

Резюмета на научни публикации

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представени за участие в конкурс за академичната длъжност „Професор“, по Рибовъдство, рибно стопанство и промишлен риболов в област на висше образование 6. Аграрни науки и ветеринарна медицина Професионално направление 6.3 Животновъдство съгласно чл. 2б от ЗРАСРБ и допълнителните изисквания съгласно приложение 8.1 на ПРАСТрУ

I. Резюмета на научни публикации заместващи хабилитационен труд, които са реферирани и индексирани в световноизвестни бази данни с научна информация (по група показатели В)

1. Sirakov, I., Velichkova, K. (2018). The influence of aquaponically grown duckweed (*Lemna minuta* Kunth) used for composition of sustainable diets on hydrochemical and technological parameters in carp (*Cyprinus carpio* L.). *Turkish Journal of Fisheries and Aquatic Sciences*, 18, 1037-1044.

Abstract: The aim of the current study was to investigate the influence of aquaponically grown duckweed (*Lemna minuta*) used as part of a biofilter in recirculation aquaculture systems, when its included in the composition (10 and 30% content of daily feed ratio) of sustainable diets on hydrochemical and technological parameters in common carp (*Cyprinus carpio* L) fingerlings cultivated in recirculation aquaponic systems. The inclusion of *L. minuta* in diets for carp fingerlings influenced the hydrochemical parameters and decreased the quantity of nitrogen and phosphorus compounds in water of tanks where carps were fed with feed containing duckweed, but difference was statistically significant only for ammonium (0.087 ± 0.008) ($P \leq 0.05$). The carps fed with a diet containing 30% (L30) duckweed of their daily feed ratio showed better survival but similar growth and FCR than fish fed with L0 and differences were not significant ($P \geq 0.05$). The lower growth and higher FCR were measured in carps fed with L10 compared to the values of these parameters in carp's fingerlings fed with L0 diet and the differences were significant ($P \leq 0.05$). The duckweed presents cheap and easy accessible ingredients for feeding of carp. Furthermore it could be used for treatment of wastewater in recirculating aquaculture systems this way increasing their sustainability.

2. Sirakov, I., Stoyanova, S. (2018). Influence of extracts of krill and chironomus larvae as feed attractants on growth, survival and feed utilisation in fry of European perch *Perca fluviatilis* Linnaeus, 1758. *Indian Journal of Fisheries*, 65(3), 42-46.

Abstract: Technological stages of European perch (*Perca fluviatilis* Linnaeus, 1758) farming and feeding norms satisfying its nutritional requirements are not well studied. A critical moment in farming of this species in recirculation systems is the transition from live feed to commercial pelleted feed. The aim of current research was to evaluate the influence of two attractants viz., extracts from krill and chironomus larvae as feed supplements for European perch (*P. fluviatilis*) fry on their survival, growth and feed utilisation. European perch fry were distributed in three experimental groups, viz., F0: fed non-supplemented control feed; Fk: fed krill extract supplemented feed and Fch: fed feed supplemented with chironomus extract. Survival of European perch supplemented with krill extract was 46% as compared to 26% in control group and 30% in fish supplemented with chironomus extract ($p < 0.05$). The highest final weight and specific growth rate were observed in perch fed feed supplemented with chironomus extract but the differences between the krill-supplemented and control

groups were not significant ($p>0.05$). Feed conversion ratio (FCR) in fish supplemented with chironomus extract was 1.91 which was significantly lower by 32.7% than control fishes and by 29.5% lower than fish fed with krill extract supplemented feed ($p<0.01$). The addition of krill extract to the feed of European perch fry improved survival rate of fry, while higher growth performance was demonstrated in fish fed with chironomus extract supplemented feed.

3. Kurdomanov, A., Sirakov, I., Stoyanova, S., Velichkova, K., Nedeva, I., Staykov, Y. (2019). The effect of diet supplemented with Proviotic® on growth, blood biochemical parameters and meat quality in rainbow trout (*Oncorhynchus mykiss*) cultivated in recirculation system. *AAFL Bioflux*, 12 (2), 404-412.

Abstract: In 2006, the European Union banned the use of all types of therapeutic antibiotics as growth promoters in livestock farming. This led to the need for alternative growth promoters supplements to be found. Such a possibility is the development of new nutritional strategies with the participation of probiotics. The purpose of this study was to trace the growth performance, meat quality and blood parameters of rainbow trout (*Oncorhynchus mykiss* W.) fed with additive of probiotic Proviotic®. The fish were fed with two feeds: control feed (CF) - without addition of supplement and experimental feed (EF)

(with supplementation of 460 mg kg⁻¹ Proviotic® in fish feed). The density of rainbow trout in recirculation system was 40 specimens per tank. The initial average weight of fish in CF variant was 13.43±2.9 g and in EF variant was 13.35±3.4 g without differences being statistically significant ($p \geq 0.05$). The continuation of experiment was 60 days. The average final weight, meat quality and blood biochemical parameters were measured at the end of experiment. Rainbow trout from the experimental group fed with supplement of Proviotic had with 5.38% higher average final weight, compared to the parameter value in trout from control variant, but without difference being statistically significant ($p \geq 0.05$). The blood biochemical parameters in experimental fish were not significantly affected by supplementation of probiotic Proviotic®. This supplement, added to extruded pellets for feeding of rainbow trout increases the quantity of crude protein and ash in fish fillets and this way is improving the quality of fish meat.

4. Velichkova, K., Sirakov, I., Stoyanova, S., Zhelyazkov, G., Staykov, Y., Slavov, T. (2019). Effect of *Acorus calamus* L. extract on growth performance and blood parameters of common carp (*Cyprinus carpio* L.) cultivated in a recirculation system. *Journal of Central European Agriculture*, 20(2), 585-591.

Abstract: The aim of this study was to determine the effect of the sweet flag (*A. calamus* L.) extract addition of growth performance, haematological (white blood cells, red blood cells, hemoglobin, hematocrit) and biochemical (glucose, urea, creatinine, total protein, albumin, ASAT, ALAT, Ca, P, Mg, triglycerides, cholesterol) blood parameters of common carp (*Cyprinus carpio* L.) cultivated in recirculation system. Carps were randomly selected and distributed into four concrete tanks for the growth trial (8 fish/tank). Fish were divided into experimental (E) and control groups (C), each of them with two replicates and mean initial weight 908.5±171.2 g and 913.8±147.4 g, respectively. They were fed with pelleted carp feed with 25% crude protein, produced by the "Top mix" company, having a granule size of 6 mm. To the fish feed on the experimental group (E) was added 1% aqueous extract of *A. calamus* root, as well as oiling the pellets with 5 mL of sunflower oil for every 100 g of feed. Carps from control group (C) were fed with feed only greased with the same

amount of sunflower oil. The daily ration that the studied fish received was 1.8% of their live weight. The duration of the trial period was 45 days. At the end of the experiment with 5.2% was measured a higher average live weight in the fish receiving the sweet flag supplement compare to the value of this parameter of carps from control group, and the differences were statistically significant ($P < 0.05$). The survival rate was 100% in control and experimental variants. At the end of the experiment, the average individual weight gain of the experimental fish fed with the supplement was higher with 53.2% compared to this one of carps from control. The feed conversion ratio in experimental carps, supplemented with 1% sweet flag extract was with 16.1% lower than that of control fish, although the differences were not relevant ($P > 0.05$). Better blood biochemical and haematological parameters were measured in carp fed with sweet flag supplement.

