

РЕЗЮМЕТА НА ТРУДОВЕТЕ, СЛЕД ЗАЩИТА НА ДОКТОРСКА ДИСЕРТАЦИЯ НА ГЛ. АС. Д-Р ГЕОРГИ ИВАНОВ ЖЕЛЯЗКОВ

За участие в конкурс за академичната длъжност „Доцент“

Област: 6. Аграрни науки и ветеринарна медицина

Професионално направление: 6.3. Животновъдство

Научна специалност: Рибовъдство, рибно стопанство и промишлен
риболов

1. **Zhelyazkov, G.,** Stratev, D. 2019. Meat quality of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta fario*) farmed in Bulgaria. Journal of Food Quality and Hazards Control, 6, 37-40.

A B S T R A C T

Background: Fish meat is outlined with high nutritional value having essential amino acids, unsaturated fatty acids, mineral and vitamins. In this short report, we compared the meat quality of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta fario*) farmed in Bulgaria.

Methods: Ten fishes from each species were purchased from a fish farm and their morphological parameters were determined. The technological properties of meat were analyzed such as water holding capacity and cooking loss as well as chemical composition such as water content, protein, fat, dry matter, and ash. Results were processed by STATISTICA 6.0 software.

Results: Higher values were significantly determined in brown trout for standard body length ($p < 0.05$), body height ($p < 0.001$), and body width ($p < 0.01$); while differences in total body length were not relevant ($p > 0.05$). Water holding capacity of rainbow trout meat ($9.49 \pm 3.86\%$) was considerably better ($p < 0.001$) than that of brown trout meat ($15.85 \pm 1.11\%$). Cooking loss in rainbow trout ($31.78 \pm 6.17\%$) was lower ($p < 0.001$) than that of brown trout meat ($44.48 \pm 4.20\%$). Protein, fat, and dry matter contents were higher in brown trout ($p < 0.001$). No statistically significant differences were found out with respect to ash content ($p > 0.05$).

Conclusion: Meat of rainbow trout cultivated in Bulgarian farm exhibited better technological properties than that of cultivated brown trout; however, nutritional value of brown trout meat was superior.

2. **Zhelyazkov, G.,** T. Yankovska-Stefanova, E. Mineva, D. Stratev, I. Vashin, L. Dospatliev, E. Valkova, T. Popova, 2018. Risk assessment of some heavy metals in mussels (*Mytilus galloprovincialis*) and veined rapa whelks (*Rapana venosa*) for human health. Marine Pollution Bulletin 128, 197–201. <https://doi.org/10.1016/j.marpolbul.2018.01.024> (IF=3.241)

A B S T R A C T

The purpose of the present study was to analyze the concentrations of lead, cadmium and mercury in mussels (*Mytilus galloprovincialis*) and veined rapa whelks (*Rapana*

venosa) caught in the Varna Bay of Black Sea and to evaluate the risk for human health from the presence of the three heavy metals. The highest average concentrations in mussels were those of cadmium (0.280 mg/kg), followed by lead (0.251 mg/kg) and mercury (0.017 mg/kg). Veined rapa whelks also showed highest levels of cadmium (1.113 mg/kg), followed by lead (0.045 mg/kg) and mercury (0.034 mg/kg). EDI values for adults consuming mussels and veined rapa whelks were below the published RfDo and PTWI values. All THQ and HI values were below 1. The consumption of *M. galloprovincialis* and *R. venosa* caught in the Varna Bay, Black Sea, did not pose any risk for the health of adult people as lead, cadmium and mercury were concerned.

3. Stratev, D., **G. Zhelyazkov**, X. S. Noundou and R. W. M. Krause, 2018. Beneficial effects of medicinal plants in fish diseases. *Aquaculture International*, 26:289–308. <https://doi.org/10.1007/s10499-017-0219-x> (IF=1.283)

ABSTRACT

Fish are constantly in contact with pathogens inhabiting water. High population density as well as poor hydrodynamic conditions and feeding lead to an increased sensitivity towards infections. In order to prevent major economic losses due to diseases, various medications are used for treatment and prevention of infections. The use of antimicrobial drugs in aquacultures could lead to emergence of resistance in pathogenic microorganisms. Alternatives are being sought over the last few years to replace antibiotics, and medicinal plants are one of available options for this purpose. These plants are rich in secondary metabolites and phytochemical compounds, which have an effect against viral, bacterial, and parasitic diseases in fish. Their main advantage is their natural origin and most of these plants do not represent threat for human health, the fish, and the environment. The goal of this review is to present information on the treatment of viral, bacterial, and parasitic diseases in fish through medicinal plants, with focus on the mechanisms of action of the identified secondary metabolites, fractions, or plant extracts.

