

РЕЗЮМЕТА НА НАУЧНИТЕ ТРУДОВЕ

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представени за участие в конкурс за „Доцент” по Рибовъдство, рибно стопанство и промишлен риболов, област на висше образование 6. Аграрни науки и ветеринарна медицина, професионално направление 6.3. Животновъдство, обявен от Тракийски Университет – Стара Загора в Държавен вестник бр. 90/20.11.2015г.

Сираков, И., 2008. Отглеждане на балканска и дъгова пъстърва при суперинтензивни технологии. *Автореферат на Дисертация* за присъждане на научна и образователна степен „Доктор”, шифър 04.02.12, Рибовъдство, рибно стопанство и промишлен риболов. Тракийски университет, Стара Загора.

Резюме: Продукцията на световната аквакултура бележи значителен напредък през последните години. Един от видовете с голямо значение за световната аквакултура е дъговата пъстърва (*Oncorhynchus mykiss*). Световната продукция на вида нараства стабилно и от 365240t през 1995г. достигна 510055t през 2001г. Подобна тенденция в производството на вида се наблюдава и в Република България.

Балканската пъстърва (*Salmo trutta m. fario* L.) е местен вид риба, но поради повишаващото се антропогенно въздействие нейните естествени популации намаляват. Използването на суперинтензивните технологии (мрежени клетки и рециркуляционни системи) ще позволи получаването на по-голямо количество зарибителен материал от този вид, чрез което ще се ускори възобновяването на естествените популации на вида.

Независимо от многобройните проучвания за влиянието на гъстотата на посадка при различните стопански видове риби, поради многофакторното въздействие върху преживяемостта, растежа, оползотворяването на храната всяко изследване с цел оптимизирането ѝ е актуално.

Целта на настоящото изследване е отглеждане на дъгова и балканска пъстърва при суперинтензивни технологии - мрежени клетки и рециркуляционни системи при различна гъстота на посадка и проследяване на влиянието ѝ върху биологични признаци и стопански показатели.

За проучване на влиянието на гъстотата на посадка върху интензивността на растежа, оползотворяването на фуража и преживяемостта на дъгова и балканска пъстърва, култивирани в мрежени клетки или рециркуляционни системи бяха проведени по 3 опита при едната и по 3 опита при другата производствена система. При опит 1 и 2 проведени в мрежените клетки беше използвана дъгова пъстърва, която беше култивирана съответно при 80, 100, 120 бр./m³ при първия и 140, 160 и 180 бр./m³ при втория опит. При култивирането на балканска пъстърва в мрежени клетки (опит №3) бяха използвани следните гъстоти на посадка - 80, 100 и 120 бр./m³. При първите два опита проведени в рециркуляционна система беше използвана дъгова пъстърва, която беше култивирана съответно при 60, 80 и 100 бр./m³ при първия и 25, 40 и 60 бр./m³ при втория експеримент. При третия опит в рециркуляционната система бяха отглеждани дъгова и балканска пъстърва при гъстота на посадка - 29 и 57бр./m³. В края на проведените опити бяха изчислени среднодневния (g), относителния прираст (%) и хранителния коефициент при рибите от различните опитни варианти.

За проучване на влиянието на гъстотата на посадка върху биохимичния статус при дъговата пъстърва, култивирана в рециркуляционна система бяха определени следните показатели: брой еритроцити (mln/mm³) и количество на хемоглобина /g%/ по Ибришимов и Лалов, 1984, кръвна захар (с о-толуидиновия метод), лактат (Barker and Summerson, 1941) и пируват по метода на Умбрайт. Изчислено беше отношението пируват/лактат.

За снижаване на разходите при отглеждане на дъгова и балканска пъстърва в мрежените клетки беше използван математически модел, въз основа на динамично детерминистично програмиране (Bellman and Dreyfus, 1962).

Беше направен анализ на икономическата ефективност при култивиране на дъгова пъстърва в мрежени клетки и рециркулационни системи.

Всички данни бяха обработени вариационно статистически.

При двата експеримента с дъгова пъстърва в мрежени клетки рибите, култивирани при най-малките опитни гъстоти на посадка (80 бр./m³) и (140 бр./m³) показаха най-висока жива маса съответно 99.05g и 114.95g, среднодневен прираст съответно - 1.64g и 0.97g и относителен прираст съответно - 57.64% и 66%. Най-нисък хранителен коефициент и при двата опита в мрежени клетки показва дъговата пъстърва, отглеждана при най-малката гъстота на посадка (80 бр./m³) и (140 бр./m³), съответно K=1.28 и K=1.16. Балканската пъстърва отглеждана в мрежени клетки при най-малката гъстота на посадка показва също по-висока жива маса (49.9g), по-висок среднодневен прираст (0.57g) и по-висок относителен прираст (56.75%) в сравнение със стойностите на посочените по-горе показатели при индивидите от останалите изследвани гъстоти. Балканската пъстърва отглеждана при най-ниската гъстота (80 бр./m³) показва и най-нисък хранителен коефициент - 1.39 в сравнение с този при индивидите от останалите изследвани гъстоти.

