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Preface

Wageningen University & Research supports the Dutch government in the implementation of laws and regulations that are needed for the production of safe food and healthy animals, and to guarantee a sustainable environment. Those research tasks that are mandatory by law are called ‘statutory research tasks’. Within the context of these tasks, Wageningen Food Safety Research (WFSR) performs research in the field of food and feed safety.

This report is meant to give competent authorities, other governmental bodies, and the food and feed industry insight in the application of maximum residue limits to processed products by way of processing factors.

Summary

1. Introduction
Pesticides are generally applied to plants in the field or to raw agricultural products during storage. Residues of pesticides may persist throughout processing of the raw materials and may contaminate feed materials. Some types of processing such as drying may result in a higher concentration of pesticide residues in the final product, compared to the unprocessed form. Legal limits (maximum residue levels or limits (MRLs)) have been set for pesticides in raw agricultural products in the EU – but not for derived, processed, and/or composite products. Processing factors (PFs) are required to calculate the distribution of pesticide residue concentrations in derived and processed products. Processing factors are calculated by dividing the residue concentration in the processed product (PP) by the residue concentration in the raw agricultural product or commodity (RAC). A procedure for the inclusion of 'specific concentration or dilution factors' in legislation has been established, but no specific PFs have thus far been listed in EU legislation. An accessible, well founded, and harmonized list of PFs for authorities and industry is currently lacking. The primary objectives of this study were to provide insight in the legal landscape on pesticide MRLs and PFs and, if possible, to develop a general approach to the application of PFs for feed materials by competent authorities. The sub-objectives of this study were: to create an overview of the lists of PFs that are currently available; to evaluate and compare these lists of PFs; to analyse how MRLs are applied to processed products by EU Member States, and to advise whether and how the use of PFs can be implemented in the assessment of the quality of raw agricultural products on the basis of processed products used as feed materials.

2. Methodology
The methodology of this study aimed to assess the currently available information on PFs via a literature study and analysis of legal documents. Two primary methodological steps were followed: providing an overview of the legal framework, followed by a description and analysis of lists of PFs. The focus was on MRLs specifically in relation to processed products.

Four lists of PFs have been identified and described. These lists and their respective approaches were subsequently analysed by comparing the type of products and pesticide residue definitions considered, sources and extrapolation of data from sources, and finally an assessment of the suggested correlation between the octanol-water partition coefficient (expressed as a log P_{ow} value) of the pesticide active substance and the pesticide's PFs.

3. Results

3.1 Legal and scientific framework
The primary active substance ('parent compound') of a pesticide in a product treated with pesticides may be accompanied by metabolites, degradation products, and/or impurities. Including all potentially related substances in a residue definition may not be practical. Two primary residue definitions are being used: one for purposes of dietary risk assessment, based on toxicologically relevant compounds; and one definition for the use of enforcement, preferably based on a single reference compound. Conversion factors can be used to interpret data in case of different residue definitions.

The Codex Alimentarius Commission (CAC) of the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) provides for a list of maximum residue limits (called CXLs) for pesticides for global trade. Regulation (EC) No 1107/2009 sets in place the framework for the placing of plant protection products on the European market. Regulation (EC) No 396/2005 sets maximum residue levels (MRLs) of pesticides in or on food and feed of plant and animal origin. It is indicated that CXLs should be considered when EU MRLs are determined. Specific MRLs are set in Annexes II ('definitive' MRLs) and III ('temporary' MRLs) of Regulation (EC) No 396/2005 for the products defined and listed in Annex I of that Regulation. Products listed in Annex I are compliant with Regulation (EC) No 396/2005 if they do not contain any pesticide residues exceeding the relevant

MRLs listed in Annex II and III, "*from the time they are placed on the market as food or feed, or fed to animals*". Annex IV lists active substances for which MRLs are not required.

The procedures for setting pesticide MRLs are primarily laid down in Articles 6 to 11 of Regulation (EC) No 396/2005 and article 8 of Regulation (EC) No 1107/2009. A large role is played by the European Food Safety Authority (EFSA) in the MRL setting procedure. Factors taken into account for new or amended MRLs include: use of the plant protection product (PPP) representing critical good agricultural practice (cGAP), a sufficient number of supervised field trials at cGAP, the pesticide residue definition, the stability of the pesticide residues during freezer storage, the availability and validity of analytical methods, their limits of quantification, dietary risk assessment parameters such as the acceptable daily intake (ADI) and acute reference dose (ARfD), and the availability of CXLs.

MRLs apply to agricultural products 'from the time they are placed on the market as food or feed'. Products in Annex I of Regulation (EC) 396/2005 are generally defined as the unprocessed form ('raw') of the agricultural product. However, processing and/or mixing of agricultural products may cause changes in the levels of pesticide residues in agricultural products. According to Article 20(1) of Regulation (EC) No 396/2005, these changes should be taken into account in the form of PFs when applying MRLs to food or feed. The PF should be considered as a combination of the process, the pesticide residue and the commodity. If a product directly corresponds to the description as given in Column 6 Annex I of Regulation (EC) No. 396/2005, the legal limits for that product must be applied without taking into account PFs. If no treatment is mentioned in the description of the product in that Annex, but the sampled product is processed, then the appropriate product treatment code must be selected.

To guide the selection of samples for enforcement analysis, pesticide residues are designated as fat soluble or not. This assessment is based on the distribution of the pesticide residue between fat and muscle in an animal. The data used for these assessments is obtained from livestock metabolism and feeding studies. In Annex II Regulation (EC) No 396/2005, it is indicated per pesticide whether that pesticide residue is fat-soluble by marking it with '(F)', following the pesticide name. This notation is related to the fat content of milk and eggs. Initially (2005), the Log P_{ow} value, which is the octanol-water partition coefficient, was seen as the 'prime indicator' for the fat solubility of a pesticide. Later (2016), it was highlighted that log P_{ow} must be seen as an 'initial indicator' and that the distribution of the residue between muscle and fat obtained from livestock metabolism and feeding studies should be the prime indicator of fat-solubility. An issue with log P_{ow} as an indicator for fat solubility is that definitions of pesticide MRLs for enforcement or dietary risk assessment may include multiple components in addition to the parent compound – each with different log P_{ow} values. In addition, there are errors in estimates of log P_{ow} with differences of one unit for the same compound being reported due to different approaches to the development of these data.

RASFF data over the last three years were studied to obtain insight in notifications related to processed products and the potential use of PFs by the member states involved. These data suggest that monitoring is highly focused on raw agricultural products rather than processed products.

3.2 Description of publicly available lists of Processing Factors

<u>1. Dutch National Institute for Public Health and the Environment (RIVM)</u>
The Dutch National Institute for Public Health and the Environment (RIVM) is a risk assessment agency in the Netherlands. RIVM has compiled a list of PFs with the primary objective to enable the dietary risk assessment of priority pesticide/agricultural product combinations for Dutch trade. The list is supported by a background document. The RIVM list is only for food products, and not for feed. Within the list, extrapolations and interpretations of certain PFs are made: extrapolations concern different commodities; interpretations concern different matrices of the same commodity.

<u>2. German Federal Institute for Risk Assessment (BfR)</u>
The German Federal Institute for Risk Assessment (BfR) has the statutory remit of providing information on possible, identified and assessed risks which food and feed, substances and products may entail for consumers in Germany. BfR has compiled PFs for a variety of pesticides in a database,

which is supported by a background document. The objectives of the compilation are: providing information to food safety inspection services on the scope of changes in residue levels during food processing operations, and; providing information to risk assessors for refined dietary exposure estimates. The focus of residue definitions in the BfR list is more on markers used for enforcement, rather than on usability for risk assessment as with the RIVM list.

3. FEDIOL

FEDIOL is the EU vegetable oil and protein meal industry association that represents the interests of the European oilseed crushers, vegetable oil refiners and bottlers. The organization has developed general guidance on PFs to be applied for fat/hexane soluble pesticides for eight commodity oilseeds. The derived PFs are general estimates. FEDIOL's approach to PFs is primarily based on the physico-chemical properties of the active substance of the pesticide – in the form of fat solubility – and the oil/fat content of the raw agricultural product. The active substance is regarded as fat soluble when it has the prefix (F) as indicated in Annex II of Regulation (EC) No 396/2005, or when the log P_{ow} of the active substance is equal to or exceeds 3. A document developed by the Dutch MVO (The Netherlands Oils and Fats Industry) in consultation with the Netherlands Food and Consumer Product Safety Authority (NVWA) refers to the FEDIOL document for application of PFs.

4. European database of Processing Factors for pesticides in food: joint project for the European Food Safety Authority (EFSA) by RIVM, BfR, and BPI (Benaki Phytopathological Institute)

BfR, RIVM, and the Benaki Phytopathological Institute (BPI, Greece) worked together in a Consortium for an EFSA funded project to establish a database of processing techniques and PFs, compatible with the EFSA food classification and description system FOODEX2. The objective of this list is to enable enforcement of processed agricultural products. In a pilot project, a second database was developed for PFs to be used for dietary risk assessment.

3.3 Evaluation and comparison of publicly available lists of Processing Factors

The FEDIOL list of PFs is a general estimate for a specific type of product (i.e. vegetable oil). Conversely, the BfR and RIVM lists, and the Compendium for EFSA, give detailed PFs for various processed forms of most commodities listed in Annex I of Regulation (EC) No 396/2005. The FEDIOL approach does not consider individual pesticides, nor does it consider pesticide residues other than the parent compound. The RIVM list focuses on residue definitions for dietary risk assessment while the BfR and Compendium for EFSA focus on residue definitions for enforcement.

Each of the described lists makes use of different sources, such as EFSA and JMPR reports. In contrast to the other lists, in the RIVM list, PFs for certain pesticide/product combinations are extrapolated and interpreted to be applicable to other commodities and matrices.

According to the FEDIOL approach: if a pesticide residue is fat soluble (i.e. the pesticide has suffix (F) in Regulation (EC) No 396/2005, or its active substance log $P_{ow} \geq 3$), then the active substance will concentrate in the fat fraction; if the pesticide residue is not fat-soluble (i.e. the pesticide has no suffix (F), or its active substance log $P_{ow} < 0$), then the active substance will concentrate in the water fraction. Data from the BfR database were plotted to detect a possible correlation between the log P_{ow} of the pesticide's active substance and established PFs for pesticides with a residue definition consisting of parent only. This correlation could not be identified.

4. Conclusion and recommendations

The legal landscape on pesticide MRLs and PFs was described in this study. Various approaches to the application of PFs were described, compared, and evaluated. The use of PFs in the application of MRLs to food and feed materials is complex and the number of individual pesticide/process/matrix combinations is very high. The above-mentioned organizations have taken different systematic approaches to this issue. It does not appear to be possible from the information studied to derive straightforward methods that would enable a generally applicable extrapolation from raw to processed products.

Due to the complexity and uncertainty of PFs, it is recommended to measure the pesticide residue concentration in the raw agricultural product as much as possible to check for compliance with legal limits. When this is not feasible, for instance in case of imported products, processed products could be sampled and analysed. In this case it is recommended to use validated PFs based on experimental data as much as possible. The databases evaluated in this report primarily focus on food products specifically; no extensive inventory of PFs has therefore been made for feed products yet. More PFs for feed products may be available in Joint FAO/WHO Meeting on Pesticide Residues (JMPR) reports and/or literature. It is recommended to investigate this literature to create a better overview of PFs for feed products. Finally, more research is recommended on the correlation between log P_{ow} of pesticide active substances and PFs for crude oil of vegetable origin for pesticides with a residue definition consisting of parent only, in order to verify the FEDIOL approach.

1 Introduction

Pesticides or plant protection products are intended to control pests such as weeds, insects, and fungi. Pesticides are generally applied to plants in the field or raw agricultural products during storage. Residues of pesticides may persist throughout processing and contaminate feed materials. Some types of processing such as drying may cause a higher concentration of pesticide residues in the final product, compared to the unprocessed form. Legal limits (maximum residue levels or limits (MRLs)) have been set for pesticides in raw agricultural products in the EU[1] – but not for derived, processed, and/or composite products, such as expeller and meal, or for products that will be processed further. A legislative procedure for the inclusion of '*specific concentration or dilution factors*' has been established in Article 20(2) of Regulation (EC) 396/2005, but no specific processing factors (PFs) 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. The formulaic definition of PFs for pesticide residues is as follows:[2]

$$Processing\ factor\ (PF) = \frac{\left(residue\ level\ \left(\frac{mg}{kg}\right) in\ processed\ product\ (PP)\right)}{\left(residue\ level\ \left(\frac{mg}{kg}\right) in\ raw\ agricultural\ product\ (RAC)\right)}$$

The primary objectives of this study were to provide insight in the legal landscape on pesticide MRLs and PFs and, if possible, develop a general approach to the application of PFs for feed materials by competent authorities. The sub-objectives of this study were to:

1. Create an overview of the lists of PFs that are currently available;
2. Evaluate and compare these lists of PFs;
3. Analyse how MRLs are applied to processed products by EU Member States;
4. Advise whether and how the use of PFs can be implemented in the assessment of the quality of raw agricultural products on the basis of processed products.