4. Nikolova, G., Y. Karamalakova, A. Zheleva, D. Stratev, I. Vashin, **G. Zhelyazkov**, V. Gadjeva, 2018. Comparative analysis of real-time oxidative stress biomarkers measured in mussels (*Mytilus galloprovincialis*) and veined rapa whelks (*Rapana venosa*) in relation to two seasons - An electron paramagnetic resonance study. *Bulgarian chemical communications*, Volume 50, Special Issue C, (pp. 58 – 63). (IF=0.238)

ABSTRACT

The aim of this study was to elucidate the radical mechanisms for protection and survival of mussels (*Mytilus galloprovincialis*) and veined rapa whelks (*Rapana venosa*) during spring and summer season by following out levels of some real-time oxidative stress (OS) biomarkers. Thirty specimens of each species were analyzed by using electron paramagnetic resonance (EPR) spectroscopy. During spring, statistically higher levels of ROS products were found in *R.venosa* compared to *M. galloprovincialis*. During summer, statistically significant higher levels of ROS products were found in both *R. venosa* and *M. galloprovincialis*, compared to the same groups during spring. NO radicals in *R.venosa* were higher, although not statistically significant than those in *M. galloprovincialis* during both spring and summer periods. During summer, statistically significant higher levels of ascorbate radicals (Asc•) were found in both *R.venosa* and *M. galloprovincialis*, compared to the same groups during spring. However, during the summer the level of ascorbate radicals measured in *R.*

venosa were significantly higher compared to *M. galloprovincialis*. Our results showed that changes in oxidative/antioxidant status may reflect the gradient of contamination confirming the rational use of biomarkers of oxidative stress in biomonitoring of contamination. *R. venosa* has effective biochemical mechanisms of protection and survival, in particular a strong antioxidant system that provides this type of high adaptability and survival against oxidative stress.

5. **Zhelyazkov, G.**, Stratev, D. 2018. Some physicochemical characteristics of fish products sampled from Bulgarian retail markets. *Journal of Food Quality and Hazards Control*, 5, 33-36.

A B S T R A C T

Background: The quality and safety of fish products is determined by chemical, physical, and microbiological parameters, important for satisfying consumers' requirements. Also, the freshness of fish is essential for evaluation of its quality. On the Bulgarian retail market, fish is commonly offered chilled, frozen, or processed. The purpose of this study was to determine some physicochemical characteristics of fish products sampled from Bulgarian retail markets.

Methods: During June to July 2017, this survey was performed on 45 samples from smoked, semi-dried, marinated, and frozen fish products sold in Bulgarian markets. These samples were collected from specialized stores for fish products, and transported to the laboratory for analysis. Water content, water activity (*aw*), pH, salt content, and ash content were determined according to the standard protocols.

Results: The highest average water content was established in frozen products, followed by almost equal values in marinated, smoked, and semi-dried fish products. The average *aw* value was also the highest in frozen products (0.975), it was almost the same in marinated and smoked (0.892); and the least in semi-dried fish products (0.905). Semi-dried (3.36%), marinated (3.19%), and smoked (3.03%) fish products had considerably higher average salt content than frozen ones (0.1%). The average pH value of marinated fish products (5.26) was lower than frozen (6.88), smoked (6.76), and also semi-dried (6.68) ones. Average ash content was substantially higher in smoked (7.16%), semi-dried (6.57%), and marinated (5.97%) fish products compared with frozen products (1.18%).

Conclusion: It is concluded that the frozen fish products sold in Bulgarian markets are probably more susceptible to spoilage than marinated, smoked, and semi-dried ones.

6. Stratev, D., T. Popova, **G. Zhelyazkov**, I. Vashin, L. Dospatliev and Elitsa Valkova, 2017. Seasonal Changes in Quality and Fatty Acid Composition of Black Mussel (*Mytilus galloprovincialis*). *Journal of Aquatic Food Product Technology*, vol. 26, (7), 871–879. <https://doi.org/10.1080/10498850.2017.1346742> (IF=0.682)

A B S T R A C T

The study was designed to assess the seasonal variations in the quality and lipid profile of mussel meat (*Mytilus galloprovincialis*) harvested along the Bulgarian coast of the Black Sea. The trial period lasted from June to October, and the sampling was carried out in the area of Varna Bay. Technological quality of the mussels was determined by measuring the water holding capacity (WHC) and cooking and roasting losses. Proximate composition, total aerobic plate count, and fatty acid analysis were carried out. Technological parameters and nutritional quality of the mussel meat were strongly affected by the season. During the summer, the mussels had higher mass, meat

content, and meat yield ($p < 0.001$) compared to the early autumn, which corresponds to the lowest protein content during this season. Lipid profile showed seasonal variations in both individual and total fatty acid amounts ($p < 0.001$). Saturated fatty acids (SFA) had the highest content in summer, while monounsaturated fatty acids (MUFA) decreased gradually until the autumn. The content of polyunsaturated fatty acids (PUFA) reached its peak in October, contributing to the most favorable values of the nutritional indices of lipids in the early autumn.

