

Резюмета на научни публикации, представени в конкурс за „Професор“ в област на висше образование 4. Природни науки, математика и информатика, професионално направление 4.3. Биологически науки по Екология и опазване на екосистемите

на доц. д-р Катя Нанева Величкова

1. Kirjakov, I., Velichkova, K. 2016. Invasive species *Lemna* L. (Lemnaceae) in the flora of Bulgaria. *Periodicum Biologorum*, vol. 118, No 2, 131–138, DOI: 10.18054/pb.2016.118.2.4165

Abstract: Background and Purpose: During the investigations of flora of Bulgaria new species from genus *Lemna* have been found in Bulgaria. Materials and methods: They were conducted during the period 2010 – 2015 for which purpose we explored diverse pools in different parts of Bulgaria (hot and cold swamps, spillages of rivers and streams, hot mineral waters). The species were determined by Flora of North America. Results: In the flora of Bulgaria we found the following new (invasive) species *L. minuta* Kunth., *L. obscura* (Austin) Daubs, *L. perpusilla* Torr. and *L. valdiviana* Philipi. Their morphology, chorology and ecology was recorded and data about the accompanying species are also given. Conclusion: Finding these *Lemna* species in several distant locations in our country is a clear indication that the species is transferred on the territory of Bulgaria a long time ago. The species are most likely invading from neighboring fields in Southeast Europe – Greece, Romania, Turkey and others.

2 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.

3 Velichkova, K., Sirakov, I., Slavcheva-Sirakova, D. 2019. Bioaccumulation, growth and photosynthetic response of a new found in Bulgaria invasive species *Lemna minuta* and *L. valdiviana* to heavy metal pollution. *Planta Daninha*, 37, Doi: 10.1590/S0100-83582019370100119

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*.

4 Sirakov, I., Velichkova, K., Stoyanova, S., Dinev, D., Staykov, Y. 2015. Application of natural zeolites and macrophytes for water treatment in recirculation aquaculture systems. *Bulgarian Journal of Agricultural Science*, 21 (Supplement 1), 147–153.

Abstract: The macrophytes enrich the water with oxygen and help to remove nutrients. The zeolite is also a natural way to combat pollution. The aim of this study was to investigate the effectiveness in waste water treatment process in RAS, applying filter with natural zeolites and macrophytic plants from genus *Lemna* and *Elodea*. The temperature and pH were measured daily with a portable combined meter in the newly constructed control and experimental RAS. Ammonium, nitrite, nitrate, total nitrogen and phosphorus were measured spectrophotometrically. At the end of the trial the fish were weighed and specific growth rate and FCR (feed conversion ratio) were calculated. The addition of zeolite and macrophytic plants as a part of filtration system of experimental RAS, decreased significantly the quantity of nitrogen and phosphorus compounds, compared to their amount in conventional one. The better water quality in experimental system, due to the presence in the filter of zeolites and macrophytic plants, influenced positively the growth of rainbow trout and feed utilization.

5 Sirakov, I., Velichkova, K., Stoyanova, S. 2015. Comparison of microbiological parameters in experimental and conventional recirculation aquaculture systems. *Journal of Applied Biology and Biotechnology*, Vol. 3 (01), pp. 021-023.

Abstract: The purpose of current study was to compare the influence on sanitary - hygienic parameters of water in recirculation aquaculture systems (RAS) using natural zeolite and macrophytes *Lemna minor* and *Elodea canadensis* like a part of its filtration system with the microbiological indicators of water in conventional RAS. For the quantitative determination the total number of mesophilic microorganisms in 1 ml of water, and the number of certain sanitary indicative (coliforms, *E.coli*, Enterobacteriaceae) and pathogenic (*Salmonella* spp.) microorganism were used textile substrates with pre-installed on them selective chromogenic nutrient media. Microbiological testing of water in the both recirculation systems indicated that the total number microorganisms, sanitary indicative coliform bacteria as well as pathogens from the genus *Salmonella* in recirculation system using natural zeolite and macrophytes like a filter more rapidly declined their numbers compared with microbiological parameters of conventional RAS.

