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Non compliance to legal limits in the period 2014-2019

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Summary

An important step in assuring the safety of our food and feed is to monitor the possible contamination of feed and feed ingredients with chemical substances that may affect safety, integrity and animal and/or human health. Plant (crop) protection products or pesticides are used in arable and horticultural production to protect crops against fungi, weeds and insects. The use of pesticides can result into (unwanted) residues of these agents on the treated crops.

According to the European legislation (Regulation (EU) 2017/625), each EU Member State is responsible for monitoring of agri-food chain legislation. Following this Regulation, in the Netherlands, the National Plan Animal Feed (NPAF) has been implemented. This NPAF prescribes, among others, the monitoring of residues of pesticides in feed materials, in terms of both the feed materials that need to be sampled, and the pesticide analyses that need to be performed on these samples.

The objective of this study was to investigate the occurrence of pesticide residues in feed materials in the Netherlands over the years. The emphasis was on non-compliance of feed materials of plant origin with EU maximum residue levels (MRLs) for pesticides. Using the pesticide monitoring data from the NPAF, we focused on those feed materials and those pesticides for which such exceedances were reported. Results of this study can help official control authorities and feed operators to (re)design their yearly monitoring programmes in a risk-based manner.

Monitoring data from the NPAF in the period 2014-2019 were collected and processed. The dataset contained in total 1756 records, referring to feed materials of plant origin that were analysed for multiple pesticide residues. Per feed material record, exceedance of MRL (yes/no) for a specific pesticide residue was reported. In the 6 study years, four different analytical methods were used, comprising a combined scope of 210 different pesticides.

Feed materials were categorized as follows: grains and products derived thereof; oilseeds, oil fruits and products derived thereof; legume seeds and products derived thereof; tubers, roots and products derived thereof; other seeds and fruits and products derived thereof; herbs, including spices and edible flowers; and feed-only products.

For feed-only products, no MRLs have been set. The compliance of the feed-only samples were determined by comparison with the MRL of the raw or related commodity. Therefore, non-compliances of feed-only samples to the MRLs should be considered *potential* exceedances of MRLs.

Results

The percentage of non-compliant samples in the category grains and products derived thereof was 10.6% (64 out of 604 samples), when all scopes were combined. Non-compliant samples were found among almost all feed material subcategories for which a reasonable number of samples had been collected (the subcategories without non-compliant samples had no or low numbers of samples). The highest incidence of non-compliant samples was found in millet and sorghum, followed by rice, oats and maize. Glyphosate, DDT(sum) and diquat were the most commonly found non-compliant pesticides, all in millet. Six cereal grain samples (all millet) were non-compliant for more than one pesticide.

In the category oilseeds, oil fruits and products derived thereof, the percentage of non-compliant samples was 14.1% (113 out of 810 samples), when all scopes were combined. Non-compliant samples were found in soy, sunflower seed, linseed, rapeseed, safflower seed, poppy seed and sesame seed. Most commonly found exceedances of pesticide residues were paraquat in soy and rapeseed, haloxyfop in linseed and mepiquat in sunflower seed. Multiple non-compliant pesticides were found in soy, rapeseed, linseed and sunflower seed. A total of 265 oils from oilseeds and -fruits were analysed; only two MRL exceedances were found, both in 2019.

In the category legume seeds and products derived thereof, 17.2% of the analysed samples exceeded the MRL for pesticides (25 out of 145 samples), when all scopes were combined. Most commonly found exceedances of pesticide residues were pirimiphos-methyl in pea and horse bean, paraquat in lupin and pea, and glyphosate in mung bean, horse bean and vetch. Multiple non-compliant pesticides were found in three samples, namely pea, lupin, and mung bean.

The 29 samples in the category tubers, roots and products derived thereof were all compliant to the MRL for pesticides.

The percentage of non-compliance to MRL for pesticide residues in the category of other seeds and fruits and products derived thereof was 23.1% (three out of 13 samples), when all scopes were combined. The most commonly found exceedance of pesticide residues was glyphosate in buckwheat and fennel seed.

In the category herbs, including spices and edible flowers, and products derived thereof, 23.1% of the samples exceeded the MRL for pesticides (11 out of 60 samples), when all scopes were combined. Most commonly found pesticides were chlorpyrifos (in spearmint leaf, marigold and dandelion) and malathion (in turmeric powder and marigold). Non-compliance to multiple pesticides in a single sample was reported for basil, marigold and dandelion.

Sampling of the various feed-only products was unevenly dispersed over the study years for all analytical scopes, with most samples collected in 2018. Most sampled were from soy bean hulls, sugar beet pulp and rice bran. Rice bran, soy bean hulls, citrus pulp, and oat hulls showed potential non-compliant levels for several pesticides.

Conclusions and recommendations
Monitoring of pesticide residues in feed materials is relevant, as in 13% of the samples taken, the MRL for one or more pesticides was exceeded. MRLs were exceeded for 46 different pesticide residues in the samples. This implies that a broad screening of pesticides remains necessary. The pesticides with the highest number of MRL exceedances were paraquat (n=71), haloxyfop (n=21), glyphosate (n=19), pirimiphos-methyl (n=16), and chlorpyrifos (n=12). For one feed category only, being tubers, roots and derived products derived thereof, no MRL exceedances were reported.

The current overview of the results from 6 years of pesticide residue monitoring in animal feed, provides valuable insights for future monitoring. From the results, recommendations for future monitoring are provided per subcategory of feed materials, related to a change in sampling numbers per matrix and/or subgroup of pesticides. Additionally, establishment of MRLs is recommended for feed-only products.

1 Introduction

An important step in assuring the safety of our food and feed is to monitor the possible contamination of feed and feed ingredients with chemical substances that may influence safety, integrity and wholesomeness. Within the European Union, limits for the maximum presence and guidance values for chemical contaminants have been established to protect human and animal health, given Good Agricultural Practices (GAP). As part of European legislation (Regulation (EU) 2017/625), each EU Member State is responsible to have official monitoring programs. According to this regulation, the National Plan Animal Feed (NPAF) is implemented in the Netherlands. For monitoring on pesticide residues in feed materials, the NPAF prescribes which feed materials need to be sampled, and which pesticide analyses need to be performed on these samples.

Plant protection products or pesticides are used in agriculture and horticulture. They protect the crops against fungi, weeds and insects. The use of pesticides may result into residues of these agents on the treated crops. The directive (EC) 2002/32 deals with undesirable substances in animal feed and sets maximum residue levels (MRLs) for the organochlorine pesticides (OC pesticides) in feed and feed materials. For other pesticides, MRLs are laid down in regulation (EC) no 396/2005 of the European Parliament and of the Council, on MRLs of pesticides in or on food and feed of plant and animal origin. MRLs have been established for approved pesticides for certain feed or food products. In order cases, a default level of 0.01 mg/kg applies to pesticides that have not been approved within the European Union. Applying Regulation (EC) 396/2005 for evaluation of compliance of the presence of pesticide residues in feed materials results into two challenges. The first one concerns dilution or concentration of pesticides in processed and/or composite products. The second challenge concerns products that are only intended for use as animal feed (the so-called feed-only products). More information about the MRLs for pesticide residues, effects of processing on pesticide residue levels, and feed-only products is available in Annex 1.

This study aimed to obtain insights into the non-compliance of feed materials of plant origin imported to and/or produced in the Netherlands to MRLs for pesticide residues. Data from the NPAF over the period 2014-2019 were used, reporting on pesticide levels exceedances of the EC maximum residue levels. Study results can help official control authorities and feed operators to (re)design their yearly monitoring programmes in a risk-based way.

2 Materials and methods

2.1 Data

For the aims of this study, data from the monitoring programme National Plan Animal Feed (NPAF) of the Netherlands Food and Consumer Product Safety Authority (NVWA) were obtained. In the NPAF, the sampling is performed using a risk-based approach, implying a prioritized collection of samples based on risk ranking. This risk-based monitoring can result in higher amount of non-compliant samples, compared to a random sampling. Data covered monitoring results of pesticides in feed materials (from plant origin) in the Netherlands between 2014 and 2019.

In the course of NPAF, samples are collected by inspectors from the Netherlands Food and Consumer Product Safety Authority (NVWA). Samples are sent to Wageningen Food Safety Research (WFSR) for chemical analyses. At WFSR multi-residue methods (MRM) and single-residue methods (SRM) are used for pesticide residue analyses (Table 1). MRM means that in one run, a wide variety of pesticide residues levels is analysed in the sample. The different pesticides included in the multi-residue method, called the scope, can vary over time. All samples (except fats and oils) in the study period had been analysed with a multi-residue method (MRM). Fats and oils analysed with a MRM method for non-polar pesticides from 2016 onwards, were included. Since 2016 and 2017, part of the samples were analysed with single residue methods (SRMs) for specific polar pesticides.

Table 1 shows an overview of the analytical methods used for analyses, together with their scopes in the study years. Annex 2 presents a detailed description of the scopes of the pesticide analyses methods.

Table 1 *Analytical method used for pesticide analyses (method, matrices), with years of application.*

Method description	Matrix	Principle Method	Years in use
Multi residue method (MRM) for pesticides	All feed materials (except oils and fats)	GC-MS/LC-MS	2014-2019
Multi residue method (MRM) for non-polar pesticides	Oils and fats	GC-MS	2016-2019
Single residue method (SRM) for paraquat	Soy products	LC-MS	2016
Single residue method (SRM) for glyphosate	Soy products	LC-MS	2016
Single residue method (SRM) for paraquat, chlormequat, cyromazine, daminozide, difenzoquat, diquat, mepiquat, and trimethyl-sulfonium cation.	All feed materials (except oils and fats)	LC-MS	2017-2019
Single residue method (SRM) for glyphosate and gluphosinate (including metabolites)	All feed materials (except oils and fats)	LC-MS	2017-2019
Single residue method (SRM) for chlorate and perchlorate	Herbs	LC-MS	2017-2019

2.2 Data processing

Each record in the dataset contained information on the sampling date, feed material, analytical method used, and exceedance of the MRL for the pesticides in the multi-method used in the particular year. Original data of the dataset were processed to allow further analyses.

The feed materials from which samples had been collected were categorised following the categories of Regulation (EU) No 68/2013 on the Catalogue of feed materials (FMC) (see Annex 4 for overview with Dutch translation). The analysed pesticide levels were evaluated with the maximum residue limits (MRLs) of the respective pesticides. For OC pesticides, the MRLs according to the directive (EC) 2002/32 were used. For other pesticides, MRLs as defined in regulation (EC) no 396/2005 were followed. In case of processed and/or dried products, processing/drying factors (Annex 1) were applied to derive the MRL. For perchlorate, analysed pesticide levels were compared with those set out in 'levels of perchlorate as reference for intra-Union trade'. For chlorate, levels as indicated on the NVWA website were used for evaluation of non-compliant levels of the pesticide. More information about the MRLs and processing/drying factors is available in Annex 1. Evaluation of the analysed pesticide level with the MRL was done without taking into account measurement uncertainty. The relative expanded measurement uncertainty for pesticides in feed matrices is 50%. After preparation of the dataset, the dataset was checked by experts at WFSR for possible errors.

In some cases the analyses with SRMs or MRMs showed analytical problems (low recovery or chromatography interference) for certain pesticides. In these cases the pesticides were reported as "not determinable". As a consequence, the number of available results per sample can be lower than the number of pesticides measured. As shown in the example below, for this study the pesticides reported as "not determinable" were interpreted as "not detected", with the exception of a product subcategory with MRL exceedance and "not determinable" results. In these cases information is given about the amount of "not determinable results" and the incidence is calculated on the actual available analytical results.

Example:
Glyphosate was reported in eight (2x soy, 6x herbs) out of 680 samples as "not determinable".
For glyphosate in soy no MRL exceedance was observed (n=104) and for glyphosate in herbs one out of 59 samples showed an MRL exceedance.

Results of processing these original data were:
- Glyphosate in soy: No MRL exceedance was observed for glyphosate in soy. Therefore the two "not determinable" results were changed in "not detected", resulting in 106 compliant results.
- Glyphosate in herbs: One MRL exceedance was observed for glyphosate in herbs. As a consequence "not determinable" in the 6 samples was changed in "not analysed", resulting in 54 instead of 59 results, and a "glyphosate non-compliance" incidence of 1/54 = 1,9%.

3 Results and discussion

Pesticides residue data were available for the following 7 feed material categories:
1. Cereal grains and products derived thereof
2. Oil seeds, oil fruits, and products derived thereof
3. Legume seeds and products derived thereof
4. Tubers, roots, and products derived thereof
5. Other seeds and fruits, and products derived thereof
6. Herbs (not a separate category of the FMC)
7. Feed-only feed materials (not a separate category of the FMC)

The pesticides data are presented for each of the above categories and include results of the following analytical methods:
- Multi residue method (MRM)
- Single residue method (SRM) for paraquat, chlormequat, cyromazine, daminozide, difenzoquat, diquat, mepiquat, and trimethyl-sulfonium cation (SRM Quats)
- SRM for glyphosate and gluphosinate (including metabolites) (SRM glyphosate)
- SRM for chlorate and perchlorate (SRM (per)chlorate).

3.1 Cereal grains and products derived thereof

Category 1 of the catalogue of feed materials contains cereal grains and derived products. In general no processing factors have to be applied for these products, with the exception of maize oil (see paragraph 3.1.5).

3.1.1 MRM scope (excluding fats and oils)

A total of 578 category 1 samples was analysed from 2014 until 2019 using the MRM, covering a variety of cereal grains and derived products (Figure 1).

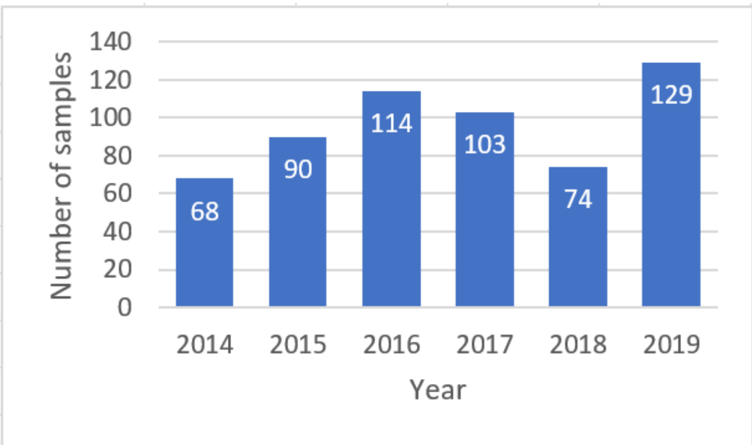

Figure 1 *Number of samples, belonging to cereal grains and products derived thereof, from 2014-2019 analysed with the multi-residue method.*

Between 3 and 12% non-compliant samples were identified over the years, with the highest percentage in 2018, see Figure 2.

