РЕЗЮМЕ НА НАУЧНИТЕ ТРУДОВЕ

на гл. ас. Албена Василева Мерджанова, дх

За участие в конкурс за заемане на академична длъжност ДОЦЕНТ в област на висшето образование 4. Природни науки, математика и информатика, професионално направление 4.2. Химически науки, по научна специалност „Химия“ обявен за нуждите на Катедра Химия в ДВ 36/27.04.2018 г.

Списъкът с резюметата на научните трудове на гл. ас. Албена Мерджанова включва:

I. **Автореферат на дисертационен труд** „Мастнокиселинен съставна черноморски и сладководни риби *(2014). Медицински Университет-Варна (51стр.)*

II. Пълнотекстови публикации, в международни научни списания, равностойни на монографичен труд (8 броя)

Участие като съавтор в глава от книга
Albena Merdzhanova, Diana A. Dobreva and Veselina Panayotova (April 25th 2018). Assessment of Proximate and Bioactive Lipid Composition of Black Sea Mussels (M. galloprovincialis) from Bulgaria, Chapter 9 in Biological Resources of Water Sajal Ray, Intech Open, DOI: 10.5772/intechopen.71909.

Пълнотекстови публикации, в български (26 бр.) и международни (9 бр.) научни списания, подредени по хронологичен ред, сред които 4 статии с импакт фактор

III. Избрани резюмета, публикувани в сборници от научни конференции – бр.

IV. Участие като съавтор в учебни помагала - 3 броя

1. „Химия, учебно помагало“ за студентите от Медицински Колеж“
2. Тетрадка по химия, за студентите по дисциплина „Неорганична и органична химия“, за специалност „Медицински лаборант“, Медицински Колеж, към МУ-Варна
3. Тетрадка по химия, за студентите по дисциплина „Химия“, за специалност „Медицина“, МУ-Варна

I. **Автореферат** на дисертационен труд „Мастнокиселинен състав на черноморски и сладководни риби“ , Медицински Университет, Варна (2014)

През последните години редица международни организации като Световната здравна организация (WHO), Организация за прехрана и земеделие (FAO) и Европейската федерация по безопасност на храните (EFSA) насочват вниманието към омега-3 (n3) и омега-6 (n6) полиненаситени мастни киселини (ПНМК) като важен компонент на човешката диета, необходим за предотвратяване на хронични заболявания, особено свързаните със сърдечно-съдовата система. Поставя се акцент върху ролята на специфичните групи мастни киселини (МК), поради доказаната роля на дълговерижните ПНМК в неонаталното и детско умствено развитие. Все по нови епидемиологични и клинични проучвания доказват ролята на n-3ПНМК за здравния статус, както и при превенцията на специфични хронични заболявания като коронарна болест на сърцето, атеросклероза, хипертония, диабет, артрит, остеопороза и други. Редица научни колективи са установили връзка между повишаване консумацията на риба и намаляване на риска от сърдечно-съдовите заболявания. Консумацията на риба в България е значително по-ниска в сравнение със средната европейска (23 kg годишно на човек), затова е предприета политика за повишаване на индивидуалната консумация на риба и рибни продукти до 7 – 8 kg на човек. Оптималното използване на черноморските риби в здравословното хранене изисква детайлно познаване на мастнокиселинния им състав. В България не са провеждани систематични изследвания на липиден и мастнокиселинен състав на черноморски риби, въпреки доказания благоприятен ефект на дълговерижните ПНМК върху човешкото здраве. Липсват систематизирани данни за енергийна стойност, детайлен мастнокиселинен състав на общите липиди и липидни индекси на традиционно консумирани български черноморски рибни видове. Затова в представеният дисертационен труд е изследван мастнокиселинния състав на 11 черноморски (трицона, кая, карагьоз, сафрид, калкан, барбуна, паламуд, зарган, чернокоп, кефал и хамсия) и 4 сладководни (шаран, толстолоб, пъстърва и сом) рибни вида със стопанско значение. За 6 от черноморските видове (трицона, кая, карагьоз, сафрид, калкан и барбуна) е проследена сезонната промяна в липидното съдържание и мастнокиселинният състав. Идентифицирани са 34 мастни киселини (МК), с права верига и четен брой С-атоми (C_{10}-$C_{24:1}$). Количествено са определени 30 броя МК, които са класифицирани в три групи: наситени (НМК), мононенаситени (МНМК) и полиненаситени (ПНМК). Определени са групите омега 3 и омега 6 ПНМК. Установени са значителни сезонни различия в разпределението на трите групи МК. Въз основа на данните от МК състав на анализираните видове са изчислени мастнокиселинни съотношения (омега-6/омега-3 ПНМК и ПНМК/НМК), липидни индекси (атерогенен, тромбогенен и холестеролемичен) и количествата на омега-3 ейкозапентаенова и докозахексаенова ПНМК в g.100 g^{-1}свежо тегло. Определена е енергийната стойност на 7 черноморски и два сладководни вида и са съставени таблици с химичен и мастнокиселинен състав на тези видове. На база на представените резултати се прави заключение, че анализираните видове имат балансиран МК състав и са много добър източник на ПНМК. Получените резултати ще бъдат полезни за специалисти в областта на храненето, както и занимаващите се с биологията на видовете.

МЕДИЦИНСКИ УНИВЕРСИТЕТ „ПРОФ. Д-Р ПАРАСКЕВ СТОЯНОВ“ ВАРНА

ФАКУЛТЕТ ПО ФАРМАЦИЯ

КАТЕДРА ХИМИЯ

АЛБЕНА ВАСИЛЕВА МЕРДЖАНОВА

МАСТНОКИСЕЛИНЕН СЪСТАВ НА ЧЕРНОМОРСКИ РИБИ

АВТОРЕФЕРАТ

на дисертация за присъждане на образователна и научна степен „ДОКТОР“

по научна специалност „Биоорганична химия, химия на природните и физиологично активни вещества“

Научен ръководител:
доц. Любомир Македонски, дх

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Проф. д-р Магдален Златанов
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ВАРНА, 2014

II. Пълнотекстови публикации, в международни научни списания, равностойни на монографичен труд (8 броя):

1.Stancheva, M., Galunska, B., Dobreva, A. D., **Merdzhanova, A. (2012).** Retinol, alpha-tocopherol and fatty acid content in Bulgarian Black Sea fish species. *Grasas y aceites*, *63*(2), 152-157 **(IF=0.780)**

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ISSN: 0017-3495
DOI: 10.3989/gya.069611

Retinol, alpha-tocopherol and fatty acid content in Bulgarian Black Sea fish species

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RESUMEN

Retinol, alfa-tocoferol y contenido en ácidos grasos de especies de peces búlgaros del Mar Negro.

El objeto de la investigación presentada es definir y comparar los lípidos totales, el perfil de ácidos grasos y el contenido de retinol y alfa-tocoferol en el tejido comestible de cuatro especies de peces con importancia comercial del Mar Negro búlgaro —espadín (*Sprattus Sprattus*), gobio de boca negra (*Neogobius Melanostomus*), chicharro (*Trachurus Trachurus*) y sábalo del Mar Negro (*Caspialosa Pontica*). Dos vitaminas liposolubles son analizadas simultáneamente mediante cromatografía líquida de alta eficacia (HPLC). El contenido mayor de retinol se encuentra en el espadín (142.3 ± 4.4 µg/100g), y de alfa-tocoferol en el chicharro (1112.7 ± 39.2 µg/100g). El contenido de ácidos grasos ha sido analizado mediante cromatografía gaseosa/espectrometría de masas (GC/MS). El contenido de ácidos grasos (AG) omega-3 (n3) es considerablemente más alto que el contenido de ácidos grasos (AG) omega-6 en todas las especies analizadas. La proporción n6/n3 está en el intervalo recomendado (0.2-1.5) para el espadín, el gobio de boca negra y el sábalo del Mar Negro. Los niveles relativamente altos de retinol, alfa-tocoferol, relaciones de ácidos grasos, n6/n3 AG y PUFA/SFA muestran que todas estas especies de peces poseen buenas propiedades nutricionales.

PALABRAS CLAVE: Alosa pontica – Mar Negro – Neogobiusrattan – Sprattus sprattus – Trahurus medditeraneus ponticus.

levels of retinol and alpha-tocopherol, FA composition, n3/n6 FA and PUFA/SFA ratios indicate that these fish species have good nutritional quality.

KEY-WORDS: Alosa pontica – Black sea – Neogobius rattan – Sprattus sprattus – Trahurus medditeraneus ponticus.

1. INTRODUCTION

Fish is an important component of a healthy diet, providing a number of substantial nutrients that are essential for achieving a balanced nutrition for children, adults and the elderly. Fish tissue is a good source of fats, proteins, vitamins and minerals. Lipids of marine fish species are rich sources of fat soluble vitamins and both saturated and unsaturated fatty acids (Tocher, 2003). The fat soluble vitamins are essential nutrients related to a diversity of biologically important processes in the human body. Retinol takes place in photo reception, regulates gene expression and cell proliferation, bone growth and reproduction. The biologically active isomer of vitamin E - alpha-tocopherol acts as an antioxidant protecting membrane structures and lipo proteins from oxidation (Anderson J. and Young L., 2008). Polyunsaturated fatty acids (PUFA) derived from fish lipids are key constituents of membrane phospholipids, precursors for the biosynthesis of biolo-

2.Stancheva, M., Merdzhanova, A., Dobreva, D. A., Makedonski, L. (2014). Common Carp (Cyprinus caprio) and European Catfish (Sillurus glanis) from the Danube River as Sources of Fat Soluble Vitamins and Fatty Acids. Czech Journal of Food Science, 32(1). **(IF=0.670)**

Vol. 32, 2014, No. 1: 16–24 *Czech J. Food Sci.*

Common Carp (*Cyprinus caprio*) and European Catfish (*Sillurus glanis*) from the Danube River as Sources of Fat Soluble Vitamins and Fatty Acids

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Abstract

STANCHEVA M., MERDZHANOVA A., DOBREVA D.A., MAKEDONSKI L. (2014): **Common carp (*Cyprinus caprio*) and European catfish (*Sillurus glanis*) from the Danube River as sources of fat soluble vitamins and fatty acids.** Czech J. Food Sci., 32: 16–24.

The total content of fat soluble vitamins and their percentages in the recommended daily intake for humans per 100 g portion, fatty acids composition, the atherogenic (IA) and thrombogenicity (IT) indices in two freshwater fish species – Common carp (*Cyprinus carpio*) and European catfish (*Sillurus glanis*) were investigated. Retinol contents in fresh edible tissues of the Common carp and European catfish were found to be 30.8 ± 3.4 mg/100 g wet weight (ww) for the Common carp 30.8 ± 3.4 µg/100 g ww and 1.9 ± 0.1 µg/100 g ww for the European catfish, cholecalciferol contents 14.8 ± 1.0 and 3.1 ± 0.1 µg/100 g ww, and α-tocopherol contents 2764.5 ± 44.0 and 2182.5 ± 31.5 µg/100 g ww, respectively. The sum of monounsaturated FA accounted for 50.02% (catfish) and 23.15% (carp). Polyunsaturated FA (PUFA) showed a higher level in the carp (36.75%) and a lower one in the catfish (21.64%). Both fishes are good sources of cholecalciferol in terms of the recommended daily intake of vitamins established in Bulgaria. Three fat soluble vitamins, n-3 PUFAs content, and IA value were higher in carp. IT values were similar for both species.

Keywords: RDI; atherogenicity index (IA); thrombogenicity index (IT); HPLC; GC-MS; human health

3.Stancheva, M., **Merdzhanova, A.**, Dobreva, D. A. (**2016**). Fat Soluble Vitamins, Cholesterol, and Fatty Acid Composition of Wild and Farmed Black Mussel (Mytilus galloprovincialis) Consumed in Bulgaria. *Journal of Aquatic Food Product Technology*, *26*(2), 181-191. **(IF=0.478)**

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2017, VOL. 26, NO. 2, 181–191
http://dx.doi.org/10.1080/10498850.2015.1108378

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Fat Soluble Vitamins, Cholesterol, and Fatty Acid Composition of Wild and Farmed Black Mussel (*Mytilus galloprovincialis*) Consumed in Bulgaria

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ABSTRACT

The most commercially important mollusk species from the Bulgarian Black Sea is the black mussel (*Mytilus galloprovincialis*). There is limited information about fat soluble vitamins, cholesterol, and fatty acid content of the Bulgarian Black Sea mussel. The aims of the present study are to determine and compare the fat soluble vitamin contents as well as relative daily intake of vitamins, cholesterol, fatty acid content, and lipid quality indices (atherogenic, thrombogenic) in the wild and farmed black mussels. Fat soluble vitamins and cholesterol were analyzed simultaneously using reverse phase high performance liquid chromatography. The fatty acid composition was analyzed by gas chromatography-mass spectrometry. In both mussels, fat soluble vitamins A and E were in high amounts, but they were a better source of vitamin D_3. Cholesterol contents were 67.54 ± 0.50 mg/100 g ww (wild) and 49.88 ± 0.30 mg/100 g ww (farmed). The fatty acid distributions of wild and farmed mussels are: saturated > polyunsaturated > monounsaturated fatty acid. The n3/n6 and polyunsaturated/saturated fatty acid ratios were greater than that recommended by the Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO). A 100-g edible portion of both mussels contained from 0.252 g (wild) to 0.425 g (farmed) of eicosapentaenoic acid (EPA, C20:5n-3) + docosahexaenoic acid (DHA, 22:6n-3).

