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Ability of different matrices to transmit African swine fever virus

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Abstract

This opinion assesses the risk posed by different matrices to introduce African swine fever virus (ASFV) to non-affected regions of the EU. Matrices assessed are feed materials, enrichment/bedding materials and empty live pigs transport vehicles returning from affected areas. Although the risk from feed is considered to be lower than several other pathways (e.g. contact with infected live animals and swill feeding), it cannot be ruled out that matrices assessed in this opinion pose a risk. Evidence on survival of ASFV in different matrices from literature and a public consultation was used in an Expert Knowledge Elicitation (EKE) on the possible contamination of products and traded or imported product volumes used on pig farms. The EKE results were used in a model that provided a risk-rank for each product's contamination likelihood ('q'), its trade or import volume from affected EU or Eurasian areas (N) and the modelled number of potentially infected pig farms (N $\times$ q). The products ranking higher regardless of origin or destination were mash and pelleted compound feed, feed additives and cereals. Bedding/enrichment materials, hydrolysed proteins and blood products ranked lowest regardless of origin or destination. Empty vehicles ranked lower than compound feed but higher than non-compound feed or bedding/enrichment material. It is very likely (95–99% certainty) that compound feed and cereals rank higher than feed materials, which rank higher than bedding/enrichment material and forage. As this is an assessment based on several parameters including the contamination and delivery to a pig farm, all of which have the same impact on the final ranking, risk managers should consider how the relative rank of each product may change with an effective storage period or a virus inactivation step.

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Summary

This opinion is part of a series of reports addressing the risk of African swine fever virus (ASFV) to non-affected regions of the EU. Specifically, it seeks to answer questions on the risk of ASF virus transmission posed by different feed, enrichment/bedding materials or empty vehicles introducing ASFV to a non-affected region. Four steps were used: a systematic literature review of the capability of ASFV to survive in a matrix; a public consultation to identify any evidence missed in the literature review; an Expert Knowledge Elicitation (EKE) on the possible contamination of products and their traded/imported volumes used on pig farms; and a model to determine the likelihood of each product to introduce ASFV based on relative risk-ranking.

The outcome of the public consultation has been published as a technical report in the EFSA Journal (EFSA, 2021a). From the systematic literature review, recently published data were available for viral persistence on cereals, oil seeds, legumes, compound feed and feed additives. No data were available for contamination of tubers, forage and roughage, tote bags, vehicles or bedding and enrichment material. Data on the survival of virus in faeces, urine and slurry have been collated from literature and were provided to the experts for the EKE.

The EKE was carried out by three independent groups of six to eight experts each. It was carried out in three steps: assessing the likelihood of contamination of a product; assessing the likelihood of the contaminated product having enough viable virus to infect a pig (the infectious dose); and assessing the volume of trade or imports of each product from an affected area in either the EU or Eurasia[1] which would be delivered to either a small-scale or large-scale pig farm.

The outcome of the modelling provided a rank of the risk of each product by the likelihood of contamination ('q'), by the volume of trade (from affected areas in Europe) or import (from affected areas in Eurasia) (N) and by the modelled number of potentially infected pig farms (N $\times$ q).

While the opinion identifies some types of feed, which may present a risk for transferring ASF to a farm, particularly in regions where wild boar contamination is present, other risk pathways are more likely to require risk management, such as moving live domestic pigs, swill feeding with products of porcine origin or allowing contact between wild boar and domestic pigs. Still, the EFSA scientific report (EFSA, 2021c) also concludes that use of locally produced hay, straw or grain, harvested from an area where ASF is present in the wild boar population, use of farm equipment from a similar area, or providing fresh forage to pigs have been identified as potential sources of ASF for domestic pigs, notably in backyard farms.

The types of feed, which consistently were ranked higher, were the feed additives, mash compound feed and pelleted compound feed and cereals. However, the detail highlights that certain feeds is more likely to be contaminated (high rank in q), but as trade/import volumes direct to farm rather than to feed producers were low (low N), these products ranked low in the modelled number of potentially infected pig farms (N $\times$ q). And conversely, some feeds may be assessed as very low risk of contamination (q), but due to the high volumes of trade/imports direct to farm (N), the ranking in the modelled number of potentially infected pig farms (N $\times$ q) was higher. For example, high volumes of pelleted compound feed and cereals are traded/imported direct to farm so even though the likelihood of contamination for an individual consignment is very low, the overall rank is higher than for those feeds, which are not used as frequently or which are moved to a compound feed producer prior to the farm even if they have the same likelihood of contamination.

Certain products, such as blood products (spray-dried blood plasma) and hydrolysed proteins, are not produced from pigs from affected areas. This information, combined with the short time window in which animals can be infected without showing clinical signs and the production of these products, results in a low rank in terms of the likelihood that infectious ASFV is present at the time of usage. The risk may increase in recently affected areas (prior to detection of outbreaks), where infected animals in the early stages of infection and without clinical signs might go undetected at ante- and post-mortem inspection in slaughterhouses. Once detected, affected areas would fall under protection/surveillance zones or infected zones, where general prohibition to move pigs apply and additionally, back tracing of prior movements takes place. Furthermore, the protein content of the products might protect the virus from the short-term high-temperature treatment expected to inactivate the virus (EFSA, 2021b).

Tubers are frequently fed to pigs, but while commercial farms mainly use dehydrated tubers, experts considered that small-scale farms using fresh tubers may not be able to avoid contamination even if these are boiled on farm before being fed. Similarly, for feed additives, if a vegetable carrier

[1] The term 'Eurasia' used in this assessment comprises areas in Europe, which are not EU Member States, and areas in Asia affected by ASFV genotype II that pose a risk due to goods being moved to unaffected areas of the EU.

material such as corn cob and rice hulls is used in their manufacturing, and there is no storage period or virus reduction step, the risk-rank of contamination ('q') is higher.

For bedding material, such as straw, and forage, such as grasses and legumes, no data were available for the survival of ASFV. Therefore, faecal and urinal contamination data were used as a proxy for ASFV survival. The time of year and proximity of a non-affected area to an affected area of origin are important considerations, as contamination decreases with increased travel or storage time and temperature. If stored or transported for considerable periods, any ASFV present will have a lower risk of survival in such products.

Transport vehicles were calculated to have a relatively lower risk-rank than compound feed and consistently higher than non-compound feed or bedding/enrichment materials; however, this depended on the origin as vehicles were considered unlikely to arrive to unaffected areas from Eurasia (low value of N). Furthermore, the rank was higher for small-scale farms than large-scale farms, when the origin was affected areas of the EU, because of the perceived lack of cleaning and disinfection standards on such small-scale farms.

This assessment has been undertaken for all unaffected areas of the EU. The hierarchy of the ranking is unlikely to change for 'q', while it could change for 'N', as in general there was little difference in rank whether a product was produced in an affected area of the EU or in Eurasia. The results suggest that some products have a higher rank when the final destination is a small-scale rather than a large-scale farm, such as tubers and empty transport vehicles, because of the perception of lower levels of biosecurity on smaller non-commercial farms. Certain feed or bedding materials are not traded over long distance or between affected and non-affected areas. For such products, the likelihood of leading to an adverse outcome is reduced for the non-affected area, but cannot be ruled out for establishments, which are in close proximity to affected areas.

For vehicles returning from other countries, the risk can be reduced by controlling whether the vehicle has transported pigs to or within affected areas, and through controls of cleaning and disinfection of trucks (certificates and visual inspection). For trucks driving back and forth between affected and non-affected areas, reduction of the risk for the farm, at which the animals are loaded onto the truck, can be achieved by loading pigs from assembly centres or transportable loading docks at some distance from the farm.