7. Peeva, S., E. Raichev, **G. Zhelyazkov**, 2017. Fish producer's attitude to the most common fish-eating birds in Central Bulgaria. *Ecologia Balkanica*, 9(2), 1-5.

A B S T R A C T

In Bulgaria part of fish farming is through using extensive production technologies. Most of the dams used for fish production are located in the lowlands of the country and are the natural habitats of herons, cormorants and pelicans. Thus these birds are considered to be pests in extensive aqua production. To clarify whether in fact the owners and workers in fish farms obey the law with regard to fish-eating birds, an anonymous survey among 80 fish producers was conducted between January and August 2014. The positive and negative responses were expressed as a percentage. The economic factor determined the negative attitude of owners towards fish-eating birds. The lack of motivation for conservation of protected bird species was due to non-payment of compensations from the government.

8. Georgiev, D., **G. Zhelyazkov**, K. Georgieva, 2015. Sex and Size Structure of Roach (*Rutilus rutilus*) and Bleak (*Alburnus alburnus*) Populations in Zhrebchevo Dam. *Ecologia Balkanica*. vol. 7, (2), pp. 51-56.

A B S T R A C T

The purpose of the present study is to analyze the sex and size structure of roach (*Rutilus rutilus*) and bleak (*Alburnus alburnus*) populations from carp family (Cyprinidae) in Zhrebchevo Dam. The survey was conducted in February 2013. The main task of the Dam visit was to collect representatives of all fish species active in the season and caught by the fishermen. In order to obtain a representative samples of fish, was taken specimen of each species, fishermen had caught. Were got 26 sexually mature roach (7♂ and 19♀) and 27 sexually mature bleak (12♂ and 15♀). A specific feature of roach sex structure is the bigger number of females (73.08%) than males (26.92%) in the population. In the bleak (*Alburnus alburnus*) population the number of males and females is almost equal with a small predominance of the females (55.55%) over the males (44.45%). The analysis of the size structure of roach and bleak populations inhabiting Zhrebchevo Dam indicates that males are relatively smaller than females and these differences apply with accuracy of ($P \leq 0.001$) for the total body length and with accuracy of ($P \leq 0.01$) for the live weight of the examined fish species. The trend is the same within the bleak population where the differences apply with accuracy of ($P \leq 0.01$) for the total body length and with accuracy of ($P \leq 0.001$) for the live weight. Bleak's yield is 88% which is higher than the one of the roach - 16%.

9. Staykov, Y., **G. Zhelyazkov**, S. Stoyanova, 2015. Effect of substitution of sunflower meal with flaxseed meal on the growth performance and chemical composition of

meat in common carp (*Cyprinus carpio* L.). Bulgarian Journal of Agricultural Science. Supplement 1, 21: 169-174. (SJR=0.196)

A B S T R A C T

The aim of the study is to investigate the effect of substitution of sunflower meal with flaxseed meal in pellets on the growth performance and chemical composition of meat in common carp (*Cyprinus carpio* L.), cultivated in recirculating system.

Fish from both experimental variants with a started live weight 1058.38 ± 60.73 - 1077.13 ± 59.67 g were reared in concrete tanks, with effective water volume of 0.8 m^3 , part of a recirculation system. The carps from experimental group (EG) were fed a diet, containing flaxseed meal, whereas fish from control group (C) received feed, supplemented with sunflower meal. Pellets were 6 mm of size and crude protein content of 26.06 % and 26.35 %. The duration of the experiment was 60 days.

To evaluate the effect of dietary flaxseed and sunflower meals on the weight gain (g) of carps, control catches were conducted at 15-day intervals. Live body weight (g) was determined by individual weighing of fish.

The final body weight of fish from experimental groups was as followed: EG – 1272.50 ± 74.54 g and C – 1222.50 ± 70.51 g, without statistically significant differences ($P > 0.05$). With respect to weight gain, the differences between groups were also insignificant ($P > 0.05$). Feed conversion ratio of fish from C was 2.29 ± 0.17 , significantly higher by 19.27%, than this one of carp from control group ($P < 0.05$). There were no considerable differences in water content, as well as the proportions of protein, fat, dry matter and mineral substances of fish meat from two groups ($P > 0.05$).