The structure of this report is as follows. In section 2, the methodology is described. This is followed by a description and discussion of the results in section 3, which consists of three major sub-sections: firstly a description of the scientific and legal background of pesticide legislation, focusing on PFs and MRLs in section 3.1. This is followed by a description of the publicly available lists of PFs in section 3.2; and finally a subsequent evaluation and comparison in section 3.3. In section 4, conclusions and recommendations are given.

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[1] Pesticide MRLs have been laid down in 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.

[2] JMPR (2016a). FAO Plant Production and Protection Paper 225: Submission and evaluation of pesticide residues data for the estimation of maximum residue levels in food and feed. Third edition. Available online at: http://www.fao.org/3/a-i5452e.pdf (last accessed on 01 October 2019).

2 Methodology

The methodology of this study aimed to assess the currently available information on PFs via a literature study and analysis of legal documents. The following two methodological steps were followed:

1. Overview of legal framework

As a first step, the general legal framework on pesticide MRLs and PFs was analysed. Four research questions guided this analysis:

1. How are maximum residue levels (MRLs) established for pesticides?
2. How should MRLs be applied to processed products?
3. Which role does fat solubility play in the distribution of pesticide residues in a processed product?
4. How are MRLs applied to processed products by Member States in practice?

The focus was on MRLs specifically in relation to processed products. This analysis was done primarily by analysing legislation (including the revisions through time), and documents (e.g. risk assessments by the European Food Safety Authority (EFSA)) that guided established MRLs. The question on how MRLs are applied to processed products by Member States in practice, is based on a case study. An assessment was made on how pesticide MRLs have historically been applied to processed products, as reported in the RASFF database.

2. Description and analysis of lists of Processing Factors

Four lists of PFs from the following four sources have been analysed:

1. Dutch National Institute for Public Health and the Environment (RIVM)
2. German Federal Institute for Risk Assessment (BfR)
3. FEDIOL (Fédération de l'Industrie de l'Huilerie de la CEE)
4. European database of PFs for pesticides in food: joint project for the European Food Safety Authority (EFSA) by RIVM, BfR, and BPI (Benaki Phytopathological Institute)

The available lists of PFs were described by mapping the approach, the manner in which PFs were established, criteria for including PFs, distinct product groups, and intended application.

The four lists and their respective approaches were subsequently analysed. This was done by comparing the type of products and pesticide residues considered, the sources and extrapolation of data from sources, intended use of the database, and finally an assessment of the suggested correlation between the log P_{ow} of the pesticide active substances and the pesticide's PFs.

3 Results and discussion

3.1 Legal and scientific background

3.1.1 Pesticide residue definitions

In many cases, the primary active substance ('parent compound') of the pesticide in a product treated with pesticides may be accompanied by metabolites, degradation products, and/or impurities.[3] To include all potential other substances in a residue definition may not be practical due to, *inter alia*, costs and/or complexity of analyses. Pesticide residues can therefore be defined in multiple ways. There are two primary residue definitions in use: one for the purposes of dietary risk assessment, and one for enforcement.

For dietary risk assessment, it is recommended that the residue definition should "*include compounds of toxicological interest where present in significant concentrations*".[4] For enforcement, the residue definition for the maximum residue level (MRL) should be: "*based on a single compound whenever possible, which is preferably recoverable with multi-residue methods; most suitable for monitoring compliance with GAP* [good agricultural practices]*, which enables unambiguous identification of source of residues; therefore including common moiety of pesticides should be avoided; the same for all commodities, if possible*".[5]

As such, the residue definition of a pesticide for dietary risk assessment and the definition for enforcement may not be the same and the residue definitions may include more than just the parent compound. Conversion factors are used to interpret data in case of differences in the residue definitions of pesticides for dietary risk assessment and for enforcement.

3.1.2 Legal framework

The Codex Alimentarius Commission (CAC) of the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) maintains a list of maximum residue limits (called CXLs) for pesticides. CXLs play a role in global trade as the World Trade Organization (WTO) agreements recognize Codex standards as the harmonized benchmark. The CXLs are established in sessions of the Codex Committee on Pesticide Residues (CCPR). Data used are derived from estimations made by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR).[6]

Regulation (EC) No 1107/2009[7] sets in place the framework for the placing of plant protection products on the European market, which is supplemented by:

- Regulation (EC) No 396/2005, which sets maximum residue levels of pesticides in or on food and feed of plant and animal origin. Regulation (EC) No 396/2005 refers to the Codex CXLs in recital 25, indicating that these CXLs should be considered when EU MRLs are determined;[8]
- Regulation (EC) No 1107/2009, specifically Article 29 which sets requirements for the authorisation for placing on the market;

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[3] *Ibid*., at p. 67.

[4] JMPR (2016b). FAO Plant Production and Protection Paper 224: Evaluation of pesticide residues for estimation of maximum residue levels and calculation of dietary intake. Training Manual. Available online at: http://www.fao.org/3/a-i5545e.pdf (last accessed on 01 October 2019). At p. 87. And *Ibid*., at p. 68.

[5] JMPR (2016b), *Ibid*., at p. 86.

[6] JMPR (2016a), 'Submission and evaluation of pesticide residues data', s*upra*, note 2.

[7] Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

[8] Regulation (EC) No 396/2005, recital 25: "*Through the World Trade Organisation, the Community's trading partners should be consulted about the MRLs proposed, and their observations should be taken into account before the MRLs are adopted. MRLs set at the international level by the Codex Alimentarius Commission should also be considered when Community MRLs are being set, taking into account the corresponding good agricultural practices.*" See also van der Meulen (2019). The Influence of the Joint FAO/WHO Food Standards Programme on EU Food Law. *EFFL* 1, pp. 29-50.

- Implementing Regulation (EU) No 546/2011.[9]

MRLs for pesticide residues have been set at the EU level in the "*interest of free movement of goods, equal competition conditions among the Member States, as well as a high level of consumer protection*".[10]

The legal definition of MRL in the EU is: "*the upper legal level of a concentration for a pesticide residue in or on food or feed set in accordance with this Regulation, based on good agricultural practice* [GAP] *and the lowest consumer exposure necessary to protect vulnerable consumers*".[11] The principle of GAP is to use pesticides according to the "*nationally recommended, authorised or registered safe use of plant protection products under actual conditions at any stage of production, storage, transport, distribution and processing of food and feed*".[12] MRLs are derived from a sufficient number of supervised field trials conducted at critical GAP (cGAP, i.e. maximum number of applications at the maximum application rate with the shortest interval between applications and the shortest pre-harvest interval as indicated on the plant protection product label). In principle the MRL is set at the 'lowest level which allows the desired effect [of the pesticide] to be obtained'.[13] However, the lowest level for a pesticide/product combination may differ between countries. In case of differences, the GAP which would lead to the 'highest acceptable level of pesticide residue in a treated crop' is used for establishing the MRL.[14] Thus, if a higher application rate is required in a given climatic zone to achieve the desired effect, compared to a different zone where a lower application rate would suffice; then the higher application rate is used for the 'critical GAP'.

Specific MRLs are set in Annexes II ('definitive' MRLs) and III ('temporary' MRLs) of Regulation (EC) No 396/2005 for the products defined and listed in Annex I of that Regulation. Annex I consists of two parts. In part A, food and feed is listed per category, group, main product of the group or subgroup, scientific names, and the part of the product to which MRLs apply. Part B lists additional specific products that also fall under the products defined in part A. For instance, blood oranges are listed in Part B as similar to oranges, and the same MRLs thus apply. Products listed in Annex I are compliant with Regulation (EC) No 396/2005 if they do not contain any pesticide residues exceeding the relevant MRLs listed in Annex II and III, "*from the time they are placed on the market as food or feed, or fed to animals*".[15] Annex IV lists active substances for which MRLs are not required.[16] For those products for which no specific MRLs are set in Annexes II and III, or for those active substances not listed in Annex IV, a default MRL of 0.01 mg/kg applies unless specific default values are listed in Annex V.[17] Annex II contains MRLs set under prior legislation.[18] Annex III concerns temporary MRLs, and consists of two parts. Pesticides included in Part A of Annex III[19] are "*active substances for which a decision on inclusion or non-inclusion [..] has not yet been taken*"[20]. Annex III Part B[21] contains pesticide MRLs for products that had not been included in the equivalent of Regulation (EC) No 396/2005's Annex I of prior legislation.

3.1.3 Procedure for establishing Maximum Residue Levels (MRLs)

The procedures for setting pesticide MRLs are primarily laid down in Articles 6 to 11 of Regulation (EC) No 396/2005 and article 8 of Regulation (EC) No 1107/2009. The European Commission has published

[9] Commission Regulation (EU) No 546/2011 of 10 June 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards uniform principles for evaluation and authorisation of plant protection products.
[10] Regulation (EC) No 396/2005, preamble 2.
[11] *Ibid.*, Article 3.2(d).
[12] *Ibid.*, Article 3.2(a).
[13] *Ibid.*, Article 3.2(a).
[14] *Ibid.*, Article 3.2(b).
[15] *Ibid.*, Article 18.1(a).
[16] *Ibid.*, Article 5.
[17] *Ibid.*, Article 18.1(b).
[18] MRLs formerly defined under Directives 86/362/EEC, 86/363/EEC and 90/642/EEC, referred to in Article 21(1).
[19] "*Temporary MRLs referred to in Articles 16(1) and 22(1)*".
[20] Regulation (EC) No 396/2005, Article 22(1).
[21] "*Temporary MRLs for products not defined in Annexes I of Directives 86/362/EEC, 86/363/EEC and 90/642/EEC*".

a guidance document on this procedure.[22] An application for modifying an existing MRL, or setting a new MRL may be submitted by *"all parties demonstrating, through adequate evidence, a legitimate interest in health, including civil society organisations, as well as commercially interested parties*".[23] Upon receipt of an application, the receiving Member State (MS) may examine it, ask another MS to do so, or the assessment may be performed by a group of MS. While assessing the application, the MS may consult the European Food Safety Authority (EFSA). Once the MS draft assessment report is complete, EFSA prepares a conclusion which includes "*details concerning the evaluation procedure and the properties of the active substance concerned*".[24] EFSA's opinion particularly focuses on the risks to the consumer and, where relevant, animals; and should include:

a. *"an assessment of whether the analytical method for routine monitoring proposed in the application is appropriate for the intended control purposes;*
b. *the anticipated LOD [limit of determination]*[25] *for the pesticide/product combination;*
c. *an assessment of the risks of the acceptable daily intake [ADI]*[26] *or acute reference dose [ARfD]*[27] *being exceeded as a result of the modification of the MRL; the contribution to the intake due to the residues in the product for which the MRLs was requested;*
d. *any other element relevant to the risk assessment."*[28]

EFSA uses a decision tree to establish MRLs, which is included in Annex 1 of this report.[29] In short, firstly the GAPs and available residues data at EU level are evaluated. This is followed by a consumer risk assessment for critical GAPs evaluated at EU level (EU Scenarios). This leads to preliminary recommendations which are compared to existing CXLs, if available. To assist with the interpretation and calculation of data from studies on pesticide residues, EFSA has developed PRIMo (Pesticide Residue Intake Model), to estimate dietary consumer exposure based on national food consumption figures.[30]

Based on the opinion by EFSA, the Commission shall present a 'review report' and a draft Regulation for adoption by the Committee on the Food Chain and Animal Health to: (i) approve the active substance (subject to conditions and restrictions), (ii) not approve it, or (iii) to amend the conditions of approval.[31] A separate procedure for establishing, changing or deleting MRLs of an active substance has been laid down in Regulation (EC) No 396/2005[32], but this may be done simultaneously with the approval procedure laid down in Regulation (EC) No 1107/2009.

