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Fish meat quality and safety*

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A b s t r a c t: Fish constitute a major part of animal protein consumption in many parts of the world. Fish is consumed as fresh fish or as frozen, salted, dried, smoked, or canned products.

Fish represents a valuable source of proteins and other nutrients in the diet of many countries. As with many animal products, fish and fishery products contain water, proteins and other nitrogenous compounds, lipids, carbohydrates, minerals and vitamins. However, the chemical composition of fish varies greatly from one species and one individual fish to another depending on age, sex, environment and season. Proteins and lipids are the major components whereas carbohydrates are detected at very limited levels (less than 0.5 percent).

Different effects of several properties like lipid contents of tissues, water temperature and feeding habits have been found responsible for the bioaccumulation and bioconcentration of the odorous compounds in fish. Increasing quantities of organic pollutants are released into the aquatic environment by humans due to industrial production, modern plant protection, more intensive use of medicines, cosmetics, household detergents etc. These compounds are present in the environment as persistent compounds because they might accumulate in the different organisms through bioaccumulation and biomagnifications. Bioaccumulation of certain heavy metals along the food chain is a well-recognized process. Essentiality and toxicity of trace metals in organisms depend on the concentration of the metal; below a certain level they could be considered as essential for biochemical processes, but in the case of a high accumulation in organisms, intoxication may occur.

Fish meat is well suitable for human nutrition, because it contains easy digestible proteins and vitamins and minerals. Among the benefits of fish meat consumption the polyunsaturated omega-3 fatty acid contents can be mentioned again. The role of the omega-3 fatty acids in human metabolism in building cell membranes and receptor structures is unequivocally proved.

Besides these, fish meat is highly nutritious, tasty and several kinds of delicious products and dishes can be prepared form the meat of nearly 1000 fish species.

***Key words:** fish, meat quality, safety.*

1. Introduction

With more than 30,000 known species, fish form the biggest group in the animal kingdom that is used for the production of animal-based foods. Only about 1000 of these species are commercially fished and used for food production. Further, some 100 crustacean and 100 molluscan species (for example mussels, snails and cephalopods) are used as food for humans. Fish constitute a major part of animal protein consumption in many parts of the world. Fish is consumed as fresh fish or as frozen, salted, dried, smoked, or canned products.

Most fish and other marine species give rise to products of great economic importance in many countries. The demand for such products has been increasing steadily during the last century and shows no sign of lessening. At the beginning of this decade captures in fisheries have shown a regular production per year of approximately 90-95 million metric tonnes. Fish products are known to provide significant amounts of important dietary factors such as nutritional and digestive proteins including high levels of essential amino acids (lysine, methionine); lipid soluble vitamins (e.g. A and D); microelements (I, F, Ca, Cu, Zn, Fe and others) and highly unsaturated fatty acids. The lipid fraction has a special interest due to its high ω-3 polyunsaturated fatty acids (PUFA) content, which has shown positive role in preveneting certain human diseases.

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2. Basic characteristics of fish flesh

2.1 Structure and organoleptic properties

Compared to terrestrial animals construction of fish muscle is very simply (*Erple*, 2008). That consists of the large generally white to off-white colour lateral muscle located on the both sides of the body. However there are some coloured fish like salmonides (red colour fish). Muscles of these species are coloured due to decomposition of the carotenoids. Fish muscle differs from the higher vertebrates. Basically two forms can be differentiated: the anaerobic white muscle tissue and the aerobe red muscle tissue. All muscle tissues constitute about 60% of the fish body (*Houlihan et al.,* 1995). Both types can be differentiated by chemical composition, physiological importance and nutritional value. Most species have more light than dark muscle.

Fish muscle also differs from the other vertebrates that several species have hundreds of teeny bones and usually they are unloved by the consumers. These fishes can't really be filleted however they are often tasty.

