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FRONT OFFICE FOOD AND PRODUCT SAFETY

RISK ASSESSMENT OF PFASs IN FEED: TRANSFER OF PFASs DETECTED IN FEED TO EDIBLE PRODUCTS OF FOOD PRODUCING ANIMALS AND POSSIBLE ANIMAL HEALTH RISKS - PART III: Dairy cow and beef cattle

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Nederlandse samenvatting

Poly- en perfluoralkyl stoffen (PFAS) zijn een door de mens gemaakte groep chemicaliën die door hun gunstige chemische eigenschappen in veel producten verwerkt zijn of worden. Uitstoot naar het milieu vindt plaats door de productie en het gebruik van deze producten. PFAS worden aangetroffen in grond, grondwater, oppervlaktewater, drinkwater en voedsel, maar ook in biologische matrixen. Een eerdere *Front Office Voedsel- en Productveiligheid* (FO) beoordeling over de overdracht van GenX[1], perfluoroctaanzuur (PFOA) en perfluoroctaansulfonzuur (PFOS) uit slootwater en gras naar voedselproducerende dieren liet mogelijke gezondheidsrisico's zien voor consumenten die voor een lange periode veel zuivelproducten en vlees consumeren van (melk)koeien die uitsluitend worden blootgesteld aan vervuild slootwater en gras (RIVM 2021b). Vanuit het nationaal plan diervoeder zijn PFAS-concentraties in maiskuil, graskuil, luzerne en vismeel onderzocht. Naar aanleiding van deze meetgegevens heeft *Bureau Risicobeoordeling & Onderzoek* (BuRO) aan het FO gevraagd om vast te stellen in welke mate er overdracht is van PFAS in het geanalyseerde voer naar landbouwhuisdieren, of er risico's zijn voor de gezondheid van landbouwhuisdieren na blootstelling aan met PFAS besmet voer, en welke concentraties PFAS in het diervoeder aanwezig mogen zijn voordat maximumgehalten (ML's) in eetbare producten van landbouwhuisdieren overschreden worden. Recent zijn ML's vastgesteld voor vlees en orgaanvlees van varkens, kippen en runderen. Voor melk zijn indicatieve gehaltes vastgesteld omdat er nog onvoldoende gegevens waren voor melk (EU 2022/1431). De ML's zijn sinds 1 januari 2023 van kracht (EU2023/915). In deze beoordeling (deel III) worden deze vragen beantwoord voor vleesrunderen en melkvee. De vragen over varkens worden in deel I beantwoord, en de vragen over leghennen en vleeskuikens in deel II.

Analyse van de vier diervoeders liet zien dat in graskuil en maiskuil geen PFAS boven de kwantificatielimieten (LOQ's) zijn aangetroffen. Hetzelfde was het geval voor luzerne, met uitzondering van PFOS dat in twee monsters werd aangetroffen. In vismeel zijn veel PFAS gedetecteerd. Aan melkkoeien kunnen kuilgras, kuilmais en luzerne gevoerd worden. Vleesrunderen krijgen van deze vier voedermiddelen alleen kuilgras en vleeskalveren alleen kuilmais. In deze beoordeling is het volwassen vleesrund een zoogkoe, aangezien voor dit soort vleesrund innamegegevens beschikbaar waren. Het voeren van vismeel

[1] GenX refers to hexafluoropropyleneoxide dimer acid (HFPO-DA), or to its ammonium salt, as used in the GenX technology.

aan melkkoeien, vleesrunderen en vleeskalveren is niet toegestaan (NVWA 2019). Alleen voor de voedermaterialen die gevoederd worden aan melkkoeien of vleesrunderen (en vleeskalveren) is de overdracht berekend. Hierbij is aangenomen dat gehaltes onder de LOQ gelijk zijn aan de LOQ. Dit is een worst-case aanname.

Om de effecten van PFAS op de diergezondheid voor melkkoeien en vleesrunderen (en vleeskalveren) in te schatten is een literatuurstudie uitgevoerd en zijn experts geraadpleegd. Vijf artikelen zijn gevonden die de gezondheidseffecten van PFAS of de kinetiek van PFAS beschrijven. Er zijn geen effecten op het welzijn van melkvee en vleesvee vastgesteld. De immuuneffecten die bij knaagdieren na blootstelling aan PFAS zijn waargenomen, komen voor bij een blootstelling via voer die minimaal 1000 maal hoger is dan de berekende maximale blootstelling van de runderen. Op basis van deze gegevens zijn geen diergezondheidseffecten te verwachten na blootstelling aan de geanalyseerde concentraties in het voer.

Voor melkkoeien is de overdracht van PFOS en PFOA via graskuil, maiskuil en luzerne naar vlees en melk geschat met PFOS en PFOA overdrachtsmodellen (Van Asselt et al. 2013; RIVM 2021b). De maximumgehalten (maximum levels; ML's) in vlees voor PFOS en PFOA worden niet overschreden door blootstelling van melkkoeien aan gehaltes van PFOS en PFOA via graskuil, maiskuil en luzerne gelijk of kleiner dan de LOQ's. Overschrijding van het indicatieve gehalte voor PFOS in melk kan niet worden uitgesloten.

De overdracht van PFNA en PFHxS via graskuil, maiskuil en luzerne naar vlees en melk van melkkoeien is geschat met een lineair model, omdat hiervoor geen overdrachtsmodellen zijn. De ML's voor PFNA en PFHxS in orgaanvlees en vlees worden overschreden wanneer PFNA en PFHxS gehaltes in graskuil, maiskuil en luzerne gelijk zouden zijn aan de LOQ's.

Om voor vleesrunderen en vleeskalveren de overdracht van PFOS, PFOA, PFNA en PFHxS via graskuil naar vlees en organen (lever en nier) te kunnen schatten is hetzelfde lineair model gebruikt. De ML's voor vlees en orgaanvlees worden overschreden bij blootstelling van vleeskalveren aan PFAS via maiskuil (met uitzondering van PFOS) en van vleesrunderen aan PFAS via graskuil bij gehaltes gelijk aan de LOQ.

Daarnaast zijn met behulp van bovenstaande modellen ook de concentraties PFAS in het voer berekend die resulteren in concentraties gelijk aan de ML voor vlees en de indicatieve gehaltes voor melk (berekend voor de melkkoe) en aan de ML voor (orgaan)vlees (berekend voor het vleeskalf en vleesrund). Voor de melkkoe was de berekende concentratie PFOS in graskuil die nodig is om het indicatieve gehalte in melk te bereiken, 1.8 keer lager dan de LOQ van de gebruikte analysemethode. Voor het vleeskalf waren de berekende concentraties PFOA, PFNA en PFHxS in maiskuil die nodig zijn om de ML's in (orgaan)vlees te bereiken, 2.7 tot 42 keer lager dan hun huidige LOQ. Voor het vleesrund waren deze berekende concentraties van PFOS, PFOA, PFNA en PFHxS in graskuil 4.2 tot 120 keer lager dan de huidig gebruikte LOQ. Dit betekent dat de gevoeligheid van de gebruikte meetmethode onvoldoende is om overschrijding van de ML's voor (orgaanvlees) in het vleeskalf en vleesrund, en van het indicatieve gehalte voor PFOS in melk uit te sluiten in de vleeskoe en het vleeskalf. WFSR werkt aan een verdere verlaging van de LOQ's voor diervoer.

Voor beide berekeningen zijn verschillende (worst-case) aannames gedaan die kunnen leiden tot een overschatting van de daadwerkelijke concentraties in dierlijke producten en daardoor tot een onderschatting van de concentraties in voer die resulteren in vleesgehaltes gelijk aan de ML's of melkgehaltes gelijk aan de indicatieve gehaltes. Het verder ontwikkelen van kinetische modellen, meer kwantitatieve innamegegevens, het analyseren van relevante voeringrediënten voor runderen, het verlagen van de LOQ's en het includeren van precursors van PFAS in de analyse zullen bijdragen aan een beter inzicht in de daadwerkelijke blootstelling via diervoeder en resulterende gehaltes in melk, vlees en orgaanvlees.

Subject
Within the Animal Feed National Plan (NP), various types of animal feed (maize silage, grass silage, lucerne and fishmeal) have been analysed for the presence of PFASs. The Office of Risk Assessment and Research (BuRO) would like to know whether there are risks for animal health following the consumption of PFAS-contaminated feed and whether (indicative) maximum levels (MLs) in animal derived products are exceeded when animals are exposed to PFAS-contaminated feed at the reported levels. Recently, MLs have been established for meat and offal originating from pig, poultry and bovine animals by the European Commission (EU 2023/915). For milk indicative levels have been established (EU 2022/1431). The temporary character of the latter level should be noted.

Questions
BuRO asked FO the following questions:

1. Is there a risk to animal health when maize silage, grass silage, lucerne and fishmeal contaminated with PFASs (at levels found in the NP 2020) are fed to meat cows, dairy cows, pigs, laying hens and broilers?

2a. What is the transfer of the PFASs (PFOS, PFOA, PFNA, PFHxS) in the above mentioned contaminated feed ingredients to bovine meat/offal and milk, pig meat/offal, chicken eggs and chicken meat/offal. Compare the estimated concentrations with the proposed MLs of these products.

2b. What is the level of PFASs (PFOS, PFOA, PFNA, PFHxS) in feed (maize silage, grass silage, lucerne and fishmeal) before the MLs for PFASs in products of animal origin? In the absence of a proposed ML, please use the current LOQ in that product.

In this assessment, Part III, the above questions are answered for dairy cows, veal calves and beef cattle. In Part I and Part II, the questions were answered for pigs, and laying hens and broilers. The conclusions in the box below only apply to dairy cows and beef cattle:

Conclusions

1. No risk of health for dairy or beef cattle are expected based on the absence of negative health effects in dairy and beef cattle in the literature and the relatively low PFAS concentrations in feed observed in samples from the NP 2020 and the estimated 1000-fold lower intake of PFOS following exposure through these feeds compared to the PFOS exposure in rat studies resulting in adverse effects on the immune response.

2a. Fishmeal is not fed to bovines and was therefore not included in this assessment. Only PFOS was detected in 2 samples of lucerne above the limit of quantification (LOQ), PFAS levels in grass silage and maize silage were below the LOQs.
Dairy cows: Calculations using the PFOS/PFOA transfer model and the measured PFOS concentration or applying the LOQ levels as exposure concentrations show that exceedances of the MLs for edible products (dairy and offal), following exposure of dairy cows to PFOS via grass silage cannot be excluded. Calculations using a linear model show

potential exceedance of PFNA and PFHxS MLs for meat or offal within the productive lifespan of a dairy cow when fed grass silage, maize silage or an incidental[2] amount of lucerne.
Beef cattle: Calculated concentrations of PFNA in meat and calculated concentrations of PFOA, PFNA, PFHxS and the sum of the 4 PFASs in offal exceed their MLs when maize silage is fed to veal calves at LOQ levels. For beef cows fed grass silage with LOQ levels, the calculated concentrations of all PFASs and the sum thereof would exceed their MLs in meat and offal, except for PFOA in meat.
Since exceedance was only observed when assuming levels equal to the LOQs, the LOQs for grass silage and maize silage should be lowered in the future. Notably, dairy cows, veal calves and beef cows are exposed to more than the feed materials included in this assessment. In addition, for most calculations, except for PFOA and PFOS transfer in the dairy cow a conservative linear model was used. To better assess feed to food transfer and risk to animal health, other feed ingredients fed should be included in the PFAS analysis.

2b. Calculated concentrations of PFOS in grass silage, resulting in levels equal to the indicative level for milk when fed to dairy cows, were 1.8 fold below the LOQ. Calculated concentrations of PFOS, PFNA and PFHxS in maize silage fed to veal calves, resulting in levels equal to the MLs for meat/offal, were 2.7 to 42 fold below the LOQ. In addition, the calculated concentrations of all four PFASs in grass silage fed to beef cows resulting in levels equal to the ML for meat/offal were 4.2 to 120 fold below the LOQ.
The calculated concentrations can be found in Table 4 (main text).

It should be noted that for most calculations, except for PFOA and PFOS transfer in the dairy cow, a linear model was used where all PFAS are assumed to accumulate. This likely results in an overestimation of the PFAS concentrations in edible products (question 2a) and an underestimation of the PFAS concentrations in feed that result in PFAS levels in edible products that are equal to the ML (question 2b). To better assess feed to food transfer and risk to animal health, it is recommended to develop new, or extend existing, transfer models for including all edible product for all types of bovines.

[2] High daily intake that occurs rarely.

1. Introduction

Poly- and perfluoroalkyl substances (PFASs) are a diverse group of man-made chemicals with carbon-fluorine bonds, one of the shortest and strongest bonds known. The fluorinated tail and functional headgroup make PFASs both hydrophobic and hydrophilic, and highly persistent in the environment. As a result of these chemical properties, PFASs are used in many products and industrial processes (e.g. household products, textiles, fire-fighting foam, food packaging materials, construction) and are emitted to the environment through industries and the (re-)use of many PFAS-containing products. Due to these emissions, in combination with the highly persistent nature of PFASs, soil, water and vegetation may be polluted.