3.1.4 Application of MRLs to processed products

As mentioned in section 3.1.2 above, MRLs apply to agricultural products 'from the time they are placed on the market as food or feed'. In principle, MRLs apply to all agricultural products on which pesticide residues may be present – whether fresh, processed and/or composite food or feed.[33] Products in Annex I of Regulation (EC) No 396/2005 are generally defined as the unprocessed ('raw')

[22] European Commission (2016). SANTE/2015/10595 Rev. 4: Guidance Document: MRL setting procedure in accordance with articles 6 to 11 of regulation (EC) No 396/2005 and article 8 of regulation (EC) no 1107/2009. Available online at: https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_mrl_guidelines_mrl-setting-proc.pdf.
[23] Regulation (EC) No 396/2005, Article 6(2).
[24] Regulation (EC) No 1107/2009, Article 12(5).
[25] Regulation (EC) No 396/2005, Article 3.2(f): "'*limit of determination' (LOD) means the validated lowest residue concentration which can be quantified and reported by routine monitoring with validated control methods*".
[26] *Ibid*., Article 3.2(j): "'*acceptable daily intake' means the estimate of the amount of substances in food expressed on a body weight basis, that can be ingested daily over a lifetime, without appreciable risk to any consumer on the basis of all known facts at the time of evaluation, taking into account sensitive groups within the population (e.g. children and the unborn).*"
[27] *Ibid*., Article 3.2(i): "'*acute reference dose' means the estimate of the amount of substance in food, expressed on a body weight basis, that can be ingested over a short period of time, usually during one day, without appreciable risk to the consumer on the basis of the data produced by appropriate studies and taking into account sensitive groups within the population (e.g. children and the unborn)*".
[28] *Ibid*., article 10(1).
[29] From: European Food Safety Authority (EFSA), Anastassiadou, M., Brancato, A., Carrasco Cabrera, L., Ferreira, L., Greco, L., ... & Miron, I. (2019). Review of the existing maximum residue levels for pyriofenone according to Article 12 of Regulation (EC) No 396/2005. EFSA Journal, 17(6), e05711.
[30] EFSA (n.d.). Pesticide evaluation: Tools. Available online at: *https://www.efsa.europa.eu/en/applications/pesticides/tools* (last accessed on 1 October 2019)
[31] Regulation (EC) No 1107/2009, Article 13.
[32] Regulation (EC) No 396/2005, Article 6-17.
[33] *Ibid*., article 2.1.

form of the agricultural product. However, processing and/or mixing of products may cause changes in the levels of pesticide residues in agricultural products. According to Article 20(1) of Regulation (EC) No 396/2005, these changes should be taken into account in the form of PFs when applying MRLs to food or feed. Article 20(2) establishes a procedure and list in Annex VI of Regulation (EC) No 396/2005 for "*specific concentration or dilution factors for certain processing and/or mixing operations or for certain processed and/or composite products*", but no such PFs are included in this Annex thus far. Also, no definition of the term 'processing factor' is provided in Regulation (EC) No 396/2005. In this report, JMPR's definition of the term (i.e. PF = [PP] / [RAC]), as provided in section 1 of this report, will be used.[34]

In general, a processing PF > 1 may indicate dehydration (e.g. dried fruits), fractionation in case of surface residues (e.g. residues in wheat bran are generally higher than in wheat flour) or a combination of both (e.g. residues in dried apple pomace are generally higher than in apple). A PF < 1 may indicate:

- dilution (e.g. addition of water during beer brewing or swelling of beans and grains during cooking), degradation during processing (hydrolysis, thermal degradation or degradation as a result of the addition of enzymes or chemicals, e.g. bleaching of oils);
- photolytic degradation (e.g. when drying grapes or tomatoes in the sun);
- removal of residues (e.g. during cooking of vegetables or deep-frying of potatoes, residues move into the cooking liquid or the frying oil leaving lower residues in the cooked or fried product);
- or fractionation of residues (e.g. after peeling of a fruit the residues remain on the peel and the residues in the flesh are lower than in the whole fruit or during oil processing the residues remain in the oilseed meal and the residues in the crude oil are lower than in the oilseeds).

According to JMPR (2016), "*the processing factor should be considered as a combination of the process, the pesticide residue and the commodity*".[35] Thus, for the interpretation of processing studies; it must be noted that "*variations in the process may produce variations of processing factors*",[36] and that reported PFs are related to the residue definitions used in the study: "*when the definition of residues for enforcement purposes and for dietary risk assessment is different, two processing factors are needed*".[37]

Member States have a statutory task to monitor pesticide residue levels in food and feed samples, and submit the monitoring results to EFSA and the European Commission. EFSA has developed a standard sample description (SSD) data model for reporting on analytical measurements of chemical substances occurring in food, feed and water to EFSA: the document describing this model provides guidelines for the reporting of pesticide residues to products in processed/unprocessed form.[38]

The general rule for unprocessed products is that "*If the food product analysed fully complies with the description in the last column of Regulation (EU) No 752/2014, a product should be reported as 'Unprocessed'*".[39] If a product is reported as being unprocessed, the legal limits as set in Regulation (EC) No 396/2005 for that product should be applied "*without the need to apply processing or peeling factors*".[40] The general rule for processed products is that for determining the PF, the most specific product treatment code should be selected. Processing steps for which there are specific codes, are e.g. peeling, juicing and milling. If no other specific code can be used to describe a processed product, the generic code 'processed' (ProdTreat code T100A) should be applied.[41]

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[34] JMPR (2016a), 'Submission and evaluation of pesticide residues data', s*upra*, note 2, at p. 53.
[35] *Ibid*.
[36] JMPR (2016b), 'Training manual', s*upra*, note 4, at p. 171.
[37] JMPR (2016a), 'Submission and evaluation of pesticide residues data', s*upra*, note 2, at p. 53.
[38] EFSA (European Food Safety Authority), Brancato A, Brocca D, Erdos Z, Ferreira L, Greco L, Jarrah S, Leuschner R, Lythgo C, Medina P, Miron I, Nougadere A, Pedersen R, Reich H, Santos M, Stanek A, Tarazona J, Theobald A and Villamar-Bouza L, 2017. Guidance for reporting data on pesticide residues in food and feed according to Regulation (EC) No 396/2005 (2016 data collection). EFSA Journal 2017;15(5):4792, 48 pp. https://doi.org/10.2903/j.efsa.2017.4792.
[39] *Ibid*. on p. 14.
[40] *Ibid*.
[41] *Ibid*. on p. 11.

Drying may be regarded as an integral part of the product or as a separate processing step. Concerning dried products, the following note is given for the product treatment code 'dehydration' (T131A):

> *"Applies to dried products (e.g. grapes (raisins), plums, apricots, dates, dry potato flakes, fungi, dried basil leaves etc.).*
> *This code should not be used for dried products that correspond with the description in Annex I of Regulation 396/2005 (e.g. dry pulses, tea, herbal infusions such as dried ginger roots, cereals dried to standard moisture content), which should be reported as 'Unprocessed' See also T999A 'Unprocessed' and T132A 'Fermentation', plus Examples 3 and 4"*[42]

For some products, multiple entries are included in Annex I of Regulation 396/2005. This is, for instance, the case for peas (*Pisum sativum*) and beans (*Phaseolus vulgaris*) due to the different growth stages at which these crops can be harvested. Peas and beans are included twice in the sub-group of legume vegetables – with and without pods – in which case the MRLs apply to the 'whole product'; but also in the main-group pulses, in which case the MRLs apply to the dry seeds. Depending on the growth stage at which the agricultural product is harvested and placed on the market, the appropriate product type should be selected. The drying of pulses "*to reach standard moisture content (ca 15-19%) is not considered as processing*".[43]

3.1.5 Application of MRLs of fat-soluble pesticides

To guide the selection of samples for enforcement analysis, pesticide residues are designated as fat soluble or not. This assessment is based on the distribution of the pesticide residue between fat tissue and muscle tissue in an animal. The data used for these assessments are obtained from livestock metabolism and feeding studies.[44]

In Annex II of Regulation (EC) No 396/2005, it is indicated per pesticide whether that pesticide is fat-soluble by marking it with '(F)', following the pesticide name. In the original version of Regulation (EC) No 396/2005, this designation was correlated to the pesticide's octanol-water partition coefficient, expressed as Log P_{ow}. Originally, footnote 5 of Annex I indicated that "*where the pesticide and/or metabolites (included in the residue definition) is/are water soluble (log P_{ow} less than 3) the MRL is expressed as mg/kg of meat (including fat), preparations of meat, offal and animal fats. Where the pesticide and/or metabolite (included in the residue definition) is/are fat soluble (log P_{ow} greater than or equal to 3) the MRL is expressed as mg/kg of fat contained in the meat, preparations of meat, offal and animal fats*". Similar wordings, referring to the Log P_{ow} value of a pesticide, were included in the original non-amended version of Annex I Regulation (EC) No 396/2005 for milk and milk products, and eggs; in footnotes 6 and 7, respectively.

The original texts of footnotes 5, 6 and 7 in Annex I of Regulation (EC) No 396/2005, which referred to the Log P_{ow} value, were replaced according to Regulation (EU) No 212/2013.[45] In the current version of Regulation (EC) No 396/2005, the designation (F) is related to the fat content of milk and eggs: MRLs are established for raw cow milk with a fat content of 4% by weight;[46] and for hen eggs with a fat content of 10% by weight.[47] There is thus no longer a reference to the Log P_{ow} value of a pesticide. No reasoning for these changes to the footnotes was provided in the preamble of Regulation (EU) No 212/2013. However, this amendment reflects a shift in the perceived correlation between fat solubility and log P_{ow}. In 2005, the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) indicated

[42] *Ibid*., on p. 13.
[43] *Ibid*., on p. 15.
[44] JMPR (2016a), 'Submission and evaluation of pesticide residues data', s*upra*, note 2, at p. 76.
[45] COMMISSION REGULATION (EU) No 212/2013 of 11 March 2013 replacing Annex I to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards additions and modifications with respect to the products covered by that Annex.
[46] Regulation (EC) No 396/2005, Annex I, footnote 5.
[47] *Ibid*., footnote 6. For milk and eggs of other species, the MRL value should be adjusted proportionally according to these fat contents of cow milk and hen eggs, respectively.

that log P_{ow} "*should be the prime indicator of fat solubility*"[48], although this was already nuanced by indicating that log P_{ow} is 'not the only factor used'.[49] In a 2015 EFSA guidance document, however, it was highlighted that log P_{ow} is an 'initial indicator'.[50] This sentiment was also indicated in the 2016 JMPR report: the "*distribution of the residue between muscle and fat obtained from livestock metabolism and feeding studies should be the prime indicator of fat-solubility*". In the absence of metabolism studies or 'other useful information', "*the partitioning of residues between fat and muscle as a function of P_{ow} can be predicted*".[51]

The calculation for predicting the distribution of pesticide residues between different matrices is as follows. The partition constant (k) is defined as the concentration of a substance in fat, divided by the concentration in muscle, which can be expressed as:

$$k = \frac{P_{ow}[fraction\ lipid]_{fat} + [fraction\ water]_{fat}}{P_{ow}[fraction\ lipid]_{water} + [fraction\ water]_{water}}$$

According to JMPR (2016a), it is assumed that muscle contains 5% lipid with the remainder water and that fat is 80% lipid.[52] Inserting these numbers in the formula for the partition constant gives the following:

$$k = \frac{(P_{ow} * 0.8) + 0.2}{(P_{ow} * 0.05) + 0.95}$$

Using this approach, from log $P_{ow} \geq 3$, the function approaches k = 16. Figure 1 shows the predicted variation for partition constant (k) for fat and muscle, and polarity (log P_{ow}) of a given pesticide. This figure was copied from the 2016 JMPR report,[53] which was slightly modified from the 2005 JMPR report.[54] Note that the formula uses P_{ow} values, while the x-axis in the figure is on a logarithmic scale.

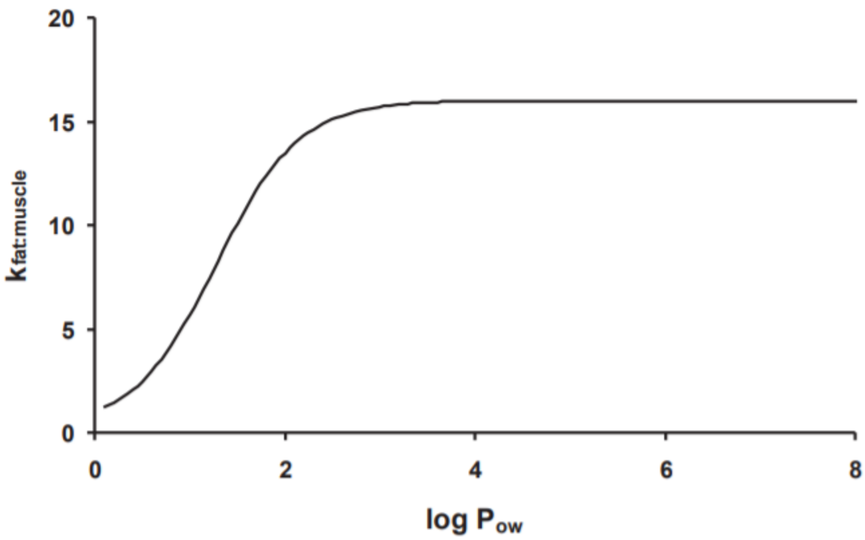

Figure 1 *Plot of predicted partition of residue between muscle and fat, based on octanol-water partition coefficient (expressed as a log P_{ow} value).*
k = concentration ratio of residues in fat/muscle.

