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# Pesticide residues in selected vegetables

BACHELOR THESIS

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# Declaration

I hereby declare that this thesis entitled “Pesticide residues in selected vegetables” is my own work and all the sources have been quoted and acknowledged by means of complete references.

In Prague, 20 April 2018 ……..…

Aneta Zemánková

## Acknowledgements

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# Abstract

As a result of the enormous growth rate of the world's population, there is also a constant increase in agricultural production and so the consumption of synthetic plant protection products. The expression "It is full of chemicals!", can be often heard and indicates a high-level of awareness of the developed society about this issue. People have become aware of the risks associated with the use of pesticides and the occurrence of their residues. And so, the organic farming has become very popular in recent years.

Therefore, this bachelor thesis was primarily focused on the detection of products used in the organic farming systems, the basic substances and substances with low-risk effect. An integral part of the work was also their description, along with the description of the substances that are widely used in conventional farming systems, still belonging to one of the most widespread methods of plant production. The Maximum Residue Limits in selected vegetables (celery, lettuce, spinach and spring onions) were also investigated.

It is very important not to underestimate the risk of exposure to either residues or pesticides. Subsequent health issues caused by their effects may be very serious and, in some cases, fatal.



**Key words:** vegetable growing, plant protection, chemicals, active substances, analytical methods, Czech market

# Abstrakt

S enormní rychlostí růstu světové populace se také neustále zvyšuje zemědělská produkce, a tím i spotřeba přípravků na chemickou ochranu rostlin. Často lze slyšet výraz “Vždyť je to plné chemie!”, což indikuje značnou informovanost vyspělé společnosti o této problematice. Lidé si začali uvědomovat rizika spojená s používáním pesticidů a výskytem jejich reziduí. A tak se v posledních letech ekologické zemědělství těší velké oblibě.

Proto se tato bakalářská práce v první řadě zabývala detekcí přípravků používaných v režimu ekologického zemědělství, základními látkami a látkami nízkorizikovými. Nedílnou součástí práce byl také jejich popis spolu s popisem látek, které se hojně používají v konvenčním zemědělství stále patřícímu k nejrozšířenějšímu způsobu pěstování plodin. U látek byly dále zjišťovány maximální legální limity reziduí pesticidů ve vybrané zelenině (řapíkatý celer, salát, špenát a jarní cibulka).

Riziko vystavení se ať už reziduím, nebo samotným pesticidům, je velice důležité nepodceňovat. Následné zdravotní problémy zapříčiněné jejich působením mohou být velmi závažné a v některých případech i fatální.



**Klíčová slova:** pěstování zeleniny, ochrana rostlin, chemikálie, aktivní látky, analytické metody, český trh

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# List of the abbreviations

**ADI** - Acceptably Daily Intake

**AJ** - Adjuvant

**As** - Arsenic

**AT** - Application term, application method or specification of use

**BS** - Basic substance

**BT** - Biopreparate

**Cd** - Cadmium

**CNS** - Central Nervous System

**CO** - Carbon monoxide

**DCPA** - Dimethyl tetrachloroterephthalate

**EU** - European Union

**FAO** - Food and Agriculture Organization

**Fe** - Iron

**FUN** - Fungicide

**GC–ECD** - Gas Chromatography - Electron Capture Detector

**GC-MSD** - Gas Chromatography - Mass Selective Detector

**GC–TOF/MS** - Gas Chromatography - Time-of-flight Mass Spectrometry

**ha** - hectare

**HER** - Herbicide

**Hg** - Mercury

**IARC** - International Agency for Research on Cancer

**Ib** - Highly hazardous

**II** - Moderately hazardous

**III** - Slightly hazardous

**IL** - Iceberg lettuce

**INS** - Insecticide

**K** - Potassium

**kg** - kilogram

**LC-MS/MS** - Liquid Chromatography - Tandem Mass Spectrometry

**Mg** - Magnesium

**ML** - Molluscicide

**MRL** - Maximum Residue Limit

**MRLs** - Maximum Residue Limits

**MRM** - Multiple Reaction Monitoring

**N/A** - Information not available

**Na** - Sodium

**Ni** - Nickel

**P** - Passive auxiliary agent

**p,p'-DDE** - p,p′-dichlorodiphenyldichloroethylene

**Pb** - Lead

**PDP** - The USDA Pesticide Data Program

**PHI** - Pre-harvest Interval

**PHS** - Plant health support

**PPPs** - Plant Protection Products

**q.s.** - the amount which is enough

**QUECHERS** - (Quick, Easy, Cheap, Effective, Rugged, Safe)

**Sb** - Antimony

**TCAB** - Transforming Care at the Bedside

**U** - Unlikely to pose an acute hazard in normal use

**US$** - The United States dollar

**USDA** - The United States Department of Agriculture

**USEPA** - United States Environmental Protection Agency

**VD** - Valid decision

**WHO** - World Health Organisation

**WSL** - While stock lasts

# 1. Introduction

Since time immemorial, vegetables have been considered as part of the diet that is indispensable source of human nutrition. In ancient times, men gained food by gathering and later deliberately began to cultivate it. Nevertheless, the changed way of life in technically developed countries and constantly decreasing demand for energy output for modern humans require the energy value of the food to be reduced. Vegetables, as a product with low energy content, is an appropriate solution. Nowadays, the popularity of vegetarianism and veganism is rising. Individuals are predominantly or completely eating plant-based food. And therefore, vegetables are an integral part to their diet.

The importance of healthy vegetables for healthy nutrition is indisputable. Thus, vegetables should be grown with the lowest possible content of various harmful substances and with the minimal damaging impacts on the environment. People's awareness that vegetables are healthy, however, has lately been shaken in the public eye by the information about the risk factors that vegetables may contain. One of these factors is pesticides and their residues. It has been suggested that we are exposed to these substances by their consumption on a daily basis. And in some cases, they might surpass the permitted limits.

The mode of action of many pesticides lies in disruption of the central nervous system (CNS) of pests (Costa, Giordano, Guizzetti & Vitalone 2008). Due to the physiological similarities of the CNS amongst many different organisms, exists the fear that these chemicals can also harm humans. The main problem is that we are not able to recognize them in food. They are invisible to the naked eye, tasteless, odourless and can quickly accumulate in our bodies.

Fortunately, people have become aware of the problems with residues and its potential health risks. On the grounds of it, every country has adopted their own agricultural policies and set the Maximum Residue Limits (MRLs) and Acceptable Daily Intake (ADI) (Caballero, Trugo & Finglas 2003).

## 2. Aim of the thesis

The aim of this thesis was to investigate the available literary and electronic information sources to provide an overview of all pesticide used for selected vegetables on the Czech market and to identify the active substances which may be potential safe and efficient equivalents to commercial pesticides with possible adverse effect on human and animal health.

# 3. Materials and methods

A systematic literature review was performed for Bachelor´s thesis. A collection of the information on the topic was executed while using relevant electronic search engines as Web of Knowledge, ScienceDirect, Scopus, PubMed and Google Scholar.

For general information on pesticides mostly printed sources were used. Identification of products for vegetables grown under the organic farming system or products with basic and low-risk substances was performed according to web source Institute of Supervising and Testing in Agriculture from the section of Register of Plant Protection Products. This website was also important electronic source of information for creating the tables of approved Plant Protection Products (PPPs) in Czechia.

Explanation of tables for selected vegetables on the Czech market:

In the following tables (Table 2 to Table 5), the PPPs approved by European Commission for selected vegetables in Czechia were listed. The selection criterion was based on a way of consumption of the vegetables which are eaten without peeling and whole.

The tables also contain the abbreviations explained below the table; Active substances in alphabetic order; The hazard class of a formuation, Pesticide type; Pre-harvest Interval; Product name in alphabetical order; Registration number; Product expiry date in the date format DD/MM/YY where the product with the longest expiry date was selected; Sale and distribution of existing stock in the date format DD/MM/YY; Disposal, storage and use of existing stock in the date format DD/MM/YY and Current status of approval. Fields marked with yellow colour indicate the products for vegetables grown under the organic farming system. Fields marked with green colour refer to products with basic or low-risk substances.

This Bachelor´s thesis was complemented by the figures for better orientation in this issue. The online FAOSTAT database was used to create the figures (Figure 6 to Figure 13) containing the data collected from 1993 to 2015 and valid for Czechia found in the Appendix describing: Pesticides use in tonnes of active ingredients, Average use of pesticides per area of cropland (kg/ha), Pesticides Import Value in US$, Pesticides

Import Value by continent in %, Pesticides Import Value by country in US$, Pesticides Export Value in US$, Pesticides Export Value by continent in %, Pesticides Export Value by country in US$, Hazardous pesticides Import Value in US, Hazardous pesticides Import Value by country in US$, Hazardous pesticides Export Value in US$ and Hazardous pesticides Export Value by country in US$.

Primary search terms used were “pesticide residues”, “active substances” and “farming systems”. For the formulation of the references the citation database Citace PRO Plus was used. All sources were listed in the section of the thesis - References.

# 4. Literature review

## 4.1 Characteristics of vegetables

The term vegetable is used to describe the tender, edible shoot, leaves, fruits and root of plants and spices. Vegetable is any part of a plant that is consumed whole or in part, raw or cooked, by humans as a food (Gopalakrishnan 2007).

Vegetable species have become very important crops as their raw consumption conserves all their valuable nutrients. And it is exactly how the human organism gets most of them - just by consuming vegetables (Pekárková 2004).

### 4.1.1 The importance of vegetables in human nutrition

In addition to vitamins, minerals, carbohydrates and fiber, many other important ingredients as aromatic, antioxidant and medicinal substances can be found in vegetables according to the latest findings (Pekárková 2004).

The main component of vegetables is water. Fresh vegetables contain 75-95 % of water depending on the type of vegetables. Therefore, the energy value is low which is an advantage rather than a disadvantage nowadays as placing a larger amount of vegetables can effectively help in the fight against the obesity.

The most important components in vegetables are vitamins of which the most signifficant are vitamin A, B and C.

Vegetables are also an important source of minerals as Fe, K, Na and Mg, which are indispensable for the organism, especially for the nourishment of brain and the nervous system (Pekárková 1992). Vegetables contain a large amount of fibre preventing constipation and promoting digestion and have a protective effect against the risk of cancers of the oesophagus, lung, breast, stomach and colorectum (WHO 2003).

**Table 1:** The most valuable vitamins contained in selected vegetables (Pekárková 1992)

| Type of Vitamin | Name of Provitamin | Vegetable |
|---|---|---|
| Provitamin A | β-carotene | lettuce, spinach |
| Vitamin B1 | thiamine | spinach, spring onion |
| Vitamin B2 | riboflavin | lettuce, spinach |
| Vitamin B6 | pyridoxine | lettuce |
| Vitamin B3 | niacin | spring onion |
| Vitamin C | L-ascorbic acid | spring onion |
| Vitamin E | tocopherol | lettuce, spinach |
| Folic acid | | spinach |

**Vitamin A** has anti-infectious effects and is important for the correct function of the eyes, development and growth.

**Vitamin B1 (thiamine)** - is important for a healthy nervous system.

**Vitamin B2 (riboflavin)** is important for cellular respiration.

**Vitamin B6 (pyridoxine)** protects against arteriosclerosis and contributes to good liver and nervous system function.

**Vitamin B3 (niacin)** prevents pellagra and promotes the activity of digestive and nervous system.

**Vitamin C** the main component is L-ascorbic acid and is important for the prevention of scurvy and other avitaminoses C. It interferes with the synthesis of many hormones, affects the absorption of iron and activates the detoxification system by which the organism is getting rid of the heterogeneous substances (among others from tobacco smoke and alcohol). Vitaminc C belongs to a group of protective anti-stress agents, increases resistance to infection and has anti-carcinogenic effects.

**Vitamin E (tocopherol)** is important for the correct function of the nervous system and blood formation.

**Folic acid** is important for hematopoiesis (Pekárková 1992).

## 4.2 Production of vegetables in Czechia

In 2016, due to favorable weather conditions and the expansion of planting areas by 9% to 14.5 thousand of hectares, also increased the total amount of harvest of vegetables by 21% and reached 298.6 thousand tons.

The consumption of vegetables in Czechia in the fresh value (kg/person/year), which is the conversion of all products from vegetables to fresh vegetables, was 87.3 in 2016 (Ministerstvo zemědělsví 2017).

Summary of the most commonly used active substances in the PPPs on vegetables in kg in 2016:

Glyphosate 1 574,03; Chlorpyrifos 12.52; Mancozeb 10 965,34; Metamitron 27.99; Metazachlor 677.71; Copper oxychloride 912.51; Pendimethalin 3 141,58; Penthoxamid 320.87; Di-1-P-Menthene 451.54; Sulphur 949.82; Tebuconazole 46.91 (Institute for Supervising and Testing in Agriculture 2016)

### 4.2.1 Celery (Apium graveolens var. dulce (Mill.) Pers.)

**Figure 1: *Apium graveolens* var. *dulce* (Mill.) Pers. (SEMO 2018)**

Family: Apiceae

Genus: *Apium*

Species: *Graveolens*

Variety: *dulce*

Pathogens: *Alternaria burnsii, Alternaria radicina, Botrytis cinerea, Erysiphe heraclei, Leveillula taurica, Sclerotinia minor, Sclerotinia sclerotiorum* (FAO 2018)

64 pesticide residues were found in spinach by the USDA Pesticide Data Program (PDP). These were mainly pesticides as Chlorantraniliprole, Spinosad, Methoxyfenozide, Permethrin, Dicloran, Cyromazine, Acephate, Linuron, Chlorothalonil, Imidacloprid, Acetamiprid, Propiconazole, Methamidophos, Azoxystrobin, Melathion, Omethoate, Oxamyl, p,p'-DDE, Flonicamid and Pyraclostrobin. The human health and environmental health effects are listed bellow:

Human health effects:

10 known or probable carcinogens, 27 suspected hormone disruptors, 12 neurotoxins, 12 developmental or reproductive toxins

Environmental effects:

16 - honeybee toxins (PAN 2018)

*Apium graveolens* var. *dulce* is grown for its enlarged, tender, edible petioles or leaf stalks (Burnie 2007). Celery is rich in fiber, an important source of minerals, vitamins and amino acids and is consumed mostly raw in salads or as celery sticks. In the past, celery was cultivated not for its culinary use, but its medicinal purposes. Nowadays, there are three different kinds of celery: self-blanching or yellow (leaf celery), green or Pascal celery and celeriac which are widely grown in Europe, South and North America (Grant 2018).