6 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*. Vol. VI, 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*.

7 Velichkova, K. 2019. Bioconcentration efficiency of *Lemna minor* L. and *Lemna gibba* L. for trace metals in three southeastern Bulgarian water reservoirs. *Anales de Biología* 41: 5-10, DOI: <http://dx.doi.org/10.6018/analesbio.41.02>

Abstract: Duckweed is used in wastewater treatment to remove inorganic substances, mineral and organic contamination. The purpose of present study was to investigate a *Lemna minor* and *Lemna gibba* bioconcentration efficiency of trace metals in three southeast Bulgarian water reservoirs. Three waterbodies located on the territory of South East Bulgaria: water canal town Elhovo, water canal Vaja Lake and water canal Mandra Lake was studied. Crude protein, lipid, ash content in studied species of *Lemna* were analyzed. The trace metal content in water and aquatic plants was determined on an atomic absorption spectrometer (AAS) "A Analyst 800" - Perkin Elmer. The concentrations of metals in both *L. minor* and *L. gibba* and for all sites showed a downward trend: Mn>Fe>Zn>Cu>Ni>Cr>Pb>Cd.

Научни трудове по показател Г:

8 Valkova, E., Atanasov, V., Velichkova, K., Kostadinova, G., Petkov, G. 2015. Content of Cd in water, sediment, aquatic plants and musculature of carp from surface waterbodies in Stara Zagora region, Bulgaria. *Bulgarian Journal of Agricultural Science*, 21 (Supplement 1), 190–195.

Abstract: Cd is released in considerable amounts through industrial effluents into soil, surface and ground water systems. These excessive amounts of cadmium releasing into the environment reach toxic levels and cause damage to the flora and fauna of aquatic ecosystems. This study was carried out in order to survey and assess the levels of Cd in the water, sediment, aquatic

plants and carp from different surface waterbodies in Stara Zagora Region, Bulgaria. International standards of ISO and BSS for sample preparation of water, sediment, aquatic plants and musculature of carp analyze were used. Concentration of Cd in the analyzed samples was determined by atomic adsorption spectrometry. Monitoring points at which was conducted the research are located in a region with a high degree of anthropogenic impact. Despite this fact, the concentrations of cadmium in all water samples tested were well below requirements defined by Directive 2008/105/EO and Directive 2013/39/EO. The concentrations of Cd were highest in sediment samples from Bedechka River (0.33 mg.kg⁻¹), Tunja River, Nikolaevo Town (0.31 mg.kg⁻¹) and Sazliika River (0.26 mg.kg⁻¹); in the aquatic plants from the Tunja River, Nikolaevo Town (1.89 mg.kg⁻¹). Concentrations of cadmium in musculature of carp of the all studied points were significantly lower than established norms. Quantities of cadmium were not accumulated in the muscles of the fish test species probably due to their accumulation in organs with active metabolism (liver).

9 Velichkova, K., Sirakov, I., Beev, G., Denev, S., Pavlov, D. 2016. Treatment of wastewater originating from aquaculture and biomass production in laboratory algae bioreactor using different carbon sources. *Sains Malaysiana* 45(4): 601–608

Abstract: The aim of present study was to explore the effect of different carbon sources on biomass accumulation in microalgae *Nannochloropsis oculata* and *Tetraselmis chuii* and their ability to remove N and P compounds during their cultivation in aquaculture wastewater. Microalgae cultivation was performed in laboratory bioreactor consisted from 500 mL Erlenmeyer flasks, containing 250 mL wastewater from semi closed recirculation aquaculture system. The cultures were maintained at room temperature (25-27°C) on a fluorescent light with a light: dark photoperiod of 15 h: 9 h. The microalgae species were cultivated in wastewater with different carbon sources: glucose, lactose and saccharose. The growth of strains was checked for 96 h period. In the present study, *N. oculata* and *T. chuii* showed better growth in wastewater from aquaculture with saccharose carbon source during the experiment. The most effective reduce of nitrate and total nitrogen was proved in *N. oculata* cultivated in wastewater with glucose as carbon source. *T. chuii* cultivated in wastewater

containing glucose showed 8.27% better cleaning effect in ammonium compared with *N. oculata*. *T. chuii* grew in wastewater with glucose as carbon source showed 19.5% better removal effect in phosphate compared with *N. oculata* strain.

