EVALUATING THE HEALTH RISKS ASSOCIATED WITH CONSUMING OF CULTIVATED / WILD MUSSELS FROM BOKA KOTORSKA BAY

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PROCENA ZDRAVSTVENOG RIZIKA POVEZANOG SA KONZUMIRANJEM GAJENIH / DIVLJIH DAGNJI IZ BOKOKOTORSKOG ZALIVA

Apstrakt

Dagnje su veoma važne za ljudsku ishranu, jer predstavljaju jeftin izvor proteina, koji čine oko 60% suve mase mekog tkiva *Mytilus galloprovincialis*. Njihovim konzumiranjem omogućen je kako jeftin izvor proteina visoke biološke vrednosti, tako i minerala i vitamina. Sa aspekta hranljivosti, dagnja je važan izvor hrane bogat bitnim elementima (Ca i Fe), kao i određenim vitaminima (B1, B2 i B3). Međutim za dagnje je poznato da poseduju veliki kapacitet akumulacije zagađujućih materija pre svega esecijalnih i neesencijalnih elemenata čiji nedostatak, kao i višak može izazvati ozbiljne zdravstvene probleme kod čoveka.

Potrošnja ribe i morskih proizvoda u evropskim zemljama, Francuska (29,7 kg po glavi stanovnika godišnje), Nemačka (12,2), Grčka (22,7), Italija (23,1), Portugal (57,4), Norveška (50), Poljska (9,6), je i dalje niska. Kako ne postoje precizni podaci o prosečnoj potrošnji školjki po glavi stanovnika za većinu zemalja, pa ni za Crnu Goru, dozvoljeni nedeljni unos (*PTWI*) se koristi za izračunavanje koncentracije elemenata koje čovek može uneti u organizam bez posledica po svoje zdravlje.

Dagnja *M. galloprovincialis* široko je rasprostranjena u priobalnim vodama Bokokotorskog zaliva. Uzgaja se na preko 16 farmi stacioniranih unutar zaliva, ali se duž cele obale zaliva takođe mogu naći i divlje dagnje koje lokalno stanovništvo koristi za ličnu potrošnju. Kako je celokupan zaliv konstantno i sve više izložen negativnom antropogenom uticaju, nameće se potreba za redovnom kontrolom živih organizama iz mora koji se koriste u ishrani čoveka.

Cilj ovoga rada bio je da se odredi kvalitet dagnje *Mytilus galloprovincialis,* odnosno da se proceni eventualni zdravstveni rizik putem konzumiranja ove morske vrste (kultivisane/divlje) sa više lokacija Bokokotorskog zaliva. U svim uzorcima školjki određivane su koncentracije gvožđa, cinka, mangana i bakra.

Izmerene koncentracije cinka i bakra u kultivisanim/gajenim dagnjama Bokokotorskog zaliva ispod su vrednosti propisanih regulativom o hrani Crne Gore. Najveće koncentracije cinka i bakra izmerene su u uzorcima divljih dagnji sa lokacije Herceg Novi, dok je najveća koncentracija gvožđa izmerena u kultivisanim dagnjama sa lokacija Kukuljina i Krašići, a najveća koncentracija mangana u kultivisanim uzorcima sa lokacije Bijela.

Na osnovu minimalnih i maksimalnih izmerenih koncentracija gvožđa, cinka, mangana i bakra u uzorcima divljih/kultivisanih dagnji i podataka za maksimalno dozvoljeni unos ispitivanih elemenata (*PTWI*) izračunat je dozvoljeni interval nedeljnog konzumiranja dagnji u kilogramima bez posledica po ljudsko zdravlje za svaki pojedinačno ispitivani element. Nedeljna količina dagnji koju je neophodno konzumirati kako bi se dostigla propisana *PTWI* vrednost varira: za Fe 11.5 – 14.8 kg i 4.8 – 21.2 kg, za Mn 12.4 – 18.8 kg i 13.4 – 26.4 kg, za Cu 147.0 – 243.0 kg i 198.0 – 233.0 kg, i za Zn 7.1 – 21.7 kg i 14.2 – 17.6 kg za divlje i uzgajene dagnje, respektivno.

Na osnovi dobijenih podataka jasno je da se radi o velikim količinama dagnji koje treba konzumirati kako bi se dostigle granične vrednosti *PTWI*a. Ovo ukazuje da divlje/kultivisane dagnje iz Bokokotorskog zaliva, u odnosu na sadržaj Fe, Zn, Mn i Cu u njima, ne predstavljaju opasnost po zdravlje ljudi i bezbedne su za ljudsku upotrebu.