Examples of varieties: Lathom Blanching Galaxy, Octavius, Granada (F1 hybrid), Moonbeam, Celebrity, Ivory Tower, Giant Pink - Mammoth Pink (Royal Horticulture Society 2018)

### 4.2.2 Lettuce (Lactuca sativa)

**Figure 2: *Lactuca sativa* (Zemánková 2018)**

Family: Asteraceae

Genus: *Lactuca*

Species: *Sativa*

Pathogens*: Botrytis cinerea , Erysiphe cichoracearum, Erysiphe pisi, Podosphaera fuliginea, Podosphaera fusca, Sclerotinia minor, Sclerotinia sclerotiorum* (FAO 2018)

52 pesticide residues were found in spinach by the USDA Pesticide Data Program (PDP). These were mainly pesticides as Imidacloprid, Mandipropamide and Propamocarb hydrochloride. The human health and environmental health effects are listed bellow:

Human health effects:

3 known or probable carcinogens, 17 suspected hormone disruptors, 10 neurotoxins, 8 developmental or reproductive toxins

Environmental effects:

14 - honeybee toxins (PAN 2018)

*Lactuca sativa* is one of the most consumed leafy vegetable (the leaves and succulent young shoots are picked for consumption) and is cultivated worldwide due to

its culinary use and high nutritive value (Kuete 2017). Because of its fast growth, it is an ideal short-season vegetable to interplant between long-season vegetables.

Lettuce suffers from numerous diseases such as Lettuce mosaic virus, downey mildew, corky boot, botrytis, sclerotinia and tiburn. Plants, which are overcrowded and stressed, are more vulnerable to dieases so their proper placing and adequate water can reduce the disease problems. Also Kelp Meal, which is a natural fertilizer made from dried seaweed (Maximum Yield 2018), can be added to the soil during planting time to boost the plant immunity and help the prevention of lettuce diseases. Aromatic herbs (thyme, oregano, basil or others) planted around lettuce patches can help with masking the plants from pests sucha as lettuce loopers. The most environment-friendly is the method when the larvae are hand-picked or sprayed by Garlic-Oil Soap Spray (Masley 2009).

Production of lettuce and chicory in Czechia in 2016 was 1,859 tonnes with harvested area of 152 ha and yield 122,303 kg/ha (FAO 2018)

There are seven main types of lettuce, and dozens of varieties within each type:

**Looseleaf lettuces** - are colourful, easy, and fast-growing lettuce varieties. They go from seed to baby salads in 5 weeks and from seed to salad in 7 weeks.
Examples of varieties: Red Oak Leaf and Green Oak Leaf (50-55 days), Red Salad Bowl (50 days), Red Sails (52 days) and Blushed Butter Oak (55 days)

**Butterhead Lettuces** - form loose, open heads of melt-in-your mouth leaves. They thrive in the warm days of fall, and the cool days from spring to early summer.
Examples of varieties: Burgundy Boston (50-55 days), Merveille des Quatre Saisons (55-60 days), Drunken Woman Frizzy Headed (55 days), Speckles (50-55 days), Flashy Butter Oak (54 days), Tom Thumb (50 days), Skyphos (45-50 days)

**Cos (Romaine) Lettuces** - form open with upright heads of deeply coloured leaves with stronger flavour than looseleaf varieties and crunchy midribs.
Examples of varieties: Breen (55 days), Jericho (57 days), Flashy Trout Back (55 days)

**Buttercrunch Lettuce** - are crosses between butterhead and romaine varieties.
Examples of varieties: Winter Density (54 days), Buttercrunch (48 days)
**Batavian Lettuces -** also known as Summer Crisp Lettuces, have thick, crunchy leaves that hold better in the heat than other varieties.
Examples of varieties: Nevada (48 days), Concept (52 days)

**Heading Lettuces (Crisphead Lettuces)** - roll their leaves into tight heads at maturity. These are the standard Iceberg lettuces, appreciated for their disease resistance and ability to stand against summer heat without turning bitter.
Examples of varieties: Summertime (48 days), Red Iceberg (50 days)

**Chinese Lettuces** - are stiff, strong-flavoured varieties grown for their stalks as well as their leaves.
Example of varieties: Celtuce (a celery-flavoured variety) (Masley 2009)

### 4.2.3 Spinach (Spinacia oleracea)

**Figure 3: *Spinacia oleracea* (Zemánková 2018)**

Family: Amaranthaceae
Genus: *Spinacia*
Species: *oleracea*
Pathogens: *Erysiphe pisi, Leveillula taurica* (FAO 2018)

54 pesticide residues were found in spinach by the USDA Pesticide Data Program (PDP). These were mainly pesticides as Permethrin, Imidacloprid, Spinosad A, Spinosad D, Cypermethrin, p,p'-DDE, Fenamidone and Boscalid. The human health and environmental health effects are listed bellow:

Human health effects:

7 known or probable carcinogens, 21 suspected hormone disruptors, 11 neurotoxins, 7 developmental or reproductive toxins

Environmental effects:

20 - honeybee toxins (PAN 2018)

*Spinacia oleracea* is a leafy vegetable, of which the leaves and tender shoots are consumed fresh or processed. Aside from high-level of antioxidants, spinach also contains a lot of vitamins and minerals. Spinach is native to central Asia (Ryder 1979), has become an important vegetable crop in most regions of the word and remarkable changes in production amounts have occurred in the past decades due to demand increase in many countries (Sabaghnia, Asadi-Gharneh & Janmohammadi 2015)

Production of spinach in Czechia in 2016 was 1,125 tonnes with harvested area of 133 ha and yield 84.694 kg/ha (FAO 2018).

There are three types of spinach with many cultivars of each:

**Savoy Spinach** - has deeply crinkled leaves, a low growth and is very productive and handles cold better than most types of spinach.

Examples of varieties: Regiment (F1 Hybrid, 37 days), Bloomsdale

**Semi-Savoy Spinach** - tends to have better disease resistance so it is usually the best choice when growing spinach at home.

Examples of varieties: Tyee (F1 Hybrid, 45 days, resistant to Downey Mildew races 1 and 3), Catalina (F1 Hybrid, 48 days), Teton (F1 Hybrid, 40-45 days, resistant to races 1-4 of Downey Mildew), Indian Summer (F1 Hybrid, 40-45 days)

**Smooth-Leafed Spinach** - has smooth, flat leaves that are easy to clean, which makes it the primary choice for processed spinach.

Examples of varieties: Space (F1 Hybrid, 45 days, resistant to races 1-3 of Downey Mildew), Red Cardinal (25-30 days) (Masley 2009)

### 4.2.4 Spring onion (Allium cepa)

**Figure 4: *Allium cepa* (Perez 2016)**

Family: Amaryllidaceae

Subfamily: Allioideae

Genus: *Allium*

Species: *cepa*

Pathogens: *Alternaria porri, Aspergillus flavus, Botrytis allii, Botrytis byssoidea, Botrytis cinereal, Leveillula Taurica, Sclerotinia minor, Sclerotinia sclerotiorum* (FAO 2018)

31 pesticide residues were found in green onions by the USDA Pesticide Data Program (PDP). These were mainly pesticides as DCPA, Azoxystrobin, Spinosad, Cyromazine and Methomyl. The human health and environmental health effects are listed bellow:

Human health effects:

4 known or probable carcinogens, 13 suspected hormone disruptors, 4 neurotoxins, 5 developmental or reproductive toxins

Environmental effects:

10 - honeybee toxins (PAN 2018)

Allium cepa, commonly known as onion, is the most widely cultivated species of genus *Allium* (EOL 2018) used as a worldwide culinary and therapeutic spice. Onion is a source of various biologically active compounds such as phenolic acids, thiosulfinates and flavonoids with a variety of pharmacological activities including anticancer, antidiabetic, antimicrobial, antioxidant and cardiovascular effects (Kuete 2017).

Generally, a spring onion differs from a bulb onion as it is supposed to be eaten young, so the defining characteristic is the lack of fully developed bulb. However, there are some varietis on the market which can be spring and bulb onions at the same time (The Gardeners Calendar 2018)

Examples of varieties: Deep Purple, Paradase, Evergreen Long White, Exhibition, Guardsman, Tokio Long White, White Lisbon (The Gardeners Calendar 2018)

## 4.3 Agricultural production systems

### 4.3.1 Conventional farming

Conventional farming, also known as industrial agriculture, refers to farming systems which include the use of synthetic hemical fertilizers, pesticides, herbicides and other continual inputs, genetically modified organisms,concentrated animal feeding operations, heavy irrigation, intensive tillage, or concentrated monoculture production. Thererefore, the conventional agriculture is typically higly resource and energy intensive as well as higly productive (APPROPEDIA 2016).

### 4.3.2 Integrated farming

Integrated farming comprises of cropping methods and other agricultural production techniques which are fulfilling both, ecological and economic demands.

The farmers must adapt to the management measures related to variety selection, crop rotation, cultivation technology, plant nutrition and plant protection to the natural environment. This also includes an optimal soil conservation by environment-friendly management systems and goal-directed fertilisation and pest control. At the same time, the attention must be paid on groundwater and surface waters together with the selection

of pesticides is contingent on the degree of ecological tolerance (Schröder, Pfadenhauer & Munch 2008).

### 4.3.3 Organic farming

There are many explanations and definitions for organic agriculture, but they all aim to state that it is a system which is depended on ecosystem management rather than external agricultural inputs. Organic farming is considering potential environmental and social impacts by eliminating the use of synthetic inputs as synthetic fertilizers and pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives and irradiation. The replacement is performed by site-specific management practices which keep and increase long-term soil fertility and prevent pests and diseases (FAO 2018).

## 4.4 Pesticides

Pesticides are chemical compounds that are used to protect crops by killing pests, including insects, rodents, fungi and weeds. Also, pesticides are used in public health to kill vectors of disease, such as mosquitoes.

By their nature, pesticides are potentially toxic to other organisms, including humans, and need to be used safely and disposed of properly. They can have acute and chronical health effect depending on the quantity and ways of human exposure (WHO 2018).

### 4.4.1 History of pesticide use

A lot of the older and cheaper (off-patent) pesticides, such as dichlorodiphenyltrichloroethane (DDT), can remain in the soil and water for years. In developed contries, these chemicals were eliminated or completely banned from agricultural use, but they are still used in many developing countries.

These chemicals have been banned by countries who signed the 2001 Stockholm Convention which is an international treaty that aims to eliminate or restrict the production and use of persistent organic pollutants (WHO 2018).

In 1962, 40 insecticides (especially DDT and lindane) were authorised together with 18 fungicides and 14 herbicides in Czechia. In 2014, 1120 pesticides were approved (Florián 2008).

### 4.4.2 Classification of pesticides

The classification of pesticides is mostly divided based on how harmful the organism is. The most important and commonly used groups of pesticides are zoocides, herbicides, fungicides, bactericides and specific preparations (Kizlink 2001).

#### 4.4.2.1 Zoocides

Zoocides are preparations that are used to kill animal pests

Depending on the target organism, zoocides are devided into:

**Insecticides**

The biggest section of zoocides designed to control insects that are harmful to humans. The insects may be directly harmful, as they are acting as disease vectors, or indirectly harmful, as destroyers of crops, food products or textile fabrics.

**Acaricides**

Acaricides are chemicals used to control mites.

**Moluscocides**

Moluscocides are chemicals used to control molluscs such as snails and slugs.

**Nematocides**

Nematocides are chemicals used to control nematodes.

**Rodenticides**

Rodenticides are chemicals used to control rodents such as rats and mice (Kizlink 2001).

#### 4.4.2.2 Herbicides

Herbicides are a broad class of pesticides that are used to remove nuisance plants, such as grasses and weeds, that may compromise the growth and yield of desired crops that are in close proximity (Vinken, Bruyn & Klawans 1968).

#### *4.4.2.3* Fungicides

A fungicide is any substance, preparation, or organism intended for destroying or controlling any fungal species during production, storage, or distribution of an agricultural commodity or food, in ornamental plants, or in situations endangering the health of animals or humans (Caballero, Trugo & Finglas 2003).

#### 4.4.2.4 Bactericides

Bactericides are chemicals used to control bacteria (Kizlink 2001).

#### 4.4.2.5 Substances assigned to pesticides

**Biopesticides**

Biopesticides are PPPs which contain biological control agents (microbials, pheromones, plant extracts etc.) for use as agricultural, horticultural and home garden pesticides.

**Adjuvants**

**S**ubstances or preparations which consist of co-formulants or preparations containing one or more co-formulants, in the form in which they are supplied to the user and placed on the market to be mixed by the user with a PPP and which enhance its effectiveness or other pesticidal properties (Health and Safety Executive 2018).

## 4.5 Pesticide residues

Pesticide residues are residues, including active substances, metabolites or degradation products of active substances, currently or formerly used in plant protection products as defined (Ministry of Agriculture 2017).

### 4.5.1 Impact of pesticide residues on human organism

Pesticides are among the leading causes of death by self-poisoning specifficaly in low- and middle-income countries. As they are intrinsically toxic and deliberately spread in the environment, the production, distribution, and use of pesticides require

strict regulation and control. Regular monitoring of residues in food and the environment is also required.

The most at-risk population are people, who are directly exposed to pesticides. This includes agricultural workers who apply pesticides, and other people in the immediate area during and right after pesticides are spread. The general population, who are not in the area where pesticides are used, is exposed to significantly lower levels of pesticide residues through food and water.

The toxicity of a pesticide depends on its function and other factors. For example, insecticides tend to be more toxic to humans than herbicides. The same chemical can have different effects at different doses (how much of the chemical a person is exposed to). It can also depend on the route by which the exposure occurs (such as swallowing, inhaling, or direct contact with the skin) (WHO 2018).

