

Preplanned Studies

Exposure to Chlorinated Paraffins in the Sixth Total Diet Study — China, 2016–2019

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Summary

What is already known about this topic?

Short-chain chlorinated paraffins (SCCPs) are persistent organic pollutants that are toxic to organisms. Medium-chain chlorinated paraffins (MCCPs) have similar properties. Chlorinated paraffins (CPs) may be biomagnified through the food chain, thereby threatening human health.

What is added by this report?

The concentrations of SCCP and MCCP in each food sample were 5–265 and 4–306 ng/g, respectively. The estimated dietary exposure to CPs was relatively lower than the threshold set in the current guidelines.

What are the implications for public health practice?

The production and use of SCCP and MCCP have not been prohibited in China yet. Further studies are needed to assess the health risks through dietary exposure to CPs.

Short-chain chlorinated paraffins (SCCPs) are persistent organic pollutants listed in the Stockholm Convention. Medium-chain chlorinated paraffins (MCCPs) structurally similar to SCCPs have similar toxicity. China is the largest producer and consumer of chlorinated paraffins (CPs) in the world. Dietary intake is considered the main route of human exposure to CPs (1).

The China National Center for Food Safety Risk Assessment launched the Sixth China Total Diet Study (TDS). The dietary survey methods, sample collection, and processing methods are referenced in the Foreword in this special issue (2). The concentrations of SCCP and MCCP in each food sample in the Sixth China TDS were 5–265 ng/g wet weight and 4–306 ng/g wet weight, respectively (Table 1). Among the 8 food categories, the highest average concentrations of SCCP and MCCP were found in meats at 63 ng/g wet weight and 70 ng/g wet weight, respectively. The average SCCP and MCCP concentrations in animal-origin foods were generally higher than those in plant-origin

foods. A possible reason could be that SCCPs and MCCPs are compounds with high octanol-water partition coefficients and tend to accumulate in the fatty tissues of animals. The highest total concentrations of SCCP in eight food categories were detected in the provincial-level administrative divisions (PLADs) of Hebei, Henan, and Shanxi, while those of MCCP were found in Henan, Hebei, and Ningxia. Overall, the total concentrations of SCCP and MCCP from the eight food samples in the northern PLADs were higher than those in the southern PLADs in this study. The total estimated dietary intakes (EDI) for SCCP and MCCP in eight food categories were listed in Table 2, which ranged from 270 to 2,844 ng/kg body weight per day (average: 1,041 ng/kg body weight per day) and 192 to 2,927 ng/kg body weight per day (average: 918 ng/kg body weight per day), respectively.

DISCUSSION

In this study, the average concentrations of SCCP in the eight food categories ranged from 27 ng/g in potatoes to 63 ng/g in meats. The average MCCP concentrations in the present study ranged from 18 ng/g in potatoes to 70 ng/g in meats. The average levels of SCCP from dairy products, meats, eggs, and cereals in this study were much lower than those found in the Republic of Korea, whereas the average levels of SCCP from vegetables in this study were higher than those found from vegetables in the Republic of Korea (15.1 ng/g wet weight) (3). However, the average CP levels in the eight food categories in China were considerably higher than those in southern Germany (4), Sweden (5), and Japan (6), which may be attributed to the higher production and use of CP in China. In general, dietary exposure to CPs in China was equal or higher than that of other studies in the world. A decrease in the production and use of CPs may be helpful to reduce human dietary exposure to CPs.

In the Sixth TDS, the average concentrations of

TABLE 1. Concentrations of short-chain chlorinated paraffin (SCCP) and medium-chain chlorinated paraffin (MCCP) in ng/g wet weight in the Sixth Total Diet Study — China, 2016–2019.