KEYWORDS

Black mussel; *Mytilus galloprovincialis*; fat soluble vitamins; fatty acids; cholesterol

4. Stancheva, M., **Merdzhanova, A.**, Dobreva, D. A., Makedonski, L. (**2010**). Fatty acid composition and fat-soluble vitamins content of sprat (Sprattus sprattus) and goby (Neogobius rattan) from Bulgarian Black Sea. *Ovidius Univ Ann Chem*, *21*(1), 23-28.

Ovidius University Annals of Chemistry Volume 21, Number 1, pp.23-28, 2010

Fatty acid composition and fat-soluble vitamins content of sprat (*Sprattus sprattus*) and goby (*Neogobius rattan*) from Bulgarian Black Sea

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Abstract Sprat and goby are commercially important Bulgarian Black Sea fish species. The fatty acid (FA) composition was analyzed by Gas Chromatography with MS detector. Lipid extraction was done according to the Bligh and Dyer method. The monounsaturated FA accounted were 26.93 % for sprat and 30.38 % for goby and palmitoleic (C 16:1) and oleic (C 18:1) acids were dominants in this group. In comparison with other groups, the polyunsaturated FA showed the high level in goby – 37.60% including eicosapentaenoic (C 20:5 n3, EPA), docosahexaenoic (C 22:6 n3, DHA) acids, and lower level on sprat – 34.33%. The level of n 3 polyunsaturated fatty acid was higher than the total n 6 polyunsaturated fatty acid in the all analyzed Black Sea fish species. HPLC method was used for determination of Vitamin A (all-trans-retinol), Vitamin D_3 (cholecalciferol) and Vitamin E (α–Tocopherol) content. The results from fat-soluble vitamins show the differences between sprat and goby. The present studies suggest that both fish species are good sources of n 3 fatty acids and vitamins A, D_3 and E.

Keywords: Black Sea fish, fatty acids, PUFA, Vitamin A, Vitamin D_3, Vitamin E

5.**Merdzhanova, A.,** Stancheva, M., Makedonski, L. (2012). Fatty acid composition of Bulgarian Black Sea fish species. *Analele Universitatii" Ovidius" Constanta-Seria Chimie*, *23*(1), 41-46.

VERSITA 10.2478/v10310-012-0006-5
Ovidius University Annals of Chemistry Volume 23, Number 1, pp.41-46, 2012

Fatty acid composition of Bulgarian Black Sea fish species

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Abstract The fatty acid compositions of three Black Sea fish species turbot *(Pseta maxima),* red mullet *(Mullus barbatus ponticus)* and garfish *(Belone belone)* were investigated. This species are considered as preferred for consumption in Bulgaria. Lipid extraction was done according to the Bligh and Dyer method. The fatty acid composition was determined by GC/MS. The saturated fatty acids amounts were 38.32 % for turbot, 35.44 % red mullet and 42.90% for garfish. Monounsaturated fatty acids were found in lowest level in comparison with other groups for garfish (23.65%) and turbot (24.85%) while for red mullet they have a highest value – 37.56%. Omega 3 polyunsaturated fatty acids as eicosapentaenoic (C 20:5 omega 3, EPA) and docosahexaenoic (C 22:6 omega 3, DHA) acids were found in highest levels in turbot (22.26%) and garfish (21.80%) and in lowest values of red mullet (9.35%). The results showed that the fish examined are good source of omega 3 polyunsaturated fatty acids, resulting in a very favourable omega 3 / omega 6 ratios, especially in turbot and garfish.

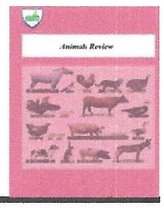
Keywords: Black Sea fish, fatty acids, PUFA, GC/MS

6. Stancheva, M., **Merdzhanova, A.,** Galunska, B., Dobreva, A. D. (2014). The Effect of Steaming Process on Fat Soluble Vitamins Content and Fatty Acid Profile in Bluefish and Rainbow Trout Fillets. *Animal Review*, *1*(1), 1-10

Animals Review, 2014, 1(1): 1-10

Animals Review

journal homepage: http://www.pakinsight.com/?ic=journal&journal=92



THEEFFECT OF STEAMING PROCESS ON FAT SOLUBLE VITAMINS' CONTENT AND FATTY ACID PROFILE IN BLUEFISH AND RAINBOW TROUT FILLETS

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ABSTRACT

Fatty acid composition and all-trans-retinol, alpha-tocopherol, and cholecalciferol content was determined and compared in raw and steamed Bluefish and Rainbow trout. Total lipids were extracted by Bligh and Dyer method followed by GC-MS. All-trans-retinol, cholecalciferol and alpha-tocopherol were analyzed simultaneously using HPLC. In comparison with raw fish fillets, analyzed fat soluble vitamin's content in steamed fish filletsfor the Trout and Bluefish decreased significantly to about 54.2% and 49.8% for retinol and 32.6% and 43.5% for alpha-tocopherol, respectively. After steaming, the cholecalciferol amounts in processed fillets decreased significantly only in Rainbow trout (23.5%), whereas in Bluefish the losses were non-significant. After cooking, the polyunsaturated fatty acid content changed significantly in the Rainbow trout (45.8%), whereas the variations in the Bluefish were minor. The major PUFA in all samples were linoleic acid (LA) and docosahexaenoic acid (DHA). PUFA/SFA ratios were between 1.01 and 1.68 for both species. Steaming increases PUFA/SFA ratio by 8.33% in Rainbow trout, but does not affect this ratio in Bluefish.

Keywords: Black sea, Fish nutrition, Human health, Oncorhynchus mykiss, Pomatomus saltatrix, Thermal processing.

7. **Merdzhanova, A.,** Dobreva D, Makedonski L. (2016). Comparison of polyunsaturated fatty acid and fat soluble vitamins content of cooked Shad (*A. immaculata*). *Journal of Agricultural Techology*,12(6):1043-1056

Journal of Agricultural Technology 2016 Vol. 12(6): 1043-1056
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Comparison of polyunsaturated fatty acid and fat-soluble vitamins content of cooked Shad (*Alosa immaculata*)

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Merdzhanova, A., Dobreva, D.A., Makedonski, L. (2016) Comparison of polyunsaturated fatty acid and fat-soluble vitamins content of cooked Shad (*Alosa immaculata*). Journal of Agricultural Technology 12(6): 1043-1056.

This study presents the evaluation of the effect of cooking (steaming and grilling) on lipids, fatty acids profile, nutritional quality indices (NQI) and fat soluble vitamins content of Black Sea shad (Alosa immaculata). The Bligh and Dyer's method was used for total lipid content determination. The fatty acid methyl esters were analysed by GC/MS and fat soluble vitamins - by RP-HPLC. The two cooking methods increased the levels of the saturated fatty acids (SFA), whereas grilling process decreased monounsaturated fatty acids (MUFA) quantity in shad tissue. Omega-3 polyunsaturated FAs (n-3 PUFA) levels significantly decreased after both thermal processes. Steaming doesn't affect the omega-6 (n-6) PUFA – their amounts remain almost unchanged. The vitamin A value decreases significantly after steaming, whereas vitamin D_3 and E remain almost unchanged. Among the three fat soluble vitamins, the grilling process affects significantly mainly vitamin A and E. In conclusion - both cooking methods are suitable for preserving the lipid nutrition quality of shad edible tissue.

Keywords: *Alosa immaculata*, Fatty acids, Fat soluble vitamins, Grilling, Steaming

8.**Albena Merdzhanova**, Diana Atanasova Dobreva, Veselina Panayotova, (2018) The comparison of proximate composition, fatty acids and fat-soluble vitamin content of the Black Sea sprat (*Sprattus sprattus L.*) during catching seasons. *Annals. Food Science and Technology* (приета, под печат)

Annals. Food Science and Technology
2018

THE COMPARISON OF PROXIMATE COMPOSITION, FATTY ACIDS AND FAT-SOLUBLE VITAMINS CONTENT OF THE BLACK SEA SPRAT (*SPRATTUS SPRATTUS* L.) DURING CATCHING SEASONS

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Abstract
The aim of the present study was to determine and compare the seasonal changes in proximate composition, fatty acid profile and fat soluble vitamins content in spring and autumn sprat (Sprattus sprattus) from the Bulgarian Black Sea waters. Crude protein was in the range 16.10 – 17.15%, fat content was from 4.20 to 6.65g/100g wet weight (w.w.). The fatty acid (FA) and vitamin's contents showed significant seasonal changes. The spring sprat was showed lower saturated fatty acid (SFA, 31.7%), higher mono unsaturated fatty acids (MUFA, 34.7%) and insignificantly lower polyunsaturated fatty acids (PUFA, 33.6%) compared to the autumn samples. In both seasons omega-3 (n-3) PUFA levels were higher than omega-6 (n-6) PUFA and presented over than 50% of total PUFAs. Different amounts of alpha-tocopherol were found in both seasons – 701.2 µg/100g ww (spring). The higher amounts of all-trans retinol (142.3 µg/100 g ww) and cholecalciferol (11.9 µg/100 g ww) were found in spring samples. Regardless of the observed seasonal changes in proximate and FA composition, fat soluble vitamins and n-3 PUFA contents sprat species caught from the Bulgarian part of Black Sea are excellent sources of the analysed components and can be recommended for healthy human diet.

Key words: proximate composition, fat soluble vitamins, human health, *Sprattus sprattus*

Участие като съавтор в книги (в глава от книга)

9. **Albena Merdzhanova**, Diana Dobreva and Veselina Panayotova (April 25th 2018) Assessment of Proximate and Bioactive Lipid Composition of Black Sea Mussels (M. galloprovincialis) from Bulgaria, *Chapter 9 in Biological Resources of Water, Editor Sajal Ray, Intech Open*, DOI:10.5772/intechopen.71909

Chapter 9

Assessment of Proximate and Bioactive Lipid Composition of Black Sea Mussels (*M. galloprovincialis*) from Bulgaria

Albena Merdzhanova, Diana A. Dobreva and Veselina Panayotova

Additional information is available at the end of the chapter

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Abstract

Farmed marine mussels from genera *Mytilus* are important for the human diet by providing high levels of proteins, omega-3 polyunsaturated fatty acids (PUFAs), fat soluble vitamins and carbohydrates. Recently, black mussels are commercially important species from the Bulgarian Black Sea. The aim of this study was to assess the seasonal changes in proximate composition and to focus on the lipid bioactive components such as fatty acids, cholesterol, fat-soluble vitamins (A, E and D_3), and carotenoids (astaxanthin, beta-carotene) in farmed mussels (*M. galloprovincialis*) from the northern part of the Bulgarian Black Sea coast. All analyzed samples presented high protein and low lipid content. The fatty acids (FA) profile was characterized by the highest amount of PUFA, as 22:6 omega-3 (n-3) dominated, regardless of the seasons. In all seasons, the content of n-3 was significantly higher than the omega-6 PUFA. The amounts of cholesterol were in the range 62.3 (summer) to 78 (autumn) mg 100^{-1} g ww. The highest amounts of vitamin D_3 (3.1 μg 100^{-1} g ww), vitamin E (2525 μg 100^{-1} g ww), astaxanthin (0.470 mg 100^{-1} g ww), and beta-carotene (0.445 mg 100^{-1} g ww) were found in the summer season. The studied mussel aquaculture from Bulgaria presented a high beneficial potential in all seasons in terms of human health protection.

