Opinion 01-2025 of the Scientific Committee established at the FASFC on the correlation between the PFAS levels in bovine blood and the levels in the meat and offal of these animals

Background & Terms of reference

In 2023, the slaughterhouse-sampled meat and liver of some cows from Belgian businesses were found not to comply with the maximum levels for PFOS described in European legislation. These post-mortem results led to a ban on the entry into the food chain of food obtained from animals coming from the affected businesses.

The Federal Agency for the Safety of the Food Chain (FASFC) wishes to propose tools to livestock farmers to enable them to manage PFAS contamination and take the best possible decisions and this within the framework of their self-checking system.

Three questions are therefore addressed to the Scientific Committee:
(1) From what values of PFAS compounds (PFOS, PFOA, PFNA and PFHxS) in the blood of a bovine animal could one suspect a non-conformity (according to Regulation (EU) 2023/915) for the meat or offal (e.g. liver and kidney) originating from that animal?
(2) What are the correlations between PFAS levels in bovine muscle tissue, liver and kidney?
(3) What are the depletion kinetics of PFAS (PFOS, PFOA, PFNA and PFHxS) in the blood of live cattle once the sources of PFAS contamination are removed?

Three questions are therefore addressed to the Scientific Committee:
(1) From what values of PFAS compounds (PFOS, PFOA, PFNA and PFHxS) in the blood of a bovine animal could one suspect a non-conformity (according to Regulation (EU) 2023/915) for the meat or offal (e.g. liver and kidney) originating from that animal?
(2) What are the correlations between the PFAS levels in bovine muscle tissue, liver and kidney?
(3) What are the depletion kinetics of PFAS (PFOS, PFOA, PFNA and PFHxS) in the blood of live cattle once the sources of PFAS contamination are removed?

Methodology

The opinion relies on literature review and FASFC control data, expert opinion and regression analysis of a selected dataset.

Conclusions

The Scientific Committee assessed the possibility of establishing an indicative value for PFAS compounds in bovine blood to estimate whether PFAS levels in meat, liver and kidney comply with the European maximum levels (Regulation (EU) 2023/915). To this end, the SciCom relied on (i) Danish Decree No 1386 of 29/11/2023, (ii) literature data and (iii) monitoring data from the FASFC. In addition, a linear regression analysis was applied to data of PFOS concentrations in blood plasma and muscle tissue from the same animals (paired results for 28 cows) (Johnston *et al.*, 2023). This analysis performed on a logarithmic transformation of the raw data allowed to determine that a PFOS content 0.3 µg/kg in meat (= legal European maximum content) corresponds to a most probable PFOS content of 6.2 µg/L in the blood plasma with a 95% confidence interval of 2.5 to 23.4 µg/L. For liver and kidney, it was not possible to apply this type of approach due to the lack of available paired data (PFOS content in blood and tissues from the same animal).

The obtained lower limit of 2.5 µg/L is close to, but more conservative, than the guide value of 3.3 µg PFOS/L blood plasma applied by the Danish authorities. The Scientific Committee considers that a PFOS level of 2.5 µg/L blood plasma is an appropriate guide value to estimate a compliance of a PFOS level in the meat, liver and kidney. For PFOA, PFHxS and PFNA, there is less to no data to derive such a guide value in blood plasma. Based on the available data, the Scientific Committee considers that the same concentration of 2.5 µg/L blood plasma can also be applied to estimate a compliance of levels of PFOA, PFHxS or PFNA in bovine meat, liver and kidney. It should be stressed that this guide value of 2.5 µg/L is subject to significant uncertainties.

Ratios between PFAS levels in bovine muscle tissue, liver and kidney were assessed using (i) FASFC control data and (ii) data from the scientific literature. The aim was to assess whether the liver or kidneys of a slaughtered cattle should be destroyed if the meat is non-compliant or vice versa. On the basis of available results for the liver (n=16), it could be determined that the PFOS concentration in the liver is between 6 and 34 times higher (on average 21 times) than that in muscle tissue, while the PFOS concentration in the kidneys (n=8) is between 3 and 12 times higher (on average 8 times) than that in muscle tissue. No such ratio could be derived for PFOA, PFNA and PFHxS due to insufficient data. It is noted that these ratios for PFOS were determined from a relatively limited number of data from different studies with differences in experimental design, and that no distinction was made between breed, sex and lactation status of the cattle when deriving the ratios.

Finally, the SciCom evaluated the possibility of determining, based on ante-mortem blood analysis, a waiting period after which bovine muscle tissue, liver and kidney will be compliant for PFAS after removal of the source of contamination. For this purpose, literature sources regarding the depletion kinetics of PFAS in bovine blood were reviewed. For PFOS, elimination half-lives in blood of 39 (lactating cow) to 120 days (ox) were distinguished. For PFOA, elimination half-lives in blood were 1.3 (lactating cow) and 19.2 days (oxen). For PFNA the elimination half-lives in blood were 8.7 (lactating cow) and 12.3 days (beef cattle), and for PFHxS the half-life was 9.3 days for beef cattle.

