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# Human health risk assessment of pesticide residues in fruit, vegetable and cereal samples from Poland – a 5-year survey

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**Abstract**

Human health risk assessment of pesticide residues in agricultural commodities is a key element of food safety strategy. The present study focused on potential risks resulting from selected fruit, vegetable and cereal samples with pesticide residues exceeding maximum residue levels (MRLs) from a 5-year survey of official control in Poland (2017–2021). A novel, common tool, the EFSA Pesticide Residue Intake Model PRIMo was used for short-term exposure calculation with embedded consumption data from EU Member States. The challenge of the research was to determine whether the International Estimated Short Time Intakes (IESTI) of toxic pesticides in the diet are acceptable or not. For the first time with long-term investigation which involved many legislative changes, we prepared a picture of the most dangerous pesticides present in fruits, vegetables and cereals for the most critical sub-populations of adults and children. We examined whether these substances have the potential to cause harm to humans. From the full spectrum of 545 analyzed pesticides, we considered 13 pesticides above safety limits in the concentration range of 0.03 to 2.5 mg · kg$^{-1}$. The most frequently detected compound was the non-authorized, organophospate insecticide chlorpyrifos, which poses toxicological risks to humans. The results of acute exposure were up to 93% ARfD for adults and up to 130% for children. The Hazard Quotient (HQ) showed that consumption of agricultural plants with potential risk can be safe for adults and children, with some exceptions. Samples containing flonicamid/Brussel sprouts (HQ = 1.3) and chlorpyrifos/rucola (HQ = 1.1) could have negative health effects on humans. However, an approach which overestimates the exposure due to a worst-case scenario ensures the widest possible safety margin for the consumers.

**Keywords:** agricultural plants, dietary exposure, hazard quotient, pesticide residues, risk assessment

## Introduction

The consumption of food derived from agricultural crops is one of the ways in which the consumer is exposed to chemical pesticide residues (EFSA 2020; Jankowska and Łozowicka 2021). Special attention should be paid to the danger of using pesticides which have negative effects on the human body. These substances occurring in fruits, vegetables and cereals, are an undesirable result of chemical protection. They may pose a potential health risk for humans (Wołejko *et al.* 2014; Valcke *et al.* 2017; Nardelli *et al.* 2021; Shalaby *et al.* 2021; Jankowska *et al.* 2022) because they can have carcinogenic, mutagenic, cytotoxic, teratogenic, neurotoxic, estrogenic or allergenic effects.

In order to assess the likelihood of adverse health effects on humans as a result of exposure to residues of plant protection products (PPP), the levels of contamination of agricultural crops, constituting the first link in the food production chain, are determined. Pesticide monitoring in the European Union at the stage of primary production is one of the main tasks of official control (EFSA 2021), to check if the dietary intake of residues has negative human health effects.

Assessing the exposure of consumer health to residues of PPP present in agricultural plants is a key element of the EU's food safety strategy plan (DG Health and Food Safety SANTE). Food available on the market should not contain pesticide residues above the applicable maximum residue levels (MRL) and each breach of pesticide limits is subject to an individual risk assessment (Ludwicki *et al*. 2011).

The risk is determined as the probability of the occurrence of undesirable effects at the level of the organism, system or subpopulation, being a resultant of the hazard of potentially hazardous physical-chemical properties of a given substance and the circumstances of exposure to that substance. Risk assessment is a multi-step process. The complete risk assessment process consists of four steps: (i) pesticide identification which involves identifying the mechanisms, physical-chemical properties and effects of a chemical substance, (ii) quantitative and qualitative risk assessment based on the determination of the dose to which humans are exposed using time and frequency factors, (iii) risk identification and characteristics, including the relationship between the magnitude of exposure and the occurrence of a specific biological effect and comparing the estimated dose value, (iv) risk management (Struciński 2016) (Fig. 1).

Human health risk assessment may be related to the general population and specific sub-populations more sensitive to the toxic effects of chemicals, e.g., children (Łozowicka *et al.* 2016). This is based on an estimation of the risk to consumers' health of exposure to the identified pesticide residues in agricultural plants and determining whether the intake of residues of toxic substances from the diet is acceptable, and if it has negative health effects on humans or/in sub-populations as a result of exposure to a specific harmful factor (Jankowska and Łozowicka 2022).

