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Poly-chlorinated biphenyls (PCB) in European sea bass from different rearing systems

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ABSTRACT: The chemical composition and the level of seven indicator congeners of PCB (BZ/IUPAC no. 28, 52, 101, 118, 138, 153, and 180) were determined in 133 specimens of farm-raised European sea bass (*Dicentrarchus labrax*). The fish were caught from different aquaculture rearing systems: extensive fish valley, semi-intensive ponds, sea-cages, and intensive concrete tanks. Fresh fillet chemical composition differed among the rearing systems (fat: 2.9, 7.5, 7.1, and 9.4%; $P < 0.001$). Total concentrations of indicator congeners were below the EU limit (200ng/g fat) for meat, poultry and eggs, being the lowest in extensively-reared sea bass (75ng/g fat), intermediate in sea bass from semi-intensive ponds (119) and sea cages (116), and the highest in intensively-reared fish (133) ($P < 0.001$). Similarly, PCB concentrations in fresh fillets were 2,438, 10,116, 8,491, and 12,952pg/g in the four systems ($P < 0.001$). The congener 153 was the most represented in all rearing systems. TEQ concentrations for the dioxin-like congener no. 118 were 50 to 200 times lower than the maximum admitted value. Total concentration of indicator congeners of PCB was poorly correlated with fish slaughter weight ($R^2 = 0.17$), while highly correlated with fat concentration of fish ($R^2 = 0.75$).

Key words: European sea bass, Poly-chlorinated biphenyls (PCB), Rearing system.

INTRODUCTION – Poly-chlorinated biphenyls (PCB), largely included in many industrial products and equipment, have a very long degradation time and, because of their high solubility in lipids, tend to accumulate and be magnified in the food chain, especially in aquatic environments (Bayarri *et al.*, 2001; Bordajandi *et al.*, 2006). Due to their bio-accumulation and recognized toxicity, EU legislation have limited PCB utilization and have forbidden their production after 2010 (Directive 96/59/CE). Depending on the number and position of chlorine atoms along the two phenyl rings, 209 congeners of PCB exist, but 15-20 congeners are more abundant in the pollutants, and seven of them are considered indicators of overall PCB contamination. Moreover, twelve PCB congeners, called “dioxin-like” because of their molecular conformation, are considered highly dangerous for human health for their potential carcinogenic effects and for a number of other serious non-cancer effects. Our study aimed to evaluate the PCB contamination level and the correlation with fish weight and body composition in European sea bass from different Italian rearing systems.

MATERIAL AND METHODS – One hundred thirty-three European sea bass (*Dicentrarchus labrax*) were caught from four aquaculture farms with different rearing systems: extensive system, a polycultured fish valley in the Venice lagoon (25 fish), semi-intensive ponds in the Marano (Udine) lagoon (28 fish), sea-cages in the Gulf of Trieste (34 fish), and intensive concrete tanks in the Orbetello (Grosseto) lagoon (46 fish). The fish were slaughtered by immersion in ice-slurry and fillets (without skin) were separated, minced and freeze-dried. Moisture, proximate composition, and gross energy concentration were determined by AOAC methods. Further information on rearing farms, sampling, and analytical methods are reported by Xiccato *et al.* (2004). Indicator PCB congeners no. 28, 52, 101, 118, 138, 153, and 180 (BZ/IUPAC numeration) were determined. For this purpose, lipids extracted from freeze-dried fillets were treated with sulphuric acid, then submitted to a solid phase extraction and gas chromatography/mass spectroscopy according to the EPA method 1668 rev. A. Data of chemical composition and PCB concentration were subjected to ANOVA using GLM procedures of SAS (1991), considering rearing system as a main factor and fish weight as a linear covariate.

RESULTS AND CONCLUSIONS – Chemical composition of sea bass fillets varied according to the rearing system ($P < 0.001$) (Table 1). Moisture was higher and ether extract and gross energy concentration lower in fish from the extensive system compared to those from intensive concrete tanks; intermediate values were found in fillets from semi-intensive ponds and sea-cages. Chemical differences likely depended on the feeding regime as described also by Alasalvar *et al.* (2002) and as discussed in a previous study (Xiccato *et al.*, 2004).

Table 1. Chemical composition of sea bass fillets.

	Rearing system				Prob.	RSD
	Extensive	Semi-intensive	Sea-cages	Intensive		
Moisture, %	75.9 ^c	70.9 ^b	70.4 ^b	68.0 ^a	<0.001	2.0
Crude protein ¹ , %	19.9 ^{ab}	19.6 ^a	20.0 ^{ab}	20.3 ^b	<0.001	0.8
Ether extract ² , %	2.9 ^a	7.5 ^b	7.1 ^b	9.4 ^c	<0.001	2.2
Gross energy ² , MJ/kg	5.77 ^a	7.82 ^b	7.92 ^b	8.82 ^c	<0.001	0.76

Total concentration of indicator congeners (expressed on fat) was lower in extensively-reared sea bass (75ng/g fat) than in intensively-reared fish (133), and intermediate in sea bass from semi-intensive ponds (119) and sea-cages (116) ($P < 0.001$, data not reported in table). A similar figure was observed also for values based on fresh fillet weight: total PCB concentration varied from 2,438pg/g in fish of the extensive system to 12,952pg/g in fish of the intensive system ($P < 0.001$) (Table 2). The congener no. 153 reached the highest concentration in all rearing systems, as found in other studies (Bayarri *et al.*, 2001, Antunes and Gil, 2004; Gil and Antunes, 2004; Storelli *et al.*, 2006). Low levels of congener no. 118, a dioxin-like PCB, were found in all groups, with the lowest value in fish from the extensive system.

