Ministry of Environment of Denmark
Environmental Protection Agency

Survey and risk assessment of pesticides in cut flowers from non-EU countries

Survey of chemical substances in consumer products No. 195

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Summary and conclusion

Many cut flowers sold to consumers in Denmark are imported from countries outside the EU. Such flowers may contain pesticides that are not approved within the EU. Consumers can potentially be exposed to the pesticides and degradation products via skin adsorption and inhalation during flower handling. When flowers are disposed of as waste, pesticides and degradation products can potentially pose a risk to the environment.

The objective of this study is to assess the risk to consumer health and the environment from pesticide residues and degradation products in cut flowers imported from non-EU countries. More specifically, with this study the Danish Environmental Protection Agency aims at:

- Obtaining an overview of which pesticides can be present in three of the most popular flower species in Denmark which are imported from Kenya, Ecuador and Colombia
- Performing chemical analyses for pesticides in flowers purchased in Denmark
- Conducting a risk assessment for selected identified pesticides and degradation products to assess the risk to consumers and to the environment.

For the survey of pesticides in cut flowers, local producers of roses, chrysanthemums and carnations were interviewed in Columbia, Ecuador and Kenya. The countries Colombia, Ecuador and Kenya have been chosen in collaboration with the Danish Environmental Protection Agency, as these countries have a large production of cut flowers that are imported into the EU.

Six producers provided information on pesticide application in their productions. Amongst others, product names and/or active ingredients were reported by the producers. The survey showed that significant fractions of pesticides used by the producers are not approved for use within the EU (fractions of approved pesticides vary between 14% and 72% within the single productions).

A total of 60 different single-species flower bouquets were bought at a Danish whole sale flower market. A single flower from each bouquet was sent to laboratory analysis.

The pesticides carbendazim, propamocarb and fipronil were detected most often in the flower samples. The five pesticides with the highest maximum concentrations in specific flower samples were carbendazim, captan/THPI, propamocarb, formetanate and iprodione (maximum concentrations between 60 – 106 mg/kg). Thus, the most frequently detected pesticide carbendazim was also measured in the highest concentration. Propamocarb and ioprodione were also among the 15 most frequently detected pesticides, while captan and formetanate were detected less frequently.

Ten out of the approximately 90 substances detected in the chemical analyses were prioritized for inclusion in the risk assessment based on the hazard properties according to the CLP Regulation (Regulation (EC) No 1272/2008), low health-based reference values, long half-lives in the soil, “Not approved”-status under the Pesticides Regulation Regulation (EC) No 1107/2009, as well as high maximum concentrations and high detection frequency in the chemical analyses. The 10 priority pesticides are:

- Fipronil
- Thiaclopride
- Carbendazim
- Chlorpyrifos
- Indoxacarb
- Spirodiclofen
- Chlorothalonil
- Myclobutanil
- Triadimenol
- Iprodione

Current knowledge on physico-chemical properties, critical effects and relevant health-based reference values was summarised in the human health hazard assessment of these 10 prioritised substances.

The human health exposure assessment considered adult consumers regularly handling cut flowers used for decoration in their homes. Relevant exposure routes are via skin and inhalation. The exposure assessment follows ECHA guidance on consumer exposure. Dermal exposure estimates were calculated for all 10 prioritised pesticides following a conservative approach in selection of exposure parameters. The exposure estimates therefore present a worst-case. Inhalation exposure to the 10 prioritised pesticides was qualitatively low based on considerations about evaporation and volatility.

For the human health risk characterisation, the health-based reference values were compared with the exposure estimates and risk characterisation ratios (RCR) were calculated. All RCR were well below 1, meaning the risk can be assumed to be controlled (Table 1-1). For one substance, chlorpyrifos, a RCR could not be calculated due to lack of hazard data. Available data on hazardous effects and dermal uptake suggest a low risk based on a qualitative consideration. However, a risk from chlorpyrifos exposure in cut flowers cannot be entirely excluded.

It must be noted that exposure to pesticides from other sources, for example, imported vegetables and fruit is possible, but has not been considered within the scope of this project. Also, the current risk assessment does not take into account the combined exposure of different substances but assesses each pesticide separately.

TABEL 1-1 RCR values for the ten prioritised pesticides.

Pesticide	RCR value dermal exposure	RCR value Inhalation	Overall conclusion
Fipronil	0,070	Qualitative low	Acceptable risk as combined RCR is low
Thiacloprid	0,002	Qualitative low	Acceptable risk as combined RCR is low
Carbendazim	0,014	Qualitative low	Acceptable risk as combined RCR is low
Chlorpyrifos	Not available	Qualitative low	Not possible to evaluate the overall risks due to lack of genotoxic data
Indoxacarb	<0,001	Qualitative low	Acceptable risk as combined RCR is low
Spirodiclofen	0,003	Qualitative low	Acceptable risk as combined RCR is low
Chlorothalonil	0,005	Qualitative low	Acceptable risk as combined RCR is low
Myclobutanil	<0,001	Qualitative low	Acceptable risk as combined RCR is low
Triadimenol	<0,0001	Qualitative low	Acceptable risk as combined RCR is low
Iprodione	0,002	Qualitative low	Acceptable risk as combined RCR is low

For the environmental risk assessment, the potential risk towards groundwater and surface water was evaluated for the scenario of disposing the flowers in a composting heap in a private garden.

The Danish quality criteria is 0.1 µg/l for individual pesticides and 0.5 µg/l for the sum of pesticides in drinking water. Calculated concentrations of pesticides leached to a groundwater aquifer under worst case conditions are generally below the quality criteria and it is therefore assessed that leaching from the flowers does not pose a risk towards groundwater.

The concentration of pesticide leaching to surface water was calculated at <0.005 µg/l under worst-case conditions and was compared to available PNEC and EC_{50} concentrations for the pesticides. Based on the calculations and the assumptions applied, it is assessed that disposing of the cut flowers does not pose a risk towards surface water.

Abbreviations

ADI	Acceptable Daily Dntake
AF	Assessment Factor
ARfD	Acute Reference Dose
CLP	Classification, Labelling and Packaging
C&L	Classification and Labelling
bw	body weight
ECHA	European Chemicals Agency
FAO	Food and Agriculture Organisation of the United Nations
JMPR	Joint Meeting on Pesticide Residues
LOAEL	Lowest Observable Adverse Effect Level
MoA	Mode of Action
MRL	Maximum Residue Level
NOAEC	No Observed Adverse Effect Concentration
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
PoD	Point of departure
RfD	Reference Dose
STOT-RE	Specific Target Organ Toxicity – Repeated Exposure
STOT-SE	Specific Target Organ Toxicity – Single Exposure
UF	Uncertainty Factor = AF
OECD	Organisation for Economic Co-operation and Development
WHO	World Health Organisation

1. Introduction

This study is part of the Danish Environmental Protection Agency's program for surveys of chemicals in consumer products.

Pesticides are used in the production of cut flowers in order to prevent plant diseases and pests. As a large part of the cut flowers sold in Denmark are imported from countries outside the EU, these may contain pesticides that are not approved within the EU. These pesticides and their degradation products can potentially be harmful to both humans and the environment. Consumers can potentially be exposed to pesticides and degradation products via skin adsorption and inhalation during flower handling. When flowers are disposed of as waste, pesticides and degradation products can be released into the environment, where they can potentially pose a risk.

The objective of this study is to assess the risk to consumer health and the impact on the environment from pesticide residues and degradation products in cut flowers imported from non-EU countries. More specifically, with this study the Danish Environmental Protection Agency aims at:

- Obtaining an overview of which pesticides can be present in three of the most popular flower species in Denmark which are imported from Kenya, Ecuador and Colombia by means of a survey
- Performing chemical analyses for pesticides in flowers purchased in Denmark
- Conducting a risk assessment for selected identified pesticides and degradation products to assess the risk to consumers and to the environment.

The report is structured into 4 main chapters:

- Chapter 1 – Introduction
- Chapter 2 – Survey of pesticides in cut flowers: This chapter describes the data collection on pesticides from non-EU countries as well as the background for selection of certain flower-producing countries and certain flower species. Furthermore, the chapter describes the initial hazard assessment and provides an overview of the legislative landscape of pesticide residues in cut flowers. The information presented in this chapter thus provides the background for the selection of samples for analysis (Chapter 3) and the risk assessment (Chapter 4)
- Chapter 3 – Chemical analysis of pesticides: This chapter reports the results of detected pesticide residues in the flower samples and provides the exposure input data for the risk assessment (Chapter 4)
- Chapter 4 – Risk assessment: This chapter explains the reasoning of pesticide selection for the risk assessment, presents methods, results and limitations of the human health and environmental risk assessment as well as provides an overall conclusion on the risk assessment.

2. Survey of pesticides in cut flowers

2.1 Data collection from flower producers

2.1.1 Approach

In order to get an overview of which pesticides are used in countries outside the EU, local flower producers in Columbia, Ecuador and Kenya were interviewed. The countries Colombia, Ecuador and Kenya have been chosen in collaboration with the Danish Environmental Protection Agency, as these countries have a large production of cut flowers that are imported into the EU. A copy of the questionnaire used during interviews with the flower producers is attached as Appendix 1.

With respect to flower species, roses, chrysanthemums and carnations have been chosen as these three flower types are popular among Danish consumers. In addition, all three flower species are produced in the three selected countries. However, it has been shown that chrysanthemums sold in Denmark are largely imported from countries within the EU or produced in Denmark. Therefore, only chrysanthemums from Ecuador and not from the other countries have been included. Chrysanthemums from Ecuador are included, as flower producers expect an increasing import of this.

In collaboration with local consultants, selected producers were visited and relevant personnel interviewed. It has been chosen to use local consultants, as these understand both the language and local culture and could visit the flower producers and carry out face-to-face interviews, rather than having to collect data via online meetings or e-mails.

In Colombia, one producer has been visited. This producer produces both roses, carnations and chrysanthemums. In Ecuador, three producers were visited, where all three produce roses, and one farm also produces other species of flowers, including chrysanthemums. In Kenya, two flower producers were visited, both producing roses.

2.1.2 Information from the flower producers

The information from the flower producers was obtained using questionnaire interviews. The producers were asked for information regarding a) the company, b) pesticide use, c) flower production, and d) legislation regarding pesticide use. The information is summarized in Table 2-1 and below.

All producers state that pesticides are used to control insects and arachnids (aphids, thrips, spiders, mites), fungal diseases (e.g. powdery mildew, botrytis mold) and physiological disorders. Some producers also specifically mention nematodes and butterfly larvae as pests. One of the producers in Ecuador (Farm 2) also states that "white rust" (a mold-like microorganism related to brown algae) is being combatted in chrysanthemums. Several producers state that fungal diseases are the most common reason for the use of pesticides. All producers state that pesticides are used in all phases of the plant's life cycle and in all phases of flower production.

The producers from Kenya state that the flowers are harvested after 6 weeks of growth. After harvest, the roses are treated with pesticides, placed in the cold chain for 24 hours and exported the following day. One of the producers from Ecuador states that flowers must be placed for min. six hours in hydration before they can be exported. In general, information from all producers indicates that it is common practice to store the harvested flowers in cool hydration until they are exported the day after harvest.

The Ecuadorian producers experience it as a challenge when a pesticide loses approval in the EU, with no alternative products available. Farm 2 in Ecuador notes that there is knowledge of EU legislation, but that the production conditions are different in Ecuador and the EU, i.e. that there are fewer alternative means of control available in Ecuador and that pesticide product prices often are too high for alternative products, if any are available.

All manufacturers state that effects on humans and the environment are taken into account during the production and use of pesticide products. Information on whether both workers and consumers or only one of these groups are considered, is lacking.

TABEL 2-1. Summary of information obtained via questionnaires from flower producers

	Kenya Farm 1	Kenya Farm 2	Ecuador Farm 1	Ecuador Farm 2	Ecuador Farm 3	Colombia Farm 1
Company information						
Size of the company	22 ha 230 employees	26 ha 450 employees	14 ha 135 employees	43 ha 588 employees (distributed over 3 locations)	12 ha 130 employees	90 ha 1.100 employees
Production of roses	√	√	√	√	√	√
Production of chrysanthemum	-	-	-	√	-	√
Production of carnations	-	-	No information	No information	-	√
Production of other species	-	-	√	√	√	√
Production capacity (million stems) of roses, chrysanthemums, carnations	Roses 15	Roses 35	Roses 13	Roses 8,7 Chrysanthemum 22	Roses 10	Roses 20 Chrysanthemum 40 Carnations 25
Share of production for EU export (%)	Roses 100%	Roses 100%	Roses 29%	Roses 15% Chrysanthemum 6,8%	Roses approx. 20%	Roses 7,5% Chrysanthemum 5% Carnations 8,8%
Pesticide use and flower production						
In cultivar development of the flowers	No information	No information	√	No information	No information	√
In vegetative propagation	No information	No information	√	√	√	√
Before harvest	No information	√	√	√	√	√
After harvest (export preparation)	√	√	√ (biocides and bactericides)	√ (fungicides and insecticides)		√ (biocides and bactericides)
Decision criteria for choosing a pesticide product	Original products Efficiency	Combination of efficiency and price	The degree of attack by pests and diseases	Life stage of pest organism	Observed by rotation scheme	Approval status Price

	Kenya Farm 1	Kenya Farm 2	Ecuador Farm 1	Ecuador Farm 2	Ecuador Farm 3	Colombia Farm 1
	Price Approval status	Price Approval status		Approval status Price	Regulation in relation to FRAC and IRAC44	
Application method	On the whole plant	Cf. instructions for use of the product in question	Spray on selected parts of the plant depending on the pest	On selected parts of the plant depending on the pest	On selected parts of the plant depending on the pest	On the whole plant and surrounding soil
Dosage1	Cf. instructions for use of the product	Cf. instructions for use of the product	Cf. national guidelines	260 – 3.300 g/ha (dissolved in 1600-2200 L/ha)	300 - 2.000 g/ha (dissolved in 2.000- 2.500 L/ha)	500 - 3.000 g/ha (dissolved in approx 2.000 L/ha)
Relationship to pesticide regulation and legislation						
Is the use of pesticides influenced by national legislation?	Yes	Yes	No	Yes	Yes	Yes
Knowledge of EU regulation regarding pesticides in cut flowers?	Yes	Yes	Yes	Yes	Yes	Yes
Comply with EU regulation regarding pesticides in cut flowers or is compliance sought?2	Yes MPS certificate	Yes MPS A+ certificate Silver certificate	Yes	Yes	Compliance with EU rules is sought. The EU is not the biggest market	Yes
Which tools and procedures are used to comply with EU regulation?3	Daily inspection for signs of disease Insect traps Quality assurance through inspectors during packaging Compliance with national regulations Annual inspection of products by authorities	In-house team for sustainability and regulatory compliance IPM	External audits Search for alternative products	Check that only approved products are purchased	No information	Previously used products were replaced.

	Kenya Farm 1	Kenya Farm 2	Ecuador Farm 1	Ecuador Farm 2	Ecuador Farm 3	Colombia Farm 1
Barriers to compliance with EU regulation of pesticides in cut flowers?	High prices of pesticides	No information	Lack of alternatives when a used product is suspended in the EU	Availability of alternative products High prices for alternative products	Lack of alternatives if used products are banned in the EU	Export practice of cut flowers: Finding a single insect renders a large batch of flowers worthless

[1] In several of the questionnaires, misleading units (e.g. 0.5 g/ha or 2,000 kg/ha) were given on the doses. In these cases, quantities and units have been adjusted to common ranges.

[2] MPS - Milieu Project Sierteelt, Environmental certification with classifications A, B and C; Silver certificate issued by the Kenya Flower Council

[3] IPM – Integrated Pest Management

[4] FRAC - Fungicide Resistance Action Committee (https://www.frac.info/fungicide-resistance-management); IRAC - Insecticide Resistance Action Committee (https://irac-online.org/)

In the following section, the pesticides used by the surveyed flower producers in the three countries are presented. All pesticides are listed with their active substances, and at the same time it is indicated whether these are included in the selected analysis program and whether the pesticides are approved in the EU (according to entry in the EU Pesticide database[1]). When indicating whether the pesticides are approved in the EU or not, no account has been taken of the crop or differences between the Member States.

2.1.2.1 Colombia

As described above, personnel from a flower producer who produces both roses, chrysanthemums and carnations were interviewed in Colombia. From this interview, an inventory of pesticides used in production, but not the actual product names, was provided.

Pesticides used in the production of flowers are presented in Table 2-2.

TABEL 2-2. Pesticides used in the production of flowers at the producer in Colombia.

Type/group	Active ingredient	Analyzed for	Approved in the EU [1]
Insecticide	Carbaryl	-	Not approved
Insecticide	Chlorfenapyr	-	Not approved
Insecticide	Necotinoides (Acetamiprid)	√	Approved
Insecticide	Pyrazole	-	Not approved
Organophosphate insecticides	Parathion	-	Not approved
	Malathion		Approved
	Methyl parathion	-	Not approved
	Chlorpyrifos	√	Not approved
	Diazinon	-	Not approved
	Dichlorvos	-	Not approved
	Phosmet	-	Not approved
	Fenitrothion	-	Not approved
	Tetrachlorvinphos	-	Not approved
	Azamethiphos	-	Not approved
	Azinphos-methyl	-	Not approved
	Terbufos	-	Not approved
Insecticide	Dichloroallyloxy	-	Not listed
Insecticide	Phenylfluoromethyl	-	Not listed
Insecticide	Pyridyloxy	-	Not listed
Fungicide	Pyrimethanil	√	Approved
Fungicide	Izopirazam	-	Not listed

[1]Cf. entry in the EU Pesticides Database (2022)

As can be seen from the table, the manufacturer stated that 21 different pesticides are used. The analysis program chosen in this study includes 3 out of the 21 substances (14%).

2.1.2.2 Ecuador

As described above, personnel from three flower producers were interviewed in Ecuador, all of which produce roses, and one of which also produces chrysanthemums.

[1] https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en

Pesticides used in the production of roses are presented in Table 2-3.

TABEL 2-3 Pesticides used in the production of roses at the three surveyed producers.