10 Valkova, E., Atanasov, V., Velichkova, K., Kostadinova, G., Mihaylova, G. 2016. Content of Pb in water, sediment, aquatic plants and musculature of common carp (*Cyprinus carpio* L.) from different water bodies in Stara Zagora region, Bulgaria. *Bulg. J. Agric. Sci.*, 22: 566–572.

Abstract: Heavy metals in high concentration in aquatic habitat (water bodies) are accumulated in different organisms, damaging their tissues and suppressing metabolic processes. The aim of present study was to survey and assessment of lead (Pb) levels in water, sediment, aquatic plants and musculature of *Cyprinus carpio* from different water bodies in Stara Zagora region, Bulgaria. International standards of ISO for sample preparation of water, sediment, aquatic plants and musculature of common carp analyze were used. The lead levels in collected samples were determined by atomic absorption spectrometry. The studied monitoring points located in a region that is under strong anthropogenic impact. However the levels of lead in the most of the investigated water bodies do not exceed the statutory requirements set by Directive 2008/105/EC and Directive 2013/39/EC. The highest lead concentrations in sediments were measured in Tunja River, Nikolaevo Town (42.96 mg.kg⁻¹), Sazliika River (25.38 mg.kg⁻¹) and Bedechka River (23.88 mg.kg⁻¹). With the highest values of this element in the aquatic plants are characterized Sazliika River (9.26 mg.kg⁻¹), Tunja River, Banya Village (8.02 mg.kg⁻¹) and Bedechka River (5.12 mg.kg⁻¹). The highest concentration of lead in the musculature, 5 times exceeding the established norms differ Jrebchevo Dam Lake (1.19 mg.kg⁻¹). These results clearly demonstrate the ability of the sediment, aquatic plants and fish to serve as excellent indicators of lead pollution.

11 Kirjakov, I., Velichkova, K. 2017. *Hormotilopsis gelatinosa* (Chlorophyceae, Chlorophyta), a rare species newly discovered in Bulgaria. *Ann. Bot. Fennici*, 54: 39-44.

Abstract: *Hormotilopsis gelatinosa* (Chlorophyceae, Chlorophyta) is a rare alga that has so far been found only in seven places around the world. Recently, it was discovered in two water-filled basins in Bulgaria. Based on observations made on the abundant material collected *in situ*, a detailed description of the species is presented.

12 Velichkova, K., Sirakov, I. 2018. Growth parameters, protein and photosynthetic pigment content of *Chlorella vulgaris* cultivated under photoautotrophic and mixotrophic conditions. *Bulg. J. Agric. Sci.*, 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.

13 Sirakov, I., Velichkova, K., Stoyanova, S., Kaymakanova, M., Slavcheva-Sirakova, D., Atanasova, R., Staykov, Y. 2018. Effect of synbiotic dietary supplementation on growth, physiological and immunological parameters in common carp (*Cyprinus carpio* L.) fingerlings and on yield and physiological parameters in lettuce (*Lactuca sativa* L.), cultivated in mesocosmos aquaponic system. *Bulg. J. Agric. Sci.*, 24(1), 140-149.

Abstract: The aim of the present research was to test the effect of commercial synbiotic (Bio balance®) on growth, physiological and immunological parameters in common carp