PFASs have also been detected in human matrixes, such as blood. For humans, one of the main routes of exposure to PFASs is through the consumption of contaminated food. Food can become contaminated through contaminated soil and water during cultivation of plants, through the accumulation of these substances in animals via feed, water and soil, through PFAS-containing food packaging and/or through PFAS-containing processing equipment. In 2021, the Front Office Food and Product Safety (FO) published the results of a revised risk assessment of GenX and perfluorooctanoic acid (PFOA) in food since the European Food Safety Authority (EFSA) established a tolerable weekly intake (TWI) for the sum of four PFASs (hereafter referred to as EFSA-4; PFOA, perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonic acid (PFOS)) (EFSA 2020; RIVM 2021a).

The transfer of several PFASs in ditch water and silage to edible products of food producing animals was determined in an earlier report (RIVM 2021b). The results of this report showed potential health risks for consumers regularly consuming dairy products and meat from dairy cows solely exposed to contaminated ditch water and grass in a worst-case scenario.

Within the National Plan Animal Feed in 2020, the presence of PFASs in animal feed (grass silage, maize silage, lucerne and fishmeal) was determined. The results showed that several PFASs were detected in some of the analysed feed materials. As a result, the BuRO asked the FO to determine whether the transfer of PFASs from these feed materials to food products of farm animals (pigs, dairy cows, beef cattle, laying hens and broilers) could result in levels above the maximum levels (MLs), whether there are health risks for farm animals due to intake of these feed materials, and what the levels of PFASs in feed should maximally be before the MLs for PFASs in products of animal origin are exceeded. Recently, MLs have been established for meat and offal originating from pig, poultry and bovine animal (EU 2023/915). For milk an indicative level has been established (EU 2022/1431), (since not enough data was available yet for milk). In this Part III of the assessment, the questions in relation to dairy cows and beef cattle are addressed.

2. Methods

The methods are described in more detail in Appendix I. Other information used as input and to support the analysis and calculations can be found in Appendices II-VI

a. Analysis of feed samples

In total, 25, 30, 40 and 32 samples of grass silage, maize silage, lucerne and fishmeal, respectively, were analysed according to an internal procedure, SOP-A-1114, at WFSR. Fresh material was extracted using acidified methanol. The final extracts were analysed by liquid chromatography coupled to tandem mass spectrometry. Isotopically labelled internal standards were added to all samples and quality control samples to allow a more accurate quantification. The complete description of the analysis of the feed samples can be found in Appendix I. The LOQs of the analysis in the four feed materials can be found in Appendix II.

b. Feed consumption data for dairy cows and beef cattle and weight (of food products) during life or at time of slaughter

An overview of intake of grass silage, maize silage, lucerne and fishmeal for dairy cows and beef cattle (including veal calves) is given in Appendix I, Table A1. In this, assessment adult beef cattle are cows not used for dairy production, also known as 'zoogkoeien' in Dutch. The intake by other adult beef cattle of the feed materials is unknown due to the large diversity of practical systems for that group.

The intake, the estimated slaughter time and the weight at which food products are produced are based on expert judgement of the department of Animal Nutrition, Wageningen University and Research (Appendix I, Table A2). In short, dairy cows are fed grass silage and maize silage and are occasionally fed lucerne as adults. Beef cattle are only fed grass silage (beef cows) or maize silage (veal calves). Fishmeal is not fed to dairy cows or beef cattle (including veal calves), since this is prohibited (NVWA 2019).

c. Calculus

i. *Maximum and indicative levels of PFASs in meat, offal and milk*

The transfer of PFASs to food products following exposure to each feed type during each life phase (Question 2a) was calculated with an average and incidental[2] scenario, when available (see Table A1, Appendix I). The PFASs concentrations in bovine meat and offal were thereafter compared with the MLs (EU 2023/915). There are no MLs for milk. However, indicative levels for milk, at which further investigation of the causes of the contamination should be carried out, have been recommended (EU 2022/1431) and were used instead. In this document the term offal summarises only the liver and kidney. In addition, the estimated concentrations in feed to prevent exceedance of these MLs and indicative levels in food are also calculated. In Table 1, the MLs for PFASs (EU 2023/915) and indicative levels for milk (EU 2022/1431) are listed. Since only MLs for PFOS, PFOA, PFNA and PFHxS were established, and BuRO is only interested in these four PFASs, this assessment will not include calculations for other PFASs measured in the feed materials.

Table 1. Maximum (MLs) and indicative levels for PFASs in μg/kg wet weight (EU 2023/915).

	PFOS (μg/kg)	**PFOA (μg/kg)**	**PFNA (μg/kg)**	**PFHxS (μg/kg)**	**Sum of 4[1] PFASs**
Meat of bovine animals, pig and poultry	0.30	0.80	0.20	0.20	1.3
Offal of bovine animals, sheep, pig and poultry	6.0	0.70	0.40	0.50	8.0
Milk[2]	0.020	0.010	0.050	0.060	Nr

[1]: Sum of PFOS, PFOA, PFNA and PFHxS.
[2]: There are no MLs for milk. In the absence of MLs, indicative levels for milk were used (EU 2022/1431).
Nr: No indicative level is recommended.

ii. *Transfer of PFASs from feed to meat, offal and milk*

In the calculations, the concentrations of PFASs in food products of dairy cows and beef cattle (including veal calves) are based on exposure to one single type of feed material. In addition, it is assumed that the animals have no internal PFASs levels due to previous

PFASs exposure (other feed materials, drinking water, soil, or in utero and during lactation).

For dairy cows, which produce milk during a major period of their life, a transfer model was available to calculate the transfer of PFOS and PFOA from feed to milk and meat (RIVM 2021b), but not for PFNA and PFHxS. However, for beef cattle (including veal calves) no models for any of the PFASs was available. If no transfer models were available to calculate the transfer, a more pragmatic linear model approach was used. The transfer model and this linear model are described in more detail in appendix I and briefly below:

- PFOS/PFOA transfer model

The concentration of PFOS and PFOA in milk and meat of dairy cows following continuous exposure can be calculated using the PFOA and PFOS transfer models for dairy cows (RIVM 2021b) during steady state. The model is based on an experimental study from Kowalczyk et al. (2013) on the transfer of PFOA and PFOS from contaminated grass (silage) and hay to milk and meat of dairy cows (n=6). Initially, only a PFOS transfer model based on this study was available (Van Asselt et al. 2013). However, the PFOA transfer data of this study enabled the scaling of the PFOS model to PFOA (RIVM 2021b). Both the PFOS model and the scaled PFOA model were used to quantify the transfer of PFOA from ditch water or grass (silage) to milk and meat of dairy cows after long-term exposure (RIVM, 2021b). Transfer of PFOA reaches steady-state within a few days. The majority OF PFOA leaves the body via urinary excretion quickly. In contrast, steady-state for PFOS is estimated to be reached after approximately 500 days and its urinary excretion is negligible. The model was initially developed for a 600 kg dairy cow with a milk production of 12.5-50 L/day. The chronic daily intake of PFAS via a single feed is used as the intake parameter for a 650 kg cow with a milk production of 29.5 L/day. At the end of their producing life, dairy cows can be slaughtered after which their meat/offal can be sold for consumption. The concentration of PFASs in meat at the end of the life of dairy cows was therefore calculated using the dairy cow PFOS/PFOA models. The assumptions made for these PFOS/PFOA transfer models were that no elimination through maternal transfer of PFASs to calves takes place during the productive life of the dairy cow.

- Linear model

Beef cattle (including veal calves) exposed to PFASs through feed are slaughtered at a certain stage in life. For this model it is assumed that all PFASs will be absorbed, distributed to either meat or offal and no elimination will take place (worst-case assumptions). The concentration (C_x) in meat/offal was determined using the following equation:

$$C_x = I_{cum,PFAS} / w_x \qquad (1)$$

in which $_x$ stands for meat or offal, $I_{cum,PFAS}$ represents the cumulative intake of PFASs of an animal until slaughter, and w_x represents the weight of the meat or offal (liver plus kidneys) at the moment of slaughter. The intake and the weight of the edible products in relation to the total body weight can be found in Appendix I (Table A1 and A2).

In contrast to beef cattle, the slaughter time of dairy cows varies. For PFOS and PFOA the equilibrium concentrations of the above described transfer model are the maximum possible concentrations at slaughter time. For the PFASs lacking a transfer model, PFNA and PFHxS, no maximum or final concentration can be determined due to the inability to determine the length of the PFAS exposure. Instead, for transfer of PFNA and PFHxS, the number of days an animal can be fed at concentrations detected in feed before the MLs in (offal) meat will be exceeded (T_{max}) is calculated, using the following equations:

$$I_{cum,max} = ML_x \cdot w_x \quad (2a)$$
$$T_{max} = I_{cum,max} / I_{daily\ PFAS} \quad (2b)$$

in which $I_{cum,max}$ is the maximum cumulative intake amount of a certain PFAS during the set period, x stands for meat or offal, ML_x is the ML of each PFAS in meat or offal (Table 1), w_x is the weight of the meat or offal at the time of slaughter and $I_{daily\ PFAS}$ is the amount of PFAS consumption per day when fed the analysed feed. This approach assumes that no elimination will take place during exposure (including elimination via dairy or maternal transfer to calves and that all PFASs will either go to meat or offal and all PFASs is absorbed).

In summary, the concentrations of PFOA, PFNA, PFHxS and PFOS in meat and offal of beef cows (and veal calves) that were exposed to contaminated maize silage were calculated using equation 1. For PFNA and PFHxS the number of days of exposure it takes to reach the ML of (offal) meat of a dairy cow was calculated using equation 2a and 2b.

iii. *Concentrations in feed resulting in levels equal to the MLs*
The concentrations of PFOS, PFOA, PFNA and PFHxS in feed based on the indicative levels for milk, MLs for bovine meat and offal were calculated for the various feeds. These concentrations were also compared to the current LOQs (Appendix II) in feed. These calculations were done with the PFOS/PFOA transfer model for dairy cow and a linear model for PFOS, PFOA, PFNA and PFHxS in beef cattle. Unfortunately, neither the PFOS/PFOA transfer model transfer nor the linear model in dairy cows could be used for PFNA and PFHxS.

- Transfer model -use of steady state assumptions

It is possible to calculate the PFOS and PFOA-concentrations in feed resulting in levels in meat of dairy cows equal to the MLs or indicative levels for milk using the steady-state assumptions of the above mentioned PFOS and scaled PFOA transfer model for the dairy cow. In other words, during a steady state situation reverse dosimetry was applied.

This model is used to calculate the concentrations of PFOS and PFOA in either grass silage, maize silage or lucerne resulting in levels equal to the MLs in meat or indicative level in milk of dairy cows. Unfortunately, the PFOS/PFOA transfer model transfer PFOS model cannot be used for other PFASs, i.e. PFNA and PFHxS.

- Linear model

Using the following equations, the concentrations ($C_{equal,x}$) in feed for beef cattle (including veal calves) resulting in levels equal to MLs were calculated:

$$I_{max,PFAS} = ML_x \cdot w_x \quad (3a)$$

$$C_{equal,x} = I_{max,PFAS} / (T \cdot I_{daily\ feed}) \quad (3b)$$

in which x stands for meat or offal, $I_{max,PFAS}$ is the maximum intake amount of a certain PFAS during the exposure period, ML_x is the ML of each PFAS in meat or offal (Table 1), w_x is the weight of the meat or offal at the time of slaughter, T is the period in days during which the animal is fed a certain feed type and $I_{daily\ feed}$ is the amount of feed consumption per day (T times $I_{daily\ feed}$ is the exposure scenario found in Table A1 of Appendix I). The weight of the edible products in relation to the total body weight can be found in Appendix I, Table A2. Also for this calculation it is assumed that all PFASs will be absorbed and distributed to either meat or offal, and no elimination will take place (worst-case assumptions for meat and offal).

d. Literature search for health effects of PFASs in dairy cows and beef cattle and transfer from feed to food in dairy cows and beef cattle

A (non-systematic) literature search was carried out to capture relevant literature to determine the health effects of PFASs in dairy cows and beef cattle and relevant transfer parameters/models of PFASs in dairy cows and beef cattle. The search terms were as follows: 'chemical name' AND (livestock OR farm animal OR bovine OR cow OR cattle) AND (health OR model). In total, five relevant articles were found in which livestock exposed to PFASs was identified and in which no health effects were reported. One paper described a kinetic model for dairy cows.

3. Results: PFASs in grass silage, maize silage and lucerne

The highest concentrations of each chemical detected per feed material above the LOQ or otherwise the LOQ (< number) fed to dairy cows and/or beef cattle is listed in Table 2. The results of the chemical analysis per sample of the feed materials can be found in Appendices III-V. The highest concentrations were combined with the maximum feed intakes to calculate the worst-case intake of PFASs. In grass silage and maize silage, the levels did not exceed the LOQs. Regarding lucerne, two out of 40 samples showed detectable levels of PFOS with a concentration of 0.068 µg/kg and 0.076 µg/kg. The number of samples in which certain PFASs were detected above the LOQ can be found in in brackets in Table 2.

Table 2. Highest concentrations found in the analysed feed samples in µg/kg. When not detected above the limit of quantification (LOQ), the LOQs were listed (in italic, with <). The number of lucerne samples in which a certain PFAS was detected above the LOQ is listed in brackets.

