SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 23 June 2021

doi: 10.2903/j.efsa.2021.6715

Safety for the environment of a feed additive consisting of nicarbazin (Coxar®) for use in turkeys for fattening (Huvepharma N.V.)

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Abstract

Following a request from the European Commission, the Panel on Additives and Products or substances used in Animal Feed (FEEDAP Panel) was asked to deliver a scientific opinion on the safety for the environment of the coccidiostat Coxar® (nicarbazin) when used in feed for turkeys for fattening. In previous assessments, the FEEDAP Panel could not conclude on the safety of Coxar® for the environment due to concerns on 4,40-dinitrocarbanilide (DNC, one of the moieties of nicarbazin). On the basis of the new data provided, the FEEDAP Panel updates its previous conclusions on the safety of Coxar® for the environment as follows: The use of nicarbazin from Coxar® in complete feed for turkeys does not pose a risk for the terrestrial and aquatic compartment and in sediment. No concern for groundwater is expected. The bioaccumulation potential of nicarbazin in the environment is low.

Keywords: Example: Coxar®, nicarbazin, coccidiostats, turkeys for fattening, safety for the environment

Requestor: European Commission

Question number: EFSA-Q-2021-00103

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Declarations of interest: The declarations of interest of all scientific experts active in EFSA's work are available at https://ess.efsa.europa.eu/doi/doiweb/doisearch.

Acknowledgements: The Panel wishes to acknowledge the contribution of Jaume Galobart I Cots, Elisa Pettenati, and Jordi Tarres Call to this opinion.

Suggested citation: EFSA FEEDAP Panel (EFSA Panel on Additives and Products or Substances used in Animal Feed), Bampidis V, Bastos ML, Christensen H, Dusemund B, Fašmon Durjava M, Kouba M, López-Alonso M, López Puente S, Marcon F, Mayo B, Pechová A, Petkova M, Ramos F, Sanz Y, Villa RE, Woutersen R, Finizio A, Focks A, Teodorovic I, Vettori MV and Azimonti G, 2021. Scientific Opinion on the safety for the environment of a feed additive consisting of nicarbazin (Coxar®) for use in turkeys for fattening (Huvepharma N.V.). EFSA Journal 2021;19(7):6715, 11 pp. https://doi.org/10.2903/j.efsa.2021.6715

ISSN: 1831-4732

The EFSA Journal is a publication of the European Food Safety Authority, a European agency funded by the European Union.

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

Regulation (EC) No 1831/2003[1] establishes the rules governing the Community authorisation of additives for use in animal nutrition and, in particular Article 9 defines the terms of the authorisation by the Commission.

The applicant, Huvepharma NV, is seeking a Community authorisation of Nicarbazin as a feed additive to be used as a coccidiostat for turkeys for fattening (Table 1).

Table 1: Description of the substances

Category of additive	Coccidiostats and histomonostats
Functional group of additive	Coccidiostat
Description	Nicarbazin
Target animal category	Turkeys for fattening
Applicant	Huvepharma NV
Type of request	New opinion

On 6 March 2018, the Panel on Additives and Products or Substances used in Animal Feed of the European Food Safety Authority ("Authority"), in its opinion on the safety and efficacy of the product, could not conclude on the safety of Nicarbazin for the environment, under the conditions of use proposed by the applicant.

The Commission gave the possibility to the applicant to submit complementary information in order to complete the assessment and to allow a revision of Authority's opinion. The new data has been received on 10 October 2018 and were already transmitted to the Authority by the applicant.

In view of the above, the Commission asks the Authority to deliver a new opinion on Nicarbazin as a feed additive for turkeys for fattening based on the additional data submitted by the applicant.

2. Data and methodologies

2.1. Data

The present assessment is based on data submitted by the applicant in the form of additional information[2] to a previous application of the same product.[3]

2.2. Methodologies

The approach followed by the FEEDAP Panel to assess the safety for the environment and the efficacy of Coxar® (nicarbazin) is in line with the principles laid down in Regulation (EC) No 429/2008[4] and the relevant guidance document: Technical Guidance for assessing the safety of feed additives for the environment (EFSA, 2008).

3. Assessment

Coxar®, containing nicarbazin as the active substance, is a feed additive intended to be used for the prevention of coccidiosis in turkeys for fattening up to 16 weeks of age at a concentration of 100 mg kg complete feed.

In 2018, the FEEDAP Panel adopted an opinion on the safety and efficacy of Coxar® (nicarbazin) for turkeys for fattening (EFSA FEEDAP Panel, 2018) and concluded that the additive is safe for the target species, consumers and users. No conclusions on the safety for the environment and efficacy could be made.