48 JMPR (2005). FAO Plant Production and Protection Paper 183: Report of the Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Core Assessment Group on Pesticide Residues Geneva, Switzerland, 20–29 September 2005. (Rome, Italy: FAO). At p. 28.
49 *Ibid*., at p. 30.
50 EFSA (2015). Estimation of animal intakes and HR, STMR and MRL calculations for products of animal origin. Available online at: https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_mrl_guidelines_animal_intake_mrl_2015_en.pdf (last accessed on 16 September 2019).
51 JMPR (2016a), 'Submission and evaluation of pesticide residues data', s*upra*, note 2, at p. 76-77.
52 Ibid., at p. 77. Note that the calculation in the JMPR document uses a ratio of 0.1:0.9 for the fraction lipid:water in muscle, instead of 0.05:0.95 as in the stated assumption. In case of a ratio of 0.1:0.9, then k approaches 8.
53 *Ibid.*
54 JMPR (2005), 'FAO Plant Production and Protection Paper 183', *supra*, note 48.

According to JMPR, an issue with log P_{ow} as an indicator for fat solubility is that definitions of pesticide residues for enforcement or dietary risk assessment may include multiple components in addition to the parent compound – each with different log P_{ow} values.[55] In addition, JMPR (2016) reports "*that there are errors in estimates of log P_{ow} with differences of one unit for the same compound being reported"* due to "*different approaches to the development of these data*".[56]

3.1.6 Application of MRLs and Processing Factors by Member States

Data from the Rapid Alert System for Food and Feed (RASFF) over the last three years were studied to obtain insight in notifications related to pesticide residues in processed products and the potential use of PFs by the member states involved. In the period 01/01/2015 – 23/03/2018, a total of 1050 notifications related to pesticide residues were logged in the RASFF database. Almost all (1039) notifications were related to food, with only a few related to feed (11).

EFSA (2019) reviewed these data, but from this report is was not clear whether member states used PFs in checking processed products for compliance with MRLs:[57] "[compared to unprocessed food products,] *processed products had a higher rate of samples without quantified residues (71.4%) and a lower occurrence of quantified residues (25.9%) as well as a lower MRL exceedance rate (2.7%)*".[58] Although EFSA (2019) made use of PFs (mainly related to peeling of oranges) in order to estimate the dietary exposure, it was emphasised that "*only a limited number of reliable processing factors are currently available and for most assessed commodities it is assumed that before and after treatment, the same residual levels are present and consumed*".

3.2 Description of publicly available lists of Processing Factors

3.2.1 Dutch National Institute for Public Health and the Environment (RIVM)

The Dutch National Institute for Public Health and the Environment (RIVM) is a risk assessment agency in the Netherlands. It conducts research and provides advice to assist government authorities at all levels in the context of this task. As mentioned in the introduction (section 1), the RIVM has developed a list of PFs. The RIVM list has been endorsed by the Ministries of Public Health, Welfare and Sport (VWS) and Agriculture, Nature and Food Quality (LNV) as the default in the Netherlands.[59] The primary objective of the list is to enable the dietary risk assessment of priority pesticide/agricultural product combinations for Dutch trade.[60] In this report, the version of 06/03/2018 was used. The PFs listed in the Excel file as well as the rationale described in a Word file can be found on the RIVM website.[61]

The RIVM database of PFs lists a number of products also included in Regulation 396/2005, which are processed in different ways, in combination with a number of prioritized pesticides.[62] Since the purpose of the list is to enable dietary risk assessment, the PFs are based on the residue definitions for dietary risk assessment and may include more than just the parent compound.[63] The RIVM list is only for food products, and not for animal feed.[64]

[55] *Ibid*., at p. 77, and EFSA (2015), *supra*, note 50, at p. 6.
[56] JMPR (2016a), 'Submission and evaluation of pesticide residues data', s*upra*, note 2, at p. 76.
[57] EFSA (European Food Safety Authority), 2019. Scientific report on the 2017 European Union report on pesticide residues in food. EFSA Journal 2019;17(6):5743, 152 pp. https:// doi.org/10.2903/j.efsa.2019.5743.
[58] *Ibid*., at p. 4.
[59] RIVM (2015). Processing factors. Retrieved on 16/10/2018 from: https://www.rivm.nl/en/chemkap/fruit-and-vegetables/processing-factors (last accessed on 1 October 2019).
[60] *Ibid*.
[61] Van der Velde-Koerts, T. (2018). Rationale 20180306_RIVM-Rationale processing factors. Available online at: https://www.rivm.nl/documenten/20180320rivm-rationale-processing-factors (last accessed on 1 October 2019).
[62] Priority substances are defined by the Netherlands Food and Consumer Product Safety Authority (NVWA) and the Dutch Productboard for Horticulture (Productschap Tuinbouw).
[63] RIVM (2015), 'Processing factors', *supra*, note 59.
[64] RIVM – van der Velde-Koerts, T. (2018), personal communication.

An extract of this Excel file for the pesticide chlorothalonil is shown in Table 1. In this example, for soya beans (code number 0401070 in Annex I of Regulation (EC) No 396/2005), nine different processed products are indicated. Per pesticide, different PFs are listed which are sourced from various EFSA and Joint FAO/WHO Meeting on Pesticide Residues (JMPR) publications. In the RIVM Excel file, a yellow cell means that the PF is a 'default different from 1'; the colour green means that the PF is 'compound specific'. A default of 1 is used if no processing information is available.

Table 1 *Extract of RIVM overview of Processing Factors (PFs).*

"EC600/2010 valid for EN name"	processing	chlorothalonil	
		PF	Refs
soya bean	raw	1.000	Default
	cooked/boiled	0.400	Default RIVM 2010
	oil (refined)	0.500	J 2010
	miso	1.000	Default
	soymilk	1.000	Default
	flour	1.000	Default
	soysauce	1.000	Default
	tofu	1.000	Default
	sec processing	1.000	Default

In this example of the pesticide chlorothalonil, a PF of 0.400 and 0.500 was defined for the cooked/boiled bean and refined oil, respectively. This means that the concentration of chlorothalonil in the cooked/boiled bean and refined oil is expected to be lower than in the non-processed soya bean. In the case of the cooked/boiled bean, it is processed as a whole. The default PF of 0.400 describes the process of swelling (water uptake) during the cooking of the beans and does not take into account any degradation or migration of residues. Conversely, in case of the refined oil it is likely that the pesticide residue is *divided* between the different fractions (e.g. the meal and oil) and is removed or degraded during the oil refinement process. The MRL for chlorothalonil in soya beans according to Regulation is (EC) No 396/2005 is 0.01* mg/kg.[65] Therefore, if the concentration of chlorothalonil in the raw agricultural product is equal to the MRL, then after applying PFs, the expected concentration in cooked/boiled soya beans would be 0.004 mg/kg, and for refined oil it would be 0.005 mg/kg.

In addition to the Excel file, a supporting document has been published by the RIVM.[66] This document contains all justifications and references for the PFs included in the Excel file. Per pesticide, a table is included in which per commodity the PF, residue definition, source, and RIVM interpretations for which commodities the PF can be extrapolated to, and interpretations on which products the PF is at least also valid. Extrapolations concern different commodities, for instance reported PFs for apple juice being extrapolated to pear juice. Interpretations concern different matrices of the same commodity, for instance reported PFs for banana pulp being interpreted to be also valid for banana sauce/puree.[67] The RIVM PFs have been obtained from the following sources:
- EFSA reviews;
- EFSA opinions;
- JMPR reports;
- JMPR evaluations.

In general, for the RIVM list, PFs listed in EFSA evaluations supersede those in JMPR evaluations, and PFs listed in later EFSA evaluations supersede those in earlier EFSA evaluations.[68]

[65] * indicates lower limit of quantification.
[66] Van der Velde-Koerts (2018), 'Rationale', *supra*, note 61.
[67] *Ibid.*, see the rationale for the pesticide Acetamiprid at p. 5-6.
[68] *Ibid*.

In the above example (see Table 1) of the pesticide chlorothalonil in refined soya bean oil, the PF was taken from JMPR (2010).[69] These JMPR reports are mostly based on unpublished proprietary data submitted for use by JMPR in making its assessments. However, extensive summaries of these studies have been drafted by JMPR and are publicly available. The general approach to RIVM extrapolations is that available PFs for products in a group or sub-group as defined in Annex I to Regulation (EC) No 396/2005 are applied to all other products in that group or sub-group. For instance, PFs for apples and pears can be extrapolated to other products in the group of pome fruits. If there is no PF for quinces, but there is a PF for apples and pears, then the PF for either apples or pears leading to the highest residue is chosen for quinces. This approach to extrapolation thus aims to base a dietary assessment on the worst-case scenario.

3.2.2 German Federal Institute for Risk Assessment (BfR)

The German Federal Institute for Risk Assessment (BfR, Bundesinstitut für Risikobewertung) has the statutory task of providing information on possible, identified and assessed risks which foods and feed, substances and products may entail for consumers in Germany.[70] BfR has compiled PFs for a variety of pesticides in a database, which is supported by a background document.[71] A description of the compilation has been published by Scholz et al. (2017).[72] The stated objectives of the compilation are:

1. *"Providing information to food safety inspection services on the scope of changes in residue levels during food processing operations, thus, they are crucial for assessing whether the starting material has been in compliance with legal standards.*
2. *Providing information to risk assessors for refined dietary exposure estimates, such as figures, to allow a more realistic assessment in cases when commodities are mainly consumed after processing. This aspect will become even more important in upcoming cumulative consumer intake assessments."*[73]

As with the RIVM list, the BfR list consists of an Excel database that lists various products from Regulation (EC) No 396/2005 in combination with a number of pesticides. However, in contrast to the overall mean values provided by RIVM, the BfR list also provides certain parameters of individual studies: a range of individual PFs as well as a median, number of trials and an assessment of the acceptability of the study (yes/no/indicative). This allows for easier assessment of study quality. The residue definitions used in the BfR list are the definitions for enforcement,[74] rather than for usability for risk assessment as with the RIVM list.

The structure of the Excel database is slightly different for BfR compared to RIVM's: whereas the RIVM database lists the pesticides in different columns; BfR has listed them in rows in a single column. The main and sub crop group and commodities are also listed in single columns. The BfR list contains PFs from the following sources:

- reports on the assessment of residues of pesticide active substances published annually by JMPR;
- the EFSA Conclusions and Reasoned Opinions prepared within the scope of the European review of active substances and the European MRL setting process;
- national monitoring programmes;
- internal quality controls of a trading company made available to the BfR.

An extract of the BfR database for the pesticide chlorothalonil in soya beans is shown in Table 2. The BfR has also made a "*graphic display of 35 typical processing procedures in the form of flow charts by means of which the database user can gain a quick overview of the relevant products and intermediate products of processing procedures and can assign processed matrices more easily*". An

[69] JMPR (2010). Pesticide residues in food 2010. Available online at: http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/JMPR/Evaluation10/2010_Evaluation.pdf (last accessed on 1 October 2019).
[70] BfR (n.d.), 'remit', available online at: http://www.bfr.bund.de/en/remit-9763.html (last accessed on 1 October 2019).
[71] BfR (2017). BfR data compilation on processing factors. Available online at: https://www.bfr.bund.de/cm/349/bfr-data-collection-on-processing-factors.pdf (last accessed on 1 October 2019).
[72] Scholz, R., Herrmann, M., & Michalski, B. (2017). Compilation of processing factors and evaluation of quality controlled data of food processing studies. *Journal of Consumer Protection and Food Safety*, 12(1), 3-14.
[73] *Ibid*. at p. 4.
[74] *Ibid*. at p. 5.

example of such a flow-chart has been included in Figure 3 in Annex 2 of this report. In the context of the present study, the flow-chart for soya bean by BfR has been amended by including feed products included in the Annex of the Feed Catalogue Regulation (EC) No 68/2013[75], and adding the available PFs for those products for the pesticide Cyfluthrin (see Annex 3). This amended flow-chart is an example of how a visual overview of a pesticide mass balance can be designed.

[75] Commission Regulation (EU) No 68/2013 of 16 January 2013 on the Catalogue of feed materials.