PFAS	***Grass silage (µg/kg)***	***Maize silage (µg/kg)***	***Lucerne (µg/kg)***
n	*25*	*30*	*40*
PFPeA	*<4.00*	*-*	*-*
PFHxA	*<1.50*	*<1.30*	*<1.50*
PFHpA	*<0.15*	*<0.30*	*<0.10*
PFOA	*<0.05*	*<0.10*	*<0.05*
PFNA	*<0.15*	*<0.30*	*<0.20*
PFDA	*<0.50*	*<0.30*	*<0.20*
PFUnDA	*<0.50*	*<0.30*	*<0.10*
PFDoDA	*<0.50*	*<0.10*	*<0.10*
PFTrDA	*<0.10*	*<0.30*	*<0.10*
PFTeDA	*<0.05*	*<0.10*	*<0.20*
PFHxDA	*<0.10*	*-*	*<0.10*
PFODA	*-*	*-*	*-*
PFBS	*<0.05*	*<0.20*	*<0.20*
PFHxS	*<0.15*	*<0.10*	*<0.10*
PFHpS	*<0.05*	*<0.10*	*<0.20*
PFOS	*<0.15*	*<0.10*	0.076 (2)
PFDS	*<0.20*	*<0.10*	*<0.20*
11Cl-PF3OudS	*<0.50*	*<0.60*	*<0.50*
9Cl-PF3ONS	*<1.00*	*<0.30*	*<1.00*
NaDONA	*<0.05*	*<0.20*	*-*
GenX	*<2.00*	*-*	*<1.00*

n: number of samples analysed; - : not determined.

4. Results: Transfer of PFASs

The highest measured concentrations or concentrations at the LOQs for feed (in case all concentrations were below LOQ), were combined with the maximum feed intakes using the scenario's from Table A1 (Appendix I) to calculate the highest chronic (incidental[2]) and more realistic chronic (average) PFAS intakes for dairy cows and beef cattle (including veal calves) based on the expert judgement of the department of Animal Nutrition, Wageningen Livestock Research (Paul Bikker). Table 3 shows the estimated concentrations in meat, offal and milk and whether they exceed the MLs. Table 4 shows the concentration in each type of feed that would result in concentrations in meat or offal equal to the MLs. To evaluate the current sensitivity of the analytical method, it is also shown whether (and to what extent) these calculated feed concentrations are below the current LOQs. The results are explained in more detail in Appendix I.

a. Dairy cows

i. *Transfer of PFOS and PFOA from feed to meat and milk*

Dairy cows are fed grass silage, maize silage or lucerne, continuously. The PFOS and PFOA concentrations in meat and milk were calculated using the PFOS/PFOA model (van Asselt, 2013; RIVM, 2021), assuming that dairy cows were not exposed during previous life stages or via other feed materials to PFASs and no elimination took place via maternal transfer to calves.

Chronic feeding with PFAS contaminated feed leads to increasing PFAS concentrations, up to a maximum concentration at equilibrium. Based on the models, this equilibrium is reached after approximately 500 days for PFOS and 4 days for PFOA. Feeding of grass silage and maize silage at levels equal to the LOQ and lucerne at the measured concentration just above the LOQ does not lead to the exceedance of the MLs for meat of PFOS and PFOA (Table 3). In addition, the indicative levels for PFOS and PFOA in milk are not exceeded after feeding maize silage or lucerne. However, the indicative level in milk for PFOS is exceeded 1.8-fold after feeding of grass silage with PFOS at an LOQ level. This indicative level for milk was reached after approximately 105 days.

ii. *Transfer of PFNA and PFHxS from feed to offal and meat*

For PFNA and PFHxS no transfer model was available to determine their concentration in meat, offal or milk and due to the variable slaughter times the linear model (equation 1) could not be used to compute their concentrations in meat or offal. Instead, equations 2a and 2b were used to calculate how many days of feeding PFNA or PFHxS contaminated feed it would take to exceed the ML in meat or offal. The results are displayed in Table 5.

When chronically feeding grass or maize silage to dairy cows, the meat MLs for both PFNA and PFHxS are exceeded within 1 to 3 months. The offal MLs are exceeded within 4 -13 days. For the incidental[2] lucerne feeding scenario, the offal MLs are reached within a month, the meat MLs within half a year (Table 5). In contrast, for the average feeding scenario, reaching the meat and offal MLs for PFNA and PFHxS takes much longer. The MLs in offal are reached within two years of feeding. The MLs in meat are only reached after the maximum expected duration of the life of a dairy cow. Note that for this calculation, it is assumed that all PFASs are distributed to either offal or meat and all PFASs are absorbed. Furthermore, no exposure prior to the productive life phase was considered nor was any form of excretion, e.g. via milk, urine, or maternal transfer to calves. These assumptions lead to a quicker accumulation of PFASs and thus an underestimation of the number of days of feeding contaminated feed (see Chapter 5; Uncertainties in the PFAS transfer in dairy cows and beef cattle). In addition to the use of LOQ when the level of PFASs was measured below the LOQ's also contributes to this underestimation.

iii. *Concentrations of PFASs in feed resulting in levels equal to the MLs for meat and indicative levels for milk*
The concentrations in feed were calculated using the PFOS/PFOA transfer model during steady state (van Asselt, 2013; RIVM, 2021), assuming that dairy cows were not exposed to any source of PFASs during previous life stages and no elimination took place via maternal transfer to calves.
The concentrations of PFOS and/or PFOA in grass silage, maize silage and lucerne resulting in levels equal to the indicative level for milk are above the reported LOQs except for PFOS in grass silage. For grass silage, the concentration of PFOS resulting in PFOS levels in milk that exceed the indicative level in milk are just below the LOQ.
Concentrations in feed resulting in levels equal to the indicative level in milk for PFNA, PFHxS could not be determined (see methods or Appendix I).

b. Beef cattle
i. *Transfer of PFASs from feed to meat and offal*
Beef cattle (including veal) are only exposed through grass silage and maize silage, respectively. The concentrations of PFOS, PFOA, PFNA and PFHxS in meat and offal were calculated using equation 1. Feeding of maize silage to rose veal calves containing PFASs at LOQ levels leads to the exceedance of the MLs for PFNA in meat. In addition, exceedance of the ML of PFOA, PFNA, and PFHxS and the sum of all four PFASs in offal is predicted when fed maize silage (Table 3). For adult beef cows all four PFASs (and the sum thereof) are predicted to exceed the ML in both meat and offal, except for PFOA in meat (Table 3) when fed grass silage containing PFASs at LOQ levels. This implies that the LOQs for most of the four PFASs are too high to exclude exceedance of MLs in meat products and that all are too high to exclude exceedance in offal.
However, due to the assumptions of the linear model, this is almost certainly an overestimation (see Chapter 5; Uncertainties in the PFAS transfer in dairy cows and beef cattle). This is especially the case for PFOA, which is almost fully excreted via urine in dairy cows. Contrary to the model prediction, PFOA is therefore not likely to accumulate in meat or offal of dairy cows.

ii. *Concentrations in feed resulting in levels equal to the MLs for meat and offal*
The concentrations in feed that result in levels equal to the ML were calculated using equation 3a and 3b. Only the concentrations of PFNA in maize silage resulting in levels equal to the MLs for meat of rose calves are below the reported LOQs in maize silage. The maximum levels of PFOA, PFNA and PFHxS for offal of rose calves were below the reported LOQs in maize silage (Table 4). For adult beef cows the concentration of PFOA, PFNA and PFHxS in grass silage resulting in levels equal to the MLs for meat are all below their reported LOQs in grass silage. The PFAS concentrations in maize silage needed to reach levels in offal of beef cows that exceed the corresponding MLs were lower than the reported LOQs for all PFASs. (Table 4). However, due to the assumptions in the linear model that was used for beef cattle, the estimated PFAS concentrations in feed are very likely an underestimation (see Chapter 6; Uncertainties in concentrations in feed resulting in levels equal to the MLs). Especially PFOA will almost certainly not to accumulate, which means that PFOA concentrations in feed resulting in levels equal to the ML are almost certainly higher.

Table 3. Overview of the MLs and the estimated concentrations in meat [1], and milk [1] from a dairy cow and in meat [2] and offal [2] from beef cattle following chronic exposure through grass silage, maize silage or lucerne with levels equal to the LOQ (except for PFOS in lucerne). When multiple intake scenarios (average and incidental [3]) are applicable, these are separated by a slash symbol. When the MLs for meat, offal or milk are exceeded, the fold exceedance is added between brackets.

	Product	***PFOS (µg/kg)***	***PFOA (µg/kg)***	***PFNA (µg/kg)***	***PFHxS (µg/kg)***	***Sum 4 [7] PFASs (µg/kg)***
MLs	*Meat*	0.30	0.80	0.20	0.20	1.3
	Offal	6.0	0.70	0.40	0.50	8.0
	Milk [4]	0.020	0.010	0.050	0.060	nr
Dairy cow fed grass silage [5]	*Meat [1]*	*0.18*	*$1.9\cdot10^{-4}$*	-	-	-
	Milk [1]	*0.036 [1.8x]*	*$3.9\cdot10^{-5}$*	-	-	-
Dairy cow fed maize silage [5]	*Meat [1]*	*0.067*	*$2.1\cdot10^{-4}$*	-	-	-
	Milk [1]	*0.013*	*$4.4\cdot10^{-5}$*	-	-	-
Dairy cow fed lucerne [6]	*Meat [1]*	*$1.3\cdot10^{-3}$ / 0.026*	*$2.8\cdot10^{-6}$ / $5.5\cdot10^{-5}$*	-	-	-
	Milk [1]	*$2.5\cdot10^{-6}$ / $5.1\cdot10^{-3}$*	*$5.6\cdot10^{-7}$ / $1.1\cdot10^{-5}$*	-	-	-
Rose veal calf fed maize silage [5]	*Meat [2]*	*0.18*	*0.18*	*0.54 [2.7x]*	*0.18*	*1.1*
	Offal [2]	*5.6*	*5.6 [8.0x]*	*17 [43x]*	*5.6 [11x]*	*34 [4.3x]*
Adult beef cow fed grass silage [5]	*Meat [2]*	*1.3 [4.3x]*	*0.42*	*1.3 [6.5x]*	*1.3 [6.5x]*	*4.32 [3.3x]*
	Offal [2]	*45 [7.5x]*	*15 [21x]*	*45 [110x]*	*45 [90x]*	*150 [19x]*

[1] : Calculations based on the transfer model from Van Asselt et al. (2013) and RIVM (2021b). Concentrations of PFASs in a dairy cow at highest concentration reached, i.e. after 500 days for PFOS and 4 days for PFOA.
[2] : Calculations based on the linear model. Note due to assumptions the concentrations in meat and offal are likely to be overestimated.
[3] : High daily intake that occurs rarely.
[4] : There are no MLs for milk. In the absence of MLs, indicative levels for milk were used (EU 2022/1431).
[5] : Calculations based on LOQs, since no PFOS, PFOA, PFNA or PFHxS was detected above their LOQs in feed.
[6] : Calculations based on LOQs, since no PFOA, PFNA or PFHxS was detected above their LOQs in feed.
[7] : Sum of PFOS, PFOA, PFNA and PFHxS.
Nr: No indicative level for milk is recommended.
- : Not applicable (concentration could not be determined using either the PFOS/PFOA model (Van Asselt et al. 2013; RIVM 2021b) or the linear model).

Table 4. Overview of the current feed LOQs and estimated concentrations [1-2] in the feed materials provided to bovines resulting in levels equal to the MLs for meat, offal and to the indicative levels [3] for milk. When multiple intake scenarios (average and incidental [4]) are applicable, these are separated by a slash symbol. When the calculated concentration in feed is below the LOQ, the fold difference is added between brackets.

	Product	***PFOS (µg/kg)***	***PFOA (µg/kg)***	***PFNA (µg/kg)***	***PFHxS (µg/kg)***
Current LOQs	*Grass silage*	*0.15*	*0.05*	*0.15*	*0.15*
	Maize silage	*0.10*	*0.10*	*0.30*	*0.10*
	Lucerne	*0.05*	*0.05*	*0.20*	*0.10*
Dairy cow fed grass silage	*Meat [1]*	*0.25*	*210*	*-*	*-*
	Milk [1]	*0.084 [1.8x]*	*13*	*-*	*-*
Dairy cow fed maize silage	*Meat [1]*	*0.49*	*370*	*-*	*-*
	Milk [1]	*0.15*	*23*	*-*	*-*
Dairy cow fed lucerne	*Meat [1]*	*18 / 0.88*	*$1.5 \cdot 10^4$ / 730*	*-*	*-*
	Milk [1]	*5.9 / 0.30*	*890 / 45*	*-*	*-*
Rose veal calf fed maize silage	*Meat [2]*	*0.17*	*0.44*	*0.11 [2.7x]*	*0.11*
	Offal [2]	*0.11*	*0.013 [7.7x]*	*0.0072 [42x]*	*0.0090 [11x]*
Adult beef cow fed grass silage	*Meat [2]*	*0.036 [4.2x]*	*0.095*	*0.024 [6.3x]*	*0.024 [6.3x]*
	Offal [2]	*0.020 [7.5x]*	*0.0023 [22x]*	*0.0013 [120x]*	*0.0017 [88x]*

[1] : Calculations based on the transfer model from Van Asselt et al. (2013) and RIVM (2021b). Concentrations of PFASs in a dairy cow at highest concentration reached, i.e. after 500 days for PFOS and 4 days for PFOA.
[2] : Calculations based on the linear model. Note due to assumptions concentrations in the feed materials resulting in levels equal to the MLs for meat and offal are likely to be underestimated.
[3] : There are no MLs for milk. In the absence of MLs, indicative levels for milk were used (EU 2022/1431).
[4] : High daily intake that occurs rarely.
Nr: No indicative level for milk is recommended.
- : Not applicable (concentration could not be determined using either the PFOS/PFOA model (Van Asselt et al. 2013; RIVM 2021b) or the linear model).

