

Risk Assessment of Chemicals in Food of Animal Origin: Studies in Market Basket of the Canary Islands, Spain

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Abstract

Risk analysis represents the most useful scientific approach for making food safety decisions. One of the three pillars of risk analysis is risk assessment, and market basket studies allow for the evaluation of exposures to hazardous elements present in food and characterizing the risk they represent, as well as identifying the most vulnerable subgroups of consumers and recommendations for consumption. As foodstuffs from animal origin are the most relevant source of the environmentally persistent toxic pollutants, during the last years we have performed monitoring studies of all the main animal origin foodstuffs that are consumed in our region (the Canary Islands, Spain). By combining these data of chemical contamination of food with those of consumption of food we have assessed the exposure of an average consumer, and identified the major risks that this exposure represents. Here we present the summary of the results obtained in these studies, which indicate that the dietary exposure to these contaminants can be considered from medium to high, in particular as it refers to dioxins, whose consumption would widely exceed the EU's tolerable daily intake of 2 pg/kg bw/day. The results of our studies may be useful for risk managers in the design of appropriate risk communication campaigns aimed to reduce the consumption of certain types of foods to protect the consumer's health.

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Introduction

As food industry has been globalized, there have been increasing concerns about food safety, both by health authorities and by consumers themselves, who are increasingly demanding healthier foods (Lee, et al., 2015). Although there has been considerable progress in most countries to strengthen food safety systems, the full guarantee of food safety so that public health is protected and economic development is promoted remains a challenge in both developing countries and developed countries (FAO, 2005).

Risk analysis is the process that integrates the stages of risk assessment, risk management and risk communication, and represents the most useful scientific approach for making food

safety decisions (Lee, et al., 2015). Risk assessment is a key step in this process and in turn comprises four elements: hazard identification; hazard characterization; the exposure assessment; and risk characterization (FAO, 2005). Typically, this assessment is approached in stages, selecting in each of them certain priority hazards based on their previous experimental characterization, and also selecting certain individual foods that may contain these hazards (Lee, et al., 2015).

The family of chemicals known as Persistent Organic Pollutants (POPs) brings together a comprehensive list of chemicals that represent very widely recognized hazard to consumers for its proven toxicity and common presence in food, par-



ticularly those of animal origin (El-Shahawi, et al., 2010). The population of the Canary Islands has been extensively studied in relation to their levels of POPs (Henríquez-Hernández, et al., 2011; Luzardo, et al., 2006; Zumbado, et al., 2005), and it has been shown that the inhabitants of these islands have relatively high levels of contamination by some of them, such as organochlorine pesticides (OCPs), mainly due to higher past use of this type of agricultural products in this archipelago (Luzardo, et al., 2006; Zumbado, et al., 2005). Therefore, studies monitoring these contaminants in food most consumed by this population were undertaken.

In this paper we present the results of the studies of the risk associated with the presence of POPs in animal foods consumed by the population of the Canary Islands.

Risk assessment of the exposure to pops through the consumption of food of animal origin in the Canary Islands, Spain

Dairy products

Consumption of dairy products in the Canary Islands is among the highest in Europe, with nearly 400 g/day of average per capita consumption (Serra Majem, L., et al., 2000). Consequently, consumer products within this group were the first to be studied.

Milk: Sixteen brands of whole milk from conventional production and 10 brands of organic whole milk were purchased randomly in supermarkets in the Canary Islands (six samples of each brand) during 2007 and 2008. In this study we found that both types of brands of milk (organic and conventional) showed detectable levels of OCPs and polychlorinated biphenyls (PCBs), but the levels detected were in all cases below the MRLs established by the European authorities. While 100% of the samples had some type of residue POPs, pollution pattern varied with the type of production. Thus, conventional milk had higher levels of OCPs, while, conversely, the level of PCB contamination was higher in organic milk. As expected, estimates of daily intake of OCPs and PCBs through milk, calculated from the average residue concentrations were below the values of tolerable daily intake (TDIs) established by international agencies. However, it is striking that a number of brands of both types of production showed a high degree of contamination by dioxin-like PCBs, so the deterministic assessment of acute intake (calculated as the highest residue value (mg/kg) combined with the value of consumption of the 97.5th percentile of eaters) indicated that some people who consume these brands could be exposed through milk consumption to such high levels of exposure to dioxins that would exceed the EU daily limits for the total diet (Luzardo, et al., 2012).

