↑, AS ↑, NSIRs ↑ and DR to *Y. ruckeri*                               | Sahan et al. (2017)                      |
| Rosa canina powder               | *O. mykiss*  | 6.79±0.02 g         | 2.71                     | 0.5, 1, 2%, 60 days                 | HS ↑ and DR to *Y. ruckeri*                                             | Acar et al. (2018)                       |
| Pomegranate seed (oil)           | *O. mykiss*  | 51.22±3.04 g        | 5.48                     | 0.1, 0.25, 0.5, 1%, 60 days         | IRGER ↑, NSIRs ↑, HS ↑ and DR to *Y. ruckeri*                           | Baba et al. (2018)                       |
| Olive leaf (ethanolic extract)   | *O. mykiss*  | 17.01±0.05 g        | 3.64                     | 250, 500, 750, 1500 mg/kg, 60 days  | NSIRs ↑, IRGER ↑, HS ↑ and DR to *Y. ruckeri*                           | Yilmaz and Ergun (2018)                  |
| Cinnamic acid                    | *O. mykiss*  | 4.48±0.03 g         | 2.46                     | 0.5, 1, 3 mL/kg, 90 days            | NSIRs ↑, HS ↑, DR to *Y. ruckeri*                                      | Gultepe, (2020)                          |

**AS=antioxidant status; DR=disease resistance; HS=health status; IRGER=immune related gene expression responses; NSIRs=non-specific immune responses**

### Table 6. Studies addressing beneficial uses of fish feed additives against *Lactococcus garvieae*

| Additives                        | Fish species | Initial body weight | Stocking density (kg/m³) | Doses and supplementation duration | Results                                                                 | References                                |
|----------------------------------|--------------|---------------------|--------------------------|-------------------------------------|-------------------------------------------------------------------------|-------------------------------------------|
| Plant oils, essential oils       | *O. mykiss*  | 18.31±0.10 g        | 6.59                     | 0.5, 1, 2%, 45 days                 | NSIRs ↑ and DR to *L. garvieae*                                        | Baba et al. (2017)                       |
| Argan oil                        | *O. mykiss*  | 12.10±0.13 g        | 2.59                     | 4, 8, 12%, 60 days                  | HS ↑ and DR to *L. garvieae*                                            | Yilmaz et al. (2020b)                    |
| Olive pomace oil                 | *O. mykiss*  | 20.05±0.15 g        | 5.21                     | 0.125, 1.5, 2.5, 3 mL/kg, 90 days   | DR to *L. garvieae*                                                    | Diler et al. (2017b)                     |
| Origanum onites essential oil    | *O. mykiss*  | 20 g                | 0.6                      | 1 and 2%, 6 weeks                   | NSIRs ↑ and DR to *L. garvieae*                                        | Baba et al. (2015)                       |
| Mushrooms                        | *O. mykiss*  | 20 g                | 0.6                      | 1 and 2%, 6 weeks                   | NSIRs ↑ and DR to *L. garvieae*                                        | Baba et al. (2015)                       |

**DR=disease resistance; HS=health status; NSIRs=non-specific immune responses**
Table 7. Studies addressing beneficial uses of fish feed additives against *Edwardsiella tarda*

| Additives                              | Fish species | Initial body weight (kg/m³) | Stocking density (kg/m³) | Doses and supplementation duration | Results                                                                 | References                      |
|----------------------------------------|--------------|-----------------------------|--------------------------|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|
| Extracts                               |              |                             |                          |                                     |                                                                         |                                 |
| *Anethum graveolens* and *Lepidium sativum* (methanolic extract) | *C. carpio* | 3.46±0.1 g                  | 1.76                     | 1 and 2 g/kg, 45 days               | NSIRs ↑, and DR to *E. tarda*                                           | Bilen et al. (2018)             |
| Olive leaf (ethanolic extract)         | *C. carpio*  | 15.90±0.93 g                | 0.318                    | 0.1, 0.25, 0.5, 1%, 60 days         | IRGER ↑, NSIRs ↑, HS ↑ and DR to *E. tarda*                              | Zemheri-Navruz et al. (2019)    |
| Essential oils                         |              |                             |                          |                                     |                                                                         |                                 |
| Citrus limon peel                      | *O. massamibicus* | 12.87±0.18 g               | 6.43                     | 0.5, 0.75, 1%, 60 days              | NSIRs ↑, HS ↑ and DR to *E. tarda*                                      | Baba et al. (2016b)             |

DR=disease resistance; HS=health status; IRGER=immune related gene expression responses; NSIRs=non-specific immune responses

Table 8. Studies addressing beneficial uses of fish feed additives against *Plesiomonas shigelloides*, *Mycobacterium salmoniphilum* and *Spironucleus salmonis*

| Additives                              | Fish species | Initial body weight (kg/m³) | Stocking density (kg/m³) | Doses and supplementation duration | Results                                                                 | References                      |
|----------------------------------------|--------------|-----------------------------|--------------------------|-------------------------------------|-------------------------------------------------------------------------|---------------------------------|
| Powders, Extracts                      |              |                             |                          |                                     |                                                                         |                                 |
| *Rosa canina* powder                   | *A. gueldenstaedtii* | 307.8±11.4 g               | 1.53                     | 5, 10, 15%, 35 days                 | NSIRs ↑ and DR to *M. salmoniphilum*                                   | Duman and Sahan (2018)          |
| Artemisia campestris (ethanolic extract) | *O. mykiss*  | 1.5-2.0 g                   | 0.18                     | 1.0, 1.5, 2.0, 2.5, 3.0 g/kg, 7 and 21 days | DR to *S. salmonis*                                                    | Diler et al. (2018b)            |
| Fruits and Plants Syrups              |              |                             |                          |                                     |                                                                         |                                 |
| Blackberry syrup                       | *O. niloticus* | 26.75±2.67 g               | 5.73                     | 7.5, 15, 30 g/kg, 90 days           | NSIRs ↑, IRGER ↑, AGER ↑, AS ↑ and DR to *P. shigelloides*             | Yilmaz (2019c)                  |