Table 2 *Extract of BfR overview of Processing Factors (PFs).*

residue definition (for monitoring)	main crop group	sub crop group	commodity	commodity code according to Reg. (EC) 396/2005	processed matrix consolidated	Range of individual PF	Median PF	Number of trials	Acceptability of study	Comments	Reference	EFSA reference
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	seed, dried	1.00	1.00	1	indicative	metabolites (SDS-3701, SDS-46851, HCB, PCBN) reported; RAC < LOQ	[272][76]	not applicable
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	seed	< 0.50	< 0.50	1	indicative	[ibid]	[272]	not applicable
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	hulls	3.50	3.50	1	indicative	[ibid]	[272]	not applicable
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	meal	< 0.50	< 0.50	1	indicative	[ibid]	[272]	not applicable
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	oil, crude	1.50	1.50	1	indicative	[ibid]	[272]	not applicable
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	oil, refined	< 0.50	< 0.50	1	indicative	[ibid]	[272]	not applicable
chlorothalonil	oilseeds and oilfruits	oilseeds	soya beans	0401070	soapstock	< 0.50	< 0.50	1	indicative	[ibid]	[272]	not applicable

[76] Kenyon, R.G.; Ballee, D.L. (1987). Residues of tetrachloroisophthalonitrile (chlorothalonil, SDS-2787), SDS-3701, SDS-46851, HCB and PCBN on soybeans - processing study.

3.2.3 FEDIOL

FEDIOL (Fédération de l'Industrie de l'Huilerie de la CEE) is the EU vegetable oil and protein meal industry association that represents the interests of the European oilseed crushers, vegetable oil refiners and bottlers. The organization has developed general guidance on PFs to be applied for fat/hexane soluble pesticides, for eight commodity oilseeds: rapeseed, sunflower seed, soya bean, coconut, palm fruit, palm kernel, groundnut/peanut, and linseed.[77] The FEDIOL document is limited to application in crude oil. The derived PFs are general estimates, but the organization has performed studies which seem to support the approach of using the log P_{ow} value as a predictor of the fate of fat/hexane soluble pesticides during processing of the mentioned commodities.[78]

FEDIOL's approach to PFs is primarily based on the physicochemical properties of the pesticide's active substance - in the form of fat solubility - and the oil/fat content of the raw agricultural product. Physicochemical criteria used to predict the fate of the pesticide's active substance during processing are the octanol-water partition coefficient (log P_{ow}) of the active substance and affinity of the active substance for the extraction solvent. In FEDIOL's approach, a pesticide is regarded as fat soluble if it has the prefix (F) as indicated in Annex II of Regulation (EC) No 396/2005, or if the log P_{ow} of the active substance is equal to or exceeds 3. With that logarithmic value, a substance is 1000 times more soluble in octanol ("*and theoretically, fat*") than in water.[79] If a pesticide active substance is fat soluble, FEDIOL indicates: "*it is reasonable to assume that the pesticide will totally concentrate in the oil after crushing. In this case, the MRL for crude oil corresponds to the seed MRL multiplied by the theoretical processing factor*".[80]

For intermediate log P_{ow} values, i.e. between 1 and 3, the FEDIOL document indicates that "it is reasonable to assume that most of the pesticide will concentrate in the oil after crushing, even though not totally. In this case, the seed MRL multiplied by the corresponding theoretical processing factor (Table 4) gives a good approximation of the MRL in crude oil". If the log P_{ow} is negative, then it is assumed that the pesticide active substance concentrates in the water phase. If no information on the polarity of a pesticide's active substance is available, and it does not have the prefix (F) in the pesticide Regulation (EC) 396/2005, then affinity of the substance for the extraction solvent (e.g. in the case of hexane) or in-house data, are recommended to be considered in the estimation of PFs. The FEDIOL overview of PFs to be applied for fat/hexane soluble pesticides is completely included in Table 3.

Table 3 *FEDIOL overview of processing factors: "Processing factors to be applied for fat/hexane soluble pesticides".*

Oilseed	Average oil %	PF
Rapeseed	40-45	2.5
Sunflower seed	40-45	2.5
Soya bean	18-21	5
Coconut (as it is for fruit incl. coconut water)	20	5
Palm fruit	50-55	2
Palm kernel	45	2
Groundnut/peanut	40-50	2.5
Linseed	40-50	2.5

[77] FEDIOL (2018). Establishing processing factors for vegetable oils and fats, Ref. 11SAF181_rev1. 27 March 2018. Available online at http://www.fediol.be/data/11SAF181_rev1_%20FEDIOL%20position%20on%20pesticide%20MRLs%20in%20vegetable%20oils%20and%20fats_FINAL.pdf (last accessed on 1 October 2019).
[78] FEDIOL provided insight in the confidential report; results are expected to be published later this year.
[79] FEDIOL (2018), 'Establishing processing factors', *supra*, note 77, at p. 3.
[80] *Ibid*., at p. 3.

In the FEDIOL document, it is acknowledged that (historically) the relation between fat solubility, log P_{ow}, and PFs was presented in the context of products of animal origin – citing the 2005 JMPR report.[81] However, as mentioned in section 3.1.5, the current (2016) version of the JMPR manual indicates that the log P_{ow} is only *indicative* of the fat solubility of a pesticide and should not be regarded as the 'prime indicator' anymore for products of animal origin.[82] Moreover, No scientific substantiation of the validity of extending the concept of using figures for fat solubility, based on metabolism studies in animals (meat/fat), to the fate of pesticides in oil of vegetable products is provided in the FEDIOL document.

According to the FEDIOL document; in case of the log P_{ow} value being between 1 and 3, then the pesticide residue should also be assumed to largely concentrate in the oil fraction. This assumption is substantiated with calculations on the percentage of the substance accumulating in fat, see Table 4. At a log P_{ow} value of 2, for instance, 99% of the substance is still expected to accumulate in the fat, just to a slightly lesser extent than 99.9% in case of a log P_{ow} value of 3.[83]

Table 4 *Examples of calculation of log P_{ow}.*

Examples	$C_{octanol}$	C_{water}	P_{ow}	Log P_{ow}	% in octanol
1	1	1	1	0	50.0%
2	10	1	10	1	90.9%
3	100	1	100	2	99.0%
4	1000	1	1000	3	99.9%

Two final remarks are given in the FEDIOL document on the use PFs in case of the pesticide residue definition in Regulation (EC) No 396/2005 comprising multiple compounds, and on the use of PFs in case of the MRL set at the limit of quantification (LOQ):

- *"When the pesticide residue definition covers different substances (parent and metabolites incl. isomers), the fat solubilities of these substances may be different. In such case, information on the log P_{ow} of each individual substance should be considered if available.*
- *The possible concentration effects of processing should be taken into account also in the cases when the MRL is set at the limit of [quantification (LOQ)].[84] The reason for this is that in some cases, undetectable traces of a substance might be present in the seeds, and concentration during processing might lead to detection of a residue in the crude oil."*[85]

Concerning the first point; as discussed in section 3.1.1., consideration of the residue definition is especially important in case of suspected risk for exceeding maximum dietary intake values. The importance of considering the properties of each individual substance in case of a residue definition with multiple substances, is also indicated in the 2016 JMPR report.[86] This statement is accompanied by a number of log P_{ow} calculations to illustrate this point.[87] In most of these examples, pesticides with a log $P_{ow} \geq 3$ were indeed found to be fat soluble in animal metabolism studies. However, in one example the distribution of the pesticide flutolanil (log P_{ow} = 3.17), which is defined as the sum of flutolanil and trifluoromethyl benzoic acid for animal commodities, was comparable for muscle and fat tissues. Thus, there are certainly exceptions to the 'rule' that pesticides log $P_{ow} \geq 3$ are by definition fat soluble.

The second remark refers to a scenario in which the concentration in the raw agricultural product approaches the LOQ, and the PF is > 1; then the concentration in the processed product may exceed the LOQ. If the MRL is set at the LOQ, then the concentration in the processed product would exceed the MRL value. However, the MRL does not apply to the processed product, but to the raw agricultural

[81] JMPR (2005), 'FAO Plant Production and Protection Paper 183', *supra*, note 48.
[82] JMPR (2016a), 'Submission and evaluation of pesticide residues data', *supra*, note 2, at p. 76-77.
[83] FEDIOL (2018), 'Establishing processing factors', *supra*, note 77.
[84] In the quote, the term 'limit of determination' (LOD) is used. Although Regulation (EC) No 396/2005 also uses this term, the abbreviation LOD is generally used for 'limit of detection', which may cause confusion.
[85] FEDIOL (2018), 'Establishing processing factors', *supra*, note 77, at p. 4.
[86] JMPR (2016a), 'Submission and evaluation of pesticide residues data', *supra*, note 2, at p. 77-78.
[87] *Ibid*., at p. 78-79.

version of it. As mentioned, according to article 20 of Regulation (EC) 396/2005, "*changes in the level of pesticide residues caused by processing and/or mixing*" (i.e. PFs) should be taken into account when applying MRLs to processed products. For pesticides not allowed for use on a specific crop (in the EU) the MRL for the raw agricultural product is also set as equal to the LOQ. If the residues of these prohibited pesticides concentrate during processing (PF > 1), residues may be quantified in samples of certain processed products, even though the concentration in the raw agricultural product was not quantifiable and therefore compliant with the MRL. In this situation, the processed product containing a quantifiable concentration of a prohibited pesticide residue is still compliant. Due to continuously increasing specificity of analytical methods, the actual LOQ in a laboratory setting may become lower than the default MRL of 0.01. These developments do not change the MRL value, unless a lower MRL has been set in Annex V of Regulation (EC) No 395/2005.

A document developed by the Dutch MVO (The Netherlands Oils and Fats Industry), in consultation with the NVWA, refers to the FEDIOL approach for the application of PFs.[88] This document concerns notifying requirements on pesticide residues for Dutch companies in the oil and fat processing industry. Additional information is provided, e.g. on measurement uncertainty and application of MRLs and PFs to products intended for animal feed. For by-products ("*i.e. fatty acid distillates*"), additional PFs may be applicable, "*depending on the degree of concentration during the particular process*".[89] The scope of the FEDIOL document only includes application in crude oil, but the MVO extends this to refined oil as well: in an example given in appendix 1 of the MVO document, the same PF for crude oil is applied to refined oil.[90] This extrapolation to refined oil and/or fatty acid distillates is disputable since the pesticide residues may be removed or degraded during the oil refinement process, thus reducing the concentration in comparison to the crude oil.

3.2.4 European database of Processing Factors for pesticides in food (Compendium for EFSA)

BfR, RIVM, and the Benaki Phytopathological Institute (Greece) worked together in a Consortium in a project funded by EFSA[91] to establish a database of processing techniques and PFs, compatible with the EFSA food classification and description system FOODEX2. The FOODEX2 database includes both food and feed. The report consists of three documents, each outlining the results of a different objective:

1. Objective 1: Compendium of Representative Processing Techniques investigated in regulatory studies for pesticides;[92]
2. Objective 2: Linking the processing techniques investigated in regulatory studies with the EFSA food classification and description system, FoodEx2;[93]
3. Objective 3: European database of PFs for pesticides in food.[94]

The objective of this list is to enable enforcement. Dietary risk assessment was not within the scope of the project. However, in a pilot project, a second database was developed for PFs to be used for that purpose. Only a limited number of compounds could be included therein however, and extension of the database was therefore recommended for future research.

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[88] MVO. MVO notifying requirements on pesticide residues. Available online at https://www.mvo.nl/en-mvo-notifying-requirements-on-pesticides (last accessed on 1 October 2019).
[89] *Ibid*., at p. 2.
[90] *Ibid*., at p. 5.
[91] EFSA grant number: GP/EFSA/PRAS/2016/01.
[92] Scholz R, 2018. Database of processing techniques and processing factors compatible with the EFSA food classification and description system FoodEx 2 Objective 1: Compendium of Representative Processing Techniques investigated in regulatory studies for pesticides. EFSA supporting publication 2018:EN-1508. 204 pp. doi:10.2903/sp.efsa.2018.EN-1508.
[93] Donkersgoed, G. van et al, 2018. Database of processing techniques and processing factors compatible with the EFSA food classification and description system FoodEx2 related to pesticide residues, Objective 2: Linking the processing techniques investigated in regulatory studies with the EFSA food classification and description system FoodEx2. EFSA supporting publication 2018:EN-1509. 25 pp. doi:10.2903/sp.efsa.2018.EN-1509.
[94] Scholz R, 2018. Database of processing techniques and processing factors compatible with the EFSA food classification and description system FoodEx 2 Objective 3: European database of processing factors for pesticides in food. EFSA supporting publication 2018:EN-1510. 50 pp. doi:10.2903/sp.efsa.2018.EN-1510.

As with the RIVM and BfR list, this database provides Excel spreadsheets.[95] The primary Excel file of PFs for enforcement purposes consists of four sheets. The first sheet ('ReadMe') gives guidance on the different codes used in the database. The second sheet ('ProcStudies Evaluation') contains the parameters considered in the evaluated studies. Parameters include e.g. the analytical method and limit of quantification (LOQ) used in the study, storage conditions considered, and an assessment on whether the reported PFs are acceptable or not, with remarks given on why or why not. In the third sheet ('List Median PF'), median PFs are provided for specific processed commodities, as well as information on the number of individual PFs the median is based on, and an assessment on whether the median PF is reliable. The final sheet ('References') contains references to all studies considered in the database.
The second Excel database for dietary risk assessment purposes contains two sheets. The first sheet is a 'ReadMe' with guidance on codes used in the database; the second sheet ('FoodEx2 coding processed foods') links products listed in the FoodEx2 database to applicable PFs listed in the first Excel file ('Compendium').