Keywords: *M. galloprovincialis*, astaxanthin, cholesterol, fat soluble vitamins, seasonal changes, omega-3PUFA

Пълнотекстови публикации в български (26 броя) и чуждестранни (9 броя) научни издания и сборници – 35 броя

10. Кръстев И., **А. Мерджанова**, „Поддържане и контрол на параметрите на газова дихателна среда при извършване на имитационни наситени водолазни спускания под налягане 1,0 MPa и 2,0 MPa“. Съюз на учените – Варна, м. X. (2000), стр.20-26

Подържане и контрол на параметрите на газовата дихателна среда при извършване на имитационни наситени водолазни спускания под налягане 1,0 MPa и 2,0 MPa

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В рамките на изпълнение на програма за създаване на методи и технически системи за дълбоководни водолазни спускания, бяха проведени 4 експеримента с продължително пребиваване на водолази в хипербарна среда,три от тях при налягане на хоризонта на насищане 1,0 MPa (100 м.в.ст) и един на 2,0 MPa (200 м.в.ст).

I. Цел и задачи на есперимептите

Експериметите бяха придружавани от комплексни научно-изследователски програми, които условно може да се разделят на технически и медикофизиологични.

Целта на технико-технологичните програми най-общо може да се определи като изследване на характеристиките на техническите системи и параметрите на газовата дихателна среда с оглед тяхното усъвършенстване и оптимизиране.

Целта на медикофизиологичните програми беше да се проследи психофизиологичното състояние на изследваните лица във всички фази на водолазното спускане: компресия, изопресия, декомпресия и постдекомпресионен период, като по този начин се даде обективна оценка за безопасността на приложените технологични схеми и технически решения.

Една от основните подпрограми на технико-технологичните изследвания се състоеше в набиране и анализиране на информацията касаеща параметрите на хипербарната среда (ХС) във всички фази на спускането, а също и оценка на възможностите на техническите системи да поддържанат тези параметри в необходимите граници.

11. **Merdjanova A.**, I. Krastev, P Ganchev. Monitoring of pollution of the respiration air in SCUBA diving. *Proceeding of Fifty international conference on marine sciences and technologies, Black Sea*, (2000), Varna, p. 31-38

MONITORING OF POLLUTION OF THE RESPIRATION AIR IN SCUBA DIVING

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Air is the natural normobaric inhabitable medium of all living creatures. Its ingredients - nitrogen, carbon dioxide, inert gases, hydrogen and other components assure normal living conditions in normobaric conditions.

The increase of pressure creates a new hyperbaric environment. It is extreme for the human organism and evokes different adaptation or pathological reactions. The need of longer underwater stay in oil production, military affairs etc. when diving covers hard tasks of great responsibility, requires in-depth research of diving. Practical mastering of hyperbaric environment has an old history. A number of profonged experiments have been carried out of the influence of unfavorable factors of hyperbaric medium like increased pressure, discending temperature, higher medium thickness, low visibility etc. that lower scuba effectiveness especially at greater depths [3, 5,1 0].

Scuba diving is generally divided into short-time diving (unsaturated) and saturated. Both physiologically important components of air - oxygen and nitrogen change their properties in hyperbaric conditions and their use as a breathing medium is limited under depths of 50 - 60 meters. In practice with the increase of pressure, and respectively depth the first noticeable changes in the human organism are provoked by nitrogen. These changes include euphoria, psychic disturbances, neuromuscle discoordination. Berth has explored this very problem back in 1878. Behnke in 1935 named it 'nitrogen narcosis' and ascribed it to the behaviour of inert gasses under pressure [3, 5, 8, 10].

Oxygen is another biologically active air component participating directly in metabolic and regulatory organism processes. Its influence depends on its partial pressure in tissue liquids, on the duration of its action and the individual's sensitivity to oxygen. The quantity of blood oxygen is directly proportional to partial pressure and respectively to the blood pressure in general. With the increase of blood pressure above certain figures oxygen has a toxic effect on the lungs and the brain. In 1878 Paul Bert discovers animals trials that an increase of the oxygen pressure leads to seizures (the effect of Paul Bert). The power of the seizures, the damage of the central nervous system and the lethal outcome depend on the partial pressure of oxygen and the duration of its action. Parallel changes in the cardio-respiratory and other systems are observable [3, 5, 9, 10].

At greater depths a value of partial pressure of 0,21 ata (as it is in the air in normobar conditions) is not enough as high pressure leads to slow-down of speed of oxygen diffusion in alveolar space and there is a danger of hypoxy. Experience shows that in deep-water diving (below 60 - 80 meters) the optimal values of partial P_{O_2} for unsaturated diving are up to 1,0 ata, and between 0,4-0,5 ata for saturated diving [3, 4, 5, 10].

To avoid all unfavorable effects for depths greater than the air range depth artificial breathing mixtures are being produced in which the content of O_2 and N_2 or N_2 is optimized or is replaced by another inert gas (He being most widely used). If the tolerance of the human organism is studied thoroughly to inert components and O_2 for certain depths, and after calculation, artificial respiratory mixtures are being prepared and their optimal composition is being monitored [3, 4, 5, 7, 10].

As we concentrate our attention on the air as a respiratory medium up to 50 meters for unsaturated scuba diving it is necessary to consider its accompanying admixtures. For scuba diving the presence of higher concentrations of harmful admixtures as CO_2, CO and N-oxides, aerosol oils etc. is of great importance. That is why we will describe briefly their harmful effect on the human organism.

1. Carbon dioxide (CO_2) is a natural concomitant air component and concentration of 0,03 - 0,04 vol. % is normal. For prolonged breathing an upper limit of 0,5 vol. % is desirable. As a rule the organism can cope with higher concentrations of CO_2. When its concentration in the air we breathe in is above 0,5 vol.% changes in external breathing are observed as well as changes in peripheral blood circulation and the bioelectrical brain activity. Symptoms of poisoning are observed at concentrations above 4 vol.% The duration of the action of high partial pressure of CO_2 (P_{CO_2}) is another important factor. Based on this we distinguish between acute and chronic poisoning. The acute form is of greater interest for scuba diving practice in short-time real and experimental diving [4, 5, 6, 7, 10, 11, 15, 16].

12. Кръстев И., **А. Мерджанова**, П. Ганчев. „Значение на водолазната намеса при оказване помощ на аварирала подводница“. Сборник с доклади от Юбилейна научна сесия с международно участие, ВВМУ-Варна, (2001 г.), 338-342

ЗНАЧЕНИЕТО НА ВОДОЛАЗНАТА НАМЕСА ПРИ ОКАЗВАНЕ ПОМОЩ НА АВАРИРАЛИ ПОДВОДНИЦИ

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Significance on diving intervention of Rescue Operations of Submersibles in emergency

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Rescue operations of submersibles in emergency situations require strictly co-ordination between the professional teams and the existing technical equipment. In spite of the tendency of using unmanned underwater technical devices and one-atmosphere apparatuses, diver's role in submersibles rescue operations remains up-to-date essential one. Moreover it could be decisive in times as it was lately proved by the tragic accident with the nuclear submarine Kursk in August, 2000. On the base of experience gained from special projects and training simulations, scientists and professionals from Bulgarian Navy and IO evaluate the diver's role in the crew rescue operations of submarines in emergency situations.

Key words: rescue operations, diving intervention, emergency, submersibles

Морските аварийно-спасителни дейности са с над 100 годишна история. В началото този тип операции са се осъществявали само на повърхността на водата, а от началото на XX век започнали да се провеждат и под вода, с помощта на водолази.

Операциите свързани със спасяване екипажите на аварирали подводници (АвП), са много сложни, скъпи и отговорни процедури, изискващи координираното участие на различни технически средства и специалисти. Независимо от инструкциите описващи стандартните процедури за действия в аварийни ситуации, често се налага да се вземат нестандартни решения, поради невъзможността да се предвидят всички варианти на аварии, както и комплексното действие на допълнителните

13. Krastev I., **A. Merdjanova**, P. Ganchev. The role of diving technologies in crew rescue operations of wrecked submersibles. *Proceeding of International scientific session "Management of natural and technological risks"*, 2001, Sofia, 85-92

РОЛЯТА НА ВОДОЛАЗНИТЕ ТЕХНОЛОГИИ ПРИ СПАСЯВАНЕ ЕКИПАЖИТЕ НА АВАРИРАЛИ ПОДВОДНИЦИ

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РЕЗЮМЕ

Операциите, свързани със спасяване екипажите на аварирали подводници, изискват координираното участие на различни технически средства и специалисти. Независимо от инструкциите, описващи стандартните процедури за действия в аварийни ситуации, често се налага да се вземат нестандартни решения, поради невъзможността да се предвидят всички възможни аварии, както и комплексното въздействие на допълнителните фактори, като дълбочина, вълнение на морето, течение, видимост, температура на околната среда и др.

Независимо от стремежа към използване на необитаеми подводни технически средства и едноатмосферни апарати, ролята на водолаза при ликвидиране на аварии с подводници , остава актуална и съществена. Често тя може да се окаже и решаваща, както това беше доказано от действията свързани с оценка на обстановката, след трагичният инцидент с атомната подводна лодка "Курск" от м. август 2000 г.

На база на опита от съвместни технически разработки и участия в учебни симулативни действия при аварийни ситуации, на специалисти от ВМС и Института по океанология, се прави оценка за ролята на водолазите при спасяване екипажите на аварирали подводници. Разгледани са алтернативни варианти за водолазна намеса в зависимост от вида на авариата, както и от факторите на околната среда-най-важен от които е дълбочината.

Ключови думи: спасителни операции, аварирала подводница, краткотрайни водолазни спускания, сатурационни водолазни спускания

14. Krastev I., A. Krastev, **A. Merdjanova**. An analysis of possible deep diving failures prevention and elimination measures. *Proceeding of International scientific session "Management of natural and technological risks"* , 2001, Sofia, 80-85

АНАЛИЗ НА ВЪЗМОЖНИТЕ АВАРИИ ПРИ ДЪЛБОКОВОДНИ ВОДОЛАЗНИ СПУСКАНИЯ. МЕРКИ ЗА ПРЕДОТВРАТЯВАНЕ И ЛИКВИДАЦИЯТА ИМ

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РЕЗЮМЕ

Дълбоководните водолазни спускания са едни от най-рисковите човешки дейности. Това се обуславя от въздействието на факторите на неблагоприятната за обитаване и работа околна среда - налягане, температура, видимост и др.

С увеличаване на налягането (респективно дълбочината), неблагоприятното въздействие на факторите на околната среда нараства прогресивно. Настъпват промени във функциите на човешкия организъм. За да не се получат патологични изменения се променят обичайните параметри на дихателната среда и се използва комплекс от технически средства, известни като Дълбоководни водолазни комплекси.

Основавайки се на анализа на възможните аварии и на резултатите от дългогодишните експериментални изследвания, провеждани в Института по океанология-БАН, във Варна, авторите правят прогнози на възможните аварии в зависимост от дълбочината и използваните технически средства и предлагат специфични мерки за предотвратяването и типови схеми за ликвидирането им.

Ключови думи: дълбоководен водолазен комплекс; отворен водолазен звънец; водолазна транспортна камера.

15. Кръстев И., **А. Мерджанова**, П. Ганчев. Експериментиране на газови дихателни смеси при ненаситени дълбоководни водолазни спускания. Сборник с доклади от IV Национална конференция по авиационна и морска медицина, Варна, 26-28.09.2001

Експериментиране на газови дихателни смеси
при ненаситени дълбоководни водолазни спускания

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Най използваната естествена дихателна среда във водолазната практика е въздухът. Причините за съществуващите ограничения в дълбочинния диапазон на приложението му (до 60 м) са проявяващите се неблагоприятни физиологични ефекти за човешкия организъм – засилващо се наркотично действие на азота и токсично действие на кислорода, под влияние на увеличаващото се налягане. За да се избегнат тези нежелателни ефекти , за по големи от въздушния диапазон дълбочини се изработват изкуствени дихателни смеси (ИДС), при които се намалява съдържанието на азот и кислород или азота изцяло се замества с друг инертен газ. Използването на ИДС е неразривно свързано с разработването на декомпресионни режими (ДР), чиято цел е повишаване на безопасността на водолазното спускане и профилактика на едно от най често срещаните професионални водолазни заболявания – декомпресионната болест.
В Института по океанология съществува звено "Водолазни системи и технологии" занимаващо се с разработка и експериментиране на ДР и изготвяне на ИДС, придружавани с подробни медико-физиологични изследвания.

16. Кръстев И., **А. Мерджанова**. Водолазната дейност в туризма - състояние, перспективи, нормативна база. Международна научна конференция кинезиология 2002, ВТУ „Св. Св. Кирил и Методи“, Велико Търново

ВОДОЛАЗНАТА ДЕЙНОСТ В ТУРИЗМА – СЪСТОЯНИЕ,
ПЕРСПЕКТИВИ, НОРМАТИВНА БАЗА

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Най-динамично развиващата се индустрия в света е туризма. Динамиката се изразява не само в огромния оборот на капитали (на второ място след нефтената индустрия), но и в непрекъснатото създаване и развитие на нови клонове и дейности включени в понятието алтернативен туризъм – екологичен, селски, спортен и др. Извънредно силно е увлечението към туризма с участие на екстремни спортове – в това число алпинизъм, летателни спортове, водни спортове, бънджи скокове. Едно от направленията, което получи много бързо развитие в последните години е подводния туризъм.