A tool commonly used in the assessment of exposure to pesticide residues is the EFSA Model PRIMo (Pesticide Residue Intake Model) (EFSA 2018) including the Global Environment Monitoring System (GEMS)/Food cluster diets (WHO 2006) relevant for the European population, which allows the estimation of long-term (chronic) and short-term (acute) risks.

In the long-term risk assessment (chronic) estimated food intake International Estimated Daily Intake (IEDI) is compared with the Acceptable Daily Intake (ADI) of the toxic substance. The ADI is the amount of a substance that can daily be ingested by a person with

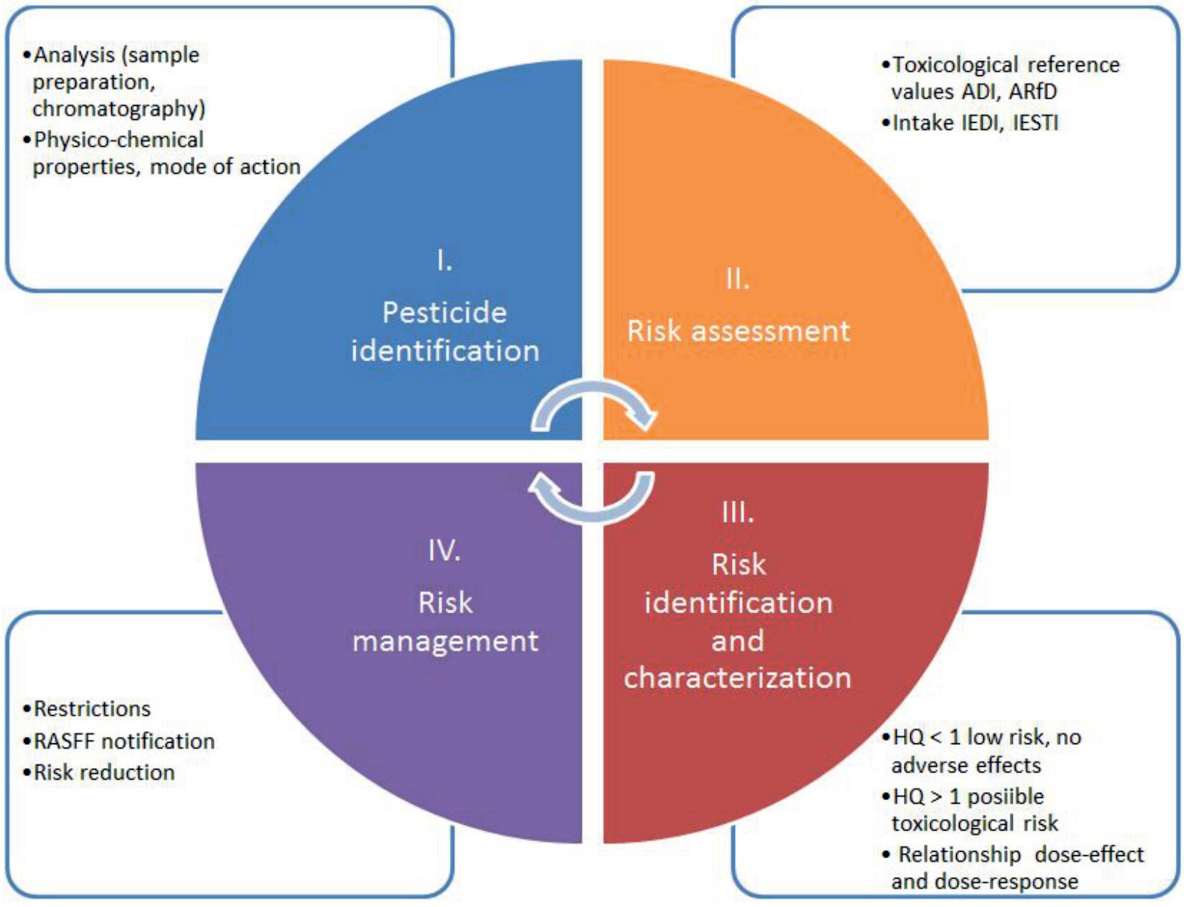


**Fig. 1.** Characterization of risk assessment steps and toxicology data

food (expressed in mg/kg body weight). In the short-term (acute) risk assessment, the estimated intake of food in 1 day/one meal the International Estimated Short Time Intake (IESTI) is compared to the Acute Reference Dose (ARfD). The ARfD is the amount of a substance, expressed in mg/kg body weight, which can be taken wthin no more than 24 h without any significant risk to the health of the consumer. Depending on the results of this assessment, incidences of the MRL being exceeded may be reported to the Rapid Alert System for Food and Animal Nutrition (RASFF).