fingerlings (*Cyprinus carpio* L.) and on plant productivity and physiological parameters in lettuce (*Lactuca sativa* L.) cultivated in mesocosmos aquaponic system. The current study demonstrated for first time that the application of synbiotic as feed supplementation in extruded pellet for carp in aquaponics recirculation system could be successful. The positive effect of Bio balance® on growth rate and feed utilization in carp fingerlings cultivated in aquaponic mesocosmos was observed and average final weight and FCR in fish fed with feed supplemented with Bio balance® were higher with 9.8% and 26.1% respectively, compared to the values of these parameters for fingerlings received feed without addition of synbiotic ($P \leq 0.05$). The bactericide and phagocytosis activities and hemoglobin content in blood of carps were higher in fish from the experimental variant (S1), compared with the values of these parameters found in fingerlings from the control variant (S0), but the differences were not significant ($P \geq 0.05$). The lettuces from S1 showed 2.14% higher fresh weight compared to that of lettuces from S0, but the difference was not significant ($P \geq 0.05$). The better yield in lettuce from experimental variant S1 where the carp feed was supplemented with synbiotic probably was result from better pH in water and the connected with this better assimilation of nutrients from the salad from S0 variant. Fingerlings diet supplemented with Bio balance® stimulates the physiological processes in the experimental plants. The positive effect of the synbiotics is reflected by improved leaf gas exchange parameters and nitrate reductase activity in lettuce.

14 Velichkova, K. 2019. Changes of structural characteristic of leaves in wheat varieties under the influence of experimentally contaminated water. *Bulgarian Journal of Agricultural Science*, 25 (2), 296–299.

Abstract: Two varieties of wheat were grown on different soil types (chernozem carbonate and humus-carbonate). The influence of experimentally polluted water was investigated on the structural characteristics on the leaves of the two varieties. A positive impact is detected under the influence of Mg600 and Cu300 on the thickness of leaves, leaf lamina and mezophils. Variety “Yantar” with humus-carbonate soils has better characteristics of structural leafy parameters in comparison with a variety “Sadovo” in the same soil parameters, which indicates that it is more resistant to the effects of the pollutants.

15 Stoyanova, S., Sirakov, I., Velichkova, K., Ali, M. 2019. Effect of feed protein level on water chemical and technological parameters of a recirculating aquaponics system for carp (*Cyprinus carpio* L.) and lettuce (*Lactuca sativa* L.) farming. *Turk. J. Fish. & Aquat. Sci.* 19 (10), 885-891.

Abstract: Aquaponics is a system integrating hydrobionts farming with cultivation of plant species (vegetables, spice herbs, flowers etc.). The aim of the present study was to establish the effect of feeds with different protein content (24% and 28%) on water chemical and technological parameters of a recirculating aquaponic system for carp (*Cyprinus carpio* L.) and lettuce (*Lactuca sativa* L.) farming. The experiment was conducted in 2 variants, each of 30-day duration, comprising feeding carps with pelleted feed either with 24% crude protein or 28% crude protein, with pellet size of 3.5 mm. Each of variants comprised 12 fish with uniform initial weight (563 ± 0.1 and 0.566 ± 0.3 g respectively), without significant difference ($P \geq 0.05$) and 17 plants in 2nd germination week. In fish growth performance traits at the end of experiments showed higher body weight in carps in the variant with 28% dietary protein (by 4.4%) and total body length (by 1.4%) as compared to those with 24% dietary protein. Fish fed feed with higher dietary protein level exhibited lower feeding coefficients vs those fed 24% protein (by 13.04%). The lettuce biomass and the length of their root system by the end of the trial were higher in the experimental variant with 28% crude protein.

16 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 in each of the 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.

17 Terzieva, S., Velichkova, K., Grozeva, N., Valcheva, N., Dinev, T. 2019. Antimicrobial activity of *Amaranthus* spp. extracts against some mycotoxigenic fungi. *Bulgarian Journal of Agricultural Science*, 25 (Suppl. 3), 120-123.

Abstract: Plants, their parts and products have been used to treat diseases and pathogens. The aim of the present study was to test different extracts from three species of genus *Amaranthus* L. – *A. deflexus* L., *A. retroflexus* L. and *A. hybridus* L. for antifungal activities. The plant extracts (methanol and ethanol) from ground and underground plant parts were tested for antimicrobial activity by agar well diffusion method. Five fungal strains (*Penicillium verrucosum* var. *verrucosum* NBIMCC 2003 NRRL F-143, *Penicillium expansum*, *Fusarium graminearum* NBIMCC 2294 IMI 155426, *Aspergillus ochraceus* NBIMCC 2002 IM-BAS, *Aspergillus niger*) were used. Antimicrobial activity was evaluated by measuring zones of inhibition of microbial growth surrounding plant extracts in the wells. The most effective extracts, which showed activity against all tested strains of microorganisms, were *A. deflexus* and *A. hybridus* ethanol flower extract, *A. retroflexus* ethanol root extract and *A. retroflexus* methanol leaves and stem extract.