| Chlorinated paraffins | PLADs | Cereals | Vegetables | Potatoes | Legumes | Eggs | Dairy products | Meats | Aquatic foods | Total |
|-----------------------|----------------|---------|------------|----------|---------|------|----------------|-------|---------------|-------|
| SCCPs | Heilongjiang | 265 | 50 | 12 | 44 | 22 | 28 | 31 | 44 | 496 |
| | Hebei | 39 | 73 | 15 | 162 | 36 | 83 | 39 | 55 | 502 |
| | Shanxi | 122 | 43 | 25 | 19 | 69 | 89 | 98 | 34 | 499 |
| | Ningxia | 30 | 70 | 28 | 89 | 55 | 85 | 35 | 23 | 415 |
| | Guangdong | 41 | 32 | 38 | 79 | 27 | 117 | 78 | 60 | 472 |
| | Qinghai | 38 | 69 | 40 | 35 | 73 | 71 | 78 | 72 | 476 |
| | Shandong | 63 | 40 | 36 | 18 | 27 | 72 | 71 | 142 | 469 |
| | Shaanxi | 36 | 18 | 14 | 28 | 101 | 82 | 58 | 62 | 399 |
| | Sichuan | 47 | 20 | 40 | 51 | 102 | 53 | 89 | 12 | 414 |
| | Liaoning | 71 | 46 | 44 | 52 | 11 | 50 | 81 | 12 | 367 |
| | Beijing | 29 | 18 | 30 | 50 | 28 | 35 | 25 | 22 | 237 |
| | Jilin | 22 | 27 | 36 | 50 | 53 | 18 | 84 | 86 | 376 |
| | Inner Mongolia | 43 | 20 | 28 | 51 | 54 | 14 | 49 | 77 | 336 |
| | Gansu | 24 | 66 | 40 | 43 | 81 | 9 | 27 | 34 | 324 |
| | Henan | 162 | 64 | 31 | 86 | 14 | 69 | 48 | 26 | 500 |
| | Shanghai | 21 | 13 | 17 | 16 | 28 | 13 | 39 | 40 | 187 |
| | Fujian | 26 | 21 | 35 | 75 | 69 | 34 | 81 | 75 | 416 |
| | Jiangxi | 5 | 12 | 14 | 12 | 53 | 46 | 32 | 42 | 216 |
| | Jiangsu | 9 | 113 | 17 | 44 | 65 | 22 | 116 | 56 | 442 |
| | Zhejiang | 23 | 55 | 27 | 76 | 70 | 43 | 98 | 71 | 463 |
| Hubei | 11 | 42 | 17 | 83 | 61 | 64 | 80 | 87 | 445 | |
| Guangxi | 9 | 24 | 19 | 69 | 74 | 30 | 45 | 47 | 317 | |
| Hunan | 38 | 19 | 23 | 12 | 81 | 39 | 80 | 36 | 328 | |
| Guizhou | 13 | 34 | 28 | 93 | 80 | 47 | 50 | 45 | 390 | |
| Mean | 49 | 41 | 27 | 56 | 56 | 51 | 63 | 53 | 395 | |
| MCCPs | Heilongjiang | 306 | 29 | 12 | 32 | 36 | 19 | 35 | 46 | 515 |
| | Hebei | 31 | 70 | 8 | 202 | 40 | 114 | 51 | 72 | 588 |
| | Shanxi | 66 | 30 | 14 | 14 | 51 | 70 | 147 | 40 | 432 |
| | Ningxia | 28 | 72 | 22 | 104 | 59 | 209 | 48 | 37 | 579 |
| | Guangdong | 40 | 21 | 15 | 111 | 31 | 104 | 81 | 82 | 485 |
| | Qinghai | 39 | 70 | 40 | 28 | 177 | 54 | 100 | 58 | 566 |
| | Shandong | 99 | 25 | 31 | 16 | 34 | 43 | 74 | 161 | 483 |
| | Shaanxi | 29 | 14 | 7 | 53 | 79 | 86 | 114 | 61 | 443 |
| | Sichuan | 47 | 18 | 20 | 78 | 47 | 39 | 76 | 12 | 337 |
| | Liaoning | 72 | 27 | 42 | 38 | 29 | 71 | 97 | 17 | 393 |
| | Beijing | 23 | 15 | 12 | 40 | 29 | 42 | 30 | 33 | 224 |
| | Jilin | 11 | 18 | 70 | 44 | 65 | 33 | 108 | 71 | 420 |
| | Inner Mongolia | 38 | 13 | 17 | 58 | 84 | 19 | 62 | 86 | 377 |
| | Gansu | 25 | 80 | 23 | 46 | 92 | 15 | 32 | 33 | 346 |
| | Henan | 141 | 69 | 24 | 110 | 97 | 111 | 58 | 16 | 626 |
| | Shanghai | 6 | 12 | 10 | 5 | 23 | 5 | 13 | 12 | 86 |
| | Fujian | 20 | 18 | 6 | 33 | 48 | 13 | 53 | 47 | 238 |
| | Jiangxi | 12 | 10 | 4 | 12 | 53 | 15 | 37 | 36 | 179 |
| | Jiangsu | 21 | 66 | 11 | 12 | 87 | 6 | 103 | 17 | 323 |
| | Zhejiang | 13 | 16 | 8 | 16 | 23 | 17 | 57 | 30 | 180 |
| Hubei | 10 | 27 | 10 | 36 | 51 | 23 | 95 | 72 | 324 | |
| Guangxi | 11 | 19 | 6 | 34 | 40 | 7 | 71 | 31 | 219 | |
| Hunan | 21 | 20 | 6 | 12 | 30 | 13 | 67 | 26 | 195 | |
| Guizhou | 13 | 20 | 8 | 35 | 62 | 11 | 71 | 53 | 273 | |
| Mean | 47 | 32 | 18 | 49 | 57 | 47 | 70 | 48 | 368 | |

Abbreviations: PLADs=provincial-level administrative divisions; SCCPs=short-chain chlorinated paraffins; MCCPs=medium-chain chlorinated paraffins.