AGER=antioxidant gene expression responses; AS=antioxidant status; DR=disease resistance; IRGER=immune related gene expression responses; NSIRs=non-specific immune responses
Author Contribution

Authors shared equally in this work. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare that they have no conflict interest.

References

Acar, U. (2018a). Effects of diet supplemented with ethanolic extract of propolis on growth performance, hematological and serum biochemical parameters and disease resistance of Mozambique tilapia (Oreochromis mossambicus) against Streptococcus iniae. Aquaculture, 495, 339-344. https://doi.org/10.1016/j.aquaculture.2018.06.007

Acar, U. (2018b). Sari kantaron (Hypericum perforatum) yağının sapan yavruşunun (Cyprinus carpio) büyüme performansını ve bazı kan parametreleri üzerine etkisini. Alıntıleri Birimler Dergisi, 33(1), 21-27. https://doi.org/10.28955/alinterizbd.343202

Acar, U., Kesbic, O. S., Inanan, B. E., & Yilmaz, S. (2019). Effects of dietary Bergamot (Citrus bergamia) peel oil on growth, haematology and immune response of European sea bass (Dicentrarchus labrax) juveniles. Aquaculture Research, 50(11), 3305-3312. https://doi.org/10.1111/are.14288

Acar, U., Kesbic, O. S., Yilmaz, S., Gultepe, N., & Turker, A. (2015). Evaluation of the effects of essential oil extracted from sweet orange peel (Citrus sinensis) on growth rate of tilapia (Oreochromis mossambicus) and possible disease resistance against Streptococcus iniae. Aquaculture, 437, 282-286. https://doi.org/10.1016/j.aquaculture.2014.12.015

Acar, U., Parrino, V., Kesbic, O. S., Lo Paro, G., Saoca, C., Abbate, F., Yilmaz, S., & Fazio, F. (2018). Effects of different levels of pomegranate seed oil on some blood parameters and disease resistance against Yersinia ruckeri in rainbow trout. Frontiers in Physiology, 9, 596. https://doi.org/10.3389/fphys.2018.00596

Altintemir, B. & Aksu, O. (2019). Masere sarımsa (Allium sativum L.) ve Tunceli sarımsağı (Allium tuncelianum Kollman) yağlarının yoğun stoklanmış gökkuşağı alabalıklarının (Oncorhynchus mykiss W.) bazı kan parametreleri ve NBT (Nitroblue Tetrazolium) enzimler üzerine etkisi. BAUN Fen Bilimleri Enstitüsü Dergisi, 21(2): 716-723. https://doi.org/10.25092/baunfbed.637083

Altınterim, B., Öztürk, E., Kutluyer, F., & Aksu, O. (2018). Yeşil çay yağının gökkuşağı alabalıklarının (Oncorhynchus mykiss) yem değerlendirme oranına ve hematolojik parametrelerine etkisi. Atatürk Üniversitesi Veteriner Bilimleri Dergisi, 13(2): 159-164. https://doi.org/10.17094/atunibvd.296989

Agnew, W., & Barnes, A. C. (2007). Streptococcus iniae: An aquatic pathogen of global veterinary significance and a challenging candidate for reliable vaccination. Veterinary Microbiology, 122(1-2), 1-15. https://doi.org/10.1016/j.vetmic.2007.03.002

Aksit, D. (2016). Balık yetiştiriciliğinde antibakteriyel direnç ve önemi. Türkiye Kliniğileri Veteriner Zəirə Bilimlər Dərgisi, 13(2): 159-164. https://doi.org/10.1016/j.turkvetmic.2007.03.002

Akşu, A. (2018). Yüzük sıcaklıkla oksidatif stresre maruz bırakılan gökkuşağı alabalıklarında (Oncorhynchus mykiss Walbaum, 1792), karayemiş yaprağı (Laurocerasus officinalis Roem.) ekstraktının büyüme, yaşam oranı ve bazı antioksidan enzimler üzerine etkisi. Su Ürünleri Dergisi, 35(2): 131-139. https://doi.org/10.12714/egefs.2018.35.2.05

Almabrok, A. A., Amhamed, I. D., Mohamed, G. A., Bilen, S., & Altiﬁ, T. A. S. (2018). Effect of Tilia tomentosa methanolic extract on growth performance, digestive enzyme activity, immune system and haematological indices of common carp (Cyprinus carpio). Marine Science and Technology Bulletin, 7(1), 12-20. https://doi.org/10.33714/masteb.421047