Other important problem of fish meat quality are off-flavours (*Tucker*, 2000).). Off-flavour is the presence of objectionable tastes and/or odorous in food. Unfortunately farmed fish tainted by different flavours perceived as unacceptable by the consumers. The off-flavour in farmed fish either, of salt or freshwater origin, might be caused by feed ingredients or natural foods, post mortem oxidative rancidity or odorous compounds absorbed from the environment (*Whitfield*, 1999). However, muddy-musty taste and odour problems are caused mainly by two natural origin isoprenoid compounds, 2-methylisoborneol (MIB) and geosmin (GSM) synthesised in the pond water and sediment by different micro-organisms, like cyanobacteria and actinomycetes (*Tucker and Martin*, 1991). These two isoprenoids can be found mostly in the sediment of the natural water bodies or fish culture systems.

Description of off-flavours might difficult because several causes:

- there are many chemical compounds responsible for disagreeable flavours;
- the same compound can be described differently by different people;
- the same compound might cause different flavours in different species;
- several flavours may be produced by more then one chemical compounds;
- variation in the concentration of an odorant may cause changes in the flavour characteristic rather than in flavour intensity (*van der Ploeg*, 1991).

2.2 Nutritional composition

Fish represents a valuable source of proteins and other nutrients in the diet of many countries. As with many animal products, fish and fishery products contain water, proteins and other nitrogenous compounds, lipids, carbohydrates, minerals and vitamins. However, the chemical composition of fish varies greatly from one species and one individual fish to another depending on age, sex, environment and season. Proteins and lipids are the major components whereas carbohydrates are detected at very limited levels (less than 0.5 percent).

Depending on their lipid content, which varies greatly from 0.2 percent to 25 percent, fish are classified as lean, semi-fatty or fatty. Fish lipids differ greatly from mammalian lipids in that they include up to 40 percent of long-chain fatty acids of highly unsaturated containing five or six double bonds. This difference entails both health (anti-thrombotic activity of polyunsaturated fatty acids) and technological (rapid development of rancidity) implications. In human nutrition, fatty acids such as linoleic and linolenic acid are considered essential as they cannot be synthesised by the organism. In marine fish, these fatty acids constitute only around two percent of the total lipids - a small percentage compared with many vegetable oils. However, fish oils contain other „essential“ polyunsaturated fatty acids which act in the same way as linoleic and arachidonic acids. As members of the linolenic acid family (first double bond in the third position, n-3 counted from the terminal methyl group), they also have neurological benefits in growing children. One of these fatty acids, eicosapentaenoic (C20:5n-3), has attracted considerable attention since Danish scientists found a significant presence of it in the diet of a group of Greenland Eskimos, who proved virtually free from arteriosclerosis. Convincing evidence exists now for the significant role of fish and fish oils in decreasing the risk of developing cardiovascular diseases and in improving foetal brain development.

Proteins of fish comprise structural proteins (actin, myosin, tropomyosin and actomyosin), sarcoplasmic proteins (myoalbumin, globulin and enzymes) and connective tissue proteins (collagen). Fish proteins contain all the essential amino acids and, like milk, eggs and mammalian meat proteins, have a very high biological value. In addition, fish proteins are an excellent source of lysine, methionine and cysteine, and can significantly raise the value of cereal-based diets, which are poor in these essential amino acids.

Also, fish meat is generally a good source of the B vitamins and, in the case of fatty species, of A and D vitamins. Vitamins can be divided into two groups, those that are soluble in fat, such as vitamins A, D, E and K, and those that are soluble in water, such as vitamins B and C. All the vitamins necessary for good health in humans and domestic animals are present to some extent in fish, but the amounts vary widely from species to species, and throughout the year. Some freshwater species such as carp have high thiaminase activity so the thiamine content in these species is usually low.

As for minerals, fish meat is a particularly valuable source of calcium and phosphorus as well as iron, copper and selenium. Saltwater fish have a high content of iodine. In addition to essential amino acids and proteins, fish nutritional attributes relate to the quality of lipids and vitamin and mineral content (FAO, Fisheries and Aquaculture Department publications).

cumulation and bioconcentration of the odorous compounds in fish. For example accumulated off-flavour contents are correlated to tissue lipid content (crude fat % in the total body) of fish (*Tucker*, 2000). In nature off-flavours may develop within a matter of hours if the level of odorous metabolites in the water rises suddenly, for example during sudden die-off odour-producing algae (*van der Ploeg*, 1991). The rate of off-flavour removal is much slower than uptake. Purge of geosmin and 2-methylisoborneol in clean water are not expected to be presented less than about five days and elimination of these compounds are relatively slow from the lipid rich tissues (*Tucker and Martin*, 1991).