### 4.5.2 Pesticide residues in food

The amount of pesticide residues in food might depend on:

- Number of applications, application dose and the interval between applications.
- Application technology
- The mechanism of action of the active substance and its metabolism in plants, animals and degradation in the environment. For plants, most pesticide residues are found on the surface of the leaves.
- The development stage of the crop at the time of application of the pesticide preparation.
- Location of the consumable part. Crop above ground has the highest levels of pesticide residue. Consumable area beneath the Earth's surface is almost without pesticide residues.
- Pre-harvest Interval

**PHI**

Pre-harvest interval is the shortest acceptable interval between the last application and harvest given in days.

**AT** (application term, application method or specification of use)

In this case, the pre-harvest interval is defined by the interval between the uniquely determined term of application or the last application and harvest of the particular crop. The term of application is expressed by the growth stage of the particular crop or other precisely specified period of use.

**"0"**

There is a "0" pre-harvest interval stated in case of a low-risk of the PPPs or an auxiliary product when there is no need to determine a pre-harvest interval (Central Institute for Supervising and Testing in Agriculture 2014).

### 4.5.3 Maximum Residue Limit (MRS)

To protect food consumers from adverse effects of pesticides, WHO reviews evidence and develops the internationally accepted Maximum Residue Limits (WHO 2018).

MRLs are set to reflect the highest amount of pesticide residue expected in food when pesticides are applied correctly in accordance with approved conditions of use.

They thus provide a mechanism to verify that produce has only been treated with pesticides according to authorised agricultural practices, both for produce treated within the EU and for imported produce (WHO 2018).

### 4.5.4 Acceptable Daily Intake (ADI)

ADI is an estimation of the amount of a substance in food or drinking water which can be consumed over a lifetime without presenting a noticeable risk to health. It is usually expressed as milligrams of the substance per kilogram of body weight. It refers to chemical substances such as food additives, pesticide residues and veterinary drugs (European Food Safety Authority 2018).

### 4.5.5 Monitoring on pesticide residues in Czechia

In 2017, 907 samples were collected to determine the presence of pesticide residues and 389 541 analyzes were performed. The amount of examined pesticides was

449. The samples were taken from the EU countries (50.7 %), Czechia (27.2 %) and third countries (18.2 %). The number of samples which were above the permitted limit was 10 (Czech Agriculture and Food Inspection Authority 2018).

### 4.5.6 Authorities of government control

In Czechia, the heterogeneous substances are monitored by the regional inspectorates which are collecting samples and sending them for laboratory analyses later. These analyses are performed in laboratories of the CAFIA in Prague and Brno, but also external laboratories are used for this purpose (Czech Agriculture and Food Inspection Authority 2018).

The issue of pesticide residues falls within the Ministry of Agriculture and the Ministry of Health (Ministry of Health 2016).

In Czechia, inspections on pesticide residues are performed by:

- The Czech Agriculture and Food Inspection Authority (CAFIA)
- The State Veterinary Administration (SVA)
- State Phytosanitary Administration (SRS)
- Central Institute for Supervising and Testing in Agriculture (ÚKZÚZ)
- Organs protecting public health (OOVZ)
- The Rapid Alert System for Food and Feed (RASFF) (Ministry of Health 2016)

## 4.6 Active substances

Active substances are the essential ingredients in a pesticide that enable the product to do its job in the form of chemicals or micro-organisms. The pesticide is the final product placed on the market.

**Low-risk substances** are active substances which have been evaluated as having a low-risk. For the approval of these substances, the standard assessment procedure applies.

**Basic substances** can be described as active substances, not predominantly used as PPPs but which may be of value for plant protection and for which the economic interest of applying for approval may be limited (Health and Safety Executive 2018).

### 4.6.1 Selected active substances with negative impact on human health

**Aclonifen**

A nitrophenyl ether herbicide used for the pre-emergence control of grass and broad-leaved weeds.

Pesticide type: herbicide

Substance group: diphenyl ether

Known relevant impurities: EU dossier - Phenol

Substance origin: synthetic

Mode of action: Systemic and selective. Inhibition of carotenoid biosynthesis.

Health issues: carcinogen, skin irritant, skin sensitier

General human health issues: possible kidney toxicant (University of Hertfordshire 2018).

**ADI:** 0.07 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.01 (lower limit of analytical determination)

Lettuce: 0.01 (lower limit of analytical determination)

Spinach: 0.01 (lower limit of analytical determination)

Spring onion: 0.01 (lower limit of analytical determination) (European Commission 2018)

**Bromoxynil**

An HBN herbicide used for post-emergence control of annual broad-leaved weeds. it is also a pesticide transformation product.

Pesticide type: herbicide, metabolite

Substance group: hydroxybenzonitrile

Known relevant impurities: EU dossier - non declared

Substance origin: synthetic

Mode of action: Selective, contact action with some systemic activity. Inhibits

photosynthesis (photosystem II).

Health issues: endocrine disrupter, reproduction/development effects, skin sensitier

General human health issues: USEPA - possible human carcinogen, possible liver and thyroid toxicant (University of Hertfordshire 2018).

**ADI:** 0.01 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05 (lower limit of analytical determination)

Lettuce: 0.01 (lower limit of analytical determination)

Spinach: 0.01 (lower limit of analytical determination)

Spring onion: 5.0 (European Commission 2018)

**Deltamethrin**

A fast-acting insecticide used to control a wide range of pests mainly in non-agricultural situations.

Pesticide type: insecticide, metabolite, veterinary substance

Substance group: pyrethroid

Known relevant impurities: EU dossier - non declared

Substance origin: synthetic

Mode of action: Non-systemic with contact and stomach action. Sodium channel modulator.

Health issues: endocrine disrupter, neurotoxicant

General human health issues: IARC Group 3 carcinogen. Endocrine issues - weak estrogenic aktivity (University of Hertfordshire 2018).

**ADI:** 0.1 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.01 (lower limit of analytical determination)

Lettuce: 0.05

Spinach: 0.01 (lower limit of analytical determination)

Spring onion: 0.3 (European Commission 2018)

**Fluazifop-P-butyl**

A post-emergence herbicide used to control grass weeds mainly in broad-leaved crops.

Pesticide type: herbicide

Substance group: aryloxyphenoxypropionate

Known relevant impurities: EU dossier - 2-chloro-5-(trifluoromethyl)pyridine <1.5g/kg

Substance origin: synthetic

Mode of action: Selective, absorbed through leaf surface. An acetyl CoA carboxylase inhibitor.

Health issues: skin sensitiser

General human health issues: Harmful if inhaled or ingested. Kidney, spleen and liver toxicant. May cause eye cateracts (University of Hertfordshire 2018).

**ADI:** 0.1 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.03 (lower limit of analytical determination)

Lettuce: 0.02

Spinach: 0.02

Spring onion: 0.01 (lower limit of analytical determination) (European Commission 2018)

**Glyphosate**

A broad-spectrum herbicide used in a wide range of cropping, utility and industrial situations to for broad-spectrum control of weeds and grasses.

Pesticide type: herbicide

Substance group: phosphonoglycine

Known relevant impurities: EU dossier - Formaldehyde < 1 g/kg; N-nitroso-glyphosate < 1 mg/kg

Substance origin: synthetic

Mode of action: Broad-spectrum, systemic, contact action translocated and non-residual. Inhibition of EPSP synthase.

Health issues: skin irritant, eye irritant

General human health issues: IARC group 2A carcinogen; USEPA - no evidence to support classification as human carcinogen. Possible bladder and liver toxicant. May cause serious eye damage. Endocrine issues - disruption of aromatase activity (University of Hertfordshire 2018).

**ADI:** 0.5 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.01 (lower limit of analytical determination)

Lettuce: 0.01 (lower limit of analytical determination)

Spinach: 0.01 (lower limit of analytical determination)

Spring onion: 0.01 (lower limit of analytical determination) (European Commission 2018)

**Iprodione**

A post-harvest fungicide used to control diseases on fruit, vegetables and other crops.

Status: not approved (European Commission 2018)

Pesticide type: fungicide

Substance group: dicarboximide

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Contact action with protectant and some eradicant activity. Signal transduction inhibitor.

Health issues: reproduction/development effects, respiratory tract

General human health issues: May cause pulmanary problems. Possible liver, adrenals, testes, postrate & spleen toxicant. Hepatotoxic in mice. USEPA - probable human carcinogen. Endocrine issues - increase weakly aromatase activity (University of Hertfordshire 2018).

**ADI:** 0.06 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05 (lower limit of analytical determination)

Lettuce: 25.0

Spinach: 0.02

Spring onion: 4.0 (European Commission 2018)

**Linuron**

A herbicide for the pre- and post-emergence control of annual grass and broad-leaved weeds.

Status: not approved (European Commission 2018)

Pesticide type: herbicide

Substance group: urea

Known relevant impurities: EU dossier - TCAB 1 mg/kg max; TCAB 1 mg/kg max; TCAOB 1 mg/kg max

Substance origin: synthetic

Mode of action: Selective, systemic with contact and residual action. Inhibits photosynthesis (photosystem II).

Health issues: reproduction/development effects, skin irritant, eye irritant

General human health issues: May cause nausea, vomiting, and diarrhea if ingested

USEPA - possible human carcinogen. Endocrine issues - competitive binding to androgen receptor, thyroid receptor agonist (University of Hertfordshire 2018).

**ADI:** 0.003 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.01 (lower limit of analytical determination)

Lettuce: 0.05 (lower limit of analytical determination)

Spinach: 0.05 (lower limit of analytical determination)

Spring onion: 0.05 (lower limit of analytical determination) (European Commission 2018)

**Mancozeb**

A fungicide for control of a wide range of pathogens including blights and scabs on crops.

Pesticide type: fungicide

Substance group: carbamate

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Broad spectrum, non-systemic, contact with protective action, acts by distrupting lipid metabolism. Multi-site activity.

Health issues: reproduction/development effects, respirátory tract irritant, eye irritant

General human health issues: May cause ovarian hyperthropy. Possible thyroid toxicant. USEPA - probable human carcinogen (University of Hertfordshire 2018).

**ADI:** 0.05 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.1 (lower limit of analytical determination)

Lettuce: 5.0

Spinach: 0.05 (lower limit of analytical determination)

Spring onion: 1.0 (European Commission 2018)

**Metaldehyde**

A contact and systemic molluscicide bait for controlling slugs and snails.

Pesticide type: molluscicide

Substance group: Cyclo-octane

Known relevant impurities: EU dossier - Acetaldehyde max 1.5 g/kg

Substance origin: synthetic

Mode of action: Contact and stomach action.

Health issues: eye irritant

General human health issues: Moderately toxic. Kidney and liver toxicant. USEPA - some evidence to suggest possible human carcinogen (University of Hertfordshire 2018).

**ADI:** 0.02 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.1 (lower limit of analytical determination)

Lettuce: 2.0

Spinach: 2.0

Spring onion: 0.05 (lower limit of analytical determination) (European Commission 2018)

**Pendimethalin**

A herbicide used to control most annual grasses and common weeds in cereals, fruit and vegetables.

Pesticide type: herbicide

Substance group: dinitroaniline

Known relevant impurities: EU dossier - 1.2-dichloroethane <= 1 g/kg; Nitroso-pendimethaline < 0.045 g/kg

Substance origin: synthetic

Mode of action: Selective, absorbed by roots and leaves. Inhibition of mitosis and cell division. Microtubule assembly inhibition.

Health issues: reproduction/development effects, respirátory tract irritant, skin irritant,

skin sensitiser, eye irritant

General human health issues: Harmful if swallowed. Thyroid & liver toxicant. Bioaccumulates. USEPA - possible human carcinogen (University of Hertfordshire 2018).

**ADI:** 0.125 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05 (lower limit of analytical determination)

Lettuce: 0.1

Spinach: 0.05 (lower limit of analytical determination)

Spring onion: 0.05 (lower limit of analytical determination) (European Commission 2018)

**Pirimicarb**

An insecticide for aphid control in a wide range of crops.

Pesticide type: insecticide

Substance group: carbamate

Known relevant impurities: EU dossier - 2-chloro-5-(trifluoromethyl)pyridine <1.5g/kg

Substance origin: synthetic

Mode of action: Selective, systemic with contact, stomach and respiratory action. Acetylcholinesterase (AChE) inhibitor.

Health issues: cholinesterase inhibitor, neurotoxicant, eye irritant

General human health issues: Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. USEPA - probable human carcinogen (University of Hertfordshire 2018).

**ADI:** 0.035 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 5.0

Lettuce: 1.5

Spinach: 0.06

Spring onion: 0.01 (lower limit of analytical determination) (European Commission 2018)

**Propyzamide**

A residual, systemic post-emergent herbicide for use in a wide range of crops to control annual and perennial weeds.

Pesticide type: herbicide

Substance group: benzamide

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Selective, systemic absorbed by roots and translocated. Microtubule assembly inhibition.

Health issues: carcinogen

General human health issues: Possible liver, kidney & spleen toxicant. Associated with thyroid follicular cell adenomas and Leydig cell benign tumours (University of Hertfordshire 2018).

**ADI:** 0.02 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05 (lower limit of analytical determination)

Lettuce: 0.6

Spinach: 0.01 (lower limit of analytical determination)

Spring onion: 0.01 (lower limit of analytical determination) (European Commission 2018)

**Pymetrozine**

A novel azomethine insecticide suitable for use in integrated crop management to control aphids and other plant sucking pests.

Pesticide type: insecticide

Substance group: pyridine

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Selective, neural inhibition of feeding behavior that eventually starves insect.

Health issues: carcinogen, reproduction/development effects, respirátory tract irritant

General human health issues: May affect most major organs at high doses. Highly toxic - harmful if swallowed. USEPA - probable human carcinogen (University of

Hertfordshire 2018).

**ADI:** 0.03 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.1 (lower limit of analytical determination)

Lettuce: 3.0

Spinach: 0.6

Spring onion: 0.02 (lower limit of analytical determination) (European Commission 2018)

**Pyridate**

A post-emergence herbicide used to control annual broad-leaved weeds.

Pesticide type: herbicide

Substance group: phenylpyridazine

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Selective with contact action, absorbed mainly by the leaves. Photosynthetic electron transport inhibitor at the photosystem II.