TABLE 2. Estimated dietary intake in ng/kg body weight per day of short-chain chlorinated paraffin (SCCP) and medium-chain chlorinated paraffin (MCCP) in food samples in the Sixth Total Diet Study — China, 2016–2019.

| Chlorinated paraffins | PLADs | Cereals | Vegetables | Potatoes | Legumes | Eggs | Dairy products | Meats | Aquatic foods | Total |
|-----------------------|----------------|---------|------------|----------|---------|------|----------------|-------|---------------|-------|
| SCCPs | Heilongjiang | 2,305 | 254 | 15 | 32 | 14 | 6 | 29 | 19 | 2,675 |
| | Hebei | 468 | 340 | 15 | 147 | 18 | 32 | 29 | 8 | 1,057 |
| | Shanxi | 2,009 | 211 | 47 | 21 | 23 | 59 | 213 | 3 | 2,587 |
| | Ningxia | 315 | 174 | 44 | 50 | 11 | 21 | 26 | 1 | 642 |
| | Guangdong | 297 | 120 | 15 | 35 | 10 | 68 | 129 | 49 | 723 |
| | Qinghai | 462 | 340 | 64 | 4 | 15 | 60 | 88 | 4 | 1,038 |
| | Shandong | 633 | 282 | 21 | 40 | 10 | 38 | 133 | 113 | 1,271 |
| | Shaanxi | 436 | 82 | 25 | 37 | 35 | 25 | 33 | 4 | 678 |
| | Sichuan | 724 | 96 | 40 | 55 | 24 | 11 | 182 | 2 | 1,132 |
| | Liaoning | 694 | 238 | 50 | 101 | 7 | 35 | 86 | 3 | 1,215 |
| | Beijing | 366 | 112 | 28 | 81 | 17 | 48 | 27 | 6 | 684 |
| | Jilin | 204 | 166 | 69 | 60 | 34 | 9 | 89 | 15 | 646 |
| | Inner Mongolia | 493 | 82 | 54 | 32 | 25 | 8 | 57 | 13 | 765 |
| | Gansu | 261 | 260 | 91 | 28 | 29 | 2 | 13 | 2 | 686 |
| | Henan | 2,377 | 282 | 40 | 74 | 7 | 21 | 42 | 2 | 2,844 |
| | Shanghai | 150 | 83 | 10 | 30 | 17 | 15 | 69 | 44 | 417 |
| | Fujian | 261 | 132 | 23 | 94 | 21 | 19 | 111 | 76 | 738 |
| | Jiangxi | 52 | 86 | 7 | 14 | 18 | 16 | 48 | 29 | 270 |
| | Jiangsu | 115 | 762 | 9 | 58 | 29 | 10 | 169 | 35 | 1,187 |
| | Zhejiang | 231 | 388 | 16 | 170 | 27 | 23 | 184 | 56 | 1,094 |
| Hubei | 92 | 276 | 24 | 88 | 24 | 7 | 69 | 57 | 637 | |
| Guangxi | 136 | 134 | 4 | 46 | 16 | 9 | 108 | 72 | 526 | |
| Hunan | 348 | 161 | 20 | 14 | 30 | 11 | 190 | 38 | 812 | |
| Guizhou | 139 | 220 | 15 | 151 | 20 | 21 | 84 | 3 | 653 | |
| Mean | | 565 | 220 | 31 | 61 | 20 | 24 | 92 | 27 | 1,041 |
| MCCPs | Heilongjiang | 2,662 | 148 | 15 | 23 | 23 | 4 | 33 | 20 | 2,927 |
| | Hebei | 372 | 326 | 8 | 183 | 20 | 44 | 38 | 11 | 1,002 |
| | Shanxi | 1,087 | 147 | 26 | 15 | 17 | 46 | 320 | 4 | 1,663 |
| | Ningxia | 294 | 179 | 35 | 58 | 12 | 51 | 36 | 1 | 666 |
| | Guangdong | 290 | 79 | 6 | 49 | 12 | 60 | 134 | 67 | 696 |
| | Qinghai | 474 | 345 | 64 | 3 | 37 | 46 | 113 | 3 | 1,085 |
| | Shandong | 994 | 176 | 18 | 36 | 13 | 23 | 139 | 129 | 1,527 |
| | Shaanxi | 351 | 64 | 13 | 70 | 28 | 26 | 65 | 4 | 620 |
| | Sichuan | 724 | 86 | 20 | 84 | 11 | 8 | 155 | 2 | 1,089 |
| | Liaoning | 703 | 140 | 48 | 74 | 19 | 50 | 103 | 4 | 1,141 |
| | Beijing | 290 | 93 | 11 | 65 | 18 | 57 | 32 | 9 | 575 |
| | Jilin | 102 | 111 | 133 | 53 | 41 | 17 | 114 | 13 | 584 |
| | Inner Mongolia | 436 | 53 | 33 | 37 | 40 | 10 | 72 | 14 | 695 |
| | Gansu | 272 | 315 | 53 | 30 | 32 | 3 | 16 | 1 | 723 |
| | Henan | 2,068 | 304 | 31 | 94 | 46 | 35 | 51 | 1 | 2,630 |
| | Shanghai | 45 | 76 | 6 | 9 | 14 | 6 | 23 | 13 | 192 |
| | Fujian | 201 | 113 | 4 | 41 | 14 | 7 | 72 | 48 | 502 |
| | Jiangxi | 120 | 72 | 2 | 14 | 18 | 5 | 55 | 25 | 311 |
| | Jiangsu | 259 | 445 | 6 | 16 | 39 | 2 | 150 | 11 | 928 |
| | Zhejiang | 131 | 113 | 4 | 36 | 9 | 9 | 107 | 24 | 432 |
| Hubei | 84 | 177 | 14 | 38 | 20 | 2 | 81 | 47 | 465 | |
| Guangxi | 164 | 106 | 1 | 23 | 9 | 2 | 170 | 48 | 524 | |
| Hunan | 192 | 170 | 5 | 14 | 11 | 4 | 160 | 27 | 583 | |
| Guizhou | 139 | 130 | 4 | 57 | 16 | 5 | 119 | 3 | 473 | |
| Mean | | 519 | 165 | 23 | 47 | 22 | 22 | 98 | 22 | 918 |