Ključne reči: dagnja, cink, gvožđe, bakar, mangan, PTWI, Bokokotorski zaliv
Keywords: mussel, zinc, iron, manganese, copper, PTWI, Boka Kotorska bay

INTRODUCTION

Aquaculture is the fastest-growing animal-food-producing sector of agriculture that includes the cultivation of aquatic organisms (FAO, 2010). Increasingly *Mytilus galloprovincialis* is used as a cultivated mussel species (Stankovic et al., 2012). This mussel is a native species of the Mediterranean Sea, the Black Sea and the Adriatic Sea (Gosling, 1992).

Montenegro is a Mediterranean country located in southeastern Europe on the Adriatic coast. In Boka Kotorska bay the harvesting and cultivation of marine organisms from the Adriatic Sea dates back centuries. Today, mussel *M. galloprovincialis* is cultivated on around 16 small farms located inside the Bay and each farm producing around 10 to 50 t of mussels per year (FAO, 2007). In addition to cultivated mussels, wild mussels are widespread throughout the Boka Kotorska bay, which are hand-collected for personal consumption.

Mussel *M. galloprovincialis* is a sedentary, filter feeding animal that through feeding, not only assimilates the food necessary for growth and development, but also accumulates contaminants present in the water. Trace elements have the ability to bioconcentrate in mussels directly from the water, bioaccumulate and biomagnify in the food chain, causing higher trophic organisms to become contaminated with high concentrations of chemical contaminants (Suseno et al., 2010). Some trace elements, such as Fe, Zn, Cu and Mn, are essential for humans and need to be consumed in adequate amounts, but in excessive amounts they can be toxic (Nasreddine et al., 2010).

As the Boka Kotorska bay receives a heavy influx of sewage and industrial effluents, as well as domestic and agricultural wastes, (Jovic et al., 2011) the determination of the levels of trace metals in mussels is very important. Also in order to ensure the safe consumption of mussels, it is essential that measures are taken to reduce the risk to consumers. Hence, the aims of this study were to determine the levels of Fe, Zn, Mn and Cu in the soft tissue of wild and cultivated mussels *M. galloprovincialis* from Boka Kotorska

bay in order to provide information on the amount of cultivated and wild mussels from the Bay that can be safely consumed.

MATERIALS AND METHODS

Fresh wild and cultivated mussels (*M. galloprovincialis*) were sampled from ten different locations in Boka Kotorska bay: Herceg Novi, Bijela, Ljuta, Perast, Sv. Stasija, Kotor, Opatovo, Tivat, Kukuljina and Krasici. At the each site, whether wild or cultivated mussels, more than 2 kg of mussels of similar length were collected, placed in plastic bags with sea water and transported to the laboratory. The 25-30 mussels from each station were pooled. Mussels were cleaned and rinsed with deionized water, dissected fresh and the soft tissue was rinsed with Milli Q water. Pooled samples were measured before and after freeze drying - lyophilization to determine the water content, pulverized and homogenized using a mill.

About 0.5 g of the mussel samples were digested with 7 ml of HNO_3 (65%), 2 ml of H_2O_2 (30%) in a microwave digestion system for 30 min and diluted to 25 ml with deionized water. A blank digest was performed in the same way. The concentrations of zinc, iron, manganese and copper in the samples of mussels were determined using a Flame Atomic Absorption Spectrometer (PerkinElmer, AAnalyst 200) with an air–acetylene flame.

The accuracy of the applied analytical procedure for the determination of trace elements in mussels was tested using SRM 2976 (Mussel homogenate; NIST) certified reference material.

RESULTS AND DISCUSSION

In the present study iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) were analyzed in wild and cultivated mussels from Boka Kotorska bay. The mean concentrations of the investigated elements in the soft tissues of *M. galloprovincialis* from ten sites are given in Table 1.

Table 1. Concentration of Fe, Zn, Mn and Cu (mean ± SD, mg kg^{-1} wet weight) in the soft tissues of mussels from Boka Kotorska bay