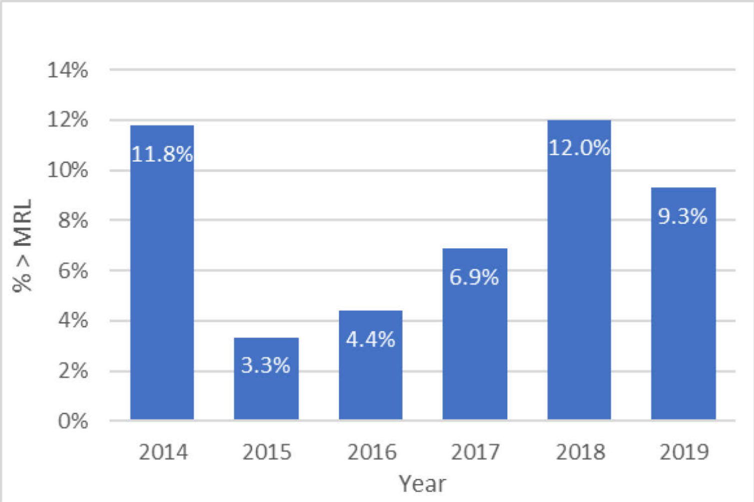

Figure 2 *Percentage non-compliant samples from 2014-2019 in cereal grains and products derived thereof, analysed with the multi-residue method.*

A more detailed view on the sample results (Table 2) reveals the highest non-compliance incidence in millet and sorghum, followed by rice, oats, and maize, and the lowest incidence for barley and wheat. For rye, spelt, and triticale non-compliant samples were not found. The incidence in millet was based on a substantial number of samples. The numbers of samples for sorghum and rice on the other hand were low and, therefore, no firm conclusions can be drawn on the non-compliance incidence in these two cereals. Likewise, the incidence of non-compliant samples for maize, barley and wheat was based on more than 100 samples each, while the number of samples was low for oat. Similarly, the absence of non-compliant samples for rye, triticale, and spelt was based on only a limited number of samples.

Table 2 *Numbers and percentage of non-compliant samples per type of cereal between 2014-2019, analysed with the multi-residue method.*

Subcategory	Cereal grain*	N	N>MRL	%>MRL
1.1	Barley	115	5	4%
1.2	Maize/Corn	166	11	7%
1.3	Millet	69	16	23%
1.4	Oats	32	3	9%
1.6	Rice	23	4	17%
1.7	Rye	12	0	0%
1.8	Sorghum	14	3	21%
1.9	Spelt	5	0	0%
1.10	Triticale	12	0	0%
1.11	Wheat	130	2	2%

*Incl. products derived thereof

3.1.2 SRM glyphosate

In category 1 feed materials, the SRM glyphosate was performed from 2017 onwards. A total of 293 samples was analysed from 2017 until 2019, covering a variety of cereal grains. Between 2.7 and 4.3% non-compliant samples were identified over the years (Figure 3).

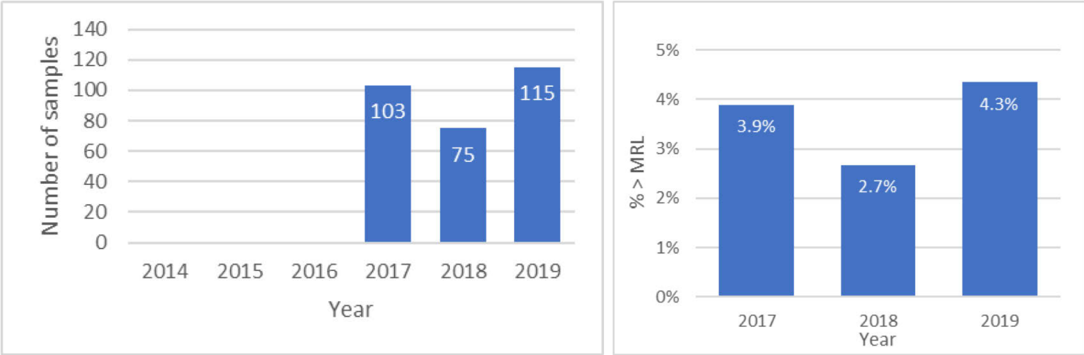

Figure 3 *Category 1 feed material samples analysed per year (left panel) and % of non-compliant samples per year (right panel) with the single-residue method glyphosate.*

Non-compliant pesticide levels were found in millet only, in 17% of the samples, although the number of samples analysed was low for some other cereals (Table 3). In all cases, one pesticide showed MRL exceedance, being glyphosate.

Table 3 *Number and percentage of non-compliant samples per type of cereal between 2017-2019, analysed with the single-residue method glyphosate.*

Subcategory	Cereal grain*	N	N>MRL	%>MRL
1.1	Barley	48		
1.2	Maize/Corn	61		
1.3	Millet	66	11	17%
1.4	Oats	11		
1.6	Rice	10		
1.7	Rye	10		
1.8	Sorghum	8		
1.9	Spelt	1		
1.10	Triticale	8		
1.11	Wheat	70		

*Incl. products derived thereof.

3.1.3 SRM quats scope

In category 1 feed materials the SRM for quats was performed from 2017 onwards. A total of 305 samples was analysed from 2017 until 2019, covering a variety of cereal grains. Between 0.0 and 3.9% non-compliant samples were identified over the years, with the highest percentage in 2017 (Figure 4).

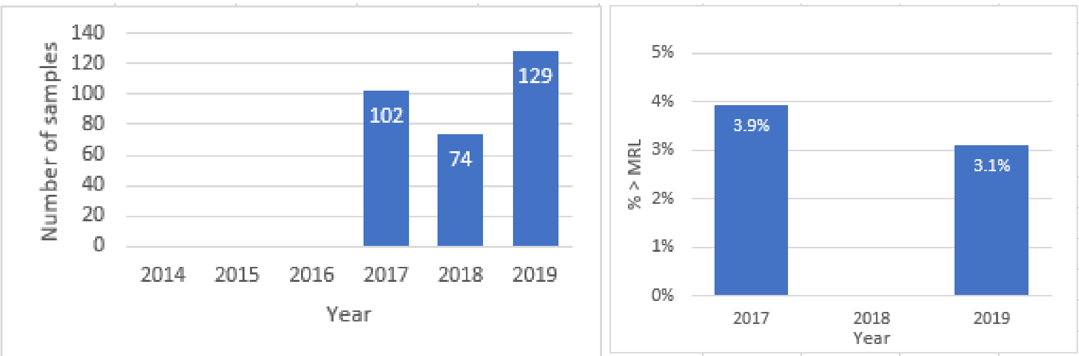

Figure 4 *Category 1 feed material samples analysed per year (left panel) and percentage of non-compliant samples per year (right panel) with the single-residue method for quats.*

With the SRM for quats, non-compliant samples were found in 12% of the millet samples. The samples of other cereal grains were compliant, although the number of analysed samples was low for several cereal grains (Table 4). In three millet samples analytical problems for diquat occurred, resulting in "not determinable" results. Non-compliant levels of diquat were found in 7 samples and of paraquat in one sample.

Table 4 *Category 1 feed material samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for quats.*

Subcategory	Cereal grain*	N	N>MRL	%>MRL
1.1	Barley	48		
1.2	Maize/Corn	84		
1.3	Millet	66*	8	12%
1.4	Oats	11		
1.6	Rice	19		
1.7	Rye	7		
1.8	Sorghum	8		
1.9	Spelt	1		
1.10	Triticale	6		
1.11	Wheat	55		

*Incl. products derived thereof.

**n=63 for diquat and n= 66 for the other components.

3.1.4 SRM chlorate/perchlorate

In 2019, 13 samples of category 1 were analysed for presence of chlorate/perchlorate: 10 millet, 2 sorghum and 1 rice sample. Perchlorate was non-compliant in three millet samples (30%).

3.1.5 MRM fat and oils scope

A total of 5 maize oils were analysed with the MRM for fats in in the period 2016 - 2019. All samples were compliant.

3.1.6 Over-all results of category 1 feed materials (cereal grains)

Non-compliant samples for the MRM scope were found in most subcategories of cereals and products derived thereof. The subcategories without non-compliant samples had no or low numbers of samples. Except for millet, none of the samples was found to be non-compliant with using the glyphosate and quats scopes. Table 5 summarises the percent of non-compliant samples for each subcategory of cereal grain and products thereof, and each method used.

Table 5 *Percent of non-compliant samples for each method and subcategory of cereal grains and products derived thereof.*

Subcategory	Cereal grain and derived products	Percent non-compliant samples*			
		MRM	SRM quat	SRM glyphosate	SRM (per)chlorate
1.1	Barley	+	-	-	?
1.2	Maize/corn	+	-	-	?
1.3	Millet	++	++	++	++
1.4	Oats	+	-	-	?
1.5	Quinoa	?	?	?	?
1.6	Rice	++	-	-	?
1.7	Rye	-	?	-	?
1.8	Sorghum	++	?	?	?
1.9	Spelt	?	?	?	?
1.10	Triticale	-	?	?	?
1.11	Wheat	+	-	-	?

* ++ = >10%.
+ = 1-10%.
- = <1%.
? = n < 10 (lack of sufficient data).

When all scopes are combined, the percent of non-compliant samples was 10.4% for cereal grains and products derived thereof (63 out of 604 samples).

Specific pesticides exceeded MRLs for specific subcategories of cereals; for instance, glyphosate, DDT (sum), and diquat for millet. The highest percent of non-compliant samples was found in the subcategory of millet and sorghum, followed by rice, oats and maize.

Table 6 summarises the number of non-compliant cereal samples, per pesticide, with all scopes combined.

Table 6 *Number of non-compliant cereal samples per pesticide, scopes combined.*

Pesticide	Number of non-compliant samples	Subcategory
Glyphosate	11	millet
DDT (sum)	9	millet
Diquat	7	millet
Propamocarb	5	barley (2), oats (2), wheat (1)
Fenitrothion	5	maize (4), sorghum (1)
Pirimiphos-methyl	4	maize (2), sorghum (2)
Tricyclazole	4	rice
Carbendazim	3	millet
Chlorpyrifos	3	millet
HCH alpha-	3	millet
HCH beta-	3	millet
Perchlorate	3	millet
Fluopicolide	2	barley
Dichlorvos	2	maize
Chlorpyrifos-methyl	1	wheat
Dimoxystrobin	1	maize
Haloxyfop	1	maize
Methomyl	1	maize
Dichlorprop	1	millet
Paraquat	1	millet
Profenofos	1	millet
Chlorpropham	1	oats
Pencycuron	1	barley

Millet seems a subcategory of specific interest, with the highest non-compliance incidence and a mixture of non-compliant pesticides in single samples, including polar pesticides as glyphosate, paraquat, diquat and even perchlorate. In the 39 non-compliant millet samples, 11 different pesticides exceeded the MRL.

Six cereal grain samples (all millet) were non-compliant for more than one pesticide. The combination of DDT (sum), HCH-α, and HCH-β was found three times; DDT (sum) and profenofos once, glyphosate and diquat once, and paraquat and carbendazim once.

MRLs for millet are generally the strictest among the cereals, although not exclusively. For all non-compliant pesticides found in millet, at least one other cereal has the same MRL. For instance, the millet glyphosate MRL is 0.1, just as for rice, while in rice no non-compliant levels were found. Also, several non-compliant pesticides in millet have the same MRL across the cereals, i.e. DDT (sum), HCH-α, HCH-β, perchlorate, paraquat, and profenofos (Table 7).

Table 7 *Maximum residue levels for pesticides in cereal grains (and products derived thereof) related to the incidence in National Plan Animal Feed.*

Pesticide	Incidence	MRL (mg/kg)							
		1.1 Barley	1.2 Maize/corn	1.3 Millet	1.4 Oats	1.6 Rice	1.7 Rye	1.8 Sorghum	1.9/1.10/1.11 Spelt/Triticale/Wheat
Glyphosate	11	20	1	0.1*	20	0.1*	10	20	10
DDT (sum)	9	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Diquat	7	0.02*	0.02*	0.02*	2	0.02*	0.02*	0.02*	0.02*
Carbendazim	3	2	0.01*	0.01*	2	0.01*	0.1	0.01*	0.1
Chlorpyrifos	3	0.6	0.05	0.01*	0.6	0.5	0.15	0.5	0.5
HCH alpha-	3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HCH beta-	3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Perchlorate	3	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Dichlorprop	1	0.1	0.02*	0.02*	0.1	0.02*	0.1	0.02*	0.1
Paraquat	1	0.02*	0.02*	0.02*	0.02*	0.05	0.02*	0.02*	0.02*
Profenofos	1	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*

* is lower limit of analytical determination.

3.2 Oil seeds, oil fruits, and products derived thereof

Category 2 of the catalogue of feed materials contains oil seeds, oil fruits and derived products.

3.2.1 MRM scope (excluding fats and oils)

A total of 507 samples was analysed in 2014-2019. The amount of samples per year is represented in Figure 5 and had an increasing trend. Products in this category included oilseeds such as rapeseed and sunflower seed and products derived thereof such as expeller and meal.

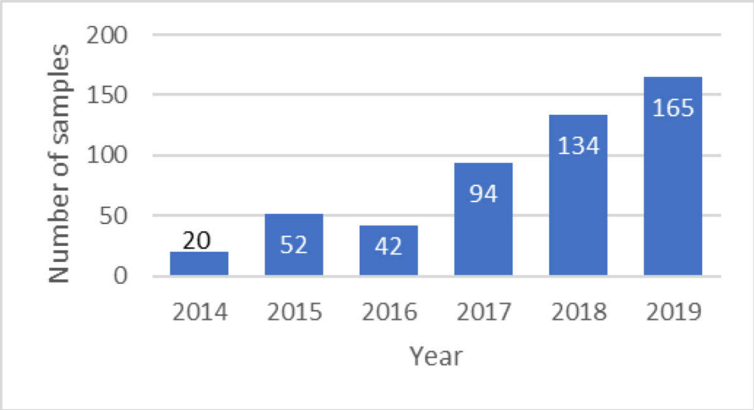

Figure 5 *Number of samples, belonging to oil seeds, oil fruits, and products derived thereof, from 2014-2019 analysed with the multi-residue method.*

Between 2 and 13% non-compliant samples were identified over the years, with the highest percentage in 2019 (Figure 6). The higher percentage in 2019 is likely to be caused by linseed samples, which comprised 41% non-compliant samples.