При трите експеримента с дъгова пъстърва в рециркулационна система рибите култивирани при най-малките опитни гъстоти на посадка (80 бр./m³, 20 бр./m³ и 29 бр./m³) показаха най-висока жива маса (съответно 161.9g, 96g и 45.26g), среднодневен прираст (съответно 2.37g, 0.61g и 0.59g) и относителен прираст (съответно 92.3%, 31.67% и 75.69%). Най-нисък хранителен коефициент при първите два опита в рециркулационна система показва дъговата пъстърва, отглеждана при най-малката гъстота на посадка 60 бр./m³ и 20 бр./m³, съответно K=1.37 и K=1.75. Балканската пъстърва отглеждана в рециркулационна система при гъстота на посадка 29 бр./m³ показва също по-висока жива маса (30.26g), по-висок среднодневен прираст (0.20g) и по-висок относителен прираст (47.05%), в сравнение със стойностите на посочените по-горе показатели при индивидите от другата изследвана гъстота. Балканската пъстърва отглеждана в рециркулационна система при най-ниската гъстота (29 бр./m³) показва по-нисък хранителен коефициент (с 31.7%) в сравнение с този установен при индивидите от другата изследвана гъстота.

Гъстотата на посадка при отглеждането на дъгова пъстърва в рециркулационна система влияе върху обменните процеси, като форсира анаеробната гликолиза и повишава концентрацията на хемоглобина, а също така увеличава броя на еритроцитите при рибите от най-високата гъстота на посадка.

Разработеният математически модел оптимизира стойностите на гъстотата на посадка при дъгова и балканска пъстърва, култивирани в мрежени клетки и позволява съкращаване на периода на тяхното отглеждане, което води до повишаване на печалбата във фермите.

Разходите за получаване на 1 kg прираст при рибите отглеждани в мрежени клетки при гъстота на посадка 140 бр./m³ са по-ниски от тези при пъстървите от гъстота 2 (160 бр./m³) и гъстота 3 (180 бр./m³), съответно с 10.7% и 17.7%. Разходите за получаване на 1 kg прираст при рибите, отглеждани в рециркулационна система при гъстота на посадка 1 (60 бр./m³) са по-ниски от тези при пъстървите от гъстота 2 (80 бр./m³) и гъстота 3 (100 бр./m³), съответно с 10.2% и 11.5%.

1. **Сираков И**, Е. Иванчева, 2003. Хидрохимична характеристика на язовир Доспат. Екология и бъдеще, 2 (3): 39 – 42.

Abstract: The hydrochemical parameters of dam Dospat were studied on account of its fish production utilization. The influence of fish production on the water quality was traced.

The study was carried out in the period 2000-2002 and included the following characteristics: soluble oxygen, pH, biochemical necessity of O₂ (BNO₅), permanganate oxydizability (PMO), ammonium, nitrite and nitrate nitrogen, phosphates and sulphur hydrate. The studied characteristics were within the regulations for second category waters as well as concerning the technological regulations for trout breeding. The decrease in the amount of fish production in comparison to that in the 80-s has influenced favourably the ecological condition of dam.

Keywords: dam Dospat, hydrochemical parameters, quality of waters, trout culture, rainbow trout.

2. **Сираков И.**, 2007. Отглеждане на дъгова пъстърва (*Oncorhynchus mykiss*) в затворена система при различна гъстота на посадката. Животновъдни науки, 44 (6): 108 – 111.

Abstract: The experiment was conducted with 190 pieces of rainbow trout in a recirculation water supply system, divided into 3 groups:

1.density – 60 ind./ m³

2.density – 40 ind./ m³

3.density – 25 ind./m³

The purpose of the research is to compare weight growth, nutrition coefficient and surviving of the rainbow trout cultivated in different density in recirculation system. The cultivated fish surviving was highest at the lowest density (77.5%) and the cultivated fish surviving was lowest at the highest density (64.5%). The absolute weight growth shows exactly the same tendency.

At this technology of cultivation, the nutrition coefficient has the highest value compared to the rainbow trout norm values and has optimal values at the lowest density (1.71).

3. **Sirakov I.**, E. Ivancheva, 2008. Influence of stocking density on the growth performance of rainbow trout and brown trout grown in recirculation system. Bulgarian Journal of Agricultural Science, 14 (2): 150-154.