[1] Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition. OJ L 268, 18.10.2003, p. 29.
[2] FEED dossier reference: FAD-2018-0080.
[3] FEED dossier reference: FAD-2015-0039.
[4] Commission Regulation (EC) No 429/2008 of 25 April 2008 on detailed rules for the implementation of Regulation (EC) No 1831/2003 of the European Parliament and of the Council as regards the preparation and the presentation of applications and the assessment and the authorisation of feed additives. OJ L 133, 22.5.2008, p. 1.

The applicant submitted new data on the safety of the additive for the environment, which is the subject of this opinion. No additional data have been provided on the efficacy in the present submission.

3.1. Safety for the environment

Nicarbazin, the active substance in Coxar®, is an equimolar complex of 4,4′-dinitrocarbanilide (DNC) and 2-hydroxy-4,6-dimethylpyrimidine (HDP) in a 70:30 w/w ratio, which splits during the intestinal passage. Consequently, the environmental risk assessment should not consider nicarbazin but both components separately.

In its recent opinion on the safety and efficacy of Coxar® for turkeys for fattening (EFSA FEEDAP Panel, 2018), the FEEDAP Panel concluded as follows:

> In its recent opinion on the safety and efficacy of Monimax® for turkeys for fattening, corresponding to a maximum use level of 50 mg nicarbazin/kg feed (EFSA FEEDAP Panel, 2017) the FEEDAP Panel stated that:
>
> A final conclusion on the risk resulting from the use of nicarbazin from Monimax® in turkeys cannot be made for the following reasons: (i) DNC refined PECs showed uncertainties linked to the very high persistence of the compound, (ii) DNC might accumulate in the sediment compartment, and (iii) DNC can potentially bioaccumulate and may cause secondary poisoning. The PEC/PNEC ratios indicate a risk for daphnids but no adverse effect were seen at the concentration tested. This adds further uncertainty to the risk assessment of DNC in the aquatic compartment. No concerns would arise for the HDP moiety of nicarbazin excreted from turkeys fed Monimax®. The potential of DNC to accumulate in soil over the years should be investigated by monitoring in a field study.
>
> The same conclusions can be extended to the current assessment considering also that the dose of nicarbazin in Coxar® (100 mg/kg complete feed) is higher than in Monimax® (50 mg/kg feed): based on the available data, the FEEDAP Panel cannot conclude on the safety of Coxar® for the environment'.

In 2019, the environmental risk assessment of the nicarbazin in Monimax® has been updated by the FEEDAP Panel, following the submission of additional data (EFSA FEEDAP Panel, 2019). The updated conclusions are the following:

> 'No concerns would arise for the HDP moiety of nicarbazin excreted from chickens for fattening, chickens reared for laying and turkeys fed Monimax®. The use of DNC moiety of nicarbazin from Monimax® in complete feed for chickens for fattening, chickens reared for laying and turkeys for fattening poses no risk for the aquatic and terrestrial compartments or for sediment. The bioaccumulation potential of DNC in the environment is low and the risk for secondary poisoning is not likely to occur'.

The same additional data to address the uncertainties linked to the high persistence of DNC for the environment has been submitted in the current dossier.

The FEEDAP Panel noted that the conclusions in 2019 were drawn for the use of nicarbazin from Monimax® in turkeys at the recommended inclusion level of 40–50 mg/kg complete feed.

With the present assessment the safety of Coxar® (containing nicarbazin) has been updated considering the data in the dossier submitted to EFSA in 2015,[5] the new data provided for the current dossier and the conditions of use of the additive under assessment, 100 mg nicarbazin/kg complete feed.

3.1.1. Phase I

Physico-chemical properties

The physico-chemical properties of DNC and HDP are summarised in Tables 2 and 3.

[5] FAD-2015-0039.

Table 2: Physico-chemical properties of DNC

Property	Value	Unit
Octanol/water partition coefficient (log K_{ow})[(a)]	3.25 (pH 5) 3.21 (pH 7) 3.23 (pH 9)	–
Water solubility (20°C)[(b)]	0.0209 (pH 5–9, 20 ± 0.5°C)	mg/L
Dissociation constant (pKa)[(a)]	12.44 ± 0.70[(1)]	–
Vapour pressure[(a)]	3.1×10^{-10}	Pa

DNC: 4,4′-dinitrocarbanilide.
(1): Estimated - substance exhibits insufficient water solubility and ultraviolet-visible absorptivity to enable experimental determination.
(a): FAD-2015-0039/Technical dossier/Reference_III_46.
(b): FAD-2015-0039/Technical dossier/Reference_III_43.