Uptake and depuration of MIB in experiments carried out by *Johnsen et al.* (1996) were increased by time interactions at increasing temperatures. Differences in rates uptake and elimination of off-flavours will differ among species in the same raring system (*Gy. Papp et al.*, 2007) and size of fish too (*Howgate*, 2004).

Table 1. Polyunsaturated fatty acids in the flesh of some of fish species found in Hungary (from *Csengeri*, 2008)
Tabela 1. Polunezasicene masne kiseline u mesu nekih vrsta riba u Mađarskoj (*Csengeri*, 2008)

species (*scientific name*)/ Vrste (naučni nazivi)	Body weight/ masa	Total fatty acids/ Ukupne masne kiseline	AA 20:4 (n-6)	EPA 20:5 (n-3)	Total (n-6)	Total (n-3)
	(g)	(%)	(g/kg)	(g/kg)	(g/kg)	(g/kg)
Asp (*Aspius aspius*)	210	3.38	1.32	1.58	5.5	7.5
Roach (*Rutilus rutilus*)	270	4.45	0.87	0.62	5.3	3.4
Common bream (*Abramis brama*)	639	3.18	1.43	1.07	5.7	4.0
Silver Carp (*Hypophthalmichthys molitrix*)	2780	3.51	1.70	2.37	4.9	10.2
Bighead carp (*Aristichthys nobilis*)	6 kg	16.4	3.66	6.56	14.5	29.6
Common carp (*Cyprinus carpio*)	577	7.84	1.00	0.56	10.4	3.7
Brown bullhead (*Ictalurus nebulosus*)	168	2.96	0.92	0.88	4.2	4.5
Pike (*Esox lucius*)	470	1.40	0.59	0.63	2.5	3.9
Perch (*Perca fluviatilis*)	287	1.47	0.61	0.57	2.2	3.4
Pike perch (*Sandra lucioperca*)	420	1.14	0.56	0.61	2.0	3.0

3. Possible environmental effects on fish flesh quality

3.1 Effects of natural originated odorous contaminants

Different effects of several properties like lipid contents of tissues, water temperature and feeding habits have been found responsible for the bioac-

3.2 Effects of contaminants originated from the industry (pesticides, medicines, cosmetics etc.)

The organic and inorganic compounds present in fish can be divided into three major groups:

Inorganic chemicals: arsenic, cadmium, lead, mercury, selenium, copper, zinc and iron.

Organic compounds: polychlorinated biphenyls (PCBs), dioxins and pesticides (e.g. chlorinated hydrocarbons).

Processing-related compounds: sulphites (used in shrimp processing), polyphosphates, nitrosamines and residues of drugs used in aquaculture (e.g. antibiotics or hormones).

Many of the inorganic chemicals are essential for life at low concentration but become toxic at high concentration. While minerals such as copper, selenium, iron and zinc are essential micronutrients for fish, other elements such as mercury, cadmium and lead show no known essential function in life and are toxic even at low concentrations when ingested over a long period. These elements are present in the aquatic environment as a result of natural phenomena such as marine volcanism and geological and geothermal events, but are also caused by anthropogenic pollution arising from intensive metallurgy and mining, waste disposal and incineration, and acidic rain caused by industrial pollution.