Regarding how PFs were derived from studies: *"according to comprehensible calculation rules and based on the residue definitions for monitoring, the individual PFs were judged for their acceptability. For each commodity/process/active substance combination a median PF was calculated from the individual ones, based on the trials from one or more studies. The database is a ready-to-use inventory of PFs for pesticides in a variety of processed food items"*.[96]

3.3 Evaluation and comparison of publicly available lists of processing factors

A number of different aspects were compared between the different publicly available lists of PFs, described in section 3.2:
- Type of products considered;
- Pesticide residues considered and intended use;
- Sources and extrapolation;
- Correlation between log P_{ow} of pesticide active substances and PFs.

3.3.1 Type of products considered

The BfR and RIVM lists and the Compendium for EFSA give detailed PFs for various processed forms of most commodities listed in Annex I of Regulation (EC) No 396/2005. The BfR list includes processed feed materials as a matrix (e.g. soya bean meal) for PFs of certain pesticides, while the RIVM list only focuses on food products and not on feed. The Compendium for EFSA is similar to the RIVM list in the sense that the focus is on food. The FEDIOL list of PFs is a general estimate for a specific type of processed product (i.e. crude oil) and is intended to be used by the food and feed industry.

3.3.2 Pesticide residues considered and intended use

The practical implementation of each list is highly influenced by its respective intended purpose, which is connected to the residue definition used. The purpose of the RIVM list is to aid in dietary risk assessment in specific cases, and pesticide residue definitions therefore may include additional metabolites of toxicological relevance. The objective of the BfR list is enforcement, which is why pesticide residue definitions are differentiated by marker compounds. One of the two stated objectives of the BfR list is to assess whether a processed food was produced from a raw product which complied with the legal MRL.[97] The FEDIOL approach discriminates between groups of pesticides based on their fat-solubility but does not consider individual pesticides, in contrast to the other lists, nor does it consider pesticide residues other than the parent compound. Residue definitions in the Compendium

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[95] Scholz et al. (2018). European database of processing factors for pesticides in food. Available online at: https://zenodo.org/record/1488653#.XJiP6SL0ltS.
[96] Scholz et al. (2018),'Compendium: Objective 1', *supra*, note 92, at p. 3.
[97] Scholz et al. (2017), 'Compilation of processing factors', *supra*, note 72.

for EFSA are also for enforcement; although the second database developed in the pilot project focuses on residue definitions for dietary risk assessment.

3.3.3 Sources and extrapolation

Each of the described lists makes use of different sources. The Compendium for EFSA contains a variety of different publications as direct sources, but also makes use of JMPR reports. Compared to the Compendium for EFSA, the BfR list also contains PFs from monitoring results. The RIVM list uses a combination of sources, but – unlike in the BfR list - PFs for certain pesticide/product combinations are extrapolated from other combinations. This was also done in the Compendium for EFSA. No such interpretations were done for the BfR list: only parameters published in literature were used, as well as an assessment of the acceptability of cited studies. According to Scholz et al. (2017), the actual processing studies have been reviewed for the current version of the list.[98] Finally, the FEDIOL approach does not link specific PFs to commodity/pesticide combinations but it is of a more general nature. The source recommended by FEDIOL for log P_{ow} values is the Pesticide Properties Database (PPDB).

3.3.4 Correlation between log P_{ow} and processing factors of pesticides

According to the FEDIOL approach: if a pesticide residue is fat soluble (i.e. the pesticide has suffix (F) in Regulation (EC) No 396/2005, or its active substance log $P_{ow} \geq 3$), then the pesticide's active substance will concentrate in the fat fraction; if the pesticide is not fat-soluble (i.e. the pesticide has not suffix (F), and its active substance log $P_{ow} < 0$), then the pesticide's active substance will concentrate in the water fraction. For pesticides with a log P_{ow} between 1 and 3, according to FEDIOL, "*it is reasonable to assume that most of the pesticide [read active substance] will concentrate in the oil after crushing, even though not totally. In this case, the seed MRL multiplied by the corresponding theoretical processing factor* [Table 4, section 3.2.3. above] *gives a good approximation of the MRL in crude oil"*.[99]

In order to determine the correlation between the log P_{ow} for the active substance and experimentally determined PFs for the pesticide residue consisting of parent only, median PFs for the crude oil fraction of rape seed and sunflower seed in the BfR list were collected (104 data points representing PFs). According to FEDIOL, both rape and sunflower seed would have a PF of 2.5.[100] Several of the 104 PFs were not used in the analysis: those with a multi-residue definition, those with a median PF reported as < X; and those marked as not being acceptable or indicative. From these 104 PFs, 24 remained after removal of non-usable data: nine for sunflower oil, and fifteen for rapeseed oil. Out of nine entries in the BfR database for sunflower oil, eight appear to be identical. The corresponding log P_{ow} values for these pesticide active substances were obtained from the Pesticide Properties Database (PPDB).[101] For the pesticide mepiquat, no log P_{ow} is reported in the PPDB and this PF was thus also not plotted. The data is shown in Annex 4, and were plotted in a scatter chart, as shown in Figure 2.

[98] *Ibid*.
[99] FEDIOL (2018), 'Establishing processing factors', *supra*, note 77, at p. 4.
[100] *Ibid*.
[101] University of Hertfordshire (n.d.). The PPDB - Pesticide Properties Database. Available online at https://sitem.herts.ac.uk/aeru/ppdb/en/ (last accessed on 1 October 2019). Log P_{ow} values are impacted by pH and temperature. The log P_{ow} values in the PPDB are reported for pH 7 and a temperature of 20°C.

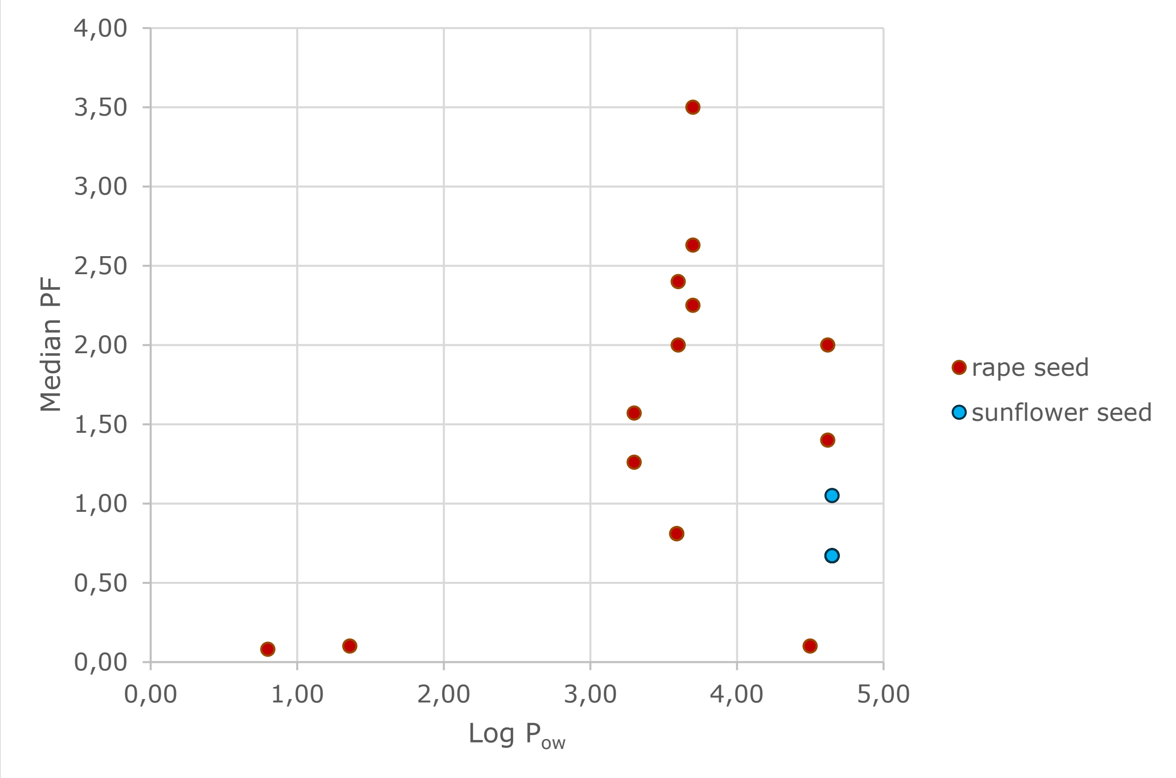

Figure 2 *Relationship between octanol-water partition coefficient (expressed as a log Pow value) and processing factors (PFs) for fat soluble and non-fat soluble pesticides in the oil fraction.*

Figure 2 indicates that the reported PFs are highly scattered without apparent correlation between the PF and log P_{ow} of a pesticide residue consisting of parent only. According to the FEDIOL approach, in case of a log P_{ow} ≥ 3, the PF for these commodities would be 2.5. For the 22 data points with log P_{ow} ≥ 3, the median PF is 1.27 and ranges from 0.08-3.5. Moreover, three data points with a log P_{ow} ≥ 3 have a corresponding PF below 1 (i.e. bottom right of Figure 2). Although these pesticides would thus be thought of as highly fat soluble under the FEDIOL approach; the low PF indicates that the residue does not concentrate in the oil fraction.

It must be noted that the number of data points with a log P_{ow} ≥ 3 is relatively small, which makes it difficult to draw any firm conclusions on PFs in this range. In addition, the processing parameters used in the studies referenced in the BfR database may be different from the parameters envisioned in the FEDIOL approach. Verification of those parameters is beyond the scope of this study. Nonetheless, the data suggest that the FEDIOL approach of predicting the PF of a pesticide in crude vegetable oil based on the pesticide’s active substance log P_{ow} value, is not substantiated by these specific data. Factors other than fat solubility should also be taken into account when determining a PF – such as time of application of a pesticide (before flowering, shortly before harvesting or post-harvesting), residue definition, surface properties of the pesticide residue, hydrolysis and heat stability of the pesticide residue.[102] In addition, the log P_{ow} values as reported in the PPDB are valid for specific parameters (pH 7 and a temperature of 20°C.): physical processing may occur under very different circumstances, and the octanol-water coefficient of a pesticide under these circumstances may therefore also differ. These factors may explain the discrepancy between the FEDIOL approach and BfR data.

[102] EU guidelines for the generation of residue data required under Dir 91/414/EC and Reg. EC 396/2005 – Appendix E on Processing studies.

4 Conclusion and recommendations

4.1 Conclusion

The legal landscape on pesticide MRLs and PFs was described in this study. In the EU, a number of legislative acts make up the legal framework – which is highly intertwined with the Codex Alimentarius system. The EU list of MRLs applies to agricultural products 'from the time they are placed on the market as food or feed'. In case of processed products, a PF should be applied to assess the dietary risk or compliance of the product.

The primary active substance residue ('parent compound') in an agricultural product treated with pesticides may be accompanied by metabolites, degradation products, and/or impurities. Including all potential other substances in a residue definition may not be practical due to costs and/or complexity of analyses.

Different pesticide residue definitions are being used by different organizations in relation to the application: either for enforcement, preferably based on a single reference compound or for dietary risk assessment, based on toxicologically relevant compounds.

The fat solubility of pesticide residues plays a role in the distribution of the pesticide residues between the different components of an agricultural product. The log P_{ow} is an indicator of the fat solubility of a pesticide, but other factors also play a role in how pesticide residues are distributed within a product.

An analysis was made of how MRLs are applied to processed products by EU member states. It appears that sampling for checking compliance with pesticide MRLs is currently largely performed on unprocessed products.

Various approaches to the application of PFs were described in an overview of the lists of PFs that are publicly available (RIVM, BfR, FEDIOL, Compendium for EFSA). These lists were evaluated and compared. A number of differences were highlighted in terms of type of products considered, pesticide residues considered and intended use, and concerning sources and extrapolation. In addition, the correlation between the log P_{ow} and PFs was evaluated for pesticides with a residue definition consisting of parent only. The use of PFs in the application of MRLs to products is complex and the number of individual pesticide/matrix combinations is very high. The mentioned organizations have taken different systematic approaches to this issue. FEDIOL adopted an approach based on fat solubility of pesticide active substances combined with the fat content of oil seeds. PFs predicted via this approach were compared to published data from the BfR database on processing studies. The predicted PFs did not correspond well with these data, which may have been due to other factors than fat solubility that play a role in the distribution of pesticide residues in processed products. It does not appear to be possible to derive straightforward methods from the information studied that would enable a generally applicable extrapolation from raw to processed products.

