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Evaluation of pesticide residues in fruits and vegetables from the region of south-eastern Poland

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A B S T R A C T

According to the World Health Organization, consumption of fruit and vegetables in Europe constituted over 30% of consumer diet. Fruits and vegetables are good sources of vitamins, minerals, fibre, and antioxidants. Besides their nutrient value, these products can be a source of toxic substances i.e. pesticide residues. The aim of this study was to determine the presence of pesticide residues in Polish fruits and vegetables and to assess if these residues pose a risk to the health of the consumer. Furthermore, compliance with legal regulations concerning the use of plant protection products in crop cultivation was ascertained.

In 2010–2012, 1026 unprocessed samples of fruits and vegetables were analysed. Pesticide residues were found in 376 samples (36.6% of tested samples). In 18 samples (1.8%), residues exceeded Maximum Residue Limits. In 28 (2.7%) samples, substances not recommended for a given crop were detected.

The highest values of long-term exposure were found for dimethoate residue in apples (1.7% ADI, adults; 6.8% ADI, children). For most detected pesticides, long-term exposures were below the values of 1% ADI for adults and 3% ADI for children.

The highest values of short-term exposure were obtained in the case of consumption of apples with azoxystrobin (4.5% ARfD, adults; 13.3% ARfD, children).

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1. Introduction

According to the World Health Organization (WHO), consumption of fruit and vegetables in Europe constituted over 30% of consumer diet (WHO, 2012). Fruits and vegetables are good sources of vitamins, minerals, fibre, and antioxidants. Besides their nutrient value, these products can be a source of toxic substances i.e. pesticide residues. Because fruit and vegetables are treated indirectly with plant protection products and are mainly eaten unprocessed, they are the main source of pesticide residue intake for humans. Human intake of toxic substances due to pesticide residues in food commodities can be much higher than intake of these substances related to water consumption and air inhalation (Juraske, Antón, Castells, & Huijbregts, 2007). It is very important to monitor such contaminants in food and to assess if they pose a risk to human health.

In Poland, the supervision of the proper regulatory compliance in the use of plant protection products is led by the State Plant Health and Seed Inspection Service on behalf of the Ministry of Agriculture and Rural Development. As part of this supervision, monitoring of pesticide residues in agricultural crops is conducted every year, over the course of which analyses are conducted, inter alia, by the Laboratory of Pesticide Residue Analysis in Rzeszow. In addition, the Laboratory performs analyzes for commercial companies.

The aim of this study was to determine the presence of pesticide residues in Polish fruits and vegetables and to assess if these residues pose a risk to the health of the consumer. Furthermore, compliance with legal regulations concerning the use of plant protection products in crop cultivation was ascertained.

2. Materials and methods

2.1. Determination of pesticide residues

In 2010–2012, 1026 unprocessed samples of fruits and vegetables from south-eastern Poland were tested in the laboratory.

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Samples were obtained during an official inspection of pesticide residues conducted on behalf of the Ministry of Agriculture and Rural Development, implemented in cooperation with the regional Inspectorates of Plant Health and Seed Inspection. Besides the national inspection programme, the laboratory has conducted monitoring analyses of pesticide residues in food of plant origin destined for export and for regional consumption.

The tests covered the determination of pesticides, from 138 in 2010 to 167 in 2012 (Table 1). Methods accredited by the Polish Centre for Accreditation were used to determine the presence of pesticide residues (ISO/IEC 17025:2005, 2005, pp. 67). The multi-residue analytical method was based on the extraction of residues with an organic solvent and further purification of the extract using column chromatography (Grzegorzak et al., 2012). Quantification of residues was carried out with Agilent 6890 and Agilent 7890 gas chromatographs, each equipped with ECD and NPD detectors. Along with the multi-residue method, spectrophotometric determination of dithiocarbamate residues expressed in mg CS_2/kg and thin layer chromatographic determination of benzimidazoles expressed as carbendazim residues were carried out (Chmiel, 1979; Murawska, 1980). Certified standards of active substances were used (Ehrenstorfer, Germany). Test results were confirmed in accordance with European Commission guidelines (Document SANCO, 2011, pp. 40).

2.2. Evaluation of pesticide residues

The obtained results were compared with the Maximum Residue Limits (MRL) in force in both Poland and the European Union (Regulation, 2005). It was additionally verified whether the pesticide was recommended for use in a given crop.

2.3. Estimation of dietary exposure

According to Directive 396/2005, the lifetime exposure, and where appropriate, the acute exposure of consumers to pesticide residues in food products should be evaluated in accordance with Community procedures and practices, with consideration of the guidelines published by the WHO (Regulation, 2005).

Dietary exposure assessment combines food consumption data with data on the concentration of chemicals in food. The resulting dietary exposure estimate may then be compared with the relevant health-based guidance value for the food chemical of concern, if available, as part of the risk characterization. Assessments may be undertaken for acute or chronic exposures, where acute exposure covers a period of up to 24 h and long-term exposure covers average daily exposure over the entire lifetime (FAO/WHO, 2009).

WHO templates, containing food consumption data, were used for dietary exposure assessments (WHO templates, 2011; WHO templates, 2012).

