PERSISTENT ORGANIC POLLUTANTS IN CANADIAN EGG YOLKS FROM FOUR DIFFERENT HATCHERY TYPES

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Abstract
Eggs from chickens raised in different Canadian hatchery types were sampled and analysed to determine PCB, dioxin/furan and PBDE levels. Egg yolks were analysed individually and were found to have median total PCB (2890 pg/g lipid) and dioxin/furan (0.43 pg TEQ/g lipid) concentrations similar to those reported in European conventionally produced eggs, regardless of whether the chickens that produced the eggs were caged, free range or fed specialised feed. The median PBDE concentration in egg yolks was 640 pg/g lipid. The PCB congener pattern was dominated by the lower chlorinated congeners, which contrasts with the pattern observed in eggs from Europe.

Introduction
Eggs from chickens raised on free range farms in Europe have been identified as having elevated levels of persistent organic pollutants (POPs) relative to conventionally produced eggs[1, 2]. Eggs collected from private owners in Europe also are reported to have higher concentrations than commercially produced free range eggs[2]. The increased exposure to the environment and the foraging of chickens raised by private owners is thought to cause the higher POP concentrations over commercially produced eggs[2]. This may be attributed to free ranging chickens having access to an open field to elect which grit, soil and food to consume, in contrast to caged or housed chickens that are only exposed to known feeds[3].

The transfer of POPs into eggs by laying chickens occurs gradually over time rather than complete elimination during the early stage of ovulation[4]. Hens are anticipated to lay eggs with similar POP concentrations over time, therefore, collection of eggs for measurement of these compounds does not require knowledge of how long a hen may have been laying.

In Canada, eggs can be produced in a number of hatchery types including battery (caged or conventional) systems. Chickens also may be identified as organic if they are fed certified organic feed, although these hens may be raised in battery facilities or free to run within a barn. Similarly, eggs identified as omega-3 are produced by hens fed a diet containing flaxseed, which is high in omega-3 fatty acids without specifications on other aspects of the hatchery. Hens allowed outdoor accessibility, however, are clearly identified as free range hens. Eggs marketed from each of these four hatchery types were collected from central and western Canada and analysed to determine POP levels.

Materials and Methods
Inspectors from the Canadian Food Inspection Agency (CFIA) collected 10 eggs from each of the four production facility types (battery, organic, omega-3, free range) in central and western Canada (n=80 eggs) in 2005/06. The samples were frozen upon receipt and retained at -20°C until extraction and analysis was initiated. Samples were thawed and individual yolks were extracted separately using acetone: hexane (2:1) following the method for milk described previously[5]. Due to the high cholesterol levels in eggs, the method was adapted to include an initial clean up using non-acidified silica gel (2 g), eluted with 4 mL hexane prior to digestion with sulphuric acid[6]. PCBs (37 congeners), dioxins/furans (2,3,7,8-substituted congeners) and PBDEs (22 congeners) were analysed by capillary gas

chromatography- high resolution mass spectrometry. The resolution was set to approximately 8,000 – 9,000 for all analytes.

The lipid content of egg yolks, determined gravimetrically, was found to range from 12.8% to 21.6% with an average of 16.2%. Free range eggs were found to have elevated lipid content (mean 19.6%) over eggs from other hatchery types (mean 15.0%). The average contribution of yolk to the total edible portion of eggs (yolk + white) was 37.6% on a whole weight basis, but 100% of the lipid content of whole eggs was present only in the egg yolks.

Results and Discussion

All egg yolks were found to have low levels of each class of POP analysed regardless of the category or region of Canada from which they were collected. In general, the PCB and PBDE distribution of residues was narrow with the exception of PBDE levels in free range eggs. A single battery egg, however, was found to have maximum total marker PCB (n=7) concentrations which were much higher (6,200 pg/g lipid) than any of the other eggs from this category which had a median level of 1,500 pg/g lipid (Figure 1).