Table 5. Overview of the number of days of feeding the described scenario until the ML is exceeded for meat [1] or offal [1]. When multiple intake scenarios (average and incidental [2]) are applicable, these are separated by a slash symbol. The results are rounded to the number of days.

Scenario	***Product***	***Time to exceeding ML (days)***	
		PFNA	***PFHxS***
Dairy cow fed grass silage [3]	*Meat [1]*	*31*	*31*
	Offal [1]	*4*	*5*
Dairy cow fed maize silage [3]	*Meat [1]*	*28*	*84*
	Offal [1]	*4*	*13*
Dairy cow fed lucerne [4] (average / incidental [2])	*Meat [1]*	*1600* / 82*	*3300* / 160*
	Offal [1]	*210 / 10*	*520 / 26*

[1] : Calculations based on the linear model. Note due to assumptions the number of days of feeding the described scenario until the ML is exceeded for meat or offal are likely to be overestimated.
[2] : High daily intake that occurs rarely.
[3] : Calculations based on LOQs, since no PFOS, PFOA, PFNA or PFHxS was detected above their LOQs in feed.
[4] : Calculations based on LOQs, since no PFOA, PFNA or PFHxS was detected above their LOQs in feed.
[*]: Exceeds expected duration of the productive life phase.

5. Question 2a: Transfer of PFASs from feed to edible bovine products

The results of the NP 2020 show that PFASs in grass silage and maize silage were not measured above the LOQ in any of the analyzed samples. Only PFOS was detected in two samples of lucerne, just above the limit of quantification (LOQ). Fishmeal is not fed to bovines and was therefore not included in this assessment (NVWA 2019).
Calculations using the PFOS/PFOA transfer model and the measured PFAS concentration or LOQ levels as exposure concentrations show that the indicative levels in milk or meat MLs are not exceeded for PFOA, PFNA and PFHxS when the dairy cows are fed grass silage, maize silage or lucerne. However, exceedance of the indicative level for milk, following exposure of dairy cows to PFOS at LOQ levels via grass silage, cannot be excluded. Calculated concentrations of PFNA in meat and of PFOA, PFNA, PFHxS and the sum of the 4 PFASs in offal would exceed their MLs when maize silage with PFAS levels at the LOQ is fed to veal calves. For beef cows fed grass silage, the calculated concentrations of all PFASs and the sum thereof exceed their MLs in meat and offal, except for PFOA in meat. It has to be noted that all calculated PFAS concentrations in edible products of bovines mentioned above are overestimations due to the assumptions made in the linear model used, except for PFOS and PFOA in meat and milk for which a transfer model was used. This indicates that more realistic models that cover all four PFASs in all products (milk, meat and offal) in dairy cows, veal calves and beef cows are needed. This could be achieved by extending the existing PFOS/PFOA model for the dairy cow to more edible products (offal) and adapting the models to include PFNA and PFHxS. Alternatively, generic physiologically-based kinetic models could be used to refine the calculations for more PFASs in edible products in both dairy cows, veal calves and beef cows. Next to the need for these models the lowering of the LOQs of the used analytical methods in feed will also help.

Uncertainties in the PFAS transfer in dairy cows and beef cattle

In this assessment, assumptions for intake and transfer had to be made for PFOS, PFOA, PFNA and PFHxS. First of all, the intake was calculated based on the highest PFAS

concentration detected in lucerne or, in the case of grass silage and maize silage, on levels equal to the LOQs. Based on the current concentrations in these feed ingredients, the actual exposure will likely be lower leading to lower transfer to meat, milk and/or offal. Besides this, the approaches used to calculate transfer have their own uncertainties.
In the transfer model model, it was assumed that no elimination of PFASs took place via maternal transfer to calves. However, maternal transfer has been described for other mammalian species (EFSA, 2020). Transfer in utero would result in a lower concentration in the mother cow.
The linear model used for all beef cattle and all PFNA/PFHxS calculations in the adult dairy cow, assumes that no excretion of PFAS takes place. However, excretion of PFHxS and PFNA through milk and/or urine is seen in dairy cows, although lower than PFOS (Kowalczyk et al. 2013; Ehlers, 2012). The excretion of PFAS via urine is also expected in beef cattle (Lupton, 2012). Therefore, the assumption that no excretion takes place in the linear model leads to an overestimation of the concentrations in meat and offal. Unfortunately we do not have enough data to quantify how large this overestimation is.
Secondly, it was assumed that PFASs do not distribute throughout the body, but are distributed solely to either the meat or offal. Kowalczyk et al. (2013) and Ehlers (2012) (n=3 for blood) actually showed that a considerable part of most of the PFASs is present in the blood, and, depending on the PFAS, they were also present in meat, liver and kidneys after approximately 28 days of exposure. They report that from the total intake of PFOS, PFOA and PFHxS, around 30% PFOS, <1% PFOA and 10% PFHxS was present in blood plasma. Of the ingested amount, around 15% PFOS and only <1% PFOA and PFHxS ended up in the liver and all three PFASs were <1% present in the kidney. In addition around 40% PFOS, <1% PFOA and 5% PFHxS of the total amount fed was measured in meat. The accumulation of PFNA is difficult to describe since all detected amounts were very low and even below the detection limit, but around 40% from the total intake ended up in blood, around 1% or <1% in the liver and the kidney and below detection limit in meat. Taken the data described above into account, for the assumption that the PFASs solely distribute to either meat or offal it can be hypothesized that this leads to an overestimation of a factor 6 for PFOS, a factor 5 for PFHxS and a factor 100 for PFOA and PFHxS in meat. For offal, this will be a 6-fold overestimation for PFOS and a 100-fold overestimation for both PFOA and PFHxS.
All assumptions described above combined will lead to an overestimation of the actual concentrations of individual PFASs in food products.

On the other hand, the assumption that dairy cows and beef cattle (including veal calves) were only exposed to PFASs through one feed material in their life time and were not exposed in utero and during lactation, can lead to an underestimation of the actual concentration of individual PFASs in food products. The actual exposure to PFASs is likely to be higher when exposure to other possible sources such as water and soil, or other feed (materials) is taken into account.

In the future, the model for dairy cows or generic physiologically-based kinetic models validated for beef cattle could be used to refine the calculations.

Notably, Kowalczyk et al. (2020) showed in their study with laying hens that precursors of some of the PFASs were found in the feed. They suggested that these precursors can be biotransformed in laying hens to PFOS and PFHxS. It is unknown whether this is true for bovines. Whether biotransformation of precursors following long-term exposure adds to the total PFAS level is unclear. When determining PFAS transfer into edible products, feed should ideally also be analysed for possible precursors.

6. Question 2b: PFAS concentrations in feed of dairy cows and beef cattle resulting in levels equal to the MLs

The feed concentrations that would result in PFAS levels in meat, offal or milk equal to the MLs are shown in Table 4. The calculated concentrations of PFOS in grass silage resulting in milk levels equal to the corresponding indicative level are below the reported feed LOQs. Calculated concentrations of PFNA in maize silage fed to veal calves, and PFOS, PFNA and PFHxS in maize silage fed to beef cows, resulting in levels equal to the MLs for meat, were also below the LOQ. In addition, the calculated concentrations of all four PFASs in maize silage fed to veal calves and in grass silage fed to beef cows resulting in levels equal to the ML for offal were all below the LOQ. However, given the assumptions made in the linear model, the calculated concentrations are lower than the actual concentrations needed to reach levels in edible products that are equal to the MLs or indicative levels.

This indicates the need for further development of the models, as described in section 6 question 2a, to help reduce the underestimation of the calculated concentrations. In addition, the lowering of the LOQs of the applied analytical methods in feed will help.

Uncertainties in concentrations in feed resulting in levels equal to the MLs

The concentrations in feed resulting in levels in meat and offal exceeding the MLs are for some PFASs a lot lower than the LOQs. Lowering the analytical LOQs in combination with more insight into the feed consumption may reduce the uncertainty in the intake of PFASs.

Similar assumptions as for Question 2a were made about the distribution and elimination of PFASs in beef cattle (including calves) and PFNA and PFHxS in dairy cows. These assumptions can lead to an underestimation of the calculated concentrations in feed (too low) resulting in levels equal to the MLs following transfer. For instance, the calculated level for PFOA in maize silage resulting in PFOA offal concentrations equal to the ML in veal calves is 7.7-fold lower than the current LOQ for this PFAS in maize silage, but the difference could also be less than 7.7-fold due to the assumption of a 100% distribution to offal.

However, the assumption that animals were only exposed through one type of feed in their life time, might cause that the calculated concentrations in feed, resulting in levels equal to the MLs, are not low enough, as animals can be exposed through various sources and to multiple PFASs. To take into account co-exposure to several PFASs via several feeds/sources, the PFAS concentrations in feed of dairy cows and beef cattle (including veal) resulting in levels equal to the MLs may need to be even lower.

In this assessment, transfer of PFASs from grass silage, maize silage, and lucerne were estimated for dairy cows and beef cattle. However, these dairy cows and beef cattle may eat less of these feed materials and more fresh feed materials such as grass (expert opinion Paul Bikker). It would be useful to analyse all feed materials that are consumed by dairy cows and/or beef cattle or compound feed. The feed ingredients fed to the selected animals can be found in Appendix VI.

7. Question 1: Health effects of PFASs in dairy cows and beef cattle

Multiple studies looked at the kinetics of PFASs in either steers (Lupton, 2012, Lupton, 2014, Lupton, 2015) or cows (Kowalczyk, 2013, Van Asselt, 2013, Lupton, 2015). Only one study reported that they measured body weight as a marker for healthy growth

(Lupton et al., 2015). In this study Angus steers (n=3) were exposed to 0.098 mg/kg bw PFOS and heifers (n=4) to 9.09 mg/kg bw PFOS in a single dose. No changes in body weight were observed during the 343 day follow-up period.
In a study by Kowalczyk et al. (2013) lactating Holstein Friesian cows (n=6) were exposed to PFASs for a longer period. Cows were fed PFAA containing feed for 28 days. Half of the cows were slaughtered directly, and the other half were fed PFAA-free feed for another 21 days. The oral intake of PFBS, PFHxS, PFOS, and PFOA in this study was 3.4 ± 0.7 (range = 2.2–5.3 µg/kg bw/day), 4.6 ± 1.0 (range = 3.3–7.4 µg/kg bw/day), 7.6 ± 3.2 µg/kg bw/day (range = 4.6–15.8 µg/kg bw/day), and 2.0 ± 1.2 µg/kg bw/day (range = 0.8–4.6 µg/kg bw/day), respectively. Again, no health effects were reported in this paper, indicating the absence of health effects following exposure to PFOS, PFOA and PFHxS.
In Lupton et al. (2012) and Lupton et al. (2014) lowline steers were exposed to only a single dose of 1 mg/kg bw PFOA and 10 mg/kg bw PFOS or 8 mg/kg bw PFOS and 1 mg/kg bw PFOA, respectively, and followed for 28 days. Also in these studies no health effects were reported.
Summarized, none of the studies described health effects following exposure to PFOS, PFOA and PFHxS. In addition, the daily exposures in these studies are 7 to 2000 fold higher than the daily exposure based on the LOQ-based concentrations in feed obtained in the NP 2020. It is therefore unlikely that adverse health effects are expected.

This is also strengthened by the results of the latest PFAS risk assessment by EFSA (EFSA, 2020). In this risk assessment, it was concluded that for animal studies the mice study by Peden-Adams et al. (2008) would be the critical study for immune effects, i.e. reduced specific antibody response. The reported highest daily PFOS exposure with no effect was 0.166 µg PFOS/kg bw and the daily exposure at which a significant effect was observed was 1.66 µg PFOS/kg bw following 28 days of exposure. Based on the analysed feeds, the highest possible daily PFOS exposure for dairy cows is $1.6\cdot10^{-3}$ µg PFOS/kg bw via grass silage, $6.0\cdot10^{-4}$ µg PFOS/kg bw via maize silage and $2.3\cdot10^{-4}$ µg PFOS/kg bw via lucerne. For veal calve this is $4.6\cdot10^{-4}$ µg PFOS/kg bw through maize silage and for beef cows $9.2\cdot10^{-4}$ µg PFOS/kg bw through grass silage. Thus, the highest daily PFOS exposure used in the current assessment is at least a 1000 times lower than the exposure at which an immunological effect was observed in rats. This is more than the 100x uncertainty factor used for intra- and interspecies variation (Lautz et al., 2021), making occurrence of health effects in dairy and beef cattle, after consumption of grass silage, maize silage or lucerne highly unlikely.
In addition, recorded PFOS 'No Observable Adverse Effect Levels' (NOAELs) in rats include a blood concentration of 40 mg/L (Luebker et al., 2005a, 2005b; ToxConsult, 2016a). NTP (2019) observed a number of PFAS effects on the liver and thyroid hormones in rats at plasma levels in the lower range of 23.7 mg/L. However, at a blood concentration of $1.7\cdot10^{-2}\cdot$mg/L no effect regarding a reduced immune response by PFOS in mice were observed. Notably, these PFOS blood concentrations are higher than the estimated total blood PFOS concentration for dairy cows fed grass silage ($2.1\cdot10^{-3}$ mg/L), dairy cows fed maize silage ($7.8\cdot10^{-4}$ mg/L), dairy cows fed lucerne (average: $1.5\cdot10^{-5}$, incidental[2]: $3.0\cdot10^{-4}$). The PFOS concentration represents the total concentration of PFOS in the blood. These calculations were performed using the transfer model that was also used for the dairy cow.