Altunoglu, Y. C., Bilen, S., Ulu, F., & Bıswas, G. (2017). Immune responses to methanolic extract of black cumin (Nigella sativa) in rainbow trout (Oncorhynchus mykiss). Fish & Shellfish Immunology, 67, 103-109. https://doi.org/10.1016/j/fsi.2017.06.002

Amhamed, I. D., Mohamed, G. A., Almabrok, A. A., Altiﬁ, T. A. S., & Bilen, S. (2018). Efficacy of dietary Cheno papodium album extract on some health parameters, digestive enzymes and growth performance in juvenile Cyprinus carpio. Alıntıleri Birimler Dergisi, 33(2), 165-176. https://doi.org/10.28955/alinterizbd.412455

Arslan, G., Sonmez, A. Y., & Yanık, T. (2018). Effects of grape Vitis vinifera seed oil supplementation on growth, survival, fatty acid proﬁles, antioxidant contents and blood parameters in rainbow trout (Oncorhynchus mykiss). Aquaculture Research, 49(6), 2256-2266. https://doi.org/10.1111/are.13686

Austin, B., & Austin, D.A. (2016). Aeromonadaceae representatives (motile aeromonads). In B. Austin & D.A. Austin (Eds.), Bacterial fish pathogens: Disease of farmed and wild fish (sixth ed., pp 161-214). Springer. https://doi.org/10.1007/978-3-319-32674-0

Baba, E., Acar, U., Ontas, C., Kesbic, O. S., & Yilmaz, S. (2016a). The use of Avena sativa extract against Aeromonas hydrophila and its effect on growth performance, hematological and immunological parameters in common carp (Cyprinus carpio). Italian Journal of Animal Science, 15(2), 325-333. https://doi.org/10.1007/1828051X.2016.1185977

Baba, E., Acar, U., Ontas, C., Kesbic, O. S., & Yilmaz, S. (2016b). Evaluation of Citrus limon peels essential oil on growth performance, immune response of Mozambique tilapia Oreochromis mossambicus challenged with Edwardsiella tarda. Aquaculture, 465, 13-18. https://doi.org/10.1016/j.aquaculture.2016.08.023

Baba, E., Acar, U., Yilmaz, S., Ontas, C., & Kesbic, O.S. (2017). Pre-challenge and post-challenge haematological changes in Oreochromis niloticus (Linnaeus, 1758) fed argan oil against Lactococcus garvieae. Aquaculture Research, 48(8), 4563-4572. https://doi.org/10.1111/are.13282