10. Georgieva, K. and **G. Zhelyazkov**, 2018. Effect of dietary phytoextracts supplementation on growth performance and blood parameters of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in a recirculation system. Trakia Journal of Sciences, 4, 292-299. doi:10.15547/tjs.2018.04.005

A B S T R A C T

The present research aimed to examine the effect of dietary phytoextracts supplementation on the growth performance, haematological (white blood cells, red blood cells, hemoglobin, *hematocrit*) and biochemical (glucose, urea, creatinine, total protein, albumin, ASAT, ALAT) blood parameters of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in a recirculation system. The fish were divided into 6 groups: one control (C) and five experimental groups in whose food was added phytoextracts of curcumin (EC), paprika (EP), thyme (ET), oregano (EO) and garlic (EG). The inclusion of phytoextracts had no significant effect on growth parameters of fish from EC, EP, ET, EO and EG groups ($P > 0.05$). Statistically significantly lower feed consumption per unit weight gain was observed in EO group vs C ($P < 0.05$). The phytoextract supplementation had significant influence on some of the haematological (white blood cells, red blood cells, hemoglobin) and biochemical (urea, creatinine, total protein, albumin, ASAT, ALAT) blood parameters of rainbow trout.

11. Stoyanova, S., **G. Zhelyazkov**, K. Velichkova, I. Sirakov, Y. Staykov, 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. doi:10.15547/tjs.2018.04.007

A B S T R A C T

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

12. Staykov, Y., I. Sirakov, **G. Zhelyazkov**, S. Stoyanova, 2018. Mobile, modular type recirculation installation, for integrated and sustainable cultivation of hydrobionts and plants. International scientific conference „Blue economy and blue development“ 1-2 June 2018, Burgas, Bulgaria. pp. 217-223. ISBN 978-619-7126-57-0

A B S T R A C T

Biotechnology is a mobile, modular, recirculating system for integrated cultivation of hydrobionts and plants under conditions of periodic change of location of the facilities and its product-volume modeling, by addition and / or removal of operating modules, depending on the specific demand on the market.

The production system is in the field of sustainable cultivation of hydrobionts and low stemmed plants – flowers, herbs and vegetables, in places with limited water flow, providing mobility and small-scale farming as an additional business. This facility is for economically efficient and sustainable growing of hydrobionts, with the optimal using of waste water in the process of cultivation of plant species. The mobile installation provides local needs for fresh products for tourist complexes, mountain resorts and other similar places.

13. Staykov, Y., I. Sirakov, **G. Zhelyazkov**, 2018. Multitrophic system for aquaculture production in floating and submersible cages. International scientific conference „Blue economy and blue development“ 1-2 June 2018, Burgas, Bulgaria. pp. 224-229. ISBN 978-619-7126-57-0

A B S T R A C T

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

14. Georgieva, K., **G. Zhelyazkov**, Y. Staykov, D. Georgiev, 2018. Effect of dietary phytoextracts supplementation on the chemical composition and fatty acid profile of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in recirculation system. Agricultural Science and Technology, 10(3), 215-221. DOI: 10.15547/ast.2018.03.041

A B S T R A C T

The present research aimed to examine the effect of dietary phytoextracts supplementation on the chemical composition and fatty acid profile in the meat of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in a recirculation system. The fish were divided into 6 groups: one control (C) and five experimental groups in the food of which phytoextracts of curcumin (EC), paprika (EP), thyme (ET), oregano (EO) and garlic (EG) were added. The inclusion of phytoextracts had no significant effect on growth parameters of fish from EC, EP, ET, EO and EG groups ($P>0.05$). No statistical differences on water content, protein and lipids were observed in the meat of fish from the control and the experimental groups ($P>0.05$). Statistically significantly higher value of the dry matter was established in ET group in comparison with C, EC, EP, EO and EG groups ($P\leq 0.001$). The values of ash were significantly lower in fish from all experimental groups compared to the control group. The inclusion of phytoextracts did not affect the fatty acid profile of fish from EP, EO and EG groups ($P>0.05$). Exceptions are EC and ET groups, which had the lowest value of C18:3n-3 α -linolenic compared to those from the control group ($P\leq 0.05$, $P\leq 0.001$).

15. **Zhelyazkov, G.**, 2018. Effect of monosodium glutamate dietary supplementation on some productive traits of common carp (*Cyprinus carpio* L.), cultivated in net cages. Agricultural Science and Technology, 10(3), 204-207. DOI: 10.15547/ast.2018.03.039

A B S T R A C T

The aim of the study was to determine the effect of a monosodium glutamate dietary supplementation on the survival rate, growth performance, feed conversion ratio and economic efficiency of common carp (*Cyprinus carpio* L.), cultivated in net cages. Two hundred carps were allotted into two experimental variants, each of them comprising two replications (Control groups – CG and CG₁; Experimental groups – EG and EG₁), with 50 fish in a group. The average initial live weight of fish from the control and experimental groups was 1141.62±79.62g and 1129.54±71.47g, respectively ($P>0.05$). The carps were cultivated in net cages with a size 3.0/3.0/2.0m. The fish were fed with extruded feed Aqua garant VITAL, a product of Garant-Tiernahrung Gesellschaft m.b.H. - Austria, with 6mm size of pellets. Monosodium glutamate in amount of 1% was added to the feed of carps from the experimental groups. The fish from the control groups received no monosodium glutamate supplementation of the diet. The feed given to the fish was 2% of the total biomass. The trial period was 60 days, control catch at 30th day were done in order to study the influence of the monosodium glutamate supplementation on the weight gain and feed conversion ratio of the common carp, cultivated in net cages. The initial (1st day), control (30th day) and final (60th day) live weights (g) were determined by individual weighing.