Table 3: Physico-chemical properties of HDP

Property	Value	Unit
Octanol/water partition coefficient (log K_{ow})[(a)]	–0.9546 (pH 5) –0.9232 (pH 7) –0.9528 (pH 9)	–
Water solubility (20°C)[(a)]	66,740 (pH 5, 20°C) 65,400 (pH 7, 20°C) 70,290 (pH 9, 20°C)	mg/L
Dissociation constant (pKa)[(a)]	3.75 (25°C)	–
Vapour pressure[(a)]	9.084×10^{-6} (20°C) 1.834×10^{-5} (25°C)	Pa

HDP: 2-hydroxy-4,6-dimethylpyrimidine.
(a): FAD-2015-0039/Technical dossier/Reference_III_45.

Fate and behaviour

The studies submitted for the characterisation of the fate and behaviour of DNC and HDP were already assessed in previous FEEDAP opinions (EFSA FEEDAP Panel, 2017, 2018, 2019). The main outcomes of those evaluations are briefly summarised below.

Fate in soil

Adsorption/desorption in soil

Two Good Laboratory Practice (GLP)-compliant studies following the OECD guideline 106 for soil adsorption/desorption (batch equilibrium method) were submitted. One study was performed with DNC,[6] and the other with HDP[7] (five soils of different properties using ^{14}C radiolabelled DNC or HDP). The geometric mean K_{oc} value of 74,128.0 mL/g suggests that DNC can be considered non-mobile. The geometric mean K_{foc} value of 101.8 mL/g suggests that HDP can be considered moderately mobile.

Degradation in soil

A GLP-compliant soil biodegradation rate study (OECD guideline 307 with an extended incubation period of up to 400 days at 20 ± 2°C) was submitted for DNC.[8] Four soils of differing properties, with unlabelled DNC, were used. The geometric mean of the soil DT_{50} was 96.6 days at 20°C. The transformation pattern exhibited a two-phase kinetics with a slower phase at longer incubation times. The half-life of the second phase was 572 days at 20°C. This value is used for the FOCUS calculations. For the soil accumulation calculation, a DT_{50} of 1,191 days at 12°C (EFSA, 2007) was considered.

A GLP-compliant soil biodegradation rate study following OECD guideline 307 was performed with four soils of differing properties using unlabelled and ^{14}C-labelled HDP.[9] The geometric mean of the soil

[6] FAD-2015-0039/Technical dossier/Reference_III_56.
[7] FAD-2015-0039/Technical dossier/Reference_III_57.
[8] FAD-2015-0039/Technical dossier/Reference_III_58.
[9] FAD-2015-0039/Technical dossier/Reference_III_59.

DT_{50} was 2.3 days at 20°C. This indicates that HDP is not persistent in soil. The recalculated DT_{50} at 12°C is 4.9 days.

Conclusions on fate and behaviour

For DNC, a K_{oc} of 74,128 L/kg and a DT_{50} of 1,191 days will be used for the assessment; for HDP a K_{oc} of 102 L/kg and a DT_{50} of 4.9 days will be used for the assessment.

Predicted environmental concentrations (PECs)

The following input values for DNC were used to calculate the initial PECs: DNC concentration in turkey feed 70.89 mg/kg, molecular weight 302.24 Daltons, vapour pressure 3.1×10^{-10} Pa, solubility 0.0209 mg/L, DT_{50} 1,191 days and K_{oc} 74,128 L/kg. The following input values for HDP were used to calculate the initial PECs: HDP concentration in turkey feed 29.11 mg/kg, molecular weight 124.14 Daltons, vapour pressure 9.084×10^{-6} Pa, solubility 65,400 mg/L, DT_{50} 4.9 days and K_{oc} 102 L/kg.

The calculated PEC initial values for both DNC and HDP are given in Table 4.