International Estimated Daily Intakes (IEDI) were calculated according to equation (1) and were then compared to Acceptable Daily Intakes (ADIs).

$$\text{IEDI} = \sum \frac{\text{Food chemical concetration} \times \text{Food consumption}}{\text{Body weight}} \quad (1)$$

For an acute exposure assessment, additional information is required on residues in single samples or individual unit crops. If such detailed data are not available, concentrations in single samples can also be derived from composite samples taken from a lot by applying a variability factor to take into account the differences in chemical concentrations in sample increments or unit crops. Calculations of the acute dietary exposure differ depending on different cases. Case 1 is the simple case where the residue in a composite sample reflects the residue level in a meal-sized portion of the commodity. Case 2 is the situation where the meal-sized portion as a single fruit or vegetable unit might have a higher residue content than a composite portion. Case 2 is further divided into case 2a and case 2b, where the unit size is less than or greater than the large portion (LP) size, respectively (FAO/WHO, 2009).

Table 1
Scope of analysis.

Group	Active substance
Insecticides	acetamiprid (0.05), acrinathrin (0.01), aldrin (0.01), alpha-cypermethrin (0.01), azinophos-ethyl (0.01), azinophos-methyl (0.05), beta-cyfluthrin (0.01), bifenthrin (0.01), bromophos-ethyl (0.01), bromophos-methyl (0.01), bromopropylate (0.01), buprofezin (0.01), cadusafos (0.01), carbaryl (0.02), carbofuran (0.02), chlorfenvinphos (0.01), chlorpyrifos (0.01), chlorpyrifos-methyl (0.01), cyfluthrin (0.01), cypermethrin (0.01), p,p'-DDD (0.01), p,p'-DDE (0.01), o,p'-DDT (0.01), p,p'-DDT (0.01), deltamethrin (0.02), diazinon (0.01), dichlorvos (0.01), dicofol (0.01), dieldrin (0.006), dimethoate (0.02), endosulfan alfa (0.01), endosulfan beta (0.01), endosulfan SO_2 (0.01), endrin (0.01), esfenvalerate (0.01), ethion (0.01), ethoprophos (0.01), fenazaquin (0.01), fenchlorphos (0.01), fenitrothion (0.01), fenpropathrin (0.01), fenthion (0.01), fenvalerate (0.01), fipronil (0.005), formothion (0.01), HCB (0.01), α-HCH (0.01), β-HCH (0.01), γ-HCH (lindane) (0.01), heptachlor (0.01), heptachlor-endo-epoxide (0.003), heptachlor-exo-epoxide (0.001), heptenophos (0.01), hexythiazox (0.01), indoxacarb (0.02), isofenphos (0.01), isofenphos-methyl (0.01), lambda-cyhalothrin (0.01), malathion (0.01), mecarbam (0.01), methacrifos (0.01), methidathion (0.01), methoxychlor (0.01), parathion-ethyl (0.01), parathion-methyl (0.01), permethrin (0.02), phosalone (0.01), phosmet (0.01), pirimicarb (0.01), pirimiphos-ethyl (0.01) pirimiphos-methyl (0.01), profenofos (0.01), propoxur (0.05), pyridaben (0.02), pyriproxyfen (0.02), quinalphos (0.01), tebufenpyrad (0.01), teflubenzuron (0.01), tetrachlorvinphos (0.01), tetradifon (0.01), triazophos (0.01), zeta-cypermethrin (0.01)
Fungicides	azaconazole (0.01), azoxystrobin (0.01), benalaxyl (0.05), bitertanol (0.05), boscalid (0.01), bromuconazole (0.01), bupirimate (0.01), captan (0.02), carbendazim[a] (0.05), chlorothalonil (0.01), cyproconazole (0.01), cyprodinil (0.02), dichlofluanid (0.01), dicloran (0.01), difenoconazole (0.01), dimethomorph (0.01), dimoxystrobin (0.01), diniconazole (0.01), diphenylamine (0.05), dithiocarbamates (mancozeb, maneb metiram propineb, thiram, zineb, ziram) (0.05), epoxiconazole (0.01), fenarimol (0.01), fenbuconazole (0.02), fenhexamid (0.05), fenpropimorph (0.02), fludioxonil (0.01), fluquinconazole (0.01), flusilazole (0.01), flutriafol (0.02), folpet (0.01), hexaconazole (0.01), imazalil (0.02), imibenconazole (0.01), iprodione (0.02), krezoxim-methyl (0.01), mepanipyrim (0.01), metalaxyl (0.01), metconazole (0.02), myclobutanil (0.01), oxadixyl (0.01), penconazole (0.01), pencycuron (0.05), picoxystrobin (0.01), prochloraz (0.01), procymidone (0.01), propiconazole (0.01), pyrazophos (0.01), pyrimethanil (0.01), quinoxyfen (0.01), quintozene (0.01), tebuconazole (0.02), tecnazene (0.01), tetraconazole (0.01), tolclofos-methyl (0.01), tolylfluanid (0.01), triadimefon (0.01), triadimenol (0.01), trifloxystrobin (0.01), vinclozolin (0.01), zoxamide (0.01)
Herbicides	acetochlor (0.01), atrazine (0.01), bromacil (0.01), chlorpropham (0.01), cyanazine (0.01), cyprazine (0.01), diflufenican (0.01), flurochloridone (0.01), lenacil (0.05), linuron (0.05), metribuzin (0.01), metazachlor (0.01), napropamide (0.05), nitrofen (0.01), oxyfluorfen (0.01), pendimethalin (0.02), prometryn (0.01), propachlor (0.01), propaquizafop (0.05), propazine (0.01), propham (0.02), propyzamide (0.01), simazine (0.01), trifluralin (0.01)
Growth retardant	paclobutrazol (0.01)

In brackets limits of quantification in mg/kg were given.
[a] Analysed only in apple and champignon samples.

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