В близост до морските курорти действат десетки хиляди водолазни центрове и училища, които предлагат широка гама от водолазни дейности : от различни нива на обучение до единични водолазни спускания за запознаване с подводната среда. За сертифицираните водолази, според нивото на подготовка и натрупан опит, се предлагат водолазни спускания в пещери, на потънали кораби, дълбоководни спускания, нощни спускания, спускания с изкуствени газови дихателни смеси и др.

17. Кръстев И., Хр. Бозов, **А. Мерджанова**. Нормативна база за безопасността на водолазната дейност – актуални проблеми, синхронизиране със световните аналози. *Proceeding of Sixth international conference on marine sciences and technologies,* Black Sea, 2002, Varna

NORMATIVE BASE FOR DIVING SAFETY: UP-TO-DATE ISSUES, SYNCHRONIZATION WITH THE WORLD-WIDE ANALOGUES

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Abstract. Diving is one of the most dangerous human activities. Despite of the rapid development and improvement of the diving technology, the underwater accidents, including these with lethal end, are with high rating. One of the ways to increase the safety is the development and effective application of adequate normative requirements. The safety measures of the European legislation are strictly regulated and determined. There is a system for supervision of their implementation.

The existing Safety Diving Rules in Bulgaria of 1963 are desperately old and ineffective. High rating of diving accidents is recorded due to some extent to the lack of normative base. According to data of the Navy Hospital - Varna, for the period 1997 - 2000, there are 41 registered accidents followed by a successful medical treatment of the divers.

All that and the necessity of thorough harmonization of our legislation with the European laws require urgent development of proper normative documents on the basis of the world- wide experience.

18. Станчева М, Добрева Д. А, **Мерджанова А,** Галунска Б, (2008). Определяне на витамин А и витамин Е чрез високо-ефективна течна хроматография в риба кая (Neogobius fluviatilis) от Българското черноморско крайбрежие. *Plovdiv University, Paisii, Hilendarski–Bulgaria, Scientific papers*, *36*(5), 45-50

ПЛОВДИВСКИ УНИВЕРСИТЕТ „ПАИСИЙ ХИЛЕНДАРСКИ" – БЪЛГАРИЯ
НАУЧНИ ТРУДОВЕ, ТОМ 36, КН. 5, 2008 – ХИМИЯ, СБ. А
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SCIENTIFIC PAPERS, VOL. 36, BOOK 5, 2008 – CHEMISTRY

ОПРЕДЕЛЯНЕ НА ВИТАМИН А И ВИТАМИН Е ЧРЕЗ ВИСОКО-ЕФЕКТИВНА ТЕЧНА ХРОМАТОГРАФИЯ В РИБА КАЯ (Neogobius fluviatilis) ОТ БЪЛГАРСКОТО ЧЕРНОМОРСКО КРАЙБРЕЖИЕ

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ABSTRACT

This study presents simultaneous determination of Vitamin A (all-trans retinol) and Vitamin E (α-tocopherol) in tissue samples from Bulgarian Black Sea Coast fish species by high-performance liquid chromatography method.

The method was applied to samples of Black Sea goby fish (Neogobius fluviatilis) and includes two stages: extraction of tocopherol and retinol from the fish tissue and subsequent quantitative HPLC determination. Quantitative determination of the fat soluble vitamins in the hexane extracts has been done by HPLC with UV-detection on RP-column Nucleosil (25 cm x 0,46 cm). The elution of tocopherol and retinol from the chromatographic column was done by mobile phase composed of 100% methanol at flow rate 0.9 ml/min. Tocopherol was detected at wavelength 295 nm and retinol at 325 nm.

Mean concentration in fresh material were 47.93 μg/100g for Vitamin A and 0.5 mg/100 g for Vitamin E. Our results are in good agreement with the data from the literature for other fish species.

Keywords: retinol, α-tocopherol, blacksee fish species, HPLC

19. Stancheva, M., Dobreva, D., **Merdzhanova, A.**, Galunska B., (2010). Vitamin content and fatty acids composition of rainbow trout (Oncorhynchus mykiss). *Plovdiv University, Paisii, Hilendarski–Bulgaria, Scientific papers*, *37*(5), 117-124.

ПЛОВДИВСКИ УНИВЕРСИТЕТ „ПАИСИЙ ХИЛЕНДАРСКИ" – БЪЛГАРИЯ
НАУЧНИ ТРУДОВЕ, ТОМ 37, КН. 5, 2010 – ХИМИЯ, СБ. А
PLOVDIV UNIVERSITY „PAISII HILENDARSKI" – BULGARIA
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VITAMIN CONTENT AND FATTY ACIDS COMPOSITION OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

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ABSTRACT

The aim of present study is to evaluate the composition and the content of fatty acids (FA) and fat soluble vitamins (A, E, D_3) in the edible tissue of farmed rainbow trout from the region of Central Bulgaria.

All-trans-retinol (vit. A), cholecalciferol (vit. D_3) and α-tocopherol (vit. E) were analyzed simultaneously using HPLC system with UV (vitamin A and D_3) and fluorescence detection (vitamin E). The sample preparation procedure includes saponification and liquid-liquid extraction of the unsaponifiable matter. Total lipids were extracted according to Bligh and Dyer method. Analysis of fatty acid methyl esters were performed using gas chromatography system with MS detection.

It was found that the lipid fraction contains substantial amounts of palmitic, palmitoleic, stearic, linolenic, arachidonic and docosahexaenoic fatty acids and fat-soluble vitamins. The retinol content in the fresh edible tissue of rainbow trout *(Oncorhynchus mykiss)* was 22.3±2.0 μg/100g; cholecalciferol – 6.0±0.29 μg/100g and α-tocopherol – 809.1± 56.0 μg/100g.

Linoleic acid (15.81%), docosahexaenoic acid (9.40%) and arachidonic acid (4.21%) were the most dominant polyunsaturated fatty acids, about 33% of total FA content. Palmitic acid (12.93%), tetracosanoic acid (3.76%) and oleic acid (3.57%) were found to be the dominant of the saturated and unsaturated FA in rainbow trout fillets.

Keywords: fat-soluble vitamins, PUFA, HPLC, GS/MS, trout

20. Stancheva M and **Merdzhanova A.,** (2011), Polyunsaturated Fatty Acids in Fish Species from Bulgaria, Annual of Konstantin Preslavsky University of Shumen, Natural Sciences Chemistry, Vol. XXI B1, 125-133

Polyunsaturated Fatty Acids in Fish Species from Bulgaria

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Abstract: The aim of the present study was to determinate the fatty acid composition of two popular Bulgarian Black Sea fish species - Black Sea goby (*Neogobius rattan*) and sprat (*Sprattus sprattus*) and one freshwater - brown turbot (*Salmo trutta fario*). The fatty acid (FA) composition was analyzed by GC-MS. Lipid extraction was done according to the Bligh and Dyer method. Methyl esters were prepared according to method EN ISO 5508:2000. The total lipid content in sprat was 2.50 g /100 g raw weight (r.w.), in goby – 1.60g/100 g r.w. while brown turbot shown a value of 3.80g/100g r.w. In comparison with other groups, the polyunsaturated FA (PUFA) showed the highest level in trout – 44.26 % including n-3 such as eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, and the lowest level in sprat – 33.94% and in goby – 37.82%. The level of total n-3 PUFAs was higher than the total n-6 polyunsaturated fatty acid in all analyzed Black Sea fish samples, while the freshwater brown trout shown a significant level of n-6 PUFAs and minimum amount of n-3 group. A n-3 /n-6 ratio was determined in all fish species.

Keywords: sprat, goby, brown trout, FAME, omega3 /omega 6 ratio, Bulgarian fish species.

21. Stancheva, M., **Merdzhanova, A.** (2011). Fatty acid composition of common carp, rainbow trout and grey mullet fish species. *Agricultural Science and Technology*, *3*(3): 285-289.

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Fatty acid composition of common carp, rainbow trout and grey mullet fish species

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Abstract. *The aim of the present study was to determinate the fatty acid composition of two commercially important freshwater fish species - rainbow trout (Oncorhynchus mykiss) and carp (Cyprinus carpio L.) and one Black Sea fish – grey mullet (Mugil cephalus). Lipid extraction was done according to the Bligh and Dyer method. Methyl esters were prepared according to method EN ISO 5508:2000. The fatty acid (FA) composition was analyzed by GC-MS. The total lipid content in rainbow trout was 11.50 g/100g raw weight (r.w.), in carp – 12.74g/100 g r.w. while grey mullet showed a value of 3.80g/100g r.w. In comparison with other groups, the polyunsaturated FA (PUFA) showed the highest level in trout – 43.13 % including ω3 such as eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids followed by grey mullet –29.1%, whereas the carp presented lowest level – 17.55%. The amounts of total ω6 PUFAs were higher than the total ω3 PUFAs in all analyzed fish samples. A ω3/ω6 and PUFA/SFA ratios were determined in all three fish species.*

Keywords: fatty acid composition, common carp, grey mullet, rainbow trout, GC-MS

22. Stancheva, M., **Merdzhanova**, A., Makedonski, L. (2011). Fatty acid composition of fish species from the Bulgarian Black Sea. Acta Medica Bulgarica, 38(1): 26-34

FATTY ACID COMPOSITION OF FISH SPECIES FROM THE BULGARIAN BLACK SEA

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Summary. The total lipids and fatty acid profile in the edible tissue of two traditionally consumed fish species from Bulgarian Black Sea coast – shad and red mullet in two seasons are determined. The fatty acid composition was analysed by GC/MS. The total content of omega-3 fatty acids was significantly higher than the total content of omega-6 fatty acids in shad whereas red mullet showed opposite trend. The omega-3/omega-6 FA ratio, an useful indicator for evaluation the relative nutritional value of a given fish, was within the recommended range for the studied Black Sea fish species. Obtained results for FA composition, omega-3/omega-6 and polyunsaturated /saturated fatty acids ratios indicate that these Black Sea fish species in both seasons – spring and autumn are good sources of essential fatty acids.

Key words: *omega-3, omega-6, fatty acids, GC/MS, fish species*

23. Stancheva, M., Dobreva, D., **Merdzhanova, A.**, Galunska, B. (2011). Fatty acid composition and fat soluble vitamins content of bighead carp (Aristichthys nobilis). *Plovdiv University, Paisii, Hilendarski–Bulgaria, Scientific papers*, *38*(5), 221-232.

ПЛОВДИВСКИ УНИВЕРСИТЕТ „ПАИСИЙ ХИЛЕНДАРСКИ" – БЪЛГАРИЯ
НАУЧНИ ТРУДОВЕ, ТОМ 38, КН. 5, 2011 – ХИМИЯ
UNIVERSITY OF PLOVDIV „PAISII HILENDARSKI" – BULGARIA
SCIENTIFIC PAPERS, VOL. 38, BOOK 5, 2011 – CHEMISTRY

FATTY ACIDS COMPOSITION AND FAT SOLUBLE VITAMINS CONTENT OF BIGHEAD CARP *(ARISTICHTHYS NOBILIS)*

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ABSTRACT

In the present study fatty acid composition and fat soluble vitamins content were analyzed in two season's samples (spring and autumn) freshwater bighead carp *(Aristichthys nobilis)*.

Analysis of fatty acid methyl esters was performed by gas chromatography system with MS detection. Vitamins A, D_3 and E were analyzed simultaneously using RP-HPLC system. The sample preparation procedure includes saponification and liquid-liquid extraction of the unsaponifiable matter.

The fatty acid and vitamins contents of the investigated fish species showed significant seasonal changes. The spring bighead carp characterized with saturated fatty acid (SFA) (37.5%) and mono unsaturated fatty acids (MUFA) (22.1%), and poly unsaturated fatty acids (PUFA) (40.4%), including essential omega 3 fatty acids (23.0%). The autumn samples showed higher SFA (40.5%) and MUFA (34.8%), and lower PUFA (24.6%), due to reduced omega 3 fatty acids (9.7%).