8. Recommendations

- To reduce the number of assumptions made, and go from worst-case to a more realistic scenario, more insight in exposure and transfer is needed:
    - In the future, a refined existing PFOS/PFOA model or generic physiologically-based kinetic models could be used to refine the calculations.

    - It would be useful to analyse other feed materials that are consumed by dairy cows and beef cattle to gain even more insight in their PFAS exposure through feed intake.
    - It would be useful to get more insight in the consumption patterns of all types of beef cattle to include these in the analysis, besides the 'zoogkoeien'.
- Since exposure to precursors of PFASs, next to PFASs, can affect the total concentration of PFASs in both dairy cows and beef cattle, it is recommended to include known precursors in the analysis of the various feeds.
- It is advised that the LOQs of analytical method for the various feed materials are lowered.

9. Conclusions and answers

Question 1. Is there a risk to animal health when maize silage, grass silage, lucerne and fishmeal contaminated with PFASs (at levels found in the NP 2020) are fed to dairy cows or beef cows?

No risk of health for dairy or beef cattle are expected based on the absence of negative health effects in dairy and beef cattle in the literature and the relatively low PFAS concentrations in feed observed in samples from the NP 2020 and the estimated 1000-fold lower intake of PFOS following exposure through these feeds compared to the PFOS exposure in rat studies resulting in adverse effects on the immune response.

Question 2a. What is the transfer of the PFASs (PFOS, PFOA, PFNA, PFHxS) in the above mentioned contaminated feed ingredients to bovine meat/offal/milk? Compare the estimated concentrations with the maximum levels (MLs) of these products.

Fishmeal is not fed to bovines and was therefore not included in this assessment. Only PFOS was detected in 2 samples of lucerne above the limit of quantification (LOQ), PFAS levels in grass silage and maize silage were below the LOQs.
Dairy cows: Calculations using the PFOS/PFOA transfer model and the measured PFOS concentration or applying the LOQ levels as exposure concentrations show that exceedances of the MLs for edible products (dairy and offal), following exposure of dairy cows to PFOS via grass silage cannot be excluded. Calculations using a linear model show potential exceedance of PFNA and PFHxS MLs for meat or offal within the productive lifespan of a dairy cow when fed grass silage, maize silage or an incidental[2] amount of lucerne.
Beef cattle: Calculated concentrations of PFNA in meat and calculated concentrations of PFOA, PFNA, PFHxS and the sum of the 4 PFASs in offal exceed their MLs when maize silage is fed to veal calves at LOQ levels. For beef cows fed grass silage with LOQ levels, the calculated concentrations of all PFASs and the sum thereof would exceed their MLs in meat and offal, except for PFOA in meat.
Since exceedance was only observed when assuming levels equal to the LOQs, the LOQs for grass silage and maize silage should be lowered in the future. Notably, dairy cows, veal calves and beef cows are exposed to more than the feed materials included in this assessment. In addition, for most calculations, except for PFOA and PFOS transfer in the dairy cow a conservative linear model was used. To better assess feed to food transfer and risk to animal health, other feed ingredients fed should be included in the PFAS analysis.

Question 2b. What is the maximum level of PFASs (PFOS, PFOA, PFNA, PFHxS) allowed in feed (maize silage, grass silage, lucerne and fishmeal) before the MLs for PFASs in animal products are exceeded?

Calculated concentrations of PFOS in grass silage, resulting in levels equal to the indicative level for milk when fed to dairy cows, were 1.8 fold below the LOQ. Calculated concentrations of PFOS, PFNA and PFHxS in maize silage fed to veal calves, resulting in levels equal to the MLs for meat/offal, were 2.7 to 42 fold below the LOQ. In addition, the calculated concentrations of all four PFASs in grass silage fed to beef cows resulting in levels equal to the ML for meat/offal were 4.2 to 120 fold below the LOQ.
The calculated concentrations can be found in Table 4 (main text).

It should be noted that for most calculations, except for PFOA and PFOS transfer in the dairy cow, a linear model was used where all PFAS are assumed to accumulate. This likely results in an overestimation of the PFAS concentrations in edible products (question 2a) and an underestimation of the PFAS concentrations in feed that result in PFAS levels in edible products that are equal to the ML (question 2b). To better assess feed to food transfer and risk to animal health, it is recommended to develop new, or extend existing, transfer models for including all edible product for all types of bovines.

References

BuRO. 2019. "Advies over de risico's van de diervoederketen - Bijlagen Februari 2019." In.: NVWA.

EFSA. 2020. "Opinion on the risk to human health related to the presence of perfluoroalkyl substances in food." EFSA Journal 18(9):6223, 391 pp.

Ehlers, S., Thesis: Analytik von Perfluoralkylsäuren in verschiedenen Matrices zur Klärung der Toxikokinetik in Tierarten, die der Lebensmittelgewinnung dienen. Westfälische Wilhelms-Universität Münster, 2012.

EU 2023/915. Commission Regulation (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006. Available via: http://data.europa.eu/eli/reg/2023/915/oj.
EU 2022/1431. Commission Recommandation (EU) 2022/1431 of 24 August 2022 on the monitoring of perfluoroalkyl substances in food. Available via: http://data.europa.eu/eli/reco/2022/1431/oj

Kowalczyk, J., Ehlers, S., Oberhausen, A., Tischer, M., Fürst, P., Schafft, H., and Lahrssen-Wiederholt, M. 2013. 'Absorption, distribution, and milk secretion of the perfluoroalkyl acids PFBS, PFHxS, PFOS, and PFOA by dairy cows fed naturally contaminated feed', Journal of Agricultural and Food Chemistry, 61: 2903-12.

Lautz, L.S., Jeddi, M.Z., Girolami, F., Nebbia, C., Dorne, J.L.C.M. 2021. 'Metabolism and pharmacokinetics of pharmaceuticals in cats (Felix sylvestris catus) and implications for the risk assessment of feed additives and contaminants'. *Toxicology,* 338: 114-127.

Luebker, D.J., Case, M.T., York, R.G., Moore, J.A., Hansen, K.J., Butenhoff, J.L. 2005a. 'Two-generation reproduction and cross-foster studies of perfluorooctanesulfonate (PFOS) in rats.' *Toxicology* 215, 126–148.

Luebker, D.J., Case, M.T., York, R.G., Moore, J.A., Hansen, K.J., Butenhoff, J.L. 2005b. 'Neonatal mortality from in utero exposure to perfluorooctanesulfonate (PFOS) in Sprague–

Dawley rats: dose–response, and biochemical and pharamacokinetic parameters.' *Toxicology* 215, 149–169.

NTP (National Toxicology Program), 2019. NTP technical report on the toxicity studies of perfluoroalkyl sulfonates (perfluorobutane sulfonic acid, perfluorohexane sulfonate potassium salt, and perfluorooctane sulfonic acid) administered by gavage to sprague dawley (Hsd:Sprague Dawley SD) rats. *NTP TOX 96*.

Lupton, S.J., Huwe, J.K., Smith, D.J., Dearfield, K.L., Johnston, J.J. 2012. 'Absorption and excretion of 14C-perfluorooctanoic acid (PFOA) in Angus cattle *(Bos taurus)',* **Journal of Agricultural and Food Chemistry**, 60:1128-34.

Lupton, S.J., Huwe, J.K., Smith, D.J., Dearfield, K.L., Johnston, J.J. 2014. 'Distribution and excretion of perfluorooctane sulfonate (PFOS) in beef cattle *(Bos taurus)',* **Journal of Agricultural and Food Chemistry**, 62: 1167-73.

Lupton, S.J., Dearfield, K.L., Johnston, J.J., Wagner, S., Huwe, J.K. 2015. 'Perfluorooctane sulfonate plasma half-life determination and long-term tissue distribution in beef cattle (*Bos taurus*)', **Journal of Agricultural and Food Chemistry**, 63: 10988-94.

Peden-Adams M.M., Keller J.M., Eudaly J.G., Berger J., Gilkeson G.S., Keil D.E. 2008. 'Suppression of humoralimmunity in mice following exposure to perfluorooctane sulfonate', Toxicological Sciences,: 104: 144–154.

RIVM. 2021a. 'Revised risk assessment of GenX and PFOA in food; Part 1: Toxicity of GenX and PFOA and intake through contaminated dairy products, egss and fish.' Front Office Food and Product Safety. National Institute for Public Health and the Environment (RIVM), Bilthoven.

RIVM. 2021b. 'Revised risk assessment of GenX and PFOA in food; Part 2: Transfer of GenX, PFOA and PFOS in ditch water and silage to edible products of food producing animals.' Front Office Food and Product Safety. National Institute for Public Health and the Environment (RIVM), Bilthoven.

Van Asselt, E., Kowalczyk, J., Van Eijkeren, J., Zeilmaker, M., Ehlers, S., Fürst, P., Lahrs-sen-Wiederholt, M., and Van Der Fels-Klerx, H. 2013a. 'Transfer of perfluorooctane sul-fonic acid (PFOS) from contaminated feed to dairy milk', Food Chemistry, 141: 1489-95.

ToxConsult 2016. "Toxicity profiles for the perfluorinated compounds PFOS, PFOA, 6: 2FTS and 8:2FTS." Prepared for AECOM. ToxConsult document ToxCR011115-RTF, dated 22nd July 2016. Appendix J in AECOM report "Stage 2C Environmental Investigation – Human Health Risk Assessment, Army Aviation Centre Oakey". http://www.defence.gov.au/Environment/PFAS/Docs/Oakey/Reports/0207-AACO-EI2-2016-HHRA_Final(FullReport).pdf.

Appendix I: Detailed description of methods and results of transfer of PFASs in feed to edible products of dairy cows and beef cattle (including veal calves)

1. Methods

a. Analysis of feed samples
The samples were analysed according to an internal procedure SOP-A-1114 at WFSR. One to five grams of fresh material (depending on the product) were extracted using acidified methanol. The extracts were cleaned using weak anion-exchange (WAX) solid phase extraction. After evaporation of the eluate, the residue was dissolved in mobile phase. The final extracts were analysed by liquid chromatography coupled to tandem mass spectrometry. Two ion transitions per compound were monitored according to international guidelines. Isotopically labelled internal standards were added to all samples and quality control samples (including ^{13}C-PFOA and ^{13}C-GenX) to allow a more accurate quantification.

As quality control, a calibration line was prepared in a relevant related product (e.g. silage or fishmeal) with addition of the PFASs from 0 to 5 ng/g. Additionally, chemical blanks were included in duplicate. Furthermore, with every series of samples, a random selection of samples was analysed as is and with addition of a relevant concentration of the PFASs (in some cases additional lower spike levels). Methods used for analysis were validated and accredited under the flexible scope. The limits of quantification (LOQs) can be found in Appendix II.

In total, 25, 30, 40 and 32 samples of grass silage, maize silage, lucerne (chunks, bales, pellets or packs) and fishmeal (fishmeal, salmon meal, pure shrimps, shrimp meal, tuna meal), respectively, have been analysed. The choice to analyse these four animal feeds within the National Plan Animal Feed is based on the conclusion of a report on the risks in the animal feed chain (BuRO 2019). In this report it is concluded that contamination of animal feed plays a role when animals are fed crops (grass, maize) from contaminated locations, and that fishmeal applied in feed can contribute to the exposure to PFASs (BuRO 2019). To answer question 1, 2a and 2b, only the concentrations of PFOS, PFOA, PFNA, PFHxS and the sum thereof were used, since for these PFASs MLs for animal derived products are available (EU 2023/915) or indicative levels in milk (EU 2022/1431).

b. Feed consumption of dairy cows and beef cattle (including veal calves)
There is hardly any recent published information on the composition of the feed of dairy cows and beef cattle. As a result, the amount, duration and type of feed fed to dairy cows and beef cattle described in this section is estimated based on the expert judgement of the department of Animal Nutrition, Wageningen Livestock Research of CBS voor rantsoenen in 2021. Intake is displayed as 88% dry matter (dm). An overview of the intake of grass silage, maize silage, lucerne dairy cows and beef cattle (including veal calves is given in Table A1.

i. *Dairy cows*
Dairy cows are continuously fed 7.0 kg grass silage dm/day and 3.9 kg maize silage dm/day. Dairy cows can be exposed to PFAS via 2555 kg grass silage dm per year (7.0 kg dm/day * 365 days) or 1424 kg maize silage dm per year (3.9 kg dm * 365 days/year)(Table A1). Dairy cows are to a limited extent fed lucerne through-out the whole year during their productive life. On average, dairy cows are fed max 0.1 kg dm/day (average scenario) to max 2 kg dm/day (incidental[2] scenario). On a yearly basis, dairy cows are fed max 36.5 kg dm (max 0.1 kg dm/day * 365 days/year; average scenario) to max 730 kg dm (max 2 kg dm/day * 365 days/year; incidental[2] scenario) (Table A1).