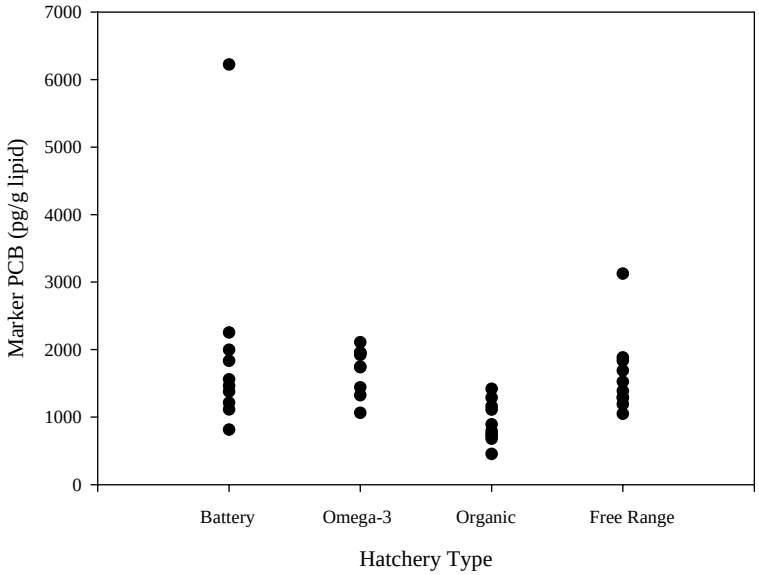

Figure 1: Total Marker PCBs (28, 52, 101, 118, 138, 153, 180) observed in egg yolks from Canada, representing each of the four types of eggs routinely marketed: battery, omega-3, organic and free range (pg/g lipid).

PCB 28 contributed the greatest amount to total marker PCBs in all egg types tested, with average contributions between 26% and 63% in battery and free range eggs, respectively. The average contribution of each of the other congeners was less than 20% to total marker PCB levels in all egg types. This profile differs from those obtained in Belgium, where PCB 153 was the dominant contributor to marker PCB levels[7]. Although PCB 28 was dominant in the current study, the relative contribution of PCB 138 (15%) and 153 (13%) were the other more prominent contributors to marker PCB levels.

Total PBDE levels in eggs ranged from 18 pg/g lipid to 3600 pg/g lipid (Figure 2) and were detected in all of the eggs analyzed regardless of what type of hatchery was used to raise chickens. Eggs identified as rich in omega-3

fatty acids were found to have elevated ΣPBDEs relative to the battery and organic eggs tested. The greatest PBDE concentration range was, however, observed in free range eggs which spanned an order of magnitude (Figure 2).

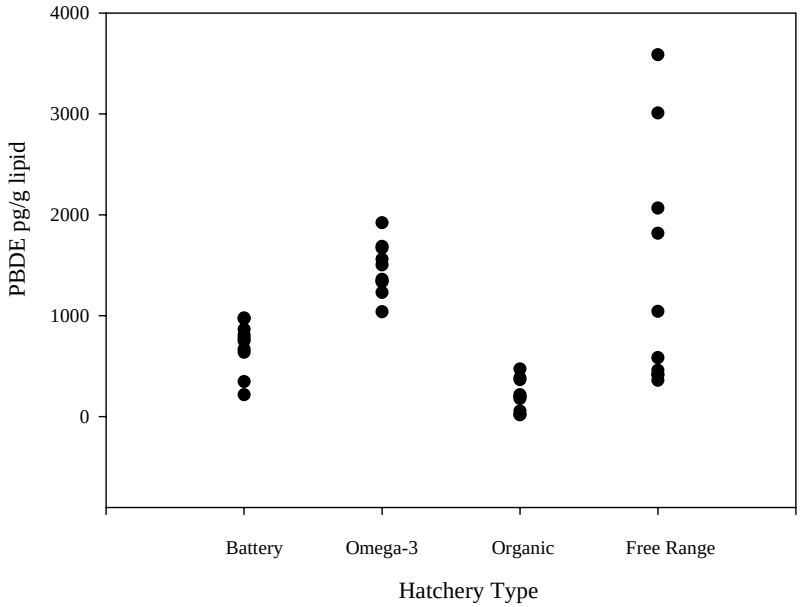

Figure 2: ΣPBDEs observed in egg yolks from each of the four types of eggs routinely marketed in Canada: battery, omega-3, organic and free range (pg/g lipid).