24. Dobreva D., **Merdzhanova, A.,** Stancheva, M., Makedonski L. (2011). Fatty acid profile and Vitamin A and E content in Horse mackerel (*T. mediterraneus*). *Asian Chemistry Letters*, 15 (1&2):1-10

Asian Chemistry Letters Vol 15, No 1&2, 2011

Fatty Acid profile and Vitamin A and E content in Horse mackerel (*Trachurus mediterraneus*)

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The aim of this study was to measure and evaluate of the total lipid, fatty acid profil and Vitamin A and Vitamin E content of Black Sea horse mackerel or scad (*Trachurus mediterraneus pontica*) catch from Bulgarian Black Sea and the same fish species from Greek coast of Mediterranean Sea (*Trachurus mediterraneus mediterraneus)*. The results from analysis showed that the sample of Black Sea scad (Spring 08) contain 5.01 g total lipid per 100 g raw weight and 2.40 g total lipid per 100 g raw weight (Autumn 08) while Greek scad present 7.90 g total lipid per 100 g raw weight (Spring 09).The fatty acid composition was analysed by Gas Chromatography with MS detector. The level of total ω3 polyunsaturated fatty acid was higher than the total ω6 polyunsaturated fatty acid in the all analyzed Black Sea fish species. The vitamins content was determinate by HPLC with UV detector. The results from measure show the differences for Vitamin A and E contents between Black Sea horse mackerel and Mediterranean horse mackerel.

25. Ivanova, V., Stancheva, M., **Merdzhanova, A.** (2012). Fatty acids composition of macroalgae from Bulgarian Black Sea coast. *Analele Universitatii" Ovidius" Constanta-Seria Chimie*, *23*(1), 35-40.

Ovidius University Annals of Chemistry Volume 23, Number 1, pp.35-40, 2012

Fatty acids composition of macroalgae from Bulgarian Black Sea coast

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Abstract Lipids and fatty acids (FA) composition of three Black Sea macroalgae *Cladophora vagabunda, Ceramium rubrum* and *Cystoseira barbata* were studied. Fatty acids composition was analyzed by GC/MS. Total lipids content varied widely among the species and ranged between 0.66 and 0.98 g per 100 g fresh weight. Generally, saturated fatty acids were major components (62–71%), with 16:0 as the most abundant saturate (41–57%). Total polyunsaturated FAs and monounsaturated FAs ranged from 28% to 38%. The green alga *Cladophora vagabunda* showed higher C18 PUFAs contents than did C20 PUFAs while for red alga *Ceramium rubrum* the trend was opposite. *Cystoseira barbata* belonging to the group of brown algae showed similar amounts of C18 and C20 PUFAs contents. *Cladophora vagabunda* was rich in linoleic acid and *Ceramium rubrum* in arachidonic acid (AA) while *Cystoseira barbata* was rich in both linoleic acid and eicosopentaenoic acid. All of the studied species had a nutritionally beneficial n6/n3 ratio (1.24–2.84:1).

Keywords: Black Sea algae, fatty acids, GC/MS

26. **Merdzhanova, A.**, Stancheva, M., Dobreva, D. A., Makedonski, L. (2013). Fatty acid and fat soluble vitamins composition of raw and cooked Black Sea horse mackerel. *Analele Universitatii" Ovidius" Constanta-Seria Chimie*, *24*(1), 27-34.

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Fatty acid and fat soluble vitamins composition of raw and cooked Black Sea horse mackerel

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Abstract. The fat soluble vitamins, as well as n3 and n6 fatty acids (FA) are essential compounds of fish lipids and exclusively provided by the diet. Fish is sometimes eaten raw, but it is usually thermal processed before consumption. Temperature processing of fish tissue enhances its taste, inactivates pathogenic microorganisms and increases its shelf life. The fat soluble vitamins (vitamins A, D_3 and E) and fatty acids are considered to be susceptible to oxidation during heating (cooking) process. The aim of the present study was to evaluate the effect of steaming (10 min at 90°C) and frying (5 min on the each side with sunflower oil) on fat soluble vitamins and fatty acids composition in Horse mackerel (*Trahurus mediterraneus*) fish fillets. Vitamins A, D_3 and E were analyzed simultaneously using RP-HPLC. The fatty acid composition was analyzed by GC-MS. The amounts of vitamin A (retinol) in cooked fish fillets (for both heat treatments) decreased significantly, compared to their content in the raw samples. In contrast vitamin D_3 (cholecalciferol) content affects only by steaming, while changes on vitamin E (alpha-tocopherol) was observed solely after frying process. The highest content of monounsaturated fatty acids (MUFA) were observed after steaming, whereas fried samples presented higher values of polyunsaturated fatty acids (PUFA) due to significant increase in linoleic acid (C18:2n6). During steaming did not reduce significant n3 and n6 PUFA levels, while frying caused a large reduction of n3 PUFAs. The ratio of n3/n6 was markedly lower in fried samples than in raw and steamed mackerel. In conclusion the Black Sea Horse Mackerel is a good source of vitamin D_3, vitamin E and n3 PUFAs. After steaming and frying process there were minimum losses in the contents of cholecalciferol and alpha-tocopherol, while retinol was reduced nearly a half. The process of frying affects most significantly three fatty acids groups, whereas after steaming was observed little influence on fatty acids profile.

Keywords: *Trahurus mediterraneus*, steaming, frying, vitamins, fatty acids, human health

27. **Merdzhanova, A.**, Makedonski, L., Stancheva, M (2013). Black Sea Shad and Red Mullet as sources of omega 3 Fatty Acids. *Scripta Scientifica Medica*, *45*, 18-23.

ORIGINAL ARTICLES

BLACK SEA SHAD AND RED MULLET AS SOURCES OF OMEGA 3 FATTY ACIDS

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ABSTRACT

PURPOSE: The purpose of this work was to study the seasonal changes of the quantity of omega-3 polyunsaturated fatty acids (n-3 PUFA) in two commonly consumed Black Sea fish species shad *(Alosa pontica)* and red mullet *(Mullus barbatus ponticus)*. These fish species appear as one of the best sources of omega-3 polyunsaturated fatty acids.

28. Stancheva, M., **Merdzhanova, A.**, Petrova, E., Petrova, D. (2013). Heavy Metals and Proximate Composition of Black Sea Sprat (Sprattus sprattus) and Goby (Neogobius melanostomus). *Bulgarian Journal of Agricultural Science*, *19*(1), 35-41.**(IF=0.2)**

Bulgarian Journal of Agricultural Science, 19 (Supplement 1) 2013, 35–41
Agricultural Academy

HEAVY METALS AND PROXIMATE COMPOSITION OF BLACK SEA SPRAT (*SPRATTUS SPRATTUS*) AND GOBY (*NEOGOBIUS MELANOSTOMUS*)

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Abstract

STANCHEVA, M., A. MERDZHANOVA, E. PETROVA and D. PETROVA, 2013. Heavy metals and proximate composition of Black Sea sprat (*Sprattus sprattus*) and goby (*Neogobius melanostomus*). *Bulg. J. Agric. Sci.*, Supplement 1: 35–41

The aim of the present study were to determine and compare the heavy metals content (Pb, Cd, Hg and As) and proximate composition in edible part of two commercially important fish species from Bulgarian Black Sea – sprat (*Sprattus sprattus*) and goby (*Neogobius melanostomus*). Determination of As, Cd, and Pb were carried out on a Perkin Elmer Zeeman 3030 spectrometer with an HGA-600 atomizer, whereas Hg was analyzed by Milestone Direct Mercury Analyzer. The levels of Cd and Pb were relatively low in both analyzed species while those for As concentration show higher value for sprat. The amounts of Hg for sprat and goby are also under permitted levels for fishes for human consumption. Proximate composition of the following nutrients was determined using standard procedures of AOAC (1991): moisture, crude protein and total lipids. Crude protein in fish samples was in the range 17.15–18.10%, while fat content was from 1.60 to 4.30 g.100 g $^{-1}$ w.w. Energy values have been calculated using FAO/WHO specific factors and were in interval 373–437 kJ.100 g $^{-1}$ w.w. Results showed that observed heavy metal contents have lower concentration of mean values than the permissible limits set by FAO/WHO in analyzed samples. It can be concluded that both species studied are safe to be consumed and have a good nutrition quality.

Key words: Heavy metals, proximate composition, Black Sea Sprat, Goby

29. Dobreva, D., Stancheva, M., **Merdzhanova, A.** (2013). Effect of frozen storage on fat soluble vitamins content in fish fillets. *Scripta Scientifica Medica, 45(3):23-26*

ORIGINAL ARTICLES

EFFECT OF FROZEN STORAGE ON FAT SOLUBLE VITAMINS CONTENT IN FISH FILLETS

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ABSTRACT

Fat-soluble vitamins content (all-trans-retinol, alpha-tocopherol and cholecalciferol) in edible tissue of Bluefish (*Pomatomus saltatrix*), a typical Black sea pelagic fish, and in Rainbow trout (*Oncorhynchus mykiss*), a typical farmed freshwater fish, were determined and compared on raw state and after frozen storage.

The sample preparation procedure includes saponification and consequent extraction of fat-soluble vitamins with n-hexane. The extract was dried under nitrogen flow and redissolved in methanol. HPLC analysis of methanolic samples was performed on ODS2 Hypersil (250x4,6, 5um) column with a mobile phase of methanol:water = 97:3. The quantification of fat-soluble vitamins was by the method of standard addition. Retinol and cholecalciferol were monitored by UV detection and alpha-tocopherol was detected by fluorescence.

The retinol and cholecalciferol contents in fresh edible tissue of Black sea Bluefish (38.5±2.4 μg.100g^{-1}ww and 11.2±1.2 μg.100g^{-1}ww, respectively) were close to values in the freshwater fish Rainbow trout (58.9±2.6 μg.100g^{-1}ww and 14.9±1.1 μg.100g^{-1}ww, respectively). Alpha-tocopherol content was several fold higher in Rainbow trout (1648.9±68.8 μg.100g^{-1}ww) than in Black sea Bluefish (427.1±37.1 μg.100g^{-1}ww).

Long period of storage affected mostly retinol and alpha-tocopherol contents in two fish species. While cholecalciferol content remained almost unchanged.

Key words: *Retinol, Alpha-Tocopherol, Cholecalciferol, Frozen storage, Fish fillet*

30. **Merdzhanova, A.,** Dobreva, D. A., Stancheva, M., Makedonski, L. (2014). Fat soluble vitamins and fatty acid composition of wild black sea mussel, rapana and shrimp. *Analele Universitatii" Ovidius" Constanta-Seria Chimie*, *25*(1), 15-23.

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Fat soluble vitamins and fatty acid composition of wild Black sea mussel, rapana and shrimp

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Abstract Many studies suggest that marine molluscs are one of the most important dietary sources of fat soluble vitamins (E, D_3 and A) and essential fatty acids (FA). The most commercially important species from the Bulgarian Black Sea are the Black mussel, rapana and shrimp. There is scarce information in the scientific literature about fat soluble vitamins and FA composition of these Black Sea molluscs. The aims of the present study are to determine and compare fat soluble vitamins content as well as relative daily intake, FA composition and atherogenic index (IA), thrombogenicity index (IT) and flesh-lipid quality index (FLQ) in wild Black Sea mussel (*Mytilus galloprovincialis*), rapana (*Rapana venosa*) and shrimp (*Crangon crangon*). Fat soluble vitamins were analysed simultaneously using RP-HPLC system. The FA profile was analysed by GC-MS. All of the analysed samples presented significant amounts of vitamin E, followed by vitamin A and D_3. Black Sea molluscs are excellent sources of fat soluble vitamins, especially for vitamin D_3 - one survey provides more than 100% of the RDI established in Bulgaria. The FA composition of total lipids showed significant differences and the present study revealed that SFA content was significantly higher than MUFA ($p<0.001$) and PUFA ($p<0.001$) (SFA>PUFA>MUFA) in shrimp and mussel whereas rapana showed opposite trends (PUFA>SFA>MUFA). The omega6/omega3 and PUFA/SFA ratios of the analysed species were greater than the FAO/WHO recommendations.

Keywords: Mytilus sp., Rapana sp., Crangon sp., fat soluble vitamins, fatty acids, Bulgarian Black Sea coast

31. Peycheva, K., Makedonski, L., **Merdzhanova, A.,** Stancheva, M. (2014). Evaluation of toxic metal levels in edible tissues of three wild captured freshwater fishes. *Analele Universitatii" Ovidius" Constanta-Seria Chimie*, *25*(1), 53-58.