To the best of our knowledge, such long-term toxicological investigations presenting the status of pesticide contamination in food and providing the exposure of consumers related to consumption of raw commodities in the diet are very rare.

Therefore, the object of this study was to estimate the human health risk of pesticide residues exceeding safety limits in fruit and vegetable samples during a 5-year survey of official control in Poland (2017–2021) when many legislative changes took place. For the first time, the results provided the status of possible human health exposure to dangerous pesticides in fruits and vegetables consumed by the most critical sub-population of adults and children. Health risk assessment by calculation of International Estimated Short Time Intakes (IESTI) and Hazard Quotients (HQ) were evaluated using a novel EFSA Pesticide Residue Intake Model PRIMo model. The data could be used by regulatory and legislative bodies in food safety strategy.

## Materials and Methods

### Sampling

The material for the research was made up of fruit, vegetable and cereal samples from a 5-year survey at the stage of primary production analyzed from 2017 to 2021. A total of 3,328 samples were analyzed. In 2017 – 383, in 2018 – 385, in 2019 – 802, in 2020 – 793 and in 2021 – 965, of which 604 were fruit samples, 924 vegetable samples and 1,800 cereal samples. In order to assess the likelihood of adverse human health effects, samples with pesticide residues exceeding MRLs were chosen as possibly posing a potential risk to consumers (16 samples).

### Reagents and standards

Solvents used in the experiments were analytical grade and were obtained from Merck (Darmstadt, Germany). The QuEChERS salts (4.0 g of magnesium sulphate, 1.0 g of sodium chloride, 1.0 g of sodium citrate, and 0.5 g of sodium citrate sesquihydrate) and the purifying mixtures were provided by Agilent (Santa Clara, USA).

### Analyzed pesticides

Pesticide standards (545 active substances) were obtained from Dr. Ehrenstorfer GmbH (Augsburg, Germany). Pesticide stock solutions and internal standards (ISs) (triphenyl phosphate (TPP) for GC-MS/MS, isoproturon-d6 for LC-MS/MS were prepared in concentrations of 0.005, 0.05, 0.5, 1.0, and 2.0 mg · $kg^{-1}$.

### Chemical analysis

Fruit, vegetable and cereal samples were prepared according to our validated, modified and accredited QuEChERS method (Rutkowska *et al.* 2018, 2019; Hrynko *et al.* 2019) European Standard EN 15662:2018 (SANTE). Quantitative and qualitative pesticide residue analysis was done using gas chromatography GC-MS/MS and liquid chromatography LC-MS/MS (Kaczyński *et al.* 2017; Kaczyński and Łozowicka 2017; Hrynko *et al.* 2018).

### Quality assurance

The reliability of the results was successfully assured and confirmed by the participation of a laboratory in which proficiency tests were organized and run by the European Commission, each year obtaining satisfactory results. The laboratory has accreditation according to PN-EN ISO/IEC 17025:2005 by the Polish Centre of Accreditation.

### Risk assessment

The risk assessment of adult and child health exposure related to the consumption of food containing pesticide residues was based on the EFSA Model PRIMo (Pesticide Residue Intake Model) with embedded consumption data of European Union Member States (WHO 2006).

### The sub-populations of adults

German women (DE) 14–50 years old with mean body weight BW = 67.47 kg, French (FR) adults ≥ 15 years old, BW = 66.4 kg, Lithuanian (LT) adults 19–64 years old, BW = 70.0 kg, Netherlands (NL) the general population 1–97 years old, BW = 63.0 kg, the Polish general population (PL) 1–96 years old, BW = 62.8 kg and British vegetarians (UK), BW = 66.7 kg.

### The sub-populations of children

Belgian children (BE) with BW = 17.80 kg, German children (DE) 2–5 years old, with mean body weight BW = 16.15 kg, Danish children (DK) 4–6 years old, BW = 22 kg, Dutch (NL) children 2–6 years old, BW = 17.10 kg, British toddlers (UK toddler) from

18 months to 4 years, BW = 8.7 kg, British children (UK) 4–6 years old, BW = 20.5 kg and British teenagers (UK) 11–14 years old, BW = 48.0 kg.