In general, strict adherence to relevant decontamination and storage processes (storage time, treatment temperature) leading to a reduction of a potential virus contamination is recommended.

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor[2]

African Swine Fever (ASF) Genotype II is now present in nine EU Member States: Belgium, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Romania. As in 2014, the disease is mainly limited geographically to the Eastern part of the EU, with the disease being maintained in the wild boar population along the EU Eastern borders, followed by occasional spill over in domestic pig holdings.

The recent developments in Romania during the summer of 2018 have highlighted a new pattern mainly focused on domestic pig holdings of any size, with few occurrences reported in wild boar. It is likely that this latter situation heavily relies on the spread through the human factor.

For the near future, the two main risks for the EU are represented by (i) the specific situation in Romania, and (ii) a more generalised risk of witnessing the so-called "jumps" of the disease, due to the long distance spread by human factor. Additionally, many Member States are also concerned on the role of different matrices in the transmission of the diseases.

Member States and the Commission are continuously updating the EU strategic approach to ASF and the related legislation. There is knowledge, legislation, scientific, technical and financial tools in the EU to properly face ASF.

The current situation in EU calls for the development of an EU strategy for the South Eastern Part of Europe based on scientific recommendations by EFSA. This strategy should be built and evolved on the base of new science available and on new experiences gained.

It is therefore necessary to better determine the extent of the problem in order to better target preventive and control measures in the light of the current evolution of the ASF epidemic updating and completing previous EFSA scientific opinions.

Terms of Reference (TOR).

In accordance with Article 29 of Regulation (EC) No 178/2002, EFSA is requested to provide a Scientific Opinion on the:

1) Estimation of the risk of spread of ASF in the South Eastern Countries of Europe; identification and description of the main risk factors.
2) Review the evaluation of the ability of matrices,[3] including vegetables, crops, hay and straw as well as sawdust, wood chips and similar materials likely to present a risk to transmit ASF. This review should take into account a retrospective analysis of ASF spread mechanisms. The different matrices should be ranked on the basis of their level of risk with a view to enhance preparedness and prevention. Propose and assess a strategy to manage the risks posed by different matrices.

In accordance with Article 31 of Regulation (EC) No 178/2002, EFSA is requested to provide a Scientific Report on the:

3) Review the epidemiological data and available information on the development of ASF in Romania and include an analysis of the temporal and spatial patterns of ASF in domestic pigs. Analyse the risk factors involved in the occurrence, spread and persistence of the ASF virus in the domestic population.

1.2. Interpretation of the Terms of Reference

ToR 1 and ToR 3 have been addressed in separate scientific assessments (EFSA AHAW Panel, 2019; EFSA, 2020).

This scientific opinion addresses ToR 2 of the mandate. EFSA is asked to assess the ability of products or materials (matrices) to present a risk of transmitting ASF, and to rank them. The full pathway from the origin in an affected area to the contact with pigs within the non-affected area should be considered in the evaluation.

[2] This mandate with the background and ToR that are presented here has been submitted to EFSA in 2018. Since then, the epidemiological situation of ASF in the EU has changed. At the moment of the adoption of this Scientific Opinion, African swine fever was present in Bulgaria, Estonia, Germany, Greece, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia. Italy present an unrelated epidemiological situation (Genotype I). Belgium was recognized free in November 2020.

[3] Table 4 of point 4.2 of EFSA Scientific Opinion on ASF - EFSA Journal 2014;12(4):3628.

To address this mandate, several assessments steps have been carried out:

1) Systematic literature review (SLR) on **any kind of matrix** that could pose a risk for transmission of ASF virus (ASFV), focussing in particular on the survival time of ASFV in the matrices.
2) Public consultation on the data collected through step 1 to identify any additional scientific findings not captured by the SLR.
3) Expert knowledge elicitation (EKE) focussing on the potential transmission of ASFV from matrices that are either **feed** (feed materials, compound feed, feed additives), **bedding and enrichment materials** used in pig farms in non-affected areas, which have their origin, partly or entirely, in ASF-affected areas and which are legally traded/moved, or **empty livestock transport vehicles** returning from ASF-affected areas to non-affected areas.
4) The likelihood of ASF transmission from affected areas in the EU and Eurasia to non-affected area of the EU, within the next 12 months via the defined products and materials, was estimated using a pathway model incorporating the estimates obtained from the EKE.

The overall aim of the risk assessment was to rank these matrices (feed, bedding or enrichment materials and empty livestock transport vehicles) according to the likelihood that they would cause an infection of a pig herd in a non-infected area.

The parameters needed to assess this likelihood were retrieved from scientific literature, survey data, or similar data sets such as trade records. The weighing of the retrieved evidence and the quantification of remaining uncertainties due to evidence gaps, low data quality, or necessary extrapolations were addressed by the EKE.

For this assessment, the matrices were clustered into five groups (Table 1).

Table 1: Groups of matrices included in the assessment that could potentially be contaminated with infectious ASFV and lead to further transmission

Group	Products	Key example(s)
1. Animal by-products for use in feed	1a. Hydrolysed proteins	
	1b. Pig blood products, spray dried porcine plasma	
2. Feed materials (contaminated, not pig derived)	2a. Cereal grains, their products and by-products	Wheat, maize, barley
	2b. Oil seeds, oil fruits, their products and by-products	Soybeans, rapeseeds (canola)
	2c. Other seeds, fruits and their by-products	Acorns, chestnuts, apples
	2d. Forages and roughage	Hay
	2e. Tubers, roots, their products and by-products	Potatoes, beetroot
	2f. Legume seeds, their products and by-products	Peas
3. Compound feed (includes products of categories 1 and 2)	3a. Mash (complete feeding-stuff)	**Organic or inorganic substances in mixtures, whether or not containing additives, intended for feeding to pigs in the form of complete feeding-stuffs or complementary feeding-stuffs**
	3b. Pellets (complete feeding-stuff)	
	3c. Minerals, Feed additives (complementary feeding-stuff)	
4. Bedding	4a. Straw	
	4b. Sawdust/woodchips	
	4c. Peat/Turf	
5. Vehicles	5. Empty vehicles for live pig transport, returning from affected areas (including equipment, like boards and gates)	

The possible spread of ASFV through empty vehicles transporting feed and bedding materials or packaging material was considered during the assessment of feed and bedding materials.

Other pathways of ASFV spread, e.g. by the movement of different types of contaminated products, fomites or vehicles and infected pigs or wild boar, by pig-derived meat or meat products that are illegally entering the food chain, or infected animals which were slaughtered and not notified or not recognised to be infected, meat or meat products which are illegally moved into non-affected areas and/or illegally swill-fed to pigs, were not part of this assessment, because regulations concerning the regionalisation, restrictions of movements of pigs, wild boar, pig meat and meat products from affected areas already exist to cover these.

The ASF-affected areas were grouped into two strata, the area within EU27 that is affected by ASFV genotype II (EU-stratum) and the area within Eurasia that is affected by ASFV genotype II (EURASIA-stratum). The latter area comprises areas in Europe, which are not EU Member States, and areas in Asia affected by ASFV genotype II.

The reasons for stratifying the affected area from which potentially contaminated matrices can originate into affected areas in the EU and in Eurasia are the different trade regulations and control measures and the different sources of trade data and outbreak data available in the EU compared to the other affected areas.

Additionally, as the mandate only required the assessment of the likelihood of transmission of ASFV genotype II, which has spread since the introduction in 2007 into Europe and Asia, the origin of potentially contaminated matrices concentrated on these two continents, and not on endemic areas in Africa.