5. Sirakov, I., Velichkova, K., Stoyanova, S., Zhelyazkov, G., Staykov, Y. (2019). The effect of diet supplemented with dandelion's (*Taraxacum officinale*) extract on the productive and blood parameters of common carp (*Cyprinus carpio* L.), cultivated in the recirculation system. *Macedonian Veterinary Review*, 42(2), 131-139.

Abstract: The aim of the current study was to test the effect of a diet supplemented with dandelion's (*Taraxacum officinale*) extract on the productive traits and blood parameters in common carp (*Cyprinus carpio* L.) cultivated in an recirculation aquaculture system. The carps were cultivated at a stocking density of 7.2 kg/m³ in recirculation aquaculture system. The fish were split into the following two experimental groups: DF (the fish were fed with feed supplemented with dandelion's extract) and CF (the fish were fed with feed without supplementation). Common carp fed with a diet added with dandelion's extract at a quantity of 0.8% from daily feed ratio, did not affect the hydrochemical parameters (pH, dissolved oxygen, and electrical conductivity). The carps fed with feed supplemented with dandelion's extract did not show better productive traits compared with these found for carp from the control variant. The carp from experimental groups had a higher survival rate, final weight, average individual weight gain and specific growth rate (SGR), respectively with 13.2%, 3.94%, 31.5% and 31.3%, compared with the average values of these parameters measured in individuals fed with the control feed, but the differences were not statistically significant ($P \geq 0.05$). Supplementation of feed with dandelion's extract significantly decreased the plasma cholesterol (4.76%) and triglyceride (61.2%) content, promoting hypolipidemic status in fish ($P \leq 0.05$).

6. Velichkova, K., Sirakov, I. (2019). The effect of diet supplemented with *Lemna minuta* Kunth extract on technological parameters, blood parameters and meat quality in rainbow trout (*Oncorhynchus mykiss* W.) cultivated in aquaponic recirculation system. *Journal of Hygienic Engineering and Design*, 28, 22-27.

Abstract: Bioactive substances in plants may use to stimulate fish nutrition intake, improve the function of the digestive system and boost immunity. The purpose of this study is to determine the effect of the *Lemna minuta* Kunth extract, supplemented to the diet on the technological parameters, blood parameters and meat quality of the rainbow trout (*Oncorhynchus mykiss* W.), cultivated in the aquaponics recirculation system. Ten specimens from this species, with an average weight of 114.45 + 12.18 g (control group) and 109.15 + 23.11 g (experimental group, with added *L. minuta* extract in feed) in good health condition were placed in each tank of aquaponics recirculation system and cultivated for 60 days. At the end of the experiment were calculated: average final weight, specific growth rates, feed

conversion ratio, meat quality and blood biochemical parameters. The blood samples were examined by the colorimetric method with blood analyzer (Mindray SC - 120). The meat quality (moisture %, dry matter %, crude protein content, fat, and ash content) were determined respectively to Bulgarian State Standards (BSS): 11374-86, BSS-ISO 5983, BSS-ISO 6492, BSS 11374-86). The data was analyzed statistically with Anova single factor Statistica 6.0 software.

The trout's, fed with feed, supplemented with *L. minuta* extract showed higher final weight and average individual weight gain, respectively with 16.4% and 46.4%, compared with the values in these parameters, found out in fish, fed with the control feed, and the differences were statistically significant ($P < 0.001$, $P < 0.05$). The fat concentrations in fillets of rainbow trout, fed with supplement, were higher with 15.4% compared to control fish ($P < 0.01$). The protein concentrations were higher with 0.4% in trout fillets of a control group compared to experimental, but the differences were not significant ($P > 0.05$). The creatinine level and Ca content were, respectively 39.5% and 37.1% higher in the blood of trout's fed with the *L. minuta* extract supplement, compare to these ones of fish from the control group, and the difference were statistically significant ($P < 0.05$). The supplemented diet with *L. minuta* affects the growth and biochemical blood parameters (creatinine and calcium) of rainbow trout cultivated in aquaponics recirculation system.

7. Sirakov, I., Velichkova, K., Slavcheva-Sirakova, D. (2019). The effect of yarrow (*Achillea millefolium*) supplemented diet on growth performance, biochemical blood parameters and meat quality of rainbow trout (*Oncorhynchus mykiss* W.) and growth of lettuce (*Lactuca sativa*) cultivated in aquaponic recirculation system. *Journal of Hygienic Engineering and Design*, 28, 28-32.

Abstract: Yarrow (*Achillea millefolium*) is medicinal plant used in Bulgarian traditional medicine to improve the condition of the digestive tract and could positively affect digestibility and assimilation of feed nutrients, as well as physiological condition in human and animal organisms. The aim of current study was to find the effect of feed, supplemented with yarrow (*Achillea millefolium*) on growth performance, blood parameters and meat quality in rainbow trout (*Oncorhynchus mykiss* W.) as well as on growth of heads and roots in lettuce (*Lactuca sativa*), raised in the aquaponics recirculation system.

The fish were fed with two feeds: control feed (CF) - without the addition of supplement and experimental feed (EF), with supplementation of the extract of yarrow in quantity of 15 g/kg of feed. The initial average weight of fish in CF variant was 114.4 ± 2.72 g and in EF variant was 109.8 ± 2.10 g without differences being statistically significant ($P \geq 0.05$). The continuation of the experiment was 60 days. The average final weight, meat quality, and blood biochemical parameters were measured at the end of the experiment. The blood samples were examined by the colorimetric method with blood analyzer (Mindray SC – 120). The meat quality (moisture %, dry matter %), crude protein content, fat and ash content were determined respectively to Bulgarian State Standards: (BSS)11374-86, BSS-ISO 5983, BSS-ISO 6492, BSS 11374-86). The data were analyzed statistically with Anova single factor Statistica 6.0 software.

The average final weight in trout from the experimental group was higher with 11.0%, compared with the value of this parameter, found for the rainbow trout from the control variant ($P < 0.001$). The aspartate aminotransferase, alkaline phosphatase and cholesterol levels in the blood of fish fed with feed supplemented with yarrow were higher, respectively

with 27.4%, 57.2%, and 24.9%, compared with average values in these blood parameters found out for fish from control variant ($P < 0.05$). The parameters of meat quality in fish from experimental groups were not affected significantly from yarrow supplementation in fish feed and were similar to those found in fish from the control group ($P \geq 0.05$). The weight of head and roots in lettuce cultivated in the aquaponics system were respectively 95.4 ± 3.06 g and 26.9 ± 0.82 g at the end of the trial.

The supplemented diet with yarrow affects the growth and biochemical blood parameters (aspartate aminotransferase, alkaline phosphatase and cholesterol) in rainbow trout and did not affect the weight of head and roots in lettuce cultivated in the aquaponics system.