### Toxicological measures

The highest residue concentration values from field trials, monitoring or official control, are used to estimate the short-term (acute) risk. In this study, a deterministic model was used which was based on a "worst--case" scenario considering a high level of consumption combined with the highest pesticide residue observed. Acute intakes for two sub-populations, adults and children, were calculated in agricultural samples with an exceedance of MRLs according to Regulation (EC) No 396/2005 to assess whether it represents a potential risk for consumers.

When calculating the risk of pesticide residue from agricultural products with a unit weight > 25.0 g, the coefficients of variation (from 3 to 10), related to the non-uniform distribution of the residues in the units constituting the analyzed sample, are additionally used. The short-term exposure IESTI were calculated according to the following algorithms:

**Case 1:** refers to commodities with unit weight of the raw agricultural commodity ($U_{RAC}$) ≤ 25 g (e.g., strawberries, currants, cherries, dill, spinach)

$$IESTI = [LP \times HR \times PF \times CF] / BW.$$

**Case 2:** for commodities with a $U_{RAC}$ > 25 g

**Case 2a:** where U < LP (e.g., tomato)

$$IESTI = [U \times HR \times PF \times CF + (LP - U) \times HR \times PF \times CF] / BW.$$

**Case 2b:** where U > LP (e.g., Chinese cabbage, celery, cucumber)

$$IESTI = [LP \times HR \times PF \times CF \times VF] / BW.$$

**Case 3:** for commodities which are generally bulked or blended before consumption (e.g., cereals – wheat, rye)

$$IESTI = [LP \times STMR \times PF \times CF] / BW,$$

where:

IESTI – International Estimated Short–Term Intake;

$U_{RAC}$ – Unit weight of the raw agricultural commodity (kg);

BW – Body Weight (kg);

LP – Large Portion (97.5th percentile of eaters) ($g \cdot kg^{-1}$ BW);

HR – Highest Residue ($mg \cdot kg^{-1}$);

MRL – Maximum Residue Level ($mg \cdot kg^{-1}$);

STMR – Supervised Trials Maximum Residue, for raw agricultural commodity (RAC) ($mg \cdot kg^{-1}$);

CF – Conversion Factor;

PF – Processing Factor (calculated as the ratio of residues in a processed product, divided by residue concentration in an unprocessed product);

VF – Variability Factor, depending on the unit weight of the whole product (URAC), different default VFs are used in the calculations: URAC < 25 g, the calculations are performed according to case 1 (VF = 1); $U_{RAC}$ between 25 and 250 g: VF = 7; URAC > 250: VF = 5 ($U_{RAC}$);

HQ – Hazard Quotient, calculated as ratio %ARfD/100, when HQ < 1 safe, HQ > 1 possible risk.

## Results and Discussion

The study assessed the short-term risk by estimating the intake of harmful pesticides present in food in 1 day/one meal. International Estimated Short-Time Intake – IESTI, and then compared with the Acute Reference Dose (ARfD).

The acute exposure for adults and children related to consumption of agricultural products containing pesticide residues exceeding safety limits for the adult and child subpopulations, expressed in %ARfD (Tables 1 and 2). Results showed that consumption of agricultural plants with potential risk can be safe for adults (all HQs < 1) (Table 1). Some exceptions have been noted for the most critical group – children (Table 2).

The most frequently detected pesticide which exceeded the MRL during the 5-year official control was chlorpyrifos which is not an approved organophosphate insecticide with MRL = 0.01 $mg \cdot kg^{-1}$ and very low value of ArfD = 0.005 $mg \cdot kg^{-1}$. Chlorpyrifos has reproductive toxicity, neurotoxicity and genotoxicity (Wołejko *et al.* 2022). The mode of action relies on inhibition of the activity of the key enzyme in the functioning of the nervous system – acetylcholinesterase (AChE). The compound can be absorbed into the human body via several routes, e.g., through the skin, inhalation and ingestion. Long-term exposure to this substance can lead to many health disorders, mainly of the nervous, cardiovascular and respiratory systems (Łozowicka *et al.* 2022).