18 Terzieva, S., Grozeva, N., Velichkova, K. 2019. Morphological studies on three *Amaranthus* species. *Bulgarian Journal of Agricultural Science*, 25 (Suppl. 3), 136-140. Abstract: The study examined indumentum, stomata and pollen morphology of *Amaranthus deflexus* L., *A. hybridus* L. and *A. retroflexus* L. from their Bulgarian populations. Mature pollen and herbarized plant parts have been observed and photographed with a scanning electron microscope (SEM). The indumentum of the three species is of multicellular, unbranched, uniseriate, glandular trichomes. Three types of stomata have been registered – anomocytic, paracytic and anisocytic with the latter type being the dominant one. Paracytic type were observed only in *A. deflexus*. Pollen grains were spheroidal, pantoporate, scabrate, with diameter from 15.4 to 24.2 μm . Among the studied three species differences in pollen morphology have been found in *A. deflexus*.

19 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 (No 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.

20 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 (No 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.

21 Sirakov, I. Velichkova, K., Rusenova N., Dinev T. 2019. In vitro test of inhibition effect of extracts from three seaweed species distributed at Black sea on different pathogens potentially dangerous for aquaponics. Romanian Biotechnological Letters, 24(1): 176-183. Abstract:

Aquaponics is innovative recirculation system where hydrobionts are cultivated together with the plants. The possibilities for control of pathogens in these systems are highly restricted. One possible strategy for inhibition of pathogenic microorganisms in aquaponics is the usage of seaweeds extracts. The study connected with the investigation of inhibition effect of seaweeds from Bulgarian Black sea coast on different pathogens is rare. The aim of current study was to test In vitro the inhibition effect of three seaweed species (*Ulva rigida*, *Cladophora vagabunda*, and *Ceramium rubrum*) distributed at Black sea in front of Bulgarian coast on different pathogens (bacteria and fungi) which are potentially harmful to hydrobionts, plants and consumer of aquaponics products. The ethanol and methanol extracts from investigated seaweed species were prepared. They were tested with agar well diffusion method against the following fish, food borne and plant pathogens: *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus cereus*, *Salmonella typhimurium*, *Candida albicans*, *Penicillium verrucosum* var. *verrucosum*, *Fusarium graminearum*, *Fusarium moniliforme* and *Aspergillus ochraceus*. The current study showed that the following extracts from seaweeds distributed in front of Bulgarian Black sea coast possess high inhibition effect (size of inhibition zone higher than 10 mm) against potentially pathogenic microorganisms in aquaponics: ethanol extract of *C. vagabunda* against *B. cereus* and *A. ochraceus*, methanol extract of *C. vagabunda* against *C. albicans*, ethanol extract of *C. rubrum* against *E.coli*, *B. cereus* and *C. albicans*.

22 Sotirov, L., Denev, S., Chobanova, S., Bozakova, N., Velichkova, K., Dinev, T., Koinarski, T. 2021. Effects of dietary marine microalgae *Schizochytrium limacinum* on natural humoral immunity of broiler chickens. *Bulgarian Journal of Agricultural Science*, 27 (No 1), 194–199.