Baba, E., Acar, U., Yilmaz, S., Zemheri, F., & Ergun, S. (2018). Dietary olive leaf (Olea europea L.) extract alters some immune gene expression levels and disease resistance to Yersinia ruckeri infection in rainbow trout Oncorhynchus.
mykiss. Fish & Shellfish Immunology, 79, 28-33. https://doi.org/10.1016/j.fsi.2018.04.063
Baba, E., Ulukoy, G., & Ontas, C. (2015). Effects of feed supplemented with Lentinula edodes mushroom extract on the immune response of rainbow trout, Oncorhynchus mykiss, and disease resistance against Lactococcus garvieae. Aquaculture, 448, 476-482. https://doi.org/10.1016/j.aquaculture.2015.04.031
Bilen, S., Altiief, T. A. S., Ozdemir, K. Y., Salem, M. A. O., Terzi, E., & Guney, K. (2020a). Effect of lemon balm (Melissa officinalis) extract on growth performance, digestive and antioxidant enzyme activities, and immune responses in rainbow trout (Oncorhynchus mykiss). Fish Physiology and Biochemistry, 46(1), 471-481. https://doi.org/10.1007/s10695-019-00737-z
Bilen, S., Altunoglu, Y. C., Ulu, F., & Biswas, G. (2016a). Innate immune and growth promoting responses to caper (Capparis spinosa) extract in rainbow trout (Oncorhynchus mykiss). Fish & Shellfish Immunology, 57, 206-212. https://doi.org/10.1016/j.fsi.2016.08.040
Bilen, S., Karga, M., Altunoglu, Y. C., Ulu, F., & Biswas, G. (2020b). Immune responses and growth performance of the aqueous methanolic extract of Malva sylvestris in Oncorhynchus mykiss. Marine Science and Technology Bulletin, 9(2), 159-167. https://doi.org/10.33714/masteb.746951
Bilen, S., Kenangolu, O. N., Terzi, E., Ozdemir, R. C., & Sonmez, A. Y. (2019). Effects of tetra (Cotinus coggyria) and common mallow (Malva sylvestris) plant extracts on growth performance and immune response in Gilthead sea bream ( Sparus aurata) and European sea bass (Dicentrarchus labrax). Aquaculture, 734251. https://doi.org/10.1016/j.aquaculture.2019.734251
Bilen, S., Ozkan, O., Alagöz, K., & Ozdemir, K. Y. (2018). Effect of dill (Anethum graveolens) and garden cress (Lepidium sativum) dietary supplementation on growth performance, digestive enzyme activities and immune responses of juvenile common carp (Cyprinus carpio). Aquaculture, 495, 611-616. https://doi.org/10.1016/j.aquaculture.2018.06.037
Bilen, S., Unal, S., & Guvensoy, H. (2016b). Effects of oyster mushroom (Pleurotus ostreatus) and nettle (Urtica dioica) methanolic extracts on immune responses and resistance to Aeromona hydrophila in rainbow trout (Oncorhynchus mykiss). Aquaculture, 454, 90-94. https://doi.org/10.1016/j.aquaculture.2015.12.010
Bilen, S., Yilmaz, S., & Bilen, A. M. (2013). Influence of tetra (Cotinus coggyria) extract against Vibrio anguillarum infection in koi carp, Cyprinus carpio with reference to haematological and immunological changes. Turkish Journal of Fisheries and Aquatic Sciences, 13(3), 517-522. https://doi.org/10.4194/1303-2712-v13_3_16
Capkin, E., Ozdemir, S., Ozturk, R. C., & Altinok, I. (2017). Determination and transferability of plasmid-mediated antibiotic resistance genes of the bacteria isolated from rainbow trout. Aquaculture Research, 48(11), 5561-5575. https://doi.org/10.1111.13378
Capkin, E., Terzi, E., & Altinok, I. (2015). Occurrence of antibiotic resistance genes in cultivable bacteria isolated from Turkish trout farms and their local aquatic environment. Diseases of Aquatic Organisms, 114(2), 127-137. https://doi.org/10.3354/dao02852
Collins, M., Farrow, J., Phillips, B., & Goddard, O. (1983). Streptococcus garvieae sp. nov. and Streptococcus plantarum sp. nov. Microbiology, 129(11), 3427-3431. https://doi.org/10.1099/00221287-129-11-3427
Cortez, R., Luna-Vital, D. A., Margulis, D., & De Mejia, E. G. (2017). Natural pigments: stabilization methods of anthocyanins for food applications. Comprehensive Reviews in Food Science and Food Safety, 16(1), 180-198. https://doi.org/10.1111/1541-4337.12244
Diler, O., & Gormez, O. (2019). Gökkuşağı alabalıklarında (Oncorhynchus mykiss) bitkisel yem katkı maddelerinden Artemisia campestris L. ve Artemisia absinthium L’un bağırsak histomorfolojisi üzerine etkisi. Süleyman Demirel Üniversitesi Eğitim ve Bilim Fakültesi Dergisi, 15(1), 10-18. https://doi.org/10.22392/egirdir.422547
Diler, O., Atabay, A., & Gormez, O. (2017a). Bitkisel katkı maddesi Artemisia vulgaris’ı gökkuşağı alabalıklarında (Oncorhynchus mykiss, Walbaum) büyüme performansı ve antioksidan aktivite üzerine etkisi. Süleyman Demirel Üniversitesi Eğitim ve Bilim Fakültesi Dergisi, 13(2), 119-131. https://dergipark.org.tr/tr/pub/egirdir/issue/30873/268454
Diler, O., Gormez, O., Diler, I., & Metin, S. (2017b). Effect of oregano (Origanum onites L.) essential oil on growth, lysozyme and antioxidant activity and resistance against Lactococcus garvieae in rainbow trout, Oncorhynchus mykiss (Walbaum). Aquaculture Nutrition, 23(4), 844-851. https://doi.org/10.1111/1541-4337.12451
Diler, O., Gormez, O., Metin, S., Ihan, I., & Diler, I. (2017c). Origanum vulgare L. ucuçu yabanı gökkuşağı alabalıklarında (Oncorhynchus mykiss) daiche, lizozim ve antioksidan aktivite ve Vibrio anguillarum’a karşı direnç üzerine etkisi. Süleyman Demirel Üniversitesi Eğitim ve Bilim Fakültesi Dergisi, 13(1), 42-57. https://doi.org/10.22392/egirdir.252029
Diler, O., Gormez, O., Terzioglu, S., & Atabay, A. (2018a). Pelin otu (Artemisia vulgaris L.’nın gökkuşağı alabalıklarında (Oncorhynchus mykiss, walbaum) hastalıklara karşı direnç ve spesifik olmayan bağışıklık sistem üzerine etkisi. Journal of Aquaculture Engineering and Fisheries Research, 4(1), 1-11. https://doi.org/10.3153/JAEFR18001
Diler, O., Gormez, O., Terzioglu, S., & Bayrak, H. (2018b). Gökkuşağı alabalığı (Oncorhynchus mykiss) yetiştiriciliğinde görülen spironucleosis enfeksiyonlarının tedavisi ve Artemisia campestris (L’)ın kullanımı. Süleyman Demirel Üniversitesi Eğitim ve Bilim Fakültesi Dergisi, 14(4), 312-323. https://doi.org/10.22392/egirdir.407905
Dugenci, S. K., & Candan, A. (2001). Gökkuşağı alabalıklarında (Oncorhynchus mykiss, Walbaum) bazı immunostimulanların spesifik olmayan bağışıklık sistemi üzerine etkisi. Türk JOURNAL OF ETHNOPHARMACOLOGY, 88(1), 99-106. https://doi.org/10.1016/s0378-8741(03)00182-x
Duman, S., & Sahal, A. (2018). Some medicinal plants as immunostimulant for fish. Journal of Ethnopharmacology, 88(1), 99-106. https://doi.org/10.1016/s0378-8741(03)00182-x
Duman, S., & Sahal, A. (2018). Some hematological and non-specific immune responses of rosehip (Rosa canina)-Fed Russian Sturgeon (Acipenser gueldenstaedtii Brandt & Ratzeburg, 1833) to Mycobacterium salmoniphilum. Brazilian Archives of Biology and Technology, 61, 1-17. http://dx.doi.org/10.1590/1678-4324-2018180283
Elder, A., & Ghittino, C. (1999). Lactococcus garvieae and Streptococcus iniae infections in rainbow trout *Oncorhynchus mykiss*: similar, but different diseases. *Diseases of Aquatic Organisms*, 36(3), 227-31. https://doi.org/10.3354/dao0363227