Location	Sample Nature	Water (%)	Fe	Zn	Mn	Cu
Herceg Novi	Wild	77.8	34.0±1.64	69.0±3.50	1,12±0.10	1.67±0.15
Bijela	Cultivated	78.2	22.2±1.67	34.5±1.50	2,01±0.17	1.05±0.05
Perast	Wild	86.6	26.5±1.58	22.6±0.13	1,43±0.05	1.61±0.07
Ljuta	Cultivated	81.0	18.5±1.12	29.2±1.04	1,44±0.21	1.24±0.04
Sv. Stasija	Wild	74.7	31.8±1.97	37.4±1.49	1,47±0.11	1.27±0.13
Kotor	Wild	76.8	27.8±1.58	27.4±2.87	1,49±0.13	1.16±0.06
Opatovo	Wild	80.3	29.6±1.39	28.0±0.89	1,24±0.18	0.99±0.08
Tivat	Wild	79.4	27.8±1.89	57.4±3.39	2,18±0.11	1.55±0.09
Kukuljina	Cultivated	81.7	82.4±2.21	27.9±0.50	1,02±0.03	1.19±0.07
Krasici	Cultivated	79.6	38.6±1.59	33.1±2.40	1,51±0.14	1.12±0.10

In comparison with the permissible limits set by the Montenegrin Food Regulation (Montenegrin Food Regulation, 2002) for Cu (30.0 mg kg^{-1} ww) and Zn (100 mg kg^{-1} ww), all concentrations (mg kg^{-1} ww) of these metals from all locations were lower

than the limits. The highest iron concentrations were measured in the cultivated mussel samples from locations Kukuljina and Krasici (82.4 and 38.6 mg kg^{-1} ww, respectively). In the case of zinc and copper, the highest concentrations were measured in wild mussel samples from locations Herceg Novi and Tivat, and Herceg Novi, Tivat and Perast, respectively, Table 1. Locations Tivat (wild mussels) and Bijela (cultivated mussels) are extracted as the locations where measured the highest concentrations of manganese, 2.18 and 2.01 mg kg^{-1} ww, respectively.

Based on the minimum and maximum concentration (Table 1) and the data for the maximum allowable intake of analyzed elements, we calculate the allowed interval of weekly mussel consumption in kg, required to exceed the FAO/WHO provisional tolerable weekly intakes (*PTWI*), Table 2. The *PTWI* defines the amount of a substance that can be ingested every week throughout a person's life with no risk of negative health effects and was established by the Joint FAO/WHO Expert Committee on Food Additives (FAO/WHO, 2004).

Table 2. The amount of wild and cultivated *M. galloprovincialis* that would need to be consumed by a 70-kg adult (per week) to exceed the FAO/WHO limits

Sample Nature	Element	Concentration (mg kg^{-1} w.w.)	Amount of mussels per week required to exceed the limit (kg)
		Minimum and maximum for any one site	Interval based on the minimum and maximum
Wild	Fe	26,50 – 34,00	11,5 – 14,8
	Mn	1,43 – 2,18	12,4 – 18,8
	Cu	1,01 – 1,67	147,0 – 243,0
	Zn	22,60 – 69,00	7,1 – 21,7
Cultivated	Fe	18,50 – 82,40	4,8 – 21,2
	Mn	1,02 – 2,01	13,4 – 26,4
	Cu	1,05 – 1,24	198,0 – 233,0
	Zn	27,90 – 34,50	14,2 – 17,6

Based on the maximum and minimum Zn levels in the investigated mussels, the amount of mussels per week required to exceed the $PTWI_{Zn}$ value (7 mg/kg body weight/week) (FAO/WHO, 2007) varied from 7.1 to 21.7 kg for wild and from 14.2 to 17.6 kg for cultivated mussels. The amount of mussels consumed per week required to exceed the estimated $PTWI_{Fe}$ (5.6 mg/kg body weight/week) (FAO/WHO, 2007) varies between 11.5–14.8 kg and 4.8–21.2 kg for wild and cultivated mussels, respectively. The amount of consumed mussel per week required to exceed the $PTWI_{Cu}$ (3.5 mg/kg body weight/week) (FAO/WHO, 2007) and $PTWI_{Mn}$ (0,385 mg/kg body weight/week) (FAO/WHO, 2004) varies from 147 to 247 kg for wild and from 198 to 233 kg for cultivated mussels, and from 12.4 to 18.8 kg for wild and from 13.4 to 26.4 kg for cultivated mussels, respectively.

Calculations based on the element concentrations present in mussels collected from the Boka Kotorska bay suggest that a large amount of mussels would need to be consumed to exceed the prescribed *PTWI* values. It can be said that both wild and cultivated mussels from the Boka Kotorska bay are safe for human consumption regarding the Zn, Fe, Mn and Cu concentrations.

CONCLUSION

In terms of prescribed *PTWI* values for the tested elements (Fe, Zn, Mn and Cu), there is no limiting factor/element in the consumption of mussels from the Bay. Concentrations found for Fe, Zn, Mn and Cu indicate that the investigated mussels from Boka Kotorska bay pose no health risk to seafood consumers.

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