Dairy cows are not fed fishmeal at any stage of their lives, since this is prohibited (NVWA, 2019).

ii. *Beef cattle*
Veal calves are fed maize silage on average for 1.6 kg dm/day during their 8 month life (=244 days). As a result, these calves are fed 390.4 kg dm maize silage (1.6 kg dm/day * 244 days)(Table A1). Veal calves are not fed grass silage, lucerne or fishmeal.

The adult beef cattle are cows not used for dairy production, also known as 'zoogkoeien' in Dutch. The intake by other adult beef cattle of the four feed materials is unknown due to the large diversity of practical systems for the group. They have calved at least once. Adult beef cattle are fed grass silage during 6 months per year (November until April = 181 days) when they are in the stable. On average this type of beef cattle lives 7.5 years before they are slaughtered, but the calculations described in this assessment only cover the last 5 years of this period, i.e. adult period. Beef cattle are fed 778.3 kg dm grass silage per year (4.3 kg dm/day * 181 days) for 5 years (Table A1). Beef cattle are not fed maize silage, lucerne and fishmeal. Feeding fishmeal is prohibited (NVWA, 2019).

Table A1. Feed consumption of dairy cows and beef cattle when fed the various feed materials

Animal	***Scenario***	***Grass silage***	***Maize silage***	***Lucerne***	***Fishmeal***
Dairy cow	*Average*	7.0 kg dm/day * 365 days= 2555 kg dm/year	3.9 kg dm/day * 365 days= 1424 kg dm/year	0.1 kg dm/day * 365 days = max 36.5 kg dm/year	-
	Incidental[1]	-	-	2 kg dm/day * 365 days = max 730 kg dm/year	-
Veal calf (rose)	*Average*	-	1.6 kg dm/day (average) * 244 days = 390.4 kg dm	-	-
Adult beef cattle	*Average*	4.3 kg dm/day * 181 days/year = 778.3 kg dm/year * 5 year = 3891 kg dm	-	-	-

[1]: High daily intake that occurs rarely.

- : not fed, dm: dry matter.

c. Calculus (input values)

Table A2. Weight and age at which dairy cows and beef cattle are slaughtered for production.

Animal (phase)	***What type of food (products)?***	***When are these produced?***	***% of weight is meat***	***% of weight is offal (liver + kidneys)***
Dairy cow	Milk + meat + liver + kidney	650 kg, at end of production approximately at age 4-6 years[1]	29.75%[2]	1.87%[2]
Veal calf (rose)	Meat + liver + kidney	At 350 kg at age 244 days[1]	62.00%[3]	2.00%[3]
Adult beef cattle[4]	Meat + liver + kidney	At 700 kg[1] at age 7.5 years	64.00%[3]	1.84%[3]

[1]: The estimated slaughter time and the weight at time of slaughter are based on expert judgement of the department of Animal Nutrition (Wageningen University and Research) based on KWIN 2022.
[2]: Van Asselt et al. (2013); RIVM (2021b): 29.75% meat (35% muscle of 85% of body weight) and 1.87% offal (1.9% liver + 0.3% kidney of 85% of body weight) for a dairy cow of 600 kg.
[3]: van Raamsdonk et al. (2007): for a meat calf of 250 kg: 62.00% meat (muscle) and 2.00% offal (1.60% liver + 0.40% kidney); for a beef cow of 500+ kg: 64.00% meat (muscle) and 1.84% offal (1.50% liver + 0.34% kidney).
[4]: The adult beef cattle are cows that have calved at least once and are not held as dairy cows, also known as 'zoogkoeien' in Dutch.

2. Results: Transfer of PFASs

a. Dairy cow fed grass silage, maize silage or lucerne

i. *Transfer of PFOS and PFOA from feed to meat and milk*

Dairy cows can be fed grass silage, maize silage and/or lucerne. The PFOS and PFOA concentrations in meat and milk (see table A3 b and c) were calculated using the PFOS/PFOA model (van Asselt, 2013; RIVM, 2021), assuming that dairy cows were not exposed during previous life stages to any source of PFAS and no elimination took place via maternal transfer. In this transfer model 99.75% of the steady state concentration is reached after approximately 500 days for PFOS and after approximately 4 days for PFOA. The model was run for a 650 kg dairy cow with a milk production of 29.5 L/day. The concentrations in offal could not be obtained with the current model, so only calculated concentrations in meat and offal are shown.

PFOS and PFOA in grass silage, maize silage and PFOA in lucerne are not detected above the LOQ (Table 2, main text). The highest concentration PFOS detected in lucerne can be found in Table 2 (main text). These LOQs or concentration (in µg/kg) were multiplied by the daily intake amount of the intake scenarios for either grass silage, maize silage or lucerne to obtain the daily intake of PFOS or PFOA (see table A3, a). As seen in table A1 the average intake of grass silage is 7.0 kg dm/day; the average intake of maize silage is 3.9 kg dm/day; the average intake of lucerne is 0.1 kg dm/day and the incidental[2] intake of lucerne is 2 kg dm/day.

The MLs for PFOS and PFOA in meat were not exceeded in any feeding scenario (Table A3, b,d). The indicative level for PFOS in milk was exceeded during chronic grass silage feeding and this exceedance was reached after 105 days of feeding and eventually reached 1.8 times the indicative level (Table A3, c,d). For the other feed materials, maize silage and lucerne, the indicative level for PFOS and PFOA in milk was not exceeded, nor was this level exceeded for PFOA in any feeding scenario (Table A3, c).

The exceedance was reached after 105 days of feeding.

Table A3. MLs and steady state concentrations of PFOS and PFOA [1] in meat and milk of a dairy cow following exposure to PFOS and PFOA when fed grass silage, maize silage or lucerne year round. When the MLs for meat or milk are exceeded, the fold exceedance is added between brackets.

	(a) PFAS intake amount (µg/day)		***(b) Concentration in meat (µg/kg)***		***(c) Concentration in milk (µg/kg)***		***(d) MLs (µg/kg)***	
	Average scenario	*Incidental scenario [2]*	*Average scenario*	*Incidental scenario [2]*	*Average scenario*	*Incidental scenario [2]*	*Meat*	*Milk [3]*
Grass silage [4]								
PFOS	1.01	-	0.18	-	0.036 [1.8x]	-	0.30	0.020
PFOA	0.35	-	$1.9 \cdot 10^{-4}$	-	$3.9 \cdot 10^{-5}$	-	0.80	0.010
Maize silage [4]								
PFOS	0.40	-	0.067	-	0.013	-	0.30	0.020
PFOA	0.39	-	$2.1 \cdot 10^{-4}$	-	$4.4 \cdot 10^{-5}$	-	0.80	0.010
Lucerne [5]								
PFOS	0.005	0.1	$1.3 \cdot 10^{-3}$	0.026	$2.5 \cdot 10^{-6}$	$5.1 \cdot 10^{-3}$	0.30	0.020
PFOA	0.0075	0.15	$2.8 \cdot 10^{-6}$	$5.5 \cdot 10^{-5}$	$5.6 \cdot 10^{-7}$	$1.1 \cdot 10^{-5}$	0.80	0.010

[1] : Calculations based on the transfer model from Van Asselt et al. (2013) and RIVM (2021b). Concentrations of PFASs in a dairy cow at highest concentration reached, i.e. after 500 days for PFOS and 4 days for PFOA.
[2] : High daily intake that occurs rarely.
[3] : There are no MLs for milk. In the absence of MLs, indicative levels for milk were used (EU 2022/1431)
[4] : Calculations based on LOQs, since no PFOS or PFOA was detected above their LOQs in feed.
[5] : Calculations based on LOQs, since no PFOA was detected above their LOQs in feed.
- : Not applicable (concentration could not be determined using either the PFOS/PFOA model (Van Asselt et al. 2013; RIVM 2021b)).

ii. *Concentration of PFOS and PFOA in feed resulting in levels equal to MLs*
Dairy cows may be exposed to PFASs through grass silage, maize silage and/or lucerne. Therefore, the PFOS and PFOA concentrations in grass silage, maize silage and lucerne that would lead to levels equal to the MLs for meat or indicative levels for milk were calculated. The concentrations in feed were calculated based on reversed dosimetry modelling, using the PFOS/PFOA transfer model (van Asselt, 2013; RIVM, 2021).

The maximum concentrations in feed (grass silage) needed to not exceed the ML for meat and for milk following year round exposure can be found in Table A4, b,c. The concentrations of PFOS and PFOA in grass silage that lead to concentrations matching the respective MLs for meat lay all above their associated LOQ in the feeding materials. The same is the case for PFOA in milk, but for PFOS in milk the LOQ is 1.8-fold higher than the levels that would result in PFOS levels matching the indicative PFOS level in milk. The concentrations of PFOS and/or PFOA in maize silage and lucerne resulting in levels equal to the MLs for milk or indicative levels for milk are all above the reported associated LOQs in feed (Table A4,b, c, d)

Table A4. Current LOQs and concentrations of PFOS and PFOA in grass silage, maize silage and lucerne fed year round to a dairy cow resulting in levels equal to the MLs for meat or milk [1]. The numbers in brackets symbolise the times the concentration is lower than the respective LOQ.

	(a) Max. intake amount (µg/day) in both scenarios		***(b) Concentration in feed (µg/kg) resulting in meat ML levels***		***(c) Concentration in feed (µg/kg) resulting in milk ML levels***		***(d) Current LOQs in feed (µg/kg)***
	Meat	*Milk*	*Average scenario*	*Incidental scenario [2]*	*Average scenario*	*Incidental scenario [2]*	
Grass silage							
PFOS	1.75	0.590	0.25	-	0.084 [1.8x]	-	0.15
PFOA	1453	89.23	210	-	13	-	0.05
Maize silage							
PFOS	1.75	0.590	0.49	-	0.15	-	0.10
PFOA	1453	89.23	370	-	23	-	0.10
Lucerne							
PFOS	1.75	0.590	18	0.88	5.9	0.30	0.05
PFOA	1453	89.23	$1.5 \cdot 10^4$	730	890	45	0.05

[1] : Calculations based on the transfer model from Van Asselt et al. (2013) and RIVM (2021b).
[2] : High daily intake that occurs rarely.
- : Not applicable (concentration could not be determined using either the PFOS/PFOA model (Van Asselt et al. 2013; RIVM 2021b)).

iii. *Transfer of PFNA and PFHxS from feed to meat and offal*

Dairy cows are exposed to PFAS through grass silage, maize silage and lucerne. Since no model is available, concentrations in milk, meat and offal following year round exposure to grass silage, maize silage and lucerne cannot be simulated using an existing model as was done for PFOS and PFOA. In contrast to beef cattle, the slaughter time of dairy cows varies which makes it more difficult to determine the length of the exposure period and thus the eventual maximum or final concentration. Instead, the number of days an animal can be fed at concentrations detected in feed before the MLs will be exceeded (T_{max}) was calculated, using the equation 2a and b (main text). This approach assumes that no elimination will take place during exposure (including elimination via dairy or maternal transfer to calves and that all PFAS will either go to meat or offal).

The concentrations detected in grass silage can be found in Table 2 (main text). Since PFNA and PFHxS are not detected above the LOQ, the LOQs will be used to calculate the concentrations in meat and offal of dairy cows (worst-case scenario). Also, it is assumed that no elimination will take place during the intake and that all PFAS will go to the meat or offal. First, the daily intake of PFNA or PFHxS (Table A5, a) is calculated by multiplying the LOQs (Appendix II) with the daily intake of the feed (Table A1). Thereafter, maximum amount of PFAS in meat or offal based on the MLs (Table A6, d) is calculated by multiplying the MLs (Table 1) with the weight of meat (29.75% of 650 kg=193.38 kg; Table A2) and offal (1.87% of 650 kg= 12.16 kg, Table A2) at the time of slaughter. By dividing the maximum level of PFAS in meat or offal based on the MLs by the daily intake amount, the number of days of feeding it takes for the concentration in dairy cows, specifically meat and offal, to exceed the ML can be calculated (Table A5, b, c).

The results indicate that, for grass or maize silage fed dairy cows, exceeding the ML for either PFNA or PFHxS in meat takes about 1 to 3 months, whereas in offal this takes a few days to 2 weeks. For dairy cows that are fed lucerne the results vary much more. For the incidental[2] lucerne feeding scenario results in exceeding of the ML; for either PFAS, in meat within a few months up to half a year, while those MLs in offal are reached within the month. For the average lucerne feeding scenario the time until the ML is exceeded strongly increases. In offal it takes about ~200 (PFNA) to ~500 (PFHxS) days until the ML is exceeded, which is still within the expected maximum duration of the modelled duration of productive life of a dairy cow. For meat it takes ~4.5 years for the PFNA concentration to reach the ML, which is just below this maximum duration of 5 years. For PFHxS, it is expected to take ~9 years for the ML to be exceeded, which is well above the the maximum expected duration of productive life of a dairy cow.

Table A5. Time during which dairy cows can be fed grass silage, maize silage or lucerne contaminated with PFNA or PFHxS before the ML of meat and offal is reached [1].