Short-term intakes in subpopulation adults were in the range of 0.033% ARfD for peas containing pirimiphos methyl (UK Vegetarians) to 93% ARfD for Brussel sprouts with carcinogenic flonicamid from the pyridine group (Dutch population) (Table 1).

As can be seen in Figure 2, possible risk can occur in two cases where a hazard quotient HQ > 1 was noted. For the sub-population of Belgian children consuming LP = 8.39 $g \cdot kg^{-1}$ BW of Brussel sprouts containing flonicamid (130.1% ARfD, HQ = 1.3) and in the case of Dutch children consuming LP = 7.61 $g \cdot kg^{-1}$ BW

**Table 1.** Short-term exposure of pesticide residues occurring in fruit, vegetable and cereal samples above safety limits for sub-population of adults

| Year | Commodity | Pesticide | HR [mg · kg⁻¹] | MRL [mg · kg⁻¹] | ARfD | LP [mg · kg⁻¹ BW] | MS critical diet | BW [kg] | LP [g · person⁻¹] | Case | VF | IESTI [mg · kg⁻¹ BW/day] | % ARfD | HQ < 1 safe > 1 risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | chinese cabbage | chlorpyrifos | 0.097 | 0.01 | 0.005 | 7.14 | NL | 63.00 | 450.00 | 2b | 5 | 0.00036 | 7.1 | safe |
| | dill | chlorpyrifos | 0.124 | 0.05 | 0.005 | 0.13 | PL | 62.80 | 8.30 | 1 | 1 | 0.00001 | 0.1 | safe |
| | currants | chlorpyrifos | 0.072 | 0.01 | 0.005 | 2.65 | NL | 63.00 | 167.00 | 1 | 1 | 0.00003 | 0.5 | safe |
| | celery | chlorpyrifos | 0.733 | 0.05 | 0.005 | 4.98 | NL | 63.00 | 314.00 | 2a | 7 | 0.00115 | 23.0 | safe |
| | spinach | desmedipham | 0.03 | 0.01 | 0.05 | 8.94 | NL | 63.00 | 563.00 | 1 | 1 | 0.00009 | 0.2 | safe |
| | strawberry | desmedipham | 0.03 | 0.01 | 0.05 | 3.94 | NL | 63.00 | 248.00 | 1 | 5 | 0.00039 | 3.9 | safe |
| | cucumber | dimethoate | 0.059 | 0.02 | 0.01 | 3.94 | NL | 63.00 | 248.00 | 2b | 5 | 0.00039 | 3.9 | safe |