Er, A., & Kayis, S. (2015). Çay bitkisi (Camellia sinensis) tohumunun gökkuşağı alabalıklarında (Oncorhynchus mykiss) Aeromomas hydrophila enfeksiyonuna karşı kullanımının araştırılması. El-Cezeri Science and Engineering Journal, 2(3), 67-74. https://doi.org/10.31202/ecjce.67145

Ewing, W., McWhorter, A., Escobar, M., & Lubin, A. (1965). Edibility of a new genus of Enterobacteriaceae based on a new species, *E. tarsa*. International Bulletin of Bacteriological Nomenclature and Taxonomy, 15(1), 33-38. https://doi.org/10.1099/00207713-15-1-33

FAO (2018). FAO Yearbook, Fishery and Aquaculture Statistics. http://www.fao.org/3/cb1213t/CB1213T.pdf

Frans, I., Michiels, C. W., Bossier, P., Willems, K. A., Lievens, B., & Rediers, H. (2011). *Vibrio anguillarum* as a fish pathogen: Virulence factors, diagnosis and prevention. *Journal of Fish Diseases*, 34(9), 643-661. https://doi.org/10.1111/j.1365-2761.2011.01279.x

Gauthier, D. T. (2015). Bacterial zoonoses of fishes: A review and appraisal of evidence for linkages between fish and human infections. *The Veterinary Journal*, 203(1), 27-35. https://doi.org/10.1016/j.tvjl.2014.10.028

Gudding, R., Lillehaug, A., & Evensen, O. (2014). Fish Vaccination. John Wiley & Sons. https://doi.org/10.1002/9781118806913

Gulec, A. K., Danabas, D., Ural, M., Seker, E., Arslan, A., & Serdar, O. (2013). Effect of mixed use of thyme and fennel oils on biochemical properties and electrolytes in rainbow trout as a response to *Yersinia ruckeri* infection. *Acta Veterinaria Brno*, 82(3), 297-302. https://doi.org/10.2754/avb201382030297

Gullu, K., Acar, U., Kesbic, O. S., Yilmaz, S., Agdamar, S., Ergun, S., & Turker, A. (2016). Beneficial effects of oral allspice, *Pimenta dioica* powder supplementation on the hematopoietic and immune responses of *Oreochromis mossambicus*. *Aquaculture Research*, 47(9), 2697-2704. https://doi.org/10.1111/are.12717

Gultepe, N. (2020). Protective effect of d-limonene derived from orange peel essential oil against *Yersinia ruckeri* in rainbow trout. *Aquaculture Reports*, 18, 100417. https://doi.org/10.1016/j.aqrep.2020.100417

Gultepe, N., Acar, U., Kesbic, O. S., Yilmaz, S., Yildirim, O., & Turker, A. (2014). Effects of dietary *Tribulus terrestris* extract supplementation on growth, feed utilization, hematological, immunological, and biochemical variables of Nile tilapia *Oreochromis niloticus*. *The International Journal of Aquaculture-Bamidgeh*, 66, 1-9. https://doi.org/10.46989/001c.20774

Guven, A., & Yalcin, S. (2017). Effects of dietary yeast autolysate on performance, some blood parameters and lysozyme activity in rainbow trout (*Oncorhynchus mykiss*). *Ankara Universitesi Veteriner Fakultesi Dergisi*, 64(3), 177-182. https://doi.org/10.1501/Vetfak_0000002796

Horne, M. T., & Barnes, A. C. (1999). Enteric redmouth disease (*Yersinia ruckeri*), in P.T.K. Woo and D.W. Bruno (Eds.), *Fish Diseases and Disorders, Viral, Bacterial and Fungal Infections*, CAB International, Wallingford.

Ispir, U., & Dorucu, M. (2005). A study on the effects of levamisole on the immune system of rainbow trout (*Oncorhynchus mykiss, walbaum*). *Turkish Journal of Veterinary and Animal Sciences*, 29, 1169-1176. https://dergipark.org.tr/tr/download/article-file/132674

Kesbic, O. S. (2019a). Effects of juniper berry oil on growth performance and blood parameters in common carp (*Cyprinus carpio*). *Aquaculture Research*, 50(1), 342-349. https://doi.org/10.1111/are.13908

Kesbic, O. S. (2019b). Effects of the cinnamon oil (Cinnamomum verum) on growth performance and blood parameters of rainbow trout (*Oncorhynchus mykiss*). *Turkish Journal of Agriculture-Food Science and Technology*, 7(2), 370-376. https://doi.org/10.24925/turjaf.v7i2.370.376.2360

Kesbic, O. S., Acar, U., Yilmaz, S., & Aydin, O. D. (2020a). Effects of bergamot (*Citrus bergamia*) peel oil-supplemented diets on growth performance, haematological and serum biochemical parameters of Nile tilapia (*Oreochromis niloticus*). *Fish Physiology Biochemistry*, 46, 103-110. https://doi.org/10.1007/s10695-019-00700-y