	(a) PFAS intake amount (µg/day)		***(b) Time to meat ML exceeded (days)***		***(c) Time to offal ML exceed (days)***		***(d) MLs (µg/kg)***	
	Average scenario	*Incidental scenario [2]*	*Average scenario*	*Incidental scenario [2]*	*Average scenario*	*Incidental scenario [2]*	*Meat*	*Offal*
Grass silage [3]								
PFNA#	1.05	-	31	-	4	-	0.2	0.4
PFHxS#	1.05	-	31	-	5	-	0.2	0.5
Maize silage [3]								
PFNA#	1.17	-	28	-	4	-	0.2	0.4
PFHxS#	0.39	-	84	-	13		0.2	0.5
Lucerne [3]								
PFNA#	0.2	0.4	1600	82	210	10	0.2	0.4
PFHxS#	0.01	0.2	3300	160	520	26	0.2	0.5

[1] : Calculations based on the linear model. Note, due to assumptions, the number of days of feeding in the described scenario until the ML is exceeded for meat or offal are likely to be overestimated.
[2] : High daily intake that occurs rarely.
[3] : Calculations based on LOQs, since no PFNA or PFHxS was detected above their LOQs in feed.

iv. *Concentration of PFNA and PFHxS in feed resulting in levels equal to MLs*
The slaughter time of dairy cows varies which makes it impossible to determine the length of the exposure period and thus the eventual concentration of PFNA and PFHxS in feed resulting in levels equal to MLs.

b. Veal (rose) fed maize silage

i. *Transfer of PFAS from feed to meat and offal*
From the four tested feed materials only maize silage is fed to veals. It is assumed that the animals have no internal PFAS levels due to previous PFAS exposure (other feed materials, drinking water, soil, or in utero and during lactation). For rose calves, there was no available transfer model. Therefore the concentration (C_x) in meat/offal was estimated

based on the cumulative intake during the modelled life state ($I_{cum,PFAS}$) using equation 1 (main text).

PFOS, PFOA, PFNA and PFHxS were not detected in maize silage above the LOQ (Table 2, main text) and the major question remaining is whether the sensitivity of the method was low enough to ensure that the MLs in meat and offal are not exceeded. These LOQs (in µg/kg) were multiplied by the cumulative intake amount of the intake scenario (average intake: 1.6 kg; Table A1) to obtain $I_{cum.\ PFAS}$ (Table A6, a). The cumulative intake is the combined intake of maize silage over the 244 days in which maize silage is fed (Table A6, b). $I_{cum.\ PFAS}$ of the two scenarios was divided by the amount of meat (62.0% of 350 kg= 217 kg) or offal (kidneys + liver, 2.00% of 350 kg= 7 kg) of a rose calve at the time of slaughter (Table A2) to calculate the concentration in meat and offal (Table A6, c and d). This calculation was made under the worst-case assumption that all PFASs will be absorbed and distributed to either meat (c) or offal (d) and no elimination will take place.

Given this method, feeding of maize silage to rose veal calves at LOQ levels only leads to the exceedance of the MLs for meat of PFNA. In addition, in offal the concentrations are predicted to exceed the ML for PFOA, PFNA, and PFHxS, as well as the sum of the 4 PFAS.

Table A6. MLs and concentrations of PFASs [1] in meat and offal of a veal calve at the time of slaughter following exposure to PFASs at LOQ levels through maize silage. When the MLs for meat and offal are exceeded, the fold exceedance is added between brackets.

	(a) LOQs in maize silage (µg/kg)	***(b) Cumulative PFAS intake amount (µg)***	***(c) Concentration in meat (µg/kg)***	***(d) Concentration in liver and kidney (µg/kg)***	***(e) MLs (µg/kg)***	
		Average scenario	*Average scenario*	*Average scenario*	*Meat*	*Offal*
PFOS	0.10	39	0.18	5.6	0.30	6.0
PFOA	0.10	39	0.18	5.6 [8.0x]	0.80	0.70
PFNA	0.30	120	0.54 [2.7x]	17 [43x]	0.20	0.40
PFHxS	0.10	39	0.18	5.6 [11x]	0.20	0.50
Sum PFAS [2]	na	237	1.1	34 [4.3x]	1.5	7.6

[1] : Calculations based on the linear model. Note due to assumptions the concentrations in meat and offal are likely to be overestimated.
[2] : Sum of PFOS, PFOA, PFNA and PFHxS.
na: not applicable.

ii. *Concentration in feed resulting in levels equal to the MLs*
Veal calves are not fed grass silage, lucerne or fishmeal, but may be exposed to PFASs through maize silage. Therefore, only the concentrations in maize silage that would lead to levels equal to the MLs for meat or offal were calculated. The concentrations were calculated using equation 3a and b (main text).

The $I_{max,PFAS}$ during the 244 day period (8 months) was calculated by multiplying the MLs for the corresponding PFAS for meat and offal (Table 1, main text) with the amount of meat (62.0% 350 kg= 164.37 kg or offal (kidneys + liver, 2.00% of 350 kg= 7 kg of a rose calve at the time of slaughter (Table A2) of an veal calve (rose) at the time of slaughter, respectively (Table A7, a). Next, the maximal intake of each PFAS was divided by the total amount of maize silage the animal eats during the life phase (Table A1) to obtain the concentration in maize silage resulting in levels equal to the MLs for PFASs in meat and offal of veal (rose) (Table A7, b, c). For this calculation it was assumed that no elimination of PFASs took place between intake and slaughter and that all PFASs will go to either the meat or offal and all PFAS is absorbed.

The concentrations of PFOS, PFOA and PFHxS in maize silage resulting in levels equal to the ML for meat are above the LOQ for those PFAS in that feed material, while the maximum concentration of PFNA lies below the LOQ. For offal the maximum concentration of PFOA, PFNA and PFHxS all are lower than their LOQ in maize silage.

Table A7. Current LOQs and concentrations of PFASs in maize silage fed to a veal calf (rose) resulting in equal levels to the MLs for meat or offal at the time of slaughter [1]. The numbers in brackets symbolise the times the concentration is lower than the respective LOQ.

	(a) Max. intake amount (µg)		***(b) Concentration in feed (µg/kg) resulting in meat ML levels***	***(c) Concentration in feed (µg/kg) resulting in offal ML levels***	***(d) Current LOQs in maize silage (µg/kg)***
	Meat	*Offal*	*Average scenario*	*Average scenario*	
PFOS	52	34	0.17	0.11	0.10
PFOA	140	3.9	0.44	0.013 [7.7x]	0.10
PFNA	35	2.2	0.11 [2.7x]	0.0072 [42x]	0.30
PFHxS	35	2.8	0.11	0.0090 [11x]	0.10

[1] : Calculations based on the linear model. Note due to assumptions the concentrations in meat and offal are likely to be overestimated.

c. Adult beef cattle fed grass silage

i. *Transfer of PFAS from feed to meat and offal*

The intake adult beef cattle of the four feed materials is unknown due to the large diversity of practical systems for the group. Only for beef cows intake data was available, i.e. cows that have calved at least once and are not held as dairy cows, also known as 'zoogkoeien' in Dutch, but referred to as beef cow in the remainder of the text. These beef cows are not fed maize silage, lucerne and fishmeal, but may be fed grass silage. However, PFOS, PFOA, PFNA and PFHxS were not detected in grass silage above the LOQ and the major question remaining is whether the sensitivity of the method was low enough to ensure that the MLs in meat and offal are not exceeded. The concentrations in the edible products of adult beef cows exposed through grass silage were calculated using equation 1 (main text) in combination with the LOQs of the method (Table A8, a).

These LOQs (in µg/kg) were multiplied by the cumulative intake amount of the intake scenario (average intake over 5 years: 3891 kg; Table A1) to obtain $I_{cum.\ PFAS}$ (Table A8, b). $I_{cum.\ PFAS}$ was divided by the amount of meat (66.0% of 700 kg= 462 kg) or offal (kidneys + liver, 1.84% of 700 kg= 12.88 kg) of an adult beef cow at the time of slaughter (Table A2) to calculate the concentration in meat and offal (Table A8, c and d). This calculation was made under the worst-case assumption that no elimination will take place and that all PFASs will go to either the meat (c) or the offal (d) and all PFAS is absorbed.

The results show that PFOS, PFNA and PFHxS could be found in meat at concentrations exceeding the MLs following exposure to grass silage at LOQ levels. Concentrations of all PFAS in offal exceeding the ML can also be found following exposure through grass silage.

Table A8. MLs and concentrations of PFASs [1] in meat and offal of a beef cows at the time of slaughter following exposure to PFASs through grass silage. When MLs for meat and offal are exceeded, the fold exceedance is added between brackets.

	(a) LOQs in grass silage (µg/kg)	***(b) Cumulative PFAS intake amount (µg)***	***(c) Concentration in meat (µg/kg)***	***(d) Concentration in liver and kidney (µg/kg)***	***(e) MLs (µg/kg)***	
		Average scenario	*Average scenario*	*Average scenario*	*Meat*	*Offal*
PFOS	0.15	580	1.3 [4.3x]	45 [7.5x]	0.30	6.0
PFOA	0.05	190	0.42	15 [21x]	0.80	0.70
PFNA	0.15	580	1.3 [6.5x]	45 [110x]	0.20	0.40
PFHxS	0.15	580	1.3 [6.5x]	45 [90x]	0.20	0.50
Sum PFAS [2]	na	1930	4.32 [3.3x]	150 [19x]	1.30	8.0

[1] : Calculations based on the linear model. Note due to assumptions the concentrations in meat and offal are likely to be overestimated.
[2] : Sum of PFOS, PFOA, PFNA and PFHxS.
na: not applicable.

ii. *Concentration in feed resulting in levels equal to the MLs*

Beef cows are not fed maize silage, lucerne and fishmeal, but may be fed grass silage. The concentrations in grass silage that may lead to MLs levels for meat or offal were calculated using equation 3 (main text).

The $I_{max,PFAS}$ during the 5 month/ per year for 7.5 years period was calculated by multiplying the MLs for the corresponding PFAS for meat and offal (Table 1, main text) with the amount of meat (6.0% of 700 kg= 462 kg, Table A2) or offal (kidneys + liver, 1.84% of 700 kg= 12.88 kg, Table A2) of an adult beef cow at the time of slaughter (Table A9, a). Next, the maximal intake of each PFAS was divided by the maximal intake (average intake: 5808 kg; Table A1) to obtain the concentration in grass silage resulting in levels equal to the MLs for PFASs in meat of beef cows (Table A9, b). This was repeated for the ML of PFASs in offal of beef cows (Table A9, c). Since the maximal intake was used to calculate these levels in feed, the concentrations in grass silage would be higher when the grass silage intake is lower. For this calculation it was assumed that no elimination of PFASs took place between intake and slaughter and that all PFASs will go to either the meat or offal and all PFAS is absorbed.

The concentrations of PFOS, PFNA and PFHxS in grass silage resulting in levels equal to the ML for meat are lower than their respective LOQs. The concentrations of all four PFAS in grass silage resulting in levels matching the ML in offal are lower than the LOQ. Ranging from just below a factor of 10 for PFOS to more than a factor 100 for PFNA and PFHxS.

Table A9. Current LOQs and concentrations of PFASs in grass silage fed to a beef cow resulting in equal levels to the MLs for meat or offal at the time of slaughter [1]. The numbers in brackets symbolise the times the concentration is lower than the respective LOQ.

	(a) Max. intake amount (µg)		***(b)Concentration in feed (µg/kg) resulting in meat ML levels***	***(c) Concentration in feed (µg/kg) resulting in offal ML levels***	***(d) Current LOQs in grass silage (µg/kg)***
	Meat	*Offal*	*Average scenario*	*Average scenario*	
PFOS	110	66	0.036 [4.2x]	0.020 [7.5x]	0.15
PFOA	300	7.7	0.095	0.0023 [22x]	0.05
PFNA	76	4.4	0.024 [6.3x]	0.0013 [120x]	0.15
PFHxS	76	5.5	0.024 [6.3x]	0.0017 [88x]	0.15

[1] : Calculations based on the linear model. Note due to assumptions the concentrations in meat and offal are likely to be overestimated.

References Appendix I

BuRO. 2019. "Advies over de risico's van de diervoederketen - Bijlagen Februari 2019." NVWA.

EU 2023/915. Commission Regulation (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006. Available via: http://data.europa.eu/eli/reg/2023/915/oj.

EU 2022/1431. Commission Recommandation (EU) 2022/1431 of 24 August 2022 on the monitoring of perfluoroalkyl substances in food. Available via: http://data.europa.eu/eli/reco/2022/1431/oj

Kowalczyk, J., Ehlers, S., Oberhausen, A., Tischer, M., Fürst, P., Schafft, H., and Lahrssen-Wiederholt, M. 2013. 'Absorption, distribution, and milk secretion of the perfluoroalkyl acids PFBS, PFHxS, PFOS, and PFOA by dairy cows fed naturally contaminated feed', Journal of Agricultural and Food Chemistry, 61: 2903-12.

RIVM. 2021b. 'Revised risk assessment of GenX and PFOA in food; Part 2: Transfer of GenX, PFOA and PFOS in ditch water and silage to edible products of food producing animals.' Front Office Food and Product Safety. National Institute for Public Health and the Environment (RIVM), Bilthoven.

Van Asselt, E., Kowalczyk, J., Van Eijkeren, J., Zeilmaker, M., Ehlers, S., Fürst, P., Lahrssen-Wiederholt, M., and Van Der Fels-Klerx, H. 2013a. 'Transfer of perfluorooctane sulfonic acid (PFOS) from contaminated feed to dairy milk', Food Chemistry, 141: 1489-95.

van Raamsdonk, L. W. D., Kan, C. A., Meijer, G. A. L., & Kemme, P. A. (2007). Kengetallen van enkele landbouwhuisdieren en hun consumptiepatronen. (Rapport / RIKILT; No. 2007.010). RIKILT.