Health issues: skin irritant, skin sensitiser

General human health issues: Potential liver and kidney toxicant. May induce haematological changes. Endocrine issues - binding to estrogen and androgen receptors (University of Hertfordshire 2018).

**ADI:** 0.036 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.15

Lettuce: 0.05 (lower limit of analytical determination)

Spinach: 0.05 (lower limit of analytical determination)

Spring onion: 1.0 (European Commission 2018)

**Spirotetramat**

New insecticide for the control of a wide range of sucking insects on crops such as fruit and potatoes.

Pesticide type: insecticide

Substance group: tetramic acid

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Stomach acting, broad spectrum, long acting insecticide that is rapidly translocated, inhibition of lipogenesis in treated insects.

Health issues: reproduction/development effects, skin sensitiser, eye irritant

General human health issues: Possible liver and kidney toxicant. May cause lung damage (University of Hertfordshire 2018).

**ADI:** 0.05 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.1 (lower limit of analytical determination)

Lettuce: 7.0

Spinach: 7.0

Spring onion: 0.1 (lower limit of analytical determination) (European Commission 2018)

**Sulfoxaflor**

Novel substance for the control of aphids in field and agricultural crops.

Pesticide type: insecticide

Substance group: sulfoximine

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: An agonist of n-Acetylcholine receptors in insects. Systemic.

Health issues: N/A

General human health issues: Possible liver toxicant. USEPA - some evidence to suggest possible human carcinogen (University of Hertfordshire 2018).

**ADI:** 0.04 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05 (lower limit of analytical determination)

Lettuce: 4.0

Spinach: 6.0

Spring onion: 0.7 (European Commission 2018)

**Tebuconazole**

A fungicide effective against various foliar diseases in cereals and other field crops.

Pesticide type: fungicide, plant growth regulator

Substance group: triazole

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Systemic with protective, curative and eradicant action. Disrupts membrane function. Sterol biosynthesis inhibitor.

Health issues: reproduction/development effects, eye irritant

General human health issues: Targets liver/blood systém. USEPA - possible human carcinogen. (University of Hertfordshire 2018).

**ADI:** 0.03 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 1.5

Lettuce: 0.5

Spinach: 0.02 (lower limit of analytical determination)

Spring onion: 2.0 (European Commission 2018)

**Tefluthrin**

An insecticide used to control a wide range of soil pests including Coleoptera, Lepidoptera and Diptera.

Pesticide type: insecticide

Substance group: pyrethroid

Known relevant impurities: EU dossier - hexachlorobenzene

Substance origin: synthetic

Mode of action: Contact and respiratory action with some repellant effects. Sodium channel modulator.

Health issues: skin irritant, eye irritant

General human health issues: Highly toxic. Possible thyroid toxicant (University of Hertfordshire 2018).

**ADI:** 0.005 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05

Lettuce: 0.05

Spinach: 0.05

Spring onion: 0.05 (European Commission 2018)

**Thiacloprid**

A chloronicotinyl insecticide for use on apples and other crops to control sucking and chewing insects.

Pesticide type: insecticide, molluscicide

Substance group: neonicotinoid

Known relevant impurities: EU and FAO dossiers - none declared

Substance origin: synthetic

Mode of action: Contact and stomach action with some systemic properties. Acetylcholine receptor (nAChR) agonist.

Health issues: endocrine disrupter

General human health issues: Possible liver and thyroid toxicant. USEPA - probable human carcinogen (University of Hertfordshire 2018).

**ADI:** 0.01 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.08

Lettuce: 1.0

Spinach: 0.15

Spring onion: 0.15 (European Commission 2018)

### 4.6.2 Selected basic and low-risk substances

**Ammonia water 25% (Ammonium hydroxide - one of the substances contained in VITALON 2000)**

An inorganic herbicide, fungicide and microbiocide used as a general purpose sterilant.

Status: not approved (European Commission 2018)

Pesticide type：microbiocide

Substance group: inorganic compound

Substance origin: synthetic

Mode of action: As a fungicide it is a protectant, inhibiting fungal spores and pathogens from entering the host tissues.

Health issues: respiratory tract irritant, skin irritant, eye irritant

General human health issues: Toxic. May cause corrosion to the esophagus and stomach with perforation and peritonitis. May cause rapid lowering of blood pressure (University of Hertfordshire 2018).

**Pesticide residues and MRLs (mg/kg):** 0,01

**Citric acid (one of the substances contained in VITALON 2000)**

A naturally occuring acid substance that is used as a disinfectant and fungicide and also used in some pesticide formulations as an acidity regulator.

Pesticide type：fungicide, microbiocide, other substance

Other constituent type: acidity regulator

Substance group: plant derived

Substance origin: natural

Mode of action: unclear mode of action

Health issues: respiratory tract irritant, skin irritant, eye irritant

General human health issues: May cause gastrointestinal irritation with nausea, vomiting and diarrhea at high doses.

**Pesticide residues and MRLs (mg/kg):** quantum satis (q.s.) (University of Hertfordshire 2018)

**Copper hydroxide (Champion 50 WP, Funguran-OH 50 WP)**

An inorganic copper compound used to protect against a number of fungal and bacterial diseases.

Pesticide type: fungicide, bactericide

Substance group: inorganic compound

Known relevant impurities: EU 2018 dossier: May contain heavy metals including Pb, Cd, As, Ni, CO, Sb & Hg.

Substance origin: synthetic

Mode of action: Absorbed copper disrupts the enzyme systems of pathogens. Multi-site activity.

Health issues: respiratory tract irritant, skin irritant, eye irritant

General human health issues: potential heavy metal poisoning (University of Hertfordshire 2018).

**ADI:** 0.15 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 40.0

Lettuce: 100.0

Spinach: 20.0

Spring onion: 5.0 (European Commission 2018)

**Copper oxychloride (Flowbrix, Korzar, Kuprikol 250 SC, Kuprikol 50)**

A protectant copper fungicide and bactericide used as a foliar spray which is approved for use in many countries including at EU level. It has a low aqueous solubility and a low volatility. As a heavy metal, copper itself will not degrade in the environment. It is moderately toxic to mammals and most biodiversity.

Pesticide type: fungicide, repellent

Substance group: inorganic compound

Known relevant impurities: EU 2018 dossier: May contain heavy metals including Pb, Cd, As, Ni, CO, Sb & Hg.

Substance origin: synthetic

Mode of action: Absorbed copper disrupts the enzyme systems of pathogens. Multi-site activity.

General human health issues: potential heavy metal poisoning (University of Hertfordshire 2018).

**ADI:** 0.15 mg/kg per day

**Pesticide residues MRLs (mg/kg):**

Celery: 40.0

Lettuce: 100.0

Spinach: 20.0

Spring onion: 5.0 (European Commission 2018)

**Ferric phosphate (Ironmax Pro)**

Used to control a variety of slugs and snails on a wide range of foods and ornamental crops.

Pesticide type: molluscicide

Substance group: inorganic compound

Known relevant impurities: EU dossier - Pb: 3mg/kg; Hg: 0.1 mg/kg; Cd: 1.0 mg/kg

Substance origin: synthetic

Mode of action: Contact action, interferes with calcium metabolism in slug / snail stomach causing it to stop feeding.

Health issues: respiratory tract irritant

General human health issues:If inhaled, iron is a local irritant to the lung and gastrointestinal tract. Liver, cardiovascular, CNS and pancreas toxicant (University of Hertfordshire 2018).

**ADI:** 0.8 mg/kg per day

**Pesticide residues and MRLs (mg/kg):** no MRL required (European Commission 2018)

**Hydrogen peroxide 100% (Hydrogen peroxide)**

An inorganic compound effective agianst microbes, including fungi and bacteria, that cause plant diseases. Hydrogen peroxide is an approved EU basic/commodity susbstance. It is highly soluble in water and in its pure state it is highly volatile but much less so diluted. It is not environmentally persistent. Hydrogen peroxide is not expected to have an immediate or delayed harmful effect on human or animal health. At higher concentrations it is toxic to aquatic systems.

Pesticide type: fungicide, bactericide, other substance

Other constituent type: disinfectant

Substance group: inorganic compound

Known relevant impurities: EU Dossier - none declared

Substance origin: natural

Mode of action: preventative and curative action

Health issues: respiratory tract irritant, skin irritant, eye irritant

General human health issues: May cause skin dermatitis. IARC group 3 carcinogen. Health impacts related to concentration (University of Hertfordshire 2018).

**ADI:** not aplicable

**Pesticide residues and MRLs (mg/kg):** no MRL required (European Commission 2018)

**Potassium hydrogen carbonate (Vitisan)**

Naturally occurring substance used for the control of several important fungal diseases of fruit and vegetables.

Pesticide type: fungicide

Substance group: inorganic compound

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Protectant and eradicant, bicarbonate causes the collapse of hyphal walls and shrinkage of fungal conidia.

Health issues: eye irritant

General human health issues: no further information available (University of Hertfordshire 2018).

**ADI:** not aplicable

**Pesticide residues and MRLs (mg/kg):** no MRL required (European Commission 2018)

**Propamocarb hydrochloride (Proplant)**

A fungicide for specific control of Phycomycetes and effective against Phytophthora spp. and Pythium spp.

Pesticide type: fungicide

Substance group: carbamate

Known relevant impurities: EU dossier - none declared

Substance origin: synthetic

Mode of action: Systemic, with protective action absorbed by roots and leaves and translocated. Lipid synthesis inhibitor.

Health issues: skin irritant, skin sensitiser

General human health issues: Endocrine issues - weak increase of aromatase activity and estrogen production (University of Hertfordshire 2018).

**ADI:** 0.29 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.05 (lower limit of analytical determination)

Lettuce: 40.0

Spinach: 40.0

Spring onion: 30.0 (European Commission 2018)

**Sodium hydrogen carbonate (Natrisan)**

A novel fungicide for the control of fungal pathogens on a range of horticultural and other crops.

Pesticide type: fungicide, passive auxiliary agent

Substance group: inorganic compound

Known relevant impurities: EU 2017 dossier: arsenic < 3mg/kg; lead < 2 mg/kg; mercury < 1 mg/kg

Substance origin: natural

Mode of action: Broad spectrum, contact activity, rapid effect. Preventative with a slight curative aktivity.

Health issues: skin irritant, eye irritant

General human health issues: Cardiac depressant in ingested in large quantities. Linked with urinary bladder hyperplasia in rats. No serious adverse health concerns (University of Hertfordshire 2018).

**ADI:** not applicable

**Pesticide residues and MRLs (mg/kg):** No MRL required (European Commission 2018)

**Spinosad (Spintor)**

An insecticide derived from naturally occurring soil fungi (naturalyte) used to control Lepidoptera.

Pesticide type: insecticide

Substance group: micro-organism derived

Known relevant impurities: EU dossier - none declared

Substance origin: natural

Mode of action: Contact and stomach action. Acts by exciting the insect nervous system, leading to involuntary muscle contractions and paralysis.

General human health issues: Possible thyroid toxicant. May cause inflammation of various organs. Linked with urinary bladder hyperplasia in rats. No serious adverse health concerns (University of Hertfordshire 2018).

**ADI:** 0.024 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 0.01 (lower limit of analytical determination)

Lettuce: 10.0

Spinach: 15.0

Spring onion: 4.0 (European Commission 2018)

**Tribasic copper sulphate (Cuproxat SC)**

A widely used copper fungicide that is approved for use in many countries including at EU level. It has a low aqueous solubility and a low volatility. As a heavy metal, copper itself will not degrade in the environment. It is moderately toxic to mammals and most biodiversity.

Efficacy & activity: Copper based products have been shown to be affective against many fungal pathogens in field trials.

Pesticide type: fungicide, algicide, bactericide

Substance group: inorganic compound

Known relevant impurities: EU 2016 dossier: May contain heavy metals including Pb, Cd, As, Ni, CO, Sb & Hg.

Substance origin: synthetic

Mode of action: Foliar absorption, prevents spore germination. Multi-site activity.

General human health issues: Potential heavy metal poisoning. May cause nausea

Mutagenic potential at high doses (University of Hertfordshire 2018).

**ADI:** 0.15 mg/kg per day

**Pesticide residues and MRLs (mg/kg):**

Celery: 40.0

Lettuce: 100.0

Spinach: 20.0

Spring onion: 5.0 (European Commission 2018)

## 4.7 Extraction techniques of pesticide residues

The analytical methods used for determination of pesticide residues in food of plant origin:

- Multiple Reaction Monitoring **(MRM)** based on **QUECHERS** (Quick, Easy, Cheap, Effective, Rugged, Safe) with Gas Chromatography - Time-of-flight Mass

Spectrometry **(GC–TOF/MS)** and Liquid Chromatography - Tandem Mass Spectrometry **(LC–MS/MS)** detection

- Gas Chromatography - Electron Capture Detector **(GC–ECD)**
- Gas Chromatography - Mass Selective Detector **(GC-MSD)**
- Liquid Chromatography - Tandem Mass Spectrometry **(LC-MS/MS)** (Khan, Kamble, Bhongale, Girme, Bahadur Chauhan & Banerjee 2017; da Costa Morais, Collins & Jardim 2018)

## 4.8 Safety measures

Nobody should be exposed to unsafe amount of pesticides, but it is almost impossible to avoid their effects nowadays.

Examples of prevention the impact of pesticides and their residues on human healh:

- Grow the plants under organic or integrated farming systems.
- Reduce the usage of pesticides in agriculture and if possible, always prefer the non-chemical methods of plant protection in the first place.
- Use only registered products and use them correctly for specific problems.
- Apply the recommended amount of approved Plant Protection Products (PPPs) to the plants abide by the conditions of the Pre-harvest Interval (PHI).
- Change various PPPs on repeated application to avoid the resistance to the relevant repetitively used product.
- Follow the instructions for application when using pesticides as proper application of pesticides with no exceeding recommended application doses is required.
- People spreading pesticides on crops, in homes or in gardens should be adequately protected by wearing gloves and face masks if necessary.
- People not directly involved in the spread of pesticides should stay away from the area during and just after a spread.
- To inspect the crops treated with pesticides for the occurrence of pesticide residues together with an inspection of crops that have been treated with post-harvest application.