The final live weight of the fish from both replications of the experimental and the control groups was as follows: 1699.36±78.43g and 1597.27±74.66g, the differences were significant ($P<0.001$). The survival rate of carps from both control and experimental group replications was 100%. The average individual weight gain of fish from the two replications (supplemented with 1% monosodium glutamate) was

569.82±3.75g which was higher than that of controls by 20.04%, the differences were 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% monosodium glutamate was 1.76 ± 0.12 , i.e. by 25.57% lower than that of control carps ($P<0.001$). The economic efficiency in the experimental groups exhibited better economic conversion ratio (0.936), by 22.65% lower than that of the non-supplemented groups.

16. **Zhelyazkov, G.**, 2018. Effect of dietary betaine supplementation on some productive traits of rainbow trout (*Oncorhynchus mykiss* W.) cultivated in recirculation system. Journal of Aquaculture Engineering and Fisheries Research, 4(2), 100-105.

A B S T R A C T

The aim of the study was to determine the effect of the dietary betaine supplementation on the survival rate, weight gain and feed conversion ratio of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in recirculation system. The fish were fed with extruded pellets "Aqua UNI", with size 2 mm. Betaine in amount of 1% and 3% was added in the feed of the rainbow trout from the experimental groups EG₁ and EG₂ respectively, the control group (CG) received no betaine supplementation of the diet. In regards to the survival of the fish from different groups no discrepancies were observed. The average individual gain of the rainbow trout was as follows: CG-70.23 ± 1.42 g, EG₁-71.93 ± 1.33 g and EG₂-73.91 ± 1.30 g, the differences were significant ($P<0.01$). The best feed conversion ration had the rainbow trout from EG₂ - $1.04 \pm 0.01\%$ and it was lower than that of the groups EG₁ and CG by $1.07 \pm 0.01\%$ and $1.13 \pm 0.02\%$ respectively, the differences were significant ($P<0.01$). The economic conversion ratio of fish production in the groups, receiving 1% and 3% dietary betaine supplementation was identical 3.47, that is lower than these ones of the fish from control group by 4.32%.

17. **Zhelyazkov, G.**, S. Stoyanova, I. Sirakov, K. Velichkova, Y. Staykov, 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

A B S T R A C T

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 ± 113.99 g and 868.50 ± 111.18 g, respectively ($P>0.05$). Fish were reared in concrete tanks with efficient volume of 0.8m^3 , 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 ± 125.91 g vs 964.94 ± 92.04 g 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 ± 31.24 g 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.

18. Stoyanova, S., **G. Zhelyazkov**, K. Velichova, I. Sirakov Y. Staykov, 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.

A B S T R A C T

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 m^3 , 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%, 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.

19. **Zhelyazkov, G.**, 2018. Effect of different diets on growth performance and survival of European perch (*Perca fluviatilis* L.) cultivated in recirculating system during transition from live food to formulated feed. Aquatic Research, 1(1), 12-17. DOI: 10.3153/AR18002.

A B S T R A C T

The purpose of the present study was to determine the influence of three different feeding methods on the growth performance and survival rate of European perch (*Perca fluviatilis* L.) cultivated in recirculating system during its transition from

natural food to pelleted feed. During the transition from natural food to formulated diet, the feed of the fish from group A was supplemented by chopped earthworms, while that of group B - with frozen bloodworms. The perch from group C were fed dough-like feed, obtained by adding of liquid betaine. The final body weight of the perch from the three groups was as follows: A- 18.99 ± 5.73 g, B - 18.49 ± 5.30 g and C - 18.06 ± 5.14 g, as the differences were not significant ($P > 0.05$). Similarly, in regard to the survival rate, the groups did not differ. The FCR in the group fed earthworms was 1.05 ± 0.02 and it was lower than that of the groups receiving bloodworms and betaine in the diet by 1.11 ± 0.02 and 1.30 ± 0.06 respectively. Significant influence of the method of feeding ($P \leq 0.001$) was found in regard to this trait.

20. Veleva-Doneva, P., S. Atanassova, **G. Zhelyazkov**, 2017. Innovative engineering methods for quality evaluation and food safety. The Małopolska School of Economics in Tarnów Research Papers Collection, 36(4), 13-23.