2. Data and methodologies

2.1. Literature review

Peer-reviewed literature was systematically searched for experimental infection or virus survival studies that examined the ability of ASFV to survive and remain viable in different matrices, as evidenced by virus isolation or in vivo studies. Studies demonstrating only the presence of ASFV-DNA through PCR and not using virus isolation were excluded from the review, as PCR-positive samples do not necessarily contain infectious virus. The review included studies on any of the different ASFV strains, as to date there is no scientific evidence that suggests that certain strains would survive better than others would. For details of the search carried out, see the protocol in Annex 1.

Where available, information on the matrix's storage conditions, its humidity, the duration of the experiment, the maximum number of days the matrix was found ASFV-positive, the first day of negative results as well as ASFV half-life were extracted from the papers identified by the search.

For categories of matrices that the Animal Health and Welfare (AHAW) panel considered to have the potential to become contaminated with ASFV, but for which no data were identified in the literature, information on the matrix production or processing parameters was collated from legal documents and peer-reviewed literature, to understand if the production process or the processing of the matrices would allow the virus to remain viable, should the matrices have been contaminated with ASFV before their production and/or processing.

2.2. Public Consultation

A public consultation on the draft data section on the ability of ASFV to survive and remain viable in different matrices was carried out from 3 to 28 February 2020. Its objectives were: i) to check the completeness of the data on ASFV survival in different categories of matrices identified in the literature review and ii) to identify other studies on the survival of ASFV in these matrix categories that had not been captured. Further, the AHAW Panel wanted iii) to gather knowledge about the production/processing parameters that might affect ASFV survival, such as temperature-time curves, pH, etc., of those matrix categories for which ASFV survival has not been studied. Finally, stakeholders were invited iv) to suggest additional categories of matrices that should be considered by the AHAW Panel regarding the likelihood of transmitting ASFV to domestic pigs. The draft data section was accessible through the EU-Survey tool and participants were able to provide comments and upload documents. The outcome of the public consultation has been published as a technical report in the EFSA Journal (EFSA, 2021a).

2.3. Expert Knowledge Elicitation

Three expert knowledge elicitations (EKEs) were carried out to elicit estimates of the likelihood that the different matrices contain infectious ASFV ('Contamination EKE'), their trade flow/movement from affected areas in the EU and Eurasia to non-affected areas in the EU ('Trade EKE') and their distribution to pig farms and their likelihood to be in contact with pigs ('Farm exposure EKE').

For each EKE, a group of six to eight experts with the relevant expertise was established. One expert supported both the Trade and the Contamination EKE, and another expert supported both the

Trade and the Farm Exposure EKE. The results of each EKE were only shared after the completion of the EKE with those experts participating in it. The EKEs consisted of a series of preparatory meetings, individual elicitations and a final group discussion following the Sheffield method[4] (EFSA, 2014). The elicitation meetings were facilitated by EFSA staff. Details on the EKEs can be found in Annex 2.

The questions on which expert knowledge was elicited and how they relate to the different elements of the pathway model (see Section 2.4) are shown in Figure 1.

The Contamination EKE experts were provided with data on wild boar (density data mapped to crop production areas, habitat suitability information), data on ASF prevalence in wild boar, information on ASFV survival in different matrices, feed crops harvesting techniques, processing parameters for feed/animal by-products potentially affecting ASFV survival, cleaning and disinfection of live pig transport vehicles and on the infectious ASFV dose.

For the Trade EKE, EKE experts received data on crop production and trade/movements, information on the most common transport means, consignment sizes and duration, the distribution of the crops in the non-affected area of the EU, including delivery and storage on farm as well as the use of the final product on farm. In addition, experts were referred to data on pig farm size and pig diet composition.

For the Farm exposure EKE, EKE experts were provided with information on size and livestock composition of farms in the EU, on the use of feed on farms, pig diet composition and the use of feed and bedding material by other livestock species than pigs.

Further details can be found in the EKE report (EFSA, 2021b).

[4] http://www.tonyohagan.co.uk/shelf/

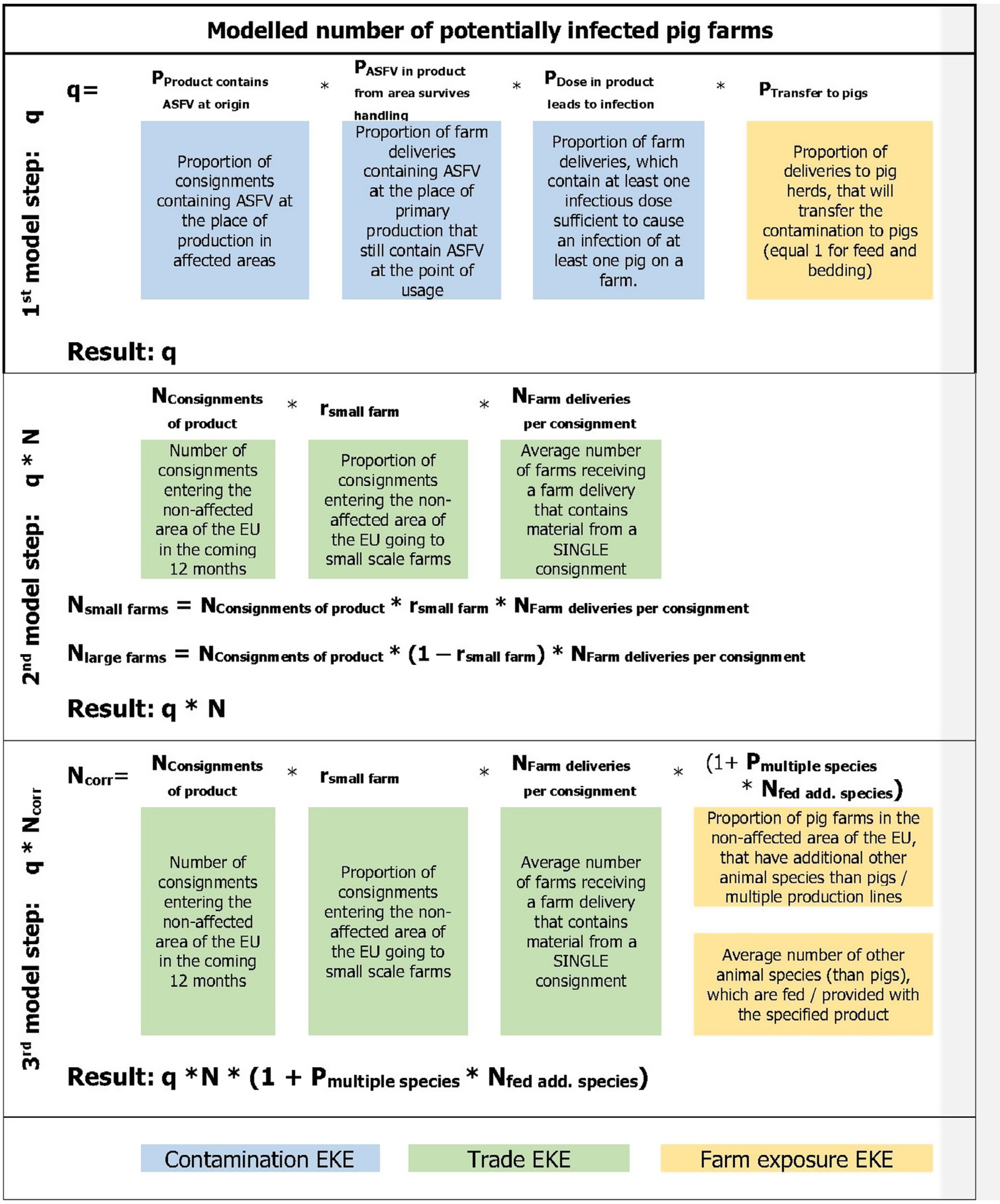

Figure 1: Mapping of estimations done in the EKEs to the three model steps (blue = estimations done in the Contamination EKE, green = estimations done in the Trade EKE, yellow = estimations done in the Farm Exposure EKE)