Table 4: Initial Predicted Environmental Concentration (PECs) of DNC and HDP, in soil (PEC_{soil}), groundwater (PEC_{gw}), surface water (PEC_{sw}) and sediment (PEC_{sed})

Input	Value	
	DNC	HDP
Dose (mg/kg feed)	70.89	29.11
Molecular weight (Dalton)	302.24	124.14
Vapour pressure (Pa) (at 25°C)	3E-10	9E-6
Solubility (mg/L)	0.0209	65,400
K_{oc} (L/kg)	74,128	102
DT_{50} in soil at 12°C (days)	1,191	4.9
Output		
PEC_{soil} (µg/kg)	329	135
PEC_{gw} (µg/L)	0.22	62
PEC_{sw} (µg/L)	0.074	21
PEC_{sed} (µg/kg dry weight)	311	157

DNC: 4,4′-dinitrocarbanilide; HDP: 2-hydroxy-4,6-dimethylpyrimidine; K_{oc}: adsorption or desorption coefficient corrected for soil organic carbon content; DT_{50}: disappearance time 50 (the time within which the concentration of the test substance is reduced by 50%).

The Phase I PEC trigger values are exceeded; therefore, a Phase II assessment is considered necessary.

3.1.2. Phase II

Exposure assessment

PECs calculation refined in Phase II

DNC – refinement of PEC_{soil} for persistent compounds

The DT_{90} for DNC is greater than 1 year, therefore the PECs refined for accumulation was calculated. The results are provided in Table 5.

Table 5: Plateau Predicted Environmental Concentration (PECs) of DNC in soil (µg/kg), groundwater (µg/L), surface water (µg/L) and sediment (µg/kg)

Compartment	$PECs_{plateau}$ of DNC
Soil	1,718
Ground water	1.31
Surface water	0.44
Sediment	1,623

DNC: 4,4′-dinitrocarbanilide.

DNC and HDP – PEC_{gw} calculation refined in Phase II

Both DNC and HDP exceed the limit for groundwater. Applying the inequality reported in the EFSA guidance for assessing the safety of feed additives for the environment (EFSA, 2008) and even considering the longest DT_{50} of 1,191 days at 12°C with a K_{oc} of 74,128, for DNC no risk for groundwater is expected. For HDP, considering a K_{oc} of 102 and a DT_{50} of 4.9 days, the inequality is not respected, suggesting a possible risk to groundwater.

The applicant provided higher tier calculations using FOCUS models. Leaching was simulated using the model FOCUS PEARL[10] and the FOCUS scenarios specified in the EFSA guidance as relevant for avian uses (Jokioinen and Piacenza). The DT_{50} used for calculation was 576.4 days for DNC (geometric mean value at 20°C) and 13.4 days (geometric mean, longest phase at 20°C) for HDP. The 80th percentile annual average concentration, for both DNC and HDP in leachate at 100 cm depth were all below 0.1 μg/L for all relevant scenarios and treatments showing an acceptable risk to groundwater.

DNC – PEC_{sw} and PEC_{sed} calculation refined in Phase II

Concentrations in surface waters for DNC were assessed by the applicant using FOCUS SWASH model which contains several surface water models (PRZM, MACRO and TOXSWA).[11] Four FOCUS scenarios that are relevant for avian use were selected. The molecule was considered incorporated into the soil and assumed to be uniformly mixed into the top 20 cm soil layer. Uptake by plant roots was set to zero.

The largest predicted environmental concentration of DNC in surface water at any time was 0.0572 μg/L for applications to turkeys. This value was considered for further assessment.

Considering sediment, since the FOCUS model does not take into account accumulation, the value calculated with the simple equation of accumulation was used for further assessment (1,818 μg/kg).

Conclusions on PEC used for calculation

The following values are used for the assessment: for DNC a PEC_{soil} of 1,718 μg/kg, a PEC_{sw} of 0.0572 μg/L and a PEC_{sed} of 1,623 μg/kg (see Table 5 and the discussion above for PEC_{sw}); for HDP, a PEC_{soil} of 135 μg/kg, PEC_{sw} of 21 μg/L and PEC_{sed} of 157 μg/kg (see Table 4).

Ecotoxicity studies

The ecotoxicity studies submitted were already assessed in previous FEEDAP opinions (EFSA FEEDAP Panel, 2017, 2018, 2019). The main outcomes of those evaluations are briefly summarised below.

For the terrestrial compartment, data were provided for plants,[12] earthworms,[13] and micro-organisms.[14] For the effect of DNC and HDP on the reproduction of earthworms, the No effect concentration (NOEC) was set on 300 and 123 mg/kg (dry weight), respectively. In two of six tested plant species, a statistically significant effect of the equimolar mixture of DNC and HDP was observed; however the effect concentration could not be calculated. The FEEDAP Panel calculated the effect concentration based on information provided in the test report. Assuming the worst case, the median effective concentration (EC_{50}) for plants was set to 102 mg/kg and 248 mg/kg of HDP and DNC, respectively.