4.2 Recommendations

There are several aspects that introduce a large degree of uncertainty when applying PFs. Each PF is connected to a process, pesticide residue and commodity. These characteristics may vary between the sampled processed product and the circumstances of the processing study underlying this PF. This uncertainty must be considered when using PFs to estimate the concentration of a pesticide residue in a raw agricultural product, based on the concentration measured in the processed product. When the exact pesticide residue concentration in the original raw agricultural product cannot be directly determined, the (non-) compliance of this concentration with the MRL cannot be determined with certainty either. Due to this complexity and uncertainty of PFs, it is recommended to measure the pesticide residue concentration in the raw agricultural product as much as possible to check for direct compliance with legal limits. If this is not feasible, for instance in case of imported products, authorities and industry should be transparent in how these interpretations are made. Preferably, significantly elevated levels in processed products are subjected to a risk analysis, taking into account the specific processing circumstances.

A comprehensive approach to the fate of pesticide residues during processing is preferred over heterogeneous data on processed products from different studies. Additional research should focus on the availability and acquiring of a mass balance of pesticide concentrations in processed products. This should be done to avoid inconsistencies between processing methods used in different studies. The availability of full mass balances was also preferred by the authors of the Compendium for EFSA.[103] It is recommended to use validated PFs based on experimental data as much as possible.

The databases evaluated in this report primarily focus on food products specifically; no extensive inventory of PFs has therefore been made for feed products yet. More PFs for feed products may be available in JMPR reports and/or literature. It is recommended to investigate this literature to create a better overview of PFs for feed products.

Finally, more research is recommended on the correlation between log P_{ow} of pesticide active substances and PFs for crude oil of vegetable origin for pesticides with a residue definition consisting of parent only to verify the FEDIOL approach.

[103] Scholz et al. (2018), 'Compendium: Objective 1', *supra*, note 92, at p. 13.

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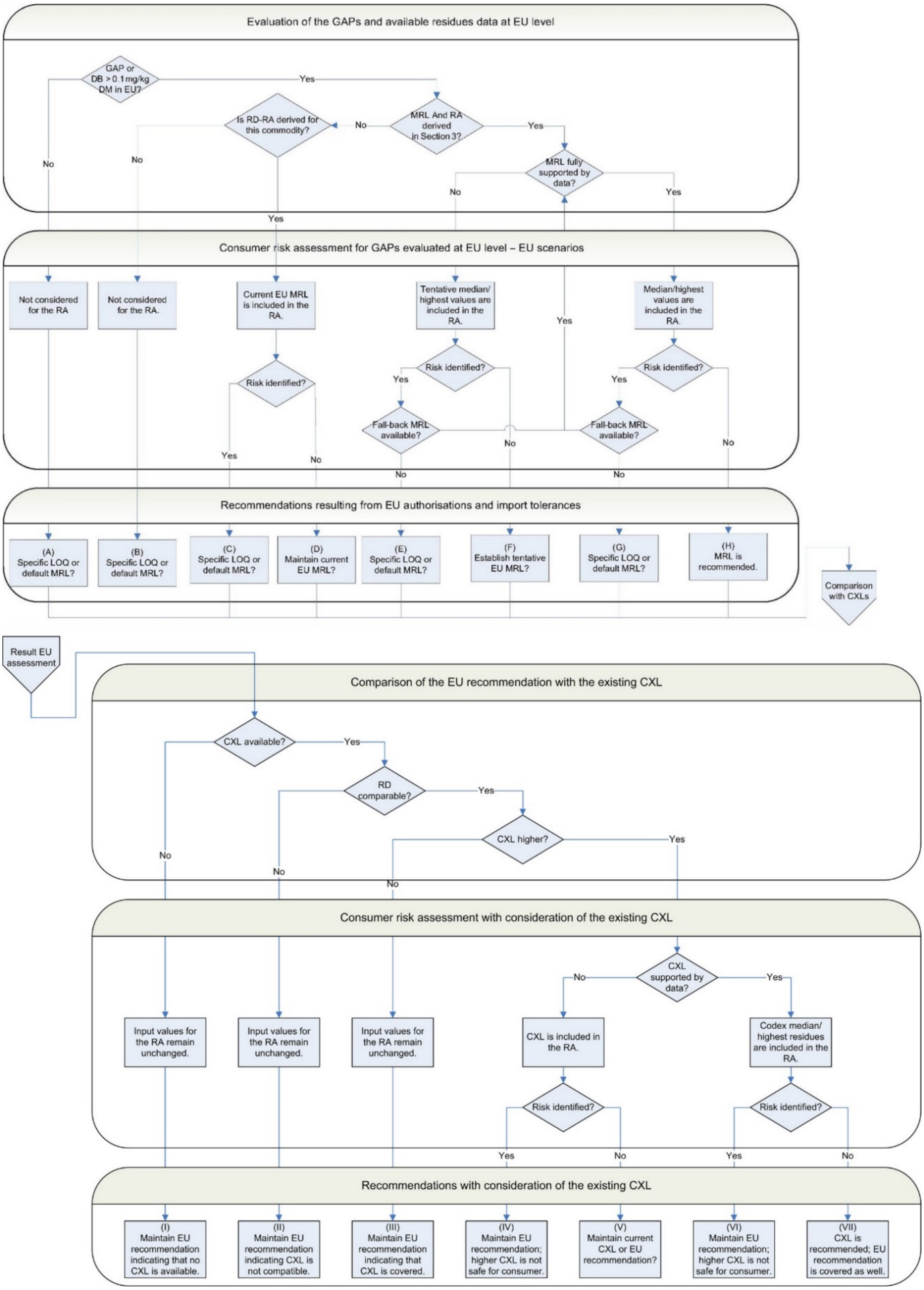
Legislation

- 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
- Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC
- Commission Regulation (EU) No 546/2011 of 10 June 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards uniform principles for evaluation and authorisation of plant protection products
- Commission Regulation (EU) No 68/2013 of 16 January 2013 on the Catalogue of feed materials
- Commission Regulation (EU) No 283/2013 of 1 March 2013 setting out the data requirements for active substances, in accordance with Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market
- Commission Regulation (EU) No 212/2013 of 11 March 2013 replacing Annex I to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards additions and modifications with respect to the products covered by that Annex
- Council Directive 86/362/EEC of 24 July 1986 on the fixing of maximum levels for pesticide residues in and on cereals
- Council Directive 86/363/EEC of 24 July 1986 on the fixing of maximum levels for pesticide residues in and on foodstuffs of animal origin
- Council Directive 90/642/EEC of 27 November 1990 on the fixing of maximum levels for pesticide residues in and on certain products of plant origin, including fruit and vegetables

Annex 1 EFSA decision tree for deriving MRL recommendations



From: European Food Safety Authority (EFSA), Anastassiadou, M., Brancato, A., Carrasco Cabrera, L., Ferreira, L., Greco, L., ... & Miron, I. (2019). Review of the existing maximum residue levels for pyriofenone according to Article 12 of Regulation (EC) No 396/2005. EFSA Journal, 17(6), e05711.

Legend

CXL: codex maximum residue limit
DB: dietary burden
DM: dry matter
EU: European Union
GAP: Good Agricultural Practices
LOQ: limit of quantification
MRL: maximum residue level
RA: risk assessment
RD: residue definition

Annex 2 Soya bean flow-charts from BfR and Compendium for EFSA

OILSEEDS AND OILFRUITS: Oilseeds 4 (soya bean)