Abstract: Rainbow trout with initial weight 20.45 g ± 0.05 and brown trout with initial weight 18.56g ± 0.08 were grown in two stocking density 1 - 29 individual.m⁻³ and stocking density 2 - 57 individual.m⁻³. Survival of fish was higher at lower density. The growth was significantly reduced at high density (P<0.05 for rainbow trout and P<0.01 for brown trout). Feed conversion ratio was favourable in tanks at low rearing density for two trout species (P<0.05). The influence of stocking density on growth and feeding ratio was higher at brown trout compared with rainbow trout.

Keywords: rainbow trout, brown trout, stocking density, survival, growth, FCR.

4. Гацева П., Д. Славчева, **И. Сираков**, М. Славчев, 2009. Мониторинг на храни относно замърсяването им с листерии. Scripta Periodica ,13 (2): 30 – 36.

Резюме:Проведен е мониторинг на храни през периода 2005-2008г. относно замърсяването им с листерии. Изследвани са общо 550 хранителни проби. С листерии са замърсени 7,6% от всички проби храни. Изолирани са 42 щама листерии в хранителните проби. Най-голямо е контаминирането на сандвичи, зеленчукови и плодови салати. Отправени са препоръки за строг здравно-хигиенен контрол при продукцията на тези рискови храни с цел превенция на хранителни заболявания.

Ключови думи:листерии, храни, замърсяване.

5. Гацева П., Д. Славчева, **И. Сираков**, С. Славчева, 2010. Сравнителна оценка на микробиологичното замърсяване на храните в пет области на Южна България . Scripta Periodica, 13(2): 28 – 35.

Резюме:Проучването включва сравнителна оценка на микробиологичното замърсяване на храни в пет области на Южна България. Изследвани са 14 групи храни, включващи 551 продукта. 16.9% (n=92) от пробите са показали отклонения по изследваните показатели. Най-висок е делът на отклоненията в хранителните проби от областите Кърджали и Хасково. Рискови по отношение на микробиологично замърсяване са сладкарските изделия, бозата и ледът. Направени са съответни препоръки относно контрола върху безопасността на храните.

Ключови думи:хранителни продукти, микробиологично замърсяване, оценка на риска.

6. Velichkova K., **I. Sirakov**, I. Kiryakov, 2011. Macrophytes in the Reservoir-cooler "Ovcharitsa". Ecology and future, 10 (1-2): 33 – 35.

Abstract: In the reservoir-cooler "Ovcharica" 24 species of macrophytes were established, of which there were 9 hydrophytes and 15 hygrophytes. This is the first material regarding macrophytes in this area. In the working process we found a new habitat of rare and protected species: *Trapa natans*.

Keywords: hydrophytes, hygrophytes, species composition, "Ovcharica".

7. Marinova, M., **I. Sirakov**, Y. Staykov, E. Ivancheva, 2011. Body and carcass parameters of sea bream (*Sparus aurata* L.) and sea bass (*Dicentrarchus labrax* L.). Agricultural science and technology, 3 (4):299 – 301.

Abstract: The aim of the study is to compare the interior and carcass parameters in two fish species prospective for cultivation in Bulgaria - sea bream (*Sparus aurata* L.) and sea bass (*Dicentrarchus labrax* L.). The weight of the internal organs and the weight of the eviscerated fish, the consumables yield (without viscera and gills) and the carcass weight have been determined. Differences have been found in the relative weight of internal organs and carcass weights in the studied fish. We identified more favorable values of weighting indices and carcass parameters in sea bream (*Sparus aurata* L.) than in sea bass (*Dicentrarchus labrax* L.).

Keywords: sea bream, sea bass, weight of carcass, weights of internal organs

8. **Sirakov I.**, Y. Staykov G. Djanovski, 2011. Consumption of dissolved oxygen in rainbow trout (*Oncorhynchus mykiss*) cultivated in raceway. Agricultural science and technology, 3 (3):220 – 223.

Abstract: The purpose of the study was to determine the dissolved oxygen consumption of rainbow trout, cultivated in raceway. The consumption analysis is based on a process automatic oxygen measurement system and compares the theoretically calculated amount of food for trout feeding based on the flow and oxygen consumption of the cultivated fish with wise used in the trout nutrition practice - calculation of feed amount according to water temperature and individual fish weight. The average amount of oxygen consumed by the fish in our trial measured in an interval of 1 minute was 0.295 mg.l⁻¹. The comparison between the calculated amount of food by the equation $\sigma = 0.054.Q$. (O in-O out) and quantity of food used in feeding of rainbow trout based on water temperature and individual fish weight did not show statistically significant differences.

Keywords: dissolved oxygen, consumption, rainbow trout, calculation of daily food ration

9. **Sirakov I.**, Y. Staykov, E. Ivancheva, G. Nikolov, A. Atanasov, 2012. Morphometric characteristic of European perch (*Perca fluviatilis*) related with sex dimorphism. Agricultural science and technology, 4(3): 203 – 207.