Increasing quantities of organic pollutants are released into the aquatic environment by humans due to industrial production, modern plant protection, more intensive use of medicines, cosmetics, household detergents etc. These compounds are present in the environment as persistent compounds because they might accumulate in different organisms through bioaccumulation and biomagnifications. In predatory fish species increasing amounts of chemicals may also be found in such way. Similarly, higher values could be present as a result of bioaccumulation, when chemicals in the body tissues accumulate over the life span of the individual. In this case, a large (i.e. older) fish will have a higher content of the chemical concerned than a small (younger) fish of the same species. The presence of chemical contaminants in fish is therefore highly dependent on geographic location, species and fish size, feeding patterns, solubility of chemicals and their persistence in the environment. (FAO Fisheries and Aquaculture Department publications)

The typical undesirables derived from marine feed ingredients are persistent organic pollutants (POPs), which are associated mainly with fish oil. In aquaculture the fat-soluble polychlorinated dioxins and furans (PCDD/F) and dioxin-like PCBs (DLPCB), commonly known as 'dioxins', are among one of the greatest challenges to food safety. Some studies has been found out that the dioxin uptake of the human population in different countries is over the WHO guided lowest value level (1-4 pg TEQ/ kg body weight/day). For example in Japan the dioxin uptake is estimated to be 3,22 pg TEQ/ kg body weight/day (*Tsutsumi et a*l., 2001) and about half of this quantity is taken from fish products. Nevertheless, the expected life time in this country is the longest over the world.

In the last decade in monitoring studies of aquatic environment around hundred of pharmaceuticals and their metabolites have been detected (*Jones et al*., 2002). The most dangerous environmental pollutants of the medicines are the antibiotics, which may contribute to the evolution of resistant pathogen bacteria infections. During the last decades tetracycline were the most important antibacterial agents used in fish farming, widely used for treatment of systemic bacterial infections. Antibiotics are permitted for treatment of fish under the responsibility of a veterinarian even in organic fish farming (e.g. EEC 2004; IFOAM, 2000; NATURLAND, 2000; BIOKONTROLL, 2001). In spite of that, several studies have shown that oxytetracycline (OTC) persist for a long time in fish tissues and long withdrawal times are necessary, moreover the OTC residues have immunosuppressive effects and cause liver damage.

3.3 Storage effects on the quality of fish flesh

Estimated results are shown that between 10 and 50 % of all produced foods have to be rejected due to post-harvest or post-slaughter spoilage (*Lunestad* 2008). Storage might cause flesh quality reduction, diseases or off-flavours as results of microbial growth and oxidation effect to the degradation of the fish tissues.

After death of the fish, a series of biochemical reactions starts, which is of paramount importance for the quality and shelf life of the products. These reactions depend on several different factors: the type of fish species, physiological condition of the fish, as well as environmental influences (water temperature, salinity). In addition, catching and harvesting methods, killing procedures have a great effect on the biochemical relations related to disintegration of the fish fillet (*Oehlenschlager and Rehbein*, 2009).

As it is well known, degradation of fish starts with enzymatic and chemical reactions of autolysis. Freezing of fish fillet directly after catch, more or less, stop most of the enzymatic reactions, depending on the temperature of the frozen fish. However, during later thawing chilled storage or further processing of the fish all biochemical reactions continue and may result in quality losses. Directly after catch, de muscle tissue of healthy fish is free from bacteria, but not he gills, skin and intestines. The bacteria penetrate into the fillet during the storage and processing, accompanied by changes in the composition of the bacterial flora. Gram-negative psychotropic rods (*Shewanella* spp., *Pseudomonas* spp., *Vibrio* spp., *Aeromonas* spp.) are important spoilage bacteria. Bacteria are also responsible for formation of the biogenic amines from precursor amino acids in spoiling fish decarboxylation. Histamine is produced from histidine, cadaverine from lysine, putrescine from ornithine, tryptamine from tryptophane, tyramine from tyrosine and agmatine from arginine (*Lehane and Olley,* 2000; *Shalaby*, 1996).

The degradation level should be characterized by determining the total volatile basic nitrogen (TVBN) content, which is in strong relations with spoilage of fish. For example short chain alcohols, carbonyls and esters, trimethylamine, hydrogen sulphide, methylmercaptan, dimethyl disulfide and dimethyltrisulfide are among the most volatile compounds being produced in degrading tissues and might caused spoilage odours in fish fillets and fish products (Olafsdottir et al., 2004). In the Codex Alimentarius Hungaricus (art.3-1-95/194) could be found MRL levels for TVBN in marine fish between 25-35 mg/100g, but around 50 mg/100 g should be acceptable. For the freshwater fish species 12 mg TVBN/100g was determined by Lengyel et al, 2000.

