Pakistan J. Zool., vol. 50(3), pp 921-928, 2018. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2018.50.3.921.928

Effects of Sage Oil (*Salvia officinalis* L.) on Haematological and Growth Parameters in Nile Tilapia (*Oreochromis niloticus*)

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ABSTRACT

In this study, effects of dietary levels of sage (*Salvia officinalis* L.) oil on growth, haematological parameters were evaluated on tilapia (*Oreochromis niloticus*). For this experiment, 360 fish (11.81± 0.02 g) were used. Fish were divided into four equal groups in three replicates and were fed with diets containing 0, 0.25, 0.5 and 1 % of sage oil for 30 days. The results showed that the haematological parameters (total red blood cell count, hemoglobin concentration, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, total white blood cell count and differential leukocyte counts) showed no significant (P>0.05) differences between the control and all other treatments. Feed intake, specific growth rate, weight gain and final weight were decreased significantly with the increase of sage oil levels in diets (P<0.05). There was no significant difference in hepatosomatic index (HIS), viscero somatic index (VSI) and condition factor (CF). The data of this study show that sage oil can be used to diets of tilapia up to 0.25% without any adverse effect on growth, feed utilization and haematological parameters.

Article Information
Received 16 March 2017
Revised 21 May 2017
Accepted 19 August 2017
Available online 13 April 2018

Authors' Contribution
FA conceived and designed the study, sampled and analysed the blood. FBH detected growth performance. FA and FBH wrote the article.

Key words
Sage oil, Haematology, Specific growth rate, *Oreochromis niloticus.*

INTRODUCTION

There is an ongrowing trend for natural substances aimed at preventing and curing diseases in aquaculture. With their minimal side effects, inexpensiveness, easily biodegradable properties and local availability, plant medicines can be used in every area and extracts can easily be prepared. Fish or shrimp diseases can be controlled and prevented by medical plants and herbal extracts (Bhuvaneswari and Balasundaram, 2006; Shankar-Murthy and Kiran, 2013).

The genus *Salvia*, with about 900 species throughout the world, as one of the most widespread members of the Lamiaceae family (Kelen and Tepe, 2008). *Salvia* species are generally known for their multiple pharmacological effects including their antibacterial, antiviral, antioxidant, anti-inflammatory, analgesic activities (Hosseinzadeh *et al*., 2009; Alizadeh and Shaabani, 2012). The major components of *S. officinalis* oils were measured as thujone (24.88%) and camphor (16.03%), (Miladinović and Miladinović, 2000). In a comprehensive study by Alizadeh and Shaabani (2012), α-thujone (41.48%), borneol (8.33%), 1,8 cineole (7.94%), β-thujone (6.75%), viridiflorol (5.85%), camphene (3.46%), α-pinene (3.24%), α-humulene (2.64%) and β-pinene (2.25%) were also been reported as the components of *S. officinalis* oil. In their study, the constituents of *S. officinalis* oil were recorded after hydrodistillation method.

In different animal species, many authors comprehensively investigated the effects of sage oil on growth performance, meat quality and blood parameters. Its effects on brolier chicks were assesed by Cabuk *et al*. (2005) and Demir *et al*. (2008). Chrastinova *et al*. (2010), studied on rabbits. Partridges *Alectoris chukar*, were investigated by Yurtseven *et al*. (2008). In teleost, Sönmez *et al*. (2015), only investigated the effect of sage oil on the growth performance and antioxidant enzyme activities in juvenile rainbow. There is no any other study in literature.

The present study was designed to evaluate the influence of dietary levels of sage oil on growth performance and haematological parameters in Tilapia and it is the first study aimed at determining the effects of sage oil on the hematological and growth parameters in *Oreochromis niloticus*.

MATERIALS AND METHODS

Fish and culture conditions

Nile tilapia (*Oreochromis niloticus*) with average body weight 11.81± 0.02 g were obtained from Dr. Nazmi Tekelioğlu Freshwater Research Station of Cukurova University. Twelve tanks (200 L) were used and fish were

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0030-9923/2018/0003-0921 $ 9.00/0

equally allotted to four groups (30 fish per tank) with three replicates for each treatment and were fed for 30 days. It was conducted at the Aquaria Research Unit of Aquaculture Faculty of Çukurova University, Adana from 1 June 2012 to 30 June 2012. Fish were fed with *ad libitum* twice a day (09:00 and 17:00). During experimental period, water was changed daily (25.5±0.5°C, dissolved oxygen 6.8± 0.4 mg/L, pH 7.1± 0.2). Fish were kept in a 12 h light/ dark photoperiod. Fish experiments were approved by the Çukurova University in Turkey and were conducted in agreement with the guidelines of Republic of Turkey University of Çukurova laboratory animal ethics committee.