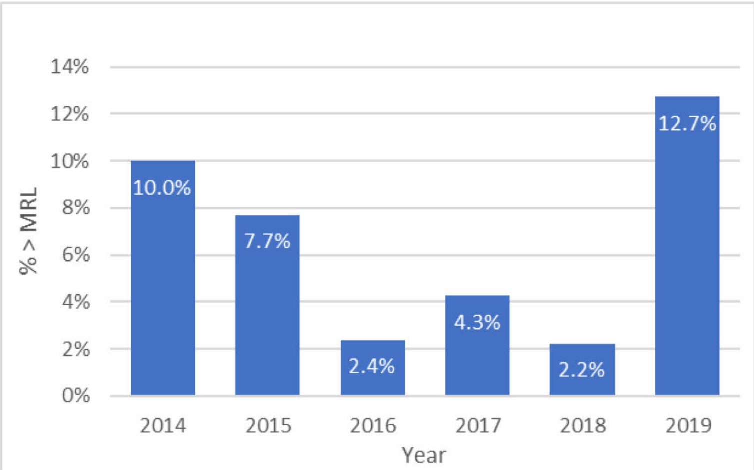

Figure 6 *Percentage non-compliant samples from 2014-2019 in oil seeds, oil grains, and products derived thereof, analysed with the multi-residue method.*

Most samples were taken from soy (n=235), and sunflower seed (n=129) followed by linseed (n=49) and rape seed (n=45) (Table 8). Incidence of non-compliant samples seemed non-specific: non-compliancy was seen in several oilseeds and products derived thereof. Most non-compliant samples were found in linseed, in 19 samples from 2019 and one from 2017. The number of samples was low in sesame seed, poppy seed and safflower seed, therefore, no firm conclusions can be drawn on the magnitude of the incidence in these oilseeds.

Table 8 *Number and percentage of non-compliant samples per type of oil seed/oil fruit between 2014-2019 and analysed with the multi-residue method.*

Subcategory	Oil seed/oil fruit*	N	N > MRL	% > MRL
2.18	Soy	235	1	0%
2.19	Sunflower seed	129	7	5%
2.8	Linseed	49	20	41%
2.14	Rape seed	45	4	9%
2.12	Palm kernel expeller/meal	14	0	
2.22	Hemp seed	12	0	
2.15	Safflower seed	8	1	13%
2.10	Niger	6	0	
2.23	Poppy seed	4	1	25%
2.17	Sesame seed	3	1	33%
2.2	Camelina	1	0	
2.4	Copra	1	0	

*incl. products derived thereof.

3.2.2 SRM glyphosate scope

A total of 210 samples was analysed in the period 2017-2019. The amount of samples per year is represented in Figure 7 on the left.

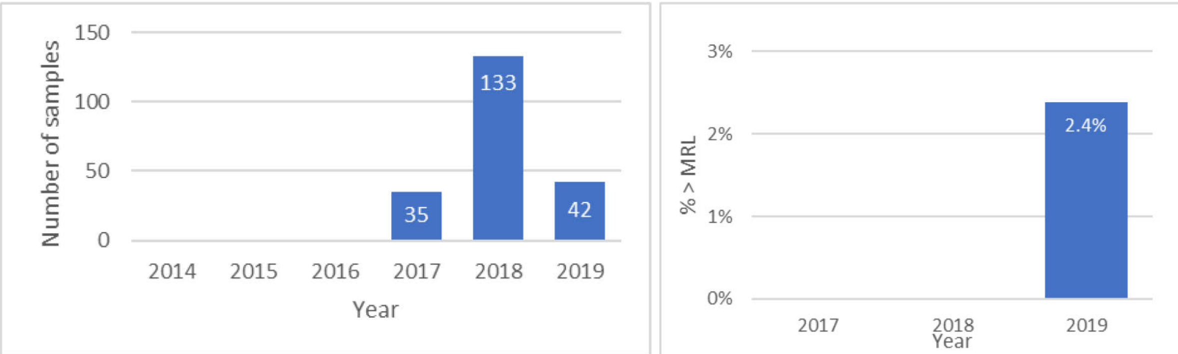

Figure 7 *Category 2 samples per year analysed (left panel) and % of non-compliant samples (right panel) with the SRM glyphosate scope.*

In Table 9, the number of samples for different products are shown. Most samples were taken from soy, followed by sunflower seed and rape seed. One of the samples, a hemp sample (2.4%), was non-compliant for glyphosate in 2019.

Table 9 *Number and percentage of non-compliant samples per type of oil seed/oil fruit analysed with the single-residue method for glyphosate.*

Subcategory	Oil seed/oil fruit*	N	N > MRL	% > MRL
2.18	Soy	101	0	
2.19	Sunflower seed	51	0	
2.14	Rape seed	26	0	
2.12	Palm kernel expeller/meal	9	0	
2.22	Hemp seed	6	1	17%
2.8	Linseed	5	0	
2.15	Safflower seed	4	0	
2.17	Sesame seed	3	0	
2.10	Niger	2	0	
2.23	Poppy seed	2	0	
2.2	Camelina	1	0	

*incl. products derived thereof.

3.2.3 SRM quats scope

A total of 379 samples was analysed with the SRM quats method between 2016-2019. In 2016 the SRM quat method contained only paraquat. Other quats and polar pesticides were added in 2017. The amount of samples per year is represented in Figure 8 on the left.

The highest percentage of non-compliant samples was reported in 2016, the percentage declined in 2017 but rose again in 2018 and 2019. No trend analysis was performed for the SRM quats scope.

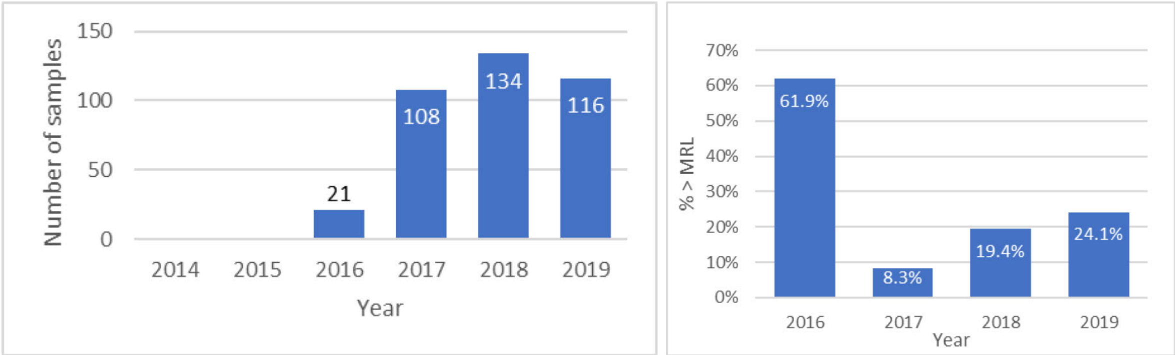

Figure 8 *Category 2 samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for quats.*

Most samples were taken from soy followed by sunflower seed, and rape seed and products derived thereof. In thirteen soy and three rape seed samples analytical problems for paraquat occurred, resulting in "not determinable" results. Non-compliant samples were found for soy, sunflower seed, and rape seed (Table 10).

Table 10 *Number and percentage of non-compliant samples per type of oil seed/oil fruit analysed with the single-residue method for quats.*

Subcategory	Oil seed/oil fruit*	N	N > MRL	% > MRL
2.18	Soy	243 (259)**	67	28%
2.19	Sunflower seed	67	8	12%
2.14	Rape seed	23 (26)***	1	4%
2.22	Hemp seed	6		
2.8	Linseed	5		
2.12	Palm kernel expeller/meal	4		
2.15	Safflower seed	4		
2.17	Sesame seed	3		
2.10	Niger	2		
2.23	Poppy seed	2		
2.2	Camelina	1		

*incl. products derived thereof.

**n=243 for paraquat and n= 259 for the other components.

***n=23 for paraquat and n= 26 for the other components.

3.2.4 SRM chlorate/perchlorate

A total of seven samples was analysed for chlorate/perchlorate in 2019. The samples consisted of linseed, kardi seed, rapeseed, hemp seed, sunflower seed, and canola seed. No non-compliant seeds were found.

3.2.5 MRM fats and oils scope

A total of 265 samples of oils and fats from oil seeds and fruits was analysed between 2016-2019. The amount of samples per year is represented in Figure 9. Only in 2019, two non-compliant samples (3.1%) were found.

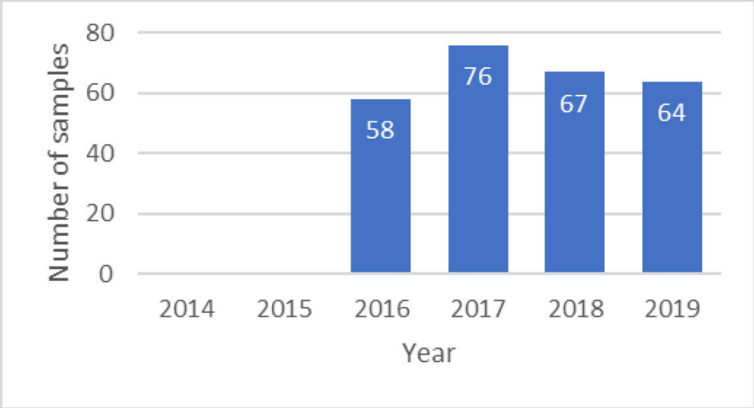

Figure 9 *Category 2 samples per year analysed (left panel) with the multi-residue method for fats and oils.*

Most samples were taken from soy oil and palm kernel oil followed by coconut, linseed, and sunflower seed oil (Table 11). Incidence of non-compliant samples occurred in linseed oil and sunflower seed oil both for chlorpyriphos.

Table 11 *Number and percentage of non-compliant samples per type of cereal between 2016-2019 and analysed with the multi-residue method for fats and oils.*

Subcategory	Origin oils/fats	N	N > MRL	% > MRL
2.18	Soy	88	0	
2.12	Palm	52	0	
2.19	Sunflower seed	37	1	3%
2.8	Linseed	25	1	4%
2.4	Copra	23	0	
2.14	Rape seed	13	0	
2.20	Vegetable oil	11	0	
2.21	Crude lecithins	8	0	
2.6	Groundnut	4	0	
2.15	Safflower seed	2	0	
2.22	Hemp seed	2	0	

3.2.6 Over-all results of category 2 feed materials (oil seeds and oil fruits)

The numbers of category 2 samples analyzed with the MRM between 2014-2019 increased over the years. Non-compliant samples were found in soy, sunflower seed, linseed, rapeseed, safflower seed, poppy seed and sesame seed. Haloxyfop in linseed was the most commonly found non-compliant MRM pesticide-oilseed combination (Table 13).

Samples taken for SRM glyphosate analyses showed low incidence of non-compliant samples between 2017-2019. Exceedance of the MRL was reported only once (in 2019 in hemp seed).

The results for the SRM quats analyses showed high number of non-compliant results, especially for soy (products) and sunflower (products).

Table 12 summaries the incidence of non-compliant samples for each subcategory of oil seed and oil fruit and each method.

Table 12 *Incidence of non-compliant samples for each method and subcategory of oil seed and oil fruits and products derived thereof.*

Subcategory	Oils seed and oil fruit and products derived thereof	Percent non-compliant samples*			
		MRM	MRM fats/oils	SRM quats	SRM glyphosate
2.4	Copra	?	-	?	?
2.8	Linseed	++	+	?	?
2.12	Palm kernel	-	-	?	?
2.14	Rape seed	+	-	+	-
2.15	Safflower seed	++	?	?	?
2.16	Sesame seed	++	?	?	?
2.18	Soy	-	-	++	-
2.19	Sunflower seed	+	+	++	-
2.20	Vegetable oil		-		
2.22	Hemp seed	-	?	?	++
2.23	Poppy seed	++	?	?	?
2.1-2.3, 2.5-2.7, 2.9-2.13	Babassu, Camelina, Cocoa, Cotton seed, Groundnut, Kapok, Mustard seed, Niger seed, Olive, pumpkin seed	?	?	?	?

* ++ = >10%.
\+ = 1-10%.
\- = <1%.
? = n < 10 (lack of sufficient data).

When all scopes are combined, the incidence of non-compliant pesticides was 13.8% for oil seeds/fruits and products derived thereof (112 out of 810 samples). Table 13 summarizes the number of non-compliant oil seed/fruit samples per pesticide with all scopes combined. Incidence of non-compliant pesticides per oilseed (or product derived thereof) in this dataset seemed only specific for haloxyfop in linseed. Four pesticides exceeded the MRL in at least two oilseeds, i.e. chlorpyrifos and deltamethrin in linseed and sunflower seed, pirimiphos-methyl in rape seed and sunflower seed, and thiamethoxam in linseed and rape seed.

Table 13 *Number of non-compliant oil seed samples per pesticide, scopes combined.*

Pesticide	Number of non-compliant samples	Subcategory
Paraquat	67	soy (66), rape seed (1)
Haloxyfop	20	linseed (20)
Mepiquat	6	sunflower seed (6)
Chlorpyrifos	5	linseed and oil (3), sunflower seed and oil (2)
Pirimiphos-methyl	4	rape seed (2), sunflower seed (2)
Thiamethoxam	4	linseed (3), rape seed (1)
Chloormequat	4	sunflower seed (3), soy (1)
Deltamethrin	3	sunflower seed (2), linseed (1)
Carbendazim	1	rape seed (1)
MCPA	1	rape seed (1)
Malathion	1	safflower seed (1)
Phoxim	1	sesame seed (1)
Chlorpyrifos-methyl	1	soy (1)
Cypermethrin	1	soy (1)
Imidacloprid	1	sunflower seed (1)
Metalaxyl	1	sunflower seed (1)
Tebuconazole	1	sunflower seed (1)
Glyphosate	1	hemp seed (1)
Vinclozolin	1	poppy seed (1)
Propargite	1	linseed (1)

Eight samples contained more than one pesticide exceeding the MRL, the results are shown in Table 14.

Table 14 *Multiple non-compliant pesticide residues per oil seed/fruit sample.*

Category	Number of non-compliant samples	Non-compliant pesticides
Linseed	4	Haloxyfop, propargite (1x) Haloxyfop, thiamethoxam, chlorpyrifos (2x) Haloxyfop, thiamethoxam, deltamethrin (1x)
Soy	1	Cypermethrin, chlorpyrifos-methyl
Sunflower seed	2	Chlorpyrifos, tebuconazole (1x) Chloormequat, mepiquat (1x)
Rapeseed	1	Carbendazim, thiamethoxam, paraquat

3.3 Legume seeds and products derived thereof

Category 3 of the catalogue of feed materials contains legume seeds and derived products.

3.3.1 MRM scope

A total of 145 category 3 samples was analysed from 2014 until 2019 using the MRM, covering a variety of legume seeds and derived products, such as flakes, paste or powder (Figure 10).

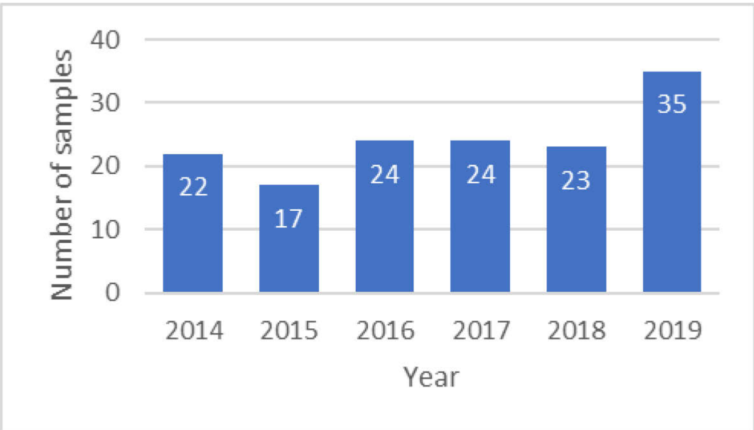

Figure 10 *Number of samples, belonging to legume seeds and products derived thereof, from 2014-2019 analysed with multi-residue method.*

Between 4 and 17% non-compliant samples were identified over the years, with the highest percentage in 2017 (Figure 11).