8. Cherpokov, J., Sirakov, I., Stoyanova, S., Velichkova, K., Simitchiev, A., Nenov, V., Slavov, T. (2020). The influence of Nu Pro® as a substitution of fish meal on the growth performance of rainbow trout (*Oncorhynchus mykiss* W.) cultivated in recirculating system. *Bulgarian Journal of Agricultural Science*, 26(1), 223–231.

Abstract: The purpose of the study was to determine the effect of the addition of NuPro® as a substitution of fish meal in feeding of rainbow trout (*O. mykiss*) on the functional properties of extruded feed as well as on growth intensity, blood biochemical and meat quality parameters in experimental fish, cultivated in recirculating system. Rainbow trout received extruded feed (2.5 mm pellets), produced by extrusion process in “University of food technologies – Plovdiv”. Two hundred and twenty five rainbow trout were divided into three groups: control (A), experimental B and C, each of them with three replicates, with a mean initial live weight, respectively 24.3 ± 7.3 , 24.3 ± 7.3 and 24.4 ± 8.5 g. The feed content for fish from experimental groups was as follows: for the control group (A) – without Nu Pro, for the group B – 33% fishmeal and 7% Nu Pro®, and that for the group C 25% fishmeal, with a content of 15% Nu Pro. The duration of the trial period was 60 days. The addition of Nu pro® on functional properties of extruded feed was retraced. At the end of the experiment, fish growth (g), their survival (%) and feed conversion ratio (K) were calculated. The blood biochemical and meat quality parameters in fish from experimental groups were also measured. The evaluation of functional properties in extruded feed showed that the use of Nu Pro® as a substitute of fishmeal has a number of advantages that include-increasing the mass flow rate during extrusion, reducing the energy consumption during extrusion, increasing shelf life due to the higher absorption index. The main disadvantage that can be indicated is the faster dissolution of the product in contact with water. At the end of the experiment, with the live weight, being highest in the rainbow trout from the experimental group (C) – 69.76 ± 25.41 g, followed by that of fish from the experimental group (B) – 67.82 ± 20.00 g and this one of individuals from group (A) – 64.01 ± 17.07 g and the statistical differences haven't been proven ($p > 0.05$). The supplementation of feed with NuPro® in the diet of rainbow trout decreased the level of alkaline phosphatase (ALP), cholesterol and triglycerides respectively with 9.29%, 16.4% and 9.47% compared with the values of these parameters in fish from control group, but the differences were not significant ($P \geq 0.05$). The partial replacement of fish meal with Nu Pro® in rainbow trout did not affect the meat quality parameters.

9. Koshinski, R., Velichkova, K., Sirakov, I., Stoyanova, S. (2020). Effect of *Angelica archangelica* L. extract on growth performance, meat quality and biochemical blood parameters of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in a recirculating system. *Bulgarian Journal of Agricultural Science*, 26(1), 232–237.

Abstract: The medicinal herbs as natural products can be use like not expensive additives in artificial diets for aquatic animals which are safe for fish and the environment. The purpose of this study is to determine the effect of the *Angelica archangelica* L. extract on the growth

performance, meat quality and biochemical blood parameters (glucose, urea, creatinine, total protein, albumin, ASAT, ALAT, ALP, Ca, P, Mg, *triglycerides*, *cholesterol*) of rainbow trout (*Oncorhynchus mykiss*). Thirty specimens from the rainbow trout with an average weight of 42.55 ± 7.48 g (control, C) and 42.51 ± 6.02 g (experimental, Ang.a.) in good health condition were placed in each tank and cultivated for 60 days. A control group (no added) and an experimental (with added 433 mg.kg^{-1} of angelica extract) option, each with a two repetition, were set in a recirculating system in the Aquaculture Base of the Faculty of Agriculture at the Trakia University. At the end of the experiment were calculated average final weight, specific growth rates, feed conversion ratio, meat quality and blood biochemical parameters. The average individual weight gain of rainbow trout from the group fed with *A. archangelica* extract supplemented was 84.61 ± 0.06 g which was with 15.01% higher compared to this one of control fish and the differences were statistically significant ($P < 0.05$). The blood biochemical parameters glucose, urea, albumin, ALP, ASAT, cholesterol in control variant were higher compare to values of this parameter of fish from the experimental ($P > 0.05$). Better growth performance and blood parameters were measured in trout fed with angelica supplement.

10. Sirakov I., Velichkova K., Slavcheva-Sirakova, D. (2021). The ProViotic® supplemented diet on growth performance, biochemical blood parameters and meat quality of common carp (*Cyprinus carpio* L.) and growth of lettuce (*Lactuca sativa*) cultivated in aquaponics. *Journal of Hygienic Engineering and Design*, 33, 26-30,

Abstract: One innovative technology where fish and plants are cultivated in the same recirculation system is aquaponic. The usage of growth promoting substances like therapeutic antibiotics is not possible solution for this sustainable and biological production technology. This lead to the need for alternative growth promoters supplements to be tested. One possible solution is a probiotics and the current studies connected with this topic in aquaponic systems are still very rare explored. The aim of this study was to retrace the effect of probiotic ProViotic® added to feed of common carp (*Cyprinus carpio* L.) on its growth, blood parameters and meat quality as well as on growth of heads and lengths roots in lettuce (*Lactuca sativa*), raised in the aquaponic recirculation system.

The fish were fed with two feeds: control feed (CF) - without addition of supplement and experimental feed (EF) (with supplementation of 460 mg.kg^{-1} ProViotic® in fish feed). The density of carp in recirculation system was 50 spc.m^{-3} . The initial average weight of fish in CF variant was 41.83 ± 1.80 g and in EF variant was 41 ± 2.71 g without differences being statistically significant ($P \geq 0.05$). The continuation of the experiment was 60 days. The average final weight, meat quality, and blood biochemical parameters were measured at the end of the experiment. The blood samples were examined by the colorimetric method with blood analyzer (Mindray SC - 120). The meat quality (moisture (%), dry matter (%), crude protein content, fat and ash content) were determined respectively to Bulgarian State Standard (BSS)11374-86, BSS-ISO 5983, BSS-ISO 6492, BSS 11374-86). The data were analyzed statistically with ANOVA single factor and T-test STATISTICA 6.0 software (StatSoft Inc., 2002).

The average final weight in carp from the experimental group was higher with 4.3%, compared with the value of this parameter, found for the fish from the control variant ($P < 0.05$). The quantity of glucose, triglycerides and alkaline phosphatase (ALP) in the blood of fish fed with feed supplemented with ProViotic were lower, respectively with 15%, 11.83%, and 38.2%, compared with the average values in these blood parameters found out for fish from the control variant, but the differences were not statistically proven ($P < 0.05$). Concerning the parameters of meat quality in fish from experimental groups the quantities of

fat and ash were higher respectively with 8.11% and 2.17% compared with values of these parameters found in the carp from the control group, but the differences were not statistically significant ($P \geq 0.05$). The weight of head and length of roots in lettuce cultivated in the aquaponics system were respectively 142.34 ± 4.73 g and 62.10 ± 1.15 cm at the end of the trial.