Experimental diets

Sage oil (obtained by hydrodistillation methods) which provided commercially (Tabia, Ankara, Türkiye) were used in this study. Experimental diets were prepared by uniformly spraying the sage oil onto an extrude feed produced by SİBAL A.Ş. (Sinop/ Turkey). Pellets were dried at room temperature and then they were stored at 4°C for further use (Lee *et al*., 2012). Fish were fed with diets containing 0, 0.25, 0.5 and 1 % of sage oil for 30 days. The proximate analysis of the experimental diet are (given in $g.kg^{-1}$) moisture, 91.6; crude protein, 434.6; crude lipid, 179.0; crude ash; 73.3; crude fiber, 2.21; nitrogen-free extracts calculated by difference, 199.4 and gross energy ($kJ\ g^{-1}$) calculated according to 23.6 kj g^{-1} protein, 39.5 kj g^{-1} lipid and 17 kj g-1 NFE, 21.43.

Blood sampling and analysis

Fish were starved for 24 h before sampling. Fish were anaesthetized with quinaldinesulphate (5 mg/L) (Sigma Chemical Co., Germany) and blood was collected with a 1mL sterile syringe fitted with a 27-gauge needle from the caudal vein (Stoskoph, 1993; Harmantepe *et al*., 2016). Five fish were randomly collected from one of the replicate tanks for haematological assay. Blood samples collected from fish were used to determine the haematological parameters (total red blood cell count, haemoglobin concentration, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, total white blood cell count and differential leukocyte counts). Red and white blood cell counts were obtained manually with a haemocytometer using Natt-Herrick's solution for dilution (Stoskoph, 1993). Haematocrit was measured by using the microhaematocrit method. Blood for haematocrit analysis was drawn into heparinised micro-capillary tubes, and was centrifuged at 12500 rpm for 4 min. Haemoglobin was measured by mixing 20µL whole blood with 5 mL drabkin's reagent and by reading the absorbance at 540 nm on spectrophotometer (Stoskoph, 1993). Direct smears for differential white blood cell counts (DWBCC) were made immediately following blood collection. The smears obtained from non heparinised blood sample were first air dried and stained with May-Grünwald-Giemsa for leukocyte differential count and were examined under oil immersion at 100 × magnification (Sahan and Duman, 2010). Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were determined by standard formulas described by Stoskoph (1993).

MCV (fl) = Hct (%) x 10 / RBC count;
MCH (pg) = Hb (g/dl) x 10 / RBC count
MCHC (g/dl) = Hb (g/dl) x 100 / Hct (%)

Growth performance detection

At the end of 30 days feeding trail, fish in each tank were weighed and sampled after 24 h starvation period. Ten fish from each tank were randomly sampled, five for analysis of muscle proximate composition and five to get a blood sample and to obtain weights of viscera and liver. Moisture, ash and crude protein in diets and in muscle were analysed using standard procedures (AOAC, 1995). The fish and diets moisture content was determinated by driying to a constant weight at 105°C for 24 h; ash by incineration in a muffle furnace at 550°C for 24 h, crude protein (Nx6.25) by the Kjeldahl method. Crude lipid was assayed using the Bligh and Dyer (1959) method.

The following growth parameters were also calculated:

Specific growth rate (SGR, % day^{-1}) =
ln (final weight)-ln (initial weight) / 30 days x 100
Feed intake (FI, g/fish) = Dry feed intake / number of fish
Feed conversion ratio (FCR) = Dryfeed intake, g / weight gain, g
Protein efficiency ratio (PER) = Weight gain, g / protein intake, g
Intake = {(FI (g/fish) x Nitrogen or lipid concentration in diet (%)/ 100)/ (Mean body weight gain (g))}x 1000
Retention = {Final mean body weight (g) x Final whole body Nitrogen or lipid concentration (%) / 100) – (Initial mean body weight (g) x Initial whole body Nitrogen or lipid concentration (%)/100)}/(Mean body weight gain (g)) x1000
Loss = Nitrogen or lipid intake (g/kg body weight gain)-Nitrogen or lipid retention (g/kg body weight gain)
Retention per intake in percent= Nitrogen or lipid retention (g/kg body weight gain) x 100)/ Nitrogen or lipid intake (g/kg body weight gain)
Hepatosomatic index (HSI, %) = (Liver weight, g / whole body weight, g) x 100
Viscerosomatic index (VSI, %) = (Viscera weight, g / whole body weight, g) x 100
Condition factor (CF) = (Weight, g/$length^3$, cm) x 100

Statistics

All data from trials were subjected one-way analysis of variance (ANOVA). Differences among means were tested using Duncan's test. The data are presented as mean ± SEM of the replicate groups. All statistical analyses were conducted using SPSS Version 13.0.