Kesbic, O. S., Parrino, V., Acar, U., Yilmaz, S., Paro, G. L., & Fazio, F. (2020b). Effects of *Monterey cypress (Cupressus macrocarpa* Hartw) leaf essential oil as a dietary supplement on growth performance and haematological and biochemical parameters of common carp (*Cyprinus carpio* L.). *Annals of Animal Science*, 1-33. https://doi.org/10.2478/aoas-2020-0041

Kwark, E. & Didinen, B. I. (2017). Gökkuşağı alabalığı (*Oncorhynchus mykiss, Walbaum 1792*)nin yemlerine biberiye bitki (Rosmarinus officinalis) yapısı ilavesinin balıkların büyüme performansını ve bazı kan parametrelerine olan etkilerini. *Yunus Research Bulletin*, 2, 193-202. https://doi.org/10.17693/yunusae.vi.287094

Lee, C. S. (2015). Dietary Nutrients, Additives and Fish Health. Wiley-Blackwell. https://doi.org/10.1002/9781119005568

Ozturk, R. C., & Altınok, I. (2014). Bacterial and viral fish diseases in Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, 14(1), 275-297. https://doi.org/10.4194/1303-2712-v14_1_30

Parrino, V., Kesbic, O. S., Acar, U., & Fazio, F. (2019). Hot pepper (*Capsicum sp.*) oil and its effects on growth performance and blood parameters in rainbow trout (*Oncorhynchus mykiss*). *Natural Product Research*, 34(22), 3226-3230. https://doi.org/10.1080/14786419.2018.1550769

Öntaş, C., Uluköy, G., BABA, E., & Mammadov, R. (2020). *Crocus cancellatus* subsp. *mazziacius* (Herbert) mathew bitki ekstratının avrupa deniz levrek balığı (*Dicentrarchus labrax, L. 1758*) doğal bağışıklık sistemi üzerine etkisi. *Acta Aquatica Turcica*, 16(1), 148-157. https://doi.org/10.22392/actaquatr.13017

Ravelo, C., Magarinos, B., López-Romalde, S., Toranzo, A. E., & Romalde, J. L. (2003). Molecular fingerprinting of fish-pathogenic *Lactococcus garvieae* strains by random amplified polymorphic DNA analysis. *Journal of Clinical Microbiology*, 41(2), 751-756. https://doi.org/10.1128/JCM.41.2.751-756.2003

Rehulk, J., Marejková, M., & Petrás, P. (2012) Edwardsiellosis in farmed rainbow trout (*Oncorhynchus mykiss*). *Aquaculture Research*, 43(11), 1628-1634. https://doi.org/10.1111/j.1365-2109.2011.02968.x

Sahan, A., & Duman, S. (2010). Influence of beta-1, 3/1, 6 glucan applications on some non-specific cellular immune response and haematologic parameters of
healthy Nile tilapia (Oreochromis niloticus L., 1758). Turkish Journal of Veterinary and Animal Sciences, 34(1), 75-81. https://doi.org/10.3906/vet-0810-21

Sahan, A., Duman, S., Colak, S. O., Cinar, E., & Bilgin, R. (2017). Determination of some hematomal and non-specific immune defences, oxidative stress and histopathological status in rainbow trout (Oncorhynchus mykiss) fed rosehip (Rosa canina) to Yersinia ruckeri. Turkish Journal of Fisheries and Aquatic Sciences, 17(1), 91-100. https://doi.org/10.4194/1303-2712-v17_1_20

Sahan, A., Ozuysak, S., & Kurutas, E. B. (2016). Determination of some hematomal parameters and antioxidant capacity in Nile tilapia (Oreochromis niloticus Linnaeus, 1758) fed ginger (Zingiber officinale Roscoe) to Aeromonas hydrophila. Turkish Journal of Fisheries and Aquatic Sciences, 16, 197-204. https://doi.org/10.4194/1303-2712-v16_1_20

Savaşer, S., Akçimen, U., Ceylan, M., Bektaş, Z. H., Yener, O., & Bulut, C. (2019). Zencefil (Zingiber officinale)’in gökkuşağı alabalıklarında (Oncorhynchus mykiss) immunostimulant ve büyüme destekleyici olarak kullanım. Journal of Limnology and Freshwater Fisheries Research 5(2), 121-135. https://doi.org/10.17216/limnfish.487812

Schliefer, K. H., Kraus, J., Dvorak, C., Klipper-Balz, R., Collins, M. D., & Fischer, W. (1985). Transfer of Streptococcus lactis and related streptococci to the genus Lactococcus gen. nov. Systematic and Applied Microbiology, 6(2), 183-195. https://doi.org/10.1016/0723-2027(85)80052-7

Teixeira, L. M., Merquiør, V. L. C., Vianni, C. E., Carvalho, C., Franca, L. S., R., Carvalho, C., Vianni, C. E., & Carvalho, C. (2013). Phenotypic and genotypic characterization of a typical Lactococcus garvieae strains isolated from water buffalos with subclinical mastitis and confirmation of L. garvieae as a senior subjective synonym of Enterococcus seriolicida. International Journal of Systematic and Evolutionary Microbiology, 46(3), 664-668. https://doi.org/10.1099/00207713-46-3-664