Product	Pest	Active ingredient	Analyzed for	Approved in the EU
Switch	Botrytis	Fludioxonil	√	Approved
		Cyprodinil	-	Approved
Scala	Botrytis	Pyrimethanil	√	Approved
Convite	Botrytis	Fluazinam	-	Approved
Sanystar	Botrytis	Iminoctadine	-	Not approved
Mirage	Botrytis	Prochloraz	√	Not approved
Meltatox	Powdery mildew	Dodemorph	√	Approved
Vivando	Powdery mildew	Metrafenone	√	Approved
Bellkute	Powdery mildew	Iminoctadine	-	Not approved
Score	Powdery mildew	Difenoconazole	√	Approved
Solvit	Powdery mildew	Penconazole	√	Approved
		Fenpropidin	-	Approved
Revus	Peronospora	Mandipropami	-	Approved
Proton	Peronospora	Propamocarb	√	Approved
Ranman	Peronospora	Cyazofamid	-	Approved
Ehofin	Peronospora	Ethaboxam	-	Not approved
Zampro	Peronospora	Ametoctradin	-	Approved
		Dimethomorph	√	Approved
Tracer	Thrips and aphids	Spinosad	√	Approved
Epingle	Thrips and aphids	Pyriproxyfen	√	Approved
Match	Thrips and aphids	Lufenuron	√	Not approved
Sivanto	Thrips and aphids	Flupyradifurone	√	Approved
Decis	Thrips and aphids	Deltamethrin	√	Approved
Danisaraba	Mites	Cyflumetofen	-	Approved
Starmite	Mites	Cyenopyrafen	-	Not approved

As can be seen from the table, the manufacturers have stated that 22 different pesticide products containing 24 different pesticides are used (iminoctadine is contained in two pesticides). The analysis program chosen for this study (see section 3.1) includes 14 of the 24 substances (58%).

Pesticides used in the production of chrysanthemums are presented in Table 2-4.

TABLE 2-4 Pesticides used in chrysanthemum production at the respondent producer.

Product	Pest	Active ingredient	Analyzed for	Approved in the EU
Switch	Botrytis	Fludioxonil	√	Approved
		Cyprodinil	-	Approved
Scala	Botrytis	Pyrimethanil	√	Approved
Convite	Botrytis	Fluazinam	-	Approved
Sanystar	Botrytis	Iminoctadine	-	Not approved

Mirage	Botrytis	Prochloraz	√	Not approved
Alto 100	White rust	Cyproconazole	-	Not approved
Eclipse	White rust	Myclobutanil	√	Not approved
Dithane FMB	White rust	Mancozeb	-	Not approved
Authority	White rust	Azoxystrobin	√	Approved
		Flutriafol	√	Not approved
Sunjet	White rust	Izopirazam	-	Not listed
Tracer	Thrips and aphid	Spinosad	√	Approved
Epingle	Thrips and aphid	Pyriproxyfen	√	Approved
Match	Thrips and aphid	Lufenuron	√	Not approved
Sivanto	Thrips and aphid	Flupyradifurone	√	Approved
Decis	Thrips and aphid	Deltamethrin	-	Approved
Starmite	Mites	Cyenopyrafen	-	Not approved
Kanemite	Mites	Acequinocyl	-	Approved
Dicarzol	Mites	Formetanate	√	Approved
Danisaraba	Mites	Cyflumetofen	-	Approved
Pirate	Mites	Chlorfenapyr	-	Not approved

As can be seen from the table, the manufacturer has stated that 20 different pesticides are used, several of which are also used in the production of roses. The 20 pesticide products contain 22 different pesticides, where the analysis program includes 11 of the 22 substances (50%).

2.1.2.3 Kenya

As described above, two flower producers have been visited in Kenya, both producing roses. One producer has not answered which pesticides are used in production, and Table 2-5 therefore only presents pesticides used in one producer's production.

Table 2-5. Pesticides used in the production of roses at the producer surveyed.

Product	Type	Active ingredient	Analyzed for	Approved in the EU
Chorus	Fungicide	Cyprodinil	√	Approved
Acrobat	Fungicide	Dimethomorph	√	Approved
		Mancozeb	-	Not approved
Ridomil Gold	Fungicide	Metalaxyl-M	√	Approved
		Mancozeb	-	Not approved
Quiksil	Miticide	Organosilicone	-	Not identified[1]
Previcure Energy	Fungicide	Propamocarb	√	Approved
		Fosetyl	-	Approved
Spirox	Fungicide	Spiroxamine	√	Approved
Dynamec	Insecticide/ Miticide	Abamectin	-	Approved
Meltatox	Fungicide	Dodemorph acetate	√	Approved
Delegate	Insecticide	Spinetoram	-	Approved
Solvit	Fungicide	Fenpropidin	√	Approved
		Penconazole	√	Approved

TOG 6	"Pre-treatment"	Sodium Dichloro-isocyanurate (troclosene sodium)	-	Approved
Danisaraba	Miticide	Cyflumetofen	-	Approved
Karatezeon	Insecticide	Lambda-cyhaloth-rin	√	Approved
Match 050EC	Insecticide	Lufenuron	√	Not approved
Teldor	Fungicide	Fenhexamid	√	Approved
Splendor	Fungicide	Spiroxamine	√	Approved
Applaud	Insecticide	Buprofezin	√	Approved
Orthena	Insecticide	Acephate	√	Not approved
Dipnoy	Dipping Solution	Imidazole	-	Not listed[2]

[1]Uncertain identification of the active substance. The product is produced in Kenya (https://www.agrid-uka.com)

[2]Imidazole is used in the production of azol fungicides and is usually not defined as an active substance.

As can be seen from the table, the manufacturer has stated that 21 different products are used in flower production. The 18 pesticides contain 20 different pesticides (Mancozeb and Spiroxamine are contained in two pesticides), where the analysis program includes 14 of the 20 substances (70%).

2.1.3 Evaluation in relation to approved pesticides in the EU

Only three out of the 21 pesticides (14%) used in production by the Colombian producer are approved in the EU (of which malathion is only allowed in two of the Member States). In rose production in Ecuador, on the other hand, 72% of the declared pesticides are approved in the EU, while 55% of the declared pesticides in chrysanthemum production are approved for use in the EU. The figure for rose production in Kenya is slightly higher with 85% EU approved pesticides.

It is noted that the database is small (1-3 producers per country), and the information is uncertain, as it is based on producer information. Nothing general can therefore be inferred about the use of EU approved vs. unapproved pesticides in the three countries.

2.1.4 Evaluation of the selected analysis program

In the beginning of the study, an analysis program for pesticides was chosen in cooperation with the Danish Environmental Protection Agency. The information about which pesticides are used in flower production provides an indication of suitability of the selected pesticide analysis program, and the pesticides used by the producers are therefore compared to the pesticides comprised in the analysis program.

14-64% of the substances (Colombia 14%, Ecuador-Roses 58%; Ecuador-Chrysanthemum 50%; Kenya-Roses 70%) used by the surveyed producers in Ecuador and Kenya are included in the analysis program. These substances make up 69 substances out of the 98 substances in the analysis package - i.e. 78% of the substances included in the analysis package. In addition, the substances used in Columbia are not specifically disclosed by the producers interviewed, which is why these substances can easily be present in the cut flowers. Against this background and seen in the light of the available ressources for the analysis of pesticides in the flowers, the chosen analysis program is considered to be suitable for the project purpose.

2.2 Selection and purchase of flowers

2.2.1 Selection of flower species

Based on the preliminary project on pesticides in flowers (Johannesen & Jacobsen 2022) and in consultation with the Danish Environmental Protection Agency, it has been chosen to focus on roses, chrysanthemums and carnations produced in Colombia, Ecuador and Kenya in the present study.

2.2.2 Purchase and analysis of flowers

Cut flowers were bought at Copenhagen Market's flower department. The flowers were bought from wholesalers who supply larger supermarkets and flower shop chains, and who could document that the flowers originate from either Colombia, Ecuador or Kenya.

A bouquet of each species of flower was purchased, where a bouquet consists of 10 flowers. The flower samples, one from each bouquet, were carefully packed and sealed in packaging supplied by the analysis laboratory.

An overview of the number of purchased flowers that were sent for analysis can be seen in Table 2-6. A double determination was carried out on each sample, i.e. a total of 120 samples was analysed.

TABLE 2-6 Number of flower samples per species and origin for analysis

Flower species/ Country of origin	Colombia	Ecuador	Kenya	Total
Chrysanthemum	-	5	-	5
Carnations	10	5	10	25
Roses	10	10	10	30
Total	20	20	20	60

2.3 Initial hazard assessment

The objective of the initial hazard assessment was to get an overview of the hazardous potential of the pesticides comprised of this study as well as enable a prioritization of substances for the selection of pesticides to be assessed in the risk assessment (see section 4.1).

All substances comprised by the analysis program were looked up on ECHAs C&L inventory[2] and their harmonized classification was noted. For substances where a harmonized classification was not available, information from the notified classification, as well as information on health and environmental hazards as reported on the Pesticide Properties Database (PPDB, Lewis et al. 2016) was used. In addition, available information has been collected on health-based reference values (ADI, ARfD, AOEL) and half-lives for the pesticides. An example of collected information is shown in Table 2-7 below.

TABLE 2-7 Information collected for the pesticides in connection with the initial hazard screening for 4 pesticides as an example.

Active ingredient	Cas no.	Health hazard category	Hazard codes	Note (e.g. if harmonized classification is not available)	Environmental hazard category	Hazard codes	Note (e.g. if harmonized classification is not available)	ADI (mg kg^{-1} bw dag^{-1})	ARfD (mg kg^{-1} bw	AOEL (mg kg^{-1} bw dag^{-1})	DT50 soil (days)	DT50 water (days)
Carbendazim	10605-21-7	Skin Sens. 1 Muta. 1B Repr. 1B	H317 H340 H360FD	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	M=10 M(Chronic)=10	0.02	0.02	0.02	50	7.9
Propamocarb	24579-73-5	Acute Tox. 4	H302	Notified classification. Possible weak skin sensitizer; Possible endocrine-disrupting effects - Slight increase in aromatase activity and estrogen production (Lewis et al. 2016)	-	-	Terrestrial and aquatic ecotoxicity interpreted as low to moderate (Lewis et al. 2016)	0.29	1	0.29	14	-

[2] https://echa.europa.eu/da/information-on-chemicals/cl-inventory-database

Fipronil	120068-37-3	Acute Tox. 3 Acute Tox. 3 Acute Tox. 3 STOT RE 1	H301 H311 H331 H372	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	-	0.0002	0.009	0.0035	142	54
Acephate	30560-19-1	Acute Tox. 4 *	H302	-	-	-	-	0.03	0.1	-	3	-

2.4 Legislation on pesticides in cut flowers and consumer safety

Cut flowers and other flower products imported into the EU must comply with a number of provisions, including provisions in the Plant Health Regulation[3]. This regulation aims to limit plant pests whose introduction into the Union's territory would cause a risk to plant health in plant production, forests, natural areas and planted areas, natural ecosystems, ecosystem services and biodiversity.

These requirements provide a great incentive for flower producers outside the EU to use effective pesticides against plant pests before importing into the EU.
Below is an explanation of how the legislation protects consumers and the environment from risks associated with handling pesticide treated cut flowers imported from non-EU countries.

2.4.1 No EU limit values for pesticide residues in cut flowers

Within the borders of the EU, according to the Pesticides Regulation[4], pesticide active substances must be approved at EU level and included on the EU's positive list. In the approval process, it is assessed i.a. whether the active substance has a low risk for the environment and health. Pesticides in which the active substances are included must subsequently be authorised by the individual member states in which the pesticide is applied. The rules on approval of pesticide active substances under the Pesticide Regulation do not apply outside the EU's borders.
Cut flowers impotent from non-EU countries into EU may therefore be treated with pesticides that are not authorised for use in the EU.

EU legislation sets limit values for pesticide residues in or on vegetable and animal foods and feedstuffs[5]. The rules on limit values for pesticide residues also apply to food imported from countries outside the EU. The interest organization Danish Horticulture (Dansk Gartneri) stated in connection with the Danish Environmental Protection Agency's project, Survey of pesticides in flowers from countries outside the EU (Johannesen and Jacobsen, 2022), that some retailers with cut flowers in Europe set their own limit values for pesticide residues in cut flowers and carry out checks on these[6]. However, there are no statutory limit values for pesticide residues in products other than food and feed, such as e.g. cut flowers, as applicable EU legislation on pesticides[4] and Pesticide maximum residue levels[5] and chemicals (REACH regulation[7] and CLP regulation[8]) does not embrace pesticide residues in cut flowers.

2.4.2 Cut flowers must be safe for consumers to handle

Products containing or releasing substances that present a hazard or risk to human health or cause damage to the environment may be regulated and restricted on the basis of § 30 of the Danish Chemicals Act[9] unless EU regulations already provide for this. The REACH Regulation

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[3] Regulation (EU) 2016/2031 on protective measures against pests of plants

[4] Regulation (EU) 1107/2009 concerning the placing of plant protection products on the market

[5] Regulation (EU) 396/2005 on maximum residue levels of pesticides in or on food of plant and animal origin and feed

[6] Danish Environmental Protection Agency, Survey of pesticides in flowers from outside the EU – a pre-project, 2022, page 20, https://www2.mst.dk/Udgiv/publikationer/2022/02/978-87-7038-390-5.pdf

[7] Regulation (EU) 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

[8] Regulation (EU) 1272/2008 on classification, labelling and packaging of substances and mixtures

[9] Bekendtgørelse nr 6 af 04/01/2023 Bekendtgørelse af lov om kemikalier

constitutes the EU's general chemicals regulation, but it only applies to substances, mixtures and articles. According to the Ministry of the Environment, a cut flower cannot be regarded as 'an object which has been given a special shape, surface or design in the course of production' within the meaning of Article 3(3) of the REACH Regulation and therefore cannot be covered by the definition of an article. It is not appropriate to consider the flower as a substance or mixture.

§ 30 of the Chemicals Act can thus be used as a legal basis to lay down rules on pesticide residues on cut flowers, or to decide in the form of injunctions or prohibitions if, because of its content or the release of a particular substance, a product presents a danger or a risk to the health of consumers or causes harm to the environment, and the order or prohibition in question is necessary to protect against it. In addition, the Minister for the Environment may, on the basis of § 32a of the Chemicals Act, issue an order for revocation if, at the latest, there is a simultaneous ban on the sale or use of the substance, product or product under § 30 or § 38 of the Chemicals Act.

The powers in § 30 and 32 of the Chemicals Act have today been delegated to the Danish Environmental Protection Agency[10], and the Danish Chemical Inspection Service can therefore decide on injunctions and prohibitions directly following these provisions.

The Product Act[11] also applies generally to consumer products marketed in the EU. According to the Product Act, consumer products may be placed on the market only if they are safe and it is the distributor who is responsible for ensuring compliance with the Product Act for the specific products they place on the market. As a general rule, the Product Act covers any product intended for consumers which is not regulated or is only partially regulated elsewhere, including if not all the risks associated with the product are regulated by the special legislation. In this case, the inspection authority in the relevant area, e.g. the Danish Chemicals Inspection Service with regard to unregulated chemical risks, will be able to use the Product Act as a legal basis for enforcement.

Pesticide residues in cut flowers are not regulated elsewhere. Prima facie, the provisions of the Product Act could therefore be used as a legal basis for enforcement in relation to the protection of consumers against possible chemical risks associated with the handling of cut flowers treated with pesticides even if these pesticides have not been added to the flowers within the EU. However, the Danish Safety Technology Authority, which is the competent authority with regard to the Product Act, has informed the Ministry of the Environment that, in their immediate assessment, the Product Act cannot be applied because something that is grown and not produced, e.g. cut flowers, cannot be regarded as a product within the meaning of the Product Act.

It is a prerequisite for enforcement under the Chemicals Act that there is a professional risk assessment of the product or equivalent scientific assessment.

[10] Bekendtgørelse nr. 1514 af 25. juni 2021 – delegationsbekendtgørelsen, jf. delegationsbekendtgørelsens § 25, nr. 6-8 og 16.

[11] Lov nr. 799 af 09/06/2020 om produkter og markedsovervågning

3. Chemical analysis of pesticides

In the following section, analysis results are summarized in relation to how often the individual pesticides were found in the samples, and in which concentrations.

3.1 Selection of analysis program

Based on which pesticides were expected to be applied on the flower-producing countries outside the EU, the inclusion of pesticides that are not approved within the EU and the resources allocated to chemical analyses in this study, a pesticide analytical program as offered by the company Eurofins was chosen in cooperation with the Danish Environmental Protection Agency.

The analysis program consists of the quantitative pesticide analysis package PSP4A-2. Each sample is prepared from all parts of the cut flower (leaves, blossom, stem). PSP4A-2 uses liquid chromatography and gas chromatography (with mass spectrometry) to qualify and quantify pesticides in the samples. The analysis program comprises approximately 90 pesticides, including a few metabolites and/or degradation products.

3.2 Detected pesticides per country and flower species

3.2.1 Results

The complete table containing all pesticides results per country and flower species can be seen in Appendix 3.

All pesticides included in the analysis program were detected in the analyses of the flower samples. Some pesticides were only detected in a single sample, while others were detected in numerous samples. The 15 most frequently detected pesticides (as well as two breakdown products) per country are shown in Table 3-1. On the 20 samples from each country, a double determination was carried out, i.e., 40 analyzed samples per country.

Carbendazim, propamocarb and fipronil are most often detected in the samples. The number of detections of pesticides and degradation products is between 451 (Colombia) and 700 (Ecuador).

It is noted that the number of detections also contains the total number of certain pesticides, which are included both individually and as a sum in the analyses. These pesticides are therefore counted twice in the total number of pesticides[12].

[12] An example here is Fipronil. Fipronil appears both as a single substance and as a sum under "Fipronil (sum)" together with the breakdown product fipronil sulfone. However, Fipronil desulfinyl, which is also a breakdown product of Fipronil, is not included in "Fipronil (sum)".

Table 3-1 Most frequently detected pesticides and degradation products per country (number of detections)

Pesticide/degradation product	Approved in the EU *	Colombia (40 samples)	Ecuador (40 samples)	Kenya (40 samples)	Number of detections (out of 120 samples)
Carbendazim	No	33	23	22	78
Propamocarb (Sum of propamocarb and its salts)	Yes	14	28	26	68
Fipronil (sum)**	not relevant	19	23	18	60
Fipronil sulfon**	not relevant	19	21	18	58
Spiroxamine	yes	18	18	21	57
Pyrimethanil	yes	13	27	16	56
Fipronil	no	19	23	8	50
Fipronil desulfinyl**	not relevant	19	23	4	46
Cyhalothrin, lambda-(incl. Cyhalothrin, gamma-)	yes	19	10	16	45
Acephat	no	2	6	30	38
Iprodion	no	4	11	22	37
Dodemorph	yes	10	12	12	34
Methamidophos	no	-	6	28	34
Hexythiazox	yes	-	6	27	33
Acetamiprid	yes	22	-	10	32
Clofentezin	yes	-	2	30	32
Pyriproxyfen	yes	10	12	10	32
Fludioxonil	yes	9	13	6	28
Residual pesticides **	not relevant	221	436	253	910
Total		451	700	577	1728

* Cf. entry on the EU Pesticides Database (2022), "not relevant" means not listed in the database (degradation product).
** The analytical parameter mentioned is either a degradation product or denotes the sum of the pesticide and its degradation product(s).