RESULTS

Haematological parameters

All values for haematological parameters are presented in Table I. No statistical difference was observed in haematological parameters including RBC, Hb, Hct, MCV, MCH, MCHC, WBC and differential leukocyte counts. The highest RBC was in fish fed with 0.5% and the lowest was in fish fed with 0%. The highest Hct and MCH were in fish fed with 0% and the lowest was in fish fed with 0.5%. The highest Hb and MCHC were in fish fed with 0% and the lowest was in fish fed with 1%. The highest MCV was in fish fed with 1% and the lowest was in fish fed with 0.5%.

Growth performance

WG and SGR of the group fed with the diet of 0.25 % sage oil did not significantly differ from the fish fed the 0% sage oil diet. The fish fed with of 0.5% and 1% sage oil diets showed significantly ($P<0.05$) lower WG and SGR in comparison with the fish fed with the 0% sage oil diet. The FI of fish fed with 0.25% and 0.5% sage oil diets was significantly ($P<0.05$) different from those of fish fed the diets containing 0% and 1% sage oil. The lowest FI was found in fish fed with the 1% sage oil diet. WG, SGR and FI decreased with the increasing levels of sage oil in diet. Significantly ($P<0.05$) high FCR was found in fish fed with the diet containing 1% sage oil. PER was significantly ($P<0.05$) lower in fish fed with feed containing 1% sage oil. Survival rate during the experimental period was 100%. Data on growth performance are presented in Table II.

Table I.- Haematological parameters after 30 days of feeding with the experimental diets.

	Supplement levels			
	0 %	**0.25 %**	**0.5 %**	**1 %**
RBC (10^6 /mm^3)	1.96 ± 0.07	1.98 ± 0.09	2.03 ± 1.03	1.98 ± 1.17
Hct (%)	37.90 ± 1.52	36.79 ± 0.62	36.06 ± 0.66	37.43 ± 0.66
Hb (g/dL)	10.29 ± 0.21	9.93 ± 0.13	9.71 ± 0.23	9.67 ± 0.30
MCV (µ3)	194.39 ± 7.69	189.27 ± 10.05	181.24 ± 10.44	195.22 ± 11.04
MCH (pg)	53.01 ± 2.09	51.26 ± 3.00	49.18 ± 3.60	50.37 ± 3.09
MCHC (g/dl)	27.45 ± 1.06	27.07 ± 0.64	27.03 ± 0.90	25.82 ± 0.66
WBC (10^3/mm^3)	42.89 ± 3.20	37.44 ± 4.40	36.44 ± 4.80	31.44 ± 2.40
Lymphocyte (%)	85.41 ± 0.90	84.70 ± 1.85	86.17 ± 1.22	84.86 ± 0.90
Neutrophils (%)	9.14 ± 0.84	9.30 ± 1.12	8.55 ± 1.11	9.28 ± 0.57
Monocytes (%)	4.51 ± 0.60	5.13 ± 0.90	4.55 ± 0.77	5.09 ± 0.97
Eosinophils (%)	0.98 ± 0.22	0.87 ± 0.20	0.73 ± 0.11	0.77 ± 0.14

Data are mean ± S.E of triplicate groups of fish, with 5 fish per group. Values within the same row having different superscripts are significantly different ($p<0.05$). RBC, red blood cell; Hct, haematocrit; Hb, haemoglobin; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; WBC, white blood cell count.

Table II.- Growth performance and feed utilization in tilapia fed with experimental diets for 30 days.