Abstract: The relationships among 15 morphometric measurements and carcass weight in European perch (*Perca fluviatilis*) were examined in connection with sexual dimorphism. The determined sex ratio was 1:1.3 in the advantage of the male sex. The female perch were larger than male perch by 20,7%, but the carcass weight of the male specimens was by 4,7% better in comparison with the ones measured in female specimens. There were found five morphometric characters that differ between genders: ID1 (1-st dorsal fin length) ($p \leq 0.05$), IA (anal fin length) ($p \leq 0.05$), hA (anal fin height) ($p \leq 0.05$), lp (pectoral fin length) ($p \leq 0.001$), IV (ventral fin length) ($p \leq 0.05$).

Keywords: European perch, *Perca fluviatilis*, morphometric parameters, sexual dimorphism

10. Velichkova, K., **I. Sirakov**, G. Georgiev, 2012. Cultivation of *Botryococcus braunii* strain in relation of its use for biodiesel production. J. BioSci. Biotech., SE/ONLINE: 157-162.

Abstract: Microalgae are reported as the potential resources to produce lipid from their biomass cell. The *Botryococcus braunii* strain was studied by using two media - BBM and 3N-BBM - and its potential for biodiesel production was established. The experiment was performed at room temperature, using fluorescent light at a photoperiod of 15/9h light and dark cycle. The duration of the

experiment was 25 days. The biomass was evaluated by measuring dry weight, optical density, chlorophyll, carotenoids and total lipids. The received results showed that the maximum vegetative growth was reached after approximately 21 days of incubation. The maximum growth rate during this period was 1.84 g/l dry weight in 3NBBM medium. The lipid content which we received from the examined strain was 25.2% in 3N-BBM medium.

Keywords: Botryococcus, biomass, biofuel, media

11. **Sirakov I.**, K. Velichkova, G. Nikolov, 2012. The effect of algae meal (*Spirulina*) on the growth performance and carcass parameters of rainbow trout (*Oncorhynchus mykiss*). J. BioSci. Biotech., SE/ONLINE:151-156.

Abstract: The effect of algae meal (*Spirulina spp.*) on the growth performance and carcass parameters of rainbow trout (*Oncorhynchus mykiss*) were studied. Algae meal was used as supplementary feed. One experimental diet – consisting of 10% Spirulina's meal + basal diets (10% SD) – was used in the trial and compared to a control diet – a basal diet (BD) with 0% algae. The initial size of rainbow trout from the control group was 14.95 g, whereas the group fed with experimental feed was at 14.66 g. They were stocked in semi-closed RAS at a density of 26 pcs/m³. The fish were acclimatized in the RAS for two weeks. The duration of the trial was 35 days. The weight gain, condition factor and average daily growth of rainbow trout fed with 10% SD were higher than those from the group fed with feed without algae supplement, but the differences were not statistically proven ($p > 0.05$). The fish fed with experimental feed showed better weight of eviscerated fish, consumable yield and carcass weight compared with the carcass parameters showed from fish fed with BD, but difference was statistically proven ($p < 0.05$) just for consumable yield.

Keywords: spirulina meal, rainbow trout, supplement, growth, carcass parameters

12. Киряков, И., К. Величкова, **И. Сираков**, 2013. Придружаващи и масово развиващи се видове и групи при род *Scenedesmus meyen* (*Chlorophyta chlorococcales*). Science & Technologies: Nautical & Environmental studies, 3(2): 19-24.

Abstract: The species from genus *Scenedesmus* are widespread and have important role in the lives of freshwater. To clarify the ecological characteristics of the environment in which they develop were analyzed the accompanying them algae species, which show a high degree of persistence, and the species that grow massively with taxa of the genus *Scenedesmus*. For 18 species of the genus *Scenedesmus* were examined samples taken from 17 pools of fish farm in Plovdiv. Five algal groups were identified in the analysis of the accompanying species in genus *Scenedesmus*.

Keywords: ecology, saprobic, *Scenedesmus*

13. Atanasoff, A., G. Nikolov, Y. Staykov, G. Zhelyazkov, **I. Sirakov**, 2013. Proximate and mineral analysis of atlantic salmon (*Salmo salar*) cultivated in Bulgaria. Biotechnology in Animal Husbandry 29 (3):571-57.

Abstract: Problem statement: Only limited information exists on nutrients in salmonoids meat in Bulgaria, which may be different and vary to a greater extent than the nutrient composition of other

fish items. The present paper is aimed to determine the proximate composition, macro and trace elements of Atlantic salmon's meat. These data could be helpful in judging the value of nutrient composition data as a base for dietary recommendations.

Organisms: 12 species of Atlantic salmon (*Salmo salar*).