The complete analytical report is due to its length not included in the present report, but is in the possession of the Danish EPA.

The 15 most frequently detected pesticides (plus two breakdown products) sorted per flower species are shown in Table 3-2. The number of detections is lowest for chrysanthemums (180), in the middle for carnations (683) and highest for roses (865). The proportion of the flower samples in which the relevant substance is found is indicated in % in brackets. It can be seen that all Chrysanthemum samples contained carbendazim, fipronil and fipronil degradation products. Carbendazim and spiroxamine were found in respectively 80 and 90% of all rose samples.

Table 3-2 Most frequently detected pesticides per flower species, number of detections (% flower samples with detection of the pesticide or breakdown product)

Pesticide	Chrysan-themum mum (10 samples)	Carnations (50 samples)	Rose (60 samples)	Number of detec-tions (out of 120 samples)
Carbendazim	10 (100%)	20 (40%)	48 (80%)	78 (65%)
Propamocarb (Sum of propamo-carb and its salts)	-	28 (56%)	40 (67%)	68 (57%)
Fipronil (sum)	10 (100%)	34 (68%)	16 (27%)	60 (50%)
Fipronil sulfon	10 (100%)	34 (68%)	14 (23%)	58 (48%)
Spiroxamine	-	3 (6%)	54 (90%)	57 (48%)
Pyrimethanil	-	26 (52%)	30 (50%)	56 (47%)
Fipronil	10 (100%)	24 (48%)	16 (27%)	50 (42%)
Fipronil desulfinyl	10 (100%)	22 (44%)	14 (23%)	46 (38%)
Cyhalothrin, lambda-(incl. Cyhalo-thrin, gamma-)	-	34 (68%)	11 (18%)	45 (38%)
Acephat	-	16 (32%)	22 (37%)	38 (32%)
Iprodion	-	10 (20%)	27 (45%)	37 (31%)
Dodemorph	-	-	34 (57%)	34 (28%)
Methamidophos	-	16 (32%)	18 (30%)	34 (28%)
Hexythiazox	-	20 (40%)	13 (22%)	33 (28%)
Acetamiprid	-	12 (24%)	20 (33%)	32 (27%)
Clofentezin	-	20 (40%)	12 (20%)	32 (27%)
Pyriproxyfen	-	20 (40%)	12 (20%)	32 (27%)
Fludioxonil	-	4 (8%)	24 (40%)	28 (23%)
Other pesticides	130	334	446	910
Total	180	683	865	1728

3.2.2 Discussion

When considering the number of detections between the countries (Table 3-1), it can be seen that there is reasonable agreement in which pesticides are detected most frequently in the samples from the three countries. In the count for Ecuador, samples from all 3 flower species are included, which is possibly the reason why the figure for Ecuador is slightly higher (700 rather than 577 and 451 in Kenya and Colombia, respectively). The data base for Kenya and Colombia is completely comparable (20 samples of roses and 20 samples of carnations), see Table 2-6. Methamidophos, hexythiazox and clofentezin are detected more frequently in samples from Kenya than in samples from Colombia, but the data base is too thin to draw general conclusions from it.

Five out of the 15 most frequently detected pesticides (plus two breakdown products) are not approved in the EU (carbendazim, fipronil, acephate, iprodione, methamidophos). The use of four out of these five has not been mentioned by the manufacturers (carbendazim, fipronil, iprodione, methamidophos, see section 2.1). The flower samples may not come from the same farms that were interviewed, and it is therefore not known whether the interviewed producers actually use these pesticides, have deliberately failed to mention these pesticides, or whether the person himself lacked knowledge that these pesticides are used.

Overall, the results indicate that there is no significant difference between which pesticides are used in production in the countries. It is noted that it is a qualitative assessment based on the numbers, and not based on statistical analysis of the results.

When considering the number of detections in the different flower species (Table 3-2), it can be seen that the number of detections is lowest for chrysanthemums (180), in between for carnations (683) and highest for roses (865). Note that the number of flower samples for each species is not the same. The numbers follow the same order as the number of samples included for each flower species and show that the more samples that are analyzed, the more different pesticides are detected. For chrysanthemums and roses, some pesticides are found in the vast majority (≥80%) of samples. It is possible that the use of these pesticides is particularly widespread in these flower species. However, it is also noted that too few samples were included in the provision to derive anything general.

Use of the fungicide dodemorph has been detected relatively frequently in roses (34 times, in 57% of the rose samples), but not found in the other two flower species. This is in accordance with the fact that the use of dodemorph is particularly linked to the cultivation of roses.

3.3 Concentrations in flower samples

3.3.1 Results

The measured concentrations are shown in Table 3-3 below. No distinction is made between different flower samples and double determination in the table. Pesticides are listed in the table by maximum values in descending order and only pesticides measured in maximum concentrations ≥ 1 mg/kg are included. For a full overview of all measured concentrations, see Appendix 2.3.

The five pesticides measured with the highest maximum concentrations are carbendazim, captan/THPI, propamocarb, formetanate and iprodione.

TABLE 3-3 Measured concentrations (mg/kg) of pesticides and degradation products in 120 flower samples, ranked by highest maximum value.

Pesticide	N	Average*	Min.	Max.
Carbendazim	78	13.98	0.022	106.0
Captan/THPI (Sum calculated as Captan)	22	33.46	2.000	85.5
Propamocarb (Sum of propamocarb and its salts, exp)	68	4.43	0.020	72.0
Formetanate	20	14.58	0.029	68.6
Iprodion	37	5.72	0.021	60.2
Captan	22	19.45	0.340	48.8
Chlorothalonil	12	13.70	0.030	33.7
Spiroxamine	57	6.97	0.020	25.4
Dodemorph	34	2.97	0.020	24.0
Thiabendazol	24	3.05	0.021	23.9
Tetrahydrophthalimide (THPI)	22	7.04	0.650	20.3
Spirodiclofen	27	3.67	0.021	20.1
Clofentezin	32	5.71	0.032	17.7
Azoxystrobin	21	2.16	0.024	15.4
Pyrimethanil	56	2.44	0.023	14.5
Prochloraz (total)	12	2.85	0.021	12.2
Acephat	38	1.96	0.029	10.2
Fludioxonil	28	1.60	0.020	8.9
Thiacloprid	10	1.95	0.022	8.4
Pyraclostrobin	16	2.27	0.027	7.7
BTS 44596	12	1.50	0.020	7.6
Cyprodinil	28	1.71	0.030	6.9
Chlorpyrifos (-ethyl)	10	3.72	1.800	6.0
Fipronil (sum)	60	1.64	0.020	6.0
Imidacloprid	20	0.68	0.020	5.9
Fipronil	50	1.71	0.020	5.8
Boscalid	20	0.57	0.021	4.9
Difenoconazol	14	1.12	0.025	4.9
Fluopicolid	12	0.80	0.027	4.2
Diflubenzuron	8	1.07	0.110	3.9
Flubendiamide	20	1.08	0.022	3.9

Pesticide	N	Average*	Min.	Max.
Cyhalothrin, lambda-(incl. Cyhalothrin, gamma-)	45	0.52	0.036	3.5
Sulfoxaflor	8	0.94	0.022	3.4
Pyrimidifen	4	1.33	0.047	3.2
Prochloraz	8	1.19	0.021	3.1
Tetraconazol	22	1.00	0.021	2.9
Methomyl	14	0.85	0.300	2.8
Spinosad (sum of spinosyn A and spinosyn D)	20	1.16	0.059	2.8
Spinosyn A	20	1.05	0.059	2.7
Teflubenzuron	20	0.86	0.023	2.6
Ethofenprox	2	2.40	2.300	2.5
Fenhexamid	6	0.77	0.020	2.4
Hexythiazox	33	0.47	0.024	2.4
BTS 44595	8	0.59	0.020	2.2
Methamidophos	34	0.84	0.043	2.2
Cyflumetofen	4	1.07	0.039	2.1
Pyriproxyfen	32	0.57	0.021	2.1
Carbofuran (sum)	2	1.85	1.800	1.9
Fipronil sulfon	58	0.23	0.021	1.8
Bupirimate	6	0.54	0.110	1.7
Dimethomorph	22	0.38	0.022	1.7
Indoxacarb (sum, R+S isomers)	16	0.36	0.042	1.7
Bifenazat	4	0.87	0.200	1.5
Clothianidin	14	0.27	0.020	1.5
Cypermethrin	10	0.43	0.180	1.5
Abamectin (sum of avermectin B1a, avermectin B1b)	6	1.08	0.540	1.4
Fenpropidin	16	0.46	0.026	1.3
Lufenuron	22	0.34	0.047	1.3
Methoxyfenozid	2	1.30	1.300	1.3
Tetradifon	2	1.20	1.100	1.3
Acetamiprid	32	0.40	0.020	1.2
Etoxazole	12	0.62	0.260	1.2
Avermectin B1b	6	0.86	0.380	1.1
Ethirimol	8	0.59	0.170	1.1
Carbofuran	2	0.96	0.920	1.0
Fipronil desulfinyl	46	0.25	0.022	1.0
Carbofuran, 3-hydroxy-	2	0.94	0.920	1.0

* The mean concentration indicates the arithmetic mean of all samples in which the pesticide or degradation product has been quantified (N). That means that samples with concentrations below the detection limit are not included in the average calculation.

3.3.2 Discussion

The most frequently detected pesticide carbendazim was also measured in the highest concentration with up to 106 mg/kg. Propamocarb and ioprodione are also among the 15 most frequently detected pesticides, while captan and formetanate were detected less frequently.

Regarding the selection of pesticides for the hazard assessment, the focus is on pesticides that have been measured in significant concentrations with a view to these being included in worst-case exposure assessments. Priority is given to pesticides that are quantified with maximum concentrations ≥ 1 mg/kg. The cut-off value of ≥ 1 mg/kg has been chosen arbitrarily, as it is estimated that lower concentrations will not result in exposures that cause health risks.

4. Risk assessment

4.1 Selection of pesticides for the risk assessment

4.1.1 Approach for the prioritization of pesticides for the hazard assessment

Some pesticides/degradation products are selected for a more thorough hazard assessment in order to assess the health and environmental risks associated with cut flowers from countries outside the EU. These substances are chosen so that they represent the worst case.

The following criteria are used to prioritize a substance in the hazard assessment:

1) Hazard properties, cf. the C&L database on ECHA's website
   a) Pesticides (and degradation products) which are classified as (known or suspected) mutagenic (H340, H341), carcinogenic (H350, H351), affecting reproduction (H360F/D, H361F/D, H362) or cause damage to organs after repeated exposure (H372 and/or H373). If no harmonized classification is available in the C&L database, the information from the notified classification is used.
   b) Pesticides (and degradation products) which have a harmonized classification as chronically toxic in the aquatic environment with the hazard statements H410, H411, H412, H413. The hazard statements from the notified classification are not used in the prioritization, both because of the uncertainty in the notified classifications and to focus on health effects in the selection of substances for the hazard assessment.

2) Reference values, cf. the PPDB database (Lewis et al. 2016)
   a) Pesticides (and degradation products) with the lowest health-based reference values (ADI or other RfD ≤0.05 mg/kg bw/day, corresponding to approximately half of all pesticides in the analysis package). If reference values are not available in the PPDB database, the values are looked up in the EU pesticide database.
   b) Pesticides (and breakdown products) with half-lives in the soil DT50 > 120 days

3) Non-approved pesticides in the EU, cf. entry in the EU Pesticides Database (2022)

4) Analysis results
   a) Pesticides and degradation products detected in the highest concentrations (maximum concentrations ≥ 1 mg/kg)
   b) Most frequently detected pesticides and degradation products (top 15)

As a starting point, the ten pesticides that meet the most criteria are selected. In case of missing overlap between the significant health and environmental hazard potential, five additional pesticides with prominent environmental hazard potential are selected.

4.1.2 Priority pesticides for the hazard assessment

Based on the screening of the pesticides, 10 pesticides/degradation products are prioritized which meet most of the criteria in terms of hazardous properties and occurrence in the analyzed flowers. Several substances meet the same number of criteria, and in these cases weight is given to whether they are approved in the EU, as well as according to the lowest ADI and highest DT50.

The 10 priority pesticides are:

- Fipronil
- Thiaclopride
- Carbendazim
- Chlorpyrifos
- Indoxacarb
- Spirodiclofen
- Chlorothalonil
- Myclobutanil
- Triadimenol
- Iprodione

These 10 priority pesticides are no longer approved in the EU.

The 10 prioritized substances have a harmonized classification and are included in the prioritization both because of their health and environmental classification, with chlorpyrifos as the only exception, as the substance does not have a health classification that triggers the prioritization. It is thus not required to select additional pesticides with prominent environmental hazard potential. The prioritized 10 substances and their hazard assessment profile are shown in Table 4-1 below.

The measured maximum concentration of triadimenol and myclobutanil is below 1 mg/kg, but both substances meet most other criteria, including that they are not approved in the EU, classification for health and environmental hazards and long (>120 days) decomposition times in the soil. The two substances are therefore included in the list of priority pesticides, cf. the method description in Section 4.1.1.

TABLE 4-1 The list of priority pesticides for the hazard assessment.

Active ingredient	Cas no.	Approved in the EU	Max concentration (mg/kg)	Number of detections in flower samples	Health hazard recategorization	Hazard code	Note (e.g. if harmonized classification is not available)	Environmental hazard category	Hazard codes	Note (e.g. if harmonized classification is not available)	ADI (mg kg⁻¹ bw dag⁻¹)	ARfD (mg kg⁻¹ bw day⁻¹)	DT50 soil (days)	DT50 water (days)
Fipronil	120068-37-3	No	5.8	50	Acute Tox. 3 Acute Tox. 3 Acute Tox. 3 STOT RE 1	H301 H311 H331 H372	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	-	0.0002	0.009	142	54
Thiacloprid	111988-49-9	No	8.4	10	Acute Tox. 3 Acute Tox. 4 STOT SE 3 Carc. 2 Repr. 1B	H301 H332 H336 H351 H360FD	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	-	0.01	0.03	0.88	1000
Carbendazim	10605-21-7	No	106	78	Skin Sens. 1 Muta. 1B Repr. 1B	H317 H340 H360FD	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	M=10 M(Chronic)=10	0.02	0.02	-	-
Chlorpyrifos	2921-88-2	No	6.0	10	Acute Tox. 3	H301	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	Substance is under assessment as PBT and POP1	0.001	0.005	386	5
Indoxacarb	173584-44-6	No	1.7	16	Acute Tox. 3 Acute Tox. 4 Skin Sens. 1 STOT RE 1 Repr. 2	H301 H332 H317 H373 (blod, nervesystem, hjerte) H361d	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	M=100 M(Chronic)=1	0.005	0.005	113.2	1.4

Active ingredient	Cas no.	Approved in the EU	Max concentration (mg/kg)	Number of detections in flower samples	Health hazard recategorization	Hazard code	Note (e.g. if harmonized classification is not available)	Environmental hazard category	Hazard codes	Note (e.g. if harmonized classification is not available)	ADI (mg kg⁻¹ bw dag⁻¹)	ARfD (mg kg⁻¹ bw day⁻¹)	DT50 soil (days)	DT50 water (days)
Spirodiclofen	148477-71-8	No	20.1	27	Skin Sens. 1B Carc. 1B STOT RE 2 Repr. 2	H317 H350 H373 H361f	-	Aquatic Chronic 1	H410	-	0.015	Not available	7	0.7
Chlorothalonil	1897-45-6	No	33.7	12	Eye Dam. 1 Skin Sens. 1 Acute Tox. 2 * STOT SE 3 Carc. 2	H318 H317 H330 H335 H351	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	-	0.015	0.05	3.53	0.82
Myclobutanil	88671-89-0	No	0.12	2	Acute Tox. 4 * Eye Irrit. 2 Repr. 2	H302 H319 H361d***	-	Aquatic Chronic 2	H411	-	0.025	0.31	560	12
Triadimenol	55219-65-3	No	0.03	2	Acute Tox. 4 Repr. 1B Lact.	H302 H360 H362	-	Aquatic Chronic 2	H411	-	0.05	0.05	250	53
Iprodione	36734-19-7	No	60.2	37	Carc. 2	H351	-	Aquatic Acute 1 Aquatic Chronic 1	H400 H410	-	0.06	-	36.2	2

[1] PBT substance - Persistent, Bioaccumulative and Toxic, POP – Persistent Organic substance, cf. ECHA Substance Infocard for chlorpyrifos.

4.2 Human health risk assessment

4.2.1 Hazard assessment

In this chapter, physico-chemical and hazard information needed for the risk assessment of the ten prioritised pesticides is presented.

A literature search was undertaken to identify the critical effects of each pesticide and relevant health-based reference values. The literature search focused on all health endpoints such as acute effects, repeated dose toxicity, genotoxicity, carcinogenicity, reproductive toxicity and neurotoxicity. A tiered strategy was undertaken where reference values were identified based on the following, in order:

- Availability of an acceptable daily intake (ADI) or tolerable daily intake (TDI) set by an authoritative body such as European Food Safety Authority (EFSA) or Joint FAO/WHO Expert Committee on Food Additives (JECFA).
- In the absence of an ADI/TDI being available, other guideline values representing safe exposure levels set by national authorities (e.g. reference dose (RfD) set by US Environmental Protection Agency) or derived no effect levels (DNEL) as specified by registrants under the EU REACH chemical regulation.
- In the absence of any of the above levels being available, a suitable point of departure (e.g. no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) for calculating a safe exposure level in the open literature.

For all 10 prioritised pesticides, a harmonised CLP classification is available, serving as a starting point for the hazard characterisation.

Pesticides with sensitizing and/or carcinogenic potential may exert their hazardous properties by a non-threshold mechanism. In such cases, it is often not possible to establish a safe level of exposure without any risk of the harmful effects. The risk assessment for non-threshold substances will be based on the determination of a DMEL value (Derived Minimal Effect Level), i.e. a level with an acceptable effect level.

4.2.1.1 Fipronil (CAS no. 120068-37-3)

Fipronil is an insecticide, for which approval in the EU expired in 2017. An overview of the physico-chemical properties is given in Table 4-2 below.

It has a harmonized classification under CLP for acute health effects following oral, dermal and inhalation exposure (Acute Tox. 3, H301, H311, H331), as well as a classification for specific organ toxicity upon repeated exposure (STOT RE 1, H372).

Health data and risk assessments are available from EFSA (2006) and USEPA (2020).