	Supplement levels			
	0 %	**0.25 %**	**0.5 %**	**1 %**
Initial weight (g)	11.81 ± 0.03	11.81 ± 0.02	11.80 ± 0.01	11.82 ± 0.02
Final weight (g)	23.05 ± 0.97 ^{a}	21.25 ± 0.62 ^{b}	19.97 ± 0.46 ^{b}	17.39 ± 0.52 ^{c}
Weight gain	11.24 ± 0.95 ^{a}	9.45 ± 0.63 ^{ab}	8.16 ± 0.46 ^{b}	5.58 ± 0.51 ^{c}
SGR	2.22 ± 0.14 ^{a}	1.96 ± 0.10 ^{ab}	1.75 ± 0.08 ^{b}	1.29 ± 0.10 ^{c}
Sage oil intake	-	0.74 ± 0.04	1.41 ± 0.05	2.19 ± 0.05
FI	11.73 ± 0.64 ^{a}	9.87 ± 0.48 ^{b}	9.38 ± 0.30 ^{b}	6.69 ± 0.61 ^{c}
FCR	1.05 ± 0.05^{b}	1.05 ± 0.02 ^{b}	1.15 ± 0.03 ^{ab}	1.20 ± 0.04 ^{a}
PER	2.20 ± 0.09^{a}	2.20 ± 0.04 ^{a}	2.00 ± 0.05 ^{a}	1.74 ± 0.04 ^{b}
Survival (%)	100	100	100	100

Data are means of triplicate groups. Values within the same row having different superscripts are significantly different ($p<0.05$). SGR, specific growth rate; FI, feed intake; FCR, feed conversion rate; PER, protein efficiency rate.

Table III.- Nitrogen and lipid budget per unit body weight gain and nutrient retention in tilapia fed with experimental diets for 30 days.

	Supplement levels			
	0 %	**0.25 %**	**0.5 %**	**1 %**
Nitrogen (g N/kg BW gain)				
Intake	73.04 ± 5.36 ^{b}	72.80 ± 2.18 ^{b}	80.16 ± 3.51 ^{ab}	92.74 ± 16.46 ^{a}
Retention	28.07 ± 0.14 ^{b}	31.54 ± 0.10 ^{a}	31.53 ± 0.09 ^{a}	31.82 ± 0.23 ^{a}
Loss	44.97 ± 5.49 ^{ab}	41.26 ± 2.08 ^{b}	48.63 ± 3.43 ^{ab}	60.92 ± 16.23 ^{a}
Lipid (g L/kg BW gain)				
Intake	188.02 ± 13.81 ^{b}	187.40 ± 5.61 ^{b}	206.35 ± 9.04 ^{ab}	238.71 ± 42.36 ^{a}
Retention	14.32 ± 0.42 ^{b}	11.86 ± 0.17 ^{c}	14.49 ± 0.29 ^{b}	21.57 ± 1.46 ^{a}
Loss	173.71 ± 13.45	175.55 ± 5.44	191.86 ± 8.77	217.16 ± 40.91
Retention (% of intake)				
Nitrogen	38.58 ± 3.02 ^{ab}	43.34 ± 1.17 ^{a}	39.386 ± 1.64 ^{ab}	34.964 ± 5.545 ^{b}
Lipid	7.63 ± 0.39 ^{b}	6.329 ± 0.10 ^{c}	7.0289 ± 0.18 ^{bc}	9.1494 ± 0.96 ^{a}

Data are means of triplicate groups. Values within the same row having different superscripts are significantly different ($p<0.05$).

Table IV.- Proximate composition of fish muscle (dry basis, except for moisture), hepatosomatic index, viscerosomatic index and conditional factor of tilapia fed with diets containing different levels of sage oil for 30 days.

	Initial	**Final supplement levels**			
		0 %	**0.25 %**	**0.5 %**	**1 %**
Dry matter	21.08 ± 0.06	20.93 ± 0.05 ^{c}	21.48 ± 0.01 ^{b}	21.58 ± 0.02 ^{ab}	21.70 ± 0.07 ^{a}
Crude protein (%)	18.65 ± 0.07	18.11 ± 0.39	19.12 ± 0.12	19.08 ± 0.45	19.04 ± 0.06
Crude lipid (%)	0.92 ± 0.06	1.17 ± 0.06 ^{ab}	1.04 ± 0.03 ^{b}	1.13 ± 0.07 ^{ab}	1.31 ± 0.07 ^{a}
Crude ash (%)	1.49 ± 0.03	1.39 ± 0.01	1.37 ± 0.00	1.35 ± 0.03	1.36 ± 0.01
CF	1.44 ± 0.05	1.71 ± 0.04	1.68 ± 0.01	1.71 ± 0.03	1.73 ± 0.04
HSI	1.15 ± 0.06	1.38 ± 0.17	1.39 ± 0.25	1.20 ± 0.09	1.33 ± 0.14
VSI	11.32 ± 0.49	13.15 ± 0.83	13.21 ± 0.27	11.88 ± 0.76	13.01 ± 0.77

Data are means of triplicate groups. Values within the same row having different superscripts are significantly different ($p<0.05$). CF, condition factor; HIS, hepatosomatic index; VSI, viscerosomatic index.