For the aquatic compartment, data for DNC are available for acute and chronic effect on algae,[15] aquatic invertebrates[16,17] and on acute toxic effects on fish.[18] No effect of DNC could be observed in any of the performed tests, thus the lowest concentration tested is proposed as the NOEC value. The DNC NOEC for algae is 10.1 μg/L. The 21-day NOEC for reproduction of daphnids was determined to be 4.51 μg/L. The 96-h LC_{50} was determined to be > 5.4 μg/L. The toxicity of HDP on the aquatic compartment was studied in tests of acute and long-term effect on algae[19] and acute effect on

[10] FOCUS PEARL version 4.4.4.
[11] FAD-2015-0039/Technical dossier/Annex 16/Appendix 1.
[12] FAD-2015-0039/Technical dossier/Reference_III_50.
[13] FAD-2015-0039/Technical dossier/Reference_III_42.
[14] FAD-2015-0039/Technical dossier/Reference_III_60.
[15] FAD-2015-0039/Technical dossier/Supplementary information February 2017/Annex 18.
[16] FAD-2015-0039/Technical dossier/Reference_III_54.
[17] FAD-2015-0039/Technical dossier/Reference_III_41.
[18] FAD-2015-0039/Technical dossier/Reference_III_55.
[19] FAD-2015-0039/Technical dossier/Supplementary information February 2017/Annex 17.

daphnids[20] and fish[21] resulting in NOEC value of 101.5 mg/L for algae. The LC_{50} and EC_{50} for fish and immobilisation for *Daphnia* were determined to be > 100 mg/L, respectively. Data on the effect of DNC[22] and HDP[23] on cyanobacteria are considered as supportive information.

Ecotoxicological data for the DNC[24] and HDP[25] for sediment-dwelling invertebrates were provided. The NOEC for DNC and HDP were determined as 241 and 557 mg/kg sediment (dry weight), respectively.

Risk characterisation (PEC/PNEC ratio) for DNC and HDP

The risk characterisation ratios for terrestrial, freshwater and sediment compartments are reported in the tables below.

Table 6: Risk characterisation (PEC/PNEC ratio) for DNC and for HDP for the terrestrial compartment

	Taxa	PEC_{soil} (µg/kg)	EC_{50} or NOEC (mg/kg)	AF	PNEC (µg/kg)	PEC/PNEC
DNC	Earthworm	1,718	300(1)	10	30,000	0.057
	Plants		248(2)	100	2,480	0.69
HDP	Earthworm	135	123.5(1)	10	12,350	0.01
	Plants		102(2)	100	1,020	0.13

AF: assessment factor; PNEC: predicted no effect concentration.
(1): NOEC.
(2): EC_{50}.

In order to address possible concerns due to the very high persistence of DNC, the applicant provided results from field monitoring studies.[26] These data were already evaluated in the previous opinion on Monimax® (EFSA FEEDAP Panel, 2019) and considered reliable. The highest soil concentration measured in field, 35.3 µg/kg in a Belgian site, was lower than the highest value modelled assuming the longest DT_{50}. These differences could be attributable to the conservative assumptions at the basis of the equations for PEC calculations (no dissipation from metabolism and/or manure degradation) and/or with field soil degradation rates that are faster than those evaluated in laboratory with the soil degradation studies.

Table 7: Risk characterisation (PEC/PNEC ratio) for the freshwater compartment for DNC

Taxa	PEC_{sw} (µg/L)	96-h LC_{50} or NOEC (µg/L)	AF	PNEC (µg/L)	PEC/PNEC
Algae *Selenastrum subspicatus*	0.0572	10.1(1)			0.6
Aquatic invertebrates *Daphnia magna*		4.51(1)	50	0.09	
Fish *Brachydanio rerio*		> 5.4(2)			

AF: assessment factor; PNEC: predicted no effect concentration.
(1): NOEC.
(2): 96-h LC_{50}.

Table 8: Risk characterisation (PEC/PNEC ratio) for sediment for DNC

Taxa	PEC_{sed} (µg/kg)	NOEC (mg/kg)	AF	PNEC (µg/kg)	PEC/PNEC
Sediment-dwelling invertebrates *Chironomus riparius*	1,623	241	10	24,100	0.07

AF: assessment factor; PNEC: predicted no effect concentration.