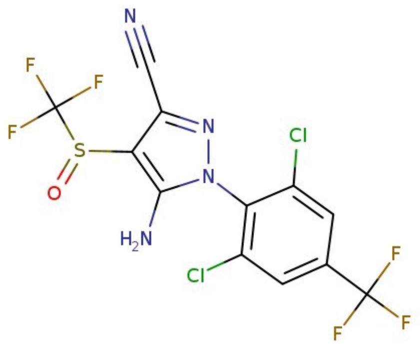
USEPA (2020) identified the nervous system, thyroid and liver as the primary mammalian targets of fipronil following oral exposure based on a multitude of responses in these tissues observed throughout the toxicity database. Fipronil did not exhibit mutagenic activity, however, chronic exposure elicited thyroid follicular cell tumours in male and female rats. Fipronil is classified as a possible human carcinogen (Group C) in the US (USEPA, 2020).

EFSA concluded that fipronil is toxic by oral, inhalation and dermal acute exposure. It is also slightly skin and eye irritating, and weakly sensitising, but not sufficiently for classification. No genotoxic or carcinogenic potential is recognized in the EFSA conclusion, as mechanism for observed tumour inductions were considered rat specific and not relevant to humans. Neither reproductive, developmental toxicity nor neurotoxicity was observed (EFSA, 2006).

The lowest available NOAEL applied in the risk assessments by EFSA (2006) and USEPA (2020) was derived from a rat carcinogenicity study with the value 0.02 mg/kg bw/day. This value was used as the point of departure (PoD) for assessing the risk from long-term oral, dermal and inhalation exposure (USEPA, 2020). Both authorities applied an overall uncertainty factor of 100, resulting in an ADI and a RfD of 0.0002 mg/kg bw/day.

With respect to acute exposure, EFSA concluded that an Acute Reference Dose (ARfD) should be derived from a developmental neurotoxicity study in the rat, with a developmental NOAEL of 0.9 mg/kg bw/day. This results in an ARfD of 0.009 mg/kg bw (EFSA, 2006). The reference value of 0.0002 mg/kg bw/day is taken forward for the risk calculation in the current assessment.

TABLE 4-2 Fipronil overview and toxicity data

Parameter	Description	Source
CAS	120068-37-3	PPDB
Pesticide group	Insecticide	PPDB
Structure		ECHA Substance Info-card
Chemical group	Phenylpyrazole	PPDB
Example pests controlled	Ants, Beetles, Cockroaches, Fleas, Termites, Thrips, Black vine weevil and other insects	
Examples of applications	Ornamentals, turf, maize, potatoes	PPDB, USEPA, 2020
Mode of action	Broad-spectrum with contact and stomach action. GABA-gated chloride channel antagonist.	PPDB
Octanol-water partition coefficient, log Kow	3,75 at 20 °C	PPDB
Solubility in water	3.78 mg/L at 20 °C	PPDB
Henry's Law Constant (interpretation)	2.31 X 10-4 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	0.002 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Acute Tox. 3* - H301 Acute Tox. 3* - H311 Acute Tox. 3* - H331 STOT RE 1 - H372 Aquatic Acute 1 - H400 Aquatic Chronic 1 - H410 M*=1000	ECHA C&L inventory

	M(Chronic)*=10000	
Reference value	ADI 0.0002 mg/kg bw/day ARfD of 0.009 mg/kg bw 0.0002 mg/kg bw/day (cRfD - chronic reference dose – all populations, and cPAD - chronic population adjusted dose – all populations, applicable for both inhalation and dermal exposure)	EFSA, 2006, USEPA, 2020

* M - The M-factor is a multiplying factor for substances that are highly toxic to aquatic environment, and is needed to account for highly toxic components when classifying a mixture.

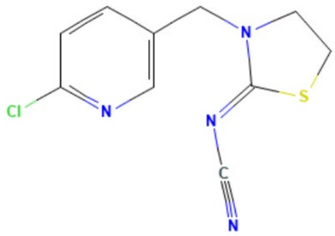
4.2.1.2 Thiacloprid (CAS no. 111988-49-9)

Thiacloprid is an insecticide, which belongs to the group of neonicotinoid insecticides. Its approval in the EU expired in 2020. An overview of the physico-chemical properties is given in Table 4-3 below.

Thiacloprid has a harmonized classification under CLP for acute health effects following oral and inhalation exposure (Acute Tox. 3, H301 and Acute Tox. 4, H332). It is classified with specific organ toxicity upon single expsoure (STOT SE 3, H336), as a suspected carcinogen (Carc. 2, H351) and may damage fertility/the unborn child (Repr. 1B, H360FD).

Short- and long-term toxicity studies are available for several mammalian organisms, i.e. rat, mouse, rabbit and dog. Thiacloprid showed target organ toxicity in the liver and carcinogenic effects were observed in both rats and mice (EFSA, 2019). Following the peer review of the risk assessments carried out by the competent authorities of the rapporteur Member State, EFSA concluded that an ADI of 0.01 mg/kg bw/day is relevant to apply in the risk assessment. The EFSA ADI is based on a NOAEL of 1.2 mg/kg bw/day for adverse liver histopathology and eye effects identified in a 2-year rat study and application of an uncertainty factor (UF) of 100.

TABEL 4-3 Thiacloprid overview and toxicity data

Parameter	Description	Source
CAS	111988-49-9	PPDB
Pesticide group	Insecticide	PPDB
Structure		PubChem (2023)
Chemical group	Neonicotinoid insecticide; Pyridylmethylamine neonicotinoid insecticide; Thiazolidine insecticide	PPDB
Example pests controlled	Aphids; Pollen beetles; Blossom midge; Codling moth; Wireworm; Fruit fly	
Examples of applications	Apples; Pears; Some citrus crops; Brussel sprouts; Cabbage; Cauliflower; Carrot; Parsnip; Peas; Potato; Oilseed rape	PPDB
Mode of action	Contact and stomach action with some systemic properties. Nicotinic acetylcholine receptor (nAChR) competitive modulator.	PPDB
Octanol-water partition coefficient, log Kow	1.26	PPDB

Solubility in water (interpretation)	184 mg/l (moderate)	PPDB
Henry's Law Constant (interpretation)	4.8 X 10-10 Pa m^3 mol^{-1} (Non-volatile)	PPDB
Vapour pressure (interpretation)	3.00 X 10-07 at 20 °C (mPa) (Low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Acute Tox. 3 H301 Acute Tox. 4 H332 STOT SE 3 H336 Carc. 2 H351 Repr. 1B H360FD Aquatic Acute 1 H400 Aquatic Chronic 1 H410 M=100 * M(Chronic)=100 *	ECHA C&L inventory
Reference value	ADI 0.01 mg/kg bw/day	EFSA, 2019

* M - The M-factor is a multiplying factor for substances that are highly toxic to aquatic environment, and is needed to account for highly toxic components when classifying a mixture.

4.2.1.3 Carbendazim (CAS no. 10605-21-7)

Carbendazim is a fungicide from the carbamate family. Its approval as pesticide in the EU expired in 2014. An overview of the physico-chemical properties is given in Table 4-4 below.

Carbendazim has a harmonized classification as a skin sensitizer (H317), as a possible mutagen (H340) and as a possible reprotoxin (H360FD).

The use of carbendazim has recently been evaluated in several product types under the Biocidal Products Regulation (EU) No 528/2012 (DE 2019) and the assessment reports are available from the German competent authority (e.g. DE 2019). EFSA evaluated carbendazim and published an opinion on the toxicological properties and maximum residue levels for carbendazim and the related substance thiophanate-methyl (EFSA, 2021).

In the assessment report by DE (2019), available data on health hazards are analysed and summarised. The target organs after repeated dose and chronic exposure to carbendazim are the liver and testes in mammals. The most sensitive species was the dog. A 2-year study in dogs revealed a NOAEL at 2.6 mg/kg bw/day based on hepatotoxicity at higher doses.

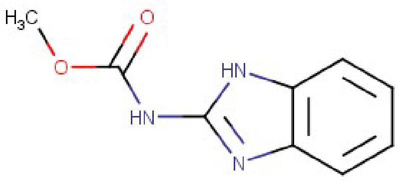
Developmental toxicity was observed in rats and rabbits with a NOAEL of 10 mg/kg bw/day at doses that were not maternally toxic. In these studies, teratogenicity (malformations) was confined to the highest dose level (90 mg/kg bw/day in rats, 125 mg/kg bw/day in rabbits) (DE 2019).

The authors regarded the NOAEL of 10 mg/kg bw/day derived from the developmental studies in rats and rabbits as the most relevant PoD for setting a systemic reference dose for long-term exposure. By using an assessment factor of 300 and assuming complete oral absorption (100 %), a long-term Acceptable Exposure Level (AEL long-term) of 0.03 mg/kg bw/day was proposed. This value is supported by the NOAEL of 2.6 mg/kg bw/d from the 2-yr study in dogs, from which an identical AEL would be derived using the default assessment factor of 100 (DE 2019).

Based on weight of evidence, similar toxicological effects of thiophanate-methyl and carbendazim, and a maternal and developmental toxicity study in the rabbit (NOAEL of 2 mg/kg bw/day, uncertainty factor of 100), EFSA (2021) concluded that there is no additional data that challenge previous conclusion as assessed by EFSA in 2010 and ECHA (referring to three assessment reports under BPR, hereunder DE 2019) and to maintain previous ADI and ARfD of carbendazim of 0.02 mg/kg bw/day, which is close to the conclusion in the assessment report by DE (2019).

The EFSA ADI of 0.02 mg/kg bw/day is taken forward as the health reference value in the current assessment.

TABLE 4-4 Carbendazim overview and toxicity data

Parameter	Description	Source
CAS	10605-21-7	PPDB
Pesticide group	Fungicide	PPDB
Structure		ECHA substance infocard
Chemical group	Benzimidazole fungicide; Carbamate fungicide	PPDB
Examples of pests controlled	Husk spot; Chocolate spot; Grey mould; Green mould; Crown rot	PPDB
Example applications	Beans; Macademia nuts; Lentils; Chickpeas; Strawberries; Sugarcane; Cereals	
Mode of action	Systemic with curative and protectant activity. Inhibition of mitosis and cell division (Beta-tubulin assembly in mitosis).	PPDB
Octanol-water partition coefficient, log Kow	1.48 at 20 °C	PPDB
Solubility in water (interpretation	8 mg/L at 20 °C (low)	PPDB
Henry's Law Constant (interpretation)	3.6 X 10-3 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	0.09 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Skin Sens. 1 - H317 Muta. 1B - H340 Repr. 1B - H360FD Aquatic Acute 1 - H400 Aquatic Chronic 1 - H410 M=10 * M(Chronic)=10 *	ECHA C&L inventory
Reference value	ADI and ARfD 0.02 mg/kg bw/ day.	EFSA, 2021
	long-term Acceptable Exposure Level (AELlong-term) 0.03 mg/kg bw/d	DE 2019

* M - The M-factor is a multiplying factor for substances that are highly toxic to aquatic environment and is needed to account for highly toxic components when classifying a mixture.

4.2.1.4 Chlorpyrifos (CAS no. 2921-88-2)

Chlorpyrifos is an insecticide, which belongs to the group of organophosphate insecticides. Its approval in the EU expired in 2020. An overview of the physico-chemical properties is given in Table 4-5 below.

Chlorpyrifos has a harmonized classification under CLP for acute health effects following oral exposure (Acute Tox. 3, H301). The European Commission also considers a classification of chlorpyrifos as toxic for reproduction, category 1B, H360D 'May damage the unborn child' as appropriate[13], based on the EFSA statement from 2019 (cited as EFSA, 2019a, see following paragraphs).

In 2014, in their conclusion on the peer review of the human health risk assessment, EFSA agreed on an ADI of 0.001 mg/kg/day, derived from NOAELs of a 2-year rat and dog studies and an UF of 100, based on the most sensitive endpoint; red blood cell cholinesterase inhibition. In the review, specific concerns on genotoxicity, endocrine disruption and developmental neurotoxicity related to insufficient data were highlighted (EFSA, 2014).

In 2019, EFSA (2019a) prepared a statement on the available outcomes of the human health assessment in the context of the pesticides peer review for the renewal of approval of the active substance chlorpyrifos (EFSA, 2019). EFSA states that the genotoxic potential of chlorpyrifos remains unclear, and therefore, toxicological reference values could not be established. Consequently, a risk assessment could not be conducted either.

EFSA also highlights uncertainties linked to a neurodevelopmental toxicity study, where effects were observed at the lowest dose tested in rats (decrease in cerebellum height corrected by brain weight). These concerns were supported by available epidemiological evidence related to developmental neurological outcomes in children. All the experts, except one, in the pesticides peer review agreed that the Point of Departure (PoD) for chlorpyrifos should be the neurodevelopmental toxicity LOAEL of 0.3 mg/kg. However, based on the overall assessment and specifically the lack of knowledge regarding the genotoxic potential, uncertainty factors and thus reference values could not be set. EFSA (2019a) concludes that the recorded toxicological effects meet the criteria for classification as toxic for reproduction category 1B (regarding developmental toxicity).

More recent literature on the genotoxic potential of chlorpyrifos has not been identified.

Based on the most recent EFSA assessment (2019a), an appropriate reference value could not be identified for chlorpyrifos, and a quantitative risk assessment can therefore not be performed in the current project. Instead, a qualitative comparison of available health and exposure data will be included.

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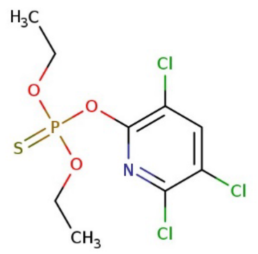
[13] [1] EC 2019: FINAL Renewal report for the active substance chlorpyrifos

TABLE 4-5 Chlorpyrifos overview and toxicity data

Parameter	Description	Source
CAS	2921-88-2	PPDB
Pesticide group	insecticide	PPDB
Structure		ECHA Substance Infocard
Chemical group	Organophosphate/organothiophosphate	PPDB
Example pests controlled	Scale; Wooly aphid; Leaf roller; Caterpillars; Corn earworm; Armyworm; Cutworms; Rootworms; Cockroaches; Flea beetles; Flies; Termites; Fire ants	
Examples of applications	Cereals including barley, wheat; Cotton; Fruit including apples, pears, grapes, pineapples, bananas, strawberries, mango; Tomatoes; Nuts; Vegetables including carrots, cabbages, cauliflower, Brussel sprouts	PPDB
Mode of action	Non-systemic with contact, inhalation and stomach action. Acetylcholinesterase (AChE) inhibitor.	PPDB
Octanol-water partition coefficient, log Kow	4.7 at 20 °C	PPDB
Solubility in water (interpretation)	1.05 mg/L at 20 °C (low)	PPDB
Henry's Law Constant (interpretation)	0.478 Pa m^3 mol^{-1} at 25 °C (moderately volatile)	PPDB
Vapour pressure (interpretation)	1.43 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Acute Tox. 3, H301 Aquatic Acute 1, H400 Aquatic Chronic 1, H410	ECHA C&L inventory
Reference value	ADI 0.001 mg/kg bw/day, derived from NOAELs ofa 2-year rat and a dog study, and an UF of 100, based on red blood cell cholinesterase inhibition.	EFSA, 2014
	Point of Departure (PoD) from the neurodevelopmental toxicity study, LOAEL of 0.3 mg/kg. Setting of reference value not possible mainly due to uncertainty regarding genotoxic potential.	EFSA, 2019a

4.2.1.5 Indoxacarb (CAS no. 173584-44-6)

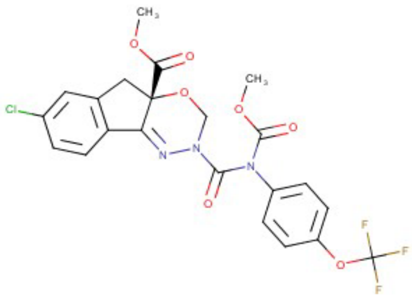
Indoxacarb is an oxadiazine insecticide whose approval in the EU expired in 2021. An overview of the physico-chemical properties is given in Table 4-6 below.

Indoxacarb has a harmonised classification with acute effects upon oral and inhalation exposure (Acute Tox. 3, H301 and Acute Tox. 4, H332), may act skin sensitizing (Skin Sens. 1B, H317) and shows organ toxicity (blood, nervous system, heart) upon repeated exposure (STOT RE 1, H372).

In 2018, EFSA published a conclusion on the peer review of indoxacarb in the framework of the renewal of the approval under the plant protection products regulation (EC) No 1107/2009. Based on a complete set of valid toxicity studies, EFSA concluded that indoxacarb is a skin sensitiser, is unlikely to be genotoxic, carcinogenic or to have endocrine disrupting properties. In the conclusion, EFSA (2018) proposed to lower the ADI from 0.006 mg/kg body weight/day to 0.005 mg/kg body weight /day, based on decreased maternal body weight gain in a two-year developmental rat study and an UF of 100.

The most recent EFSA ADI is taken forward as the health reference value in the current assessment.

TABLE 4-6 Indoxacarb overview and toxicity data

Parameter	Description	Source
CAS	173584-44-6	PPDB
Pesticide group	Insecticide	PPDB
Structure		ECHA Substance Infocard
Chemical group	Oxadiazine insecticide	PPDB
Example pests controlled	Beet armyworm, Fire ants; Cockroaches; Caterpillars	
Examples of applications	Cotton; Brassicas; Sweet corn; Lettuce; Fruiting vegetables; Fruit including apples, pears, cherries	PPDB
Mode of action	Contact and stomach action. Voltage-dependent sodium channel blocker.	PPDB
Octanol-water partition coefficient, log Kow	4.65 at 20 °C	PPDB
Solubility in water	0.2 mg/L at 20 °C (low)	PPDB
Henry's Law Constant (interpretation)	6.00 X 10-5 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	9.8 X 10-6 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Acute Tox. 3 - H301 Skin Sens. 1B - H317 Acute Tox. 4 - H332 STOT RE 1 - H372 Aquatic Acute 1 - H400	ECHA C&L inventory

	Aquatic Chronic 1 - H410 M*=1 M(Chronic)*=1	
Reference value	ADI 0.005 mg/kg bw/day	EFSA, 2018

* M - The M-factor is a multiplying factor for substances that are highly toxic to aquatic environment, and is needed to account for highly toxic components when classifying a mixture.

4.2.1.6 Spirodiclofen (CAS no. 148477-71-8)

Spirodiclofen is a tetronic acid insecticide whose approval in the EU expired in 2020. An overview of the physico-chemical properties is given in Table 4-7 below.

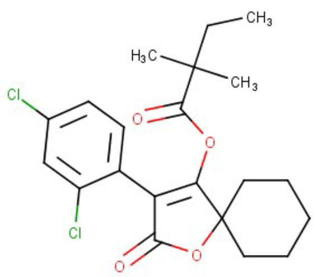
Spirodiclofen has a harmonized classification as a potential skin sensitizer (Skin Sens. 1B, H317), possible carcinogen (Carc. 1B, H350) and as a suspected reprotoxin (Repr. 2, H361f). It is also classified for organ toxicity upon repeated exposure (STOT RE 2, H373).