Fish lipids are not stable during storage at any temperature. Lipolysis and lipid oxidation may occur in chilled or frozen fish, leading to unpleasant flavours and tastes caused by carbonyl compounds and short-chain carbonic acids. Binding of free fatty acids to fish muscle proteins may results in texture deterioration Speed and extent of lipolysis and of oxidation of unsaturated fatty acids are higher in dark muscle than in white muscle. During frozen storage, lipid degradation is not completely stopped, but continues at lower rate, leading to increased concentrations of free fatty acids, which can be used as quality indicators.

4. Demonstration of some studies on fish meat quality in the HAKI

4.1 Fish meat quality and the microelements

Bioaccumulation of certain heavy metals along the food chain is a well-recognized process. Essentiality and toxicity of trace metals in organisms depend on the concentration of the metal; below a certain level they could be considered as essential for biochemical processes, but in the case of a high accumulation in organisms, intoxication may occur. Freshwater fishes can regulate the levels of essential elements: copper, chromium, molybdenum, and zinc over a range of ambient concentrations, and some regulation of nonessential metals such as cadmium and mercury may also occur. Some of our results demonstrated that differences in micro and macroelement concentrations exist among fish collected from different areas, depending on the feeding, water quality and geographical properties of the area. Our investigation also revealed that trace metal levels in fish depend also on age, body size of the fish, feeding habits, season and temperature of the water, and other factors that influence the metabolic rate of fish (*Sandor et. al,* 2001; *Sandor et al.*, 2000; *Zubcova et al.,* 2001). This work was partially supported by the European Union EU FP5 INCO-COPERNICUS project.

4.2 Studies on xenobiotics and toxic metals in fish meat

In the EU FP6 framework (FOOD –CT-2006-16249 Project Aquamax) our institute had evaluated some fish meat quality determinations to assess the transfer of toxicants and xenobiotics from feed to consumable fish meat. Concentration levels of heavy metals and organochlorine pesticide compounds in fish samples from organic farming fish ponds and transition ponds to organic technology were examined in these monitoring assays.

Toxic metals and food safety of fish meat

The sampled fish species were: Common carp, Gibel carp, Black bullhead, Perch, Pike-perch and Pike, that showed low levels of toxic elements in the bony meat portions. Comparison concentrations of toxic elements, Cr, Cd, Ni, Pb (d.m.) in fish samples from different ponds we have found that fish from organic pond showed somewhat lower levels than those from the transition one (*Hegedűs et. al,* 2009, *Oncsik et al.,* 2009). Levels of toxic elements determined in these samples were lower in the fillet of Common carp than in eviscerated whole fish. We have compared the predator fish heavy metal content with some of bottom feeders, where differences could be observed. The sampled predator fish were young specimens and showed low levels of contamination with elements. In conclusion, levels of cadmium and lead measured in this monitoring study were well below to the maximum levels as defined by the COMMISSION REGULATION (EC) No 1881/2006.

Organochlorine contaminants in fish meat and food safety

In the fish meat samples mentioned above some hexachloro-cyclohexane (BBHC – β-HCH and Lindane - γ-HCH), aldrin, low levels DDT residues, endosulfan and endrin-ketone were observed (*Fazekas et al,* 2009). In samples from transition pond both HCH compounds (BBHC and Lindane) were present. Also the measurements revealed that fatty fish meat (Common carp and Gibel carp) contain generally higher levels of pesticide residues. Finally we conclude that the levels were lower than those defined as maximum residue limits (MRL) for pork meat in the Commission Regulation (EC) No 149/2008. (No MRLs were found for fish in the regulations.)

