SHORT-CHAIN CHLORINATED PARAFFINS (SCCPs) IN EGGS FROM SIX COUNTRIES

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Introduction

There are a range of studies on various persistent organic pollutants (POPs) in eggs[1-4]. Eggs have been found to be sensitive indicators of POPs contamination in soils and are an important exposure pathway from soil pollution to humans. Eggs from contaminated areas can readily lead to exposures which exceed thresholds for the protection of human health[2,5,6]. Chickens and their eggs might therefore be considered ideal "active samplers" and indicator species for POPs contaminated sites. However, there are as yet, few systematic studies linking pollution sources, related exposures and concentrations of contaminants in eggs.

This study examines, for first time, short-chain chlorinated paraffins (SCCPs) in pooled samples of free-range chicken eggs from polluted hot spots in several countries. The objective is to obtain a better understanding of the levels of these chemicals in the environment at sites demonstrated to have been contaminated by other POPs in previous studies.

SCCPs were listed in Annex A to the Stockholm Convention on POPs at the 8th Conference of the Parties held in 2017. The major sources of releases of SCCPs are likely the formulation and manufacturing of products containing SCCPs, such as polyvinyl chloride (PVC) plastics, as well as their use in metalworking fluids. SCCPs are not expected to degrade significantly by hydrolysis in water. They persist in sediment longer than 1 year and their atmospheric half-lives range from 0.81 to 10.5 days, indicating that they are relatively persistent in air. SCCPs have been detected in diverse environmental samples (air, sediment, water, wastewater, fish and marine mammals). Available data indicate that SCCPs can accumulate in biota. The International Agency for Research on Cancer considers some SCCPs (average C_{12}, average 60% chlorination) to be possible carcinogens (groups 2B). [7]

Materials and methods

Free-range chicken eggs were collected from 9 localities; in Cameroon (2), Ghana (1), Kazakhstan (2), Thailand (1), Czech Republic (1) and Ukraine (1). In addition, two pooled samples were bought from supermarkets in two countries: Ghana and Czech Republic. The eggs from supermarkets in Accra (6 eggs) and Prague (10 eggs) were analysed to help establish background levels. The number of eggs in pooled samples ranged from 3 to 5 eggs/sample. A more detailed description is included in the individual report for each country[8-11]. The number of individual eggs in pooled samples was dependent on eggs available at the sampled sites at the time of sampling. Samples were collected within the three-year period 2016 – 2018[8-11]. The choice of sampled sites was prioritised according to industrial or other human activity criteria. The sites with potential releases of POPs had priority, especially locations with dumpsites or landfills. We partially followed a similar protocol of site selection as employed in IPEN's previous free-range egg studies[1].

Analytical method. SCCPs were extracted using a solvent mixture n-hexane: acetone (3:1, *v/v*) in a Soxhlet apparatus. The purification of the primary extracts was carried out using gel permeation chromatography on the Bio Beads S-X3 column with a mixture of cyclohexane: ethyl acetate (1:1, *v/v*) as a mobile phase. The purified extract was analyzed using a gas chromatography coupled with high-resolution mass spectrometry operating in negative chemical ionization mode (GC-NCI-HRMS, Agilent 7200B GC / Q-TOF, Agilent Technologies, USA). For the quantification, the dependence of the chlorine response on the individual SCCP groups was

used.

Results and discussion

Levels of SCCPs in eggs. Results of analyses for SCCPs are summarized in Table 1 and the graph presented in Figure 1. The highest levels were measured in egg samples from an e-waste and car wreck scrapyard in Agbogbloshie, Accra, Ghana and from the vicinity of a landfill with common open burning in Baskuduk, Mangystau Region, Kazakhstan. SCCPs in eggs from other sites in this study, including metallurgical sites and dumpsites in Asian and African countries had SCCP levels 3 or more times the levels in eggs from supermarkets considered as background levels (<50 – 62 ng/g lipid). By way of comparison, the EU limit for SCCPs in water is 0.4 μg l^{-1} (~ng g^{-1}) [12].

The total concentrations of SCCPs in eggs from an e-waste polluted area in South China[13] ranged from 477 to 111000 ng/g lipid. The level of SCCPs in eggs from Agbogbloshie (2067 ng/g lipid) or Baskuduk (1950 ng/g lipid) are higher than minimum level but also much lower than maximum level from the South China site.

Table 1: Summary of results of instrumental analyses for SCCPs in free-range eggs for localities in each of the three countries plus supermarket eggs serving as reference background levels of SCCPs.

Continent	**Africa**			
Country	Cameroon		Ghana	
Locality	Yaoundé - Etetak Quart.	Yaoundé - TKC Quart	Accra - supermarket	Accra - Agbogbloshie
Suspected source of contamination	Dumpsite	Dumpsite	None/unknown	E-waste and car wrecks
SCCPs (in ng/g lipid)	149	152	62	2067
Uncertainty	30	30	12	410
Continent	**Asia**			
Country	Kazakhstan		Thailand	
Locality	Shetpe	Baskuduk	Samut Sakhon	
Suspected source of contamination	Cement kiln/car wrecks/waste	Landfill site	Medium size metallurgical plants	
SCCPs (in ng/g lipid)	127	1950	173	
Uncertainty	25	390	35	
Continent	**Europe**			
Country	Czech Republic		Ukraine	
Locality	Prague - supermarket	Pitarne	Kriviy Ryh	
Suspected source of contamination	None/unknown	PVC recycling	Metallurgy/coke production	
SCCPs (in ng/g lipid)	< 50*	< 50*	< 50*	
Uncertainty	-	-	-	

* below LOQ

Conclusions

Short-chain chlorinated paraffins (SCCPs), a group of POPs recently added to the list of chemicals regulated under the Stockholm Convention, were analyzed in pooled free-range chicken egg samples from 9 localities in 6 countries and compared with eggs from chickens raised at larger farms, most likely without access to outside

areas, and considered therefore as background samples. SCCPs were detected in all eggs. The highest levels were found in eggs from localities with minimally controlled or fully uncontrolled dumping and open burning of waste. The waste seems to be the major source of contamination. A certain level of contamination, threefold or more times background levels was observed in eggs from localities with dump sites, cement kilns and metallurgical activities. These findings underline the need to control SCCPs in food samples in home grown food in developing countries and countries with economies in transition, in particular. It also highlights the need for better control of SCCPs flow in wastes, including stricter limits for definition of POPs waste under the Stockholm and Basel Conventions.

Acknowledgements: The study was financially supported by the Government of Sweden through IPEN, Global Greengrants Fund and Thai Health Foundation. European Commission grants via EU Aid support for actions in Kazakhstan and Thailand made possible sampling of egg samples in respective countries.

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