The supplemented diet with ProViotic® increased the growth of carp and did not affect negatively the meat quality and blood biochemical parameters in fish as well as the weight of head and length of roots in lettuce cultivated in the aquaponic system.

II. Резюмета на научни публикации (по група показатели Г)

Статии и доклади, публикувани в научни издания, реферирани и индексирани в световноизвестни бази данни с научна информация.

1. Stoyanova, S., Staykov, Y., Zelqzkov, G., Sirakov, I., Nikolov, G. (2016).

Fish production and some traits of meat quality in rainbow trout (*Oncorhynchus mykiss*) farmed in different production systems. *Agricultural Science and Technology*, 8(4), 346-350;

Abstract: The rainbow trout (*Oncorhynchus mykiss*), an important species in Bulgarian aquaculture, is farmed in different production systems as raceways, net cages etc. The aim of the present study was to evaluate the effect of two different rearing systems on fish production, survival rate, meat chemical, mineral composition and farming economic efficiency of cultivated rainbow trout (*Oncorhynchus mykiss*). The information from a survey on fish production and economic efficiency traits was collected from two national rainbow trout farms using the two commonest fish farming systems: in raceways, Happy Fish Ltd fish farm and in net cages, Forest Group Ltd fish farm. The average individual weight gain (g), total weight gain (kg), feed conversion ratio, production costs of 1 kg fish and the economic efficiency coefficients were determined for the two studied fish farms. The final live weight of rainbow trout in net cages was 0.30 kg vs

0.35 kg in raceways. The average individual weight gain was higher in raceways farming system (0.30 kg) than in net cages farm (0.26 kg). The mortality rate of fish in raceways was considerably lower: only 1% as compared to that in net cages (4%). The feed conversion ratio at the end of the experiment showed identical values for trout in both farms 1.01. The meat water content of fish reared in raceways and net cages was $77.46 \pm 0.65\%$ and $74.52 \pm 0.52\%$ respectively ($P \leq 0.01$). The protein content of fish meat was higher in fish farmed in net cages $18.84 \pm 0.29\%$ as compared to fish cultivated in raceways $17.60 \pm 0.49\%$ ($P 0.05$). Meat fat content of rainbow trout, reared in the net cage system was also considerably higher ($5.26 \pm 0.30\%$) than the respective parameter in fish farmed in ponds ($3.60 \pm 0.15\%$) ($P \leq 0.001$). The content of Ca and P was higher in rainbow trouts reared in raceways (138.96 ± 1.12 mg.kg and 2844.32 ± 39.31 mg.kg

1) compared with the values of these parameters of fish in net cages (134.46±1.96 mg.kg⁻¹ and 2690.31±42.81 mg.kg⁻¹) (P≤0.05). The K and Na content exhibited the opposite tendency with substantially higher values in trouts farmed in net cages (2658.26±48.75 mg.kg⁻¹ and 671.31±16.16 mg.kg⁻¹) than in fish in raceways (2552.90±39.93 mg.kg⁻¹ and 569.32±13.75 mg.kg⁻¹) (P≤0.05, P≤0.001). The production costs of 1 kg rainbow trout were by 17.27% lower in the Forest Group farm than in the Happy Fish farm. The coefficient of economic efficiency in the net cage farm was by 23.44% higher than that of the raceways production system.

2. Velichkova, K., Sirakov, I., Valkova, E., Stoyanova, S., Kostadinova, G. (2017). Bioaccumulation and protein content of *Lemna minuta* Kunth and *Lemna valdiviana* Phil.in Bulgarian water reservoirs. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*, 6, 104-107.

Abstract: Lemna sp. have an important role indifferent aspect of aquatic ecosystems serving as a food source, by providing shelter to fish and aquatic invertebrates, changing water quality by regulating oxygen balance, nutrient cycles, and accumulating heavy metals. The aim of present study was to investigate a new found species of Lemna in Bulgarian water reservoirs regarding their protein content and bioaccumulation of heavy metals. Two water bodies located on the territory of South East Bulgaria –Tvardica Dam Lake with growing *L. minuta* and Nikolaevo fishpond with growing *L. valdiviana* were studied. Crude protein, lipid, ash content in two species of Lemna were analysed. The heavy metal in water and aquatic plants was determined on an atomic absorption spectrometer (AAS) "A Analyst 800" - Perkin Elmer.

The highest quantity of protein was measured in *L. minuta* (26.42%), which was 8.71% more compared to *L. valdiviana* (24.12). The concentrations of metals in the *L. minuta* and *L. valdiviana* followed a downward trend: Mn>Fe>Zn>Cu>Ni>Cr>Pb>Cd. The series of bioaccumulation is in descending order: Mn>Fe>Cu>Zn>Cr>Cd>Pb>Ni for *L. minuta*, and Mn>Fe>Zn>Cu>Cd>Pb>Cr>Ni for *L. valdiviana*.

3. Zhelyazkov, G., Stoyanova, S., Sirakov, I., Velichkova, K., Staykov, Y. (2018). Effect of nutmeg extract supplementation on some productive traits and economic efficiency of common carp (*Cyprinus carpio* L.) cultivated in recirculation system. *Agricultural science and technology*, 10(1), 54-56, DOI: 10.15547/ast.2018.01.013.

Abstract: The aim of the present study was to evaluate the effect of a dietary nutmeg extract supplement on the survival rate, growth performance, feed conversion ratio and economic efficiency of common carp (*Cyprinus carpio* L.) reared in a recirculation system. Thirty-two carps were allotted into two experimental variants, each of them comprising two replications with 8 fish in a group. The average initial live weight of carps from the control group (CG) and experimental group (EG) was 866.56±113.99g and 868.50±111.18g, respectively (P>0.05). Fish were reared in concrete tanks with efficient volume

of 0.8m³, elements of the recirculation system. They were fed pelleted carp feed with 25% crude protein produced by “Top mix” company, with pellet size of 6mm. The feed of fish from the EG was supplemented with 1% powdered nutmeg extract after lubricating the pellets with 5ml sunflower oil per 100g feed. Control carps received the same amount of sunflower oil-lubricated feed. The daily ration of fish from both replications was 1.8% of their live weight. The experiment duration was 45 days. The initial and final live weights were determined by individual weighing. By the end of the experiment, there was a tendency towards statistically insignificant higher average live weight in fish supplemented with 1% nutmeg extract – 986.44±125.91g vs 964.94±92.04g in non-supplemented controls (P>0.05). The survival rate of carps from both control and experimental group replications was 100%. The average individual weight gain of carps from the two EG replications (supplemented with 1% nutmeg extract) was 117.94±31.24g which was higher than that of controls by 16.58% but the differences were not statistically significant (P>0.05). At the end of the trial, the analysis of consumed feed amount showed that feed conversion ratio in the group supplemented with 1% nutmeg extract was 3.05±0.78, i.e. by 23.28% lower than that of control carps (P>0.05). The group that received 1% nutmeg extract exhibited better economic conversion ratio (2.71), by 4.06% lower than that of the non-supplemented group.