| | raspberry | dithiocarbamates | 0.13 | 0.05 | 0.6 | 3.97 | NL | 63.00 | 250.00 | 1 | 1 | 0.00020 | 0.03 | safe |
| | lettuce | famoxadon | 0.067 | 0.01 | 0.2 | 2.20 | UK Vegetarian | 66.7 | 146.6 | 2b | 5 | 0.00011 | 0.055 | safe |
| 2018 | rucola | chlorpyrifos | 0.142 | 0.05 | 0.005 | 2.43 | NL | 65.8 | 159.8 | 2b | 5 | 0.00172 | 34.5 | safe |
| | spinach | dimethoate | 0.052 | 0.01 | 0.01 | 4 | FR | 66.4 | 265.6 | 1 | 1 | 0.00021 | 2.1 | safe |
| | tomato | pirimiphos methyl | 0.185 | 0.01 | 0.1 | 6.43 | LT | 70 | 450 | 2a | 7 | 0.00293 | 2.9 | safe |
| 2019 | celery | chlorpyrifos | 0.068 | 0.01 | 0.005 | 3.2 | DE women 14–50 | 67.47 | 215.9 | 2b | 5 | 0.00109 | 21.8 | safe |
| | wheat | imidacloprid | 0.546 | 0.1 | 0.08 | 8.40 | UK 15–18 years | 63.8 | 536.1 | 3 | 1 | 0.00084 | 1.05 | safe |
| | pea | pirimiphos methyl | 0.35 | 0.01 | 0.1 | 3.32 | UK Vegetarian | 66.7 | 221.5 | 3 | 1 | 0.00003 | 0.033 | safe |
| 2020 | rye | pirimiphos methyl | 2.53 | 0.5 | 0.1 | 4.85 | LT | 70 | 339.7 | 3 | 1 | 0.00243 | 2.43 | safe |
| 2021 | cherrries (sweet) | iprodion | 0.036 | 1 | 0.06 | 10 | DE women 14–50 | 67.47 | 674.7 | 1 | 1 | 0.000360 | 3.6 | safe |
| | brussels sprouts | flonicamid (sum of flonicamid. TFNA and TFNG) | 1.55 | 0.6 | 0.025 | 6 | NL | 65.8 | 394.8 | 1 | 1 | 0.009300 | 93.0 | safe |
| | Chinese cabbage | chlorpyrifos | 0.14 | 0.01 | 0.005 | 5.062696 | UK 15–18 years | 63.8 | 323 | 2b | 5 | 0.003544 | 70.9 | safe |
| | dill | chlorpyrifos | 2.5 | 0.01 | 0.005 | 0.326 | NL | 65.8 | 21.4508 | 1 | 1 | 0.000815 | 16.3 | safe |
| | dill | cyfluthrin | 0.13 | 0.02 | 0.01 | 0.33 | NL | 65.80 | 21.45 | 1 | 1 | 0.000042 | 0.4 | safe |
| | dill | esfenvalerate | 0.56 | 0.05 | 0.0175 | 0.326 | NL | 65.8 | 21.4508 | 1 | 1 | 0.000183 | 1.8 | safe |
| | dill | prosulfocarb | 1 | 0.05 | 0.1 | 0.326 | NL | 65.8 | 21.4508 | 1 | 1 | 0.000326 | 3.3 | safe |