Cheese: In 2008 we developed an independent survey in our archipelago to analyze the relevance of cheese (a dairy product frequently consumed by the population of these islands) as an active source of organochlorine contaminants and to evaluate its impact on consumers. We sampled 54 of the top-selling, commercially available brands of cheese conventionally produced and 7 commercially available brands of cheese organically produced that are sold from various supermarkets in the Canary Islands (Spain), and characterized the risk of the dietary exposure

for the inhabitants of this archipelago. As described for milk, we observed that cheese consumption could be a major exposure route for dioxin-like PCBs and also, on a much smaller scale, for OCPs. Our results could be considered somewhat worrisome because we demonstrated that there are some cheese brands that are highly contaminated by organochlorine contaminants (but there were also a number of cheese brands that showed undetectable levels of these toxicants). This means that, as in the case of milk, the deterministic assessment of acute intake indicated that a given consumer could be exposed to as much as 60% of EU's TDI for dioxins, only through cheese intake (Almeida-González, et al., 2012).

Yogurt: Similar to the rest of dairy products we also studied the presence of POPs in conventional and organic yogurts marketed in the Canary Islands (17 brands of conventional and 15 brands of organic yogurt, 5 samples of each). From this research forward we decided to also explore in food samples the presence the semi persistent group of polycyclic aromatic hydrocarbons (PAHs). As we reported for other dairy products, yogurt samples also presented different residues belonging to the three groups studied, although in most cases detected levels were below EU's MRLs. We observed that the levels and frequency of detection were lower in organic yogurt. However, we should note that the maximum permitted levels for dioxins (2.5 pg WHO-TEQ/g fat) were exceeded in 6 samples of conventional yogurt and 3 samples of organic yogurt. Also noteworthy is the fact that most yogurt samples of both production modes showed detectable residues of benzo[k]fluoranthene, benzo[b]fluoranthene and chrysene, which are characterized by their mutagenic and carcinogenic potential. Our estimates of chronic exposure to organic pollutants through the consumption of yogurt indicate that consumers are generally exposed to low levels of POPs. However, the deterministic approach of acute exposure indicates that there might be some consumers who are exposed to amounts of some pollutants that far exceed safety limits set by international organizations, simply by eating yogurt (Rodríguez-Hernández, et al., 2015).

Eggs

Another animal origin food that we investigated were eggs. We performed the quantitative analysis of 16 PAHs, 20 OCPs, and 18 PCBs in a total of a 36 composites of 6 eggs each from three different production types (conventional, free-run and organic), all of them produced in the Canary Islands. Unlike the observations in European studies, OCPs and PCBs residues were not significantly higher in free-range eggs. The levels of contamination by these organochlorine compounds in the 100% of the eggs of this study were extremely low and none of the samples surpassed the MRLs established in the EU. Therefore, the level of exposure of the inhabitants of the archipelago is well below the established TDIs and we could consider that the contribution of eggs to the total daily intake is negligible. However, as reported for dairy products it is possible that consumers are unwittingly exposed to high levels of dioxin-like compounds through consumption of eggs, since our results show that the TDI had been largely overcome if 5% of the samples had been consumed. Finally, it is very interesting the finding that the consumers that choose eggs from free-ranging hens have a significantly lower intake of carcinogenic PAHs, what is very relevant,

especially in children. Therefore, the consumption of organic or free-run eggs can be a good option for reducing the exposure to these carcinogenic contaminants (Luzardo, et al., 2013).

Meat and Processed Meat

Epidemiologic studies have linked consumption of red or processed meat with obesity, type 2 diabetes, cardiovascular diseases, and cancer (Boada, L.D., et al., 2016). Spain is among the highest consumers of meat per capita within the EU. Therefore, we assessed the daily exposure to carcinogenic pollutants in meat and its associated risks in the Canarian population. Based on the preferences of consumers we acquired 100 samples of meat and charcuterie that reflect the variety available in the Canarian market, and we quantified in these samples the concentration of 33 chemicals with calculated carcinogenic potential in these samples. The carcinogenic risk associated with intake of these contaminants through consumption of each type of meat or meat product (taking into account the current consumption pattern of the same by the Spanish population) was subsequently calculated. According to our estimations carcinogenic risk ratios are higher than 1 in the case of beef, pork, lamb and chicken consumption, and also in the case of Spanish “chorizo” (values between 1.33 and 13.98). Referencing the maximum tolerable intake of these foods depending on the level of contamination by carcinogens they contain is possible to calculate the maximum number of servings per month that would allow lower carcinogenic risk, and according to our calculations a maximum of 5 servings per month should be consumed (Rodríguez-Hernández,

et al., 2015). We also performed these estimations considering the consumption of organic meat and meat products and we found no differences (Rodríguez-Hernández, et al., 2015a), being the recommendations the same.