Appendix II – LOQs for PFAS analysis in µg/kg in feed

Full name	***Abbreviation***	***Grass silage***	***Maize silage***	***Lucerne***
Perfluoropentanoic acid	PFPeA (C5)	4.00	-	-
Perfluorohexanoic acid	PFHxA (C6)	1.50	1.30	1.50
Perfluoroheptanoic acid	PFHpA (C7)	0.15	0.30	0.10
Perfluoroctanoic acid	PFOA (C8)	0.05	0.10	0.05
Perfluornonanoic acid	PFNA (C9)	0.15	0.30	0.20
Perfluordecanoic acid	PFDA (C10)	0.50	0.30	0.20
Perfluorundecanoic acid	PFUnA (C11)	0.50	0.30	0.10
Perfluordodecanoic acid	PFDoA (C12)	0.50	0.10	0.10
Perfluortridecanoic acid	PFTrDA (C13)	0.10	0.30	0.10
Perfluortetradecanoic acid	PFTeDA (C14)	0.05	0.10	0.20
Perfluorhexadecanoic acid	PFHxDA (C16)	0.10	-	0.10
Perfluoroctadecanoic acid	PFODA (C18)	-	-	-
Perfluorbutane sulfonic acid	PFBS (C4)	0.05	0.20	0.20
Perfluorhexane sulfonic acid	PFHxS (C6)	0.15	0.10	0.10
Perfluorheptane sulfonic acid	PFHpS (C7)	0.05	0.10	0.20
Perfluoroctane sulfonic acid	PFOS (C8)	0.15	0.10	0.05
Perfluordecane sulfonic acid	PFDS (C10)	0.20	0.10	0.20
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	0.50	0.60	0.50
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	1.00	0.30	1.00
Sodium dodecafluoro-3H-4, 8 dioxanonanoate	NaDONA	0.05	0.20	-
Hexafluoropropylene oxide dimer acid	GenX/HFPO-DA	2.00	-	1.00

- : not determined.

Appendix III – Analytical results of PFASs in grass silage[3]

Number	1	2	3	4	5	6	7	8	9	10
SAMPLE_ID	200606737	200606738	200606739	200606979	200606980	200606981	200606982	200606983	200606984	200606985
VWA CODE	75090994	75091001	75091028	75091036	75091044	75091052	75179448	75179421	75179456	75411391
PRODUCT:	graskuil	graskuil	graskuil	graskuil	graskuil	graskuil	plantaardig voeder-middel eu= graskuil	plantaardig voeder-middel eu= graskuil	plantaardig voeder-middel eu=grakuil	graskuil
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	12-11-20	12-11-20	12-11-20	16-11-20	16-11-20	16-11-20	17-11-20	17-11-20	17-11-20	17-11-20
PFPeA (ng/g)	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PFUnDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PFDoDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)										
PFBS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFHxS (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFHpS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFOS (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
GenX (ng/g)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0

[3] The concentration PFAS is expressed in ng/g. This is equal to µg/kg. In the main text and appendix I and II µg/kg was used as unit for consistency in the units during calculations.

Number	11	12	13	14	15	16	17	18	19	20
SAMPLE_ID	200606986	200606987	200607556	200607557	200607558	200607559	200607560	200607561	200607762	200607763
VWA CODE	75411375	75411383	75091079	75179502	75179472	75179499	75411413	75411367	75173164	75173148
PRODUCT:	graskuil	graskuil	graskuil	plantaar-dig voe-dermiddel eu=grassi-lage (graskuil)	plantaar-dig voe-dermiddel eu=grassi-lage (gras-kuil)	plantaar-dig voe-dermiddel eu= gras-silage (graskuil)	kuilgras	kuilgras	graskuil	graskuil
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	17-11-20	17-11-20	18-11-20	19-11-20	19-11-20	19-11-20	19-11-20	19-11-20	20-11-20	20-11-20
PFPeA (ng/g)	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PFUnDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PFDoDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)										
PFBS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFHxS (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFHpS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFOS (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
GenX (ng/g)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0

Number	21	22	23	24	25
SAMPLE_ID	200607928	200607929	200607930	200607936	200608374
VWA CODE	75173172	75173199	75179529	75411456	75173229
PRODUCT:	graskuil	graskuil	plantaardig voedermiddel eu=grassilage (graskuil)	kuilgras	graskuil
LAND VAN HERKOMST:	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	24-11-20	24-11-20	24-11-20	24-11-20	24-11-20
PFPeA (ng/g)	<4.0	<4.0	<4.0	<4.0	<4.0
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15
PFDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50
PFUnDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50
PFDoDA (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)					
PFBS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050
PFHxS (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15
PFHpS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050
PFOS (ng/g)	<0.15	<0.15	<0.15	<0.15	<0.15
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050
GenX (ng/g)	<2.0	<2.0	<2.0	<2.0	<2.0

Appendix IV – Analytical results of PFASs in maize silage[3]

Number	1	2	3	4	5	6	7	8	9	10
SAMPLE_ID	200603930	200603931	200603932	200603933	200603934	200603935	200603936	200603937	200603938	200603939
VWA CODE	75410867	75410794	75090633	75172478	75090692	75090684	75090706	75410808	75410816	75090676
PRODUCT:	snijmais	snijmais	snijmais	maiskuil	snijmais	snijmais	snijmais	snijmais	snijmais	snijmais
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	13-10-2020	6-10-2020	6-10-2020	15-10-2020	12-10-2020	12-10-2020	12-10-2020	12-10-2020	7-10-2020	6-10-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
PFHpA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFOA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFNA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFUnDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFTeDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHxDA (ng/g)										
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
11Cl-PF3OUdS (ng/g)	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
9Cl-PF3ONS (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
NaDONA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
GenX (ng/g)										

Number	11	12	13	14	15	16	17	18	19	20
SAMPLE_ID	200603940	200603941	200603942	200603943	200603944	200604424	200604425	200604426	200604427	200604428
VWA CODE	75410786	75078757	75090641	75078722	75090668	75179278	75411073	75179235	75179146	75410956
PRODUCT:	snijmais	snijma-iskuil	snijmais	snijma-iskuil	snijmais	plantaardig voeder-middel eu= snijmais	snijmais	plantaardig voeder-middel eu= snijmais	plantaardig voeder-middel eu=snijmais	snijmais
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	6-10-2020	1-10-2020	2-10-2020	1-10-2020	2-10-2020	22-10-2020	21-10-2020	21-10-2020	20-10-2020	19-10-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
PFHpA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFOA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFNA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFUnDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFTeDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHxDA (ng/g)										
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
11Cl-PF3OUdS (ng/g)	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
9Cl-PF3ONS (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
NaDONA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
GenX (ng/g)										

Number	21	22	23	24	25	26	27	28	29	30
SAMPLE_ID	200604429	200604430	200604432	200604433	200604686	200604825	200604829	200605180	200605468	200605839
VWA CODE	75179138	75411111	75172486	75172516	75172648	75179286	75179294	75411235	75411251	75173067
PRODUCT:	plantaardig voeder-middel eu= snijmais	snijmais	snijmais	snijmais	snijma-iskuil	plantaardig voeder-middel eu=snijmais	plantaardig voeder-middel eu= snijmais	snijmais	snijmais	maiskuil
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	19-10-2020	22-10-2020	16-10-2020	16-10-2020	23-10-2020	26-10-2020	27-10-2020	29-10-2020	2-11-2020	4-11-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
PFHpA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFOA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFNA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFUnDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
PFTeDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHxDA (ng/g)										
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
11Cl-PF3OUdS (ng/g)	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
9Cl-PF3ONS (ng/g)	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
NaDONA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
GenX (ng/g)										

Appendix V – Analytical results of PFASs in lucerne[3]

Number	1	2	3	4	5	6	7	8	9	10
SAMPLE_ID	200598296	200598297	200598298	200598299	200598300	200598718	200599402	200599403	200599404	200599405
VWA CODE	75090498	75090536	75090471	75090528	75090501	75421745	75180829	75180802	75180772	75180799
PRODUCT:	lucerne brok	timothee brok	lucerne brok	esparcette brok	lucerne pakken	plantaardig voeder-middel eu=lu-cerne	lucerne-pellets	lucerne-pellets	lucerne-pellets	lucerne-pellets
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	18-08-2020	18-08-2020	18-08-2020	18-08-2020	18-08-2020 20	20-08-2020	26-08-2020	26-08-2020	26-08-2020	26-08-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFUnDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFOS (ng/g)	<0.050	<0.050	<0.050	0.068	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)										
GenX (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Number	11	12	13	14	15	16	17	18	19	20
SAMPLE_ID	200599406	200599407	200599408	200599465	200599466	200599467	200599469	200599470	200600119	200600120
VWA CODE	75180764	75421753	75421761	75421877	75421893	75421915	75421907	75421842	75410697	75410719
PRODUCT:	lucerne-pellets	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	lucerne	lucerne
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	26-08-2020	26-08-2020	26-08-2020	27-08-2020	27-08-2020	27-08-2020	27-08-2020	27-08-2020	03-09-2020	03-09-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFUnDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFOS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)										
GenX (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0				

Number	21	22	23	24	25	26	27	28	29	30
SAMPLE_ID	200600121	200600122	200600123	200600124	200604092	200604094	200604123	200604124	200604126	200604462
VWA CODE	75410689	75180837	75410727	75410743	75410921	75410883	75410913	75410891	75410905	75179197
PRODUCT:	lucerne	lucerne	lucerne	lucerne-pellets	lucerne-pellets	lucerne-pellets	lucerne-pellets	lucerne-pellets	lucerne-pellets	plantaardig voeder-middel eu= lu-cerne
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
DATUM MONSTERNAME:	03-09-2020	03-09-2020	03-09-2020	03-09-2020	15-10-2020	15-10-2020	15-10-2020	15-10-2020	15-10-2020	20-10-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFUnDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFOS (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)										
GenX (ng/g)										

Number	31	32	33	34	35	36	37	38	39	40
SAMPLE_ID	200604830	200604831	200604832	200605761	200605764	200605766	200610448	200610449	200610450	200610455
VWA CODE	75411154	75411162	75411189	75090951	75090935	75090919	75419899	75419902	75419872	75419864
PRODUCT:	lucerne	lucerne	lucerne	lucerne balen	timotee brok	lucerne brok	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaardig voeder-middel eu= lu-cerne	plantaar-dig voe-dermiddel eu= lu-cerne brok
LAND VAN HERKOMST:	NL	NL	NL	NL	NL	NL	FR	NL	NL	NL
DATUM MONSTERNAME:	27-10-2020	27-10-2020	27-10-2020	03-11-2020	03-11-2020	03-11-2020	03-11-2020	03-12-2020	03-12-2020	03-12-2020
PFPeA (ng/g)										
PFHxA (ng/g)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
PFHpA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFOA (ng/g)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
PFNA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFUnDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFDoDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTrDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFTeDA (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxDA (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFODA (ng/g)										
PFBS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFHxS (ng/g)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFHpS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
PFOS (ng/g)	<0.050	<0.050	<0.050	<0.050	0.076	<0.050	<0.050	<0.050	<0.050	<0.050
PFDS (ng/g)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
11Cl-PF3OUdS (ng/g)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
9Cl-PF3ONS (ng/g)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
NaDONA (ng/g)										
GenX (ng/g)					<1.0					

Appendix VI – Feed regularly fed to dairy and meat cows (in Dutch)

Feed composition, for dairy and meat cows. Qualitative, global by descending proportion

melkvee	jongvee, 0-2 jaar	vleesvee, rose en rood
Mengvoer	**Mengvoer**	**Mengvoer**
Maïs	Maïs	Maïs
Palmpitschr/-schilfers	Gerst	Palmpitschr/-schilfers
Gerst	Palmpitschr/-schilfers	Tarweproducten
tarwe	Gedroogde bietenpulp	Gerst
Sojaschroot/-schilfers (+bestendig)	Kool-raapz. Schr/-schilfers (+bestendig)	Tarwe
Kool-raapz. Schr/-schilfers (+bestendig)	Tarwe	Kool-raapz. Schr/-schilfers (+bestendig)
Gedroogde bietenpulp	Sojahullen	Sojaschroot/-schilfers (+bestendig)
Zonnebloemschr/-schilfers	Zonnebloemschr/-schilfers	Zonnebloemschr/-schilfers
Sojahullen	Sojaschroot/-schilfers (+bestendig)	Maisglutenvoer
Vinasse/melasse	Vinasse/melasse	Gedroogde bietenpulp
		Vinasse/melasse
Ruwvoer, 70%	**Ruwvoer, 80-95%**	**Ruwvoer, 40-60%**
vers gras	vers gras	snijmaissilage
grassilage/hooi	grassilage/hooi	
snijmaissilage	snijmaissilage	
Vochtrijk krachtvoer, 5%		**Vochtrijk krachtvoer, 10-15%**
bietenperspulp		bietenperspulp
bierbostel		bierbostel
tarwegistconcentraat		tarwegistconcentraat
maisglutenvoer		maisglutenvoer
aardappelpersvezel		aardappelpersvezel

The meat cow has diet that is close to a combination of melkvee and jongvee.
Provided by the department of Animal Nutrition, Wageningen Livestock Research. Based on the availability of the products and the prices in 2020.