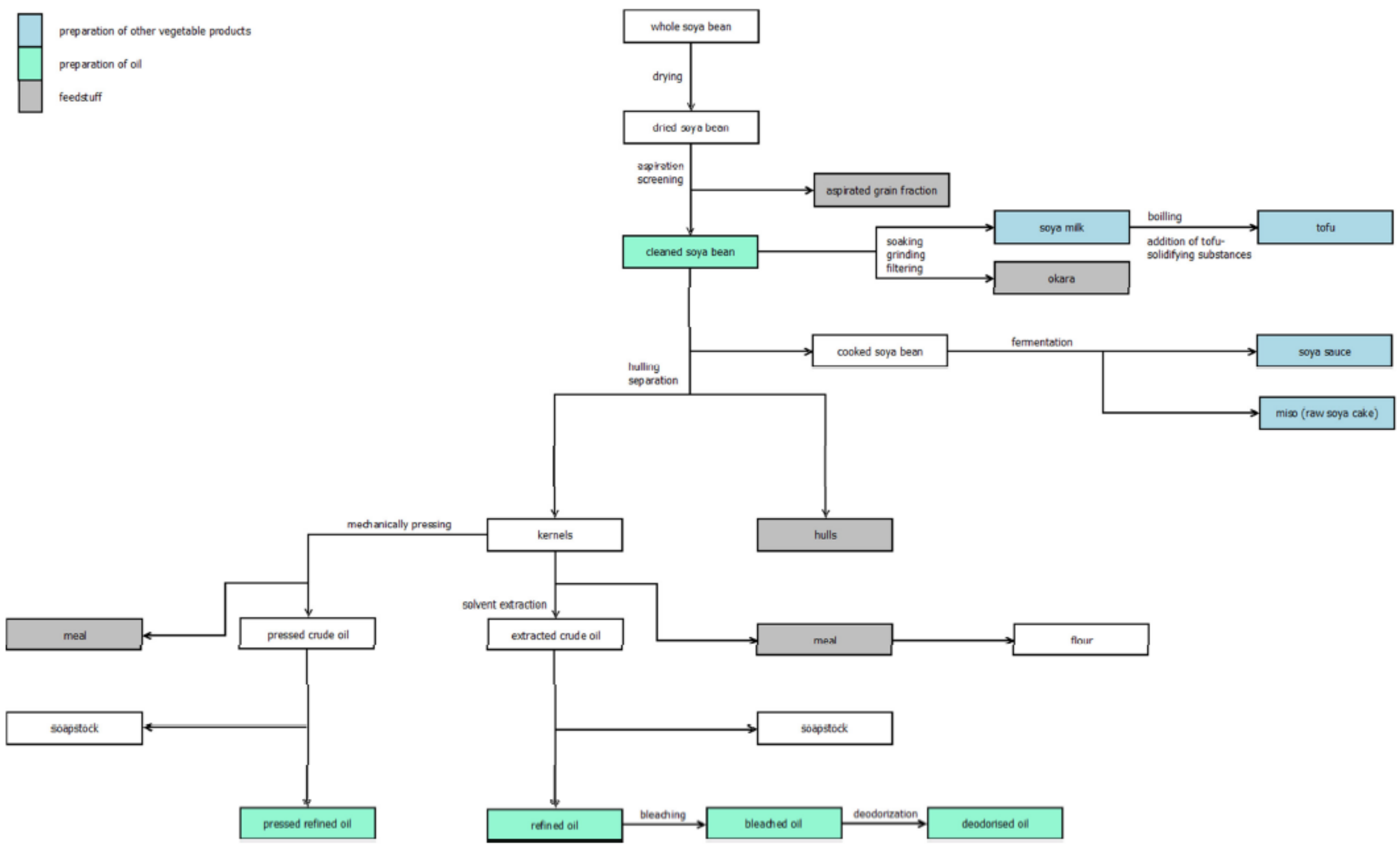


Figure 3 *Example of a graphic flow-chart developed by BfR.*

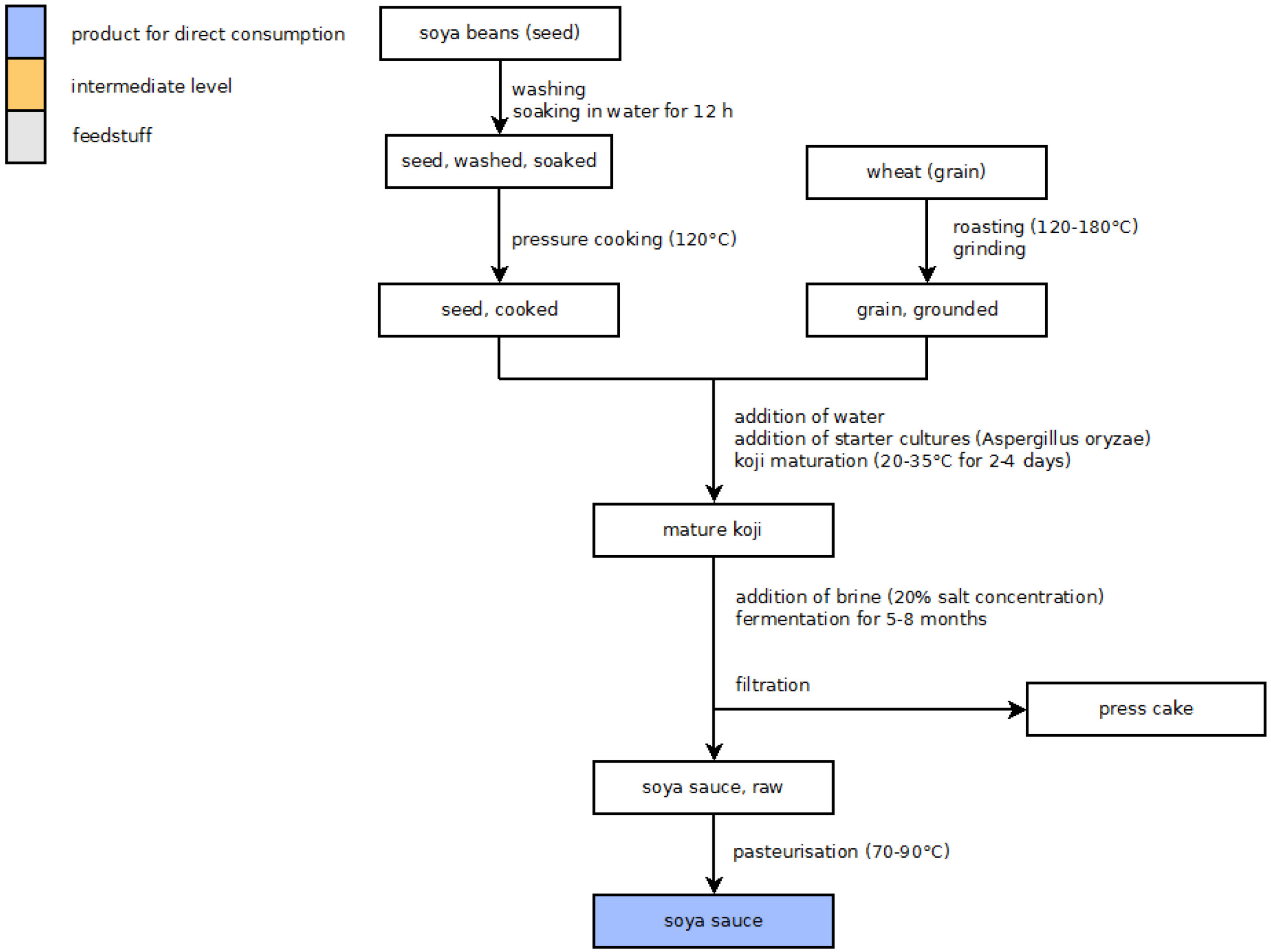


Figure 4 *Example of a graphic flow-chart developed in the European database of processing factors for pesticides in food (Compendium for EFSA).*

Annex 3 Amended soya-bean flow-chart

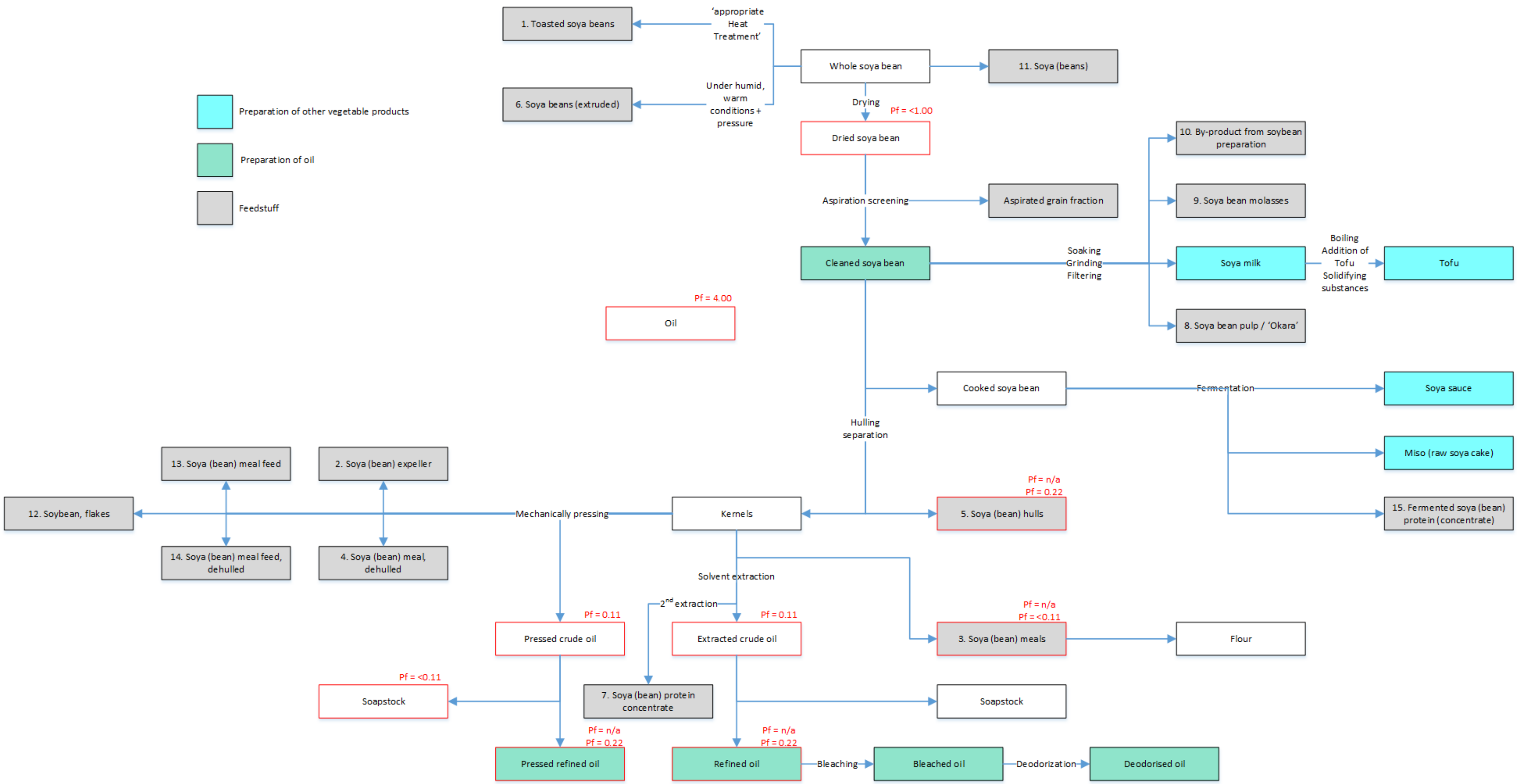


Figure 1 *Amended BfR soya-bean flow-chart, including feed products and reported processing factors, for the pesticide Cyfluthrin.*

Annex 4 Data used to plot log P_{ow} and processing factors of pesticides

Sub crop group	residue definition (for monitoring)	Log P_{ow}	Median PF	Number of trials	Comments	Reference	EFSA reference intern	Processed matrix consolidated	range of individual PF
rape seed	Acetamiprid	0.80	0.08	2	SOP PO 353	[1471]	not applicable	oil, crude	0.06, 0.10
	cycloxydim	1.36	0.10	4	metabolites (BH 517-5-OH-TSO2, BH 517-TSO) reported	[329]	not applicable	oil, crude	0.10 - 0.20
	dimoxystrobin	3.59	0.81	2	liquid/liquid partitioning with a acetonitrile/methanol mixture	[470]	not applicable	oil, crude	< 0.63, 1.00
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	dimoxystrobin	3.59	0.81	2	liquid/liquid partitioning with a acetonitrile/methanol mixture	[470]	not applicable	oil, crude	< 0.63, 1.00
	fluazifop-P-butyl (fluazifop acid (free and conjugate))	4.50	0.10	2	residues reported for fluazifop-p-butyl and its metabolite fluazifop-p	[616]	not applicable	oil, crude	0.09, 0.10
	fluopyram	3.30	1.57	2	active metabolites (fluopyram-pyridylacetic acid, fluopyram-benzamide, fluopyram-carboxylic acid) reported	[648]	not applicable	oil, crude	1.00, 2.14
	fluopyram	3.30	1.26	2	active metabolites (fluopyram-pyridylacetic acid, fluopyram-benzamide, fluopyram-carboxylic acid) reported	[649]	not applicable	oil, crude	1.25, 1.27
	penthiopyrad	4.62	2.00	3	active metabolites reported (753-A-OH, PAM, DM-PCA, 753-F-DO)	[979]	EFSA Journal 2012;10(10):2948	oil, crude, pressed	0.80 - 2.60
	penthiopyrad	4.62	1.40	3	active metabolites reported (753-A-OH, PAM, DM-PCA, 753-F-DO)	[979]	EFSA Journal 2012;10(10):2948	oil, crude, extracted	0.50 - 2.30
	picoxystrobin	3.60	2.40	2	active metabolites reported ((E)-3-Methoxy-2-[2-(6-trifluoromethyl-2-pyridyloxymethyl)-phenyl]acrylic acid, 6-(Trifluoromethyl)-1H-pyridin-2-one, 2-[2-(6-Trifluoromethyl-2-pyridyloxymethyl)] benzoic acid)	[1414]	EFSA Journal 2016;14(6):4515	oil, crude, pressed	1.60, 3.20

Sub crop group	residue definition (for monitoring)	Log P_{ow}	Median PF	Number of trials	Comments	Reference	EFSA reference intern	Processed matrix consolidated	range of individual PF
	picoxystrobin	3.60	2.00	2	active metabolites reported ((E)-3-Methoxy-2-[2-(6-trifluoromethyl-2-pyridyloxymethyl)-phenyl]acrylic acid, 6-(Trifluoromethyl)-1H-pyridin-2-one, 2-[2-(6-Trifluoromethyl-2-pyridyloxymethyl)] benzoic acid)	[1414]	EFSA Journal 2016;14(6):4515	oil, crude, extracted	1.40, 2.50
	tebuconazole	3.70	3.50	2		[1149]	not applicable	oil, crude, extracted	2.00, 5.00
	tebuconazole	3.70	2.25	2		[1149]	not applicable	oil, crude, pressed	1.00, 3.50
	tebuconazole	3.70	2.63	2		[1149]	not applicable	oil, crude	1.50, 3.75
sunflower seed	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	0.67	3		[365]	not applicable	oil, crude	0.10 - 2.38
	famoxadone	4.65	1.05	2	SOP PO 353	[365]	not applicable	oil, crude	0.11, 2.00

[329]: Schulz, H. (2003). Determination of the residues of Cycloxydim and its metabolite in rape and processed products following treatment with BAS 517 24 H under field conditions in Germany and Spain 2001.

[365]: Foster, A.; Haigh, I. (2009). Magnitude of residues of cymoxanil and famoxadone in processed fractions of sunflowers (oilseeds) following exaggerated applications of cymoxanil/famoxadone (DPX-KP481) 50WG (1:1) - Europe, season 2008.

[470]: Versoi, P. L.; Abdel-Baky, S. (2001). The magnitude of BAS 505 F residues in canola seed processed fractions

[616]: Bolygo, E. (1994). Fluazifop-P-butyl: Residues in oilseed rape and its processed products following spring application from a field study (RS-9306) and processing studies (93 10 47 017 and P 66232503) carried out in Germany during 1993-94.

[648]: Schöning, R.; Räcker, T.; Telscher, M. (2007). Determination of the residues of AE C656948 in/on winter rape and summer rape and the processed fractions (oil, refined; oil, screwpressed; crude oil; extracted meal; oil, solv. extracted; pomace) after spraying of AE C656948 (500 SC) in the field in Southern France and Italy.

[649]: Schöning, R.; Räcker, T.; Telscher, M. (2007). Determination of the residues of AE C656948 in/on winter rape seed and the processed fractions (oil, refined; oil, screwpressed; crude oil; extracted meal; oil, solv. extracted; pomace) after spraying of AE C656948 (500 SC) in the field in Germany.

[979]: Thiel, A.; Rodgers, C. A. (2009). Magnitude of residues of Penthiopyrad and its metabolites in processed fractions of canola (oilseed) following applications of DPX-LEM17 20SC under maximum label rate - USA and Canada, 2007.

[1149]: Wolters, A.; Erler, S.; Billian, P. (2007). Determination of the residues of Tebuconazole in/on winter rape seed and the processed fractions (oil, screwpressed; extracted meal; oil, sol. extracted; crude oil; oil, refined; pomace) after spraying of Folicur (250 EW) in the field in Northern France and Germany.

[1414]: Thiel, A. (2010). Magnitude of residues of picoxystrobin and its metabolites in processed fractions of canola following application of DPX-YT669 250SC (250 g a.i./L) at 5x maximum label rate - USA, Canada 2008.

[1471]: Schneider, E. (2016). Determination of Acetamiprid residues in oilseed rape raw agricultural commodity and processed fractions following two foliar applications with Acetamiprid 12% SL under field conditions in Northern Europe in 2016.

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