- Considerable attention must be paid to products intended for the production of food for infants and young children.
- Developing new types of pesticides (WHO 2018).

If the pesticide already occurs in food, the consumer may reduce effects of pesticide residues in the following ways:

- Wash fresh fruit and vegetables carefully with clean and warm water as it removes pesticides from the surface more effectively.
- Peeling the fruit and vegetables but some pesticides are systemic, which means they can be found inside of the fruit and vegetables and we do not remove them by either peeling or washing.
- Cooking and baking also reduces (WHO 2018).

# 5. Results and discussion

In this study, from the list of active substances in the tables (Table 2 to Table 5) were selected those substances, which have a negative impact on human health and are a controversial topic in society along with those which are a safer option and were described as well as the analytical methods of pesticide residues detection. Maximum Pesticide Limits (MRLs) for lettuce (*Lactuca sativa*), celery *(Apium graveolens* var. *dulce* (Mill.) Pers.*)*, spinach *(Spinacia oleracea)* and spring onion *(Allium cepa)* were found depending on data availability.

**Celery:**

11 active substances, together with 40 different PPPs for application on celery on the Czech market, were identified in total.

32 PPPs are used in conventional farming systems.

7 PPPs are suitable for celery grown under the organic farming systems.

1 PPP is approved as a low-risk substance.

**Lettuce:**

44 active substances, together with 69 different PPPs for application on lettuce on the Czech market, were identified in total.

55 PPPs are used in conventional farming systems.

4 PPPs are suitable for lettuce grown under the organic farming systems.

7 PPPs are approved as products low-risk substances.

**Spinach:**

37 active substances, together with 99 different PPPs for application on spinach on the Czech market, were identified in total.

86 PPPs are used in conventional farming systems.

10 PPPs are suitable for spinach grown under the organic farming systems.

3 PPPs are approved as products with basic or low-risk substances.

**Spring onion:**

15 active substances, together with 28 different PPPs for application on spring onion on the Czech market, were identified in total.

24 PPPs are used in conventional farming systems.

3 PPPs are suitable for spring onion grown under the organic farming systems.

1 PPP is approved as a low-risk substance.

At present, it is almost impossible to avoid the human exposure to pesticides. To reduce this risk, the goals are to properly apply the recommended amount of approved Plant Protection Products (PPPs) to the plants abide by the conditions of the Pre-harvest Interval (PHI), but always give preference to non-chemical methods in the first place, and use them correctly for specific problems; to change various PPPs on repeated application to avoid the resistance to the relevant repetitively used product; to grow the plants under organic or integrated farming systems; to reduce the amount of commercial pesticides used in the agriculture and develop their potential safe and efficient alternatives or use the products with basic or low-risk substances currently available on the market; and to prevent the entry of pesticides into human food. It is vital to pay an increased attention to products intended for the production of food for infants and young children. Therefore, it is crucial to ensure that pesticides are not present in food or do not exceed the Maximum Residue Limits (MRLs).

**Table 2:** Approved Plant Protection Products for celery in Czechia (Institute for Supervising and Testing in Agriculture 2018)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Celery** | Azoxystrobin | U | FUN | 14 | Ortiva | 4247-4, 4247-7, 4247-8, 4247-9 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Azoxystrobin | U | FUN | 14 | Zakeo | 4247-11 | 31.12.22 | 31.12.22 | 31.12.22 | VD |
| | Bacillus thuringiensis ssp. kurstaki | III | INS | AT | Lepinox Plus | 5258-0, 5258-1 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Copper hydroxide | II | FUN | 7 | Champion 50 WP | 3646-5, 3646-7, 3646-10, 3646-11 | 05.04.17 | 05.10.17 | 05.10.18 | WSL |
| | Copper hydroxide | II | FUN | 7 | Funguran-OH 50 WP | 4473-0 | 31.12.16 | 30.06.17 | 30.06.18 | WSL |
| | Copper oxychloride | II | FUN | 7 | Flowbrix | 4605-0 | 10.05.17 | 10.11.17 | 10.11.18 | WSL |
| | Copper oxychloride | II | FUN | 7 | Korzar | 1048-12 | 10.05.17 | 10.11.17 | 10.11.18 | WSL |
| | Copper oxychloride | II | FUN | 7 | Kuprikol 250 SC | 4485-0, 4485-2 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Copper oxychloride | II | FUN | 7 | Kuprikol 50 | 1048-5, 1048-7, 1048-9, 1048-10, 1048-11 | 20.05.17 | 20.11.17 | 20.11.18 | WSL |
| | Cyantraniliprole | N/A | INS | 14 | Benevia | 5286-0 | 14.09.27 | 14.09.27 | 14.09.27 | VD |
| | Deltamethrin | II | INS | 7 | Scatto | 5364-0 | 31.10.19 | 31.10.19 | 31.10.19 | VD |
| | Difenoconazole | II | FUN | 14 | Difcor 250 EC | 4747-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Difenoconazole | II | FUN | 14 | Score 250 EC | 4014-7, 4014-10 | 21.10.16 | 21.04.17 | 21.04.18 | WSL |
| | Ferric phosphate | III | ML | AT | Ironmax Pro | 5597-0 | 31.12.31 | 31.12.31 | 31.12.31 | VD |
| | Linuron | III | HER | AT | Afalon 45 SC | 3969-10, 3969-10D | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Afalon 45 SC Allium | 3969-10D | 03.06.17 | 03.12.17 | 03.06.18 | WSL |

**Table 2: (Continued)**

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Celery** | Linuron | III | HER | AT | Afalon Dispersyjny 450 SC | 3969-10V | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Aflin 45 SC | 3969-10D | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | AGRO-Linuron 450 | 3969-10D | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Agrosales - Linuron 45 SC | 3969-10D | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Alon 45 SC | 3969-10D/3 | 10.04.17 | 10.04.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Anuron 450 SC | 3969-10D, 3969-10D/2 | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | BEC Linuron | 3969-10D | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Ipirex 45 SC | 4664-0D/1 | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | Ipiron 45 SC | 4664-0 | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | KeMiChem-Linuron 450 SC | 3969-10D/4 | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | NURON 450 | 3969-10D/5, 3969-10D/6 | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Linuron | III | HER | AT | ODRG - Linuron 45 SC | 3969-10D/1 | 03.06.17 | 03.12.17 | 03.06.18 | WSL |
| | Pendimethalin | III | HER | AT | AV Pendimeth 330 | 3269-2D/5 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | AV Pendimeth 400 | 3699-6D/1 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | Pendifin 400 SC | 5541-0 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | Pendimex 330 EC | 5024-0D/1 | 31.07.18 | 31.07.18 | 31.07.18 | VD |

**Table 2: (Continued)**

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Celery** | Pendimethalin | II | HER | AT | Sharpen 33 EC | 5024-0 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | Sharpen 40 SC | 5025-0, 5025-1 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | Stomp 330 E | 3269-2 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | Stomp 330 EC | 3269-2V | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pendimethalin | II | HER | AT | Stomp 400 SC | 3699-6 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Prosulfocarb | II | HER | AT | Boxer | 4566-0 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Pymetrozine | II | INS | 14 | Chess 50 WG | 4595-1 | 30.06.17 | 31.12.17 | 31.12.18 | WSL |
| | Pymetrozine | II | INS | 14 | Plenum | 4595-1, 4595-3, 4595-5, 4595-6 | 30.06.19 | 30.06.19 | 30.06.19 | VD |

Explanation (Table 2):

1) Hazard class of a formulation (International Program on Chemical Safety 2009)

2) Date format DD/MM/YY

3) Product with the longest expiry date

AT - Application term, application method or specification of use

FUN - Fungicide

HER – Herbicide

Ib - Highly hazardous

II - Moderately hazardous

III - Slightly hazardous

INS - Insecticide

ML – Molluscicide

N/A - Information not available

PHI - Pre-harvest Interval

U - Unlikely to pose an acute hazard in normal use

VD - Valid decision

WSL - While stock lasts

Products for vegetables grown under the organic farming system

Product with low-risk substances

**Table 3**: Approved Plant Protection Products for lettuce in Czechia (Institute for Supervising and Testing in Agriculture 2018)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stocks[2)] | Disposal, Storage and Use of Existing Stocks[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lettuce** | Acetamiprid | N/A | INS | 3 | SUBSTRAL CAREO Ultra - Pest concentrate[4)] | 4665-1 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Acetamiprid | N/A | INS | 14 | SUBSTRAL CAREO Ultra - Spray against pests![5)] | 5074-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Ammonium sulfate, Polyacrylamide | N/A | AJ | 0 | Adaptic | 1723-0C | 29.03.21 | 29.03.21 | 29.03.21 | VD |
| IL | Azoxystrobin | U | FUN | 14 | Amistar | 4247-1 | 31.12.22 | 31.12.22 | 31.12.22 | VD |
| IL | Azoxystrobin | U | FUN | 14 | Ortiva | 4247-4 | 20.10.17 | 20.04.18 | 20.04.19 | WSL |
| | Bacillus subtilis str. QST 713 | N/A | FUN, BT | AT | Serenade ASO | 5396-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Bacillus thuringiensis ssp. Kurstaki | III | INS | AT | Lepinox Plus | 5258-0, 5258-1 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Basic substance | N/A | FUN | 5 | Lecithins[6)] | 0000-60 | | | | VD |
| | Boscalid (formerly Nicobifen), Pyraclostrobin | U | FUN | 14 | Signum | 4738-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Clove and cinnamon mixture | N/A | PHS | 0 | Herb mixture on mold[7)] | 1803-0C | 09.01.28 | 09.01.28 | 09.01.28 | VD |
| | Cyprodinil, Fludioxonil | U | FUN | 7 | Switch | 4751-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Deltamethrin | II | INS | 7 | Decis AL | 5029-0, 5029-1 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Deltamethrin | II | INS | 7 | Decis Forte | 5450-0 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Deltamethrin | II | INS | 7 | Decis Mega | 4244-15 | 31.10.18 | 31.10.18 | 31.10.18 | VD |

**Table 3:** (Continued)

| Vegetable | Active Substance | Hazard Class | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stocks[2)] | Disposal, Storage and Use of Existing Stocks[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lettuce** | Dimethoate | II | INS | 21 | Danadim Progress | 4809-0 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Dimethomorph, Mancozeb | U | FUN | 21 | Acrobat MZ WG | 4497-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Fenhexamid | U | FUN | 3 | Teldor 500 SC | 4325-0, 4325-4, 4325-5 | 31.12.31 | 31.12.31 | 31.12.31 | VD |
| | Ferric phosphate | III | ML | AT | Ironmax Pro | 5597-0 | 31.12.31 | 31.12.31 | 31.12.31 | VD |
| | Fluazifop-P-butyl | III | HER | 42 | Fusilade Forte 150 EC | 4318-0 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Fluopyram | N/A | FUN | 7 | Moon Privilege | 5064-1 | 31.01.25 | 31.01.25 | 31.01.25 | VD |
| | Fosetyl-Al | U | FUN | 14 | Aliette 80 WG | 3511-11 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Hydrogen peroxide 100% | N/A | BS | 0 | Hydrogen peroxide[8)] | 0000-60 | | | | VD |
| | Imidacloprid | N/A | INS | AT | Gaucho 70 WS | 4062-1 | 31.07.20 | 31.07.20 | 31.07.20 | VD |
| | Indoxacarb | II | INS | 14 | Steward | 4612-0 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Iprodione | III | FUN | 14 | AV Iprod | 4678-0D/1 | 05.03.18 | 05.06.18 | 05.06.18 | WSL |
| | Iprodione | III | FUN | 14 | Rovral Aquaflo | 4678-0, 4678-1 | 05.03.18 | 05.06.18 | 05.06.18 | WSL |
| | Lambda-cyhalothrin | II | INS | 7 | Karate with Zeon technology 5 CS[9)] | 4419-3 | 30.06.20 | 30.06.20 | 30.06.20 | VD |
| | Lambda-cyhalothrin | II | INS | 7 | Karis 10 CS | 4915-1 | 30.06.20 | 30.06.20 | 30.06.20 | VD |
| | Mancozeb, Metalaxyl-M | U, II | FUN | 14 | Ridomil Gold MZ Pepite | 4543-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mandipropamid | U | FUN | 7 | Revus | 4608-0 | 31.07.24 | 31.07.24 | 31.07.24 | VD |

**Table 3:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stocks[2)] | Disposal, Storage and Use of Existing Stocks[2)3)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lettuce** | Metaldehyde | II | ML | AT | Clartex Neo | 5051-0 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Metaldehyde | II | ML | AT | Desimo Duo | 5052-1 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Granulax against slugs[10)] | 5052-2 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Lima Oro 5% | 5325-0, 5325-1 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Limanish Premium | 5235-2 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | METALDEHYD NOVI | 5050-0D/1 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Metaldehyde | II | ML | AT | Metarex Inov | 5050-0 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Metaldehyde | II | ML | AT | Metarex M | 5235-0 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Slimax | 5052-0 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Slimex | 5235-1 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Pendimethalin | II | HER | AT | Stomp 400 SC | 3699-6 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Pirimicarb | II | INS | 7 | Agri Pirimicarb 50 WG | 4408-0D, 4408-0D/1, 4408-0D/8 | 08.07.17 | 06.12.17 | 06.12.18 | WSL |
| | Pirimicarb | II | INS | 7 | BEC Pirim | 4408-0D, 4408-0D/9 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | Karin | 4408-0D, 4408-0D/7 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | Karin 50 WG | 4408-0D/3 | 10.04.17 | 10.04.17 | 10.08.19 | WSL |
| | Pirimicarb | II | INS | 7 | PIRI 50 | 4408-0D/6 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | Pirimor 50 WG | 4408-0, 4408-7, 4408-8 | 30.04.19 | 30.04.19 | 30.04.19 | VD |