A B S T R A C T

The improvement of quality of life and human activity has many directions. One of them is providing high-quality and safe food. Advancements in sensor technologies, data mining and processing algorithms have provided technical capabilities for development of innovative engineering methods that guarantee certainty regarding the quality control of food and public health. The potential of Near Infrared Spectral Analysis and Aquaphotomics as non-destructive and rapid methods for monitoring food quality through observation of water absorbance bands is presented.

21. Yonkova, P. Y., H. A. Bardarova, **G. I. Zhelyazkov**, R. S. Simeonov, K. K. Dimitrov, G. Penchev, G. S. Vateva and M. G. Stefanov, 2017. Age-related anatomical and microscopic features of the oesophagus and stomach in the rainbow trout (*Onchorynchus mykiss*). Bulg. J. Vet. Med., 20, Suppl. 1, 45–49.

A B S T R A C T

The objective of this study was to describe the most important morphological features of the esophagus and different parts of the stomach in rainbow trouts at different age. Twenty rainbow trouts were divided into 2 groups, 10 numbers in each, at age 1.5 years old (1st group) and 3 years old (2nd group). Anatomical and microscopic measurements were performed. The length of the esophagus and stomach comprises more than one third of the entire gastrointestinal tract in rainbow trouts. The cardiac length was significantly shorter than pyloric one. *Lamina muscularis mucosae* and *submucosa* were not observed in oesophageal wall. The thickness of the inner muscular layer of the cardiac region was 2.8 and 1.5 times greater than the outer longitudinal layer in the 1st and 2nd group. The cardiac circular muscular layer was 22 times greater in the trouts from 1st group and 19 times in the 2nd group. The vascular and myenteric plexuses were better developed in the cardiac region.

22. Popova, T., D. Stratev, I. Vashin, **G. Zhelyazkov**, E. Valkova and L. Dospatliev, 2017. Seasonal Changes in the Quality and Fatty Acid Composition of Meat in Rapa Whelk (*Rapana venosa*) from the Bulgarian Black Sea Coast. Turkish Journal of Agricultural and Natural Sciences, vol. 4(3): 277–283.

A B S T R A C T

The study was conducted to evaluate the seasonal variations in the quality and lipid profile of rapa whelk meat (*Rapana venosa*) harvested in the Bulgarian coast of Black Sea. The trial period lasted from June to October and the sampling was carried out in the area of Varna Bay. Technological quality of the whelks was determined by measuring the water holding capacity (WHC), as well as cooking losses. Further determination of the chemical composition, fatty acid analysis and total aerobic plate count were done. Strong seasonal influence on the meat quality characteristics in rapa whelk was observed in the study. The live weight of the whelks was the highest in October ($P < 0.001$). Consequently, the content of meat and the other body parts (gut and operculum content) were highest in the early autumn as well. The increased content of meat was accompanied by lower WHC ($P < 0.001$). The chemical composition of the rapa whelks differed significantly between the months of fishing. Both moisture and lipid had highest content in July, while proteins and ash increased in October. Similarly, lipid profile was significantly affected by the season. Most favourable fatty acid composition and related nutritional indices of lipid healthy value were found in October.

23. Stoyanova S., Y. Staykov, **G. Zelqzkov**, I. Sirakov, G. Nikolov, 2016. Fish production and some traits of meat quality in rainbow trout (*Oncorhynchus mykiss*) farmed in different production systems. Agricultural Science and Technology, vol. 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 $17.60 \pm 0.49\%$ ($P \leq 0.05$). 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 ($138.96 \pm 1.12 \text{ mg.kg}^{-1}$ and $2844.32 \pm 39.31 \text{ mg.kg}^{-1}$) compared with the values of these parameters of fish in net cages ($134.46 \pm 1.96 \text{ mg.kg}^{-1}$ and $2690.31 \pm 42.81 \text{ mg.kg}^{-1}$) ($P \leq 0.05$). The K and Na content exhibited the opposite tendency with substantially higher values in trouts farmed in net cages ($2658.26 \pm 48.75 \text{ mg.kg}^{-1}$ and $671.31 \pm 16.16 \text{ mg.kg}^{-1}$) than in fish in raceways ($2552.90 \pm 39.93 \text{ mg.kg}^{-1}$

and $569.32 \pm 13.75 \text{ mg.kg}^{-1}$ ($P \leq 0.05$, $P \leq 0.001$). 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.

24. **Zhelyazkov, G.**, T. Popova, D. Stratev, 2015. Chemical composition and fatty acid profile of marinated mackerel (*Scomber scombrus*) during processing and storage. Macedonian Journal of Animal Science, vol. 5, (2), pp. 75–80.