Spirodiclofen is a relatively new substance (first application for use in EU in 2002). In the framework of evaluating the substance, EFSA published an updated conclusion on the peer review including hazard assessment of the substance (EFSA, 2009).

EFSA (2009) concluded that spirodiclofen has no genotoxic, reproductive and developmental toxicity potential. The subchronic NOAEL for neurotoxicity is 70 mg/kg bw/day, while the chronic neurotoxicity NOAEL is 110 mg/kg bw/day. The established ADI is 0.015 mg/kg bw/day (100 safety factor applied) is based on a 1-year dog study with a 100 safety factor.

Several studies on acute toxic effects were available, but no effects were observed below 2000 mg/kg bw in an acute oral toxicity study in rat, neither were there any acute neurotoxic effects, embryotoxic or developmental effects at levels, which did not induce maternal toxicity. The allocation of an Acute Reference Dose (ARfD) was not considered necessary (EFSA, 2009).

TABLE 4-7 Spirodiclofen overview and toxicity data

Parameter	Description	Source
CAS	148477-71-8	PPDB
Pesticide group	Insecticide	PPDB
Structure		ECHA Substance Infocard
Chemical group	Tetronic acid insecticide	PPDB
Example pests controlled	Mites; Pear sucker; Scale insects; Earwigs; Aphids; Whitefly	
Examples of applications	Fruit including apple, pear, grape, peach, apricot, nectarine, orange, currants, citrus, berries; Tomatoes; Cucumber; Almonds; Coconut	PPDB

Mode of action	Selective, non-systemic, distrupts mite development. Inhibitor of acetyl CoA carboxylase.	PPDB
Octanol-water partition coefficient, log Kow	5.83 at 20 °C	PPDB
Solubility in water	0.05 mg/L at 20 °C (low)	PPDB
Henry's Law Constant (interpretation)	2.00 X 10-2 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	3.00 X 10-4 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification*	Skin Sens. 1B - H317 Carc. 1B - H350 Repr. 2 - H361f STOT RE 2 - H373 Aquatic Chronic 1 - H410 M(Chronic)*=10	ECHA C&L inventory
Reference value	ADI 0.015 mg/kg bw/day	EFSA, 2009

* M - The M-factor is a multiplying factor for substances that are highly toxic to aquatic environment, and is needed to account for highly toxic components when classifying a mixture.

4.2.1.7 Chlorothalonil (CAS no. 1897-45-6)

Chlorothalonil is a fungicide, which belongs to the group of chloronitrile fungicides. Its approval in the EU expired in 2019. An overview of the physico-chemical properties is given in Table 4-8 below.

Chlorothalonil has a harmonized classification under CLP as eye damaging (H318) and skin sensitizing substance (H317) as well as acute toxicity upon inhalation (H330) and specific organ toxicity following single exposure (H335). It is also classified as a suspected carcinogen (H351).

EFSA conducted a peer review of the pesticide risk assessment of chlorothalonil in 2018 (EFSA, 2018a). The experts concluded that the substance presents a low acute toxicity profile via oral or dermal exposure; however, chlorothalonil was shown to be very toxic if inhaled as reflected in the harmonised classification (Acute Tox. 2, H330 'Fatal if inhaled') and irritant to the respiratory tract (STOT SE 3, H335 'may cause respiratory irritation'). It may cause serious eye damage and allergic skin reactions (harmonised classification: Eye Dam. 1, H318 and Skin Sens. 1, H317); however, the peer review experts considered that a category 1A for skin sensitisation may be appropriate (EFSA, 2018a).

The main target organs of chlorothalonil upon short- and long-term exposure in rats and mice are the kidneys (preneoplastic and neoplastic lesions) and forestomach (also preneoplastic and neoplastic lesions, the latter being considered to be rodent-specific and of low relevance to humans) (EFSA, 2018a).

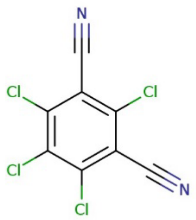
The majority of experts also concluded that given the fact that benign and malignant kidney tumours were observed in two species and two out of three independent studies in rats, that the human relevance could not be excluded. Thus, a classification as a category 1B (Carc. 1B, H350 'May cause cancer') may be appropriate (EFSA, 2018a).

For the risk assessment, a short-term NOAEL is 1.5 mg/kg bw/day from a 90-day rat study, and an overall long-term NOAEL of 1.8 mg/kg bw/day from a 26-month study in rats was considered as most relevant (EFSA, 2018a). The relevant NOAEL for carcinogenic effects were higher with 3.8 mg/kg bw/day in rats and 30.4 mg/kg bw/day in mice.

Chlorothalonil is unlikely to be genotoxic in vivo and insufficient evidence is available with respect to developmental toxicity. It is also unlikely to present endocrine-disrupting properties. Chlorothalonil did not present potential for neurotoxicity or immunotoxicity (EFSA, 2018a).

EFSA (2018a) concludes on an ADI of 0.015 mg/kg bw/day based on kidney toxicity with a NOAEL of 1.5 mg/kg bw/day from the 90-day study in rat and an ARfD of 0.05 mg/kg bw, based on a NOAEL for acute effects in a rabbit developmental toxicity study of 5 mg/kg bw/day for bw loss observed at the beginning of exposure at 10 mg/kg bw/day (100 UF applied).

TABLE 4-8 Chlorothalonil overview and toxicity data

Parameter	Description	Source
CAS	1897-45-6	PPDB
Pesticide group	Fungicide	PPDB
Structure		ECHA Substance Infocard
Chemical group	Chloronitrile	PPDB
Example pests controlled	Rust; purple spot; Leaf blight; Anthracnose; Downy mildew; Ring spot; Stalk rot; Botrytis rot; PodD & stem blight	
Examples of applications	Cereals; Vegetables including asparagus, beans, cabbage, cauliflower, broccoli, carrot, onions, celery, curcubits; Corn for seed; Fruit including cranberries, melon; Mushrooms; Peanuts; Potatoes	PPDB
Mode of action	Non-systemic, broad-spectrum, foliar action with some protectant properties. Acts by preventing spore germination and zoospore motility. Multi-site activity.	PPDB
Octanol-water partition coefficient, log Kow	2.94 at 20 °C	PPDB
Solubility in water	0.81 mg/L at 25 °C (low)	PPDB
Henry's Law Constant (interpretation)	2.5 X 10-2 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	0.076 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Skin Sens. 1 - H317 Eye Dam. 1 - H318 Acute Tox. 2* - H330 STOT SE 3 - H335	ECHA C&L inventory

	Carc. 2 - H351 Aquatic Acute 1 - H400 Aquatic Chronic 1 - H410 M=10 *	
Reference value	ADI 0.015 mg/kg bw/day ARfD of 0.05 mg/kg bw	EFSA, 2018a

* M - The M-factor is a multiplying factor for substances that are highly toxic to aquatic environment, and is needed to account for highly toxic components when classifying a mixture.

4.2.1.8 Myclobutanil (CAS no. 88671-89-0)

Myclobutanil is a fungicide, which belongs to the group of triazoles and conazoles pesticides. Its approval in the EU expired in 2021. An overview of the physico-chemical properties is given in Table 4-9 below.

Myclobutanil has a harmonized classification under CLP as eye irritating (Eye Irrit. 2, H319) and as acute toxic if swallowed (Acute Tox. 4, H302). It is also classified as reprotoxin, suspected of damaging the unborn child (Repr. 2, H361).

EFSA conducted a peer review of the pesticide risk assessment of myclobutanil in 2010 (EFSA, 2010a).

Acute toxicity studies in mammals led to the conclusion that myclobutanil should be classified as “Harmful if swallowed”. The substance was not toxic via dermal and inhalation routes, nor is it a skin irritant or a skin sensitiser. The already existing classification as eye irritating was considered not to be necessary (EFSA, 2010a).

The primary target organ following short-term exposure is the liver. An overall subchronic NOAEL of 3.09 mg/kg bw/day was proposed.

In long-term studies in rat, the target organ appeared to be the testes and the relevant NOAEL for long-term toxicity is 2.5 mg/kg bw/day from a rat study. In a two-generation rat study, myclobutanil, at a dietary concentration of 80 mg/kg bw/day produced reduced parental body weight and liver effects, and decreased weight gain in pups during lactation; at slight parental toxic doses the number of females delivering litters was reduced and the incidence of still-born pups increased. The relevant parental, offspring and reproductive NOAEL was 16 mg/kg bw/day.

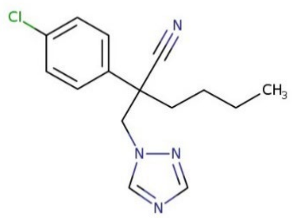
Fertility of females was not affected in a developmental rat study. However, clinical signs of toxicity were observed in dams and viability of foetuses was affected. The relevant parental NOAEL is 94 mg/kg bw/day, while the relevant developmental NOAEL is 31 mg/kg bw/day (EFSA, 2010a).

No indication of neurological effects was found in the toxicological studies. Myclobutanil does not show any genotoxic potential, nor any carcinogenic potential (EFSA, 2010a).

EFSA (2010a) concluded on an ADI is based on the relevant NOAEL from the long-term rat study, applying a safety factor of 100, resulting in an ADI of 0.025 mg/kg bw/day. The rat developmental toxicity study was considered as the most appropriate to use for setting the ARfD. The NOAEL of 31 mg/kg bw/day and an AF of 100 was used to propose ARfD is 0.31 mg/kg bw.

The ADI of 0.025 mg/kg bw/day is selected for the current risk assessment.

TABLE 4-9 Myclobutanil overview and toxicity data

Parameter	Description	Source
CAS	88671-89-0	PPDB
Pesticide group	Fungicide	PPDB
Structure		ECHA Substance Infocard
Chemical group	Triazole, conazole	PPDB
Example pests controlled		
Examples of applications	Perennial and annual crops; Turf; Landscape ornamentals; Fruit trees; Vines	PPDB
Mode of action	Broad spectrum, systemic with protective, eradicative and curative action. Disrupts membrane function by inhibiting sterol biosynthesis.	PPDB
Octanol-water partition coefficient, log Kow	2.89 at 20 °C	PPDB
Solubility in water	132 mg/L at 25 °C (moderate)	PPDB
Henry's Law Constant (interpretation)	4.33 X 10-4 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	0.198 mPa at 20 °C (low volatility)	PPDB
Boiling point	390.8 °C	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Acute Tox. 4* - H302 Eye Irrit. 2 - H319 Repr. 2 - H361d Aquatic Chronic 2 - H411	ECHA C&L inventory
Reference value	ADI 0.025 mg/kg bw/day ARfD is 0.31 mg/kg bw	EFSA, 2010a

4.2.1.9 Triadimenol (CAS no. 55219-65-3)

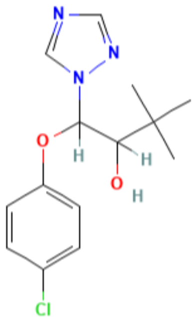
Triadimenol is a fungicide, which belongs to the class of triazoles. Its approval in EU expired in 2019 according to the information in EU Pesticides database. An overview of the physico-chemical properties is given in Table 4-10 below.

Triadimenol has a harmonized classification under CLP as acutely toxic via ingestion (Acute Tox. 4, H302), may damage fertility (Repr. 1B, H360) and may cause harm to breast-fed children (Lact., H362).

In 2008, EFSA (2008) concluded in their peer review of the pesticide risk assessment of triadimenol an ADI and a ARfD of 0.05 mg/kg bw/day, based on several different studies. The point of departure for derivation of ADI was a 2-year rat study with a NOAEL of 5 mg/kg bw/day together with an UF of 100. Effects on reproduction started to be seen at 15 mg/kg bw/day, and at 25 mg/kg bw/day developmental effects were seen. For acute toxicity endpoints such as neurotoxicity, the ARfD was earlier derived based on a NOAEL of 2 mg/kg bw/day by the expert body Joint Meeting on Pesticide Residues (JMPR) administered by FAO and WHO, but the large dosing in the study was taken into account in setting the EU ARfD and the overall NOAEL of 5 mg/kg bw/day and a UF of 100 was later used by EFSA (EFSA, 2015).

The ADI of 0.05 mg/kg bw/day was also used by EFSA in consumer risk assessment when reviewed the existing MRLs for triadimenol in 2016 (EFSA, 2016a). The EFSA ADI is taken forward as the health reference value in the current assessment.

TABLE 4-10 Triadimenol overview and toxicity data

Parameter	Description	Source
CAS	55219-65-3	PPDB
Pesticide group	Fungicide, Metabolite	PPDB
Structure		PubChem (2023)
Chemical group	Triazole, conazole	PPDB
Example pests controlled	Powdery mildew; Rusts; Bunts; Smuts; Eyespot	PPDB
Examples of applications	Cereals including wheat, rye, triticale, oats, barley; Beet crops; Brassicas; Grapes	PPDB
Mode of action	Selective with curative, protective and eradicant action. Disrupts membrane function. Sterol biosynthesis inhibitor.	PPDB
Octanol-water partition coefficient, log Kow	3.18 at 20 °C	PPDB
Solubility in water	72 mg/L at 25 °C (moderate)	PPDB
Henry's Law Constant (interpretation)	3.5 X 10-6 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	0.0005 mPa at 20 °C (low volatility)	PPDB
Boiling point	Decomposes before boiling	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Acute Tox. 4 - H302 Repr. 1B - H360 Lact. - H362 Aquatic Chronic 2 - H411	ECHA C&L inventory
Reference value	ADI 0.05 mg/kg bw/day ARfD 0.05 mg/kw bw/day	EFSA 2008

4.2.1.10 Iprodione (CAS no. 36734-19-7)

Iprodione is a fungicide belonging to the group dichlorophenyl/dicarboximides. Its approval in EU expired in 2017 according to the information in EU Pesticides database. An overview of the physico-chemical properties is given in Table 4-11 below.

Iprodione has a harmonized classification under CLP for suspected of causing cancer (Carc. 2, H351).

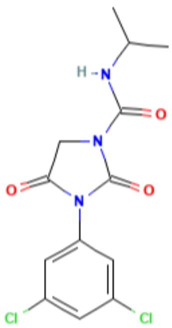
The substance has low acute toxicity when administered orally, dermally or by inhalation to rats. It is not a skin or eye irritant or a skin sensitiser. In the EFSA Conclusion on the peer review of the pesticide risk assessment of iprodione (EFSA, 2016b) new toxicological reference values were established. Some critical areas of concern were identified amongst others for mammalian toxicity where the peer review proposes a classification of iprodione as 'Carc. Cat. 1B (H350)' based on the tumours observed in several organs and in different species (interstitial Leydig cell tumours in rats and ovary luteomas, benign and malignant liver cell tumours in mice), as well as progression to malignancy in liver tumours (and possibly pituitary adenocarcinoma). There was also a potential for endocrine disruption of iprodione based on a plausible endocrine-mediated (antiandrogenic) mode of action.

During this peer review of data, the NOAEL of 6 mg/kg bw/day from the 2-year rat study was changed to a LOAEL. The ADI was therefore lowered from 0.06 mg/kg bw to 0.02 mg/kg bw applying an UF of 300, including an additional UF of 3 for using LOAEL as starting point. A new ARfD of 0.06 mg/kg bw was established which previously was not deemed necessary.

An ARfD was not set during the first review. The experts agreed that an ARfD was needed for iprodione on the basis of developmental toxicity seen in rabbits. The agreed ARfD is 0.06 mg/kg bw based on the LOAEL of 20 mg/kg bw/day. An additional UF of 3 to the standard 100 considering the use of a LOAEL was applied (EFSA, 2016b).

The EFSA ADI is taken forward as the health reference value in the current assessment.

TABLE 4-11 Iprodione overview and toxicity data

Parameter	Description	Source
CAS	36734-19-7	PPDB
Pesticide group	Fungicide	PPDB
Structure		PubChem (2023)
Chemical group	Dichlorophenyl/dicarboximide fungicide	PPDB
Example pests controlled	Botrytis, Minilia, Rhizoctonia, Sclerotinia - damping-off	
Examples of applications	Vegetables including carrots; Lettuce; Ornamentals; Fruit including apples, pears, plums, apricots and peaches; Root crops; Cotton; Sunflowers; Turf	PPDB

Mode of action	Contact action with protectant and some eradicant activity. Signal transduction inhibitor.	PPDB
Octanol-water partition coefficient, log Kow	3.0 at 20 °C	PPDB
Solubility in water	6.8 mg/L at 25 °C (low)	PPDB
Henry's Law Constant (interpretation)	7.0 X 10-6 Pa m^3 mol^{-1} at 25 °C (non-volatile)	PPDB
Vapour pressure (interpretation)	0.0005 mPa at 20 °C (low volatility)	PPDB
Boiling point	Data not available	PPDB
Approval status under Reg. (EC) No 1107/2009	Not approved	EU pesticides database
CLP classification	Carc. 2 - H351 Aquatic Acute 1 - H400 Aquatic Chronic 1 - H410	ECHA C&L inventory
Reference value	ADI 0.02 mg/kg bw/day ARfD 0.06 mg/kg bw/day	EFSA, 2016

4.2.2 Exposure assessment of consumers handling cut flowers

The scope of this project is to evaluate the potential health risks to adult consumers regularly handling cut flowers used for decoration in their homes. Variability in exposure may occur as a result of location of flowers in the home, activities within a location, socioeconomic status, consumer preferences, dietary habits and other lifestyle choices. A variety of individuals may live in the home and therefore for the purposes of the exposure assessment only the adult was included as they would be most likely to handle cut flowers in the home. Following the age category provided in the EFSA guidance on the assessment of exposure in risk assessment of plant protection products (EFSA, 2022), adults are defined as persons between 18-65 years of both genders.

Certain characteristics of individuals may place them at increased risk of adverse health effects associated with pesticide exposure. Exposure to pesticides during foetal development phase may contribute to developmental toxicity effects, however in this assessment the foetal developmental stage is not considered.

Relevant exposure routes for the consumers considered here are exposure via skin and inhalation to chemical residues from the cut flowers. The oral intake is disregarded as cut flowers are used for ornamental purpose only and there will be no ingestion of the product. There may be minimal oral exposure from hand to mouth activity. However, this route of exposure is not considered to contribute significantly to overall exposure.

Cut flowers may be available to consumers as single flowers, groups of the same type of flower, and/or a mixture of different flowers. While consumers may be exposed to flower bouquets that vary in size and composition, this project considers exposure to the highest detected concentration of each of the prioritised pesticides but without considering the combined exposure from the mixture of substances.