PBDE 99 consistently contributed the greatest to total PBDE levels (mean 37 - 41%) in eggs from all hatchery types examined in this study. Although eggs of piscivorous bird species are dominated by PBDE 47[8], variability in the congener profiles has been reported. The differences in congener profiles have been attributed to both food consumption patterns and species differences. The other prominent congeners following PBDE 99 were 47, 183, 153 and 100 in the present study, similar to PBDE patterns in eggs from other bird species regardless of location.

Although organic eggs from central Canada had lower ΣPCB and ΣPBDE concentrations than eggs from other hatchery types, organic eggs were found to have a greater concentration range (0.31 – 3.6 pg TEQ/g lipid]) in ΣPCDD/F than observed in eggs from the other hatchery types (0.18 – 0.99 pg TEQ/g lipid, 0.12 –2.0 pg TEQ/g lipid and 0.06 – 0.49 pg TEQ/g lipid; battery, omega-3 and free range, respectively). The median ΣPCDD/F concentration observed in battery produced eggs from western Canada (0.58 pg TEQ /g lipid) was very slightly higher than observed in those from central Canada (0.43 pg TEQ/g lipid). In contrast, the median ΣPCDD/F concentrations in omega-3 rich eggs was higher in eggs from central Canada (0.69 pg TEQ/g lipid) relative to those from western Canada (0.39 pg TEQ/g lipid) (Figure 3). Although minor differences in concentration were observed, eggs from Canada were found to have ΣPCDD/F levels below 3 pg TEQ/g lipid, with the exception of a single organic egg collected in central Canada (3.9 pg TEQ/g lipid).

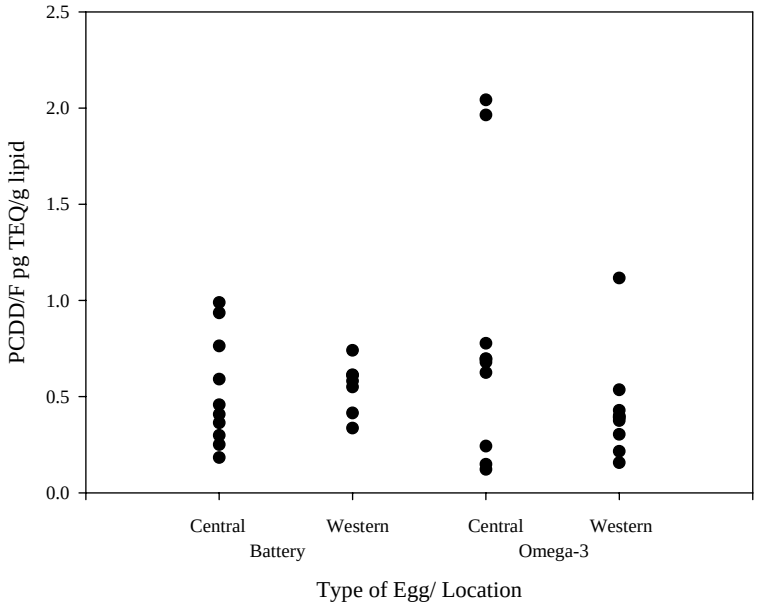

Figure 3: Comparison of individual ΣPCDD/F TEQ concentrations in battery and omega-3 eggs from central and western Canada.

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