Approach: The aim of this study was to determine the proximate composition and levels of iron, potassium, sodium, calcium, phosphorus, magnesium, copper, selenium and zinc in Atlantic salmon cultivated for the first time in Bulgaria. The content of protein, fat and ash and concentrations of iron, potassium, sodium, calcium, phosphorus, magnesium, copper, selenium and zinc were determined by automatic systems and electro thermal atomic absorption spectrometry (ETAAS) after microwave digestion. Mean values and their respective coefficients of variation were calculated from the measured concentrations.

Conclusion: In order to provide an accurate overview and to be able to calculate reliable dietary intakes, it is important to know the fish composition data.

Keywords: Atlantic salmon, Proximate composition, Macro elements, Trace elements

14. **Sirakov, I., K. Velichkova, G. Beev, Y. Staykov, 2013.** The influence of organic carbon on bioremediation process of wastewater originate from aquaculture with use of microalgae from genera *Botryococcus* and *Scenedesmus*. Agricultural science and technology, 5 (4): 443 – 447.

Abstract: Advantages of using algae for wastewater treatment include: low operational cost, possibility of recycling assimilated nitrogen and phosphorus within the algae biomass as a fertilizer, accumulated biomass for biofuel. Our purpose was to study the influence of organic carbon on bioremediation process of wastewater originate from aquaculture with use of microalgae from genera *Botryococcus* and *Scenedesmus*. Algae cultivation was initiated in a bioreactor of 500 ml Erlenmeyer flask containing 250 ml wastewater. The experiment was conducted in variants without any organic carbon sources and the other with organic carbon source – glucose (1,125g.l⁻¹). Light regime was adjusted at 15:9 h light:dark cycle in an illumination incubator until the end of experiment. The temperature was kept between 25 and 27°C. The pH varied between 6.5 and 7.5 and by this reason it was not adjusted. Species grown in wastewater with added glucose showed a better cleansing effect compared with the same grown in wastewater without any carbon sources. Better growth indicators and faster absorption of wastewater compounds was observed in *S. dimorphus*.

Keywords: aquaculture, biomass, *Botryococcus braunii*, organic carbon sources, *Scenedesmus dimorphus*, wastewater.

15. Velichkova, K., **I. Sirakov, 2013.** The Usage of Aquatic Floating Macrophytes (*Lemna* and *Wolffia*) as Biofilter in Recirculation Aquaculture System (RAS). Turkish Journal of Fisheries and Aquatic Sciences, 13: 101-110 (**IF=0.591, 2013**).

Abstract: Conventional water treatment in recirculation aquaculture systems (RAS) is a limited technology to answer the challenges of so called “sustainable aquaculture”. This is why new and innovative technologies need to be invented and introduced in RAS. The aim of the conducted study was to determine the possible advantages of using two macrophytic plants – *Lemna minor* and *Wolffia*

arrhiza and their quality as biological filter in a RAS for the cultivation of fingerlings from common carp. The temperature, dissolved oxygen, pH and conductivity were measured daily with a portable combined meter and with a probe appropriate for the parameters in the newly constructed control and experimental RAS (with floating macrophytes as a biological filter). Ammonium, nitrite, nitrate, total nitrogen and phosphorus were measured spectrophotometrically. At the end of the trial the fish were weighed and individual weight gain, specific growth rate and FCR (feed conversion ratio) were calculated. The utilization of two macrophytes (*Lemna* and *Wolffia*) in their quality as a biofilter in RAS increased dissolved oxygen in the water, significantly decreased the quantity of total dissolved solids, ammonia, nitrite, orthophosphate as well as total phosphorus in water, and significantly increased the growth of the cultivated carp's fingerlings.

Keywords: *Lemna*, *Wolffia*, biofilter, RAS, water quality, carp's fingerlings.

16. Velichkova K, I. Sirakov, G. Georgiev, 2013. Cultivation of *Scenedesmus dimorphus* strain for biofuel production. Agricultural science and technology, 5 (2): 181–185.

Abstract: Microalgae have several advantages, including higher photosynthetic efficiency as well as higher growth rates and higher biomass production compared to other energy crops.

The *Scenedesmus dimorphus* strain was studied by using two media – BBM and 3N-BBM, and its potential for biofuel production was established. The temperature varied between 25 – 27°C during the experiment. Fluorescent light was used to assure optimal light condition and a photoperiod of 15/9h light and dark cycle was maintained. The duration of the experiment was 25 days. Dry weight, optical density, chlorophyll, carotenoids and total lipids were measured for the biomass evaluation. The received results showed that the maximum vegetative growth was reached after approximately 16 days of incubation. The maximum growth rate during this period was 1.690 mg.l⁻¹ dry weight in 3N-BBM medium, and in BBM medium – 0.960 mg.l⁻¹. The lipid content which we received from the examined strain was 21.6% in BBM medium, and in 3N-BBM – 18.5%.