Duration of the exposure is likely to be a week as this is the expected life-time of a bouquet. However, since the reference values used in the risk assessment are based on daily uptake, the exposure per day is considered. The results from the exposure assessments are therefore considered to be worst-case scenario because days without exposure are not considered.

The exposure assessment will consider the main exposure routes, via skin and via inhalation, individually. The total exposure to pesticides from flowers will then be calculated as the sum of each of the two exposure routes for each of the relevant pesticide substances. None of the ten prioritized pesticides evaluated are any longer approved for use in EU. Exposure from other sources, for example, imported vegetables and fruit is possible, but such additional exposure is not considered within the scope of this project.

4.2.2.1 Dermal exposure of consumers

The general exposure scenario in focus for this project is based on the following realistic worst-case assumptions. Dermal exposure via skin contact will occur when arranging and re-arranging cut flowers to be put in a vase for decoration. It is assumed that the general public will not use personal protective equipment such as gloves when handling the flowers. The default values used for the dermal exposure scenario is based on the ECHA guidance on consumer exposure assessments where the scenarios for article use is considered representative for handling cut flowers (Table 4-12). The dermal dose (D_{der}) is calculated in the first tier of the exposure assessment based on the analytical results of the project, the parameters presented in Table 4-12 and using the below default equation (ECHA, 2016b).

$$D_{der} = \frac{C_{der} \times TH_{der} \times A_{skin} \times n}{BW}$$

In the first tier of the exposure assessment, the dermal dose is assuming 100% dermal absorption of the pesticides in contact with skin. This is an overestimation as substance specific dermal absorption rates were usually reported in the range of 1-20% in the EFSA peer reviews of the substances.

TABLE 4-12 Values used for the dermal consumer exposure scenario.

Parameter	Value used in dermal exposure assessment	Unit
C_{Der} Concentration of the analyzed substance in cut flowers	Based on results from chemical analysis	mg/cm^3
TH_{der} Thickness of product layer on skin	0.001 (for articles)	cm
A_{skin} Skin surface in contact with the article	420	cm^2
n Frequency of handling cut flowers	1	/day
BW Body weight	60	kg
D_{der} Dermal dose	Outcome of the exposure assessment - external dose	mg/kg$_{bw}$/d

Concentration of residue substances in cut flowers (C_{Der})

The concentration of residue substances (C_{Der}) available for exposure is calculated from the analysis of residual substances of the project. The analysed values are given in mg pesticide per kilogram cut flower in the report from the analytical laboratory. As the equation for dermal exposure is based on concentration (C_{Der}), i.e. amount of pesticide per volume, the analytical data was recalculated using the below equation. The calculations were based on the mean weight of all the flowers analyzed in the project and the estimated volumes of the cut flowers.

$$C_{Der} = \frac{Analyzed\ value\ \left[\frac{mg}{kg}\right] * Average\ flower\ weight\ [kg]}{Estimated\ flower\ volume\ [cm^3]}$$

Depending on the selected analytical method used, there is an uncertainty related to the analytical results. The whole flower (petals and stem) is processed and analyzed; therefore, the residue levels may be underestimated as the majority of the residue is expected to be situated on the surface of the flower.

Thickness of product layer on skin (*TH_{der}*)

In accordance with the ECHA guidance on consumer exposure, a default value of 0.001 cm is used to estimate the thickness of the substance layer on skin when calculating the dermal exposure for substances migrating from articles, i.e. cut flowers (ECHA, 2016b).

Skin area (*A_{skin}*)

When the general public is handling cut flowers, it is considered to be restricted to arranging and re-arranging them in a vase. When changing water, the stem of the flowers may be cut to stay fresh. The body parts in contact with the cut flowers will therefore be limited to the palms of the hands. The National Institute for Public Health and the Environment (RIVM) in the Netherlands has established a default value for the total surface area for two hands (back and front) to 840 cm^2. Based on this, this project is considering the skin area of the palms of two hands to be 420 cm^2 (RIVM, 2014). In this scenario the palms of the hands are therefore regarded as the main contact area, not considering any use of cut flowers for hair decoration or other less common uses.

Frequency of handling cut flowers (*n*)

The frequency of handling cut flowers is estimated to be once daily as a worst-case scenario, based on recommendations from florists to change water regularly.

Body weight of general consumer (*BW*)

To establish the exposed dose per body weight, a standard female body weight of 60 kg is used for adults, as specified in the ECHA's REACH guideline document, R.15 (ECHA, 2022b). This selection of body weight can be seen as a conservative approach for those individuals with a higher personal mass. According WorldData.info the average body weight in Denmark for males is 86.8 kg and for females is 70.2 kg (RIVM, 2014).

4.2.2.2 Inhalational exposure of consumers

Inhalation exposure may be relevant when keeping cut flowers in a vase indoors. Depending on the volatility of the different chemical substances applied to cut flowers by the producers, the inhalation of evaporated residue substances may be a relevant exposure route. Vapor pressure and Henry's Law Constant, H^{cp}_V (m^3Pa/mol) is therefore relevant to consider for the different substances. Henry's law Constant reflects the relative volatility of a particular substance and is relevant for the distribution from bodies of water (i.e. water in a wase). The substance specific Henry's Law Constant, H^{cp}_V, describes the partial pressure of a gas within a liquid and its concentration within that liquid (Sander et al, 2021). The H^{cp}_V constant can be derived by the following equation:

$$H_V^{cp} = \frac{Pressure\ (P_{gas})}{Amount\ concentration\ (C_{liquid})}$$

Chemical substances with high H^{cp}_V constants will volatilize from water into air and can be widely distributed. Chemical substances with low H^{cp}_V constant tend to persist in the water.

If these two physical/chemical parameters of the ten prioritised substances indicate they are volatile, exposure assessment for the inhalation route is developed. For the inhalational route of exposure some default values are used for the exposure assessments. These are presented in Table 4-13, and further explained below.

The inhalational exposure of consumers is based on the ECHA guidance on consumers exposure assessments, where the scenarios for article use is considered representative for handling cut flowers. The inhaled dose, D_{inh} is in the first tier of the exposure assessment calculated based on the analytical results, information from Table 4-13 and using the below default equation. (ECHA, 2016b)

$$D_{inh} = \frac{F_{resp} \times (Q_{prod} \times F_{Cprod}) \times 1000 \times IH_{air} \times T_{contact} \times n}{V_{room} \times BW}$$

TABLE 4-13 Values used for the inhalational consumer exposure scenario.

Parameter	Value used in inhalational exposure assessment	Unit
Q_{prod} Average weight of the flowers	31	g
F_{Cprod} Weight fraction of substance in cut flowers	Results from chemical analysis	g/g_{flower}
V_{room} Room size	20	m^3
F_{resp} Respirable fraction of inhaled substance	1	no unit
IH_{air} Inhalation rate of person	20	m^3/day
$T_{contact}$ Duration of contact per event	1	day
n Mean number of events per day	1	/day
BW Body weight	60	Kg
D_{inh} Inhaled dose	Outcome of the exposure assessment	mg/kg_{bw}*d

Flower weight and weight fraction (Q_{prod} and F_{Cprod})
Both the weight of the flower and the weight fraction of the substance was determined in the chemical analysis. As a worst-case scenario, it is assumed that the entire concentration of the analyzed chemicals in cut flowers will be released to the indoor air which will be inhaled by the consumer. This is called the complete release assumption in ECHA guidance document on consumer exposure.

Room size (V_{room})
The same reference document also defines a default room volume as 20 m^2 and no ventilation (ECHA, 2016b). This is in the same range as the information used by Danish Environmental Protection Agency for several assessments evaluating exposure in children's rooms. For those studies, room volume was set to 17.4 m^3 based on a floor area of 7 m^2 (RIVM, 2014).

Respirable fraction (F_{resp})
In the first tiered phase, 100-% absorption is considered when calculating the inhalation dose, as a worst-case scenario. The respirable fraction is therefore set to 1.

Inhalation rate (IH_{air})
The inhalation rate of an adult person is set to the default values presented by ECHA (ECHA, 2016b) that references RIVM (RIVM, 2014), which specifies an inhalation volume of 20 m^3/day for adults engaged in light exercise.

Duration ($T_{contact}$) and frequency of use (*n*)
Exposure is likely to be for a week as a worst-case scenario, although this is considered a conservative approach. As cut flowers at home may last for at least a week, the concentration of pesticides is expected to decline over time. Standard recommendations from florists are to change water in the vase and cut the stems of cut flowers regularly. As a worst case scenario, it is expected the bouquet is rearranged, i.e. handled every day, the duration of contact per day is set to one.

Body weight (*BW*)
In order to establish the exposed dose per body weight, a standard female body weight of 60 kg is used for adults, as specified in the ECHA's REACH guideline document, R.15. (ECHA, 2016b)

4.2.2.3 Exposure assessment of ten prioritized pesticides
The ten highest prioritized pesticide substances (section 4.1) were included in the hazard, exposure and risk assessment part. As presented in Chapter 3, both the maximum concentration and mean concentration of the analyzed pesticide substances are available. In the first-tier scenario, the maximum concentration values are used for the exposure assessment.

Several other parameters are used in the exposure assessment as well, as described in Table 4-12 and Table 4-13 above, many of which are standard exposure values set by authoritative bodies in the EU. The equation for dermal exposure is based on the concentration of the substance in the flower, presented as gram of pesticide per cm^3 of flower. This requires a re-calculation of the concentration results as they were presented in Chapter 3 (concentrations provided in mg/kg).

An estimation of the size of the flowers was obtained by measuring the area of flowers at the point of purchase. Measurement was undertaken using the mobile application "Petiole" which measures the flower area using a smartphone. Five flowers of each type were randomly selected and measured, 30 flowers in total, i.e. three sorts of roses, two sorts of carnations and one sort of chrysanthemums. The size of the flowers varied both within the same sort, but even more so when comparing the different types.

FIGURE 4-1 Photos of one carnation and three different types of roses from the study

The flowers consisted of two parts: the stem including leaves and the flower head. It was difficult to get adequate measurements of the stems, and data was only available for carnations. General assumptions of stem width and height was therefore used as basis for the determination. The stem of a flower was seen as the geometric equation of a cylinder, where *h* is the height and *r* is the radius of the flower stem:

$$Volume_{cylinder} = h * \pi * r^2$$

The mean values of the measured data on the flower head area were used to calculate their volumes using the geometrical equation of the area of a circle to determine the radius (*r*) of the flower head and then calculate the volume of a hemisphere shape:

$$Area_{circle} = \pi * r^2$$

$$Radius_{circle} = \sqrt{(\frac{Area}{\pi})}$$

$$Volume_{hemisphere} = (2/3) * \pi * r^3$$

The total volume of a flower was determined by adding the estimated volume of the stem with the calculated volumes of the flower head. In this way the area measurements of the flowers were used to determine the concentrations of the analyzed pesticides in the cut flowers.

TABLE 4-14 Average data on flower volumes divided on flower type and based on area measurements of 30 randomly selected flowers.

Flower species	Estimated stem height (cm)	Estimated stem width (cm)	Estimated stem volume (cm^3)	Average measured flower head area (cm^2)	Estimated flower head radius (cm)	Estimated flower head volume (cm^3)	Total average volume (cm^3)
Carnations (n=10)	40	0.5	7.9	37	3.4	82	90
Roses* (n=15)	40	0.5	7.9	134	6.5	575	583
Chrysanthemums* (n=5)	40	0.5	7.9	143	6.7	630	638

*No data available for the stem area of roses or chrysanthemums, hence an approximation of an average size flower was done.

From the data presented in Table 4-14, it can be seen that the volumes of the flowers vary from 90 cm^3 for carnations to 638 m^3 for chrysanthemums, i.e. more than 7 times. In the first tier calculations of the exposure estimation, the estimated volume of carnations is used as a worst case scenario, as they have the smallest volume. The concentration of the measured pesticides will therefore be comparatively higher when based on a generic size of a carnation compared to roses or chrysanthemums. As the equation used is based on the concentration of pesticides in flowers, it is independent of the size of the bouquet.

4.2.2.4 Dermal exposure assessment

Based on above mentioned standard input parameters, the assumptions of the size of the flowers, the substance specific analytical results and the physical-chemical data of the substance the potential consumer exposure of the pesticides via cut flowers were assessed.

An example of the exposure calculation is shown here with fipronil. Exposure via dermal contact with the cut flowers was assessed using the equations presented in section 4.2.2.1. Basis for the dermal exposure assessment calculations is the concentration of each of the pesticides, which is given in milligrams of pesticide per cubic centimetres of flower. Therefore, the dermal exposure will be independent of the number of flowers handled.

$$Exposure\ (D_{der}) = \frac{C_{der} \times TH_{der} \times A_{skin} \times n}{BW} = \frac{(Analyzed\ value\ [mg/kg] \times Average\ flower\ weight\ [kg] \times TH_{der}\ [cm] \times A_{skin}\ [cm^2] \times n\ [1/day]}{Volume\ of\ carnations\ [cm^3] \times body\ weight\ [kg]}$$

$$= \frac{5{,}8\ [mg/kg] \times 0{,}03 [kg] \times 0{,}001 [cm] \times 420\ [cm^2] \times 1 [1/day]}{90\ [cm^3] \times 60 [kg]} = 1{,}4 * 10^{-5}\ mg/kg\ bw\ per\ day$$

An overview of the calculated exposure estimates for all ten prioritised pesticides is given in Table 4-15.

TABLE 4-15 Dermal exposure estimates for the ten prioritised pesticides.

Pesticide	Dermal exposure dose (mg/kg bw/d)
Fipronil	$1,4*10^{-5}$
Thiacloprid	$2,0*10^{-5}$
Carbendazim	$2,6*10^{-4}$
Chlorpyrifos	$1,5*10^{-5}$
Indoxacarb	$4,1*10^{-6}$
Spirodiclofen	$4,8*10^{-5}$
Chlorothalonil	$8,1*10^{-5}$
Myclobutanil	$2,4*10^{-7}$
Triadimenol	$7,2*10^{-8}$
Iprodione	$1,5*10^{-4}$

4.2.2.5 Inhalation exposure assessment

Exposure to pesticide residues from the cut flowers via inhalation is dependent on the vaporisation rate of each of the substances. Substances with higher vapor pressure will vaporize more readily at a given temperature than substances with lower vapor pressure. Based on the definition in the EU Industrial Emissions Directive, substances with a vapour pressure of 0.01 kPa or lower at 20°C are regarded as non-volatile. For comparison, the vapour pressure for water at 20°C is 2.3 kPa. Based on the vapour pressure of the prioritized pesticides and that the typical conditions for keeping cut flowers indoor is at room temperature, the exposure via inhalation is considered to be insignificant, if the vapour pressure of the substance is below 0.01 kPa. In such cases, no substance specific exposure assessment for the inhalational route is performed. For example, the vapour pressure of fipronil is 0.002 mPa at 20 °C, which is below the cut-off value of 0.01 kPa. The calculation of an exposure estimate via the inhalational route is therefore not relevant.

Another source of pesticides in air may be potential evaporation of active substances from the water in the vase containing the cut flowers. It may therefore also be relevant to consider the Henry's Law Constant, H_V^{cp} (Pa*m^3/mol) for different substances, as it reflects the relative volatility of a particular substance from water. (Sander et al, 2021). Fipronil for example, the Henry's Law Constant, H_V^{cp} is 2.31 X 10^{-4} Pa m^3 mol^{-1} at 25 °C and the substance is therefore considered as non-volatile with low potential to evaporate. Chlorpyrifos on the other hand is moderately volatile as H_V^{cp} is 0.478 Pa m^3 mol^{-1} at 25 °C, but as the solubility in water is low, 1.05 mg/L at 20 °C, the amount of Chlorpyrifos leaching from the stems of the cut flowers is considered neglectable.

An overview of the inhalation exposure estimates for the ten prioritised pesticides is given in Table 4-16.

TABLE 4-16 Inhalation exposure estimates for the ten prioritised pesticides.

Pesticide	Inhalation exposure dose (mg/kg bw/d)	Note
Fipronil	-	Inhalation exposure assessment is not relevant due to low volatility Henry's Law Constant: 2,31*10^{-4} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 0,002 mPa at 20 °C
Thiacloprid	-	Inhalation exposure assessment is not relevant due to low volatility Henry's Law Constant: 4,8*10^{-10} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 3*10^{-7} mPa at 20 °C
Carbendazim	-	Inhalation exposure assessment is not relevant due to low to moderately volatility Henry's Law Constant: 3.6*10^{-3} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 0,09 mPa at 20 °C
Chlorpyrifos	-	Inhalation exposure assessment is not relevant due to low to moderately volatility Henry's Law Constant: 0,478 Pa m^3 mol^{-1} at 25 °C Vapour pressure: 1,43 mPa at 20 °C
Indoxacarb	-	Inhalation exposure assessment is not relevant due to low to moderately volatility Henry's Law Constant: 6,0*10^{-5} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 9,8*10^{-6} mPa at 20 °C
Spirodiclofen	-	Inhalation exposure assessment is not relevant due to low to moderately volatility Henry's Law Constant: 2,0*10^{-2} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 3,0*10^{-4} mPa at 20 °C
Chlorothalonil	-	Inhalation exposure assessment is not relevant due to low to moderately volatility Henry's Law Constant: 2,5*10^{-2} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 0,076 mPa at 20 °C
Myclobutanil	-	Inhalation exposure assessment is not relevant due to low to moderately volatility Henry's Law Constant: 4,33*10^{-4} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 0,198 mPa at 20 °C
Triadimenol	-	Inhalation exposure assessment is not relevant due to low volatility Henry's Law Constant: 3,5*10^{-6} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 0,0005 mPa at 20 °C
Iprodione	-	Inhalation exposure assessment is not relevant due to low volatility Henry's Law Constant: 7,0*10^{-6} Pa m^3 mol^{-1} at 25 °C Vapour pressure: 0,0005 mPa at 20 °C

4.2.3 Risk characterisation of consumers handling cut flowers

In the risk assessment, the values for each of the relevant exposure routes (i.e. dermal exposure or exposure via inhalation) are compared with relevant health-based guidance values which are protective of health, and which were identified in the hazard assessment. Those reference values, most often defined as ADI values were identified in chapter 10 for the ten prioritized pesticide substances in scope of this project.

4.2.3.1 Results

Following the ECHA procedure for risk assessment of chemicals, risk characterisation ratios (RCRs) can be derived to decide if risks are adequately controlled for the identified population, in this case consumers of cut flowers. In such a quantitative comparison per substance, the outcome of the exposure assessment per exposure route and of the hazard assessment is compared and risk is considered acceptable when the RCR is below one (ECHA, 2016c).

