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Consumption of foods of animal origin as determinant of contamination by organochlorine pesticides and polychlorobiphenyls: Results from a population-based study in Spain

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HIGHLIGHTS

- Dietary habits and POPs serum levels have been reported in the Canarian population.
- Poultry, rabbit, and cheese consumption increased risk of having serum cyclodienes.
- Sausage and meat consumption increased the risk of having DL-PCBs in serum.
- Dietary pattern may be used for identifying individuals at risk for high POPs burden.

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ABSTRACT

The level of contamination with persistent organic pollutants (POPs) and dietary habits and food consumption was extensively studied in the population from the Canary Islands (Spain). Because foodstuffs of animal origin are well known to be prominent contributors to these contaminants, the current study aimed to assess the role of the dietary intake of animal products as a probability factor for increased serum POPs. The intake of animal products (dietary variables) as a determining factor for serum POP levels was investigated using multivariate statistical models. Our results showed that while poultry, rabbit, and cheese consumption increases the probability of having high levels of non-DDT-derivative pesticides, sausage, yogurt, lard, and bacon consumption decreases the probability of having high levels of these pesticides. In addition, poultry, rabbit, eggs, cream, and butter consumption increased the probability of having detectable levels of marker PCB, while dairy desserts decreased the probability of having detectable levels of these PCBs. On the contrary, sausage and meat consumption increased the probability of having detectable levels of dioxin-like PCBs (DL-PCBs). The current results confirm that dietary intake of foodstuffs of animal origin is a relevant risk factor for the accumulation of POPs (and therefore their serum levels). Our study indicates that the analysis of dietary patterns may be useful for identifying those individuals that will probably present a high body burden of POPs. Because POPs can exert deleterious effects on human health, the identification of populations at risk of being highly contaminated is mandatory in order to implement policies that minimize the exposure to these compounds.

1. Introduction

Humans are exposed to a large number of anthropogenic chemicals in daily life. Some chemicals are easily degraded in the human body, whereas others are retained and slowly metabolized.

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Persistent organic pollutants (POPs) are a large group of compounds that are characterized as being highly lipophilic, having a low water solubility and being resistant to degradation (Luzardo et al., 2012; Rylander et al., 2012). POPs include the polychlorinated biphenyls (PCBs), which were detected in human blood already in the 1970s (Fukano and Doguchi, 1977), and the organochlorine pesticides (OCs), among others. There are many in vitro studies that indicate the toxic potential of these compounds (Boada et al., 2007; Valerón et al., 2009), but also many epidemiological studies that demonstrate endocrine dysfunction and neurodevelopmental and immunosuppressive effects in humans with long-term, low-dose exposure to POPs (Mostafalou and Abdollah, 2013). Furthermore, POPs' exposure has been linked to an increased incidence of important lifestyle-related diseases, such as cancer, obesity, and diabetes (Holtcamp, 2012; Mostafalou and Abdollah, 2013; Swaminathan, 2013). In addition, some forms of PCBs, non-ortho- and mono-ortho-PCBs, are known to have a coplanar conformation, exhibit toxic actions similar to 2,3,7,8-tetrachlorodibenzo-p-dioxin, and are called dioxin-like PCBs (DL-PCBs) (Van den Berg et al., 2006).

Many sources of these man-made toxicants have been identified and eliminated in past decades; however, their occurrence in our environment is still a major concern. Although direct exposure from the surrounding environment is possible, more than 95% of human exposure appears to be via food consumption (Focant et al., 2003; Darnerud et al., 2006). Due to the highly lipophilic nature of these chemicals, they enter human body along with food fat. Consequently, animal products are considered to be the major source of POPs for humans (Fries, 1995; Luzardo et al., 2012; Almeida-González et al., 2012; Rylander et al., 2012). However, because foods are consumed as complex combinations, analyzing dietary patterns and behaviors that lead to an increased POP burden may be helpful.