Fish and seafood

Finally, to complete the study of animal foods, we also studied the presence of toxic contaminants, including heavy metals, in seafood species most consumed in the Canary Islands. Mean concentrations of these chemicals in seafood species were combined with the pattern of consumption of these food products in order to calculate the daily intake of these contaminants. On the basis of the calculated intakes, risk ratios were determined for both carcinogenicity and acute toxicity, and for both the Spanish adult population and children. Our results showed that daily intake chemical contaminants through consumption of seafood can be considered low or very low for individual pollutants, compared with reference values, except in the case of HCB and As. In any case, taking into account the additive effects of multiple pollutants, the current consumption of whitefish in adults and children, and bluefish in the case of adults presents a moderate carcinogenic risk for Spanish consumers (especially in relationship with their concentrations of As). Therefore, a decrease in the consumption of fish and seafood is recommended to avoid the carcinogenic risk associated to these pollutants, especially in the case of white fish, whose consumption should be reduced to one-third of the current level, according to our calculations (Rodríguez-Hernández, et al., 2016).

Table 1: Summary of the estimated daily intake of toxic pollutants through the consumption of animal origin foodstuffs (ng/kg b.w./day)

CONVENTIONAL PRODUCTION												
	Dairy products		Eggs		Meat		Processed meat		Fish and seafood		Total	
	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children
HCB	0.87	1.98			56.91	72.92	2.48	5.42	36.8	18.3	97.06	98.62
Ciclodienes	2.56	6.32	0,11	0,23								
DDTs	3.09	6.65	0.02	0.03	67.36	112.59	5.3	13.69	84.4	43.7	160.17	176.66
HCHs	2.86	5.69	0.001	0.002	7.65	14.29	0.51	1.3	14.77	7.9	25.79	29.18
OCPs	11.52	26.34	0.18	0.36	131.92	199.8	8.29	20.41	135.97	69.9	287.88	316.81
M-PCBs	0.51	1.23	0.13	0.26	52.35	102.31	10.43	25.7	144.2	74.4	206.98	202.41
TEQs	0.825	1.537	0.003	0.006	0.2	0.37	0.02	0.07	0.5	0.2	1.548	2.183
PAH (B(a)Peq)	0.04	0.09	2.41	5.97	4.38	8.1	13.29	38.79	9.4	5.3	27.07	52.19
ORGANIC PRODUCTION												
	Dairy products		Eggs		Meat		Processed meat		Fish and seafood		Total	
	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children
HCB	0.78	2.08			58.91	80.87	2.48	5.42	36.8	18.3	98.97	106.67
Ciclodienes	0.78	2.23	0.09	0.18								
DDTs	1.28	3.57	0.02	0.04	98.4	141.43	5.3	13.69	84.4	43.7	189.4	202.43
HCHs	0.34	0.95	0.002	0.004	40.37	58.21	0.51	1.3	14.77	7.9	55.99	68.36
OCPs	3.61	10.15	0.12	0.25	197.68	280.51	8.29	20.41	135.97	69.9	345.67	381.22
M-PCBs	0.51	1.24	0.06	0.13	50.86	97.53	10.43	25.7	144.2	74.4	205.49	197.53
TEQs	4.112	6.698	0.003	0.006	0.1	0.19	0.02	0.07	0.5	0.2	4.735	7.164
PAH (B(a)Peq)	0	0	0.99	2.34	52.3	3.82	6.92	38.79	9.4	5.3	26.51	51.01

Conclusion

As shown in Table 1, in which we have summarized the values of exposure to contaminants through food of animal origin in adults and children of the Canary Islands, the dietary exposure can be considered high in many cases, in particular as it refers to dioxins, which would widely exceed the EU's TDI (2 pg/kg bw/day). This can be seen particularly worrisome if we consider that we have only been able to evaluate a few dozens of the more than 2800 chemicals classified into eight major groups relevant to food security that may appear in food (natural components, environmental pollutants, substances intentionally added to food, waste, naturally occurring contaminants, pollutants, contaminants packaging process and materials in contact with food and other substances). Moreover, if we take into consideration that we only evaluated food of animal origin (which could be considered a limitation of these studies) we conclude that legacy pollutants still pose a risk to the health of consumers, and it would need to change the dietary habits of the population to protect consumers from the adverse effects of these chemicals.

The results of our studies in the Spanish population are not too different from other made in this (Yebrá-Pimentel, et al., 2015; Fernandez-Gonzalez, et al., 2015) and other other countries around the world (Caldas, et al., 2012; Gueguen, et al., 2011; Eqani, et al., 2015), indicating that is important to maintain surveillance programs that monitor the trend of persistent pollutants in animal origin foodstuffs. The results of our studies may be taken of utility for risk managers in the design of appropriate risk communication campaigns aimed to reduce the consumption of certain types of foods with the aim of obtaining an optimal risk-to-benefit balance of animal origin food consumption.

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