A B S T R A C T

The aim of the present study was to determine the changes in the chemical composition and physicochemical properties in mackerel (*Scomber scombrus*) occurring after marinating and subsequent refrigerated storage of the marinated products in vegetable oils. Samples from raw mackerel, freshly marinated (0 day) and stored for 30 and 60 days in sunflower and linseed oil were taken. The chemical composition of the processed fish showed decrease in the content of lipids and increase in the minerals. No considerable changes were observed in the water, dry matter and proteins. The changes observed in the physicochemical parameters were connected with augmentation of the water holding capacity (WHC) and reduction in the water activity due to the higher chloride concentration and lower percentage of free water. Similar trend was observed in the products during storage in the vegetable oils and this led to the relatively long shelf-life of 60 days. The ratios n-6/n-3 and PUFA/SFA were below 4 and about 2 respectively, showing favourable fatty acid profile in the studied fish products.

25. **Zhelyazkov, G.**, 2015. The effect of stocking density on some hydrochemical parameters and growth traits in European perch (*Perca fluviatilis* L.), cultivated in a recirculation system. Agriculture Science and Technology. vol. 7, (2), 238–241.

A B S T R A C T

The aim of study is to determine the effect of two stocking densities on some hydrochemical parameters and growth traits in cultivation of perch (*Perca fluviatilis* L.) in recirculation system. Fish stocking material of 555 perch (*Perca fluviatilis* L.) with live weight of 21.05–28.85 g, that were divided in two groups, each of them with three replications, at a stocking density of SD_1 - 137 fish/m³ and SD_2 - 94 fish/m³. The fish are cultivated in concrete tanks with a volume of 0.8 m³, that are a part of the recirculation system. They were fed *ad libitum* three times a day with extruded pellets for trout “Aqua UNI“, a product of “Aqua garant“, with a size of the pellets of 2 mm. The trial lasted 60 days. The hydrochemical parameters in the recirculation system during the trial were determined through methods adapted for fish breeding. To study the influence of the stocking density on the weight gain and the feed conversion in perch (*Perca fluviatilis* L.), cultivated in recirculation system the average live weight (g) was determined as the fish were individually weighed at the beginning and the end of the trial. During the experimental period the mortality of the perch was also studied as the dead fish were daily controlled. At the end of the trial period the weight gain (g), survival rate (%) and the feed conversion ratio (K) of the fish were determined. In the conditions of the experiment we found that the higher stocking density does not invoke changes in most of the hydrochemical parameters of the recirculation system. The only exception is the decreased content of the oxygen dissolved in water in SD_1 -

7.51±0.12 mg.l⁻¹ compared to SD₂ - 8.31±0.13 mg.l⁻¹, as the differences are significant (P<0.05), although its values are within the optimal range of the species cultivated. At the end of the trial a tendency toward higher live weight in the fish from SD₂ - 41.82±15.01 g was observed being 4.89 % higher than the SD₁ fish. The analysis of the data concerning the survival rate show a trend toward higher value in the SD₁ - 92.12±4.58 %, while in SD₂ it is considerably lower 72.00±20.78 %, however no significant difference was found (P>0.05). The weight gain of the perch from the three replicates of SD₁ show that it is 16.18±4.18 g, this being 14.71 % lower than that of the individuals of SD₂, but the difference was not significant (P>0.05). The feed conversion ratio of the individuals of SD₁ is 1.06±0.04 and it is 17.92 % lower than that in the SD₂ fish, as the difference were significant P<0.05.

26. **Zhelyazkov, G.**, Y. Staykov, D. Georgiev, 2015. Effect of dietary betaine supplementation on some productive traits of common carp (*Cyprinus carpio* L.) cultivated in recirculation system. Conference proceedings of 7th International conference “Water and fish”, Belgrade-Zemun, Serbia, pp 518-525. ISBN 978-86-7834-224-0

ABSTRACT

The aim of the study was to determine the effect of the dietary betaine supplementation on the survival rate, weight gain and feed conversion ratio of common carp (*Cyprinus carpio* L.), cultivated in recirculation system. Forty eight carps with an average initial weight 1238.13±39.19 - 1241.25±29.73 g were divided in three groups, each of them with two replications. The fish were cultivated in concrete tanks with a volume of 0.8 m³, that were part of the recirculation system. The fish were fed with extruded feed "Aqua VITAL", a product of "Aqua garant", with 6 mm size of pellets. Betaine in amount of 1 % was added to the feed of carps from the experimental group EG₁, while this one of the fish from the second experimental group (EG₂) contained 3 %. The carp from the control group (CG) received no betaine supplementation of the diet. The feed given to the fish was 2 % of the live weight. The trial period was 60 days, control catch at 30th days was done in order to study the influence of the dietary betaine supplementation on the weight gain and feed conversion ratio of the carp (*Cyprinus carpio* L.), cultivated in recirculation system. The live weight (g) at the control catch was determined as the fish were weighted individually. The final live weight of the carp from the experimental and the control groups was as follows: EG₁ - 1727.50±40.52 g, EG₂ - 1749.39±33.45 g and CG - 1646.88±26.51 g. In the fish from EG₂ the values of this parameter were higher than those of the individuals from EG₁ and CG, respectively by 1.27 % and 6.22 %, but the differences were not significant (P>0.05). The average individual gain of the carp from the two replicates of CG was 406.25±20.61 g, that was respectively 20.46 % and 25.08 % lower, than that these ones of the fish receiving 1 % and 3 % betaine and the differences were significant (P<0.001). The best feed conversion ration had the carp from EG₂ - 1.49. This trait showed lower values than those of the fish from EG₁ and CG, respectively by 3.36 % and 24.16 % (P<0.001). In regards to the survival of the fish from different groups no discrepancies were observed. The economic conversion ratio of fish production in the group, receiving 1 % of betaine is 1.66, that is lower than these ones in EG₂ and CG, respectively by 10.34 % and 15.66 %.