The intake, retention, loss values of N and Lipid are presented in Table III. N and Lipid intake improved with rising levels of sage oil in diet while significantly ($P<0.05$) lower N and lipid intake was found in fish fed with the 1% sage oil diet. No difference was found on N retention among groups, except for the 0% sage oil replacement. The highest N loss rate was found the group fed with 1% sage oil diet. Lipid retention significantly ($P<0.05$) improved with rising levels of sage oil in diet. There were no significant differences between groups for lipid loss value. The highest N retention (% of intake) was observed from the group fed with diets of 0.25% replacement. The N retention of fish fed with 0.25% and 1% sage oil diets was significantly ($P<0.05$) different, except for the 0% sage oil replacement. Lipid retention (% of intake) improved with increasing levels of sage oil and, differences between all the other groups were significant ($P<0.05$).

Muscle proximate composition, hepatosomatic ındex (HIS), viscerosomatic ındex (VSI) and condition factor (CF)

The proximate composition of muscle of tilapia is presented in Table IV. There were no significant differences between groups for crude protein and ash of muscle. Dry matter and lipid content were significantly ($P< 0.05$) affected by dietary sage oil levels. The highest lipid content was found the group fed with 1% sage oil diet while the lowest was determined in group fed with 0.25% sage oil diet. CF, HIS, VSI values did not show any significant differences among the groups.

DISCUSSION

The blood parameters in fish can change with factors such as nutrition, environmental conditions, diseases, stocking density, environmental pollutants. The haematological parameters in the assessment of fish health has recently been confirmed by Aydın *et al*. (2016). Therefore, the blood parameters in the assessment of the health status of fish is one of the most important indicators (Blaxhall, 1972; Aydın *et al*., 2016).

Immunostimulants can act such as herbs, probiotics and vitamins can elevate the non-specific defense mechanisms, the specific immune response and disease resistance of fish (Lin and Shiau, 2005; Kumar *et al*., 2006; Yin *et al*., 2008; Tanekhy *et al*., 2016). Other than that, in some cases the additives' properties or their high concentrations can inhibit the haematological parameters of fish (Talas and Gulhan, 2009).

In this study, no statistical differences were observed in haematological parameters including RBC, Hb, Hct, MCV, MCH, MCHC, WBC and differential leukocyte counts. Although not a study on fish, Demir *et al*. (2008) reported not affected on Hb, Hct, RBC, WBC, lymphocytes, monocytes, and eosinophils values of broilers fed with sage powder. Furthermore, in studies using different fish species and immunostimulants, Yilmaz *et al*. (2012) reported that *Dicentrarchus labrax* which was exposed garlic oil, ginger oil and combination of the two oils via bath immersion for 96 h was not affected by RBC, Hct, Hb, MCV, MCH and MCHC values. Also Lim *et al*. (2009) reported that Nile tilapia fed with different levels of lipid and vitamin E diets was not affected by RBC, WBC, Hb, Hct, MCV, MCH and MCHC values. RBC values' being unaffected by sage oil is in agreement with previous study that vitamin C was used (Adewolu and Aro, 2009). Nevertheles, RBC increased significantly in Nile tilapia fed with ginseng, Biogen®, β-1,3/1,6 glucan (Ashraf and Goda, 2008; Mehrim, 2009; Sahan and Duman, 2010), in common carp fed with plant extracts (Abasali and Mohamad, 2010; Mohamad and Abasali, 2010). Results from this study showed that there was no significance the Hb and Hct values between sage oil diets and control group. The present observation was in corroboration with the findings of Adewolu and Aro (2009) and Sahan and Duman (2010) who reported that vitamin C and β-1,3/1,6 glucan in diets had no significant alternations of Hct and Hb values. Other researchers have determined an increase in Hb, Hct values in Nile tilapia (Ashraf and Goda, 2008; Mehrim, 2009).

In this study, there was no significant differences in MCV, MCH and MCHC as erythrocyte indices between sage oil diets and control group. Similar results were observed in *O. niloticus* fed with the diet supplemented with Biogen® under different stocking densities (Mehrim, 2009) but no significant differences was observed with MCV and MCH values in *O. niloticus* fed with the diets supplemented with β-1,3/1,6 glucan (Sahan and Duman, 2010).