Chou *et al.* (2023) implemented a physiological-based pharmacokinetic (PBPK) model implemented in an interactive generic platform publicly accessible via the internet where tissue waiting times for PFOA, PFOS and PFHxS can be calculated for beef cattle and dairy cows. This platform could be used to predict waiting times for these PFAS in beef cattle and dairy cows. An important limitation of the platform is that several parameter values need to be known to enter into the application, in particular the number of animals, PFAS concentration in soil or water, time interval of dosing of PFAS contamination, exposure frequency and exposure duration. It will often prove difficult if not impossible for a livestock farmer to know or determine these values. In addition, the source of contamination may be different, it could be, for example, contaminated feed, and not soil or water. In addition, scientific publications report other equations that would approximate depletion kinetics in blood plasma or blood serum (Johnston *et al.*, 2023; Mikkonen *et al.*, 2023), but also these turn out to be of little use in practice because of the required parameters that need to be known and the complexity. Therefore, the working group itself developed a pragmatic approach for calculating a waiting time after which a second blood sample should be collected and analysed, in case of an initial blood test indicating an excess PFAS level. The equation for calculating such a waiting time (see recommendations below) contains as constants the target value for PFAS in blood plasma of 2.5 µg/L and an elimination half-life for PFAS (for which a value from literature should be selected). Therefore, such a calculated withdrawal time is subject to significant uncertainties.

Recommendations

When a contamination by PFAS is detected on a farm, it is recommended to identify and eliminate the source of contamination (e.g. water, soil or feed) or to prevent animals from having access to it. The Scientific Committee recommends the threshold value of 2.5 µg/L of bovine blood plasma as a suitable guide value to estimate ante-mortem a compliance against the legal European maximum levels of PFOS, PFOA, PFHxS or PFNA in the meat, liver and kidney. As discussed above, this guide value of 2.5 µg/L is subject to significant uncertainties. The Scientific Committee emphasises that it cannot be excluded that possible non-compliant results of PFAS may be observed in the meat, liver or kidney of cattle following a blood test complying with the 2.5 µg/L guide value.

The Scientific Committee therefore recommends assessing in the near future the number of cases in which a level of PFOS, PFOA, PFHxS or PFNA in blood plasma not exceeding the guide value of 2.5 µg/L is actually related to meat, kidney and liver conformity for these 4 PFAS. It is therefore recommended to determine and to collect paired data (from the same animal) concerning PFAS in the blood plasma, muscle tissue, liver and kidney of bovines originating from businesses affected by a PFAS contamination. These additional data can then serve as a basis for confirming or, if necessary, adjusting the indicative value of 2.5 µg/L.

If an analysis of a bovine blood plasma would show that the concentration of PFOS, PFOA, PFHxS or PFNA is higher than the guide value of 2.5 µg/L, then it is recommended to perform another blood plasma analysis at a later date until a result lower than this value is obtained. This later data can be calculated using the following equation:

$$withdrawal\ time\ t = \frac{(\log C_0 - \log 2{,}5) \times 2.303}{(0{,}693/DT_{50})}$$

Equation of the withdrawal time (t, in days) in blood plasma/serum to obtain the targeted guide value, where C_0 represents the starting concentration (µg/L) of PFOS, PFOA, PFHxS or PFNA in the blood plasma/serum, i.e. the concentration measured at initial sampling; 2,5 µg/L the suggested blood plasma/serum concentration guide value; DT_{50} the blood plasma/serum elimination half-life of PFOS, PFOA, PFHxS or PFNA (days).

Here, the Scientific Committee also refers to the uncertainties discussed above. The waiting time should therefore be considered as an indication to determine a time when a second blood test may be useful. However, it cannot be excluded that after the estimated waiting time a bovine would still show a PFAS level in blood plasma higher than 2.5 µg/L. In addition, calculated withdrawal times are expected to be rather long based on the relatively long elimination half-lives of PFAS described in the literature. For these reasons, the practical usefulness of these withdrawal times is rather low.

In addition, for PFOS, it is recommended to use the following ratios to estimate its relative concentration in bovine muscle tissue, liver or kidney without having to carry out separate measurements in all these tissues: the PFOS concentration in liver is on average 21 times (between 6 and 34 times) higher than that in muscle tissue, while the PFOS concentration in kidney is on average 8 times (between 3 and 12 times) higher than that in muscle tissue. The uncertainties applicable to these ratios are discussed above. The Scientific Committee recommends sampling paired samples (from the same animal) of muscle tissue, liver and kidney from Belgian bovines in the near future to verify these PFOS ratios between the different animal tissues.

The full text is available on this website in dutch and in french.