2.4. Modelling

In order to rank the different products and materials based on their likelihood to transmit ASFV to pigs in non-affected areas of the EU, a simple, three-step pathway model from primary production to farm was applied, using the estimates made by the EKE experts in the three EKEs (Figure 1). In the first step, the likelihood that a single farm delivery of a given product contains a dose of infectious ASFV sufficient to infect at least one pig on the farm was calculated. In a second step, the volumes of each product reaching different farm types (small/large) in non-affected areas of the EU were calculated. The modelled number of potentially infected pig farms is the product of the likelihood that a single farm delivery of a product will contain a dose of ASFV that is large enough to cause an infection in at least one pig on the farm (first step) and the number of deliveries. Finally, in the third step, the number of farm deliveries was corrected to account for the possibility that additional deliveries of feed or bedding or enrichment material intended for other animal species than pigs are provided to pigs (see Section 2.4.3). Where no relevant differences of the products' estimates existed for the regions of origin (EU/Eurasia) of the products or the place of use (small- or large-scale farms), or where the uncertainty of the estimate of one stratum was considered to cover also the other stratum, the estimations were not stratified by these. An overview of the stratifications done for the different questions is provided in Table 3.

2.4.1. Likelihood that a single farm delivery of a product will contain a dose, which is large enough to cause an infection in at least one pig on the farm (Step 1)

2.4.1.1. Feed products and bedding or enrichment material

In the first step, we calculated the likelihood that a single farm delivery of a product under consideration will contain a dose large enough to cause an infection in at least one pig on the farm.

First the proportion of consignments within the next 12 months, which could become contaminated with infectious ASFV at the place of primary production was calculated: $\mathbf{P_{Product\ contains\ ASFV\ at\ origin}}$. This calculation considered the primary production in affected-areas of the EU and Eurasia (e.g. statistics on area and yield of primary production), the habitat suitability to wild boars (e.g. statistics on predicted prevalence) and the prevalence of ASF in the wild boar and domestic pig population (e.g. statistics on positive wild boars/domestic pigs).

The inactivation of ASFV taking place between the primary production and the final use of the product on the pig farm was taken into account, considering the duration and conditions of storage and transport between primary production and point of use, the different processing steps, the level of decontamination they achieve, characteristics of the existing quality control and possibilities for cross-contamination. This resulted in a single parameter, the proportion of farm deliveries containing infectious ASFV at the place of primary production that still contain infectious ASFV at the point of usage: $\mathbf{P_{ASFV\ in\ product\ survives\ handling}}$.

For compound feed products, which consist of several ingredients, such as feed additives, minerals and complete compound feed in the form of mash or pellets, the probability of the final product containing infectious ASFV (after transport and processing of the ingredients of the compound product) was calculated, resulting in the proportion of farm deliveries containing any material from affected areas that could contain infectious ASFV at the point of usage: $\mathbf{P_{Product\ contains\ infectious\ ASFV\ at\ usage}}$.

Finally, the probability that the farm deliveries contaminated with infectious ASFV contain at least one infectious dose sufficient to cause an infection of at least one pig on a farm was calculated. Information on the kind of contamination at origin, the homogenisation, dilution and inactivation of virus was used, as well as the frequency and mode of feeding to pigs. This resulted in the proportion of deliveries, which contain at least one infectious dose sufficient to cause an infection of at least one pig on a farm: $\mathbf{P_{Dose\ in\ product\ leads\ to\ infection}}$.

For all feed stuff it was assumed that the material is given in its entirety to pigs and not used for other livestock species. The last model parameter ($\mathbf{P_{Transfer\ to\ pigs}}$) has been set to 1 for feed and bedding/enrichment materials, as these products have per definition direct contact to pigs. The step was concluded by the multiplication of the factors as follows:

- **Single feeding products and bedding material:**

$$q = P_{\text{Product contains ASFV at origin}} \times P_{\text{ASFV in product survives handling}} \times P_{\text{Dose in product leads to infection}} \times P_{\text{Transfer to pigs}}$$

- **Compound feed:**

$$q = P_{\text{Product contains ASFV at usage}} \times P_{\text{Dose in product leads to infection}} \times P_{\text{Transfer to pigs}}$$
$$(P_{\text{Transfer to pigs}} = 1)$$

The product 'q' is the estimate of the likelihood that a single farm delivery of the product under consideration will contain a dose of ASFV that is large enough to cause an infection in at least one pig on the farm.

2.4.1.2. Empty vehicles for pig transport returning from affected areas to the non-affected area of the EU

A similar approach is taken for empty vehicles returning after unloading in affected areas of the EU and Eurasia. The three parameters have the following adapted definitions:

$\mathbf{P_{Vehicle\ contaminated\ with\ infectious\ ASFV\ at\ unloading}}$: Proportion of empty vehicles returning from affected areas to non-affected areas of the EU that will have become contaminated with infectious ASFV at the place of unloading in the affected area.

$\mathbf{P_{ASFV\ in\ vehicle\ survives\ handling}}$: Proportion of empty vehicles that will have become contaminated with infectious ASFV at the place of unloading in the affected area and that still contain infectious ASFV at the point of loading (usage) after cleaning and disinfection, travel etc.

$\mathbf{P_{Dose\ in\ empty\ vehicles\ leads\ to\ infection}}$: Proportion of empty vehicles, which contain at least one infectious dose of ASFV sufficient to cause an infection of at least one pig during the next pig transport.

Further, an additional parameter was introduced to account for the transfer of the infectious dose from the empty lorry to the pigs on the farm, considering biosecurity procedures on the farm, pig behaviour during loading and transmission via staff and equipment on the lorry or farm. The parameter: $\mathbf{P_{Empty\ vehicles\ come\ into\ contact\ with\ pigs}}$ describes the proportion of empty vehicles that will transfer an existing contamination with infectious ASFV on the lorry to at least one pig on the farm.

Therefore, two results describe the likelihood that a single empty vehicle for pig transport will contain an amount of infectious ASFV that is sufficient to cause an infection in at least one pig on the lorry (infection on lorry) or on the farm (infection on farm):

- **Empty vehicles (infections on lorry):**

$$q = P_{Vehicle\ contaminated\ with\ infectious\ ASFV\ at\ unloading} \times P_{ASFV\ in\ vehicle\ survives\ handling} \times P_{Dose\ in\ empty\ vehicle\ leads\ to\ infection}$$

- **Empty vehicles (infections on farm):**

$$q = P_{Vehicle\ contains\ infectious\ ASFV\ at\ unloading} \times P_{ASFV\ in\ vehicle\ survives\ handling} \times P_{Empty\ vehicles\ come\ into\ contact\ with\ pigs} \times P_{Dose\ in\ empty\ vehicles\ leads\ to\ infection}.$$

2.4.2. Modelled number of potentially infected pig farms in non-affected areas of the EU (Step 2)

In the second step, the modelled number of potentially infected pig farms in the non-affected area of the EU was calculated. This included the calculation of the number of farm deliveries of the product to farms in the non-affected area with material originating in the affected areas of the EU or Eurasia.