The WBC values of fish was not affected from dietary sage oil levels compared to control fish. There seems to be research that supports our findings, no significant differences were observed in WBC for Nile tilapia fed with Ginsana G115-supplemented diets (Ashraf and Goda, 2008) and for *Clarias gariepinus* fed with vitamin C supplemented diets (Adewolu and Aro, 2009). However, an increased WBC values in fish has previously been reported by other researchers when fed with diets with Biogen®, plant extracts and β-1,3/1,6 glucan (Mehrim, 2009; Abasali and Mohamad, 2010; Sahan and Duman, 2010).

DWBCC, showing percentages of lymphocytes, monocytes, neutrophils and eosinophils, was not affected by the sage oil levels in the diet. Ashraf and Goda (2008) and Mehrim (2009) reported not effected on DWBCC of ginseng and biogen added in diets. Besides, MesalhyAly *et al*. (2008) reported that tilapia fed with diets including garlic was not effected by neutrophils and eosinophils values.

Supplement of sage oil at 0.25 % did not affected WG and SGR on *Oreochromis niloticus* but WG and SGR have been decreased when fed with diets with sage oil level of 0.50% and 1%. Similarly, Yilmaz *et al*. (2006) obtained a reduction in growth rate in common carp fed with diets with *Ferula coskunii* with levels of 0, 1.5, 3.0 and 4.5 g. On the contrary, while growth was not affected with garlic in *Oreochromis niloticus* (MesalhyAly *et al*., 2008), with garlic peel in *Clarias gariepinus* (Thanikachalam *et al*., 2010) and with cumin (*Cuminium cyminum*) in *Oreochromis mossambicus* (Yilmaz *et al*., 2012). On the contrary, Sönmez *et al*. (2015) reported that weigh gain, SGR and FCR in juvenile rainbow trout (*Oncorhynchus mykiss*) was not affected by increasing the level of sage oil in diet and significantly higher than the control group. Sönmez *et al*. (2015) reported that weigh gain, SGR and FCR in juvenile rainbow trout (*Oncorhynchus mykiss*) specific growth rate was found to be the highest in all groups of the sage oil treated.

However, an increased growth peformance in *Ictalurus punctatus* and in *Oreochromis niloticus* has been reported by researchers when fed with diets containing oregano essential oil (*Origanum heracleoticum*) and baker yeast (*Saccharomyces cerevisiae*), respectively (Zheng *et al*., 2009; Goda *et al*., 2012).

In the present study, feed intake of fish was affected increasing the sage oil levels. It was observed that the fish

had problems for taking the feed with the rise of the sage oil levels, because sage oil had a peculiar strong, aromatic odor. Therefore, it seems that the decline in growth was from the decrease in feed intake.

The previous studies have reported that fish fed with diets containing immunostimulants, demonstrated an increase of feed efficiency (FCR and PER) (Zheng *et al*., 2009; Goda *et al*., 2012). However, in this study, FCR and PER values of fish fed with the diets containing high sage oil levels were worse than the other diets. The deterioration of PER values may mean that due to a decrease in feed intake, fish compensates this by breaking down proteins because of its energy needs.

Although Khattab *et al*. (2004) and Eid and Mohamed (2008) obtained a reduction of lipid content in fish, the lipid retention and lipid content in muscle improved the group fed with the diet replacement of 1% sage oil. This situation can be explained by 1% of sage oil can disrupt the lipid metabolism in liver. At the end of the experiment it was observed that there had been a increase on nitrogen loss values in fish which was fed with 1% sage oil. This also can be explained by disrupting the lipid metabolism, fish preferred proteins.

CONCLUSIONS

Based on the present study, sage oil in tilapia diets should be used up to 0.25% application dose. Because 0.25% sage oil application dose did not have any adverse effects on the growth, feed utilization and hematological parameters. It was concluded that because of its unique odour especially in higher application doses (0.5% and 1%) prevents fish from taking the feed effectively.

ACKNOWLEDGMENTS

The research was supported by the Academic Research Projects Unit of Cukurova University (Project Number: YUMYO-2009-BAP1). We would also like to thank the President of the Sibal Feed Company, Mr. Engin Savaş, supplying fish feed and Serhat Ozkütük for reviewing the manuscript.

Statement of conflict of interest

Authors have declared no conflict of interest.

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