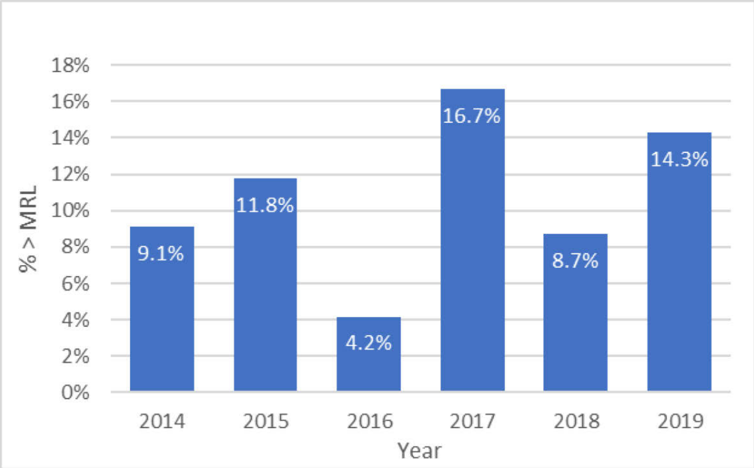

Figure 11 *Percentage non-compliant samples from 2014-2019 in legume seeds and products derived thereof, analysed with multi-residue method.*

A more detailed view on the samples reveals the highest sampling for pea (n=82) and lupin (32), with an incidence of 12% and 6% non-compliant samples respectively (Table 15). For other legumes, sampling was more incidental, as were the non-compliant samples. Noteworthy is that both lentil samples were non-compliant. No conclusions can be drawn on the general incidence of non-compliant samples across the subcategories of legumes, given the very low sample numbers for most of the subcategories.

Table 15 *Number and percentage of non-compliant samples per type of legume seed between 2014-2019 and analysed with the multi-residue method.*

Subcategory	Legume seeds*	N	N > MRL	% > MRL
3.1	Beans	1		
3.2	Carob	1		
3.5	Fenugreek seed	5		
3.6	Guar (germs) meal	1		
3.7	Horse bean	7	1	14%
3.8	Lentil	2	2	100%
3.9	Lupin	33	2	6%
3.10	Mung bean	5	1	20%
3.11	Pea	82	10	12%
3.12	Vetch	8		

* incl. products derived thereof.

3.3.2 SRM glyphosate scope

In category 3 feed materials, the SRM for glyphosate was performed from 2017 onwards. A total of 82 samples was analysed from 2017 until 2019, covering a variety of legumes (Figure 12). In 2017 two non-compliant samples were found (8%), in 2018 one non-compliant sample was found (4%), all three for glyphosate levels. In 2019 no non-compliant samples were found. Whether non-compliant samples are incidental or generic cannot be concluded from these numbers.

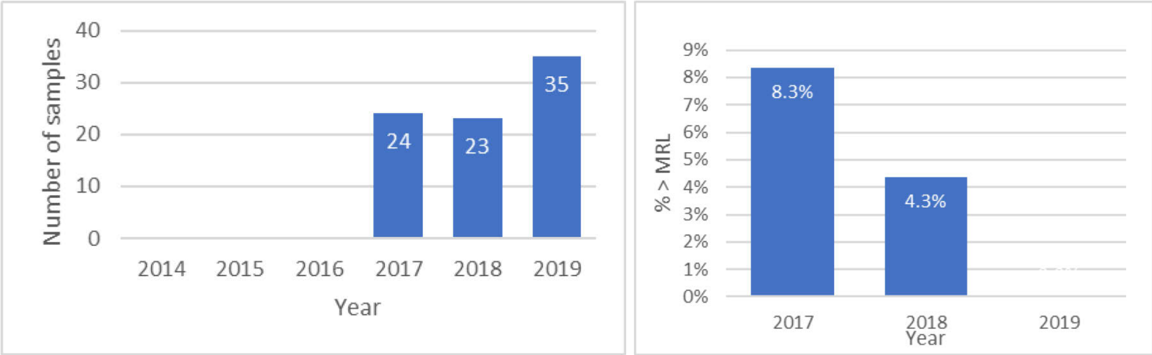

Figure 12 *Category 3 samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for glyphosate.*

The number of samples and the non-compliant samples per subcategory are displayed in Table 16.

Table 16 *Number and percentage of non-compliant samples per type of legume seed, analysed with the single-residue method for glyphosate.*

Subcategory	Legume seeds*	N	N > MRL	% > MRL
3.2	Carob	1		
3.5	Fenugreek seed	5		
3.6	Guar (germs) meal	1		
3.7	Horse bean	5	1	20%
3.9	Lupin	18		
3.10	Mung bean	2	1	50%
3.11	Pea	45		
3.12	Vetch	5	1	20%

* incl. products derived thereof.

3.3.3 SRM quats scope

In category 3 feed materials, the SRM for quats was performed from 2017 onwards. A total of 82 samples was analysed from 2017 until 2019, covering a variety of legumes. Between 4 and 13% non-compliant samples were identified over the years, with the highest percentage in 2018 (Figure 13).

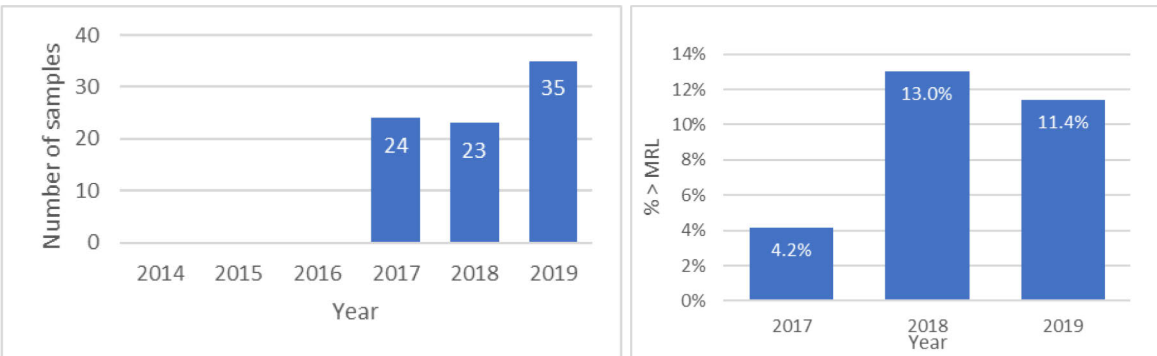

Figure 13 *Category 3 samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for quats.*

Again, apart from pea, sample numbers were low or incidental for subcategories. Noteworthy is the low incidence in pea (paraquat, once), as well as the rather high incidence in lupin; four out of

18 samples were non-compliant, three times for paraquat, once for chlormequat. Other non-compliant levels were found in vetch samples (twice diquat), and in mung beans, for trimethyl-sulfonium cation, once (Table 17).

Table 17 *Number and percentage of non-compliant samples per type of legume seeds, analysed with the single-residue method for quats.*

Subcategory	Legume seeds*	N	N > MRL	% > MRL
3.2	Carob	1		
3.5	Fenugreek seed	5		
3.6	Guar (germs) meal	1		
3.7	Horse bean	5		
3.9	Lupin	18	4	22%
3.10	Mung bean	2	1	50%
3.11	Pea	45	1	2%
3.12	Vetch	5	2	40%

* incl. products derived thereof.

3.3.4 SRM chlorate/perchlorate

No non-compliant chlorate/perchlorate levels were found in nine samples. One sample was taken in 2018, eight in 2019, and they consisted of five fenugreek samples, two pea, one vetch, and one carob sample.

3.3.5 Over-all results of category 3 feed materials (legume seeds)

In category 3, pea and lupin were sampled most often. In pea samples, most non-compliant samples were detected with the MRM scope, while paraquat exceeded the MRL once. In lupin, both the MRM scope and the SRM quats scope revealed non-compliant pesticide levels. For other legumes, sampling was more incidental, as were the non-compliant samples.

Table 18 *summaries the incidence of non-compliant samples for each subcategory of legume seed and each method.*

Subcategory	Legume seeds*	Percent non-compliant samples*		
		MRM	SRM quat	SRM glyphosate
3.7	Horse beans	++	?	++
3.8	Lentils	++	?	?
3.9	Lupin	+	++	-
3.10	Mung beans	++	++	++
3.11	Peas	++	+	-
3.12	Vetch	?	++	++
3.1-3.6 3.13, 3.14	Beans, carob, chick peas, ervil, fenugreek seed, guar (germs) meal chickling vetch, monantha vetch	?	?	?

* ++ = >10%.
+ = 1-10%.
- = <1%.
? = n < 10 (lack of sufficient data).

No firm conclusions can be drawn on the general incidence of non-compliant samples across the subcategories of legumes, given the low sample numbers. No relations could be made for specific pesticide-legume combinations.

When all scopes are combined, the incidence of non-compliant pesticides is 17.2% for legume seeds and products derived thereof (25 out of 145 samples). Table 19 summarizes the number of non-compliant legume seeds samples per pesticide with all scopes combined.

Table 18 *Number of non-compliant legume seed samples per pesticide, scopes combined.*

Pesticide	Number of non-compliant samples	Subcategory
Pirimiphos-Methyl	8	pea (7), horse bean (1)
Paraquat	4	lupin (3), pea (1)
Glyphosate	3	mung bean (1), horse bean (1), vetch (1)
2,4-D	3	lentil (2), pea (1)
Cypermethrin	3	pea (3)
Diquat	2	vetch (2)
Propamocarb	2	lupin (2)
Acephate	1	mung bean (1)
Chlorpyrifos	1	mung bean (1)
Methamidophos	1	mung bean (1)
Trimethyl-sulfonium cation	1	mung bean (1)
Chloormequat	1	lupin (1)

More than one non-compliant pesticide was found in three samples. One pea sample exceeded the MRLs for cypermethrin and pirimiphos-methyl; one lupin sample exceeded the MRLs for chlormequat and propamocarb, and one mung bean sample exceeded the MRLs for methamidophos, acephate, chlorpyrifos, and trimethyl-sulfonium cation.

3.4 Tubers, roots, and products derived thereof

Category 4 of the catalogue of feed materials contains tubers, roots and derived products.

3.4.1 MRM and SRM scopes

Twenty-nine category 4 samples were analysed with the MRM in the period 2016-2019 (Figure 14). Samples consisted of sugarbeet molasses in 2016 and 2017, and of garlic and tapioca in 2018 and 2019. No MRL exceedances were found in category 4 samples with the MRM. The garlic and tapioca samples were also analysed with the SRM glyphosate and quats scopes, no MRL exceedances were detected (Figure 14). The garlic samples were also analysed, and compliant, for chlorate/perchlorate levels.

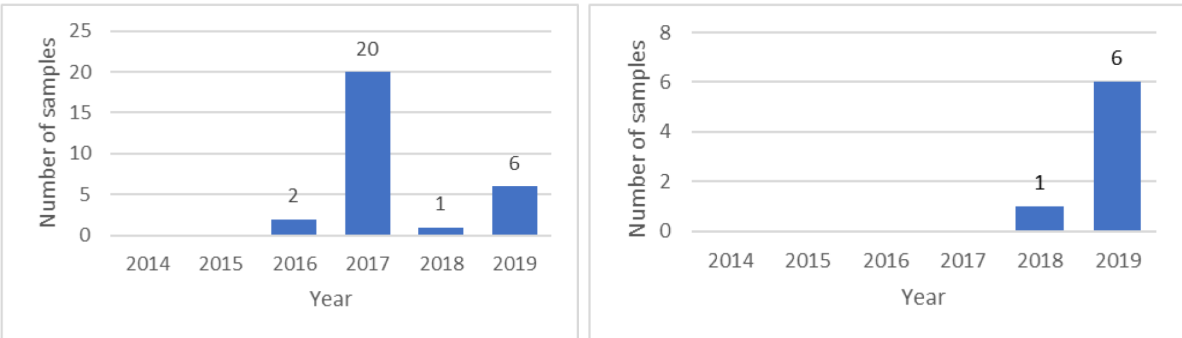

Figure 14 *Number of samples, belonging to tubers, roots, and products derived thereof, analysed with multi-residue method (left panel) and analysed for both single-residue methods for glyphosate and for quats (right panel).*

3.5 Other seeds and fruits, and products derived thereof

Category 5 of the catalogue of feed materials contains tubers, roots and derived products.

3.5.1 MRM scope

A total of 13 category 5 samples was analysed from 2015 until 2019 using the MRM, covering various other seeds and fruits and derived products, such as anise seed, caraway seed, buckwheat and graminaceous seeds (Figure 15). No exceedances of MRL where found among these samples.

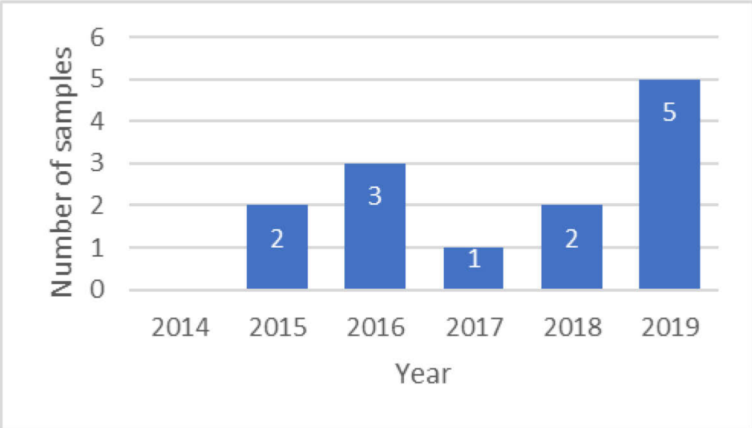

Figure 15 *Number of samples, belonging to other seeds and fruits, and products derived thereof, analysed with multi-residue method.*

3.5.2 SRM glyphosate scope

A total of seven category 5 samples was analysed in 2018 and 2019 using the SRM glyphosate scope (Figure 16). The exceedances consisted of two out of three buckwheat samples and one fennel seed sample. However, the number of samples for these years was low and, therefore, no firm conclusions can be drawn on the magnitude of these years.