4. Velichkova, K., Sirakov, I. 2018. Growth parameters, protein and photosynthetic pigment content of *Chlorella vulgaris* cultivated under photoautotrophic and mixotrophic conditions. *Bulgarian Journal of Agricultural Science*, 24(1), 150-155.

Abstract: The purpose of this study was the determination of growth parameters, chlorophyll, carotenoid and protein content of the green microalgae *Chlorella vulgaris* cultivated under different mixotrophic and photoautotrophic conditions. Microalgae cultivation was initiated in a laboratory bioreactor of 500ml Erlenmeyer flask containing 250 ml nutrition media BBM. The cultures were maintained at room temperature (25-27°C) on a fluorescent light with a light:dark photoperiod of 12 h:12 h. The strains were checked for 96 hours growth period in photoautotrophic variants with carbon dioxide (2%, v/v), mixotrophic –CO₂ + 3g.l⁻¹ glucose, mixotrophic – CO₂ + 3g.l⁻¹ lactose. In the present study we found that *C. vulgaris* showed better growth in mixotrophic conditions with CO₂ and glucose. Higher content of chlorophylls, carotenoid and protein was obtained in the photoautotrophic culture.

5. Velichkova, K., Sirakov, I., Rusenova, N., Beev, G., Denev, S., Valcheva, N., Dinev, T. (2018). In vitro antimicrobial activity on *Lemna minuta*, *Chlorella vulgaris* and *Spirulina* sp. extracts. *Fresenius Environmental Bulletin*, 27(8), 5736-5741.

Abstract: Aquatic plants play a major role in sustaining life and are among the most productive ecosystems in the world. The aim of present study was to test different extract from *Spirulina* sp., *Chlorella vulgaris* and *Lemna minuta* for antibacterial, anti-yeast and antifungal activities. The plant extracts (methanol and ethanol) were tested for antimicrobial activity by the agar well diffusion method. Eleven bacterial, yeast and fungal strains were used. The

antimicrobial activity was evaluated by measuring zones of inhibition of microbial growth surrounding the plant extracts in the wells. The most effective extract was *L. minuta* ethanol which showed activity against all tested strains of microorganisms with the exception of *B. cereus*. Ethanol extracts of the three studied aquatic plants showed better activity than the methanol extracts.

6. Koshinski, R., Velichkova, K., Sirakov, I., Stoyanova, S. (2018). Growth performance, biochemical blood parameters and meat quality of rainbow trout (*Oncorhynchus mykiss* W.) fed with *Cnicus benedictus* L. extract. *Trakia Journal of Sciences*, 4, 300-306;

Abstract: Aquaculture development is influenced by various environmental factors and nutrition with herbal additives can affect the growth in aquaculture and to improve indicators such as digestibility, nutrition effectiveness and food taste. The purpose of this study was to trace growth performance, meat quality and biochemical blood parameters (glucose, urea, creatinine, total protein, albumin, ASAT, ALAT, Ca, P, Mg, triglycerides, cholesterol) of rainbow trout (*Oncorhynchus mykiss* W.) fed with additive blessed thistle (*Cnicus benedictus* L.) extract. To achieve the objective a control group (no added) and an experimental (with added 1363 mg.kg⁻¹ of blessed thistle extract) option, each with a two repetition, were set in a recirculating system in the Aquaculture Base of the Faculty of Agriculture at the Trakia University. Forty specimens from the fish species rainbow trout with an average weight of fish 13.32±3.07 g (control) and 13.33±2.58 g (experimental) in good health condition were placed in each tank and cultivated for 60 days. At the end of the experiment were calculated average final weight, specific growth rates, feed conversion ratio, meat quality and blood parameters. Trout from the experimental group, fed with supplement had with 8.52% higher average final weight compared to the parameter value of fish from control (P<0.001). The blood biochemical parameters ASAT and ALAT in control variant were higher with 27.4% and 44% respectively, compare to values of this parameter of fish from the experimental (P>0.05). Experimental fish fed with additive blessed thistle have a higher electrolytes level of magnesium (Mg) with 5.26% compared to control group (P>0.05). The protein content in the fish of the control group and experimental were of close value, but not statistically proven. The blessed thistle supplementation in the diet led to lower the lipid content in the fillets of the rainbow trout with 19.7% compare to values of this parameter of fish from control group and was statistically proven (P<0.05). This result shows that fish fed with the supplement are more useful and dietetic in their quality as human food. Rainbow trout fed with blessed thistle supplement have better growth performance and blood parameters.

7. Stoyanova, S., Zhelyazkov, G., Sirakov, I., Velichkova, K., Staykov, Y. 2018. Influence of dietary cinnamomum verum extract on the growth and economic efficacy of common carp (*Cyprinus carpio* L.), reared in a recirculation system. *Trakia Journal of Sciences*, 4, 307-312;

Abstract: The use of herbs as feed additives for fish showed a stimulating effect on growth, feed assimilation and increase its digestibility. The aim of research was to assess the outcome of feeding dietary cinnamon extract on the survival rate, growth performance, feed conversion and production efficiency of common carp (*Cyprinus carpio* L.), farmed in recirculation system. Thirty-two carps were distributed in two experimental variants, with two replicates of eight fish per group each. The average weight of the carps from the control and experimental group (CG) and EG) was 866.56 ± 113.99 g and 869.38 ± 96.88 g, respectively ($p > 0.05$). The average individual carp grown EG was by 18.98% higher vs CG fish, with no significant differences between groups ($p > 0.05$). The economic efficiency of feed with extract of cinnamon in the experimental group had better coefficient of economic efficiency 2.71, which is lower by 4.61% compared to the coefficient of the controls.

8. Sirakov, I., Velichkova, K., Stoyanova, S., Staykov, Y. (2018). Growth performance, biochemical blood parameters and meat quality of rainbow trout (*Oncorhynchus mykiss* W.) fed with licorice (*Glycyrrhiza glabra* L.) supplemented diet. *Trakia Journal of Sciences*, 4, 284-291;

Abstract: Licorice (*Glycyrrhiza glabra*) is medicinal plant characterized with sweet flavor which has been used in Bulgarian traditional medicine to improve the condition of the digestive tract and could positively affect digestibility and assimilation of feed nutrients in human and animal organisms. The studies connected with the effect of licorice in fish are limited. The aim of current study was to find the effect of feed supplemented with licorice *Glycyrrhiza glabra* on growth performance, blood parameters and meet quality in rainbow trout (*Oncorhynchus mykiss* W.), raised in the recirculation system. The fish were fed with two feeds: control feed (CF) - without the addition of supplement and experimental feed (EF), with supplementation of 300 mg.kg⁻¹ licorice in pellets. The stocking density of rainbow trout in recirculation system was 50 pcs.m⁻³. The initial average weight of fish in CF variant was 13.30 ± 3.07 g and in EF variant was 13.40 ± 3.55 g without differences being statistically significant ($p \geq 0.05$). The continuation of the experiment was 60 days. The average final weight, meat quality, and blood biochemical parameters were measured at the end of the experiment. The SGR and FCR were also calculated. Fish from the experimental group fed with a supplement of licorice had with 8.54% higher average final weight compared to the parameter's value in trouts from the control variant ($p < 0.05$). SGR in rainbow trout's from experimental variants was higher with 6.9% compared to the value of SGR in fish from CF variant. The blood biochemical parameters in experimental trouts were not significantly affected by supplementation of licorice extract. The average values of glucose, ASAT, and ALAT in control variant were higher respectively with 3.96%, 57.2% and 10.3% compared to values in these parameters measured in the blood of fish from the experimental variant, but differences were not statistically proven ($p \geq 0.05$). The meat quality parameters were affected from the addition of licorice in feed for trouts and the moisture, fat, and ash quantities were higher respectively with 2.49%, 36.4% and 12.5% compared with the average values of these parameters found for

fish from CF group ($p < 0.05$). The extract from licorice added to feed for the feeding of rainbow trout increases the growth of fish and affect the meat quality parameters ($p < 0.05$), but did not affect significantly the blood parameters ($p \geq 0.05$).