Antibiotic residue levels in Common carp samples after drug administration

Antibiotics are permitted for treatment of fish under the responsibility of a veterinarian even in organic fish farming (e.g. EEC 2004; IFOAM, 2000; NATURLAND, 2000; BIOKONTROLL, 2001). In connection to the possible emergency use of veterinary drugs laboratory studies were planned in the EU FP7 framework mentioned above to determine the residue depletion of selected antibiotics: Oxytetracycline (OTC) and Flumequine (FLU). Results in the feeding experiments with OTC medicated feed showed a continuous accumulation of OTC level in muscle skin during the treatment period and a very long elimination period. The calculated withdrawal period for maximum residue limit (MRL for quantity at the muscle in EU COUNCIL REGULATION (EEC) No 2377/90) was much longer than the prescribed one in Directive 2004/28/EC. According to our results, this 500 degree-days withdrawal time would not be sufficient enough for decreasing the OTC concentration to the allowed residue level (MRL) at temperature of around 20°C. This is in correspondance with the results reported by *Zhang and Li*, (2007) for grass carp in OTC feeding examinations. The elimination half-lives measured in muscle and liver after oral administration of OTC in common carp are also longer than values of other fish species reared nearly in the same conditions. After some months of the treatments residues of OTC can be detected in liver of common carp and also active OTC molecules in the muscle with skin. According to these observations, we did not recommended administration of OTC treatment for food fish in the Hungarian common carp farming (*Sándor et al.,* 2010), because our investigations confirm the accumulation of OTC and its metabolites in drug-treated animals.

Results of the feeding experiments with flumequine medication present shorter withdrawal periods for muscle with skin and liver than values found in the literature for other fish species, sometimes at similar conditions. Total depletion of FLU could not be detected, but the remaining concentrations are under maximum residue level recommended by the EU regulation (EEC No. 2377/90). In conclusion, our experimental data for flumequine administration in feed of fish suggest that FLU might be used safely in common carp farming.

4.3 Studies on off-flavours in different fish species farmed in Hungary

Accumulation of MIB and geosmin in tissues of five important fish species was studied in the flesh of herbivorous grass carp (*Ctenopharyngodon idella*), the bottom feeding omnivorous common carp (*Cyprinus carpio*), the plankton feeding silver carp (*Hypophthalmichthys molitrix*), the omnivorous tilapia (*Oreochromis niloticus*), and the carnivorous African catfish (*Clarias gariepinus*), (*Gy. Papp et al.,* 2007). Fish were collected from four different experimental aquatic ecosystems of our institute, including a traditional fishpond, and different pilot-scale experimental aquaculture systems like a pond recycling system, effluent-fed fishponds and a combined aquaculture-algae (CAA) system, during 2002-2005. MIB and GSM contents were analysed with an improved GC-MS method of *Zhu et al.* (1999).

According to our published results negligible MIB contents were found in the fish fillets from all of the studied aquatic ecosystems. However geosmin was detected in various concentrations, from trace levels to tens of micrograms per kg in the fillet of analysed fish species during the study period. Off-flavour caused mainly by geosmin and it was always lower in fillets of carnivorous African catfish (*Clarias gariepinus*) and herbivorous grass carp (*Ctenopharyngodon idella*) than in species with other feeding habits in the same aquatic system. GSM concentration was significantly higher in the fillet of carp reared in traditional fish pond than that of fish from the other studied systems. Geosmin concentrations were usually higher in the fillet of bottom feeding omnivorous carp than those we found in the all studied species with other feeding habits in the same aquatic ecosystem at the same day of sampling. Overall, geosmin tainting of fish fillets showed a general relationship with the feeding habits of these species.

5. Benefits and hazards of fish consumption

Fish meat is well suitable for human nutrition because it contains easy digestible proteins and vitamins and minerals.

Among the benefits of fish meat consumption the polyunsaturated omega-3 fatty acid contents can be mentioned again. The role of the omega-3 fatty acids in human metabolism in building cell membranes and receptor structures is unequivocally proved. Function of these fatty acids in vision, in reproduction, in pre-natal and post-natal development of human brain is also well documented (*Lauritzen et al.*, 2001; *Curtis et al.,* 2004; *SanGiovanni and Chew*, 2005).

Besides these, fish meat is highly nutritious and tasty. Several kinds of delicious products and dishes can be prepared form the meat of nearly 1000 fish species.