The annual number of consignments going from the affected areas of the EU and Eurasia to the non-affected area of the EU was calculated: $\mathbf{N_{Consignments\ of\ product}}$. For this calculation, the annual import and intracommunity trade volume of the product under consideration (based on EUROSTAT statistics), typical sizes of trade consignments by different means of transportations (e.g. lorry, coastal ship, container, etc.) and the proportion which is used as pig feed were considered. The calculation was done for the two areas of origin, the EU and Eurasia; and for six reference products of the different feed categories: blood products (animal by-products), cereal grains (non-pig-derived feed materials), oil seeds, forage, pellets (complete compound feed) and straw (bedding material).

For compound feed, it was assumed that its place of production is close to the place of usage in the EU and that only the ingredients are imported from Eurasia or traded from EU MS. Instead of using trade consignments, production lots, which are used in the non-affected areas of the EU, were counted. The place of production was counted as the EU (including affected and non-affected areas).

The import and intracommunity trade of the other products within the feed categories was extrapolated using the average need of these products for pig feeding/bedding in the non-affected areas of the EU:

$$N_{Consignments\ of\ product} = \text{Extrapolation factor} \times N_{Consignments\ of\ reference\ product}.$$

The extrapolation factors are listed with the reasoning provided in Table 2.

The incoming consignments were divided into the part going to small-scale[5] farms and the remaining part going to large-scale farms. The proportion of consignments entering the non-affected

[5] Small-scale farms: < 100 pigs/< 50 breeding sows); large-scale farms: > 99 pigs/> 49 breeding sows. The definitions of small- and large-scale farms used in this assessment are provided in Annex 2, section 7.2.2.3.

area of the EU going to small-scale farms was calculated, considering the farm structures and sizes, and average use in the non-affected areas of the EU ($\mathbf{r_{small\ farms}}$) (proportion going to large-scale farms: (1− $r_{small\ farms}$)). The calculations were done for the reference products and transferred to all products within the same feed category. Because the handling of animal by-products is allowed only in registered feed mills, we assumed that these products do not reach pig farms directly.

Finally, to adjust for the distribution of large trade consignments to smaller farm deliveries, the average number of farms receiving a farm delivery that contains material from a single consignment was calculated, considering the typical sizes of trade consignments, farm deliveries, the average number of pigs on small- and large-scale farms and the demand of the pigs during a typical storage time for the different products: $\mathbf{N_{Farm\ deliveries\ per\ consignment}}$. For forage, it was assumed that the processing takes place on the farm of its final use; therefore, this factor was set to one farm per consignment. For all other reference products, the estimates were calculated separately for small- and large-scale farms, and these reference estimates were used for the other products within the same feed category.

Wooden toys were handled under the category of bedding material and therefore extrapolated from the calculations for straw, despite wooden toys having a different trade pattern (e.g. being traded more globally).

The product of all factors is the number of farm deliveries of the product under consideration to farms in the non-affected area of the EU containing material from the affected areas of the EU or Eurasia:

- **Feed deliveries to small-scale farms:**

  $N = N_{Consignments\ of\ product} \times r_{small\ farms} \times N_{Farm\ deliveries\ per\ consignment}$

- **Feed deliveries to large-scale farms:**

  $N = N_{Consignments\ of\ product} \times (1 - r_{small\ farms}) \times N_{Farm\ deliveries\ per\ consignment}$

A similar approach was taken for empty vehicles returning after unloading in affected areas of the EU and Eurasia. The three parameters have the following adapted definitions:

$\mathbf{N_{Empty\ vehicles}}$: Number of empty vehicles returning from affected areas in the EU or Eurasia to the non-affected area of the EU in the coming 12 months.

$\mathbf{r_{small\ farms}}$: Proportion of empty vehicles entering the non-affected area of the EU going to small-scale farms.

$\mathbf{N_{Farms\ per\ return}}$: Average number of farms reached with a single vehicle for loading.

This results in the following numbers of farm contacts by empty vehicles for loading in the non-affected areas of the EU:

- **Empty vehicles loading on small-scale farms:**

  $N = N_{Empty\ vehicles} \times r_{small\ farms} \times N_{Farms\ per\ return}$

- **Empty vehicles loading on large-scale farms:**

  $N = N_{Empty\ vehicles} \times (1 - r_{small\ farms}) \times N_{Farms\ per\ return}$

Finally, the modelled number of potentially infected pig farms in the non-affected areas of the EU was calculated as the product of the likelihood for an infection after one delivery 'q' and the number of deliveries 'N':

- **Modelled number of potentially infected pig farms:** $N \times q$.

Table 2: Calculation of extrapolation factors from different patterns of product use

	Farm type	Small farms			Large farms			Weighted average	Extrapolation factor
	Pig type	**Breeding sows**	**Piglets**	**Fatteners**	**Breeding sows**	**Piglets**	**Fatteners**		
	Unit								
Weighing									
Total number of pigs in non-affected areasof EU(1)	[–]	623,850	2,032,970	4,186,230	11,108,970	38,786,620	76,754,920	133,493,560	
Feed per pig and day(2)	[kg/day]	3.65	0.55	2.20	3.65	0.55	2.20		
Total feed per day	[kg/day]	2,277,053	1,118,134	9,209,706	40,547,741	21,332,641	168,860,824	243,346,098	
Animal by-products for use in feed									
Blood(2)	[% diet]	0.50	3.00	1.00	0.25	2.75	0.50	0.69	**1**
Hydrolysed proteins(2)	[% diet]	0.25	1.00	0.00	1.00	2.25	0.00	0.37	**0.541**
Non-pig derived feed materials									
Cereals(2)	[% diet]	65.00	62.50	67.50	67.50	62.50	70.00	68.75	**1**
Legumes(2)	[% diet]	12.50	12.50	14.50	13.00	13.75	11.00	11.73	**0.171**
Oil seeds (2, not extrapolated)	[% diet]	8.50	8.50	7.00	8.50	10.25	9.00	8.94	**0.130**
Tubers(2)	[% diet]	2.50	3.50	2.50	3.00	3.25	1.00	1.61	**0.023**
Other seeds(2)	[% diet]	2.50	4.50	2.50	2.50	2.25	2.75	2.66	**0.039**
Forage (2, not extrapolated)	[% diet]	4.00	0.25	2.00	4.00	0.25	1.50	1.84	**0.027**
Weighing									
Total number of pigs in non-affected areas of EU(1)	[–]	623,850	2,032,970	4,186,230	11,108,970	38,786,620	76,754,920	133,493,560	
Bedding per pig and year									
Straw(2)	kg/year	165.0	5.0	65.0	210.0	35.0	97.5	86.6	**1**
Sawdust(2)	kg/year	165.0	36.0	0.0	0.0	0.0	0.0	1.3	**0.015**
Peat(2)	kg/year	No correction factor was used for peat							
Toys(2)	kg/year	0.0	0.0	0.5	0.0	0.0	0.5	0.3	**0.004**
Weighing									
Number of pig holdings in non-affected areas(3)	[–]	255,370	173,920	574,850	80,120	58,250	95,810	1,238,320	
Compound feed									
Pellets(2)	[%farms]	82.5	82.5	84.0	67.0	72.5	61.5	80.1	**1**

	Farm type	Small farms			Large farms			Weighted average	Extrapolation factor
	Pig type	Breeding sows	Piglets	Fatteners	Breeding sows	Piglets	Fatteners		
Additives[(2)]	[%farms]	0.5	0.5	0.1	20.0	9.0	18.5	3.4	**0.042**
Mash[(2)]	[%farms]	15.5	8.5	17.5	13.8	18.0	19.5	15.8	**0.197**

Rows in blue: reference products/rows in grey: products were directly assessed.
(1): Ref.: Livestock of pigs in small- and large-scale farms, organic farming for different pig types in the year 2013 (EUROSTAT: ef_lspigaa).
(2): Ref.: Midpoint of ranges elicited from trade experts (EFSA, 2021b).
(3): Ref.: Pig holdings in small- and large-scale farms for different pig types in the year 2013 (EUROSTAT: ef_lspigaa).