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Evaluation of toxic metal levels in edible tissues of three wild captured freshwater fishes

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Abstract River ecosystems are vulnerable to heavy metal pollution. Fish samples are considered as one of the most indicative factors, in fresh water systems, for the estimation of trace metals pollution potential since they are the final chain of aquatic web. The objective of the present study is to evaluate the concentration of some toxic elements (As, Hg, Pb, Cd and Ni) in edible part of three wild fresh water fish species (zander (*Sander lucioperca*), wels catfish (*Silurus glanis*) and European carp (*Cyprinus Carpio*)) caught from Bulgarian part of Danube river collected during 2010. The Danube River is the European Union's longest and the continent's second longest river that passes through or touches the borders of ten countries. It has a great importance in regard to biodiversity, economics and transportation. The elements (As, Pb, Cd and Ni) were assayed using Perkin Elmer Zeeman 3030 electrothermal atomic absorption spectrometer with an HGA-600 atomizer. Determination of Hg was performed using Milestone Direct Mercury Analyzer DMA-80. The results were expressed as μg/g dry weight. The order of heavy metal accumulation in the edible part of zander is As>Hg>Pb> Ni> Cd while the other two fish species show a different metal accumulation Hg > As >Pb> Ni > Cd. In all heavy metals, the accumulation of mercuric and arsenic proportion was significantly high in all three fish types.

Keywords: Danube River, fish, toxic elements, ETAAS, Mercury Analyzer

32. Dobreva, D., **Merdzhanova, A.**, Makedonski, L., Stancheva, M. (2014). Seasonal changes in fatty acid composition and fat soluble vitamins content of grass carp and common carp. *Agricultural Science and Technology*, *6*(3), 271-277.

AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 6, No 3, pp 271 - 277, 2014

Seasonal changes in fatty acid composition and fat soluble vitamins content of grass carp and common carp

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Abstract. *The aim of the present study is to evaluate the seasonal changes in total lipids and fatty acid (FA) composition, and fat soluble vitamins (A, D_3 E) content in the edible tissue of two freshwater fish species – grass carp and common carp. The FA and vitamins contents of the investigated fish species showed significant seasonal changes. All spring samples were characterized by lower saturated fatty acid (SFA) levels (from 35.9% to 36.0%) and higher polyunsaturated fatty acids (PUFA) (from 14.6% up to 30.1%), including the essential omega 3 PUFA compared to the autumn specimens. The autumn carp and grass carp showed significant decrease of the monounsaturated fatty acids (MUFA) levels. All autumn samples showed lower PUFA (from 13.3% to 30.0%) values, due to reduction of linoleic acid (C 18:2 n6) levels in carp and grass carp. PUFA/SFA and n-3/n-6 ratios decreased in all fish species in the autumn season. The fat soluble vitamins content of the analyzed species in the two seasons were in the ranges: from 8.56±0.68µg/100g to 24.44±5.8 µg.100g^{-1} wet weight (ww) for all-trans-retinol; from 5.41±0.33 µg.100g^{-1} ww to 30.87±5.1 µg.100g^{-1} ww cholecalciferol and from 1051.8±38.470 µg.100g^{-1} ww to 3133.1± 57.8 µg.100g^{-1} ww α-tocopherol, respectively. All analyzed cyprinid species in both seasons are good sources of fat soluble vitamins and PUFAs, which makes them a desirable part of the human diet.*

33. **Merdzhanova, A.**, Dobreva, D., Stancheva, M. (2015). Quality evaluation of dietary lipids of Channel Catfish (Ictalurus punctatus) from Bulgaria. *Bulgarian Journal of Agricultural Science*, *21*(1), 202-207. **(IF=0.2)**

Bulgarian Journal of Agricultural Science, 21 (Supplement 1) 2015, 202–207
Agricultural Academy

QUALITY EVALUATION OF DIETARY LIPID OF CHANNEL CATFISH (*ICTALURUS PUNCTATUS*) FROM BULGARIA

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Abstract

MERDZHANOVA, A., D. DOBREVA and M. STANCHEVA, 2015. Quality evaluation of dietary lipid of channel catfish (*Ictalurus punctatus*) from Bulgaria. *Bulg. J. Agric. Sci.,* Supplement 1, 21: 202–207

Fish lipids are important components of diet due to their significance as energy, essential fatty acids and fat soluble vitamins sources. No data is available on fatty acid (FA) composition and fat soluble vitamins content of freshwater channel catfish from Bulgarian fish market. The objectives of the present work were to investigate the total lipid content, FA profile, lipid quality indices (atherogenic, thrombogenic), fat soluble vitamins (A, E and D_3) as well as relative daily intake of vitamins of Channel catfish (*Ictalurus punctatus*). The potential nutritional and medicinal value of FA composition and vitamins content to consumers were evaluated. The FA composition was analyzed by GC–MS. Fat soluble vitamins were analyzed simultaneously using RP–HPLC. The FA distribution of catfish is: SFA>MUFA>PUFA. The n3/n6 and PUFA/SFA ratios were greater than the recommended by FAO/WHO. A portion of 100 g contained 0.245 g of EPA+DHA n-3 PUFA. Catfish tissue presented significant amounts of vitamin E (1374.5 ± 158.1 μg.100 g $^{-1}$ ww), followed by vitamin A (36.2 ± 0.7 μg.100 g $^{-1}$ ww) and D_3 (17.7 ± 0.7 μg.100 g $^{-1}$ ww). This species is excellent source of fat soluble vitamins, especially for vitamin D_3 – one survey provides more than 300% of the RDI established in Bulgaria. This study provides specific nutritional information with respect to the consumption of channel catfish for nutrient balance as foodstuff. Since fish tissue is a valuable source of essential nutrients, a detailed analysis for evaluation the nutrient composition and content on fish lipids is needed.

Key words: channel catfish, fatty acids, lipid quality indices, vitamin E, vitamin A, vitamin D_3
Abbreviations: FA – fatty acid; GC–MS – gas chromatography with mass detection; RP–HPLC–reverse phase – high pressure liquid chromatography; SFA – Saturated fatty acids; MUFA – monounsaturated fatty acid; PUFA – polyunsaturated fatty acid; n-3 PUFA – omega-3 polyunsaturated fatty acid; n-6 PUFA – omega-6 polyunsaturated fatty acid; EPA – eicosapentaenoic fatty acid, n-3 PUFA; DHA – docosahexaenoic fatty acid, n-3 PUFA; RDI – recommended daily intake

34. Dobreva, D., **Merdzhanova, A.**, Stancheva, M. (2015). The impact of different cooking methods on fat soluble vitamins content and fatty acid composition of the Black Sea Shad (*A. immaculata*) *Scientific Works of University of Food Technologies*, LXII: 310 – 314

НАУЧНИ ТРУДОВЕ НА
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Влияние на различни готварски методи върху съдържанието на мастноразтворими витамини и мастни киселини в Черноморски Карагьоз (*Alosa immaculata*)

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The impact of Different Cooking Methods on Fat Soluble Vitamins' Content and Fatty Acid Composition of the Black Sea Shad (*Alosa immaculata*)

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Abstract

The aim of the present study was to evaluate the effect of steaming (10 min at 90°C) and grilling (15 min, 220°C) on lipid, fat soluble vitamins' contents, and the fatty acid's group profile of Shad (Alosa immaculata).

The total lipid content was determined according to Bligh&Dyer method. Fat soluble vitamins were determined by RP-HPLC. Fatty acid methyl esters were analysed by GC/MS.

The amount of vitamin A in steamed fillets decreases significantly compared to raw samples, whereas vitamin D_3 and E remain almost unchanged. Among the three fat soluble vitamins, the grilling process affects significantly only vitamin A and E. The steaming tends to increase the saturated fatty acid (FA) levels, whereas grilling increases monounsaturated fatty acids. The steaming, results in significant decrease in omega- 3 FA levels. After grilling the omega-6 amounts remain almost unchanged, whereas the omega-3 polyunsaturated FA were significantly decreased.

After steaming and grilling the shad showed insignificant losses of vitamin D and E contents, while retinol was reduced nearly in half. The FA composition of shad tissue did not reveal great losses in omega-3 FA after heat treatments. We can conclude that both cooking methods are suitable for preserving the biological active components in shad.

Keywords: *Alosa immaculata*, grilling, n–3, n-6, steaming, fatty acids, fat soluble vitamins

35. Bratoeva, K., Radanova, M., Merdzhanova A. (2015). Effect of allopurinol on oxidative stress in obesity and liver content of free fatty acids. *J. BioSci. Biotechnol.*, SE/ONLINE: 91-96

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Bratoeva *et al.* *J. BioSci. Biotechnol.* **2015**, SE/ONLINE: 91-96

RESEARCH ARTICLE

Effect of allopurinol on oxidative stress in obesity and liver content of free fatty acids

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ABSTRACT

Oxidative stress appears as the key feature associated with dysfunction in adipose tissue and a major factor in the mechanisms of altered lipid metabolism in obesity. Cellular response of adipocytes in the conditions of oxidative stress results in maintaining systemic pro-inflammatory state, insulin resistance and increased accumulation ofvery long-chain saturated fatty acids (VLCSFAs) to the liver, which are lipotoxic and lead to further injury. Therefore, the therapeutic purposes of lowering the production of ROS, may have beneficial effects on obesity and its associated complications. The aim of the study was to determine the influence of allopurinol (xanthine oxidase inhibitors) on oxidative stress in adipose tissue and liver saturated fatty acids content in a model of fructose-induced obesity. We used a model of high-fructose diet (HFD) in male rats Wistar (16 weeks, 35% glucose-fructose corn syrup), divided into three groups: control; HFD; HFD and allopurinol administration (150 mg/kg in drinking water for 16 week). Analysis of fatty acids was performed by Gas Chromatograph with MS detector. Serum levels of glucose and uric acid (UA); weight, markers of oxidative stress- MDA (malondialdehyde), glutathione (GSH) and glutathione peroxidase (Gpx) in the retroperitoneal tissue were investigated. The results showed significantly elevated of VLCSFAs, retroperitoneal tissue/ body weight ratio, MDA, Gpx, glucose and UA levels in serum and decreased levels of glutathione in HFD rats compared to the control group. In the group treated with allopurinol the retroperitoneal tissue/ body weight ratio, the levels of MDA, Gpx, VLCSFAs, UA and glucose levels in serum were significantly reduced while glutathione levels were elevated in comparison with HFD rats. The inhibition of xanthine oxidase and UA by allopurinol prevents the development of oxidative changes in adipose tissue. This effect probably suppresses inflammation in adipose tissue, improves insulin sensitivity, reduce VLCSFAs levels and thereby prevent the further lipotoxicliver damage.

Key words: allopurinol, free fatty acids, adipose tissue, xanthine oxidase, oxidative stress.

36. **Merdzhanova, A.,** Dobreva, D. A., Georgieva, S. (2016). Nutritional evaluation of aquaculture mussels (M. galloprovincialis) from the Black Sea, Bulgaria. *Ovidius University Annals of Chemistry*, *27*(1), 1-7.

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Ovidius University Annals of Chemistry Volume 27, Number 1, pp. 1-7, 2016

Nutritional evaluation of aquaculture mussels *(M. galloprovincialis)* from the Black Sea, Bulgaria

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Abstract. In recent years black mussels are one of the most commercially important species from the Bulgarian Black Sea. The marine mollusks are valuable healthy food, low in calories and fats and high in proteins. They are a major dietary source of fat soluble pigments - astaxanthin, carotenoids and polyunsaturated fatty acids (PUFA). To our knowledge the information about the nutritional quality of mussels from the Bulgarian Black Sea waters, based on chemical composition, fat soluble pigments, cholesterol and PUFA content is very limited. The aim of the present study is to determine and compare protein, lipid, carbohydrate and energy values, fat soluble pigments, cholesterol and fatty acid composition in farmed mussels (*Mytilus galloprovincialis*) from the Bulgarian northern and southern parts of the Black Sea coast. The mussel samples were analyzed for lipids (Bligh & Dyer method), crude proteins (Kjeldahl method), carbohydrates and moistures according to the AOAC (1990) methods. Fatty acids were analyzed by the GC-MS system. Fat soluble pigments and cholesterol were analyzed simultaneously by the RP-HPLC system. Lipid and protein content were found to be higher in mussels from the northern region. In accordance with the Commission Regulation (EC) No. 116/2010 all analyzed mussel samples can be classified as high in protein and low in fats and carbohydrates. The amount of cholesterol, contained in all mussel populations is significantly low, while the omega-3 (n-3) is significantly higher than the omega-6 PUFA. A portion of 100 g edible tissue provides 0.500 g more of the required amount of eicosapentaenoic acid (20:5) and docosahexaenoic acid (22:6) n-3 PUFA according to EFSA (2012). It can be concluded that the studied mussel aquaculture in the Black Sea is beneficial food for the human health and it is advisable to be part of a proper or a preventive diet of Bulgarian consumers.