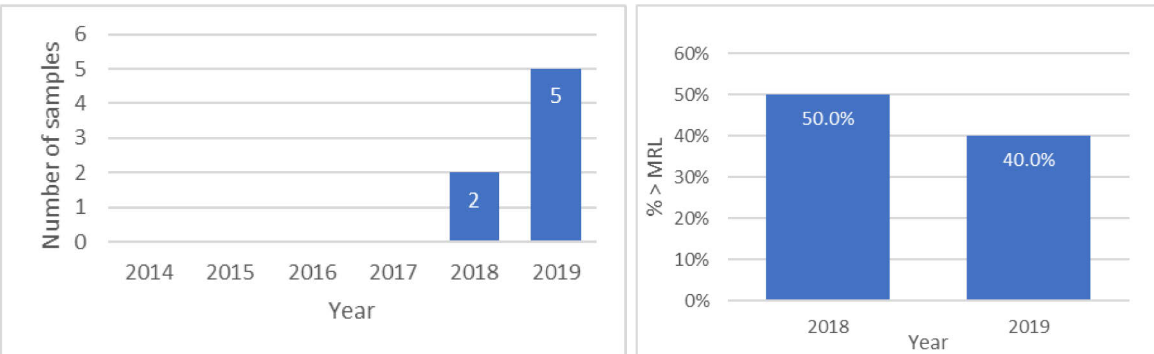

Figure 16 *Category 5 samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for glyphosate.*

3.5.3 SRM quats scope

A total of seven category 5 samples was analysed in 2018 and 2019 using the SRM quats scope (Figure 17). One out of three buckwheat samples showed analytical problems for diquat and was reported as "not determinable" for this pesticide.

In 2018, 50% of the samples exceeded the MRL. The exceedances consisted of one out of three buckwheat samples. However, the number of samples for these years was low and, therefore, no firm conclusions can be drawn on the magnitude of these years.

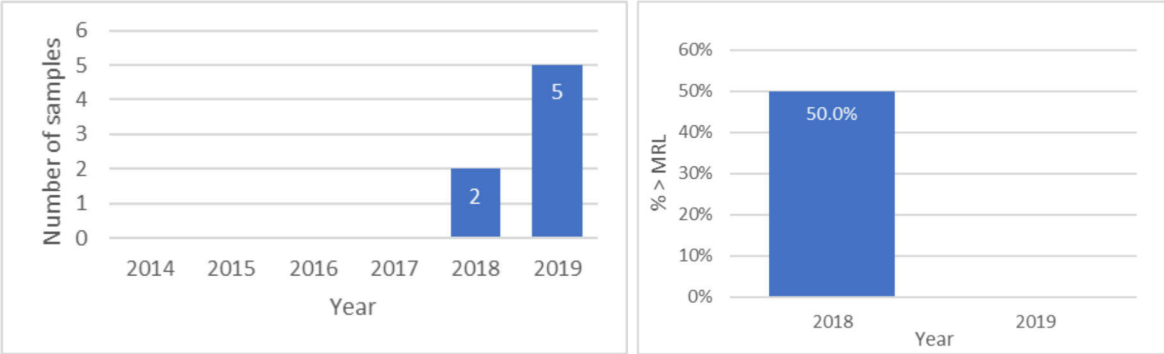

Figure 17 *Category 5 samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for quats.*

3.5.4 SRM chlorate/perchlorate

A total of four category 5 samples was analysed in 2019 for chlorate/perchlorate. No MRL exceedances were found among these samples.

3.5.5 Over-all results of category 5 feed materials (other seeds and fruits)

Few exceedances of MRL were found among other seeds and fruits and products derived thereof. However, fewer samples were taken in this category than in previously mentioned categories.

When all scopes are combined, the incidence of non-compliant pesticides is 23.1% for “other seeds/ fruits and products derived thereof” (three out of 13 samples). Table 20 summarizes the number of non-compliant other seeds/fruits samples per pesticide with all scopes combined. Exceedances were found for glyphosate and quats in buckwheat and fennel seed.

Table 19 *Number of non-compliant other seed and fruit samples per pesticide, scopes combined.*

Pesticide	Number of non-compliant samples	Subcategory
Glyphosate	3	buckwheat (2), fennel seed (1)
Chloormequat	1	buckwheat (1)
Diquat	1	buckwheat (1)

3.6 Herbs (including spices, edible flowers)

Herbs, spices and edible flowers are found in category 7 (other plants, algae and derived products) or 13 (miscellaneous) in the feed material catalogue, no subcategories apply for herbs.

3.6.1 MRM scope

A total of 60 herb samples was analysed from 2017 until 2019 using the MRM, covering herbs, flowers and powders (plant, sweet pepper) (Figure 18). Nine MRL exceedances were found among herb and flower samples.

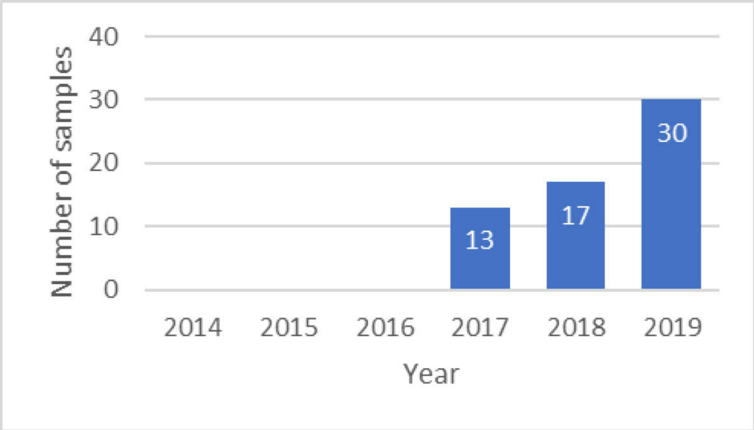

Figure 18 *Number of samples, belonging to herbs, from 2017-2019 analysed with the multi-residue method.*

Between 8 and 18% non-compliant samples were identified over the years, with the highest percentage in 2018 (Figure 19).

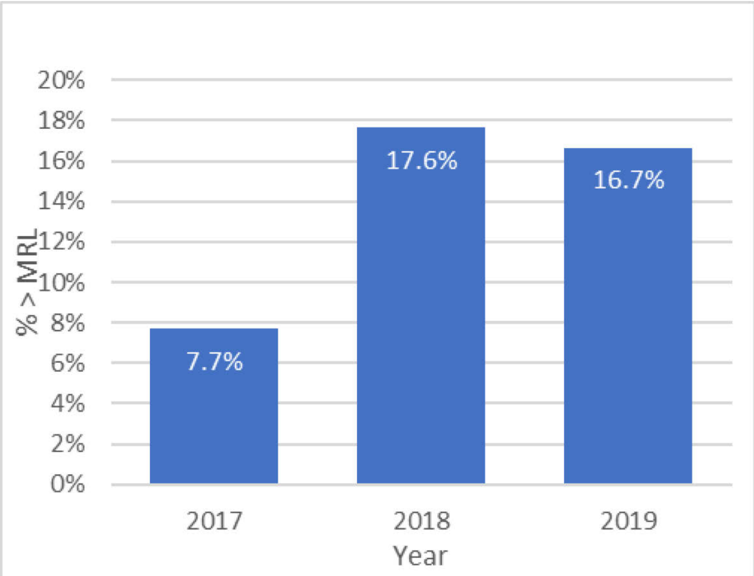

Figure 19 *Percentage non-compliant samples from 2017-2019 herbs, analysed with the multi-residue method.*

3.6.2 SRM glyphosate scope

A total of 59 herb samples was analysed in 2017 until 2019 using the SRM glyphosate scope. Due to analytical problems, glyphosate could not be determined in five of the 59 samples of herbs. In 2019, one dandelion sample exceeded the MRL (Figure 20).

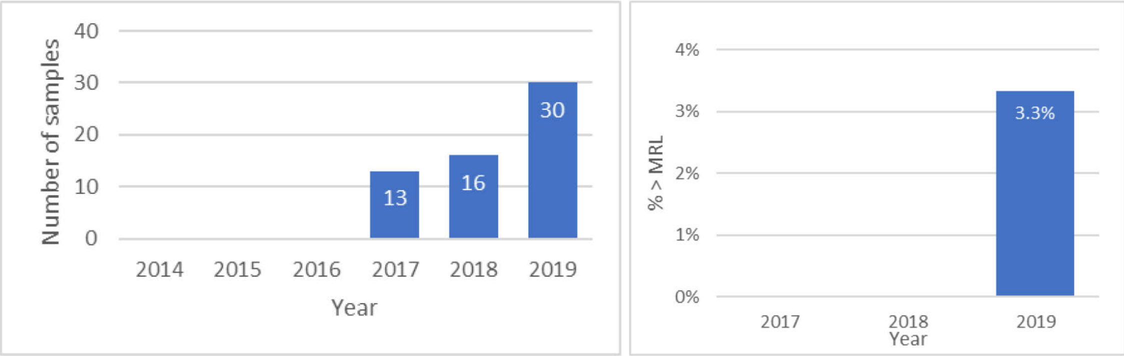

Figure 20 *Number of herb samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for glyphosate.*

3.6.3 SRM quats scope

A total of 58 herb samples was analysed in 2017 until 2019 using the SRM quats scope. Diquat and paraquat could not be determined in 24 out of these 58 samples due to analytical problems. In 2018, one basil sample exceeded the MRL (Figure 21).

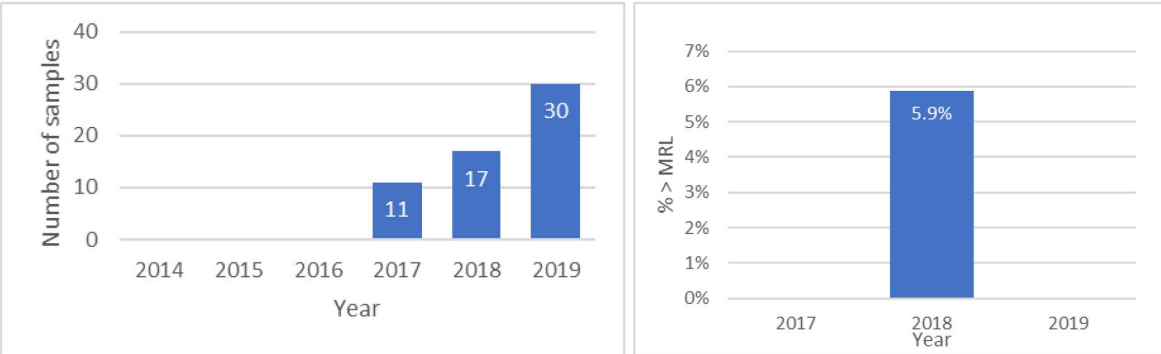

Figure 21 *Number of herb samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for quats.*

3.6.4 SRM chlorate/perchlorate

A total of 46 herb samples was analysed. In 2019, the MRL was exceeded for chlorate in 3 samples: a sweet pepper powder sample, a basil sample and a coriander sample.

3.6.5 Over-all results of category herbs

A considerable amount of herb, spices and eatable flowers samples was analysed between 2017-2019. The most exceedances were found with the MRM method with an increasing trend over the years. Only one exceedance was found with the glyphosate, and quats scopes among the samples.

When all scopes are combined, the incidence of non-compliant pesticides is 18.3% for herbs (11 out of 60 samples). Table 21 summarizes the number of non-compliant herb samples per pesticide with all scopes combined.

Table 20 *Number of non-compliant herb samples per pesticide, scopes combined.*

Pesticide	Number of non-compliant samples	Product(s)
Chlorpyrifos	3	Spearmint leaf, marigold, dandelion
Malathion	2	Turmeric powder, marigold
Benzoylprop-ethyl	1	Nettle lead
Bifenthrin	1	Parsley
Chlorate	3	Sweet pepper powder, basil, coriander
Chlorothalonil	1	Basil
Dodine	1	Dandelion
Glyphosate	1	Dandelion
Procymidon	1	Coriander
Thiamethoxam	1	Marigold
Trimesium	1	Basil

In three samples multiple pesticides exceeded the MRL: a basil, a marigold and a dandelion sample. The dandelion sample and basil sample contained three pesticides, and the marigold sample contained two pesticides exceeding the MRL. Chlorpyriphos exceedances were found in both dandelion and marigold, the other pesticides exceedances consisted of different pesticides.

3.7 Feed-only

Separate MRLs have not been set yet for feed-only products. In this report, the pesticide levels of the feed-only products were compared to the MRL of the raw commodity, with only a moisture factor taken into account in case of dried products. The MRL of the raw commodity was used as comparison, as the basic principle is that the raw agriculture commodity should meet the standards before it is processed. It is in many cases unclear whether or not a PF should be applied to a feed only product, as these are often highly processed, and may also depend on the manufacturer. For citrus pulp, the lowest MRL for grapefruits, oranges, lemons, limes, and mandarins was used for each pesticide. Some products fell outside of the raw commodity definition altogether, such as soy bean hulls, oat shells. For these products, the MRLs of soy and oat were used, respectively. Therefore, all exceedances should be considered *potential* exceedances of MRLs. For grass and straw, no nearest raw commodity could be identified, hence no MRL evaluation was done.

3.7.1 MRM scope (excluding fats and oils)

Sample numbers were unevenly dispersed over the years, with most feed-only samples taken in 2018 (Figure 22).

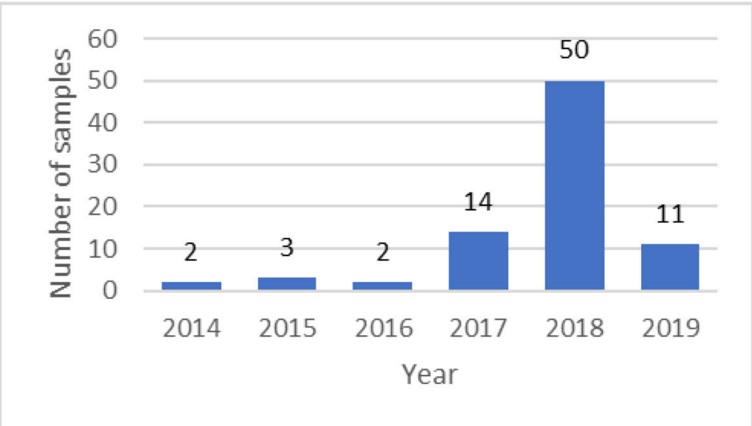

Figure 22 *Number of feed-only samples from 2014-2019, multi-residue method.*

Most sampled were soy bean hulls, sugar beet pulp and rice bran. No potential MRL exceedances were found in the 17 sugar beet pulp samples (Table 22). Rice bran, soy bean hulls, citrus pulp, and oat hulls did reveal potential non-compliant pesticide levels. Rice bran potential exceedances seemed common and were found in seven of the 15 samples. In soy bean hulls, the incidence was lower (one in 25 samples). All 12 citrus pulp samples showed potential non-compliance, however, the pesticide pattern in these samples was nearly identical and the samples might have originated from the same batch. Incidence levels in other products were based on only limited samples.

Table 21 *Potential non-compliant feed-only products.*

Subcategory	Feed-only product	N	N > MRL	% > MRL
1.4.6	Oat hulls	1	1	100%
1.6.10	Rice bran	15	8	53%
2.18.5	Soy (bean) hulls	25	1	4%
4.1.10	Dried (sugar) beet pulp	17		
5.13.2	Citrus pulp, dried	12	12	100%
5.14.1	White clover seed	1	-	
5.24.1	Graminaceous seeds	1	-	
7.6.1	(Sugar) cane molasses	3		
12.2.1	Vinasses	5		

Incidence of potential MRL exceedances showed a clear increase over the years (Figure 23).