2.4.3. Effect of multiple species on farms on the expected number of outbreaks (Step 3)

In the third step, the effect of multiple species on farms on the expected number of outbreaks was calculated. On farms with multiple animal species and/or multiple production lines, farm deliveries intended for animal species other than pigs being used for feeding of pig cannot be excluded. As the proportion of small farms with multiple species is high, some farm deliveries that are diverted to feed pigs might be missed in the assessment. To account for this possibility, two more parameters were calculated.

For small- and large-scale farms, the proportion of pig farms in the non-affected area of the EU that have additional animal species other than pigs/multiple production lines was calculated, considering the farm structure (e.g. data from EUROSTAT) in non-affected areas of the EU: $\mathbf{P_{multiple\ species}}$. This proportion (stratified by farm type) was used in the calculation for all products, as they are product independent.

Finally, the main animal production lines that use similar feed as pig production lines were computed. The average number of animal species (other than pigs), which are fed/provided with the product under consideration, was calculated per product and farm type: $\mathbf{N_{fed\ add.\ species}}$. This led to a corrected number of farm deliveries that can infect pigs on the farm:

- **Corrected number of farm deliveries:**

  $N_{corr} = N \times (1 + P_{multiple\ species} \times N_{fed\ add.\ species})$

and a corrected expected modelled number of potentially infected pig farms in the non-affected area of the EU:

- **Corrected modelled number of potentially infected pig farms considering multiple species on farm:** $N_{corr} \times q$.

The third step was not performed for empty vehicles, as it was assumed that lorries for pig transport are specialised for transporting pigs.

Table 3: Strata assessed as being different within each combination of model parameters and products

	Parameter definition			Products															Vehicles
	Stratification: None, Regions (Reg: EU/Eurasia), Farms (Farm: small-/large-scale farms) [na=not used in the model/const = constant value/Extra = extrapolated from the reference]			Animal by-products		Non-pig derived feed materials						Compound feed			Bedding				
	Products		Vehicles																
	Single feeding products/bedding material	Compound feed		Hydrolysedproteins	Blood products, spray dried plasma[1]	Cereal grains, their products and by-products[1]	Legume seeds, their products and by-products	Tubers, roots, their products and by-products	Other seeds, fruits and their by-products	Oil seeds, oil fruits, their products and by-products	Forages and roughage	Feed additives, premix	Mash	Pellets[1]	Straw[1]	Sawdust/woodchips	Peat/Turf	Enrichment/wooden toys	EMPTYvehicles[2]
Step 1: Likelihood of an outbreak caused by one farm delivery	$P_{Product\ contains\ ASFV\ at\ origin}$: Proportion of consignments containing ASFV at the place of production in affected areas	$P_{Product\ contains\ ASFV\ at\ usage}$: Proportion of farm deliveries containing any material from affected areas that contain ASFV at the point of usage	$P_{Vehicle\ contains\ ASFV\ at\ unloading}$: Proportion of empty vehicles used for transport of pigs returning from affected areas to non-affected areas of the EU that will become contaminated with ASFV at place of unloading in the affected areas.	None		Reg	Reg	Reg	Reg	Reg	None	None	None	None	None	None	None	None	Farm
	$P_{ASFV\ in\ product\ from\ area\ survives\ handling}$: Proportion of farm deliveries containing ASFV at the place of primary production that still contain ASFV at the point of usage		$P_{ASFV\ in\ vehicle\ survives\ handling}$: Proportion of empty vehicles containing ASFV after unloading that still contain ASFV at the point of loading (usage) after cleaning, travel etc.	None	None	Reg	Farm	Farm	None	None	None				None	None	None	None	None
	$P_{Dose\ in\ product\ leads\ to\ infection}$: Proportion of farm deliveries, which contain at least one infectious dose sufficient to cause an infection of at least one pig on a farm.		$P_{Dose\ in\ empty\ vehicles\ leads\ to\ infection}$: Proportion of empty vehicles, which contain at least one infectious dose sufficient to cause an infection of at least one pig during a following pig transport	None		Farm	Farm	Farm	None	Farm	None	Farm	Farm	None	Farm	None	None	None	None
	$P_{Transfer\ to\ pigs} = 1$ (na)		$P_{Empty\ vehicles\ come\ into\ contact\ with\ pigs}$: Proportion of empty vehicles, that will transfer an existing contamination with ASF to at least one pig on the farm	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Const = 1	Farm

	Parameter definition			Products															Vehicles
	Stratification: None, Regions (Reg: EU/Eurasia), Farms (Farm: small-/large-scale farms) [na=not used in the model/const = constant value/Extra = extrapolated from the reference]			Animal by-products		Non-pig derived feed materials						Compound feed			Bedding				
	Products		Vehicles																
	Single feeding products/bedding material	Compound feed		Hydrolysedproteins	Blood products, spray dried plasma(1)	Cereal grains, their products and by-products(1)	Legume seeds, their products and by-products	Tubers, roots, their products and by-products	Other seeds, fruits and their by-products	Oil seeds, oil fruits, their products and by-products	Forages and roughage	Feed additives, premix	Mash	Pellets(1)	Straw(1)	Sawdust/woodchips	Peat/Turf	Enrichment/wooden toys	EMPTYvehicles(2)
Step 2: Estimated number of ASF outbreaks	$N_{Consignments\ of\ product}$: Number of consignments entering the non-affected area of the EU in the coming 12 months		$N_{Empty\ vehicles}$: Number of empty vehicles entering the non-affected area of the EU in the coming 12 months	Extra	Reg	Reg	Extra	Extra	Extra	Reg	Reg	Extra	Extra	EU/EA = 0	Reg	Extra	Extra	Extra	Reg
	$r_{small\ farms}$: Proportion of consignments entering the non-affected area of the EU going to small scale farms		$r_{small\ farms\ (vehicles)}$: Proportion of empty vehicles returning to the non-affected area of the EU going to small scale farms	Const = 0	Const = 0	None(1)				None	None	None(1)			None(1)				None
	$N_{Farm\ deliveries\ per\ consignment}$: Average number of farms receiving a farm delivery that contains material from a SINGLE consignment		$N_{Farms\ per\ return}$: Average number of farms reached with a single vehicle for loading	Const = 0	Const = 0	Farm(1)				None	Const = 1	Farm(1)			Farm(1)				Farm
Step 3: Additional scenarios	$P_{multiple\ species}$: Proportion of pig farms in the non-affected area of the EU, that have additional other animal species than pigs/multiple production lines.		na	General parameter (all feed products): Farm															na
	$N_{fed\ add.\ species}$: Average number of animal species (other than pigs), which are fed/provided with the specified product.		na	Farm	Farm	Farm	Farm	Farm	Farm	Farm	Farm	const = 0	const = 0	const = 0	Farm	Farm	Farm	Farm	na

EU: European Union; EA: Eurasia.
(1): Reference product within the product group.
(2): empty vehicles used for pig transport returning from affected areas.

2.4.4. Final calculation leading to the ranking of the different products

The three-step pathway model was developed to compare the risk of transmission of ASFV through different products for feed and bedding material: the model parameters were estimated by three separate groups of experts and no calibration step by adjusting to the current number of newly infected farms in the non-affected areas of the EU was performed after the calculation of the modelled number of potentially infected pig farms. Therefore, the model results rate the ability of different matrices to present a risk of transmitting ASF, and consequently, the final comparison between matrices was performed in a relative manner.