[20] FAD-2015-0039/Technical dossier/Reference_III_44.
[21] FAD-2015-0039/Technical dossier/Reference_III_48.
[22] FAD-2015-0039/Technical dossier/Reference_III_53.
[23] FAD-2015-0039/Technical dossier/Reference_III_47.
[24] FAD-2015-0039/Technical dossier/Reference_III_51.
[25] FAD-2015-0039/Technical dossier/Reference_III_52.
[26] Technical dossier/DNC soil persistence report.

Table 9: Risk characterisation (PEC/PNEC ratio) for sediment for HDP

Taxa	PEC_{sed} (µg/kg)	NOEC (mg/kg)	AF	PNEC (µg/kg)	PEC/PNEC
Sediment-dwelling invertebrates					
Chironomus riparius	157	557	10	55,700	0.003

AF: assessment factor; PNEC: predicted no effect concentration.

To address the possible persistence in sediment, due to the high K_{oc} and DT_{50} in soil, a further cumulative worst-case PEC_{sed} concentration has been quantified by the applicant taking into account the accumulation of DNC in sediment over a 50-year period of continual DNC application. A DT_{50} of 224.7 days (at 12°C, derived from a water-sediment study) was used to calculate the DNC concentration remaining in the sediment after one year from the applications. This evaluation has been already assessed for Monimax® and considered reliable.

After 50 years continuum application, the PEC_{sed} was 337.3 µg/kg. Even considering twice the value to account for the application rate of Coxar®, the predicted accumulation results far below the one considered for risk assessment. The risk characterisation of DNC through the continual use of Coxar® for turkeys for fattening, results in a PEC/PNEC ratio < 1, indicating no risk to sediment-dwelling organisms.

DNC potential for bioaccumulation and risk for secondary poisoning

As assessed in the previous opinion on Monimax®, the log K_{OW} for DNC is > 3, but an *in silico* calculated bioaccumulation factor indicates that DNC does not bioaccumulate in the environment. A risk for secondary poisoning for worm/fish eating birds and mammals is not likely to occur.

Conclusions on safety for the environment

The use of nicarbazin from Coxar® in complete feed for turkeys at a maximum level of 100 mg/kg complete feed does not pose a risk for the terrestrial and aquatic compartment and in sediment. No concern for groundwater is expected. The bioaccumulation potential of nicarbazin in the environment is low and risk for secondary poisoning is not likely to occur.

4. Conclusions

The use of nicarbazin from Coxar® in complete feed for turkeys at a maximum level of 100 mg/kg complete feed does not pose a risk for the terrestrial and aquatic compartment and in sediment. No concern for groundwater is expected. The bioaccumulation potential of nicarbazin in the environment is low and risk for secondary poisoning is not likely to occur.

5. Documentation as provided to EFSA/Chronology

Date	Event
04/12/2018	Dossier received by EFSA. Environmental risk assessment for Coxar (nicarbazin). Submitted by Huvepharma NV.
13/02/2019	Reception mandate from the European Commission
02/03/2021	Acceptance of the mandate by EFSA – Start of the scientific assessment
23/06/2021	Opinion adopted by the FEEDAP Panel. End of the Scientific assessment

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EFSA (European Food Safety Authority), 2008. Technical Guidance of the Scientific Panel on Additives and Products or Substances used in Animal Feed (FEEDAP) for assessing the safety of feed additives for the environment. EFSA Journal 2008;6(10):842, 28 pp. https://doi.org/10.2903/j.efsa.2008.842

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Abbreviations

CAS	Chemical Abstracts Service
DM	dry matter
DNC	4,4′-dinitrocarbanilide
DT_{50}	Disappearance Time 50 (the time within which the concentration of the test substance is reduced by 50%)
DT_{90}	Disappearance Time 90 (the time within which the concentration of the test substance is reduced by 90%)
EC_{50}	EC_{50} median effective concentration which results in a 10% reduction in growth rate
ErC_{50}	median effective concentration which results in a 50% reduction in growth rate
FOCUS	FOCUS FOrum for Co-ordination of pesticide fate models and their USe
GLP	Good Laboratory Practice
HDP	2-hydroxy-4,6-dimethylpyrimidine
K_{foc}	organic-carbon normalized Freundlich distribution coefficient
K_{oc}	adsorption or desorption coefficient corrected for soil organic carbon content
LC_{50}	Median lethal concentration
log K_{ow}	octanol/water partition coefficient
FEEDAP Panel	Panel on Additives and Products or Substances used in Animal Feed
MW	molecular weight
OECD	Organisation for Economic Co-operation and Development
PEC	predicted environmental concentration
pKa	dissociation constant
PNEC	predicted no effect concentration