Sub-populations adults: DE – Germany, FR – France, LT – Lithuania, NL – Netherlands, PL – Poland, UK – United Kingdom
HR – highest residue, MRL – Maximum Residue Level, ARfD – Acute Reference Dose, LP – large portion, VF – variability factor, IESTI – International Estimated Short Time Intake, HQ – Hazard Quotient

**Table 2.** Short-term exposure pesticide residues occurring in fruit, vegetable and cereal samples above safety limits for sub-population of children

| Year | Commodity | Pesticide | HR [mg · kg⁻¹] | MRL [mg · kg⁻¹] | ARfD | LP [mg · kg⁻¹ BW] | MS critical diet | BW [kg] | LP [g · person⁻¹] | Case | VF | IESTI [mg · kg⁻¹ BW/ day] | % ARfD | HQ < 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | Chinese cabbage | chlorpyrifos | 0.097 | 0.01 | 0.005 | 7.43 | NL | 17.10 | 127.00 | 2b | 5 | 0.0004 | 7.4 | safe |
| | dill | chlorpyrifos | 0.124 | 0.05 | 0.005 | 5.74 | BE | 17.80 | 102.10 | 1 | 1 | 0.0003 | 5.7 | safe |
| | currants | chlorpyrifos | 0.072 | 0.01 | 0.005 | 9.29 | DE | 16.15 | 150.00 | 1 | 1 | 0.0001 | 1.9 | safe |
| | celery | chlorpyrifos | 0.733 | 0.05 | 0.005 | 9.18 | NL | 17.10 | 157.00 | 2b | 5 | 0.0023 | 45.9 | safe |
| | spinach | desmedipham | 0.03 | 0.01 | 0.05 | 22.60 | BE | 17.80 | 402.30 | 1 | 1 | 0.0002 | 0.5 | safe |
| | strawberry | desmedipham | 0.03 | 0.01 | 0.05 | 11.70 | NL | 17.10 | 200.00 | 1 | 5 | 0.0012 | 11.7 | safe |
| | cucumber | dimethoate | 0.059 | 0.02 | 0.01 | 11.70 | NL | 17.10 | 200.00 | 2b | 5 | 0.0012 | 11.7 | safe |
| | raspberry | dithiocarbamates | 0.13 | 0.05 | 0.6 | 5.61 | DE | 16.15 | 90.60 | 1 | 1 | 0.0003 | 0.05 | safe |
| | lettuce | famoxadon | 0.067 | 0.01 | 0.2 | 5.38 | DE | 16.15 | 86.9 | 2b | 5 | 0.0003 | 0.13 | safe |
| 2018 | rucola | chlorpyrifos | 0.142 | 0.05 | 0.005 | 7.61 | NL | 18.4 | 140.1 | 2b | 5 | 0.00541 | **108.1** | risk |
| | spinach | dimethoate | 0.052 | 0.01 | 0.01 | 22.60 | BE | 17.8 | 402.3 | 1 | 1 | 0.00118 | 11.7 | safe |
| | tomato | pirimiphos methyl | 0.185 | 0.01 | 0.1 | 10.11 | BE | 17.8 | 180 | 2a | 7 | 0.01076 | 10.8 | safe |
| 2019 | celery | chlorpyrifos | 0.068 | 0.01 | 0.005 | 7.48 | BE | 17.8 | 133.2 | 2b | 5 | 0.00254 | 50.9 | safe |
| | wheat | imidacloprid | 0.546 | 0.1 | 0.08 | 14.45 | UK 4–6 years | 20.5 | 296.2 | 3 | 1 | 0.00144 | 1.8 | safe |
| | pea | pirimiphos methyl | 0.35 | 0.01 | 0.1 | 6.56 | UK 11–14 years | 48 | 315 | 3 | 1 | 0.00007 | 0.07 | safe |
| 2020 | rye | pirimiphos methyl | 2.53 | 0.5 | 0.1 | 6.32 | UK toddler | 8.7 | 55 | 3 | 1 | 0.00316 | 3.2 | safe |
| 2021 | cherrries (sweet) | iprodion | 0.036 | 1 | 0.06 | 12.22727 | DK | 22 | 269 | 1 | 1 | 0.000440 | 4.4 | safe |
| | brussels sprouts | flonicamid (sum of flonicamid. TFNA and TFNG) | 1.55 | 0.6 | 0.025 | 8.393258 | BE | 17.8 | 149.4 | 1 | 1 | 0.013010 | **130.1** | **risk** |
| | Chinese cabbage | chlorpyrifos | 0.14 | 0.01 | 0.005 | 6.426966 | BE | 17.8 | 114.4 | 2b | 5 | 0.004499 | 90.0 | safe |
| | dill | chlorpyrifos | 2.5 | 0.01 | 0.005 | 0.48 | NL | 10.20 | 4.90 | 1 | 1 | 0.001200 | 24.0 | safe |
| | dill | cyfluthrin | 0.13 | 0.02 | 0.01 | 0.48 | NL | 10.20 | 4.90 | 1 | 1 | 0.000062 | 1.0 | safe |
| | dill | esfenvalerate | 0.56 | 0.05 | 0.0175 | 0.48 | NL | 10.2 | 4.896 | 1 | 1 | 0.000269 | 2.7 | safe |
| | dill | prosulfocarb | 1 | 0.05 | 0.1 | 0.48 | NL | 10.2 | 4.896 | 1 | 1 | 0.000480 | 4.8 | safe |

Sub-populations children: BE – Belgium, DE – Germany, DK – Denmark, NL – Netherlands, UK – United Kingdom
HR – highest residue, MRL – Maximum Residue Level, ARfD – Acute Reference Dose, LP – large portion, VF – variability factor, IESTI – International Estimated Short Time Intake, HQ – Hazard Quotient