The ratios between the risk of different products are described for the likelihood of products containing enough ASFV to infect a pig (q), for the number of farm deliveries of products (N) and finally for the modelled number of potentially infected pig farms ($N \times q$). The results of each model step were standardised to the maximum of 1. The reported risks in the final comparisons are expressed as relative values compared to the maximum risk of all products and strata (EU/Eurasia, small-/large-scale farms).

3. Assessment

3.1. Results of the Literature Review and Public Consultation

The literature search identified 21 peer-reviewed publications that fulfilled the eligibility criteria. During the public consultation, two additional papers that fulfilled the eligibility criteria were identified and included in the data extraction. In addition, information on processing parameters provided by the European Feed Manufacturers Federation (FEFAC) and the Gelatine Manufacturers of Europe were included in the data section.

The data section has been structured into two parts: the first (Section 3.1.1) is related to survival of ASFV in products derived from ASFV-infected domestic pigs, focussing on animal by-products for use in feed; the second (Section 3.1.2) summarises data regarding ASFV-survival in other matrices that may become contaminated with ASFV through direct contact with ASFV-infected animals and/or through indirect contact (e.g. excretions) with ASFV infected animals. Information on survival of ASFV in unprocessed meat and processed meat products derived from ASFV-infected domestic pigs identified in the literature review and the public consultation is available in Annex 3 (Section 1).

The literature review includes only experimental infection or virus survival studies that examined the ability of ASFV to survive and remain viable in different matrices, as evidenced by virus isolation. Studies demonstrating only the presence of ASFV DNA through PCR and not using virus isolation were excluded from the review, as PCR-positive samples do not necessarily contain infectious virus. However, products found negative by virus isolation may still contain a small amount of infectious virus, and so relying only on studies using virus isolation as a detection method could therefore underestimate the survival time of ASFV. In most of the identified studies, except one (Petrini et al., 2019), which carried out challenge studies on virus isolation negative samples, inoculation of pigs with these samples did not result in infection.

3.1.1. ASFV survival in products derived from infected pigs

3.1.1.1. Animal by-products for use in feed

Category 3 animal by-products (ABP) destined for use in feed must have undergone one of the processes listed in Chapter III of Annex IV of Regulation 142/2011. These include methods 1–5 and 7 as listed in Table 4. For method 7, no standard conditions are prescribed, however, the method should be authorised by the competent authority in the MS.

Table 4: Standard processing methods for Category 3 animal by-products, Chapter III of Annex IV of Regulation 142/2011

Method	Maximum particle size of raw material to be treated	Core temperature achieved	Minimum time at core temperature	Special details
Method 1 (pressure sterilisation at 3 bars)	50 mm	> 133°C	20 min without interruption	The pressure (3 bars) must be produced by the evacuation of all air in the sterilisation chamber and the replacement of the air by steam ('saturated steam'); the heat treatment may be applied as the sole process or as a pre- or post-process sterilisation phase; the processing may be carried out in batch or continuous systems
Method 2	150 mm	> 120°C	50 min	Processing must be carried out in batches
Method 2	150mm	> 110°C	120 min	Processing must be carried out in batches
Method 2	150 mm	> 100°C	125 min	Processing must be carried out in batches
Method 3	30 mm	> 120°C	13 min	Processing may be carried out in batch or continuous systems
Method 3	30 mm	> 110°C	55 min	Processing may be carried out in batch or continuous systems
Method 3	30 mm	> 100°C	95 min	Processing may be carried out in batch or continuous systems
Method 4	30 mm	> 130°C	3 min	After reduction the animal by-products must be placed in a vessel with added fat Processing may be carried out in batch or continuous systems
Method 4	30 mm	> 120°C	8 min	After reduction the animal by-products must be placed in a vessel with added fat Processing may be carried out in batch or continuous systems
Method 4	30 mm	> 110°C	13 min	After reduction the animal by-products must be placed in a vessel with added fat Processing may be carried out in batch or continuous systems
Method 4	30 mm	> 100°C	16 min	After reduction the animal by-products must be placed in a vessel with added fat Processing may be carried out in batch or continuous systems
Method 5	20 mm	> 100°C	60 min	After reduction and before application of the heat treatment, the animal by-products must be heated until they coagulate and then pressed so that fat and water are removed from the proteinaceous material Processing may be carried out in batch or continuous systems
Method 6	20 mm	> 80°C	120 min	After reduction and before application of the heat treatment, the animal by-products must be heated until they coagulate and then pressed so that fat and water are removed from the proteinaceous material Processing may be carried out in batch or continuous systems

Method	Maximum particle size of raw material to be treated	Core temperature achieved	Minimum time at core temperature	Special details
Method 7* (alternative methods)	Not defined	Not defined	Not defined	Any processing method that has been authorised by the competent authority and has been demonstrated to reduce relevant hazards in the starting material to a level which does not pose any significant risks to public and animal health with the final product complying with specific microbiological standards

*: A list of approved methods in 2018 is available at https://efsa.onlinelibrary.wiley.com/cms/attachment/3483307c-9a2f-436f-8715-082174dd3dfe/efs25314-fig-0003-m.jpg.

3.1.1.1.1. Hydrolysed proteins for use in feed

No data on ASFV survival in hydrolysed proteins were identified in the literature review. Hydrolysed proteins must be produced by a process, which involves appropriate measures to minimise contamination (Regulation 142/2011, Annex X, chapter II, section 5). According to Hou et al. (2017), the general procedures for the production of hydrolysed proteins from animal products (including by-products) through chemical, enzymatic, or microbial hydrolysis include a heat treatment (pasteurisation) (Table 5). These general procedures may be modified for peptide production, depending on protein sources and product specifications.

Table 5: Production process of hydrolysed proteins (Hou et al., 2017)

Hydrolysis	Separation	Decontamination	Further processing
Hydrolysis of proteins by cell-free proteases, microorganisms, acids, or bases	Centrifugation, filtration, microfiltration	Heat-treatment (pasteurisation)	Drying

3.1.1.1.2. Rendered fats for use in feed

No data on ASFV survival in rendered fats were identified in the literature review. According to Commission Regulation (EU) No 142/2011, Annex IV Chapter III, rendered fats must be produced using any of the processing methods 1–5 or processing method 7 (Table 8).

3.1.1.1.3. Gelatine for use in feed

No data on ASFV survival in gelatine for use in feed were identified in the literature review. The following raw material from pigs can be used for the production of gelatine intended for human consumption: bones and pig skins (Regulation (EC) No 853/2004, Section XIV of Annex III), and category 3 material can be used to produce gelatine suitable for animal consumption (Commission Regulation (EU) No 142/2011) (Table 6). In both cases, the process includes treatment with acid or alkali and extraction of gelatine by heating one or several times in succession (for gelatine from species other than bovines no specific temperatures are prescribed in the Regulation).