Terzioglu, S., & Diler, O. (2016). Effect of dietary sage (Salvia officinalis L.), licorice root (Glycyrrhize glabra L.), blueberry (Vaccinium myrtillus L.) and echinacea (Echinacea angustifolia Bell) on nonspecific immune and resistance to Vibrio anguillarum infection in rainbow trout, (Oncorhynchus mykiss). Süleyman Demirel Üniversitesi Eğitim Üretim Fakülteleri Dergisi, 12(2), 110-118. https://doi.org/10.22392/egirdir.284921

TUİK (2019). Su ürünleri istatistikleri. https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-1118&d=1

Ulukoy, G., Baba, E., & Birincioglu, S. S. (2016). Effects of dietary Lentinula edodes extract on liver and gut histology of rainbow trout (Oncorhynchus mykiss), Walbaum 1792. Fish & Shellfish Immunology, 53, 106. https://doi.org/10.1016/j.fsi.2016.04.068

Ulukoy, G., Metin, S., Kubilay, A., Guney, S., Yildirim, P., Guezely, M., Seydim, Z., Kalk-Tas, T., & Guemus, E. (2017). The effect of kefir as a dietary supplement on nonspecific immune response and disease resistance in juvenile rainbow trout, Oncorhynchus mykiss (Walbaum 1792). Journal of the World Aquaculture Society, 48(2), 248-256. https://doi.org/10.1111/jwas.12336

Woo, P. T. K., & Bruno, D. W. (2017). Fish diseases and disorders,. Volume 3: Viral, bacterial and fungal infections., In: Woo PTK, Cipriano RC (eds): Wallingford, UK, CAB International.

Woo, P. T. K., & Cipriano, R. C. (2017). Fish viruses and bacteria: pathobiology and protection. CABI Publishing. Wallingford, UK. https://doi.org/10.1079/9781780647784.0000

Yarsan, E. (2013). Veteriner hekimlikte antibiotikler (pratik bilgiler rehberi). Güneysip Kitabevi.

Yıldırım, O. (2008). Aquafeed industry in Turkey: its aquafeed projections towards the year 2015. Turkish Journal of Fisheries and Aquatic Sciences, 8(1), 93-98. https://www.tr;jfis.org/abstract.php?lang=en&id=595

Yılmaz, S., Ergun, S., Kaya, H., & Gurkan, M. (2014). Influence of Tribulus terrestris extract on the survival and histopathology of Oreochromis mossambicus (Peters, 1852) fry before and after Streptococcus iniae infection. Journal of Applied Ichthyology, 30(5), 994-1000. https://doi.org/10.1111/jai.12458

Yılmaz, E. (2019d). Effects of dietary anthocyanin on innate immune parameters, gene expression responses, and ammonia resistance of Nile tilapia (Oreochromis niloticus). Fish & Shellfish Immunology, 93, 694-701. https://doi.org/10.1016/j.fsi.2019.08.033

Yılmaz, E. (2020). Effect of dietary carob (Ceratonia siliqua) syrup on blood parameters, gene expression responses and ammonia resistance in tilapia (Oreochromis niloticus). Aquaculture Research, 51(5), 1903-1912. https://doi.org/10.1111/are.14540

Yılmaz, E., & Er, M. (2019). Effects of figs and rosemary extracts on rainbow trout (Oncorhynchus mykiss) on growth performance and blood parameters. Acta Aquatica Turcica, 15(1), 19-25. https://doi.org/10.17216/egirdir.429630

Yılmaz, E., Celik, E. S., Ergun., S., & Yılmaz, S. (2020b). Effects of dietary olive pomace oil on growth performance, some immune parameters and disease resistance (Lactococcus garvieae) of rainbow trout (Oncorhynchus mykiss). Journal of Anatolian Environmental and Animal Sciences, 5(4), 597-604. https://doi.org/10.35229/jaes.798086

Yılmaz, E., Ergun, S., & Yılmaz, S. (2020a). Effects of supplementation of L-alliin and oleuropein into rainbow trout (Oncorhynchus mykiss) feeds on growth performance, some immune parameters and disease resistance (Aeromonas salmonicida subsp. salmonicida). Journal of Limnology and Freshwater Fisheries Research, 6(3), 180-188. https://doi.org/10.17216/limnfish.746677

Yılmaz, E., Ergun, S., & Yılmaz, S. (2015b). Influence of carvacrol on the growth performance, hematomal, non-specific immune and serum biochemistry parameters in rainbow trout (Oncorhynchus mykiss). Food and Nutrition Sciences, 6(5), 523-531. https://doi.org/10.4236/fns.2015.65054

Yılmaz, S. (2019a). Effects of dietary caffeic acid supplement on antioxidant, immunological and liver gene expression responses, and resistance of Nile tilapia, Oreochromis niloticus to Aeromonas veronii. Fish & Shellfish Immunology, 86, 384-392. https://doi.org/10.1016/j.fsi.2018.11.068

Yılmaz, S. (2019b). Karabaş otu (Lavandula stoechas) yağının sazan balığı (Cyprius carpio) yemeline ilavesinin büyüme performansı ve bazı kan parametreleri üzerine etkileri. ÇOMU Ziraat Fakültesi Dergisi, 7(1), 187-193. https://doi.org/10.33202/comuagri.451304
Yilmaz, S. (2019c). Effects of dietary blackberry syrup supplement on growth performance, antioxidant, and immunological responses, and resistance of Nile tilapia, *Oreochromis niloticus* to *Plesiomonas shigelloides*. *Fish & Shellfish Immunology*, 84, 1125-1133. https://doi.org/10.1016/j.fsi.2018.11.012