Abbreviations: PLADs=provincial-level administrative divisions; SCCPs=short-chain chlorinated paraffins; MCCPs=medium-chain chlorinated paraffins.

SCCP and MCCP were significantly lower than those in the Fifth Total Diet Study except the increased concentrations of MCCP in meats (7–9). The highest average concentrations of SCCP and MCCP were found in meats in the present study, while in the Fifth China TDS, the average concentrations of SCCP and MCCP in aquatic foods were the highest. The ratio of MCCP to SCCP in each food category exhibited an increase from the Fifth to the Sixth TDS. This indicated that MCCPs may have become alternative products of SCCPs since SCCPs were listed as initial persistent organic pollutants of the Stockholm Convention.

The highest EDI values of SCCP and MCCP in the present study were much lower than the tolerable daily intake proposed by the International Programme on Chemical Safety (100 µg/kg body weight per day) (10). The European Food Safety Authority margins of exposure for total SCCP and total MCCP in eight food categories were 2×10^3 and 4×10^4 (11), respectively, which were much higher than 1,000, indicating that SCCPs and MCCPs ingested from food may not pose a significant risk to human health in China. The EDI of SCCP and MCCP in cereals was the highest among eight food categories, but cereals did not have the highest concentration of SCCP and MCCP. This could be due to the dietary habits in China, where there was higher daily consumption of cereals than meats.

Some limitations of this study include how apparatus for the food sample collection and storage could have been contaminated by chlorinated paraffins and how the complexity of CP mixtures posed a challenge for analysts. Complete separation or purification of individual isomers or congeners was also difficult. Also, there was a lack of standard methods for analysis of chlorinated paraffins.

The dietary exposure and health risk assessment of CP in 8 food categories of 24 PLADs were investigated in this study. Levels of SCCP and MCCP in legumes, cereals, meats, and aquatic foods exhibited a decrease from the Fifth to the Sixth China TDS, except the increased concentrations of MCCP in meats. The ratio of MCCP to SCCP in the foods investigated in this study tended to increase. The estimated dietary exposure to CPs was lower than the threshold set in the current guidelines. Further studies need to be performed to evaluate the health risks through dietary exposure to CPs and the results would be helpful for the development of chlorinated paraffin regulations.

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