Keywords: biofuel, biomass, media, *Scenedesmus dimorphus*

17. Velichkova K., I. Sirakov, S. Stoyanova, 2014. Biomass production and wastewater treatment from aquaculture with *Chlorella vulgaris* under different carbon sources. Scientific bulletin. Series F. Biotechnologies, Vol. XVIII, 83-88.

Abstract: Algae are sustainable sources of biomass for fuel, food, feed and essential for their growth are light, CO₂, and inorganic nutrients like nitrogen and phosphorous. The aim of our study was to explore the effect of different carbon sources on biomass accumulation in microalgae *Chlorella vulgaris* and its ability to remove N and P compounds during its cultivation in aquaculture wastewater. Microalgae cultivation was initiated in bioreactor from 500 ml Erlenmeyer flask 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 12 h: 12 h. The microalgae were cultivated in wastewater with two different carbon sources: carbon dioxide (2%, v/v), and sodium bicarbonate (NaHCO₃) (1.125g.l⁻¹). The growth of strain was checked for 96 hours period. In our study *C. vulgaris* showed better growth in wastewater from aquaculture with bicarbonate utilization as carbon source during the experiment.

Keywords: aquaculture, biomass, carbon sources, *Chlorella vulgaris*, wastewater.

18. **Sirakov I.**, K. Velichkova , 2014. Bioremediation of wastewater originate from aquaculture and biomass production from microalgae species - *Nannochloropsis oculata* and *Tetraselmis chuii*. Bulgarian Journal of Agricultural Science, 20 (1):66-72.

Abstract: The cultivation of microalgae in wastewater leads to the removing of nutrients and at the same time, produces biomass which can be further exploited as a biofuel. At the same time, *Tetraselmis sp.* and *Nannochloropsis sp.* have a high nutritional value, and for this reason they have been widely used as a food supply in the aquaculture industry for hatchery grown herbivores. The aim of current study was to compare the biomass accumulation of two microalgae species *Nannochloropsis oculata* and *Tetraselmis chuii* cultivated in wastewater originate from recirculation aquaculture system (RAS) and explore their abilities for nitrogen and phosphorus compound removal. A bioreactor consisted of 500 ml Erlenmeyer flasks, containing 250 mL of wastewater from semi closed recirculation aquaculture system. The cultures were maintained at room temperature (25-27°C) under a fluorescent light with a light:dark photoperiod of 15 h: 9 h, with sterile air containing 2% (v/v) CO₂. Optical density, chlorophyll and carotenoids were measured for the biomass evaluation for a 10 days growth period. In our study *N. oculata* removed 78.4% of total nitrogen and 92% of nitrate. At the end of experiment for *T. chuii* cultivation in wastewater, phosphorus decreased by 79%, which was by 26.7% higher, compared to that of the phosphorus removal rate of *N. oculata*.

Keywords: biomass, *Nannochloropsis oculata*, *Tetraselmis chuii*, RAS, wastewater

19. Stoyanova S., K. Velichkova, G. Nikolov, A. Atanasoff, **I. Sirakov**, 2014. Oxygen uptake in a freshwater air-breathing fish with macrophytes. Turkish Journal of Agricultural and Natural Sciences, 1(1):915-918.

Abstract: In the cultivation of various fish species in aquaculture is an important to have enough dissolved oxygen available for fish respiration. This oxygen can be produced by the photosynthesis of aquatic plants and algae. The purpose of this study is to investigate the influence of two macrophytes *Myriophyllum spicatum* and *Lemna minor* on uptake of oxygen in the feeding of perch. The experimental part was consisted of three tanks with *Perca fluviatilis* - as one without macrophytes (like a control) and the other two with macrophytes (*Lemna minor*, *Myriophyllum spicatum*). Oxygen uptake rate was measured at water temperature 23±1°C. The measurement of pH, dissolved oxygen and temperature was made with a portable combined meter. The mean oxygen uptake rate is better in the cultivation of *Perca fluviatilis* with *Lemna minor*.

Keywords: *Lemna minor*, *Myriophyllum spicatum*, oxygen uptake, *Perca fluviatilis*

20. **Sirakov I.**, 2015. Flesh quality in rainbow trout (*Oncorhynchus mykiss* W.) and brown trout (*Salmo trutta m. fario* L.) cultivated in recirculation aquaculture system. International Journal of Current Microbiology and Applied Sciences, (4):50-57. (**IF=2.015, 2015**).