Using the Canary Islands Nutrition Survey (1997–98), the Spanish population of the Canary Islands was extensively studied regarding their dietary habits (Serra Majem et al., 2000a, b; García-Segovia et al., 2006; Núñez-González et al., 2011). In parallel the pattern of contamination by POPs in this population has been also studied in depth, and current levels of contamination by OCs have been described as high for humans and other species from this region (Zumbado et al., 2005; Luzardo et al., 2006, 2009, 2014; Henríquez-Hernández et al., 2011; Camacho et al., 2013). However, there are no studies evaluating the main determinants of serum POP levels in this population. In this paper, we report an evaluation of the role of animal foodstuffs as determinants of serum POPs levels in this population. Because the study population has an alarming rate of obesity (Núñez-González et al., 2011), we paid especial attention to the potential impact of diet on the levels of the compounds considered to be environmental obesogens (Legler et al., 2011; Holtcamp, 2012).

2. Materials and methods

2.1. Subjects

The sample population included subjects enrolled in the Canary Islands Nutrition Survey (ENCA is the acronym for the Spanish denomination of this survey), which was conducted from 1997 to 98 in a representative sample of the population of the Canary Archipelago ($n = 1747$, ages 6–75 y.o., both genders). All the participants were subjected to two individual interviews with questions about dietary variables, life habits, and health conditions. A subsample of 607 participants had blood extracted after 12-h fasting to determine biochemical parameters and the presence of organochlorinated contaminants. In addition, anthropometric variables were collected; participants were weighed and measured without shoes or outer clothing. The characteristics of the population studied are shown in Table 1.

2.2. Dietary data

The methodology of the ENCA has been published previously (Serra Majem et al., 2000a, b; García-Segovia et al., 2006; Núñez-González et al., 2011). In brief, a semi-quantitative food-frequency questionnaire (SFFQ, 88 items) was used to assess the usual diet for the participants. The questionnaire was modified from a previously validated questionnaire to account for the Canarian dietary features (Martín-Moreno et al., 1993). The food items were categorized into the following groups: cereals, dairy products, fruits, vegetables, meat, eggs and fish, olive oil and other fats, sweets, nuts, and beverages (including alcoholic drinks). The questionnaire also included data on dressings, cooking and frying fats to describe the fat intake pattern. A food composition database was established based on the Spanish food composition tables (Serra Majem et al., 2000a; García-Segovia et al., 2006). In addition, the participants answered a lifestyle questionnaire inquiring about sociodemographic variables, chronic diseases history, smoking habits, alcohol consumption, physical activity, family history of diseases, menstrual and reproductive events and nutritional beliefs, opinions and attitudes. Data for dietary habits have previously been published elsewhere (Serra-Majem et al., 2000b). In this work, the population was stratified into high, medium and low consumers for each group of animal products (milk, yogurt, cheese, dairy desserts, cream and butter, eggs, fish, meat, poultry and rabbit, sausage, organ meat, lard and bacon). Table 2 shows the consumption pattern of these foods showed in the study population.

2.3. Level of POP contamination

With respect to serum OC levels, the methodology used has been reported previously (Zumbado et al., 2005; Luzardo et al., 2006). Briefly, a two-mililiter aliquot of serum was used to measure the OCs, including six DDT-derivatives (p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, and o,p'-DDD) and four non-DDT derivative pesticides (aldrin, dieldrin, endrin, and lindane). These contaminants were extracted by liquid–liquid extraction and measured by gas chromatography with electron capture detector (GC-ECD).

Table 1
Characteristics of the study population.

Characteristics	*N* (%)
Total samples	607 (100.0)
Gender	
Men	284 (46.7)
Women	323 (53.2)
BMI	
<19.99	90 (14.8)
20–24.99	196 (32.2)
25–29.99	187 (30.8)
>30	104 (17.1)
Smoking habit	
Non-smoker	321 (52.8)
Ex-smoker	97 (15.9)
Smoker	144 (23.7)
Cholesterol	
<200	281 (46.3)
200–250	205 (33.8)
>200	106 (17.5)
Triglycerides	
<200	541 (89.1)
>200	51 (8.4)