Abstract: The aim of the study was to evaluate the effect of dehydrated whole cell dietary marine microalgae *Schizochytrium limacinum* on natural humoral immunity of broiler chickens, including serum lysozyme concentrations, alternative pathway of complement activation, beta (β) lysine, alfa (IFN- α) and gamma (IFN- γ) interferons. The first completely randomised experimental design included 90 (ninety) and the second – 120 (one hundred twenty) one day-old Ross 308 male broiler chickens that were obtained from a local commercial hatchery. Upon arrival, all chickens were individually weighted, wing-banded, and assigned randomly in three (Experiment 1) and fourth (Experiment 2) groups respectively, with three subgroups (replicates) of thirty birds each. They were housed in separate pens into wire type experimental cages that were placed in an environmentally controlled experimental poultry house. All experimental basal diets were formulated to meet or exceed broiler chick's nutritional requirements. The microalgae used in this study was a dehydrated, whole-cell *Schizochytrium limacinum* CCAP 4087/2, as a source of highly unsaturated fatty acids (DHA and EPA), supplemented with low and moderate doses. Water and feed were provided *ad libitum* throughout the experiments. The trials were terminated when the broiler chickens were 42 day of age. On the base of obtained results we can conclude that marine microalgae *Schizochytrium limacinum*, supplemented with low and moderate dietary doses, don't alter immune functions of tested indices in broiler chickens and even increase them after six weeks of treatment.

23 Kiryakov, I., Velichkova, K. 2015. *Muriella australis* J. Phillipson (Chlorophyta), a new species for the algal flora of Bulgaria. *Anales de Biologia* 37: 119-121. (web of science) Abstract: A new species and genus *Muriella australis* for the algal flora of Bulgaria are reported in this article. This rare species (known only from *locus classicus* in Australia, isolated from soil) was discovered also in Rhodope Mountains, Bulgaria in aerophilic coating on the bed of the fountains in village Slaveyno (Smolyan district). The diagnosis of the species was extended and expanded. A review of the species to the genus concerned was accomplished.

24 Kiryakov, I., Velichkova, K. 2016. A new cyanobacterial species of *Anabaena* genus (Nostocales, Cyanobacteria) from Bulgaria. *Anales de Biología* 38: 69-72. DOI: <http://dx.doi.org/10.6018/analesbio.38.06>

Abstract: A new species of cyanobacterial genus *Anabaena* Bory ex Born. Et Flah. (Nostocales) from Rhodope Mountains in Bulgaria is described. *Anabaena rhodopensis* sp. nova. has akinetes with sculptured cell walls. Biometrical data for size of vegetative cells, heterocytes and akinetes are given.

25 Sirakov, I., Velichkova, K., Stoyanova, S., Slavcheva-Sirakova, D., Staykov, Y. 2017. Comparison between two production technologies and two types of substrates in an experimental aquaponic recirculation system. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*. Vol. VI, 98-103.

Abstract: Two of the main parameters, which defined the cleaning capacity of cultivated plants and productivity of aquaponics systems, are the type of hydroponic compartment and plant's growing media. The aim of current research was to compare the cleaning capacity and plant's productivity of media bed and raft hydroponic sections as a part of a model aquaponic recirculation system. The impact of different plant growing mediums (cotton wool and rockwool) on lettuce yields was also retraced. For the purpose of this research two types of hydroponic sections (media bed and deep water sections) were constructed and integrated into an existing recirculation aquaculture system. For the trial 36 lettuce seedlings were used. Half of the plants were transferred to cotton wool and the other half of the lettuce plants were transferred to rockwool (Grodan®) substrates and afterwards all plants were placed in hydroponic pots. Eighteen lettuce seedlings (half planted on cotton wool and the other half on rockwool (Grodan®) substrate) were planted on the hydroponic section filled with lightweight expanded clay aggregate (LECA) and the other eighteen plants (half planted on cotton wool and the other half on rockwool (Grodan®) substrate) were planted on the floating raft hydroponic section. The hydrochemical parameters were measured during the trial. At the end and middle of the trial the fresh weight of lettuce plants was measured. 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 aquaponic system. The raft technology showed better plant productivity compared with the one found for the LECA bed technology. The productivity of lettuce plants is highly dependent on the type of plant growing medium, when they are cultivated in the floating raft technology.