9. Velichkova, K., Sirakov, I. (2019). Accumulation, growth and photosynthetic response of *Lemna minuta* Kunth to heavy metal pollution. *Fresenius Environmental Bulletin*, 28 (6), 4579-4583.

Abstract: Heavy metal cause some physiological and biochemical changes if they present with toxic concentrations in aquatic environments. The study was conducted in order to trace the potential of the aquatic plant *Lemna minuta* for the bioaccumulation of Zn, Mn and Fe from contaminated water at low levels of these elements. The duckweed species was traded separately with ZnCl₂, MnCl₂·4H₂O, FeCl₃ (Valerus, Bulgaria) at 1 mg.l⁻¹ concentrations for 96 hours period. In response to metal exposure, relative growth rate (RGR), bioconcentration factor (BCF), tolerant index (Ti) and photosynthetic pigments of *L. minuta* were studied. The highest relative growth rate reduction of this aquatic plant was found with Fe (1 mg.l⁻¹) treatment which is 50% lower compared to control. The BCF of the metals on the species were in decreasing order: Fe > Zn > Mn. The manganese content of 1 mg.l⁻¹ led to an increase photosynthetic pigments.

10. Velichkova, K., Sirakov, I., Denev, S. (2019). In vitro antibacterial effect of *Lemna minuta*, *Chlorella vulgaris* and *Spirulina* sp. extracts against fish pathogen *Aeromonas hydrophila*. *AACL Bioflux*, 12(3), 936-940.

Abstract: The aim of the present study was to test extracts from *Spirulina* sp., *Chlorella vulgaris* and *Lemna minuta* against fish pathogen *Aeromonas hydrophila*. The water extract of these three aquatic plants were prepared. The plants were extracted in water solution at proportion 1:10. The received homogeny solutions were filtered and centrifuged at 7000 rpm for 30 minutes. Afterwards the extracts were filtered with sterile syringe filters with the size 0.2 μm. The bacterial strain of *Aeromonas hydrophila* (ATCC 7965) was used in current research. The bacterial activities of plant extract against *A. hydrophila* were tested with disk diffusion method. The aqueous extracts of all three test plants showed a good inhibitory effect against the fish pathogen. From the in vitro test conducted it was observed that the aqueous extract of *C. vulgaris* showed the highest zone of inhibition against *A. hydrophila* (12 mm).

11. Velichkova, K., Sirakov, I., Stoyanova, S., Staykov, Y. (2019). Cultivation of lettuce (*Lactuca sativa* L.) and rainbow trout (*Oncorhynchus mykiss* W.) in the aquaponic recirculation system. *Journal of Central European Agriculture*, 20(3), 967-973.

Abstract: Aquaponics is combined growing fish and plants in a recirculating system. Therefore, it is very important to achieve optimal conditions for their cultivation. The purpose of this study was to trace the influence of the water used by the cultivated fish on the biomass of the lettuce in the aquaponic system. In this connection, two types of hydroponic sections were built and

integrated into an existing recirculation aquaculture system. The hydrochemical parameters were measured during the trial. The duration of experiment was 60 days. Forty specimens from the fish species rainbow trout (*Oncorhynchus mykiss*) with an average weight of 13.4 g in good health condition were growing of the each of tanks of the aquaponic system. Sixteen lettuce seedlings were planted on the hydroponic section filled with light weight expanded clay aggregate (LECA) and the other sixteen plants were planted on the floating raft hydroponic section. At the end of the trial the fresh weight of the lettuce plants was measured. The productivity of lettuce plants is highly dependent on the type of plant growing medium and the fish biomass. A better removal capacity in ammonium, nitrate and ortho-phosphate were observed in the LECA section compared with the cleaning capacity in the raft section as a part of experimental aquaponics system.

12. Velichkova, K., Sirakov, I., Slavcheva-Sirakova, D. (2019). Bioaccumulation, growth and photosynthetic response of a new found in Bulgaria invasive species *Lemna minuta* Kunth and *L. valdiviana* Phil. to heavy metal pollution. *Planta Daninha*, 37.

Abstract: Heavy metals can meet in the surrounding environment as natural ingredients or from agricultural, industrial and chemical industries. The study was conducted in order to trace the potential of the aquatic plant *L. minuta* and *L. valdiviana* for the bioaccumulation of Cu, Cd, and Pb from contaminated water at low levels of these elements. Each of the duckweed species was treated separately with CuSO₄.5H₂O, CdSO₄, Pb SO₄ (Valerus, Bulgaria) at 0.5 and 1 mg L⁻¹ concentrations of for 96 hours. After conducting the experiments, relative growth rate (RGR), bioconcentration factor (BCF), tolerant index (Ti) and photosynthetic pigments of two *Lemna* species were studied. The solution with higher metal concentration more inhibits the growth of macrophytes. The BCF of the metals on the two species were in decreasing order: Cu > Pb > Cd. Our study showed that *L. minuta* and *L. valdiviana* at a concentration of 0.5 mg L⁻¹ copper have better affected on the photosynthetic apparatus compared to the control. Better bioaccumulation ability was established in *L. minuta* compared to *L. valdiviana*.

13. Sirakov I., 2019. The cleaning capacity and productivity of LECA and Floating raft aquaponic filters in an integrated recirculation system. *Bulgarian Journal of Agricultural Science*, 26(1), 243-247.

Abstract: The aim of current study was to investigate the effect of periodically flooded LECA® and Floating raft aquaponic filters with water from an integrated recirculation system on its cleaning capacity and productivity of a common carp (*Cyprinus carpio* L.) and lettuce (*Lactuca sativa*). The aquaponic system contained two types' hydroponic sub-systems (media bed and deep water culture). The water flow rate in them was maintained at 0.5 l.min⁻¹ and periodically was stopped (every 4 h) for one hour. The influence of pointed flooding regime in both filters on average weight of cultivated carps, water cleaning capacity, as well as lettuce productivity was tested.

The periodically flooded with water filters did not affect negatively the cultivated fish in current study. Better cleaning capacity of ammonium nitrogen, nitrate nitrogen and orthophosphate phosphorus in tested water regime was found for LECA® filter and they were lower respectively with 69.2%, 2.77% and 18.7% compared with the average values in these parameters found for floating raft aquaponics filter. The better yield of cultivated lettuce in tested flooding regime was found for LECA® filter and it was higher with 1.3% compared with this found for floating raft system.