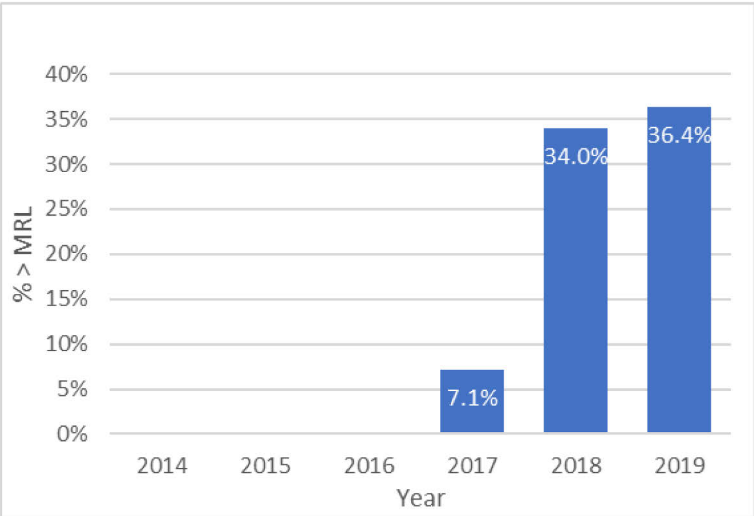

Figure 23 *Percentage of potential non-compliant samples from 2014-2019 in feed-only products, analysed with the multi-residue method.*

3.7.2 MRM Fats and oils

Four glycerol samples were analysed in 2018 with the MRM for fats, no MRL evaluation could be done, as the raw commodity for glycerol could not be defined.

3.7.3 SRM glyphosate scope

A total of 19 samples were analysed with the SRM for glyphosate, all were compliant (Figure 24). Samples consisted mostly of rice bran with individual samples of soy bean hulls, oat shells, grass seeds, and clover seeds.

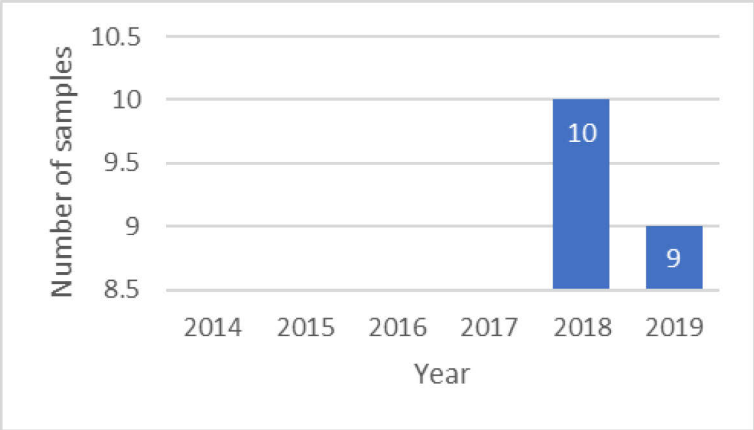

Figure 24 *Number of feed-only samples, analysed with the single-residue method for glyphosate.*

3.7.4 SRM quats scope

A total of 47 samples was analysed with the SRM for quats (Figure 25). Samples consisted mostly of soy bean hulls and rice bran with individual samples of, oat shells, grass seeds, and clover seeds. Due to analytical problems, paraquat could not be determined in ten out of the 30 samples of soy bean hulls. MRLs were potentially exceeded in 12 samples, ten times for paraquat in soy bean hulls, and twice for trimethyl-sulfonium cation in rice bran. The potential non-compliant levels of paraquat in soy hulls were found in all four 2016 samples, two of the eight 2017 samples, and four of the eight 2018 samples (Table 23).

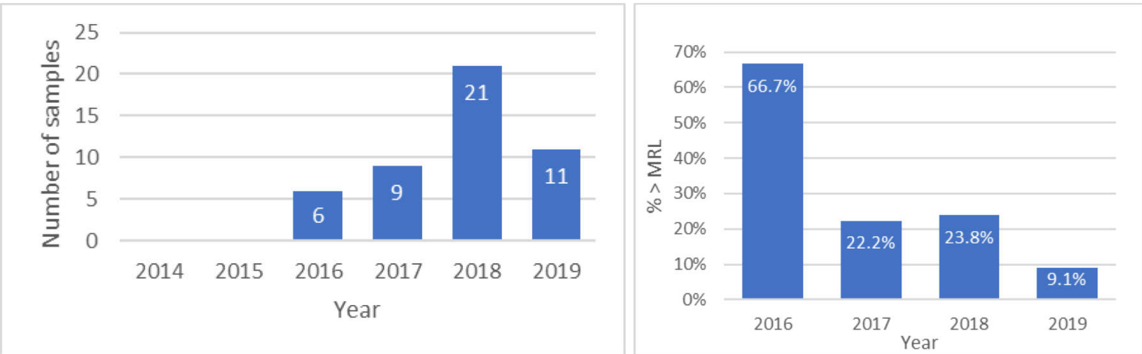

Figure 25 *Number of feed-only samples per year analysed (left panel) and % of non-compliant samples (right panel) with the single-residue method for quats.*

Table 22 *Potential non-compliant feed-only products, analysed with the single-residue method for quats.*

Subcategory	Feed-only product	N	N > MRL	% > MRL
1.4.6	Oat hulls	1		
1.6.10	Rice bran	14	2	14%
2.18.5	Soy (bean) hulls	20 (30)*	10	50%
5.14.1	White clover seed	1	-	
5.24.1	Graminaceous seeds	1	-	

*n=20 for paraquat and n= 30 for the other components.

3.7.5 SRM chlorate/perchlorate

One clover seeds sample was also analysed, and compliant, for chlorate/perchlorate levels.

3.7.6 Over-all results of category "feed-only"

Sample numbers were unevenly dispersed over the years for all scopes, with most samples taken in 2018. Most sampled were soy bean hulls, sugar beet pulp and rice bran. citrus pulp, rice bran, soy bean hulls, and oat hulls showed potential non-compliant levels for several pesticides in the MRM. Rice bran potential exceedances seemed common and were found in eight of the 15 samples with the MRM. Potential non-compliance for tricyclazole was found most often (Table 24). Multiple potential MRL exceedances were found in in four rice bran samples, up to seven and eight in two samples. In soy bean hulls, incidence was lower, one in 25 samples. No potential MRL exceedances were found in the 17 sugar beet pulp samples.

Regarding the polar pesticides, paraquat potential non-compliance was consistent in soy bean hulls, also two of the 14 rice bran samples showed potential non-compliance for trimethyl-sulfonium cation, coinciding with MRL exceedances for MRM pesticides. Glyphosate and chlorate/perchlorate analyses did not show potential MRL exceedances.

Table 23 *Potentially non-compliant pesticides in feed-only products.*

Pesticide	Number of potentially non-compliant samples	Product
Bifenthrin	12	citrus pulp (pellets)
Propargite	12	citrus pulp (pellets)
Paraquat	10	soy (bean) hulls
Tricyclazole	5	rice bran
Thiamethoxam	4	rice bran
Triazophos	4	rice bran
Buprofezin	2	rice bran
Carbendazim	2	rice bran
Chlorpyrifos	2	rice bran
Fenobucarb	2	rice bran
Trimethyl-sulfonium cation	2	rice bran
Fipronil	1	rice bran
Permethrin	1	oat hulls
Deltamethrin	1	soy (bean) hulls
Pirimiphos-methyl	1	citrus pulp (pellets)

3.8 Overall results across categories

In this paragraph the pesticide results of the different product categories and scopes are summarised. The incidence proved to be quite similar (between 10-25%) for the different feed material categories, with the exception of "tubers/roots" which showed no non-compliant results. Highest incidence was observed in the categories "other seeds/fruits", legume seeds, and herbs (Table 25).

Table 24 *Number of samples and percent non-compliant samples for the different product categories (with feed-only products), all scopes combined.*

Product category*	N	N>MRL	%>MRL
Cereal grains	604	64	10.6%
Oil seeds/fruits and	810	113	14.1%
Legume seeds	145	25	17.2%
Tubers, roots	29	0	-
Other seeds/fruits	13	3	23.1%
Herbs	60	11	18.3%
Feed-only products	(95)	(31)	(32.6%)
Total	1661 (1756)	216 (247)	13.0% (14.1%)

*including products derived thereof.

When looking at the non-compliant product subcategories more in detail, the low numbers of samples for mung bean, buckwheat, lentil, and fennel seed were all non-compliant. In addition, millet, linseed and vetch proved to be the products with the highest percentage of non-compliant samples (Table 26).

Table 25 *Subcategories, displayed in descending percent of non-compliance, and including details of the non-compliant pesticides.*

EU-code	Subcategory	N samples	N pesticides > MRL	% > MRL	Pesticide
3.10	mung bean	5	5	100	Glyphosate (1), Chlorpyrifos (1), Acephate (1), Methamidophos (1), Trimethyl-sulfonium cation (1)
5.6	buckwheat	4	4	100	Glyphosate (2), Diquat (1), Chloormequat (1)
3.8	lentil	2	2	100	2,4-D (2)
5.20	fennel seed	1	1	100	Glyphosate (1)
1.3	millet	69	45	65	Glyphosate (11), DDT som (9), Diquat (7), Chlorpyrifos (3), Carbendazim (3), alpha-HCH (3), beta-HCH (3), Perchlorate (3), Paraquat (1), Dichlorprop (1), Profenofos (1)
2.8	linseed	74	28	38	Haloxyfop (20), Chlorpyrifos (3), Thiamethoxam (3), Deltamethrin (1), Propargite (1)
3.12	vetch	8	3	38	Diquat (2), Glyphosate (1)
2.17	sesame seed	3	1	33	Phoxim (1)
3.7	horse bean	7	2	29	Glyphosate (1), Pirimiphos-methyl (1)
2.23	poppy seed	4	1	25	Vinclozolin (1)
13.1	herbs	60	14	25	Chlorpyrifos (3), Malathion (2), Glyphosate (1), Thiamethoxam (1), Benzoylprop-ethyl (1), Bifenthrin (1), Chlorate (3), Chlorothalonil (1), Dodine (1), Procymidon (1), Trimesium (1)
1.8	sorghum	14	3	21	Pirimiphos-methyl (2), Fenitrothion (1)
2.18	soy	361	69	19	Paraquat (66), Chloormequat (1), Cypermethrin (1), Chlorpyrifos-methyl (1)
3.9	lupin	33	6	18	Paraquat (3), Propamocarb (2), Chloormequat (1)
1.6	rice	23	4	17	Tricyclazole (4)
3.11	pea	82	12	15	Pirimiphos-methyl (7), Cypermethrin (3), Paraquat (1), 2,4-D (1)
2.19	sunflower seed	166	18	11	Mepiquat (6), Chloormequat (3), Pirimiphos-methyl (2), Chlorpyrifos (2), Deltamethrin (2), Imidacloprid (1), Metalaxyl (1), Tebuconazole (1)
2.14	rape seed	58	6	10	Pirimiphos-methyl (2), Paraquat (1), Thiamethoxam (1), Carbendazim (1), MCPA (1)
2.15	safflower seed	10	1	10	Malathion (1)
1.4	oats	32	3	9	Propamocarb (2), Chlorpropham (1)
2.22	hemp seed	14	1	7	Glyphosate (1)
1.2	maize	172	11	6	Fenitrothion (4), Pirimiphos-methyl (2), Dichlorvos (2), Haloxyfop (1), Dimoxystrobin (1), Methomyl (1)
1.1	barley	115	5	4	Propamocarb (2), Fluopicolide (2), Pencycuron (1)
1.11	wheat	145	2	1	Propamocarb (1), Chlorpyrifos-methyl (1)

Focusing on the different pesticides, paraquat, haloxyfop, glyphosate, pirimiphos-methyl, chlorpyrifos, and diquat were found most often to exceed the MRL (Table 27).

Table 26 *Pesticides, displayed in descending number of non-compliant results and including details of the non-compliant subcategories.*

Pesticide	N>MRL	Subcategory*
Paraquat	71	soy (66), lupin (3), millet (1), pea (1), rape seed (1)
Haloxyfop	21	linseed (20), maize (1)
Glyphosate	19	millet (11), buckwheat (2), hemp seed (1), horse bean (1), mung bean (1), vetch (1), fennel seed (1), herbs (1)
Pirimiphos-methyl	16	pea (7), maize (2), sorghum (2)
Chlorpyrifos	12	millet (3), linseed (3), herbs (3), sunflower seed (2), mung bean (1)
Diquat	10	millet (7), vetch (2), buckwheat (1)
DDT (som)	9	millet (9)
Propamocarb	7	barley (2), oats (2), lupin (2), wheat (1)
Chloormequat	6	sunflower seed (3), soy (1), lupin (1), buckwheat (1)
Mepiquat	6	sunflower seed (6)
Fenitrothion	5	maize (4), sorghum (1)
Thiamethoxam	5	linseed (3), rape seed (1), herbs (1)
Carbendazim	4	millet (3), rape seed (1)
Cypermethrin	4	pea (3), soy (1)
Tricyclazole	4	rice (4)
2,4-D	3	lentil (2), pea (1)
Chlorate	3	herbs (3)
Deltamethrin	3	sunflower seed (2), linseed (1)
HCH alpha-	3	millet (3)
HCH beta-	3	millet (3)
Malathion	3	herbs (2), safflower seed (1)
Perchlorate	3	millet (3)
Chlorpyrifos-methyl	2	wheat (1), soy (1)
Dichlorvos	2	maize (2)
Fluopicolide	2	barley (2)
Trimethyl-sulfonium cation	2	mung bean (1) herbs (1)
Acephate	1	mung bean (1)
Benzoylprop-ethyl	1	herbs (1)
Bifenthrin	1	herbs (1)
Chlorothalonil	1	herbs (1)
Chlorpropham	1	oats (1)
Dichlorprop	1	millet (1)
Dimoxystrobin	1	maize (1)
Dodine	1	herbs (1)
Imidacloprid	1	sunflower seed (1)
MCPA	1	rape seed (1)
Metalaxyl	1	sunflower seed (1)
Methamidophos	1	mung bean (1)
Methomyl	1	maize (1)
Pencycuron	1	barley (1)
Phoxim	1	sesame seed (1)
Procymidon	1	herbs (1)
Profenofos	1	millet (1)
Propargite	1	linseed (1)
Tebuconazole	1	sunflower seed (1)
Vinclozolin	1	poppy seed (1)

*including products derived thereof and between brackets the number of non-compliant samples.

4 Discussion

MRL evaluation was done without taking measurement uncertainty (MU) into account. Any outcome above the MRL was considered an exceedance. This means that levels of pesticides were considered an exceedance of the MRL also when the level was above the MRL, but below the MRL if the MU would have been subtracted from the reported level. Conversely, levels were not considered an exceedance of the MRL if they were below the MRL, even when the level with added MU would have been above the MRL. This is in line with how exceedances are reported to NVWA, and EFSA.