26 Stoyanova, S., Sirakov, I., Velichkova, K., Staykov, Y. 2016. Heavy metal content in the meat of common carp (*Cyprinus carpio* L.) and rainbow trout (*Oncorhynchus mykiss* W.), cultivated under different technologies. *Agric. science and techn.*, vol. 8, No 1, 90-93. (web of science)

Abstract: Water pollution from industrial production and developing agriculture is a serious problem in aquaculture. The aim of this study was to determine the content of heavy metals Zn, Pb, Ni and Cd in the muscles of common carp (*Cyprinus carpio* L.) and rainbow trout (*Oncorhynchus mykiss* W.), grown under different technologies. In the current study were investigated common carp (*Cyprinus carpio* L.) and rainbow trout (*Oncorhynchus mykiss* W.), cultivated in net cages, earthen ponds and raceways. The concentration of heavy metals in the muscles of fish was determined by the methods of AAS in the scientific laboratory of the Faculty of Agriculture. The influence of different production technologies on the bioaccumulation of Zn, Pb, Ni and Cd (in the flesh of common carp and rainbow trout) was found. The Ni content in muscles was 31.25% higher in common carp, cultured in earthen ponds, compared with its content in the flesh of the fish raced in net cages. The concentration of Pb and Ni in rainbow trout, raced in raceways was higher than that determinate of rainbow trout cultivated in net cages, by 25.0% and 7.14%, respectively. The concentration of Cd and

Zn of these species, grown in raceways were lower by 33.33% and 2.14%, respectively, compared with their concentration in rainbow trout, cultivated in net cages.

27 Slavcheva-Sirakova, D., Shopova, N., Kostsdinov, K., Filipov, S., Velichkova, K. 2020. Climate analysis and effects of abiotic stress on salad grounded in underground greenhouse and outdoor and effects of organic fertilizers in the fight with stress factors. Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 2, 251-259.

Abstract: In the study was determined the impact of organic fertilizers as anti-stress agents and their impact on the particular species. Also was carried out an evaluation of the plant anti-stress response, by applying different methods of reporting and looking for ways to overcome it. Climate change and coming with them abiotic stressors, a consequence of extreme weather conditions, especially affect on salad grown outdoors. What are the climate fluctuations in hydrothermal conditions and how they can affect the growth and development conditions? This question is very relevant at the moment. Therefore a general hydrothermal characterization of the climate in the Plovdiv region for the period 1990-2019 has been made. In the study were made analyses of the basic conditions during the period investigated, the presence of stressors, as well as an assessment of the impact of major meteorological factors on salad crop productivity, on three different varieties, using four different formulations of organic fertilizers, and also control variants with mineral fertilizer and without fertilizing. The goal was to increase plant resistance to abiotic stress and to guarantee the yield by optimizing nutrition.

28 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.

29 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.

30 Stoyanova, S., Sirakov, I., Velichkova, K., Staykov, Y. 2015. Chemical composition and content of heavy metals in the flesh of the different marine fish species. J. BioSci. Biotechnol., SE/ONLINE: 297-301.

Abstract: The aim of current studies was to determinate the levels of heavy metals like Zn, Pb, Ni and Cd in flesh of some important fish species – mackerel (*Scomber scombrus*); European sprat (*Sprattus sprattus*); horse mackerel (*Trachurus mediterraneus ponticus*) and bluefish (*Pommatomus saltatrix*). The received concentrations are analyzed and compared against the maximum levels allowed for fish, purposed for human consumption and nutritional value of fish was evaluated. The concentration of heavy metals were, measured by atomic absorption spectrophotometry after digestion of the samples, using heating digester. The muscles of mackerel were characterized by the highest content of protein (19.20%), which was higher respectively with 1.4%, 6.8% and 5.31% compared with its content in horse mackerel, sprat and bluefish. The lipids in mackerel's muscles showed the highest content (18.09%) compared with its value in the muscles of horse mackerel, sprat and bluefish and it was higher respectively with 37.5%, 63.0% and 33.1%. The highest concentration of metals in the muscles of the studied fish species were determinate for Zn, and the lowest for Cd. The highest levels of Pb, Cd and Zh were found in muscles of sprat and the content of Ni was found to be highest in the muscles of horse mackerel. The examined fish were safe for human consumption, regarding the daily intake and safety aspect.

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