Contamination, generally, has a negative impact on the quality of food and may imply a risk to human health. Several studies have concluded that levels of different inorganic and organic chemicals in fish intended for human consumption are low and probably below levels likely to affect human health. Nevertheless, they can be of potential concern for populations for whom fish constitutes a major part of the diet and for pregnant and nursing women and young children who consume substantial quantities of oily fish.

The EU has taken measures to minimize contaminants in foodstuffs. Community measures have been taken for the following contaminants of relevance to fish and seafood: metals (cadmium, lead, mercury, inorganic tin), dioxins and PCBs and polycyclic aromatic hydrocarbons (PAH). For heavy metals: (cadmium, lead and mercury), maximum levels have been established by Commission Regulation 466/2001/EC of 8 March 2001, setting maximum residues levels for certain contaminants in foodstuffs. For dioxins and PCB there is separate legislation for food and feed. In the case of food, maximum limit values were set in Council Regulation (EC) No 2375/2001 of 29 November 2001. In the case of feed, maximum limit values were set in Council Directive 2001/102/EC13. The EU regulation (EEC No. 2377/90) limits the drug residues in all animal species which are used for food production. The European Food Safety Authority has published an opinion on the health risks related to the consumption of wild and farmed fish on 22 June 2005 with reference to these contaminants. This provides advice on the safety and nutritional contribution of wild and farmed fish. (See: http://www.efsa.europa.eu/en/science/contam/contam_opinions/1007.html

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Kvalitet i bezbednost ribe

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R e z i m e: Riba u mnogim zemljama predstavlja značajan izvor životinjskih proteina. Konzumira se kao sveža riba ili zamrznuta, soljena, dimljena ili kao konzerva.

Riba predstavlja važan izvor proteina životinjskog porekla, kao i mnogih drugih hranljivih materija, u mnogim zemljama. Kao i sa mnogim proizvodima životinjskog porekla, riba i proizvodi od ribe sadrže vodu, proteine i druga azotna jedinjenja, lipide, ugljene hidrate, minerale i vitamine. Međutim, hemijski sastav ribe varira u velikoj meri zavisno od vrste, kao i pojedinačnih riba, i takođe zavisi od starosti, pola, sredine i sezone. Proteini i lipidi su glavne komponente, dok su ugljeni hidrati otkriveni u veoma ograničenom sadržaju (manje od 0,5 procenata).

Meso ribe je pogodno za ishranu ljudi, jer sadrži lako svarljive proteine, vitamine i minerale. Prednost konzumiranja mesa ribe je i u sadržaju polinezasićenih omega-3 masnih kiselina. Uloga omega-3 masnih kiselina u ljudskom metabolizmu, u izgradnji ćelijskih membrana i strukturi receptora, je neopozivo dokazana.

Različiti uticaji nekoliko odlika kao što su sadržaj lipida u tkivima, temperatura vode i navike u ishrani se smatraju odgovornim za bioakumulaciju i biokoncentraciju mnogih jedinjenja u ribljem mesu. Količine organskih zagađivača koje ljudi kroz industrijsku proizvodnju, modernu biljnu proizvodnju, intenzivnije korišćenje lekova, kozmetičkih sredstava, deterdženata u domaćinstvu, i sl., ispuštaju u vodenu sredinu, su u stalnom porastu. Ova jedinjenja su prisutna u životnoj sredini *kao postojana jedinjenja, jer se mogu akumulirati u različitim organizmima kroz biološku akumulaciju i biološko uvećavanje. Bioakumulacija određenih teških metala duž lanca ishrane je dobro poznat proces. Bitnost i toksičnost metala u tragovima u organizmu zavise od koncentracije metal. Ispod određenog nivoa, mogu se smatrati bitnim/ključnim za biohemijske procese, ali u slučaju visoke akumulacije u organizmu, može doći do intoksikacije.*

Pored toga, meso ribe je izrazito hranljivo, ukusno i nekoliko različitih vrsta ukusnih proizvoda i jela se mogu pripremati of mesa koje potiče od skoro 1000 vrsta riba.

Ključne reči: *riba, kvalitet mesa ribe, bezbednost.*

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