EU legislation states that processed materials should be evaluated, taking into account changes in the levels of pesticide residues caused by processing and/or mixing, in those cases where MRLs have not been set out for the processed and/or composite food or feed itself. The most straightforward processing factors (PFs) have been taken into account in this report. First of all, a PF for moisture content rarely leads to discussion, although for some products a range of moisture content is more applicable than a specific number. Secondly, a PF for fat soluble pesticides in vegetable oils is also rather straightforward as is a PF for polar pesticides in meal. These three PFs are given in Annex 1 and Annex 3. PFs for processing of oils to fatty acids, or distillates, are still a matter of debate, a debate that would benefit from more actual, public data from a controlled research setting, on the relocation of pesticides during industrial processing. Even more controversial are PFs leading to lower MRLs, like for fat soluble pesticides in meal, and polar pesticides in vegetable oils. These are not generally applied, even though the basic scientific principle of mass conservation dictates that if accumulation of a pesticide in one fraction of a product leads to a higher MRL, a lower MRL should apply for that pesticide in the remainder of that product.

A number of processed products are only used for feed purposes, such as straw and hay, and soy hulls. These are described in regulation (EC) no 396/2005 under 1200000 in Annex I, part A as:

> *"products or part of products exclusively used for animal feed production"*, and footnote (1) of part A reads:
>
> *"(1) MRLs do not apply to products or part of products that by their characteristics and nature are used exclusively as ingredients of animal feed, until separate MRLs are set in the specific category 1200000."*

These separate MRLs have not been set yet, see also Annex 1 of this report. In this report, pesticide levels were compared with the MRL for the nearest raw commodity, if available, for which an MRL has been established. Apart from MRL evaluation, a uniform list of feed-only products is at the moment not available. Products were categorised as feed-only in this report in line with NVWA in the period the samples were taken, on a case-by-case basis. Increasing insight and discussion with the feed industry might lead to changes in this categorisation in the future.

Due to analytical problems it was sometimes not possible to report results for a specific pesticide in a sample. These "non-determinable" results cause small differences in the numbers of observations per pesticide and product group. Only when one or more MRL exceedances occurred in a product group, the number of results was corrected for this. In all other cases, it was decided to translate the "non-determinable" results into "not-detected" results. The reasons for this were:
- the incidence, the most important element of the report, becomes more accurate with this approach.
- the limited amount of "non-determinable" results. With the MRM methods this concerned 0.2% and with the SRM methods 1.2% (SRM glyphosate) resp. 3.2% (SRM quats) of the pesticide results.
- the readability. Specifying in all tables the pesticides for which a few results are less reduces the readability of the report.

Currently the MRM for pesticides contains 210 different pesticides (see Annex 2). This set of pesticides is based on recommendations of the European Reference Laboratory (EU RL) and existing residue data from the EU and NL in matrices relevant for animal feed (EFSA report, literature). It would be useful to evaluate if relevant pesticides are missing in these sources, and if so, if they could be added to the MRM.

When determining the maximum residue limits (MRLs) for pesticides, it is defined for each pesticide which substance (s) must be measured exactly (EU 396/2005). In most cases this residue definition is limited to the pesticide in question itself (parent compound), sometimes with some specific metabolites. For a number of pesticides like clofentezine, iprodione, metalaxy and procymidone, the residue definition is not limited to parent / specific metabolites, but all metabolites / degradation products of the pesticide that contain a characteristic part of the molecule ("common moiety") must be measured.
These "common moieties" are not yet included in the current SRMs and MRMs. For future monitoring it would be valuable to include these in the analytical methods.

5 Conclusions and recommendations

Monitoring of pesticide residues in feed is a relevant effort, as in more than 10% of the samples taken, the MRL for one or more pesticides was exceeded, looking at data from a six year period, from 2014 to 2019. A total of 1756 feed materials of plant origin was analysed for pesticide residues, including 95 feed-only products for which no MRL has been established. In 216 of the remaining 1661 samples (= 13.0%) one or more pesticide levels exceeded the MRL. The overall table of MRL exceedances (Table 25) shows no clear hierarchy in main feed categories. Only one feed category did not show any pesticide levels above the MRL, i.e. category 4 of the catalogue which contains tubers, roots and derived products. Twenty nine samples were analysed with the MRM and seven with the SRMs. Exceedance of MRLs in the other categories ranged from 10.4% in cereal grains and derived products (cat. 1) to 23.1% in other seeds and fruits and derived products (cat. 5).

The overview of pesticide residue monitoring provides valuable insights for the yearly drafting of the ongoing NPAF. The combination of sample numbers and percentage of MRL exceedance have been translated to recommendations for future monitoring, for each subcategory. These recommendations have been grouped in main feed categories.

MRLs were exceeded for 46 different pesticide residues in the samples in this overview (Table 27). The pesticides with the highest number of exceedances (N>MRL) were paraquat, haloxyfop, glyphosate, pirimiphos-methyl, and chlorpyrifos. Only a few pesticide-product combinations seems less relevant as indicated in the recommendations. This implies that a broad screening of remains necessary.

5.1 Recommendations

Cereal grains and products derived thereof, category 1:

- Sampling of all categories of cereal grains for pesticide residues remains relevant.
- Keep the focus on millet and include perchlorate monitoring for this cereal grain.
- Increase sampling of sorghum and rice.
- If relevant, increase sampling of cereals grains for which data are lacking: quinoa, spelt, triticale.
- The SRMs for glyphosate and quats seemed only relevant for millet. Reconsider the use of these methods for all other cereal grains.

Oils seeds and oil fruits and products derived thereof, category 2:

- Sampling of oil seeds/fruits remains relevant, with the exception of oils and fats.
- Sampling of oils and fats could be reduced and shifted from soy/palm oils to sunflower/linseed oils and oils for which sample numbers were low or absent.
- Increase sampling of sesame seed, poppy seed, safflower seeds and hemp seeds and decrease sampling of palm (kernel).
- If relevant, increase sampling of oil seeds/fruits for which sample numbers were low or absent.
- In contrast with the SRM for quats, the MRM and SRM for glyphosate did not seem relevant for soy (products). Reconsider the use of these methods for soy (products).

Legume seeds and products derived thereof, category 3:

- Increase sampling of legume seeds, especially for mung beans, lentil, horse bean, vetches and to less extend lupine and peas.
- If relevant, increase sampling of legume seeds for which sample numbers were low or absent: beans, carob, chick peas, ervil, fenugreek seed, guar (germs) meal chickling vetch, monantha vetch.
- The SRM for glyphosate did not seem relevant for peas and to less extent for lupin.

Tubers, roots and products derived thereof, category 4:

- If relevant, increase sampling of tubers, roots for which sample numbers were low or absent.
- Decrease sampling of sugar beet molasses.

Other seeds and fruits, and products derived thereof, category 5:

- If relevant, increase sampling of “other seeds and fruits”; sample numbers were low or absent for all subcategories.

Herbs:

- Sampling of herbs remains relevant, given the higher than average incidence of MRL exceedance (25%).
- If possible, specify which parts of the herbs were sampled, as different MLRs sometimes apply for leaves or seeds.

Feed-only feed materials:

- Decrease sampling of sugar beet pulp.
- Establish MRLs for this subcategory.
- Establish a uniform list of feed-only products.

References

- Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC

- Commission Regulation (EU) No 68/2013 of 16 January 2013 on the Catalogue of feed materials

Annex 1 Background information

Maximum residue levels for pesticides

The directive (EC) 2002/32 deals with undesirable substances in animal feed and sets maximum limits (MRLs, maximum residue level) for the organochlorine pesticides (OC pesticides) in feed and feed materials. In the past, various OC pesticides were used in the EU. Since the 1970s, -80s in the last century, applications for these agents have been limited or prohibited due to public health risks. Because OC pesticides are very persistent, they are still present in the environment. Also, outside the EU, some OC pesticides still have approvals. This does not change the fact that the raw materials imported into the EU must comply with EU regulations. The MRLs for these pesticides are the most straightforward in terms of evaluation of an exceedance of this MRL, as they are set generally for feed materials and compound feed, including exceptional MRLs for fats and oils.

For other pesticides, MRLs are laid down in regulation (EC) no 396/2005 of the European Parliament and of the Council, on maximum residue levels of pesticides in or on food and feed of plant and animal origin. MRLs have been established for approved pesticides for groups of products. For instance, 499 MRLs have been established for the product group 'wheat' (part of the category 'cereals')-, that includes durum wheat, einkorn wheat/small spelt/one-grain wheat, emmer wheat, Khorasan wheat, spelt, triticale, tritordeum, and other species of genus triticum, not elsewhere mentioned.
A default level of 0.01 mg/kg applies to pesticides that have not been approved.

The MRLs, including their evolution in time, for pesticide-product combinations can be retrieved through a website of the European Commission via https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN. This database contains close to 1500 active substances and 381 entries on product groups, subdivided in categories. Specific combinations can be retrieved and viewed online, or exported to excel, for instance:

Pirimiphos-methyl (F)	Pesticide residues and maximum residue levels (mg/kg)			
Code number	**Groups and examples of individual products to which the MRLs apply**	**Reg. (EU) No 2016/53**	**Reg. (EC) No 839/2008**	**Reg. (EC) No 149/2008**
0500030	. Maize/corn	0.5	5	5
Footnotes	**(F) = Fat soluble**			

The 396/2005 regulation poses two challenges for MRL evaluation in feed materials. One challenge concerns dilution or concentration factors for processed and/or composite products, this is elaborated upon in paragraph 'processing factors'. The second challenge concerns products only intended for animal feed, this is dealt with in paragraph 'feed only products'.

For perchlorate levels were compared with those set out in 'levels of perchlorate as reference for intra-Union trade'.
https://ec.europa.eu/food/sites/food/files/safety/docs/cs_contaminants_catalogue_perchlorate_statement_food_update_en.pdf
Since only recently levels have been established in EU law: VERORDENING (EU) 2020/685, 20th of May, 2020.

For chlorate, levels as indicated on the NVWA website were used for evaluation of non-compliant levels. https://www.nvwa.nl/onderwerpen/inspectieresultaten-bestrijdingsmiddelen-in-voedingsmiddelen/wettelijke-normen-resten-bestrijdingsmiddelen-in-voedingsmiddelen/interventiewaarden-voor-chloraat-in-levensmiddelen

De vastgestelde interventiewaarden chloraat

- Alle plantaardige producten, behalve groenten, genoemd in Annex I van verordening (EG) nr. 396/2005: 0,1 mg/kg
- Alle groenten, behalve wortelen, genoemd in Annex I van verordening (EG) nr. 396/2005: 0,25 mg/kg
- Wortelen: 0,2 mg/kg
- Overige producten, met uitzondering van zuigelingen- en babyvoeding: 0,1 mg/kg

Voor zuigelingen- en opvolgvoeding en babyvoeding blijven de MRL's van kracht zoals geformuleerd in de richtlijnen Verordening (EU) 2016/127 en 2006/125/EG.

Meer informatie over de regelgeving voor Voeding voor specifieke groepen vindt u in het Handboek Regelgeving Voeding voor specifieke groepen.

Figure X *Screenshot of NVWA website on chlorate levels (June 2nd, 2020).*

Processing factors

Some types of processing such as drying or oil extraction may cause a higher concentration of pesticide residues in a processed product, compared to the unprocessed form. Article 20 in EU regulation 396/2005 on this topic reads as follows:

"Article 20:
MRLs applicable to processed and/or composite products

1. Where MRLs are not set out in Annexes II or III for processed and/or composite food or feed, the MRLs applicable shall be those provided in Article 18(1) for the relevant product covered by Annex I, taking into account changes in the levels of pesticide residues caused by processing and/or mixing.

2. Specific concentration or dilution factors for certain processing and/or mixing operations or for certain processed and/or composite products may be included in the list in Annex VI. That measure, designed to amend non-essential elements of this Regulation, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 45(3)."

However, no specific processing factors (PF) have thus far been included in this Regulation. As such, an accessible, well founded, and harmonized list of PFs for authorities and industry is currently lacking.

In consultation with NVWA, PFs are being applied by WFSR when evaluating exceedances of MRLs. Two types of PF are applied, one dealing with a change in moisture content, and the other dealing with oil or fat extraction. For a reduction of moisture, the general formula for the PF is:

$$PF = (\%\ of\ dry\ matter\ in\ processed\ product)/(\%\ of\ dry\ matter\ in\ original\ product)$$

As an example: dried herbs contain ~10% moisture, while fresh herbs contain ~80%, this leads to a PF of 90/20 = 4.5. Whether or not a moisture PF has been applied is indicated in the results sections for the different product categories.

PFs for products resulting from fat or oil extraction work two ways. There will be an increase of fat soluble pesticides in the fat fraction, and an increase for polar pesticides in the meal fraction.

For the fat soluble pesticides in the fat fraction of the unprocessed product the PF is:

$$PF = (100)/(\%\ of\ fat\ in\ unprocessed\ product)$$

For the polar pesticides in meal the PF is:

$$PF = (100)/(\%\ of\ nonfat\ fraction\ in\ unprocessed\ product)$$

The range of PFs dealing with fat extraction are given in Table 28, with the black numbers indicating the most commonly used PFs. Furthermore, whether or not a fat extraction PF has been applied is indicated in the results sections for the different product categories. Fat soluble pesticides are defined as such when its log P_{ow} value is above 3. These are indicated with (F) in the EU pesticide database. The P_{ow} is defined as the ratio of the concentration of the pesticide in the octanol phase divided by the concentration in the water phase. For polar pesticides the log P_{ow} value is below 1.

Table 27 *Processing factors dealing with fat extraction.*

Fat (%)	0	10	20	25	30	40	45	50	55	60	70	75	80	90	100
PF polar pesticides to meal	1.00	1.11	1.25	1.33	1.43	1.67	1.82	2.00	2.22	2.50	3.33	4.00	5.00	10.00	-
PF fat soluble pesticides to fat	-	10.00	5.00	4.00	3.33	2.50	2.22	2.00	1.82	1.67	1.43	1.33	1.25	1.11	1.00

An example of a fat soluble pesticide in the unprocessed product and its oil fraction is chlorpyriphos in soy, which has an MRL of 0.05 mg/kg. Soy contains 20% oil, which translates to a PF of 5, leading to an MRL of 0.25 mg/kg in soybean oil.
The translations of the fat soluble pesticide MRLs in the MRM from unprocessed products to oils are given in Annex 2.

An example of polar pesticide in the unprocessed product and its non-fat fraction is chlormequat in sunflower seeds, which has an MRL of 0.01 mg/kg. Sunflower seeds contain 40% oil, which translates to a PF of 1.67, leading to an MRL of 0.0167 mg/kg in soybean oil. The translations of the polar pesticide MRLs in the SRMs from unprocessed products to meals are given in Annex 3.

Feed only products

A number of processed products are only used for feed purposes, such as straw and hay, or soy hulls. These are described in regulation (EC) no 396/2005 under 1200000 in Annex I, part A as:
"*products or part of products exclusively used for animal feed production*",

and footnote (1) of parts A reads:
"(1) MRLs do not apply to products or part of products that by their characteristics and nature are used exclusively as ingredients of animal feed, until separate MRLs are set in the specific category 1200000."