**Table 3:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stocks[2)] | Disposal, Storage and Use of Existing Stocks[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lettuce** | Pirimicarb | II | INS | 10 | Pirimor SG | 5550-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Polyether-polymethylsiloxane-copolymer, rape seed oil methyl ester | N/A | AJ | 0 | Velocity | 1724-1C | 03.01.21 | 03.01.21 | 03.01.21 | VD |
| | Potassium hydrogen carbonate | N/A | FUN | 1 | VitiSan | 5476-0, 5476-1 | 31.08.20 | 31.08.20 | 31.08.20 | VD |
| | Propamocarb hydrochloride | U | FUN | 0 | Proplant | 4518-0 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Propamocarb, Fosetyl | U | FUN | 21 | Previcur Energy | 4785-0, 4785-1, 4785-2, 4785-4, 4785-5 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Propyzamide | U | HER | AT | Careca | 4957-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Propyzamide | U | HER | AT | Kerb 50 W | 3172-2V | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Propyzamide | U | HER | AT | Lactico 50 WP | 3172-2D/1 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Propyzamide | U | HER | 42 | Proper Flo | 4859-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Propyzamide | U | HER | AT | Prozamid 50 WP | 3172-2D | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Pymetrozine | N/A | INS | 7 | Chess 50 WG | 4595-1 | 30.06.17 | 31.12.17 | 31.12.18 | WSL |
| | Pymetrozine | N/A | INS | 7 | Plenum | 4595-1, 4595-3, 4595-5, 4595-6 | 30.06.19 | 30.06.19 | 30.06.19 | VD |
| | Sodium hydrogen carbonate | N/A | P | AT | NatriSan | 1711-0C | 27.04.17 | 27.10.17 | 27.10.18 | WSL |
| | Sulfoxaflor | N/A | INS | 7 | Gondola | 5347-0 | 18.08.26 | 18.08.26 | 18.08.26 | VD |
| | Thiacloprid | II | INS | 7 | Calypso 480 SC | 4328-2 | 30.04.19 | 30.04.19 | 30.04.19 | VD |

**Table 3:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stocks[2)] | Disposal, Storage and Use of Existing Stocks[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lettuce** | Trifloxystrobin | U | FUN | 7 | Flint | 4403-3V | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Trifloxystrobin | U | FUN | 7 | FLINT 50 WG | 4403-3D/4 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Trifloxystrobin | U | FUN | 7 | Monili 50 WG | 4403-3D/1 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Trifloxystrobin | U | FUN | 7 | TRIFLOXY | 4403-3D/5 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Trifloxystrobin | U | FUN | 7 | Zato 50 WG | 4403-3 | 31.07.18 | 31.07.18 | 31.07.18 | VD |
| | Urtica spp. | N/A | BS | 0 | Nettle[11)] | 0000-60 | | | | VD |

Explanation (Table 3):

1) Hazard class of a formulation (International Program on Chemical Safety 2009)

2) Date format DD/MM/YY

3) Product with the longest expiry date

4) Koncentrát proti škůdcům

5) Postřik proti škůdcům!

6) Authorisation date: 29.07.2015

7) Bylinková směs na plísně

8) Authorisation date: 28.03.2017

9) Kaarte se Zeon technologií 5 CS

10) Granulax against slugs proti slimákům

11) Authorisation Date: 29.03.2017

AJ - Adjuvant

AT - Application term, application method or specification of use

BS - Basic substance

BT - Biopreparate

FUN - Fungicide

HER - Herbicide

Ib - Highly hazardous

II - Moderately hazardous

III - Slightly hazardous

IL - Iceberg lettuce

INS - Insecticide

ML - Molluscicide

N/A - Information not available

P - Passive auxiliary agent

PHI - Pre-harvest Interval

PHS - Plant health support

U - Unlikely to pose an acute hazard in normal use

VD - Valid decision

WSL - While stock lasts

Products for vegetables grown under the organic farming system

Products with basic and low-risk substances

**Table 4:** Approved Plant Protection Products for spinach in Czechia (Institute for Supervising and Testing in Agriculture 2018)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spinach** | Azadirachtin | N/A | INS | 7 | NeemAzal-T/S | 5156-0, 5156-1 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Bacillus subtilis strain QST 713 | N/A | FUN, BT | AT | Serenade ASO | 5396-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Bacillus thuringiensis ssp. kurstaki | III | INS | AT | Lepinox Plus | 5258-0, 5258-1 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Boscalid (formerly Nicobifen), Pyraclostrobin | U | FUN | 28 | Signum | 4738-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Deltamethrin | II | INS | 3 | Decis AL | 5029-0, 5029-1 | 31.10.18 | 31.10.18 | 31.10.18 | WSL |
| | Deltamethrin | II | INS | 7 | Scatto | 5364-0 | 31.10.19 | 31.10.19 | 31.10.19 | VD |
| | Ferric phosphate | III | ML | AT | Ironmax Pro | 5597-0 | 31.12.31 | 31.12.31 | 31.12.31 | VD |
| | Fluazifop-P-butyl | III | HER | 42 | Fusilade Forte 150 EC | 4318-0 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Indoxacarb | II | INS | 14 | Steward | 4612-0 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Metaldehyde | II | ML | AT | Clartex Neo | 5051-0 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Metaldehyde | II | ML | AT | Desimo Duo | 5052-1 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Granulax against slugs[4)] | 5052-2 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Limanish Premium | 5235-2 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | METALDEHYD NOVI | 5050-0D/1 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Metaldehyde | II | ML | AT | Metarex Inov | 5050-0 | 31.05.21 | 31.05.21 | 31.05.21 | VD |

**Table 4:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spinach** | Metaldehyde | II | ML | AT | Metarex M | 5235-0 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Slimax | 5052-0 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Metaldehyde | II | ML | AT | Slimex | 5235-1 | 31.05.22 | 31.05.22 | 31.05.22 | VD |
| | Phenmedipham | U | HER | 28 | Betasana SC | 4540-0 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Pirimicarb | II | INS | 7 | Agri Pirimicarb 50 WG | 4408-0D, 4408-0D/1, 4408-0D/8 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | BEC Pirim | 4408-0D, 4408-0D/9 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | Karin | 4408-0D, 4408-0D/7 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | Karin 50 WG | 4408-0D/3 | 10.04.17 | 10.04.17 | 10.08.19 | WSL |
| | Pirimicarb | II | INS | 7 | PIRI 50 | 4408-0D/6 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 7 | Pirimor 50 WG | 4408-0, 4408-7, 4408-8 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Quizalofop-P-ethyl | II | HER | 28 | Targa 10 EC | 4910-0 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Spirotetramat | III | INS | 7 | Movento 150 OD | 4708-0 | 30.04.25 | 30.04.25 | 30.04.25 | VD |
| | Sulfoxaflor | N/A | INS | 7 | Gondola | 5347-0 | 18.08.26 | 18.08.26 | 18.08.26 | VD |

Explanation (Table 4):

1) Hazard class of a formulation (International Program on Chemical Safety 2009)

2) Date format DD/MM/YY

3) Product with the longest expiry date

4) Granulax proti slimákům

AT - Application term, application method or specification of use

BT - Biopreparate

FUN - Fungicide

HER – Herbicide

Ib - Highly hazardous

II - Moderately hazardous

III - Slightly hazardous

INS - Insecticide

ML – Molluscicide

N/A - Information not available

PHI - Pre-harvest Interval

U - Unlikely to pose an acute hazard in normal use

VD - Valid decision

WSL - While stock lasts

Products for vegetables grown under the organic farming system

Product with low-risk substances

**Table 5:** Approved Plant Protection Products for spring onion in Czechia (Institute for Supervising and Testing in Agriculture 2018)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Aclonifen | U | HER | AT | Bandur | 4776-0 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Ammonia water 25%, Citric acid, Tartaric acid, Titanium sulfate | N/A | AJ, PHS | 0 | VITALON 2000 | 1703-0C | 23.03.19 | 23.03.19 | 23.03.19 | VD |
| | Azoxystrobin | U | FUN | 14 | AV Azoxy | 4247-4D/4 | 31.12.22 | 31.12.22 | 31.12.22 | VD |
| | Azoxystrobin | U | FUN | 14 | AZOXY-I | 4247-4D/5 | 31.12.22 | 31.12.22 | 31.12.22 | VD |
| | Azoxystrobin | U | FUN | 14 | Ortiva | 4247-4, 4247-4D/3, 4247-4V, 4247-7, 4247-8, 4247-9 | 31.12.22 | 31.12.22 | 31.12.22 | VD |
| | Azoxystrobin | U | FUN | 14 | Zakeo | 4247-11 | 31.12.22 | 31.12.22 | 31.12.22 | VD |
| | Azoxystrobin, Difenoconazole | U, II | FUN | 21 | Askon | 5065-0, 5065-1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Bacillus subtilis str. QST 713 | N/A | FUN, BT | AT | Serenade ASO | 5396-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Bromoxynil | II | HER | 28 | Pardner 22.5 EC | 3784-3 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Clethodim | N/A | HER | 56 | MAGPIE | 5122-0D/1 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Clethodim | N/A | HER | 56 | Select Super | 4903-0 | 31.05.21 | 31.05.21 | 31.05.21 | VD |
| | Clove and cinnamon mixture | N/A | PHS | 0 | Herb mixture on mold[4)] | 1803-0C | 46761 | 46761 | 46761 | VD |
| | Copper hydroxide | II | FUN | 3 | Champion 50 WG | 5297-0, 5297-1, 5297-2, 5297-3 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Copper hydroxide | II | FUN | 7 | Champion 50 WP | 3646-5, 3646-7, 3646-10, 3646-11 | 05.04.17 | 05.10.17 | 05.10.18 | WSL |

**Table 5:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Copper hydroxide | II | FUN | 7 | Funguran-OH 50 WP | 4473-0 | 31.12.16 | 30.06.17 | 30.06.18 | WSL |
| | Copper oxychloride | II | FUN | 7 | Flowbrix | 4605-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Copper oxychloride | II | FUN | 7 | Korzar | 1048-12 | 10.05.17 | 10.11.17 | 10.11.18 | WSL |
| | Copper oxychloride | II | FUN | 7 | Kuprikol 250 SC | 4485-0, 4485-2 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Copper oxychloride | II | FUN | 7 | Kuprikol 50 | 1048-5, 1048-7, 1048-9, 1048-10, 1048-11 | 20.05.17 | 20.11.17 | 20.11.18 | WSL |
| | Cyantraniliprole | N/A | INS | 1 | Benevia | 5286-0 | 14.09.27 | 14.09.27 | 14.09.27 | VD |
| | Deltamethrin | II | INS | 10 | Decis Protech | 4538-4, 4538-6, 4538-7, 4538-8 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Deltamethrin | II | INS | 10 | Decis Mega | 4244-11, 4244-15 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Deltamethrin | II | INS | 10 | Rhago 50 EW | 4244-15D/1 | 31.10.18 | 31.10.18 | 31.10.18 | VD |
| | Deltamethrin | II | INS | 8 | Scatto | 5364-0 | 31.10.19 | 31.10.19 | 31.10.19 | VD |
| | Dimethoate | II | INS | 14 | Danadim Progress | 4809-0 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Dimethomorph, Mancozeb | U | FUN | 14 | Acrobat MZ WG | 4497-0, 4497-1, 4497-2, 4497-3 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Dimethomorph, Mancozeb | U | FUN | 14 | Acrobat Plus WG | 4497-0V | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Dimethomorph, Mancozeb | U | FUN | 14 | AV Acro WG | 4497-0D/3 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Dimethomorph, Mancozeb | U | FUN | 14 | COZEP | 4497-0D/7, 4497-0D/8 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Dimethomorph, Mancozeb | U | FUN | 14 | MANCOMORPH 690 | 4497-0D/6 | 31.01.19 | 31.01.19 | 31.01.19 | VD |

**Table 5:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Ferric phosphate | III | ML | AT | Ironmax Pro | 5597-0 | 31.12.31 | 31.12.31 | 31.12.31 | VD |
| | Fluazifop-P-butyl | III | HER | 28 | Agrosales - Fluazifop | 4318-0D/3 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Fluazifop-P-butyl | III | HER | 28 | Fusilade Forte 150 EC | 4318-0, 4318-0D/4, 4318-0V | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Fluazifop-P-butyl | III | HER | 28 | ODRG - Fluazifop | 4318-0D/6 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Fluazifop-P-butyl | III | HER | 28 | Susilade Forte | 4318-0D/5 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Fluopicolide, Propamocarb hydrochloride | N/A, U | FUN | 7 | Infinito | 4602-2, 4602-5, 4602-6 | 31.07.19 | 31.07.19 | 31.07.19 | VD |
| | Fluopyram, Tebuconazole | N/A, II | FUN | 7 | Luna Experience | 4979-0, 4979-1 | 31.08.19 | 31.08.19 | 31.08.19 | VD |
| | Glyphosate | III | HER | AT | Agroklasik 360 TF | 5524-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Barbarian Super 360 | 5376-1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Clinic TF | 5444-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Clinic Up | 5547-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Conan 360 SL | 5376-1D/1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Dominator 360 TF | 5525-3 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Figaro 360 | 5554-1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Gallup Super 360 | 5376-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Glister Ultra | 5463-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |

**Table 5:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Glyphosate | III | HER | AT | Glyfo Star | 5532-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Glyfogan Extra | 3915-13 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Kaput Harvest TF | 5444-1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Kaput Harvest Up | 5547-1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Landmaster 360 TF | 5525-2 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Madrigal 360 | 5554-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Monosate G | 5376-6 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | R.A.M. Glyfosát | 5444-0D/1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Rodeo Star | 5538-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Rosate 360 TF | 5525-1 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Taifun 360 | 3915-8 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Taifun 360 SL | 3915-5V, 3915-8V | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | TAIFUN MK | 3915-5V | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Tartan Super 360 | 5376-2 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Glyphosate | III | HER | AT | Vival 360 TF | 5525-0 | 31.12.18 | 31.12.18 | 31.12.18 | VD |
| | Haloxyfop-P | II | HER | 28 | Gallant Super | 5069-0 | 31.12.21 | 31.12.21 | 31.12.21 | VD |
| | Lambda-cyhalothrin | II | INS | 28 | Hunter SPU | 4831-2 | 30.06.17 | 30.06.17 | 30.06.17 | VD |