The RCR is calculated as follows:

$$RCR = \frac{Exposure}{Health\text{−}based\ guidance\ value\ (i.e.\ ADI)}$$

The risk assessment of fipronil is used as an example on how the RCR values were derived:

$$RCR = \frac{Exposure,\ D_{Der}}{ADI} = \frac{1{,}4\times10^{-5}\ [mg/kg\ bw/day]}{0{,}0002\ [mg/kg\ bw/day]} = 0{,}07$$

As the RCR value for dermal exposure of fipronil is below one, the health-related risks can be considered to be controlled when the exposure levels do not exceed the appropriate ADI. As no inhalational RCR was derived due to a qualitatively assessment based on the low volatility and evaporation of fipronil, the overall conclusion is that the risks are controlled.

For all of the ten selected pesticide substances in scope of this risk assessment the outcome of the risk assessment is presented in Table 16 below. For nine out of the ten substances the RCR values are well below one and the health-based risks are considered acceptable.

Lack of hazard data on chlorpyrifos is hindering derivation of health-based guidance value for this substance. It is therefore not possible to define any health-based guidance values for all toxicological endpoints, which is required for performing a quantitative risk assessment. In cases where quantitative risk assessments cannot be performed it is prescribed that qualitative risk assessments should be undertaken. One approach for qualitative risk assessments is to assign the substance to a hazard band as described in the ECHA guidance part E on risk characterisation (ECHA, 2016c). This is done based on the hazard classification of substances following the CLP regulation. The hazard classification of chlorpyrifos does not reflect the concerns raised by EFSA, nor the fact that the European Commission also considers a classification of chlorpyrifos as toxic for reproduction due to the effects seen in the neurodevelopmental toxicity study. Hence assigning a hazard band based on CLP classification does not take all potential hazards into consideration for this substance. EFSA (2019a) highlighted in their most recent risk assessment an uncertainty regarding the genotoxic potential of the substance. Depending on if the genotoxic potential would be seen as category 1 or 2, chlorpyrifos could be assigned high or moderate hazard. Either way, for potentially carcinogenic substances, the exposure should be as low as possible. In this initial risk assessment, the exposure assessment is based upon a worst-case scenario where 100% absorption of the dermal dose is considered. For chlorpyrifos, there are substance specific data from a human study indicating that dermal absorption is only 1% (EFSA, 2014). The exposure value for chlorpyrifos of $1{,}5*10^{-5}$ mg/kg bw/day, as calculated in chapter 10, is therefore expected to be overestimating the actual exposure.

TABLE 4-17 RCR values for the ten prioritised pesticides.

Pesticide	RCR value dermal exposure	RCR value Inhalation	Overall conclusion
Fipronil	0,070	Qualitative low	Acceptable risk as combined RCR is low
Thiacloprid	0,002	Qualitative low	Acceptable risk as combined RCR is low
Carbendazim	0,014	Qualitative low	Acceptable risk as combined RCR is low
Chlorpyrifos	Not available	Qualitative low	Not possible to evaluate the overall risks due to lack of genotoxic data
Indoxacarb	<0,001	Qualitative low	Acceptable risk as combined RCR is low
Spirodiclofen	0,003	Qualitative low	Acceptable risk as combined RCR is low
Chlorothalonil	0,005	Qualitative low	Acceptable risk as combined RCR is low
Myclobutanil	<0,001	Qualitative low	Acceptable risk as combined RCR is low
Triadimenol	<0,0001	Qualitative low	Acceptable risk as combined RCR is low
Iprodione	0,002	Qualitative low	Acceptable risk as combined RCR is low

4.2.3.2 Discussion

In this project a health risk assessment has been made based on the analytical results of pesticide residues in duplicate samples of 60 cut flowers (5 chrysanthemums, 25 carnations and 30 roses).

Applying a conservative approach, the worst-case scenario was developed building on the following method and assumptions:

- the maximum concentration detected in the flowers for each of the ten prioritized pesticides was used in the exposure assessment, irrespective of in which type of flower it was detected.
- the volume of the smallest type of flower species (carnation) was used in the exposure calculation, to minimize 'dilution' of the pesticide amount in a larger flower volume in the calculation.
- 100% dermal absorption was assumed when calculating the dermal dose. Dermal absorption rates were usually reported in the range of 1-20% in the EFSA peer reviews of the substances (see chapter 9).

The above-mentioned bullets lead to an overestimation of the calculated exposure estimates. Still, the calculated exposure estimates are at least one tenth of the health-based guidance values which are protective of health (i.e ADI). The actual margin to risk can be anticipated to be even larger. A refinement of the worst-case scenario is therefore not considered necessary.

There are also some uncertainties related to the risk assessment. Uncertainties are related to:

- the selected analytical method used in the study. The whole flower (petals and stem) is processed and analysed in the method used. The residue levels may be underestimated as the majority of the pesticide residues are expected to be situated on the surface of the flower. This analytical method may therefore lead to a dilution of the pesticide and potentially generate a lower result in the exposure assessment, possibly leading to an underestimation of the risk.
- The calculation of the flower volume is a simplification of a complex structure. The actual volume of the flower heads could be smaller due to the air between the petals.

This simplification could impact the exposure assessment, as a higher estimated volume results in a lower pesticide concentration, possibly leading to an underestimation of the risk.
- An authoritative health-based reference value for chlorpyrifos has not been available, thus not allowing for a quantitative risk assessment. The discrepancy between available hazard data and current harmonised classification impedes a qualitative risk estimation. A comparison of the available hazard data with the calculated exposure estimate, as well as consideration of limited dermal uptake, suggests a low risk from chlorpyrifos exposure in cut flowers. However, a risk cannot be excluded.

Cumulative exposure from other potential sources (e.g. uptake via food or drinking water) has not been considered in this project. It is not known whether the contribution from cut flowers is a substantial contribution to the overall pesticide exposure. However, it is considered unlikely that the cut flowers contribute significantly to the cumulative exposure from various sources, as the calculated exposure estimates are well below the health-based reference values. Mixture toxicity has not been considered. From the chemical analyses of the cut flowers, it can be seen that one flower contains a variety of different pesticides. The current risk assessment does not take into account the combined exposure of different substances but assesses each pesticide separately. In order to perform mixture-based risk assessment, EFSA recommends using mechanistic information on toxicity, i.e. mode of action or adverse outcome pathway to group chemicals. This in-depth analysis was out of scope for this project.

4.3 Environmental risk assessment

The scope of this project is to evaluate the potential environmental risk towards groundwater and surface water when disposing of the cut flowers. The project considers exposure to the highest detected concentration of each of the pesticides but without considering the combined exposure from the mixture of substances. A standard bouquet is assumed to consists of ten flowers of the same type, i.e. ten carnations from the same producer.

To assess the environment risk associated with the discarded flowers, it is assumed that the worst case scenario is disposing of the flowers in a composting heap in a private garden. Discarded cut flowers in homes may also be deposited in the waste bins and end up being incinerated which is not assessed to pose a risk towards groundwater and surface water. A smaller portion of the cut flowers may also end up on composting facilities, that collect any leachate and send it to wastewater treatment plants, which again reduces the risk towards groundwater and surface water.

The risk assessment is based upon a tiered approach. In the first tier the risk is calculated from the annual amount of pesticide leached from the flowers and assumes that this amount of leached pesticide is dissolved in an annual water abstraction of a small waterworks. The resulting groundwater concentration is then compared to the Danish quality criteria for drinking water, which is 0.1 µg/l for individual pesticides. The quality criteria for the sum of pesticides in drinking water is 0.5 µg/l.

An analysis of abstraction permits for small waterworks with an abstraction of less than 1 mill. m^3/year (Jupiter database at www.geus.dk) shows that the average yearly permitted abstraction is 129,000 m^3, whereas the median is 60,000 m^3. According to the Danish drinking water order (drikkevandsbekendtgørelsen) a small waterworks is defined as having an abstraction of less than 36,500 m^3/year. Using an annual abstraction of 10,000 m^3 in the risk calculation therefore seems to be a conservative approach. According to vandetsvej.dk, an average Danish consumer uses 105 m^3/year. If a household consists of 4 individuals and half of the abstracted amount of water is used for watering of plants and animals (agriculture), an annual water abstraction of 10,000 m^3 (corresponding to a very small waterworks) would provide water for 12 households a day.

A worst case scenario assumes the following;

- All of the pesticide is leached to soil
- All of the leached pesticide is transported from the soil to the groundwater aquifer or a surface water body i.e. sorption and degradation is not taken into account

In this scenario the following assumptions are used:

- A bouquet of flowers consists of 10 flowers
- A consumer buys a bouquet of flowers for home use 15 times a year. Specific data for this assumption has not been found in the literature, but it is considered a reasonable assumption
- The average weight of a flower is 31 g

The highest average concentration of pesticide is used in the calculations. As reported in chapter 3, the highest average concentration is 33.46 mg/kg for captan/THPI. Captan is not one of the prioritized substances in the human risk assessment, but as the drinking water quality criteria does not depend on the type of pesticide, it is assessed that using the highest average pesticide concentration will ensure a robust environmental risk assessment.

Based on this scenario the maximum leaching from the flowers is calculated as 156 mg/yr:

$$Maximum\ leaching = \ Max. average\ conc. x\ average\ weight\ x\ 10 \frac{flowers}{bouquet} x\ 15\ bouquets/yr$$

Assuming all of the pesticide is leached to the groundwater (10,000 m^3) the resulting concentration in the groundwater would be 0.016 µg/l which is approx. 6 times below the drinking water quality criteria. If 6 consumers (corresponding to half the population for the very small waterworks mentioned above) dispose of their flowers on the garden heap in the same abstraction area, then the calculated leaching of pesticides would just meet drinking water criteria.

Assuming that the flower bouquet consists of 10 flowers with the 10 highest average concentrations of pesticides, the total amount of pesticides is 125 mg/kg. The maximum leaching from the flowers in this scenario is calculated as 581 mg/yr. Under the same assumptions as above, the resulting concentration in the groundwater would be 0.06 µg/l, which is well below the drinking water quality criteria for sum of pesticides (0.5 µg/l). If 8 consumers dispose of their flowers on the garden heap in the same abstraction area, then the calculated leaching of pesticides would just meet drinking water criteria.

The calculations are based on the assumption that all of the pesticides in the flowers are leached to the groundwater aquifer within a year without taking account of degradation and sorption. This assumption alone entails that the calculations above significantly overestimate the risk towards groundwater. It is therefore assessed that leaching from the flowers does not pose a risk towards groundwater.

Leaching to surface water can be calculated using the median minimum flow for a small stream of 1-10 l/s (Miljøstyrelsen, 2014), which on an annual basis corresponds to 31,500-315,000 m^3/yr. In the worst case scenario, where the leached pesticides are transported directly to the stream without being degraded, adsorbed, diluted or retained in the soil, this would result in a water concentration below 0.005 µg/l. Quality criteria for pesticides in surface waters exist only for few of the pesticides. Instead Predicted No Effect Concentrations (PNEC) have been reviewed for the 11 pesticides with the highest average concentrations measured in the flowers. Where PNEC-values cannot be found, the lowest aquatic Effect Concentration (EC_{50}) is used, see Table 4-18.

Table 4-18 shows that only one of the 11 pesticides (chlorothanolil) has a very low PNEC-value (0.004 µg/l for marine water) near the above calculated concentration level. The other PNEC-values and EC_{50}-values are well above the calculated concentration level. Based on the calculation and the assumptions used it is assessed, that leaching from the flowers does not pose a risk for surface water.

TABLE 4-18 Lowest aquatic EC_{50} and PNEC for the 11 pesticides with the highest average concentrations.

Pesticide	Lowest aquatic EC_{50} µg/l	PNEC µg/l	Reference
Captan	-	1.65	Ineris (2009)
Formetanat	1.7	-	Lewis et al. (2016)
Carbendazim	-	0.15	ECHA
Chlorothalonil	-	0.004 (marine)	ECHA
Tetrahydroph-thalimid	-	-	
Spiroxamin	3	-	Lewis et al. (2016)
Iprodion	-	0.35	Ineris (2009)
Clofentizin	-	-	
Propamocarb	100,000	-	Lewis et al. (2016)
Spirodiclofen	-	0.035 (marine)	ECHA
Thiabendazol	1.2	-	Lewis et al. (2016)

Based on these calculations and the assumptions used it is assessed that disposing of the cut flowers does not pose a risk towards groundwater and surface water. For some of the assumptions used, data do not exist, and even though a conservative approach has been sought in quantifying the assumptions, uncertainties in the risk calculations do exist.

4.4 Overall conclusion

Health-based reference values for ten prioritised pesticides were compared to worst-case exposure estimates by calculation of risk characterisation ratios (RCR). For RCR smaller than 1, the risk can be assumed to be controlled.

Some uncertainty regarding the risk related to pesticide exposure is related to cumulative exposure from other potential sources (e.g. uptake via food or drinking water) and combined exposure of different substances (as several pesticides were detected in each flower sample). The consideration of cumulative exposure from other potential sources or and combined exposure of different substances has not been within the scope of this study.

For nine out of the ten substances each of the RCR values are ≤ 0,07 and the health-based risks are considered acceptable. For one substance, chlorpyrifos, a RCR could not be calculated due to lack of hazard data. Available data on hazardous effects and dermal uptake suggest a low risk based on a qualitative consideration. However, a risk from chlorpyrifos exposure in cut flowers cannot be entirely excluded.

The environmental risk assessment is based on worst case scenarios, where leached pesticides from the flowers are transported directly to the groundwater aquifer or surface water body without being degraded, adsorbed or diluted. It is concluded that disposing of the cut flowers does not pose a risk towards groundwater and surface water based on these worst case scenarios.

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Appendix 1. Questionnaire for interview of the flower producers

QUESTIONNAIRE - PESTICIDES IN CUT FLOWERS

Dear flower producer (put in the correct name),
Resent research has brought attention to the application of pesticides in the production of cut flowers imported to the European Union (EU). Examination of flowers reveals heavy contamination by pesticide residues. Actions are needed to address this issue before it will affect the import of cut flowers to EU and thereby to Denmark.
On behalf of the Danish Environmental Protection Agency (EPA), Ramboll is conducting this investigation on application of pesticides in flower production. The aim of the project is to ensure that cut flowers imported to EU and thereby reaching the flower markets in Denmark comply with EU regulation and do not contain pesticide residues posing a threat to the human health of costumers and the end users as well as the environment.
The outcome, based on the results and flower producers' due diligence, should hence support the sustainment of the current local flower productions around the world for export of cut flowers to EU.
Below you will find an introduction to the overall project followed by a questionnaire regarding which pesticides are applied in flower production. Answers will be anonymized in the report and flower producers will not be mentioned by name neither in the report nor in public accessible communication.

INTRODUCTION TO THE PROJECT
Cut flowers imported to and sold on the European market have all been treated with different pesticides to prevent plant pests and diseases. The applied pesticides at the production sites might not be in compliance with European regulation and could potentially pose a risk to human health and environment.
The project aims at determining, which pesticides are applied in the production of two popular cut flower types: roses and chrysanthemums. The project will at a later stage compare the findings obtained from the flower producers' questionnaire with exported flowers sold at retailers in Denmark. Cut flower samples will be analyzed for pesticides and degradation products. The project will determine whether the cut flowers imported from countries outside EU pose a health hazard for individuals handling them and whether they will be a hazard for the environment when disposed of as waste. The knowledge obtained in the project will be available for the producers and can be used as support for the process of potentially replacing problematic pesticides with EU approved pesticides in due time to maintain or increase future market shares.

QUESTIONNAIRE
To acquire/obtain data on the pesticide being applied in the production of cut flowers, we have prepared the following questionnaire that, with your help, will provide information on pesticide application from "Seeds to Flowers" for roses and chrysanthemums.
For each application we are interested in obtaining answers to the listed questions below if accessible via the flower producers. Hence, the degree of detail in the answer may vary.

Questions - Flower producer

1. What is your role on the farm?

2. What is the size of the farm (e.g. production area, number of employees)?

3. Do you produce both roses and Chrysanthemums?

4. How many of these flowers do you produce per year in average?

5. Do you produce different types of these flowers? If so, are they produced differently?

6. Do you know, how much (number/quantities of flower) you export to EU markets?

Questions – Application of pesticides

7. The product name (Active ingredient/pesticide and name of the producer - It would be optimal if you could obtain a photo of the label on the container of the pesticide product)?

8. Purpose of use (Against insects, diseases, and physiological disorders?)

9. Time of application (In which time periods (during the year and day) are the product/pesticide normally applied and at which crop growth stage? Are there regulatory limits to the time of application?)

10. Is the application conducted pre-harvest, at harvest or post-harvest? 10.1. In this regard, when is the flower harvested, and is the cut flower exported immediately after harvest?

10.2. If pre-harvest – what is the flower development stage at application (BBCH code)?

11. The applied dose (If possible, in kg/ha and the amount of water it has been diluted with)?
12. Application method (Is the application focused on certain parts of the flower, the whole flower or the soil surrounding it?)
13. Conditions at the time of application (e.g. in the field or greenhouse, need of nutrition and conditions for spray drift and evapotranspiration looking at air temperature and solar radiation/light)

Questions – Production of flowers

14. Your cultivar development of the flowers 14.1. Do you conduct cultivar development?

14.2. If so, do you apply pesticide products in this connection?

15. Your choice in vegetative methods 15.1. Which vegetative method do you apply (cuttings/budding/grafting or in vitro)?

15.2. Do you apply pesticide products in this context?

16. Your pest-management methods against insects, diseases, and physiological disorders 16.1. Which types of insects (e.g. aphids, spider, mites and thrips), diseases (e.g. powdery mildew, downy mildew and botrytis blight), and physiological disorder (e.g. bullheads, blind shoots and leaf drop) are causes for the application of pesticides?

16.2. What drives your choice in which pesticide product to be applied?

17. Your methods for preparing cut flowers for export 17.1. Do you apply pesticide products or other products (potentially containing pesticides) as preservatives to maintain the high quality of the cut flower during export?

17.2. If so, would it be possible to obtain information on the product – optimal, a photo of the label on the container of the product?

Questions - Regulation of pesticides

18. Are you affected by the national regulation of pesticides?

19. Are you familiar with the EU regulation on pesticides for cut flowers?

20. Are you already complying with the EU-regulation on pesticides for the cut flowers being exported to the EU or are you aiming at it? 20.1. If yes, what measures have you put in place to comply with EU regulations on pesticides?

20.2. If no, would that be something you would consider in the future and hereby only applying pesticides and doses being allowed in the EU production of flowers?

21. Are there any barriers to complying with EU regulations on pesticides? Please elaborate if there are.

Do you consider the impact of pesticide residues on humans and the environment in connection with your production and product?