These separate MRLs have not been set yet. However, the basic principle is also that the raw agriculture commodity should have met the standards before it was processed. For instance, it should not be the case that citrus fruits that exceed an MRL are processed into juice that does not contain pesticides and citrus pulp (= feed-only) with high levels of pesticides. The starting point is at all times that the unprocessed product must meet the standard. It is in many cases unclear whether or not a PF should be applied to a feed only product, as these are often highly processed, and may also depend on the manufacturer.

Annex 2 Scope of pesticides methods

Table 28 *Pesticides and PCBs, which are covered by the multi-residue method (MRM) for feed materials (excl. oils and fatty acids).*

Scope multi residue method					
2,4-D	DDD o,p′- (TDE)	Etofenprox	Hexythiazox	Paraoxon-methyl	Pyrimethanil
Acephate	DDD p,p′- (TDE)	Fenazaquin	Imazalil	Parathion	Pyriproxyfen
Acetamiprid	DDE o,p′-	Fenbuconazole	Imidacloprid	Parathion-ethyl	Quinclorac
Aldicarb	DDE p,p′-	Fenhexamid	Iprodione	Parathion-methyl	Quizalofop
Aldicarb sulfone	DDMU*	Fenitrothion	Iprovalicarb	PCB 101	Simazine
Aldicarb sulfoxide	DDT o,p′-	Fenobucarb	Isodrin	PCB 118	Spinosyn A
Aldrin	DDT p,p′-	Fenpropidin	Isoprocarb	PCB 138	Spinosyn D
Atrazine	Deltamethrin	Fenpropimorph	Isoproturon	PCB 153	Spiromesifen
Azoxystrobin	Diazinon	Fensulfothion	Kresoxim-Methyl	PCB 180	Spiroxamine
Bendiocarb	Dichlorprop (2,4-DP)	fenthion-O	Linuron	PCB 52	Tebuconazole
Benzoylprop-ethyl	Dichlorvos	fenthion-O sulfoxide	Lufenuron	Penconazole	Tebufenozide
Bifenthrin	Dicloran	Fenthion-sulfone	Malaoxon	Pencycuron	Tebufenpyrad
Bitertanol	Dieldrin	Fenvalerate	Malathion	Pendimethalin	Teflubenzuron
Boscalid	Difenoconazole	Flamprop-isopropyl	MCPA	Permethrin	Terbucarb
Bromopropylate	Diflubenzuron	Flamprop-methyl	Mecoprop	Phorate	Tetradifon
Buprofezin	Dimethenamid	Fluazifop	Mepronil	Phosmet-oxon	Tetramethrin
Carbaryl	Dimethoate	Fluazifop-P-Butyl	Metalaxyl	Phoxim	Thiabendazole
Carbendazim	Dimethomorph	Fludioxonil	Metconazole	Pirimicarb	Thiacloprid
Carbofuran	Dimoxystrobin	Flufenoxuron	Methamidophos	Pirimicarb, desmethyl-	Thiamethoxam
Carbofuran, hydroxy	Disulfoton	Fluquinconazole	Methidathion	Pirimiphos-Methyl	Thiodicarb
Chlordane cis- (alpha)	Disulfoton-sulfone	Fluroxypyr	Methiocarb	Prochloraz	Thiophanate-Methyl
Chloridazon	disulfoton-sulfoxide	Fluroxypyr-methylheptylester	Methiocarb sulfone	Procymidone	Triadimefon
Chlorobenzilate	Diuron	Flusilazole	Methiocarb sulfoxide	Promecarb	Triadimenol
Chlorothalonil	Dodemorph	Flutriafol	Methomyl	Propamocarb	Triazophos
Chlorpropham	Dodine	Fuberidazole	Metolcarb	Propargite	Triazoxide
Chlorpyriphos	Endosulfan alpha-	Gibberellic acid	Metoxuron	Propham	Trichlorfon
Chlorpyriphos-methyl	Endosulfan beta-	Haloxyfop	Metribuzin	Propiconazole	Tricyclazole
Clofentezine	Endosulfan sulphate	HCB	Monocrotophos	Propoxur	Trifloxystrobin
Clothianidin	Endrin	HCH alpha-	Myclobutanil	Propyzamide	Triflumuron
Coumaphos	Endrin ketone	HCH beta-	Omethoate	Pyraclostrobin	Trimethacarb 235-
Cyfluthrin	Epoxiconazole	HCH delta-	Oxadixyl	Pyrazophos	Trimethacarb 345-
Cyhalothrin lambda-	Ethiofencarb	HCH gamma- (Lindane)	Oxamyl	Pyrethrins Pyrethrin I	Triticonazole
Cypermethrin	Ethiofencarb sulfone	Heptachlor	Oxamyl-oxime	Pyrethrins Pyrethrin II	Vamidothion
Cyproconazole	Ethiofencarb sulfoxide	Heptachlor epoxide (iso B)	Oxychlordane	Pyridaben	Vinclozolin
Cyprodinil	Ethion	Hexaconazole	Oxydemeton-methyl	Pyridaphenthion	Zoxamide

*DDMU is a degradation product, which is not reported.

Table 29 *Pesticides and PCBs, which are covered by the multi-residue method (MRM) for oils and fatty acids.*

Scope multi residue method olis and fatty acids					
Aldrin	DDE o,p'-	Endosulfan, beta-	HCH, gamma- (Lindane)	Oxychlordane	Pirimiphos ethyl-
Boscalid	DDE, p,p'-	Endrin	Haloxyfop etotyl-	PCB 101	Pirimiphos methyl-
Chlordane, cis- (alpha)	DDT, o,p'-	Endrin ketone	Haloxyfop methyl-	PCB 118	Tebuconazole
Chlordane, trans- (gamma)	DDT, p,p'-	Fenitrothion	Heptachlor	PCB 138	Cyfluthrin
Chlorpyriphos	Deltamethrin	Fluazifop butyl-	Heptachlor epoxide (iso B)	PCB 153	Cypermethrin
Chlorpyriphos methyl-	Dieldrin	HCB	Malathion	PCB 180	Anthraquinone
DDD o,p'-	Endosulfan sulphate	HCH, alpha-	Metalaxyl	PCB 28	Biphenyl
DDD, p,p'-	Endosulfan, alpha-	HCH, beta-	Methoxychlor	PCB 52	Phenylphenol ortho-

Table 30 *Pesticides which are covered by the single-residue method (SRM) for quats.*

Scope single residue method for quats					
Chlormequat	Difenzoquat	Diquat	Daminozide	Mepiquat	Paraquat
Trimethyl-sulfonium cation	Cyromazine				

Table 31 *Pesticides which are covered by the single-residue method (SRM) for glyphosate.*

Scope single residue method for glyphosate	
Glyphosate	Gluphosinate (incl. metabolites)

Annex 3 EU MRLs of fat soluble pesticides in oils and polar pesticides in meals

For OC pesticides, the MRLs according to the directive (EC) 2002/32 were used (Commission Regulation (EU) 2019/1869 of 7 November 2019 amending and correcting Annex I to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for certain undesirable substances in animal feed). For other pesticides, MRLs as defined in regulation (EC) no 396/2005 were followed (Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC).

Table 32 *EU MRLs of fat soluble pesticides in oils.*

Pesticide	EU MRLs (mg/kg)											
	Soy bean (20% fat)		Palm fruit (±50% fat)		Palm kernel (±45% fat)		Sunflower seed (± 40% fat)		Rape seed (±40% fat)		Cocos (±20% fat)	
	bean	oil	boon	oil	bean	oil	kernel	oil	seed	oil	nut	oil
Anthraquinone	0.02	0.1	0.02	0.04	0.02	0.04	0.02	0.05	0.01	0.025	0.02	0.1
Biphenyl	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05
Boscalid	3	15	1	2	1	2	1	2.5	1	2.5	1	5
Chlorpyriphos	0.05	0.25	0.05	0.1	0.05	0.1	0.05	0.125	0.05	0.125	0.05	0.25
Chlorpyriphos-methyl	0.05	0.25	0.05	0.1	0.05	0.1	0.05	0.125	0.05	0.125	0.05	0.25
Cypermethrin	0.05	0.25	0.05	0.1	0.05	0.1	0.2	0.5	0.2	0.5	0.05	0.25
Deltamethrin	0.05	0.25	0.05	0.1	0.05	0.1	0.05	0.125	0.1	0.25	0.05	0.25
Fenitrothion	0.02	0.1	0.02	0.04	0.02	0.04	0.02	0.05	0.02	0.05	0.02	0.1
Fluazifop ester	5	25	0.1	0.2	0.1	0.2	0.2	0.5	15	37.5	0.2	1
Haloxyfop ester	0.5	2.5	0.05	0.1	0.05	0.1	0.2	0.5	0.2	0.5	0.05	0.25
Malathion*	0.02	0.1	0.02	0.04	0.02	0.04	0.02	0.05	0.01	0.025	0.02	0.1
ortho-Phenylphenol	0.1	0.5	0.1	0.2	0.1	0.2	0.1	0.25	0.1	0.25	0.1	0.5
Pirimiphos-ethyl	0.01	0.05	0.01	0.02	0.01	0.02	0.01	0.025	0.01	0.025	0.01	0.05
Pirimiphos-methyl	0.5	2.5	0.01	0.02	0.01	0.02	0.5	1.25	0.5	1.25	0.01	0.05
Propazine	0.01	0.05	0.01	0.02	0.01	0.02	0.01	0.025	0.01	0.025	0.01	0.05
Tebuconazole	0.15	0.75	0.02	0.04	0.02	0.04	0.02	0.05	0.5	1.25	0.05	0.25

*Malathion is considered fat soluble, because its Log Pow of 2,75 is very close to 3.

Table 33 *EU MRLs of polar pesticides in meals.*

Pesticide	EU MRLs (mg/kg)											
	Soy bean (20% fat)		Palm fruit (±50% fat)		Palm kernel (±45% fat)		Sunflower seed (± 40% fat)		Rape seed (±40% fat)		Cocos (±20% fat)	
	bean	meal	boon	meal	bean	meal	kernel	meal	seed	meal	nut	meal
Chlormequat	0.01	0.0125	0.01	0.0182	0.01	0.0182	0.01	0.0167	7	11.69	0.01	0.0125
Cyromazine	0.05	0.0625	0.05	0.091	0.05	0.091	0.05	0.0835	0.05	0.0835	0.05	0.0625
Daminozide	0.1	0.125	0.1	0.182	0.1	0.182	0.1	0.167	0.1	0.167	0.1	0.125
Diquat	0.3	0.375	0.01	0.0182	0.01	0.0182	0.9	1.503	1.5	2.505	0.02	0.025
Mepiquat	0.05	0.0625	0.05	0.091	0.05	0.091	0.05	0.0835	4	6.68	0.05	0.0625
Glufosinate (incl. metabolites)	2	2.5	0.03	0.0546	0.03	0.0546	0.03	0.0501	1.5	2.505	0.1	0.125
Glyphosate	20	25	0.1	0.182	0.1	0.182	20	33.4	10	16.7	0.1	0.125
Paraquat	0.02	0.025	0.02	0.0364	0.02	0.0364	0.02	0.0334	0.02	0.0334	0.02	0.025
Trimethyl-sulfonium cation	10	12.5	0.05	0.091	0.05	0.091	0.05	0.0835	0.05	0.0835	0.05	0.0625

Annex 4 English-Dutch product names

Table 34 *English-Dutch translation of products with number in Catalogue of feed materials (Commission Regulation (EU) 2019/145 of 30 January 2019 correcting the Dutch language of Regulation (EU) No 68/2013 on the Catalogue of feed materials).*

Number catalogue	English	Nederlands
	Cereal grains and products derived thereof	
1.1	Barley	Gerst
1.2	Maize/corn	Maïs
1.3	Millet	Gierst
1.4	Oats	Haver
1.6	Rice	Rijst
1.7	Rye	Rogge
1.8	Sorghum	Sorghum
1.9	Spelt	Spelt
1.10	Triticale	Triticale
1.11	Wheat	Tarwe
	Oil seeds, oil fruits and products derived thereof	
2.1	Babassu	Babassus
2.2	Camelina	Vlashuttentutzaad
2.3	Cocoa	Cacao
2.4	Copra	Kokos
2.5	Cotton seed	Katoenzaad
2.7	Kapok	Kapok
2.8	Linseed	Lijnzaad
2.9	Mustard seed	Mosterdzaad
2.10	Niger seed	Nigerzaad
2.11	Olive	Olijf
2.12	Palm	Palmpit
2.13	Pumpkin seed	Pompoenzaad
2.14	Rapeseed	Kool-raapzaad
2.15	Safflower seed	Saffloerzaad
2.17	Sesame seed	Sesamzaad
2.18	Soya bean	Sojaboon
2.19	Sunflower seed	Zonnebloemzaad
2.22	Hemp seed	Hennepzaad
2.23	Poppy seed	Papaverzaad
	Legume seeds and products derived thereof	
3.1	Beans	Bonen
3.2	Carob	Johannesbrood
3.3	Chick peas	Kikkererwten
3.4	Ervil	Linzenwikke
3.5	Fenugreek	Fenegriekzaden
3.6	Guar	Guar
3.7	Horse beans	Paardenbonen
3.8	Lentils	Linzen
3.9	Sweet lupins	Lupinen
3.10	Mung beans	Mungobonen
3.11	Peas	Erwten
3.12	Vetches	Wikken
3.13	Chickling vetch	Reukerwt
3.14	Monantha vetch	Vicia articulata

Number catalogue	English	Nederlands
Tubers, roots and products derived thereof		
4.1	(Sugar) beet molasses	(Suiker)bietenmelasse
4.5	Garlic	Knoflook
4.6	Manioc/tapioca	Maniok/Tapioca/Cassave
Other seeds and fruits, and products derived thereof		
5.3.1	Anise seed	Anijszaad
5.6.1	Buckwheat	Boekweit
5.9.1	Caraway seed	Karwijzaad
5.20.1	Fennel seed	Venkelzaad
5.24.1	Graminaceous seeds	Zaden van grasachtigen
Herbs		
	Dandelion	Paardebloem
	Basil	Basilicum
	Sweet pepper powder	Paprika poeder
	Marigold	Goudsbloem
	Spear mint leaf	Kruizemuntblad
	Coriander	Koriander
	Tumeric powder	Kurkuma poeder
	Nettle leaf	Brandnetelblad
	Parsley	Peterselie
Feed-only feed materials		
1.4.6	Oat hulls	Haverdoppen
1.6.10	Rice bran	Rijstevoermeel
2.18.5	Soy bean hulls	Sojabonendoppen
4.1.10	Dried (sugar) beet pulp	Gedroogde (suiker)bietenpulp
5.13.2	Citrus pulp	Citruspulp, gedroogd
5.14.2	White clover seed	Zaad van witte klaver
5.24.1	Graminaceous seeds	Zaden van grasachtigen
7.6.1	(Sugar) cane molasses	(Suiker)rietmelasse
12.2.1	Vinasses	Vinasse (gecondenseerd melasseperssap)

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