Table 2. Concentration of seven PCB indicators (pg/g fresh fillet).

	Rearing system				Prob.	RSD
	Extensive	Semi-intensive	Sea-cages	Intensive		
Congener no. 28	41 ^a	173 ^{bc}	91 ^b	232 ^c	<0.001	205
Congener no. 52	74 ^a	324 ^b	336 ^b	404 ^b	<0.01	328
Congener no. 101	163 ^a	813 ^b	708 ^b	1,029 ^c	<0.001	522
Congener no. 118	107 ^a	507 ^b	333 ^b	588 ^b	<0.001	318
Congener no. 138	515 ^a	1,969 ^{bc}	1,661 ^b	2,501 ^c	<0.001	898
Congener no. 153	851 ^a	3,595 ^{bc}	2,977 ^b	4,865 ^c	<0.001	1,694
Congener no.180	687 ^a	2,735 ^{bc}	2,385 ^b	3,333 ^c	<0.001	1,374
Total indicator PCB	2,438 ^a	10,116 ^{bc}	8,491 ^b	12,952 ^c	<0.001	4,525

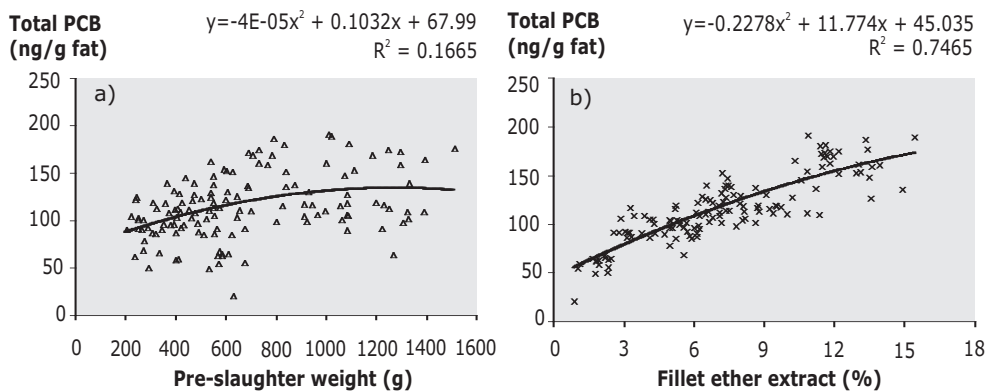
Differences in the feeding regime of fish likely accounted for our results as reported also by other authors (Antunes and Gil, 2004; Gil and Antunes, 2004): PCB appeared less abundant in the food chain of the natural aquatic system, as in extensive fish valley, than in the artificial food chains used in the other three rearing systems. In any case, the PCB contamination levels we observed were lower than those measured in a study of fishes caught in the North Adriatic sea (Bayarri *et al.*, 2001). This latter study also showed a high variability in PCB contamination level (200 to 81,000pg/g of fresh product) likely depending both on the distance from pollutant industries and the body fat level in the different species. A high variability was also found by Bordajandi *et al.* (2006) who observed that different species of fish captured along the South-west Spanish coast presented PCB levels (sum of 22 congeners) from 861 to 23,787pg/g fresh product.

The concentrations of the seven indicator congeners as detected in our study (75 to 133ng/g fat) were below the limit (200ng/g fat) set by EU for meat, eggs, poultry and derived products for human consumption (Decision 1999/788/CE). Whereas no limit has been set for fishery and aquaculture products for total PCB or the seven indi-

cators, the Directive 2006/13/CE set the maximum level of dioxin-like PCB at 2.5pg PCB-TEQ/g fresh fish. TEQ (toxic equivalency quantity) is obtained as the sum of the product of the concentration of each of the 12 dioxin-like PCB congeners by their specific toxicity coefficient. In our study, TEQ concentrations for the congener no. 118 were 0.011, 0.051, 0.059, and 0.033pg/g of fresh product for the four rearing systems, which is 50 to 200 times lower the maximum admitted value.

A regression equation to predict the concentration of the seven indicator congeners (total PCB) based on fish slaughter weight showed a low coefficient of determination ($R^2=0.17$) (Figure 1a). To the contrary, total PCB concentration was highly correlated with the fat content of fish ($R^2=0.75$) (Figure 1b).

Figure 1. Relationship between fish slaughter weight (a) or fillet ether extract (b) and total PCB.



In conclusion, significant differences in PCB contamination were recorded depending on the rearing system, with the lowest concentrations in sea bass from the extensive fish valley and the highest ones in artificially-fed fish. In all systems, however, PCB contamination was largely below the admitted limits for human consumption and the values detected in areas exposed to industrial development.

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