14. Sirakov, I. (2019). The influence of two different lights intensities on cleaning capacity and productivity in aquaponic filter part of biological filtration in recirculation aquaculture system. *AAFL Bioflux*, 12(5), 1746-1754.

Abstract: Aquaponics is sustainable technology where fish and plants are cultivated in integrated recirculation system. In this innovative technology the meaning of light on the cleaning capacity and plants productivity in aquaponic section is still remained not very well studied. In the current study we hypothesized that the higher light intensities would increase the cleaning capacity and plant productivity in aquaponic section of the system. The aim of current research was to retrace the effect of two light intensities (54.8 ± 2.59 and 35.5 ± 3.2 w m⁻²), received respectively by the addition of artificial light (fluorescent tubes) and natural light condition on nitrogen and phosphate compounds in water, as well as on the plant's productivity in aquaponics raft system as a part of recirculation aquaculture system. The trial was conducted in greenhouse where temperature and humidity was controlled with air conditioner and fans. The aquaponic system consisted from 10 fish tanks followed by mechanical (sedimentation tank), biological filter (moving bed biofilter), sump and 8 raft aquaponics tanks. Three plant growth promoting lamps FLUORA T8 (18 w, Osram Fluorescent Fluora Tubular Linear Lamp) were used as a source of additional artificial light. The lamps were turned on at 6.30 am and stopped at 6.00 pm. For the second light regime natural light condition without additional artificial light was used. At the end of trial the growth of cultivated fish and lettuce was measured as well as hydrochemical parameters. The final weight in trout, cultivated in the system was higher with 52.8%, compared with the value in this parameter found out for the rainbow trout at the start of the trial. The average concentration of ammonium was lower with 11.6% compared with its value measured for aquaponic raft systems, where plants were exposed to natural light conditions and the difference was significant ($p < 0.05$). The artificial light positively affected also cleaning capacity of aquaponic filter, concerning average concentration of nitrates and phosphate and they were lower, respectively with 4.54% and 18.3% compared with the average concentration in these parameters found out for the aquaponics filter exposed to only natural light. The made measurement in the end of trial showed that the lettuce cultivated in aquaponics filter exposed to additional artificial light had higher yield and length of roots

and they were higher, respectively with 2.29% and 5.7%, compared with the values in these parameters found for plants cultivated in aquaponics filter exposed only on natural light, but the differences were not statistically significant ($p \geq 0.05$).

15. Velichkova, K., Sirakov, I., Dinev, T. (2020). Removal of indicator and pathogenic bacteria by *Lemna minuta* in an aquaponic recirculation system. *Fresenius Environmental Bulletin*, 29 (4), 2222-2227.

Abstract: The use of eco-technologies, such as duck- weed insetting, for wastewater treatment is becoming popular because of its affordability and efficiency of pathogen removal. The purpose of the current research was to study the influence of *Lemna minuta* as a single plant in aquaponic recirculation system on the indicator microorganisms and pathogens in water. The aquaponic recirculation system consisted of 10 fish cultivation tanks and 4 plant tanks. The cleaning block of the system consisted of one mechanical filter (settling tank) and moving bed biofilter. Weekly samples of control water, fish tanks, and tanks with *L. minuta* were taken in four replicates. For the quantitative detection of some sanitary indicator microorganisms (coliforms, *Enterobacteriaceae*), pathogens (*Salmonella* spp.) and total count in the treated water, medium plates (Compact Dry EC; Compact Dry ETB; Compact Dry SL and Compact Dry TC, R- Biopharm AG, Germany) coated with dry culture medium were used.

16. Velichkova, K., Sirakov, Veleva, P. (2020). Use of *Lemna minuta* Kunth. for composition of sustainable diets and influence on hydrochemical, technological and blood biochemical parameters in common carp (*Cyprinus carpio* L.) cultivated in aquaponics. *Bulgarian Journal of Agricultural Science*, 26 (3), 274–279.

Abstract: The purpose of this study was to investigate the influence of aquaponically grown *L. minuta* used as a part of biofilter in recirculation aquaculture systems, with its subsequent inclusion in the composition (50 and 100% content of daily feed ratio) in sustainable diets on hydrochemical, biochemical blood and technological parameters in common carp (*Cyprinus carpio* L.) fingerlings cultivated in aquaponics recirculation systems. At the end of the experiment were calculated average final weight, specific growth rates, feed conversion ratio, meat quality and blood biochemical parameters. The inclusion of up to 100% duckweed (*L. minuta*) in feed for common carp fingerlings decreases the quantity of ammonium, nitrite, nitrate and phosphate accordingly with 66%, 71.4%, 38.8% and 44.1% compared with the quantities of these parameters found for experimental groups fed with feed without inclusion of *L. minuta*. The carps fed with inclusion of up to 50% duckweed showed better growth of fish, SGR and FCR compared with fish fed with a diet without substitution of duckweed.

17. Velichkova, K., Sirakov, I., Stoyanova, S. (2020). Growth efficiency, biochemical blood parameters and meat quality of rainbow trout (*Oncorhynchus mykiss* W.), fed with supplement of sweet flag extract (*Acorus calamus* L.). *Bulgarian Journal of Agricultural Science*, 26 (Suppl. 1), 180-185.

Abstract: Different plants and their parts can be used as a supplement in food for human and animal. The purpose of this study is to establish the growth rate, meat quality and biochemical blood parameters (glucose, urea, creatinine, total protein, albumin, ASAT, ALAT, Ca, P, Mg, triglycerides, cholesterol) of rainbow trout (*Oncorhynchus mykiss*), fed with sweet flag extract (*Acorus calamus*). The fish from the control group C (without supplement) and the experimental A.c (supplemented with 1% *Acorus calamus* extract), each with two repetitions, were placed in a recirculating system at the Aquaculture Base of the Faculty of Agriculture of the Trakia University. Thirty specimens of rainbow trout with average fish weight of 42.55 ± 7.48 g (C) and 45.01 ± 8.94 g (A.c) in good health were placed in each tank and cultivated for 60 days. At the end of the experiment, average final weight, specific growth rates, feed conversion factor, meat quality and blood parameters were established. At the end of the experiment, the average live weight of fish fed with sweet flag extract was 6.53% higher than the value of the same indicator of the trout in the control group ($P < 0.05$). The calcium, phosphorus and magnesium levels in the blood of rainbow trout from the experimental group were 71.2%, 37.36% and 37.5% higher respectively than the levels of the same minerals in the control group ($P < 0.05$). Fish fed with sweet flag extract supplement have better growth rate and lower feed conversion ratio.

18. Velichkova, K., Sirakov, I., Vylkova, E. (2020). The effect of sweet flag (*Acorus calamus* L.) supplemented diet on growth performance, biochemical blood parameters and meat quality of rainbow trout (*Oncorhynchus mykiss* W.) and growth of lettuce (*Lactuca sativa* L.) cultivated in aquaponic recirculation system. *AAFL Bioflux*, 13(6), 3840-3848.