Keywords: black mussels, astaxanthin, n-3 PUFA, energy value.

37. Bratoeva K, Stoyanov G S, **Merdzhanova A**, Radanova M. (November 07, 2017) Manifestations of Renal Impairment in Fructose-induced Metabolic Syndrome. Cureus 9(11): e1826. doi:10.7759/cureus.1826

Cureus

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DOI: 10.7759/cureus.1826

Manifestations of Renal Impairment in Fructose-induced Metabolic Syndrome

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Disclosures can be found in Additional Information at the end of the article

Abstract

Introduction

International studies show an increased incidence of chronic kidney disease (CKD) in patients with metabolic syndrome (MS). It is assumed that the major components of MS - obesity, insulin resistance, dyslipidemia, and hypertension - are linked to renal damage through the systemic release of several pro-inflammatory mediators, such as uric acid (UA), C-reactive protein (CRP), and generalized oxidative stress. The aim of the present study was to investigate the extent of kidney impairment and manifestations of dysfunction in rats with fructose-induced MS.

Methods

We used a model of high-fructose diet in male Wistar rats with 35% glucose-fructose corn syrup in drinking water over a duration of 16 weeks. The experimental animals were divided into two groups: control and high-fructose drinking (HFD). Serum samples were obtained from both groups for laboratory study, and the kidneys were extracted for observation via light microscopy examination.

Results

All HFD rats developed obesity, hyperglycemia, hypertriglyceridemia, increased levels of CRP and UA (when compared to the control group), and oxidative stress with high levels of malondialdehyde and low levels of reduced glutathione. The kidneys of the HFD group revealed a significant increase in kidney weight in the absence of evidence of renal dysfunction and electrolyte disturbances. Under light microscopy, the kidneys of the HFD group revealed amyloid deposits in Kimmelstiel-Wilson-like nodules and the walls of the large caliber blood vessels, early-stage atherosclerosis with visible ruptures and scarring, hydropic change (vacuolar degeneration) in the epithelial cells covering the proximal tubules, and increased eosinophilia in the distant tubules when compared to the control group.

Conclusion

Under the conditions of a fructose-induced metabolic syndrome, high serum UA and CRP correlate to the development of early renal disorders without a clinical manifestation of renal dysfunction. These phenomena are of particular importance for assessing the risk of developing future CKD.

Categories: Endocrinology/Diabetes/Metabolism, Pathology, Nephrology
Keywords: amyloid a, metabolic syndrome, chronic kidney disease, fructose

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38. Bratoeva K., Radanova M., **Merdzhanova A.**, Donev I., (2017) Protective Role of S-Adenosylmethionine Against Fructose-Induced Oxidative Damage in Obesity. Journal of Mind and Medical Sciences, Vol. 4/ No. 2 (October, 2017).

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doi: 10.22543/7674.42.P163171

Research Article

Protective role of S-Adenosylmethionine against fructose-induced oxidative damage in obesity

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Abstract

Introduction. It has been shown that S-adenosylmethionine (S-AMe) stimulates glutathione synthesis and increases cell resistance to the cytotoxic action of free radicals and pro-inflammatory cytokines. The aim of this study was to determine the effect of S-adenosylmethionine on the oxidative stress in adipose tissue in a model of fructose-induced obesity.

Methods. The study was performed on male Wistar rats divided into 3 groups: control, fructose fed (HFD) (35%, 16 weeks), and HFD + S-AMe (20 mg/kg). We examined the changes in the ratio of retroperitoneal adipose tissue weight / body weight; levels of reduced glutathione (GSH) and malondialdehyde (MDA) in the retroperitoneal adipose tissue, and serum levels of GSH and TNF-α.

Results. Significant increases in the retroperitoneal adipose tissue, MDA, and serum TNF-α were identified, as well as decreased tissue and serum levels of GSH in rats fed with a high-fructose diet as compared with the control group. In the group fed with HFD and S-AMe, we found significant reduction in the retroperitoneal adipose tissue and decreased levels of MDA and serum TNF-α, as well as increased tissue and serum levels of GSH as compared with the group only on HFD.

In conclusion, our results show that fructose-induced obesity causes oxidative stress in hypertrophic visceral adipose tissue. The administration of S-AMe improves the antioxidative protection of adipocytes, and reduces oxidative damage and excessive accumulation of lipids and inflammation.

Keywords: S-adenosylmethionine, fructose, oxidative damage, obesity

39. Panayotova V., Dobreva D., **Merdzhanova A.**, Stacheva M., L. Makedonski (2017) Seasonal changes in fatty acid composition and alpha-tocopherol content in Cystoseira barbata. Proceedings of the Institute of Fishing Resources, Volume 28,73-79

Seasonal changes in fatty acid composition and alpha-tocopherol content in Cystoseira barbata

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Abstract

Целта на настоящото проучване е да се проучат сезонните промени в съдържанието на общи липиди, мастнокиселинния състав и съдържанието на токоферол в кафявите водорасли Cystosera barbata. Мастнокиселинният състав и съдържанието на витамин Е показват значителни промени в изследваните сезони. Пролетните проби се характеризират с по-високи количества наситени мастни киселини (НМК – от 62% на 70%) и мононенаситени мастни киселини (МНМК – 8% до 13%) и по-ниско съдържание на полиненаситени мастни киселини (ПНМК от 29% на 16% от общите мастни киселини). По-ниските количества ПНМК се дължат главно на значителното намаляване на линоловата (C18:2n-6) и арахидоновата киселини (C20:4n-6) през пролетта. Съдържанието на токоферол намалява значително в пролетния сезон, съответно от 7.2 до 4.7 mg.g-1 липид.

Keywords: Cystoseira barbata, Black Sea, fatty acids, α-tocopherol

40. **Merdzhanova, A.**, Ivanov, I., Dobreva, D. A., Makedonski, L. (2017). Fish Lipids as a Valuable Source of Polyunsaturated Fatty Acids. Acta Scientifica Naturalis, 4(1), 70-75.

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Fish Lipids as a Valuable Source of Polyunsaturated Fatty Acids

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Abstract: *This article presents information about omega-3 (n-3) and omega-6 (n-6) polyunsaturated fatty acid (PUFA) contents in a broad range of commercially important fish species available on Bulgarian fish markets. The aim is to raise consumers' awareness and encourage them to eat fish. Fish species from the Black Sea coast have relatively high proportion of n-3 PUFAs, of which more than 80% is by EPA (eicosapentaenoic acid, C 20:5 n-3) and DHA (docosahexaenoic acid, C 22:6 n-3). Extensive epidemiological studies show that fish consumption is inversely associated with the incidence of cardiovascular diseases (CVD), stroke and the functioning of the brain. About 0.5 g of omega-3 (EPA+DHA) a day or two servings of oily fish a week are required to reduce the risk of death from CVD. PUFAs needs should be satisfied not only with food additives but with fish lipids containing food.*

Key words: *omega-3, omega-6, Black Sea fish, health benefits*

41. Panayotova V., **Merdzhanova A**, Dobreva D., Zlatanov M., L. Makedonski (2017) Lipids of Black Sea Algae: Unveiling Their Potential for Pharmaceutical and Cosmetic Applications, Journal of IMAB, 23(4):1747-1751. DOI: 10.5272/jimab.2017234.1747

Journal of IMAB
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https://www.journal-imab-bg.org

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Journal of IMAB - *Annual Proceeding (Scientific Papers)*. 2017 Oct-Dec;23(4)

Original article

LIPIDS OF BLACK SEA ALGAE: UNVEILING THEIR POTENTIAL FOR PHARMACEUTICAL AND COSMETIC APPLICATIONS

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ABSTRACT

Background: Bulgarian Black Sea coast is rich in algae, regarding biomass and algal biodiversity. The red algae *Gelidium crinale* (Rhodophyta) and brown algae *Cystoseira barbata* (Phaeophytes) are among the most abundant species along the Bulgarian Black Sea shore. Yet information about their lipid composition is limited.

Purpose: Present study was conducted to investigate biologically active substances in two underexplored seaweed lipids. Total lipids, total phospholipids, fat soluble vitamins and carotenoids were analysed. In addition, the specific distribution of fatty acids group among the total lipids and total phospholipids were elucidated.

of bioactive natural products which may have a significant role in health promotion, mainly in diseases prevention and treatment. Moreover, seaweeds have been used since ancient times as food, sources of medicine, but despite their abundance, nowadays they are poorly exploited. This article focuses on the Black Sea red and brown algae species lipid composition. Algal total lipid content is usually low, but they contain a high proportion of polyunsaturated fatty acids (PUFA) combined with other interesting secondary metabolites as vitamins, pigments, proteins etc. PUFA are of the utmost importance for human metabolism. Besides their structural role, they possess other beneficial effects, like antioxidant activities, prevention of cardiac diseases,

42. Dobreva, D. A., **Merdzhanova, A.** Makedonski, L. (2017). Fat soluble nutrients and fatty acids in skin and fillet of farmed rainbow trout. *Bulgarian Chemical Communications,* 49 (Special Issue G):118-123 **(IF=0.29)**

Bulgarian Chemical Communications, Volume 49, Special Issue G (pp.118 –123) 2017

Fat soluble nutrients and fatty acids in skin and fillet of farmed rainbow trout

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This study compares the fat soluble components in the muscle and edible skin parts of farmed rainbow trout (*Oncorhynchus mykiss W.*) fillets, sampled at two growth stages, from fish markets from Bulgaria. Insufficient information is available about the differential fat soluble pigments, cholesterol, vitamins and fatty acid compositions of rainbow trout fillets when eating them with or without the skin left on. Vitamins A, D_3 and E, β-carotene and cholesterol were analyzed simultaneously using HPLC system with UV and FL detection (vitamins A and E). Total lipids were extracted according to Bligh and Dyer method. Analysis of fatty acid methyl esters (FAME) were perform by GC/MS. The average lipid content, the cholesterol and vitamin E amounts and the saturated fatty acids were significantly higher in the skin than in the muscle, whereas the proportion of vitamin A and D_3, eicosapentaenoic acid (C20:5 ω-3) and docosahexaenoic acid (C22:6 ω-3) were higher in the muscle.

Key words: *Oncorhynchus mykiss, vitamins, carotenoids, cholesterol, PUFA*

43. Georgieva G, Dobreva D., Panayotova V., **Merdzhanova A.**(2017) Phenolic compounds in edible plants, Varna Medical Forum 2017, (приета, под печат)

ФЕНОЛНИ СЪЕДИНЕНИЯ В ЯДЛИВИ РАСТЕНИЯ

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АБСТРАКТ

През последните години значително нараства интереса към изследването на химичния състав на ядливи растения, особено на съдържанието им на биологично активни съединения с лечебно-протективен потенциал. Такива растения традиционно се използват както в европейската, така и в азиатската култури, за подобряване на аромата и вкуса, както и за обогатяване на хранителната стойност на ястията. Ядливите растения се консумират както в сурово състояние като салати, добавки, подправки, гарнитур, така и след термична обработка.

Важна характеристика на ядивните растения е голямото разнообразие на естествени биологично активни вещества - включително флавоноиди и фенолни киселини, антоцианини и др., които се съдържат в листата или други техни части. Полифенолите са голяма група вторични растителни метаболити. Най-често срещаните фенолни съединения в растителната храна са фенолните киселини и флавоноидите.

Известно е, че приема на фенолни съединения влияе позитивно върху човешкото здраве. Тази група вещества се характеризират с доказани противовъзпалителни, противоалергични и противовирусни свойства, както и с потенциал за превенция на някои сърдечно-съдови заболявания, хипертония, диабет и др. Тези свойства се дължат на двойната роля на фенолните съединения - като антиоксиданти и като субстрати.

В България има сравнително малко и ограничена информация за състава на полифенолни киселини и флавоноиди в ядливи растения. Разширяване обхвата на подобна информация би предоставило възможност за информиран избор храна, от страна на консуматора, както и употребата им във фармацията (фитотерапия, лечебна козметика), включване в лечебни хранителни режими – като хранителни добавки и компоненти на функционални храни и др.

Ключови думи: фенолни киселини, флавоноиди, функционални храни

44. Bratoeva K., Stoyanov G S, **Merdzhanova A.**, Radanova M., (2018) Association between serum CK-18 levels and the degree of liver damage in fructose-induced Metabolic syndrome , **Metabolic Syndrome and Related Disorders**, (приета за печат)

ASSOCIATION BETWEEN SERUM CK-18 LEVELS AND THE DEGREE OF LIVER DAMAGE IN FRUCTOSE-INDUCED METABOLIC SYNDROME

Kameliya Bratoeva, MD, PhD, [1] Silviya Nikolova, PhD [2] Albena Merdzhanova, PhD, [3] George St. Stoyanov, MD, [4] Eleonora Dimitrova, MD, PhD, [5] Javor Kashlov, MD, PhD, [5] Nikolay Conev, MD, PhD, [5] Mariya Radanova, PhD [6].