Abstract: The recirculation aquaculture systems (RAS) possess a variety of advantages compared with conventional technology (raceway and net cages) which are used for rainbow and brown trout

cultivation. These advantages will be obviously the reason of the increasing development of this ecologically friendly technology also in Bulgaria. But the questions connected with the quality of the raised fish still remains open. This made a study on the influence of cultivation technology on the body composition of two trout species raised in RAS both necessary and highly valuable for Bulgarian aquaculture. In current research a recirculation aquaculture system whose filter consisted from mechanical and biological compartments was used. The initial average weight of brown and rainbow trout cultivated in RAS in the conducted study was 19.56 ± 0.08 g and 20.45 ± 0.05 g respectively without significant differences between them. The stocking density which we used for both trout species was 57 pcs.m^{-3} . For the investigation of flesh's quality 10 fishes were caught from each experimental repetition at the beginning and in the end of the trial. The flesh fillets of farmed rainbow trout and brown trout were homogenized separately to obtain a homogeneous sample. The fish homogenate was analyzed for moisture, crude protein, total fat, ash, mineral and amino acid content. The flesh samples of rainbow trout showed higher lipid (35.8% higher quantity compared with their content at the beginning of the experiment) and better essential amino acid contents (the content of total essential amino acid (TEAA) and essential amino acid/ nonessential amino acid ratios (EAA/NEAA) increased during the experiment) compared with these obtained for brown trout, but differences in the other exanimate parameters for both tested trout species were not significant which showed that both tested fish species are appropriate for the cultivation in RAS in relation to their respective fillet quality.

Keywords: Rainbow trout, Brown trout, Flesh quality, RAS.

21. **Sirakov, I., K. Velichkova, S. Stoyanova, 2015.** Comparison of microbiological parameters in experimental and conventional recirculation aquaculture systems. *Journal of Applied Biology and Biotechnology*, 3(1):21-23.

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 *Eloдея 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.

Keywords: Macrophyte, microbiological parameters, RAS, zeolite.

22. **Сираков, И., 2015.** Влияние на гъстотата на посадка върху морфологичните признаци при балканската пъстърва (*Salmo trutta m. fario*) при отглеждането ѝ в рециркуляционна система. *Екология и бъдеще*, 13(4):46 – 52.

Abstract: The influence of stocking density on morphological parameters in brown trout (*Salmo trutta m. fario*) raised in closed recirculation system was studied. The stocking density of 29 and 57 pcs.m^{-3} were tested. The received results showed that the influence of stocking density was significant on body height, pelvic and dorsal fin lengths.

Keywords: brown trout, morphology, stocking density

23. **Sirakov, I.**, K. Velichkova, S. Stoyanova, Y. Staykov, 2015. The importance of microalgae for aquaculture industry. Review. *International Journal of Fisheries and Aquatic studies* 2(4):81-84.

Abstract: The aquaculture is a fast growing sector and constantly increasing its production. This review was done in order to establish the positive and negative importance of microalgae for the aquaculture due to the growing significance of this sector. The review is divided into four sections: (1) microalgae – a valuable additive in feeding in aquaculture, (2) coloring and biologically active compounds, (3) purification of water, (4) algal toxins.

Keywords: Aquaculture, microalgae, toxins, water purification.

24. **Sirakov, I.**, D. Slavcheva-Sirakova, 2015. The influence of climate changes on the hydrobionts: a review. *Journal of Biodiversity and Environmental Sciences (JBES)*, 6 (3): 315-329 (**IF=1.356, 2015**).

Abstract: Climate and its changes have a direct impact on the development of the different hydrobiont species. These effects on aquatic organisms could be either positive or negative. Every species adapts specifically to natural periodic and seasonal changes, however, the response to unexpected climate changes is inconsistent and not always adequate. Climate-related factors could influence food safety via numerous pathways, namely changes in temperature and rainfall, increased frequency and intensity of extreme meteorological phenomena, ocean warming and increased acidity of aquatic habitats, higher pollution level. Climate change could also have a socioeconomical impact on population feeding i.e. agriculture, animal production (aquaculture), global trade, demographic factors and human behaviour. The paper is aimed at describing some of current and future climatic changes and their possible impact on aquatic organisms in general. Global climate influences the ocean, but the ocean also plays an essential role in global climate patterns. Aquatic organisms are actively involved in the turnover of carbon dioxide and other compounds, hence hydrobionts should not be ignored.

Keywords: Climate changes, Hydrobionts, Greenhouse gases, Ocean acidification.

25. **Sirakov I.**, K. Velichkova, S. Stoyanova, D. Dinev, Y. Staykov, 2015. Application of Natural Zeolites and Macrophytes for Water Treatment in Recirculation Aquaculture Systems. *Bulg. J. Agric. Sci.*, Supplement 1, 21: 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.

Keywords: RAS, zeolite, *Elodea*, *Lemna*, water treatment

26. Стоянова, С., Г. Николов, **И. Сираков**, Й. Стайков, 2015. Влияние на добавката на екстракт от чесън (*Allium sativum*) във фуража върху растежните показатели на сибирската есетра (*Acipenser baeri*), отглеждана в рециркуляционна система. Science&Technology, Nautical & Environmental studies, 5 (2): 75-79.