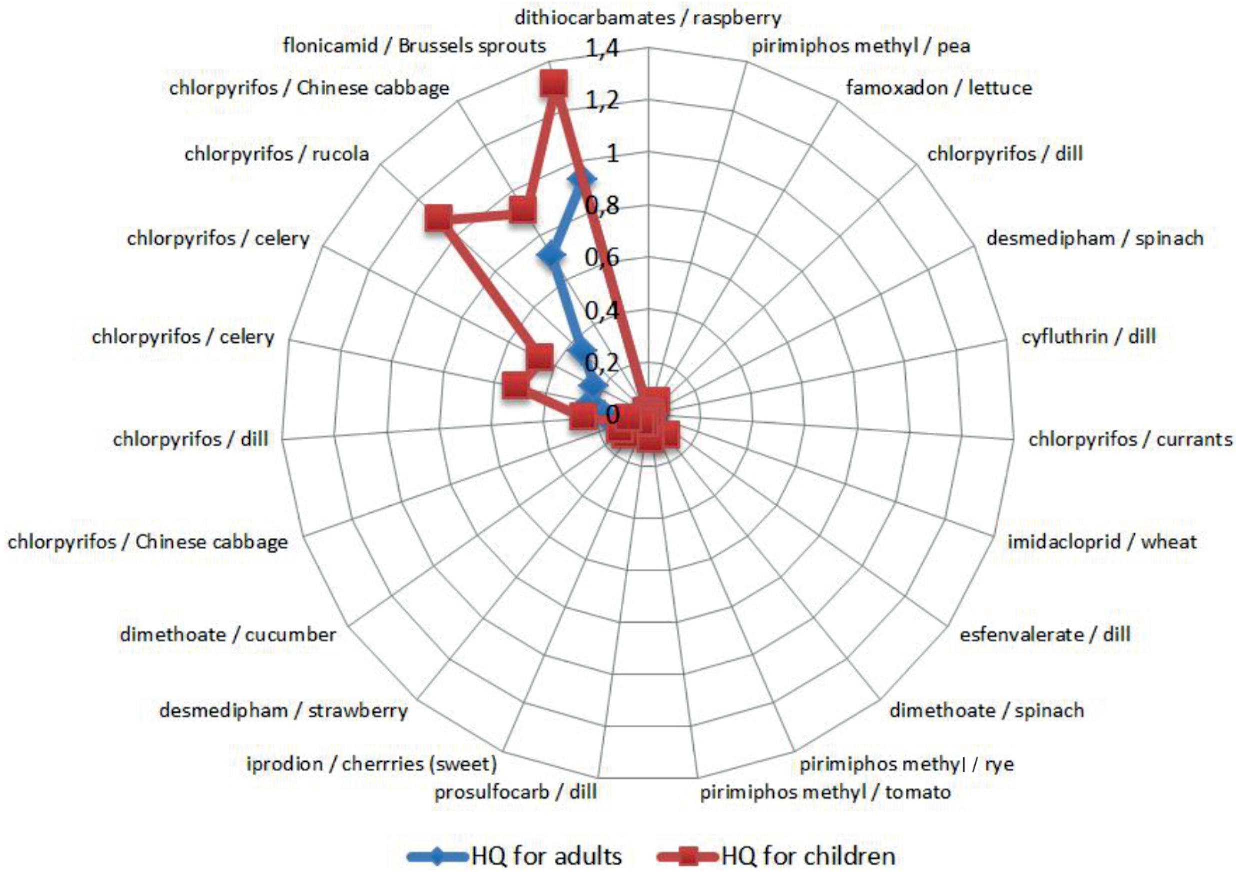


**Fig. 2.** Hazard Quotient presented for combination pesticide/commodity for children and adults

of rucola with chlorpyrifos (108.1% ARfD, HQ = 1.1) (Table 2). The exceedances of the HQ can be explained by the much lower body weight of children, up to seven times, than of adults.

Nevertheless, the EFSA PRiMo model uses the most critical diet to estimate short-term exposure, which includes other diets that lead to lower exposure. This method realistically overestimates the exposure by estimating the theoretical maximum residue dose for adults and children collected in the entire EU population because it uses large portion that is the 97.5 percentile of the reported consumption distribution.

Having considered the above, it can be concluded that no products were found whose consumption could have negative health effects resulting from the presence of pesticide residues during a 5-year survey. It is in line with EFSA considerations (EFSA 2020) about acute risk assessments based on the deterministic screening method that the limited number of exceedances of the ARfD (1.4% of samples) would not likely pose concerns for adults and children.

Based on the data received, it was estimated that the presence of pesticide residues in fruit, vegetable and cereal samples from Poland poses a low risk of exposure to consumer health and is not a cause for concern.

## Conclusions

The assessment of the risk of exposure to pesticide residues for the health of adults and children related to the consumption of fruits and vegetables was based on the EFSA PRIMo model with embedded consumption data based on a "worst-case" scenario considering a high level of consumption in combination with the highest observed residue level. The short-term exposure calculation of the adult and child sub-populations showed that in some cases the exposure exceeded toxicological limits (HQ>) and could pose a risk to the health of consumers. However, such critical ingestions seem very improbable. Nevertheless, using an approach that overestimates the exposure due to the use of a worst-case scenario ensures that the results of the risk assessment take into consideration the broadest possible margin of consumers' safety and guarantees their healthcare.

Thus, continuous pesticide monitoring is suggested especially in minor crops where there is a problem with plant protection. Special attention needs to be paid to agricultural plants with the non-authorized organophospate insectide chlorpyrifos.

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