27. **Zhelyazkov, G.**, D. Georgiev, L. Dospatliev, Y. Staykov, 2014. Determination of Heavy Metals in Roach (*Rutilus rutilus*) and Bleak (*Alburnus alburnus*) in Zhrebchevo Dam Lake. *Ecologia Balkanica*. vol. 5, Special Edition pp. 15-20.

A B S T R A C T

The aim of this study was to examine the concentration of iron (Fe), nickel (Ni), lead (Pb), manganese (Mn), copper (Cu), chromium (Cr), cadmium (Cd) and zinc (Zn) in roach (*Rutilus rutilus*) and bleak (*Alburnus alburnus*) as species for human consumption. Two fresh water fish species, roach and bleak were caught from Zhrebchevo Dam Lake in Bulgaria. Determination of heavy metals (Fe, Cu, Ni, Pb, Zn, Mn, Cr and Cd) in muscle samples were performed with electro thermal atomic absorption spectrometry (ETAAS). The heavy metal content in the meat of roach and bleak were found to be 0.59 ± 0.032 - 0.69 ± 0.128 mg kg⁻¹ for Cu, 6.59 ± 0.224 - 7.34 ± 0.142 mg kg⁻¹ for Fe, 0.03 ± 0.025 - 0.04 ± 0.012 mg kg⁻¹ for Ni, 0.06 ± 0.044 - 0.07 ± 0.031 mg kg⁻¹ for Pb, 4.05 ± 0.263 - 5.46 ± 0.388 mg kg⁻¹ for Zn, 0.49 ± 0.060 - 0.72 ± 0.080 mg kg⁻¹ for Mn, 0.09 ± 0.036 - 0.1 ± 0.045 mg kg⁻¹ for Cr, 0.01 ± 0.002 - 0.01 ± 0.003 mg kg⁻¹ for Cd. The data show that the differences between the content of Fe, Cu, Mn, Zn, Cr and Ni in roach and bleak are significant, while these ones of Pb and Cd are not significant. The significant differences in the content of heavy metals in muscles of roach and bleak are as a result of multiple factors, including season, food, chemical properties of water or sediment. The data established during the investigation show that the edible part of fish do not carry heavy metals loads and concentrations are below the legal value for fish and fish products established by the Food and Agriculture Organization and national legislation. This paper is helpful to consumers and academics concerning the mineral of body composition of roach (*Rutilus rutilus*), and bleak (*Alburnus alburnus*).

28. 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*. vol. 29 (3), 571-579.

A B S T R A C T

Problem statement: Only limited information exists on nutrients in salmonoids meat in Bulgaria, which may to 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.

29. Atanasoff, A., V. Ivanov, G. Nikolov, **G. Zhelyazkov**, B. Petrova, 2012. Effects of dietary Vitasil on growth performance of carp (*Cyprinus carpio*). "Book of proceedings" 3rd International Scientific Meeting 2-4 September 2012, Ohrid, R. of Makedonia, pp 90-92.

A B S T R A C T

Problem statement: We investigated the effect of Vitasil supplementation on growth performance of carp (*Cyprinus carpio*). Two hundred and forty carp with initial average weight 63.3 ± 0.2 g were divided into three groups and reared in nine concrete tanks (1 m x 1 m x 1 m).

Approach: The animals were fed with 3 diets: The feeds were I based only (control), II standard trout diet (with high content of protein and fat), and III trout diet with 5 % Vitasil.

Results: The results show that dietary Vitasil levels significantly influenced the growth of the carp compared with the control group, average weight gain (AWG) in all treatment groups, body weight gain (BWG), specific growth rate (SGR) and feed conversion ratio (FCR) in fish fed with diets supplemented with 5% Vitasil were significantly increased ($P < 0.001$).

Conclusion: In general, with the supplementation of Vitasil, particularly at dose 55, growth performance can be improved effectively.