Abstract: The aim of current study was to find the effect of feed, supplemented with sweet flag (*Acorus calamus* L.) on growth performance, blood parameters and meat quality in rainbow trout (*Oncorhynchus mykiss* W.) as well as on growth of heads and roots in lettuce (*Lactuca sativa* L.), raised in the aquaponic recirculation system. Ten specimens from the rainbow trout with an average weight of 114.45 ± 12.18 g (control, C) and 108.85 ± 21.24 g (experimental, A. c.) in good health condition were placed in each tank of aquaponics recirculation system and cultivated for 60 days. At the end of the experiment were calculated: average final weight, specific growth rates, feed conversion ratio, meat quality and blood biochemical parameters. The blood samples were examined by the colorimetric method with blood analyzer (Mindray SC - 120). The meat quality (moisture %, dry matter %, crude protein content, fat, and ash content) were determined respectively to Bulgarian State Standards (BSS): 11374-86, BSS-ISO 5983, BSS-ISO 6492, BSS 11374-86). The fish fed with feed supplemented with *A. calamus* extract showed higher final weight with 8.84%, compared to the values of this parameter of trouts from the control group at the end of the experiment ($p \leq 0.01$). The average values of ALB and ALAT were respectively with 26.84% and 52.26% higher in the control group, compared to the value of the same parameter of

trouts fed with the *A. calamus* extract supplement ($p \leq 0.05$). The content of crude protein was higher in trouts from experimental group with 1.1% compared with the average value of this parameter found for fish from control group ($p \geq 0.05$). The weight of head and roots in lettuce cultivated in aquaponic system were respectively 95.4 ± 3.06 g and 26.9 ± 0.82 g in the end of trial.

Sweet flag extract used as a supplement improve feeding and physiological condition in fish without significantly affect the productivity in aquaponic aquaculture.

19. Velichkova, K., Sirakov, I., 2021. In vitro test of inhibition effect of *Lemna minuta*, *Chlorella vulgaris* and *Spirulina* sp. extracts on *Saprolegnia parasitica*, *AAFL Bioflux*, 14(1), 349-356.

Abstract: One of the most important oomycete pathogens in fish is *Saprolegnia parasitica*. Its development in freshwater pools leads to major problems in freshwater hatcheries. The aim of the present study was to test extracts from *Spirulina* sp., *Chlorella vulgaris* and *Lemna minuta* against fish pathogen *S. parasitica*. The ethanol, aqueous and methanol extract of these three aquatic plants were prepared. From the rainbow trout fish farm in Tvarditsa, Bulgaria we obtained eggs with signs of saprolegniasis. From the infected eggs, the mycelia of the pathogenic fungal microorganism were separated and cultivated. The methanol extracts from the three tested species did not show activity against the fish pathogen *S. parasitica*. For ethanol extracts of the plants we found a very good inhibitory effect on the studied pathogen. *C. vulgaris* had the strongest inhibitory effect of the three tested plant extracts.

Статии и доклади, публикувани в нереферирани списания с научно рецензиране или публикувани в редактирани колективни томове.

1. Stoyanova, S., Zhelyazkov, G., Velichkova, K., Sirakov, I., Staykov, Y. (2018). Effect of savory extract supplementation on some productive traits and economic efficiency of common carp (*Cyprinus carpio* L.). *Aquatic Research*, 1(3), 110-114, DOI: 10.3153/AR18012.

Abstract: The purpose of this study is to evaluate the effect of a dietary savory extract supplement on the survival rate, growth performance, feed conversion ratio and economic efficiency of common carp (*Cyprinus carpio* L.) reared in a recirculation system. Thirty-two carps were allotted into two experimental variants, each of them comprising two replications with 8 fish in a group. The average initial live weight of fish from both replications from the control group (CG) and experimental group (EG) was 866.56 ± 113.99 g and 866.81 ± 119.10 g, respectively ($p > 0.05$). They were kept in concrete tanks with efficient water volume of 0.8 m³, elements of the recirculation system. Carps were fed pelleted carp feed with 25% crude protein, produced with pellet size of 6 mm. The feed of fish from the EG was supplemented with 1% powdered savory extract, after lubricating the pellets with 5 ml sunflower oil per 100 g feed. Control carp received the same amount of sunflower oil-lubricated feed. The daily ration of fish from both replications was 1.8% of their live weight. The experiment duration was 45 days. Survival rates during the

experiment showed 100% survival in carps, supplemented with 1% savory extract as well as in control fish. The average individual weight gain of carps from the two EG replications (supplemented with 1% savory extract) was 154.63 ± 28.39 g, which was higher than that of controls by 57.18% (Table 3), as the differences were statistically significant ($p < 0.001$). At the end of the trial, the analysis of consumed feed amount showed that feed conversion ratio in the group supplemented with 1% savory extract was 2.25 ± 0.43 e.g. by 67.11% lower than that of control group, as the differences were statistically significant ($p < 0.001$). The group that received 1% savory extract exhibited better economic conversion ratio (1.98), by 42.42% lower than that of the non-supplemented group.

2. Sirakov, I., Velichkova, K., Slavcheva-Sirakova, D. (2018). In vitro study of the use of some medicinal plants against the fish pathogen *Aeromonas hydrophila*. *Scientific Bulletin. Series F. Biotechnologies*, XXII, 168-171.

Abstract: In current study the antibacterial activity of different medicinal herbs against fish pathogen *Aeromonas hydrophila* was evaluated. The water extract of medicinal herbs (*Glycyrrhiza glabra*, *Rhodiola rosea*, *Althaea officinalis*, *Sambucus nigra*, *Inula helenium*, *Pinus sylvestris*, *Ocimum basilicum*, *Salvia officinalis*) were prepared by the following method: the plants were extracted in water solution at proportion 1:10. The received homogeneity solutions were filtered and centrifuged at 7000 rpm for 30 minutes. Afterwards the extracts were filtered with sterile syringe filters with the size $0.2 \mu\text{m}$. The bacterial strain of *Aeromonas hydrophila* (ATCC 7965) was used in current research. The bacterial activity of plant extract against *Aeromonas hydrophila* were tested with disk diffusion method. The highest antibacterial effect against *Aeromonas hydrophila* were determined in water extract of *Salvia officinalis* and its inhibition zone was higher with 33.34% compared with the size of zone measured for the control variant.

3. Staykov, Y., Sirakov, I., Zhelyazkov G, 2018. Multitrophic system for aquaculture production in floating and submersible cages, Book of report from International scientific conference „Blue economy and blue development“, 224-229.

Abstract: The multitrophic system for aquaculture production in submersible and floating cages is a highly efficient, innovative biotechnology for the cultivation of different hydrobionts. The integrated production operates in closed cycle with the aim to increase economic efficiency of the aquafarm. The effective use of waste organic and dissolved inorganic substances from the feeding of fish cultivated in rigid well and net cages-floating and submersed, is accomplished. Cultivated mussels near the cages use waste organic matters. The algae cultivation is installed after the shellfish cultivation system and they use the dissolved inorganic substances. This cultivation technology ensures sustainable and environmental friendly aquaculture, while preserving the equilibrium in the aquatic ecosystem.

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