Yilmaz, S., & Ergun, S. (2014). Dietary supplementation with allspice *Pimenta dioica* reduces the occurrence of streptococcal disease during first feeding of Mozambique tilapia fry. *Journal of Aquatic Animal Health*, 26(3), 144-148. https://doi.org/10.1080/08997659.2014.893459

Yilmaz, S., & Ergun, S. (2018). Trans-cinnamic acid application for rainbow trout (*Oncorhynchus mykiss*): I. Effects on haematological, serum biochemical, non-specific immune and head kidney gene expression responses. *Fish & Shellfish Immunology*, 78, 140-157. https://doi.org/10.1016/j.fsi.2018.04.034

Yilmaz, S., Acar, U., Kesbic, O. S., Gultepe, N., & Ergun, S. (2015a). Effects of dietary allspice, *Pimenta dioica* powder on physiological responses of *Oreochromis mossambicus* under low pH stress. SpringerPlus, 4(1), 719. https://doi.org/10.1186/s40064-015-1520-7

Yilmaz, S., Ergun, S., & Celik, E. S. (2013a). Effect of dietary herbal supplements on some physiological conditions of sea bass *Dicentrarchus labrax*. *Journal of Aquatic Animal Health*, 25(2), 98-103. https://doi.org/10.1080/08997659.2013.768561

Yilmaz, S., Ergun, S., & Celik, E. S. (2018b). The effect of dietary carob (*Ceratonia siliqua*) syrup on growth performance, haematological, serum biochemical and immunological parameters in tilapia (*Oreochromis mossambicus*). *Turkish Journal of Agriculture - Food Science and Technology*, 6(12), 1820-1826. https://doi.org/10.24925/turjaf.v6i12.1820-1826.2184

Yilmaz, S., Ergun, S., & Celik, E. S. (2016). Effect of dietary spice supplementations on welfare status of sea bass, *Dicentrarchus labrax* L. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 86(1), 229-237. https://doi.org/10.1007/s40011-014-0444-2

Yilmaz, S., Ergun, S., & Soytas, N. (2013b). Herbal supplements are useful for preventing streptococcal disease during first-feeding of tilapia fry, *Oreochromis mossambicus*. *The Israeli Journal of Aquaculture-Bamidgeh*, 65, 1-5. https://ija.scholasticahq.com/issue/2837

Yilmaz, S., Ergun, S., & Soytas, N. (2013c). Dietary supplementation of cumin (*Cuminum cyminum*) preventing streptococcal disease during first-feeding of Mozambique tilapia (*Oreochromis mossambicus*). *Journal of BioScience and Biotechnology*, 2(2), 117-124. http://www.jbb.uni-plovdiv.bg/documents/27807/59545/jbb_2013-2%282%29-pages_117-124.pdf/57e419a9-12f8-46ee-9a46-8da97f47ac?version=1.0

Yilmaz, S., Ergun, S., & Turk, N. (2012). Effects of cumin-supplemented diets on growth and disease (*Streptococcus iniae*) resistance of tilapia (*Oreochromis mossambicus*). The Israeli Journal of Aquaculture-Bamidgeh, 64, 1-5. http://hdl.handle.net/10524/23593

Yilmaz, S., Ergun, S., Celik, E. S., Yigit, M., & Bayizit, C. (2019a). Dietary trans-cinnamic acid application for rainbow trout (*Oncorhynchus mykiss*) II. Effect on antioxidant status, digestive enzyme, blood biochemistry and liver antioxidant gene expression responses. *Aquaculture Nutrition*, 25(6), 1207-1217. https://doi.org/10.1111/anu.12935

Yilmaz, S., Ergun, S., Yigit, M., Yilmaz, E., & Ahmadifar, E. (2020c). Dietary supplementation of black mulberry (*Morus nigra*) syrup improves the growth performance, innate immune response, antioxidant status, gene expression responses, and disease resistance of Nile tilapia (*Oreochromis niloticus*). *Fish & Shellfish Immunology*, 107, 211-217. https://doi.org/10.1016/j.fsi.2020.09.041

Yilmaz, S., Sova, M., & Ergun, S. (2018a). Antimicrobial activity of trans-cinnamic acid and commonly used antibiotics against important fish pathogens and nonpathogenic isolates. *Journal of Applied Microbiology*, 125(6), 1714-1727. https://doi.org/10.1111/jam.14097

Yonar, M. E., Yonar, S. M., Ispir, U., & Ural, M. S. (2019). Effects of curcumin on haematological values, immunity, antioxidant status and resistance of rainbow trout (*Oncorhynchus mykiss*) against *Aeromonas salmonicida* subsp. achromogenes. *Fish & Shellfish Immunology*, 89, 83-90. https://doi.org/10.1016/j.fsi.2019.03.038

emheri-Navruz, F., Acar, U., & Yilmaz, S. (2019). Dietary supplementation of olive leaf extract increases haematological, serum biochemical parameters and immune related genes expression level in common carp (*Cyprinus carpio*) juveniles. *Fish & Shellfish Immunology*, 89, 672-676. https://doi.org/10.1016/j.fsi.2019.04.037