Appendix 2. Selected analysis results

Appendix 2.1 Detected pesticides and degradation products per country (number of detections)

Pesticide	**Colombia (40 samples)**	**Ecuador (40 samples)**	**Kenya (40 samples)**	**Number of detections (out of 120 samples)**
Carbendazim	34	22	22	78
Propamocarb (Sum of propamocarb and its salts, exp	14	28	26	68
Fipronil (sum)	20	22	18	60
Fipronil sulfon	20	20	18	58
Spiroxamine	18	18	21	57
Pyrimethanil	14	26	16	56
Fipronil	20	22	8	50
Fipronil desulfinyl	20	22	4	46
Cyhalothrin, lambda-(incl. Cyhalothrin, gamma-)	20	9	16	45
Acephat	2	6	30	38
Iprodion	4	11	22	37
Dodemorph	10	12	12	34
Methamidophos	-	6	28	34
Hexythiazox	-	6	27	33
Acetamiprid	22	-	10	32
Clofentezin	-	2	30	32
Pyriproxyfen	10	12	10	32
Cyprodinil	2	14	12	28
Fludioxonil	10	12	6	28
Spirodiclofen	14	7	6	27
Thiabendazol	4	8	12	24
Captan	2	20	-	22
Captan/THPI (Sum beregnet som Captan)	2	20	-	22
Dimethomorph	2	14	6	22
Fipronil sulfid	10	12	-	22
Lufenuron	8	2	12	22
Tetraconazol	20	-	2	22
Tetrahydrophthalimide (THPI)	2	20	-	22
Azoxystrobin	4	6	11	21
Boscalid	-	8	12	20
Flubendiamide	6	-	14	20
Formetanate	10	10	-	20
Imidacloprid	-	14	6	20

Pesticide	Colom-bia (40 sam-ples)	Ecuador (40 sam-ples)	Kenya (40 sam-ples)	Number of de-tections (out of 120 samples)
Spinosad (sum of spinosyn A and spinosyn D)	-	20	-	20
Spinosyn A	-	20	-	20
Teflubenzuron	2	-	18	20
Spinosyn D	-	18	-	18
Famoxadon	-	2	14	16
Fenpropidin	12	-	4	16
Indoxacarb (sum, R+S isomers)	-	8	8	16
Pyraclostrobin	2	12	2	16
Clothianidin	6	8	-	14
Difenoconazol	-	8	6	14
Flupyradifurone	-	14	-	14
Methomyl	-	14	-	14
Acrinathrin	-	-	12	12
BTS 44596	6	4	2	12
Chlorthalonil	-	12	-	12
Etoxazole	2	10	-	12
Fluopicolid	-	8	4	12
Prochloraz (total)	6	4	2	12
Emamectin	6	-	5	11
Buprofezin	-	-	10	10
Chlorpyrifos (-ethyl)	-	10	-	10
Cypermethrin	-	10	-	10
Penconazol (sum of constituent isomers)	8	2	-	10
Tebuconazol	8	2	-	10
Thiacloprid	6	-	4	10
BTS 44595	4	2	2	8
Diflubenzuron	-	8	-	8
Ethirimol	-	4	4	8
Prochloraz	4	2	2	8
Spinetoram	2	4	2	8
Sulfoxaflor	-	8	-	8
Thiophanat-methyl	6	-	2	8
Flonicamid	-	-	7	7
Abamectin (sum of avermectin B1a, aver-mectin B1b a	-	-	6	6
Avermectin B1a	-	-	6	6
Avermectin B1b	-	-	6	6
Biphenthrin	2	4	-	6
Bupirimate	-	4	2	6
Fenhexamid	2	-	4	6
Flutriafol	-	4	2	6
Oxadiazon	-	6	-	6

Pesticide	Colom-bia (40 sam-ples)	Ecuador (40 sam-ples)	Kenya (40 sam-ples)	Number of de-tections (out of 120 samples)
Procymidon	-	6	-	6
Spirotetramat	6	-	-	6
Spirotetramate (sum)	6	-	-	6
Spirotetramat-enol	6	-	-	6
Triforine	-	-	6	6
Bifenazat	2	2	-	4
Cyflumetofen	2	-	2	4
Deltamethrin	-	2	2	4
Fenazaquin	4	-	-	4
FM-6-1 (metabolite triflumizole)	-	4	-	4
Kresoxim-methyl	2	2	-	4
Mandipropamid (any ratio of constituent iso-mers)	-	2	2	4
Metalaxyl	4	-	-	4
Metalaxyl/Metalaxyl-M (sum)	4	-	-	4
Pyrimidifen	2	2	-	4
Spirotetramat-ketohydroxy	4	-	-	4
Thiamethoxam	4	-	-	4
Triflumizol	-	4	-	4
Triflumizol/FM-6-1 (sum)	-	4	-	4
2-Phenylphenol	-	2	-	2
Amitraz (sum)	-	2	-	2
BTS 27271	-	2	-	2
Carbofuran	-	2	-	2
Carbofuran (sum)	-	2	-	2
Carbofuran, 3-hydroxy-	-	2	-	2
Cyantraniliprole	-	-	2	2
Dinotefuran	2	-	-	2
Ethofenprox	-	-	2	2
Karanjin	-	-	2	2
Methoxyfenozid	-	-	2	2
Metrafenon	-	2	-	2
Myclobutanil (sum of constituent isomers)	-	-	2	2
Profenofos	2	-	-	2
Pymetrozin	-	2	-	2
Pyridaben	-	-	2	2
Spiromesifen	2	-	-	2
Tetradifon	2	-	-	2
Triadimenol	-	2	-	2
Total	462	689	577	1728

“-“ means not detected.

Appendix 2.2 Detected pesticides and degradation products per flower species (number of detections)

Pesticide	Chrysan-themum-mum (10 samples)	Carnati-ons (50 sam-ples)	Roses (60 sam-ples)	Number of de-tections (out of 120 samples)
Carbendazim	10	20	48	78
Propamocarb (Sum of propamocarb and	-	28	40	68
Fipronil (sum)	10	34	16	60
Fipronil sulfon	10	34	14	58
Spiroxamine	-	3	54	57
Pyrimethanil	-	26	30	56
Fipronil	10	24	16	50
Fipronil desulfinyl	10	22	14	46
Cyhalothrin, lambda-(incl. Cyhalothrin,	-	34	11	45
Acephat	-	16	22	38
Iprodion	-	10	27	37
Dodemorph	-	-	34	34
Methamidophos	-	16	18	34
Hexythiazox	-	20	13	33
Acetamiprid	-	12	20	32
Clofentezin	-	20	12	32
Pyriproxyfen	-	20	12	32
Cyprodinil	-	4	24	28
Fludioxonil	-	10	18	28
Spirodiclofen	-	18	9	27
Thiabendazol	-	4	20	24
Captan	10	2	10	22
Captan/THPI (Sum beregnet som Cap-	10	2	10	22
Dimethomorph	-	2	20	22
Fipronil sulfid	8	10	4	22
Lufenuron	-	18	4	22
Tetraconazol	-	4	18	22
Tetrahydrophthalimide (THPI)	10	2	10	22
Azoxystrobin	-	8	13	21
Boscalid	-	8	12	20
Flubendiamide	-	6	14	20
Formetanate	-	10	10	20
Imidacloprid	-	2	18	20
Spinosad (sum of spinosyn A and spi-	-	2	18	20
Spinosyn A	-	2	18	20
Teflubenzuron	-	18	2	20
Spinosyn D	-	2	16	18
Famoxadon	-	10	6	16
Fenpropidin	-	10	6	16
Indoxacarb (sum, R+S isomers)	8	2	6	16
Pyraclostrobin	-	2	14	16
Clothianidin	8	6	-	14
Difenoconazol	-	-	14	14
Flupyradifurone	10	-	4	14
Methomyl	10	-	4	14
Acrinathrin	-	10	2	12
BTS 44596	-	8	4	12
Chlorthalonil	10	-	2	12
Etoxazole	10	2	-	12
Fluopicolid	-	-	12	12
Prochloraz (total)	-	8	4	12
Emamectin	-	2	9	11
Buprofezin	-	8	2	10
Chlorpyrifos (-ethyl)	10	-	-	10

Pesticide	Chrysan-themum-mum (10 samples)	Carnati-ons (50 sam-ples)	Roses (60 sam-ples)	Number of de-tections (out of 120 samples)
Cypermethrin	10	-	-	10
Penconazol (sum of constituent isomers)	-	8	2	10
Tebuconazol	-	8	2	10
Thiacloprid	-	8	2	10
BTS 44595	-	4	4	8
Diflubenzuron	6	-	2	8
Ethirimol	-	-	8	8
Prochloraz	-	4	4	8
Spinetoram	-	8	-	8
Sulfoxaflor	-	6	2	8
Thiophanat-methyl	-	6	2	8
Flonicamid	-	-	7	7
Abamectin (sum of avermectin B1a, aver-	-	6	-	6
Avermectin B1a	-	6	-	6
Avermectin B1b	-	6	-	6
Biphenthrin	-	2	4	6
Bupirimate	-	-	6	6
Fenhexamid	-	2	4	6
Flutriafol	4	-	2	6
Oxadiazon	6	-	-	6
Procymidon	-	-	6	6
Spirotetramat	-	6	-	6
Spirotetramate (sum)	-	6	-	6
Spirotetramat-enol	-	6	-	6
Triforine	-	6	-	6
Bifenazat	-	2	2	4
Cyflumetofen	-	4	-	4
Deltamethrin	-	-	4	4
Fenazaquin	-	4	-	4
FM-6-1 (metabolite triflumizole)	-	4	-	4
Kresoxim-methyl	-	2	2	4
Mandipropamid (any ratio of constituent	-	-	4	4
Metalaxyl	-	-	4	4
Metalaxyl/Metalaxyl-M (sum)	-	-	4	4
Pyrimidifen	-	2	2	4
Spirotetramat-ketohydroxy	-	4	-	4
Thiamethoxam	-	4	-	4
Triflumizol	-	4	-	4
Triflumizol/FM-6-1 (sum)	-	4	-	4
2-Phenylphenol	-	-	2	2
Amitraz (sum)	-	-	2	2
BTS 27271	-	-	2	2
Carbofuran	-	-	2	2
Carbofuran (sum)	-	-	2	2
Carbofuran, 3-hydroxy-	-	-	2	2
Cyantraniliprole	-	-	2	2
Dinotefuran	-	2	-	2
Ethofenprox	-	-	2	2
Karanjin	-	2	-	2
Methoxyfenozid	-	-	2	2
Metrafenon	-	-	2	2
Myclobutanil (sum of constituent isomers)	-	-	2	2
Profenofos	-	2	-	2
Pymetrozin	-	-	2	2
Pyridaben	-	-	2	2
Spiromesifen	-	2	-	2
Tetradifon	-	2	-	2
Triadimenol	-	-	2	2

Pesticide	Chrysan-themum-mum (10 samples)	Carnati-ons (50 sam-ples)	Roses (60 sam-ples)	Number of de-tections (out of 120 samples)
Total	180	683	865	1728

“-“ means not detected.

Appendix 2.3 Measured concentrations (mg/kg) of pesticides and degradation products in 120 flower samples, ranked by highest maximum value.

Pesticide	n	Average	Min	Max
Carbendazim	78	13.98	0.022	106.0
Captan/THPI (Sum beregnet som Captan)	22	33.46	2.000	85.5
Propamocarb (Sum of propamocarb and its salts, exp	68	4.43	0.020	72.0
Formetanate	20	14.58	0.029	68.6
Iprodion	37	5.72	0.021	60.2
Captan	22	19.45	0.340	48.8
Chlorthalonil	12	13.70	0.030	33.7
Spiroxamine	57	6.97	0.020	25.4
Dodemorph	34	2.97	0.020	24.0
Thiabendazol	24	3.05	0.021	23.9
Tetrahydrophthalimide (THPI)	22	7.04	0.650	20.3
Spirodiclofen	27	3.67	0.021	20.1
Clofentezin	32	5.71	0.032	17.7
Azoxystrobin	21	2.16	0.024	15.4
Pyrimethanil	56	2.44	0.023	14.5
Prochloraz (total)	12	2.85	0.021	12.2
Acephat	38	1.96	0.029	10.2
Fludioxonil	28	1.60	0.020	8.9
Thiacloprid	10	1.95	0.022	8.4
Pyraclostrobin	16	2.27	0.027	7.7
BTS 44596	12	1.50	0.020	7.6
Cyprodinil	28	1.71	0.030	6.9
Chlorpyrifos (-ethyl)	10	3.72	1.800	6.0
Fipronil (sum)	60	1.64	0.020	6.0
Imidacloprid	20	0.68	0.020	5.9
Fipronil	50	1.71	0.020	5.8
Boscalid	20	0.57	0.021	4.9
Difenoconazol	14	1.12	0.025	4.9
Fluopicolid	12	0.80	0.027	4.2
Diflubenzuron	8	1.07	0.110	3.9
Flubendiamide	20	1.08	0.022	3.9
Cyhalothrin, lambda-(incl. Cyha-lothrin, gamma-)	45	0.52	0.036	3.5
Sulfoxaflor	8	0.94	0.022	3.4
Pyrimidifen	4	1.33	0.047	3.2
Prochloraz	8	1.19	0.021	3.1
Tetraconazol	22	1.00	0.021	2.9
Methomyl	14	0.85	0.300	2.8
Spinosad (sum of spinosyn A and spinosyn D)	20	1.16	0.059	2.8
Spinosyn A	20	1.05	0.059	2.7
Teflubenzuron	20	0.86	0.023	2.6

Ethofenprox	2	2.40	2.300	2.5
Fenhexamid	6	0.77	0.020	2.4
Hexythiazox	33	0.47	0.024	2.4
BTS 44595	8	0.59	0.020	2.2
Methamidophos	34	0.84	0.043	2.2
Cyflumetofen	4	1.07	0.039	2.1
Pyriproxyfen	32	0.57	0.021	2.1
Carbofuran (sum)	2	1.85	1.800	1.9
Fipronil sulfon	58	0.23	0.021	1.8
Bupirimate	6	0.54	0.110	1.7
Dimethomorph	22	0.38	0.022	1.7
Indoxacarb (sum, R+S isomers)	16	0.36	0.042	1.7
Bifenazat	4	0.87	0.200	1.5
Clothianidin	14	0.27	0.020	1.5
Cypermethrin	10	0.43	0.180	1.5
Abamectin (sum of avermectin B1a, avermectin B1b a	6	1.08	0.540	1.4
Fenpropidin	16	0.46	0.026	1.3
Lufenuron	22	0.34	0.047	1.3
Methoxyfenozid	2	1.30	1.300	1.3
Tetradifon	2	1.20	1.100	1.3
Acetamiprid	32	0.40	0.020	1.2
Etoxazole	12	0.62	0.260	1.2
Avermectin B1b	6	0.86	0.380	1.1
Ethirimol	8	0.59	0.170	1.1
Carbofuran	2	0.96	0.920	1.0
Fipronil desulfinyl	46	0.25	0.022	1.0
Carbofuran, 3-hydroxy-	2	0.94	0.920	1.0
Spiromesifen	2	0.78	0.750	0.8
Flupyradifurone	14	0.38	0.024	0.8
Deltamethrin	4	0.37	0.071	0.7
Triflumizol/FM-6-1 (sum)	4	0.37	0.083	0.7
Dinotefuran	2	0.66	0.650	0.7
Tebuconazol	10	0.27	0.053	0.6
Flonicamid	7	0.35	0.026	0.5
Acrinathrin	12	0.21	0.051	0.5
Triflumizol	4	0.26	0.050	0.5
Kresoxim-methyl	4	0.35	0.330	0.4
Avermectin B1a	6	0.23	0.160	0.3
Procymidon	6	0.18	0.046	0.3
Penconazol (sum of constituent isomers)	10	0.08	0.020	0.3
Spinosyn D	18	0.14	0.034	0.3
Thiophanat-methyl	8	0.11	0.041	0.2
Profenofos	2	0.21	0.200	0.2
Spirotetramate (sum)	6	0.16	0.110	0.2

Cyantraniliprole	2	0.16	0.150	0.2
Flutriafol	6	0.07	0.023	0.2
Buprofezin	10	0.08	0.021	0.2
FM-6-1 (metabolite triflumizole)	4	0.09	0.028	0.2
Mandipropamid (any ratio of constit-uent isomers)	4	0.09	0.032	0.2
Famoxadon	16	0.07	0.029	0.2
Pyridaben	2	0.14	0.130	0.2
Spinetoram	8	0.08	0.023	0.2
Biphenthrin	6	0.10	0.023	0.1
Pymetrozin	2	0.08	0.020	0.1
Spirotetramat	6	0.10	0.045	0.1
Emamectin	11	0.05	0.020	0.1
Fipronil sulfid	22	0.05	0.020	0.1
Myclobutanil (sum of constituent isomers)	2	0.11	0.094	0.1
Fenazaquin	4	0.05	0.022	0.1
Metrafenon	2	0.08	0.075	0.1
Metalaxyl	4	0.06	0.059	0.1
Metalaxyl/Metalaxyl-M (sum)	4	0.06	0.059	0.1
2-Phenylphenol	2	0.06	0.054	0.1
Spirotetramat-enol	6	0.05	0.031	0.1
Thiamethoxam	4	0.04	0.021	0.1
Oxadiazon	6	0.04	0.032	0.1
Triforine	6	0.03	0.020	0.05
BTS 27271	2	0.03	0.032	0.04
Triadimenol	2	0.03	0.028	0.03
Amitraz (sum)	2	0.03	0.029	0.03
Spirotetramat-ketohydroxy	4	0.02	0.024	0.03
Karanjin	2	0.01	0.010	0.01

Survey and risk assessment of pesticides in cut flowers from non-EU countries
Cut flowers sold to consumers in Denmark are imported from non-EU countries and may contain pesticides that are not approved within the EU. Consumers can be exposed to the pesticides during flower handling, and the environment can be exposed, when flowers are disposed of as waste.

The objective of this study is to assess the risk to consumer health and the environment from pesticide residues in flowers from non-EU countries.
Within this project, a survey of pesticides applied in flower production at several producers in Kenya, Ecuador and Colombia has been conducted. Furthermore, chemical analyses of pesticides in flowers from non-EU countries have been performed. Finally, a risk assessment for selected pesticides has been conducted.

For the health risk characterisation, the health-based reference values were compared with the exposure estimates, and risk characterisation ratios (RCR) were calculated. All RCR were below 1, meaning the risk can be assumed to be controlled. For one substance, chlorpyrifos, a RCR could not be calculated due to lack of hazard data. Exposure to pesticides from other sources, for example, imported vegetables and fruit, as well as combined exposure of different substances, have not been considered in the risk characterisation.

For the environmental risk assessment, the risk towards groundwater and surface water was evaluated for the scenario of disposing the flowers in a composting heap in a private garden. Overall, based on the data and assumptions applied, leaching of pesticides from disposed flowers does not pose a risk towards groundwater or surface water.

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