Abstract: The use of garlic as additive in the feed of hydrobionts have shown a stimulatory effect on the growth and feed utilization because of increased digestibility and assimilation of ingredients. The aim of this study was to determine the influence of garlic (*Allium sativum*) as feed additive (0.25% from daily ratio) on the growth, FCR (feed conversion ratio) and mortality in siberian sturgeon cultivated in recirculation aquaculture system. The stocking density of fish was 3 kg/m³. The study didn't show significant effect of garlic as feed additive for Siberian sturgeon on the growth and FCR in cultivated fish and has shown positive effect on survival of fish.

Keywords: *Acipenser baeri*, *Allium sativum*, recirculating system.

27. Velichkova, K., **I. Sirakov**, Y. Staykov, 2015. Integrated use of two microalgal species for the treatment of aquaculture effluent and biomass production. Environmental Engineering and Management Journal (in print) (**IF=1.065, 2015**).

Abstract: One of the main challenges for the development of biomass algal system production is the high operational and capital costs for these technologies. A great opportunity to overcome these challenges may however exist in the integration of wastewater treatment with algal biomass production. The algae are used for treatment of industrial wastewater, for purification of effluent originating from livestock production, while the studies concerning the use of algae species for the treatment of aquaculture effluent are very few. The aim of our research was to compare the nitrogen and phosphate removal efficiency and the growth of two microalgae species – *Scenedesmus dimorphus* and *Botryococcus braunii*, cultivated in the wastewater, originating from freshwater aquaculture production. A laboratory bioreactor was used for algae cultivation. It consisted of 500 ml Erlenmeyer flasks, containing wastewater from semi closed recirculation aquaculture system. Light regime was adjusted at 15:9 h light: dark cycle, the air was enriched with CO₂ up to 1% and the water temperature was kept between 25 and 27°C. Samples for water chemical analysis and growth measurement were taken at the beginning of the trial, at the 24th, 96th and the 168th hour after the start of the experiment. A better removal efficiency of nitrogen compound from wastewater originate from aquaculture was determined for *B. braunii* and the concentration of ammonia, nitrite, nitrate and total nitrogen decreased at the end of trial by 50%, 84.4%, 63.1% and 61.5% respectively. A better phosphate removal efficiency (77.8%) and better growth rate were found for *Sc. dimorphus* when aquaculture effluent was used as a growing media.

Keywords: aquaculture, *Botryococcus braunii*, *Scenedesmus dimorphus*, wastewater treatment

28. Stoyanova, S., I. Sirakov, K. Velichkova, Y. Staykov (2016). Heavy metal content in the meat of common carp (*C. carpio* L.) and rainbow trout (*O. mykiss* W.) cultivated at different technologies. Agricultural science and technology (in print).

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 a 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*) and rainbow trout (*Oncorhynchus mykiss*), 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 Agricultural Faculty. It was found the influence of different production technology on the bioaccumulation of Zn, Pb, Ni and Cd in the flesh of the common carp and the rainbow trout. The nickel content in muscles was 31.25% higher in a common carp cultured at earthen ponds, compared with its content in the flesh of the fish raised in the net cages. The concentration of lead and nickel in rainbow trout raised in raceways were higher than that determined for rainbow trout cultivated in net cages respectively with 20.0% and 6.67%. The concentration of cadmium and zinc in rainbow trout raised in raceways were lower respectively with 50.0% and 2.19% compared with their concentration in rainbow trout cultivated in net cages.

Keywords: aquaculture, cultivation technology, *Cyprinus carpio*, heavy metals, *Oncorhynchus mykiss*.

29. Velichkova K., I. Sirakov, G. Beev, S. Denev, D. Pavlov, 2016. The influence of different carbon sources in wastewater treatment originated from aquaculture with the usage of microalgae. *Sains Malaysiana* (in print) (**IF=0.446, 2015**).

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 250ml 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 15h: 9h. The microalgae species were cultivated in wastewater with different carbon sources: glucose, lactose and saccharose. The growth of strains was checked for 96 hours 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.

Keywords: biomass; *Nannochloropsis oculata*; *Tetraselmis chuii*; wastewater

30. Stoyanova, S. I. Sirakov, K. Velichkova, Y. Staykov, 2016. Chemical composition and content of heavy metals in the flesh of the different marine fish species. *J. BioSci. Biotech.*, 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.

Keywords: AAS (Atomic Absorption Spectroscopy); chemical composition; heavy metal; *Pomatomus saltatrix*; *Sprattus sprattus*; *Scomber scombrus*; *Trachurus mediterraneus ponticus*.

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