**Table 5:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Lambda-cyhalothrin | II | INS | 28 | Kaiso Sorbie | 4831-0 | 30.06.17 | 30.06.17 | 30.06.17 | VD |
| | Mancozeb | U | FUN | 28 | Anthra WP | 3068-10D/1 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28 | Dithane DG Neotec | 3664-11, 3664-12, 3664-14, 3664-16, 3664-17 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28 | Dithane M 45 | 3068-10 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28 | Dithane NeoTec | 3664-16V | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28 | Dithane Neo Tec | 3664-16V | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28 | Mankozeb 75 Neo | 3664-16D/1 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28 | Mastana SC | 4972-0 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb | U | FUN | 28/42 | NOVOZIR MN 80 NEW | 3068-8 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Mancozeb, Metalaxyl-M | U, II | FUN | 7 | Ridomil Gold MZ Pepite | 4543-0, 4543-1, 4543-2, 4543-4 | 31.01.19 | 31.01.19 | 31.01.19 | VD |
| | Pirimicarb | II | INS | 14 | Agri Pirimicarb 50 WG | 4408-0D, 4408-0D/1, 4408-0D/8 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 14 | BEC Pirim | 4408-0D, 4408-0D/9 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 14 | Karin | 4408-0D, 4408-0D/7 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 14 | Karin 50 WG | 4408-0D/3 | 10.04.17 | 10.04.17 | 10.08.19 | WSL |
| | Pirimicarb | II | INS | 14 | PIRI 50 | 4408-0D/6 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Pirimicarb | II | INS | 14 | Pirimor 50 WG | 4408-0 | 30.04.19 | 30.04.19 | 30.04.19 | VD |

**Table 5:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Propaquizafop | U | HER | 30 | Agil - S | 4239-9D/6, 4239-9V | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Agil 100 EC | 4239-9, 4239-10 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Agnus | 4239-9D/9 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | AKILL | 4239-9D/16 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | AV Propaq | 4239-9D/1 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Euro-Chem Quizafop 100 | 4239-9D/15 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | GAIL CZ | 4239-9D/18 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Galeon 100 EC | 4239-9D/8 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Garland Forte | 4239-11 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Ligar 100 EC | 4239-9D/5 | 10.04.17 | 10.04.17 | 10.08.18 | WSL |
| | Propaquizafop | U | HER | 30 | QUIZAFOP 100 | 4239-9D/20, 4239-9D/21, 4239-9D/22 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | RexStar 100 EC | 4239-9D/1, 4239-9D/2, 4239-9D/10, 4239-9D/17 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Propaquizafop | U | HER | 30 | Zetrola | 4239-13 | 30.11.22 | 30.11.22 | 30.11.22 | VD |
| | Pyridate | III | HER | AT | Lentagran WP | 4698-0 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Quizalofop-P-ethyl | II | HER | 42 | Quant 10 EC | 4910-0D/1 | 30.11.19 | 30.11.19 | 30.11.19 | VD |
| | Quizalofop-P-ethyl | II | HER | 42 | Targa 10 EC | 4910-0, 4910-0V | 30.11.19 | 30.11.19 | 30.11.19 | VD |

**Table 5:** (Continued)

| Vegetable | Active Substance | Hazard Class[1)] | Pesticide Type | PHI | Product Name | Registration Number | Product Expiry Date[2)3)] | Sale and Distribution of Existing Stock[2)] | Disposal, Storage and Use of Existing Stock[2)] | Current Status of Approval |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spring onion** | Spinosad | III | INS | 7 | SpinTor | 4515-0, 4515-1, 4515-2, 4515-3 | 30.04.19 | 30.04.19 | 30.04.19 | VD |
| | Spirotetramat | III | INS | 7 | Movento 150 OD | 4708-0 | 30.04.25 | 30.04.25 | 30.04.25 | VD |
| | Tefluthrin | Ib | INS | AT | Force 1,5 G | 4660-0 | 31.12.19 | 31.12.19 | 31.12.19 | VD |
| | Tribasic copper sulphate | II | FUN | 3 | Cuproxat SC | 3910-0, 3910-5 | 31.01.19 | 31.01.19 | 31.01.19 | VD |

Explanation (Table 5):

1) Hazard class of a formulation (International Program on Chemical Safety 2009)

2) Date format DD/MM/YY

3) Product with the longest expiry date

4) Bylinková směs na plísně

AJ - Adjuvant

AT - Application term, application method or specification of use

BT - Biopreparate

FUN - Fungicide

HER – Herbicide

Ib - Highly hazardous

II - Moderately hazardous

III - Slightly hazardous

INS - Insecticide

ML – Molluscicide

N/A - Information not available

PHI - Pre-harvest Interval

PHS - Plant health support

U - Unlikely to pose an acute hazard in normal use

VD - Valid decision

WSL - While stock lasts

Products for vegetables grown under the organic farming system

Products with basic and low-risk substances

# 6. Conclusions

Nowadays, most crops are treated with chemical pesticides as without their utilisation, the estimated production losses are on average around 40 % (Florián 2008). Improper agricultural practises result in excessive pesticide residues on vegetables, causing a potential risk on human health.

However, if farmers observe the safety measures and use pesticides in recommended amount, it is very unlikely that the pesticide residues will appear in food. And if so, there is a high probability that the MRLs, approved by Eurpoean Comission, will not be exceeded.

**And future prospective**

This knowledge serves as a basic literature review for the writing of diploma thesis which should lead to the actual realization of the detection of pesticide residues by specific analytical methods.

The criterion for choosing fruit and vegetables for future research can be followed by the high potential of the occurrence of pesticide residues or by selecting those on which the products with active substance glyphosate is applied. Samples will be collected from all farming systems (conventional, integrated and organic) described in this thesis.

The author considered the topic very interesting as it has been widely discussed by both, experts and the general public, in recent years.