Mary Ann Liebert, Inc

Abstract

Background: The pathogenesis of non-alcoholic fatty liver disease as a component of metabolic syndrome (MetS) involves the activation of apoptosis in steatotic hepatocytes. Caspase-generated fragments such as cytokeratin-18 (CK-18) in patients with various hepatic impairments are investigated as markers for diagnosis and assessment of disease severity. The goal of the study was to capture early biomarkers of apoptosis and elucidate their role in assessing the presence and extent of hepatic damage in a MetS model.

III. Избрани резюмета публикувани в сборници от международни научни конференции (с импакт фактор)

1. 21st European Congress on Obesity, ECO 2014, 28-31 May 2014, Sofia Bulgaria, **Merdzhanova A.**, Makedonski L., Stancheva M.,
Proximate composition of commercially important fish species

Vol. 7,
Supplement 1,
May 2014

21th European Congress on Obesity (ECO2014)

Sofia, Bulgaria, May 28–31, 2014

T2:PO.007

Proximate composition and fatty acid profile of three commercially important fish species from Bulgaria

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Introduction: The aim of the present study was to determine the proximate composition and fatty acid profile in two freshwater fish from carp family – common carp (*Cyprinus carpio)* and bighead carp (*Aristichthys nobilis*) and one Black Sea fish species – horse mackerel (*Trahurusm mediterraneus ponticus*) traditionally consumed in Bulgaria.
Methods: Proximate composition was determined according to standard procedures: moisture, crude protein (Kjeldahl method), total lipids (Bligh and Dyer method,1959). Analysis of fatty acid methyl esters was performed by Gas Chromatography – Mass Spectrometry.
Results: Crude protein was in the range 15.24–19.55%, fat content was from 3.80 to 12.76 g.100g-1w.w. Energy values were in interval 440–750 kJ.100g-1 w.w. The fatty acid (FA) contents of the investigated fish species showed significant diferences. The freshwater species were characterized with lower saturated FAs in range from 35.95% (carp) to 37.53% (bighead carp). Carp presented highest monounsaturated FAs (49.41%) and lowest polyunsaturated FAs (PUFA) (14.55%), including omega-3 FAs (4.00%). Bighead carp and horse mackerel showed significant lower monounsaturated FAs and higher PUFAs and omega-3 PUFA compared to carp.
Conclusion: The studied species were characterized by a good nutritional quality due to their higher protein and omega-3 PUFA contents and relatively low lipid and energy levels. All analyzed species showed omega-6/omega-3 ratio below recommended maximum values of 4.0 and PUFA/SFA ratio above recommended minimum values of 0.4. The presented results are important in order to inform consumers and to promote fish consumption in Bulgaria.

2. 21st European Congress on Obesity, ECO 2014, 28-31 May 2014, Sofia Bulgaria, Dobreva D.A., **Merdzhanova A.**, Stancheva M.,
Effect of thermal processing on fat soluble vitamin contents in black sea shad (A. pontica)

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Supplement 1,
May 2014

21th European Congress on Obesity (ECO2014)

Sofia, Bulgaria, May 28–31, 2014

T2:PO.046

Effect of thermal processing on fat soluble vitamin contents in Black Sea shad *(Alosa pontica)*

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Introduction: Introduction: Fishes are regarded as important natural food sources of fat soluble vitamins, which are necessary for healthy diet. Temperature processing of fish tissue enhances its taste, inactivates pathogenic microorganisms and increases its shelf life. The fat soluble vitamins are considered to be especially susceptible to oxidation during cooking process before consumption.
The aim of the present study was to evaluate the effect of steaming (10 min at 90oC) and grilling (7 min on each side) on retinol (vitamin A), cholecalciferol (vitamin D3) and alpha-tocopherol (vitamin E) contents in Shad fillets.
Methods: The sample preparation procedure includes saponification and extraction of fat soluble vitamins with n-hexane. HPLC analysis was performed on RP column with a mobile phase of methanol:water = 97:3.
Results: The retinol, cholecalciferol and alpha-tocopherol content in fresh fish fillets are 4.4 ± 0.1 μg/100g, 45.1 ± 1.5 μg/100g and 1971.0 ± 62.9 μg/100g, respectively. The amount of vitamin A in steamed fillets decreases significantly (~ 40%), when compared to its content in the raw samples. In contrast vitamin D3 and vitamin E remain almost unchanged. Among three fat soluble vitamins, the grilling process affects significantly only vitamin A and vitamin E content.
Conclusion: The sample preparation procedure includes saponification and extraction of fat soluble vitamins with n-hexane. HPLC analysis was performed on RP column with a mobile phase of methanol:water = 97:3.

3. 21st European Congress on Obesity, ECO 2014, 28-31 May 2014, Sofia Bulgaria, Bratoeva K. and **Merdzhanova A.**
Different roles of free fatty acids in an experimental model of obesity

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Differential roles of free fatty acids in an experimental model of obesity

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Introduction: High-fructose diet causes obesity, metabolic and oxidative damage to hepatic steatosis in rodents and has been successfully used for the modeling of a fatty liver disease in humans. The latest studies of various dietary models showed that autophagy is involved in both the lipid metabolism and the limitation of the oxidative damages in the liver. Different lipid classes may also have different effects on cells function. Given the importance of lipogenesis in liver injury, the aim of this study was to determine the effects of the free fatty acids on autophagy and oxidative stress in fatty liver in fructose-induced experimental model.
Methods: Male Wistar rats were divided into two groups (n = 7): control group (on a standard diet), and fructose fed (35% in the drinking water, 16 weeks). Body and retroperitoneal fat weight were determined. Analysis of fatty acids was performed by GasChromatography-Mass spectrometry. Liver injury was assessed biochemically and histologically together with hepatic Beclin1 (initiating autophagy protein) expression.
Results: The results showed increase body ($p < 0.05$) and retroperitoneal fat ($p < 0.01$) weight, liver MDA levels ($p < 0.05$), microvesicular steatosis, suppressed Beclin1 expression and an increased in the ratio of very long-chain saturated to unsaturated fatty acids- C20:0-C24:0 in fructose fed rats compared with control group.
Conclusion: Fructose induces obesity and de novo lipogenesis in hepatocytes with threefold increased accumulation of very long-chain saturated fatty acids (VLCSFAs). Excess VLCSFAs coincided with suppressed autophagy, oxidative damage and steatosis, which identifies them as an important factor in liver injury in obesity.

4. 12th European Nutrition Conference, FENS 2015, October 20 -23, Berlin, Germany,
A. Merdzhanova, S Georgieva , M. Stancheva and L.Makedonski
Persistent organochlorine pollutants in fish from Danube River and from Black Sea, Bulgaria

12th European Nutrition Conference (FENS)

Berlin, Germany, October 20–23, 2015

Abstracts

149/737. Persistent organochlorine pollutants in fish from Danube River and from Black Sea, Bulgaria

Author(s): (1) Albena Merdzhanova; (2) Stanislava Georgieva; (2) Mona Stancheva; (2) Lubomir Makedonski.

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Introduction: Persistent organochlorine pollutants (POPs) like polychlorinated biphenyls (PCBs) and DDT residues (DDTs) are widespread, persistent and toxic organic environmental contaminants and can still be a problem for the human health. PCBs and DDTs were determined in three freshwater fish species: common carp (Cyprinus carpio), catfish (Silurus glanis), pike-perch (Sander lucioperca) and four marine fish: shad (Alosa pontica pontica), bluefish (pomatomus saltatrix), goby (Neogobius melanostsmus) and turbot (Psseta maxima maeotica). The fish samples were collected from Danube River and from Black Sea, Bulgaria in 2010.

Objectives: The POPs were analyzed in order to investigate the presence of PCBs and DDTs in freshwater fish species and to compare the results to the levels in marine fish species from Black Sea.

Method / Design: The fifteen congeners of PCBs, p,p'-DDT and its two main metabolites p,p'-DDE and p,p'-DDD were determined by capillary gas chromatography system with mass spectrometry detection.

Results: The DDTs were the predominant contaminants in investigated species, with the p,p'- DDE contributing to more than 67% to the total DDTs. The mean concentration of DDTs in freshwater fish was found 23.41 ng/g wet weight and mean PCBs concentration - 9.55 ng/g ww. In marine fish were determined the highest levels of PCBs (47.81 ng/g ww) and DDTs (217.00 ng/g ww) in shad.

Conclusions: The levels of DDTs and PCBs were determined lower than those found in similar fish species from other aquatic ecosystems. The sum of the six Indicator PCBs did not exceed the European maximum limit of 75 ng/g wet weight.

Keywords: (maximum 5): PCB, DDT, fish, Black Sea, Bulgaria

5. 12th European Nutrition Conference, FENS 2015, October 20 -23, Berlin, Germany,
A. Merdzhanova, M. Stancheva and D. A. Dobreva
Nutritional quality of marine and freshwater fish species from Bulgaria

12th European Nutrition Conference (FENS)

Berlin, Germany, October 20–23, 2015

Abstracts

149/727. Nutritional quality of marine and freshwater fish species from Bulgaria

Author(s): (1) Albena Merdzhanova; (2) Mona Stancheva; (2) Diana Dobreva.

Affiliation: *(1) Department of Chemistry. Faculty of Pharmacy. Medical University of Varna; (2) Department of Chemistry. Medical University. Varna.*

Introduction: Many studies suggest that marine and freshwater fish are one of the most important dietary sources of essential polyunsaturated fatty acids (PUFA) and fat soluble vitamins (E, D3 and A). It is well known that the nutritional benefits of sea food consumption are mainly attributed to several potential cardio protective effects of omega-3 (n-3) PUFAs. Fat soluble vitamins are essential components of marine lipids and they control a variety of biologically important processes in the human body.

Objectives: The aims of the presented study were to compared the nutritional quality based on PUFA, fat soluble vitamins content; and lipid quality indices of three Black Sea fish: shad (Alosa imaculata), goby (Neogobius melanogaster) and turbot (Pseta maxima) and three freshwaters species: Common carp (Cyprinus carpio), catfish (Silurus glanis) and brown trout (Salmo trutta fario).

Method / Design: Total lipid (TL) content was determined according to Bligh&Dyer. Fatty Acid Methyl Esters were performed by GC/MS system. Vitamins A, D3 and E were analysed simultaneously using RP-HPLC system.

Results: Black Sea fish showed SFA>PUFA>MUFA distributions, while freshwater fish presented species-specific FA patterns. Marine fish contained higher omega-3 PUFA levels compared to freshwaters. All analyzed fish contained over than 0.250g.100g-1wet weight EPA+DHA n-3.

The fat soluble vitamins content were in range: 3.1±0.2µg–41.3±1.6µg.100g-1ww (vitamin D3); 1.9±0.07µg–30.8±2.1µg.100g-1ww (vitamin A) and 461.5±0.07µg-3293.7±140.7µg100g-1ww (vitamin E). Black Sea shad provides eight times higher amounts of vitamin D3 RDI.

Conclusions: All species are valuable sources of EPA+DHA n-3 and fat soluble vitamins. Marine fish and brown trout have better nutritional quality than common carp and catfish.

Keywords: (maximum 5): fatty acids, fat soluble vitamins, human health, lipid quality indices

IV. Участие като съавтор в учебни помагала – 3 броя

1. „Химия, учебно помагало“ за студентите от Медицински Колеж“

2. Тетрадка по химия, за студентите по дисциплина „Неорганична и органична химия“, за специалност „Медицински лаборант“, Медицински Колеж, към МУ-Варна

МЕДИЦИНСКИ УНИВЕРСИТЕТ - ВАРНА

КАТЕДРА ПО ХИМИЯ

ТЕТРАДКА

ЗА УПРАЖНЕНИЯ

ПО НЕОРГАНИЧНА И ОРГАНИЧНА ХИМИЯ

ЗА СТУДЕНТИ ОТ СПЕЦИАЛНОСТ

МЕДИЦИНСКИ ЛАБОРАНТИ

2016г.

3. Тетрадка по химия, за студентите по дисциплина „Химия“, за специалност „Медицина“, МУ-Варна

МЕДИЦИНСКИ УНИВЕРСИТЕТ - ВАРНА

КАТЕДРА ПО ХИМИЯ

ТЕТРАДКА

ЗА УПРАЖНЕНИЯ

ПО Химия

ЗА СТУДЕНТИ ПО МЕДИЦИНА

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