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# Appendix

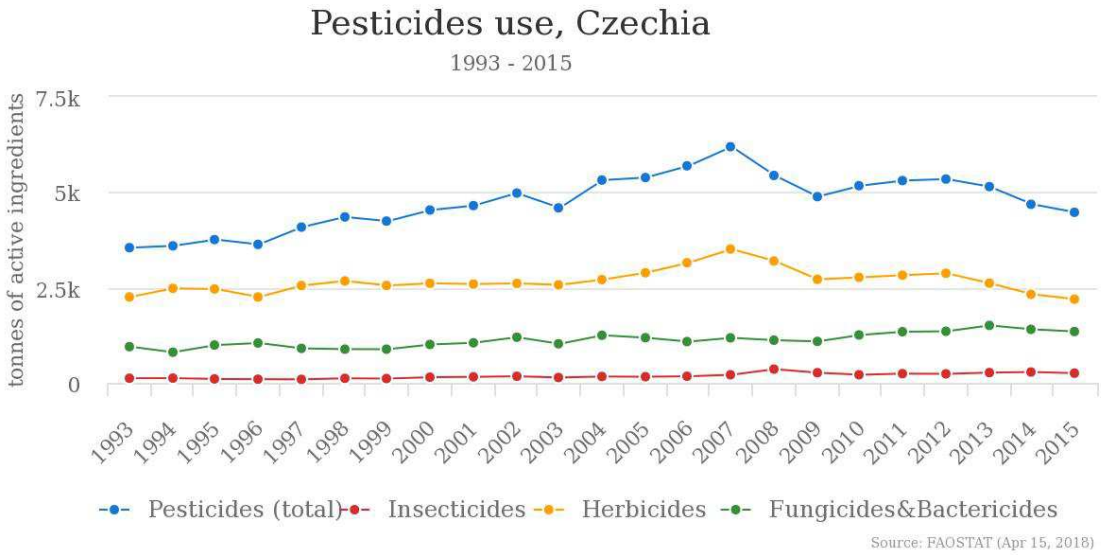


**Figure 5:** Pesticides use in tonnes of active ingredients in Czechia (FAO 2018)

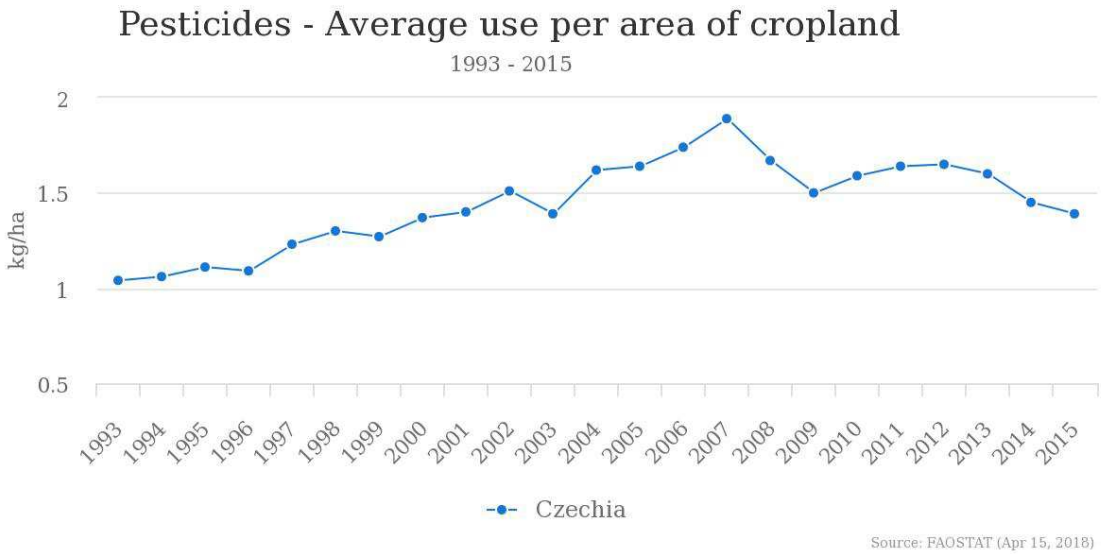


**Figure 6:** Pesticides - Average use per area of cropland (kg/ha) in Czechia (FAO 2018)

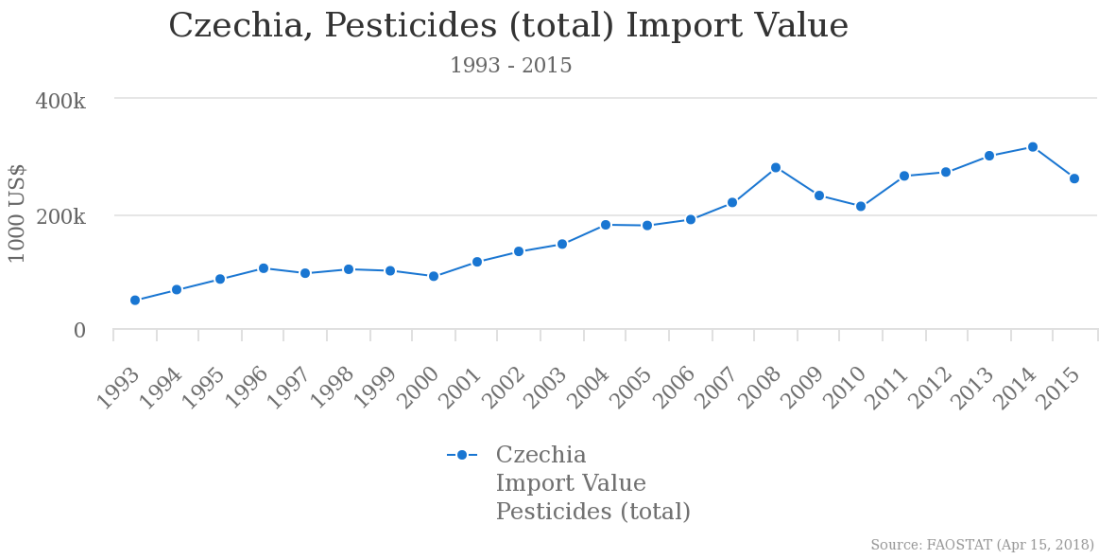


**Figure 7**: Czechia, Pesticides (total) Import Value in US$ (FAO 2018)

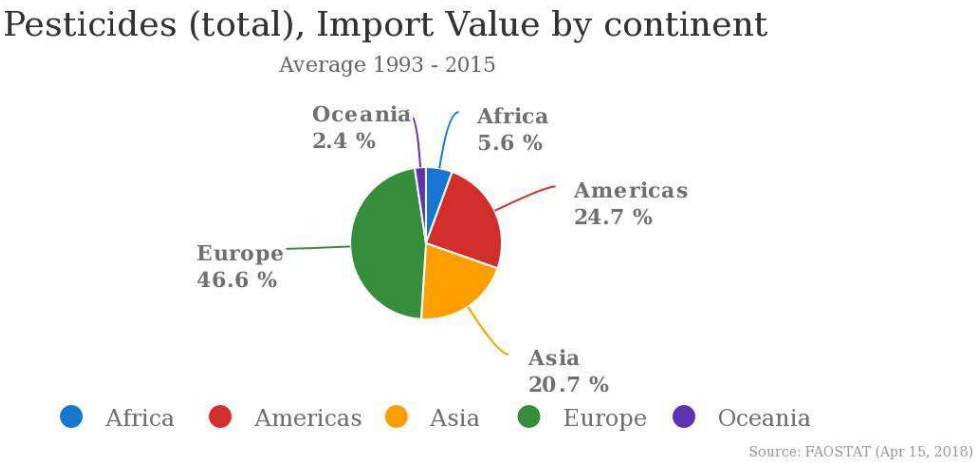


**Figure 8:** Czechia, Pesticides (total) Import Value by continent in % (FAO 2018)

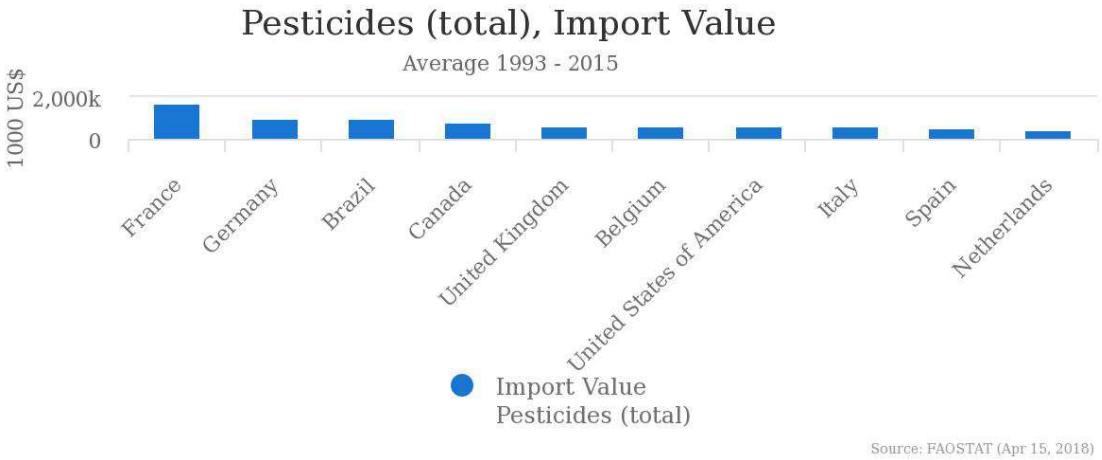


**Figure 9:** Czechia, Pesticides (total) Import Value by country in US$ (FAO 2018)

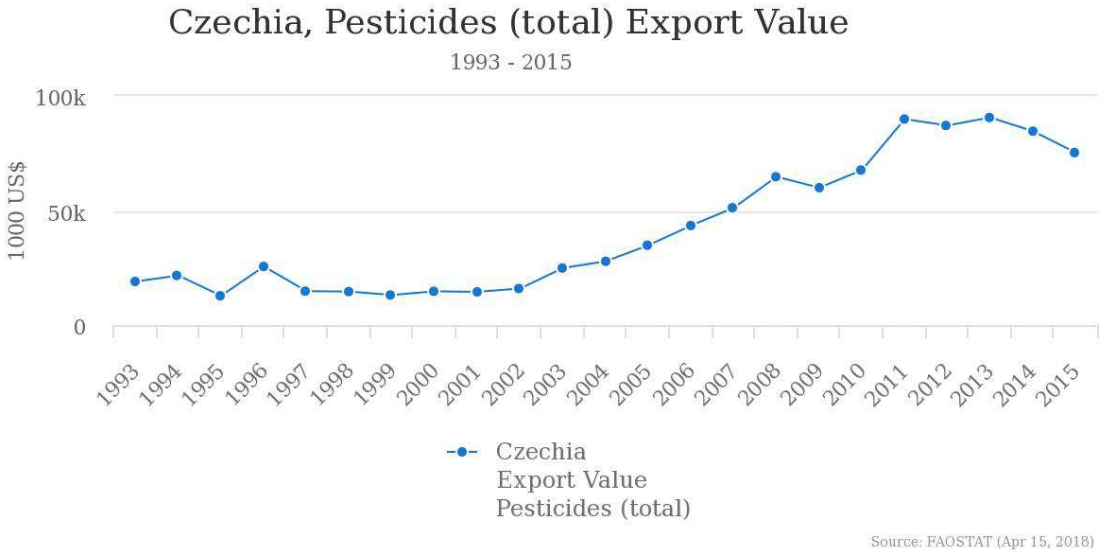


**Figure 10:** Czechia, Pesticides (total) Export Value in US$ (FAO 2018)

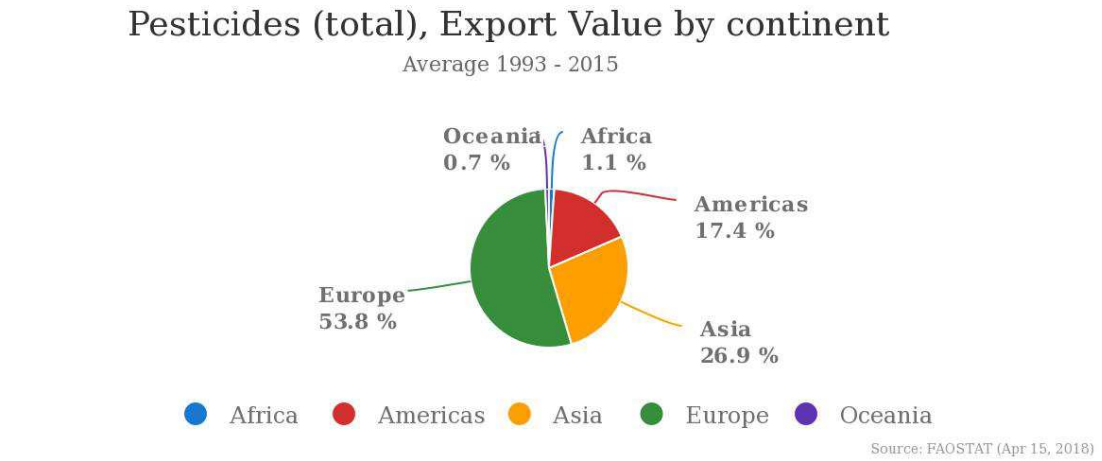


**Figure 11:** Czechia, Pesticides (total) Export Value by continent in % (FAO 2018)

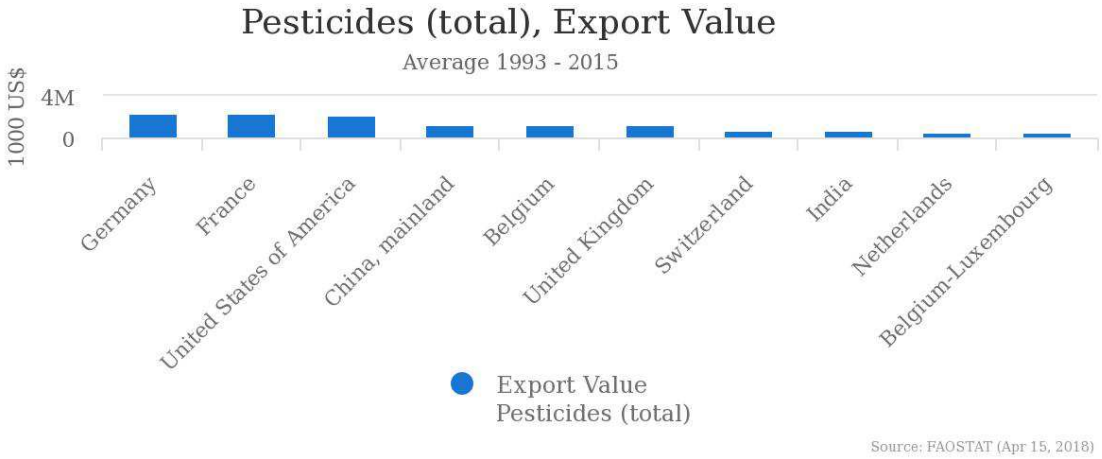


**Figure 12:** Czechia, Pesticides (total) Export Value by country in US$ (FAO 2018)

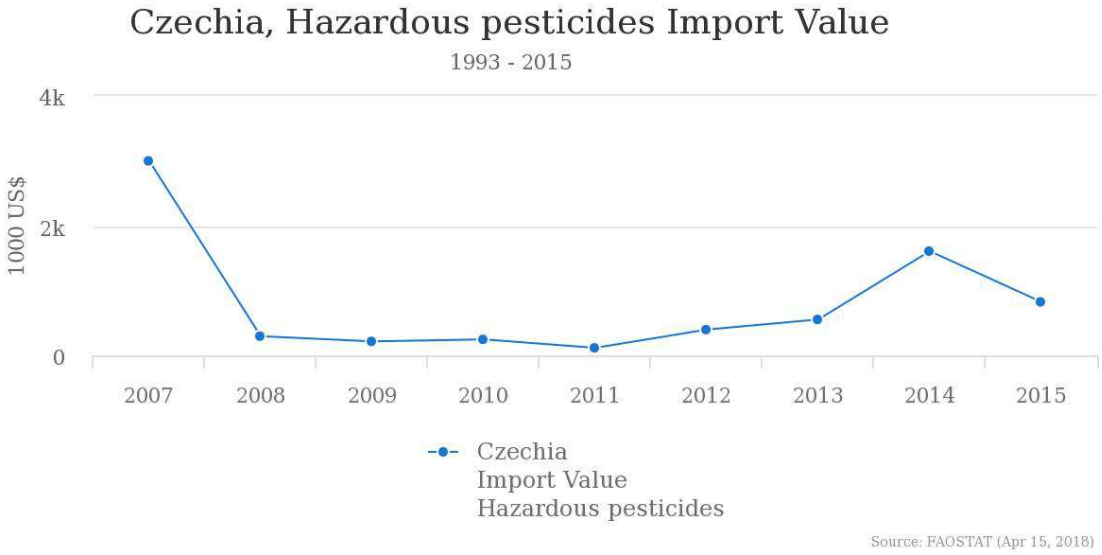


**Figure 13:** Czechia, Hazardous pesticides Import Value in US$ (FAO 2018)

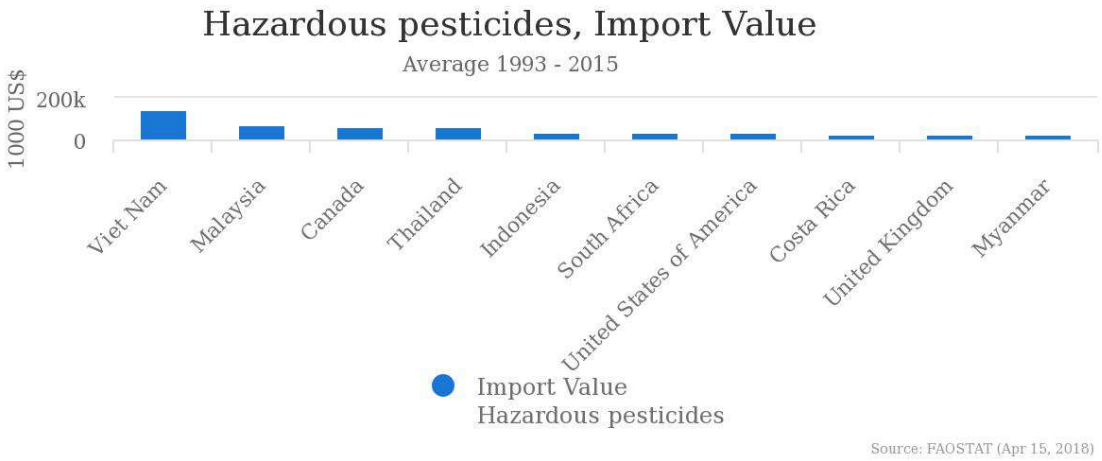


**Figure 14:** Czechia, Hazardous pesticides Import Value by country in US$ (FAO 2018)

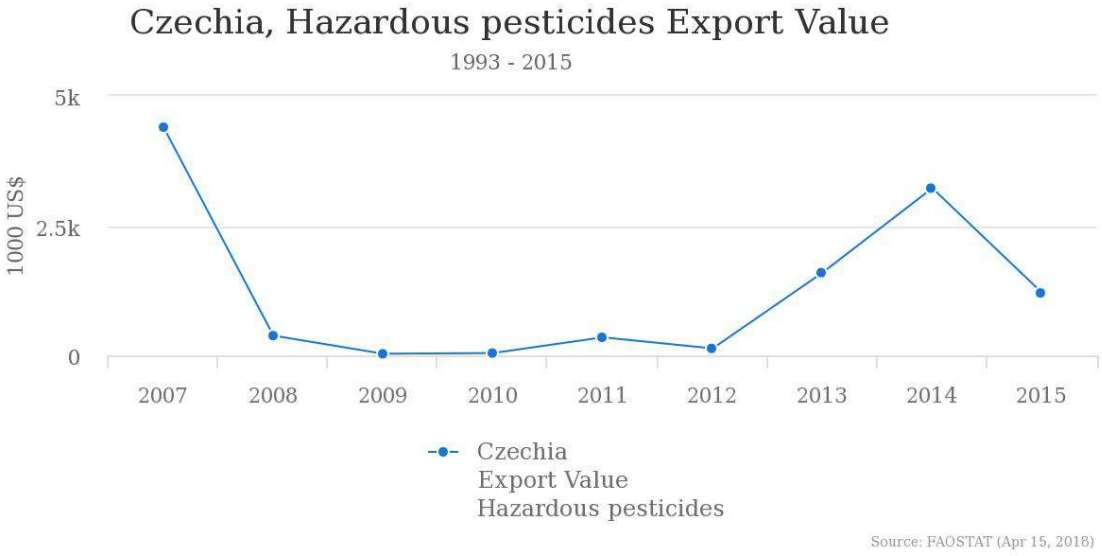


**Figure 15:** Czechia, Hazardous pesticides Export Value in US$ (FAO 2018)

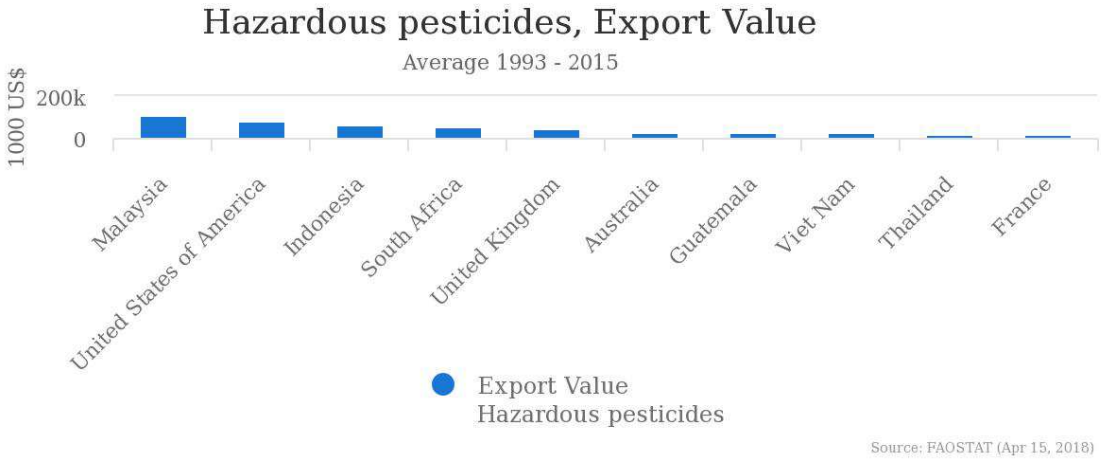


**Figure 16:** Czechia, Hazardous pesticides Export Value by country in US$ (FAO 2018)