Table 6: Production process of gelatine, (Regulation (EC) No 853/2004, Commission Regulation (EU) No 142/2011)

Treatment of material	Extraction of gelatine	Purification	Further processing	Preservatives
Treatment with acid or alkali, followed by one or more rinses; adjustment of pH	Heating one or several times in succession	Filtration and sterilisation	Drying, pulverisation or lamination	Sulfur dioxide, hydrogen peroxide

According to information provided to EFSA by the Gelatine Manufacturers of Europe, gelatine fit for human consumption, including all products derived from the production of gelatine fit for human consumption, and collagen fit for human consumption are obtained from raw materials pursuant to

Regulation (EC) No 853/2004. This means that all the raw materials used for the manufacture of these products derive from animals which have been slaughtered in a slaughterhouse and whose carcasses have been found fit for human consumption following ante- and post-mortem inspection. Technical gelatine needs to be produced in accordance with the ABP regulation and only category 3 material can be used. The gelatine manufacturing process follows the steps of bone pretreatment (degreasing of porcine bones and production of processed animal proteins and fat, followed by demineralisation of bones and production of Dicalcium Phosphate (DCP) (see also Section 3.1.1.1.6) and pretreatment of pigskins.

For the degreasing of porcine bones and production of processed animal proteins and fat, the soft tissue including fat on the untreated bones has to be removed. In the EU, bones are degreased with hot water at a temperature of minimum 70°C for at least 30 min. Other degreasing processes complying with Regulation EC 853/2004 Annex III Section XIV/XV may also be used. Bones are subsequently washed and dried. The turbulent action of the hot water and the sliding and rubbing of the crushed bone loosens the soft tissue from the bone. The contents of the degreasing vessel are separated into bones and liquids containing meat, fat and water. The suspended solids in the meat/fat/water liquid originated during the degreasing process are separated from the fat/water liquid and dried to processed animal proteins (first by-product). The fat/water liquid is purified to result in water and bone fat, which is a second by-product of the bone degreasing process. For the demineralisation of bones and production of DCP, the degreased bone chips are submitted to a demineralisation process where the inorganic component of the bones (mainly natural phosphates and calcium carbonate) are removed. The defatted bones are treated with dilute hydrochloric acid (pH 1–2) over a period of at least two days for bovine bones; shorter times are usually used for porcine bones. The phosphoric liquor obtained is treated with lime, resulting in a precipitate of dicalcium phosphate at pH 4–7. The precipitate of dicalcium phosphate is finally dried with hot air until DCP with a moisture content of 1–2% is obtained. Degreased and deionised bone chips, named ossein, are neutralised before extraction of the gelatine and further processing for the production of acid bone gelatine, or they are treated with lime (pH > 12) for at least 20 days before extraction and further processing for the production of limed bone gelatine.

During the pretreatment of pig skins, the pig skins are cut into pieces and acidified, to a pH of below 3, for at least 5 h. The treated pig skins, after neutralisation, are transferred to the extraction tanks.

After the pretreatment of the raw materials described above, the following common steps are applied for all types of gelatine. The gelatine is extracted from the porcine ossein or pig skins, with hot water at temperatures between 50 and 60°C and 100°C. This is followed by a filtration and deionisation of the extracted gelatine. During filtration and ion exchange the temperature of the solution is kept at minimum 55°C. After the ion exchangers the gelatine solution is concentrated by evaporation at a minimum temperature of 80°C. The concentrated gelatine solution is submitted to a UHT treatment. The greaves remaining in the extraction tanks after the gelatine extraction are further processed. They are separated into suspended solids and a fat/water liquid. The suspended solids are dried to processed animal proteins (gelatine process-derived proteins, GPD). The fat/water liquid and the fat from the extraction are purified to porcine fat and water (Gelatine Manufacturers of Europe, 2020) (Table 7).

3.1.1.1.4. Collagen for use in feed

No data on ASFV survival in collagen for use in feed were identified in the literature review. Collagen for use in feed must be produced by a process ensuring that unprocessed Category 3 material is subjected to a treatment involving washing, pH adjustment using acid or alkali followed by one or more rinses, filtration and extrusion. After that treatment, collagen may undergo a drying process (Commission Regulation (EU) No 142/2011) (Table 7).

Table 7: Temperatures and pH involved in the production of gelatine and collagen and their by-products by raw material used (Gelatine Manufacturers of Europe, 2020)

Product	Feed material catalogue	Raw material	T°	pH
Gelatine	9.12.1	Porcine Skins	UHT treatment Drying at 50–60°C	Below pH 3
Gelatine	9.12.1	Porcine Bones	Degreasing (70–90°C). Heat treatment min. 138°C for min. 4 s	Below pH 2 and/or above pH 12.0
Collagen	9.10.1	Porcine Skins		Below pH 3
Collagen	9.10.1	Porcine Bones	Degreasing (70–90°C)	Below pH 2 and/or above pH 12.0
GPDP (gelatine process derived proteins)	9.5.1	Porcine Bones	Degreasing (70–90°C). Min. 30 min	na
GPDP (gelatine process derived proteins)	9.5.1	Porcine Skins	Extraction (at least 95°C). Min. 30 min	Preparation pH below 3
Greaves	9.13.1	Porcine Skins	Extraction (at least 95°C)	Preparation pH below 3
Animal fat	9.2.1	Porcine Bones	Degreasing (70–90°C)	na
Animal fat	9.2.1	Porcine Skins		Preparation pH below 3
Bone DCP	11.3.1	Porcine Bones	Degreasing (70–90°C)	Demineralisation of the defatted bones in HCl solution of pH below 2

DCP: Dicalcium Phosphate.

3.1.1.1.5. Blood products for use in feed

No data on ASFV survival in blood products for use in feed were identified in peer-reviewed scientific literature. Blood products for use in feed must be submitted to any of the processing methods 1–5 or processing method 7 (Commission Regulation (EU) No 142/2011) (Table 4).

The plasma utilised for production of spray-dried porcine plasma (SDPP) is collected at veterinary-inspected abattoirs from animals designated fit for human consumption. Specifically, blood is collected into containers with anticoagulant and the erythrocytes are removed by centrifugation. The blood of 6,000–10,000 animals slaughtered on the same day is pooled. The plasma obtained is subsequently spray-dried and used for the production of food, feed and for industrial applications. Commercial spray-driers used for the industrial production of SDPP reach an outlet temperature of 80°C (Gerber et al., 2014). The main applications of spray-dried porcine plasma (SDPP) in animal feed include its use to improve performance and gut health in young piglets where SDPP is used in milk replacers, creep feed and weaning diets as an alternative source of lactogenic immunoglobulins and other bioactive glycoproteins that are present in sow's milk, and as a gelling agent in wet pet food (Kalmar et al., 2018). In a study funded by the European Association of Blood Products Producers (EAPA), Blazquez et al. (2018) spray-dried 0.5 kg samples of liquid concentrated porcine plasma (28% solid) inoculated with ASFV (strain BA-71) (final $TCID_{50}$ concentration of $10^{5.77}$ per mL of liquid concentrated plasma) in a laboratory spray-dried at an inlet temperature of 200°C and at 80°C outlet temperature. Virus titration results showed that the spray drying had inactivated 4.11 $\pm$ 0.20 log10 $TCID_{50}$/mL of the inoculated ASFV.

3.1.1.1.6. Dicalcium phosphate and tricalcium phosphate of animal origin for use in feed

No data on ASFV survival in dicalcium phosphate or tricalcium phosphate for use in feed were identified in the literature review. According to Commission Regulation (EU) No 142/2011, dicalcium phosphate must be prepared from Category 3 material that has been finely crushed and degreased with hot water and treated with dilute hydrochloric acid (at a minimum concentration of 4% and a pH of less than 1.5) over a period of at least two days. The obtained phosphoric liquor must be treated with lime, resulting in a precipitate of dicalcium phosphate at pH 4–7, which has to be air-dried with an inlet temperature of 65–325°C and an end temperature between 30°C and 65°C (Table 8). A detailed description of the demineralisation of bones and production of DCP has been provided by the Gelatine Manufacturers of Europe (2020) (see Section 3.1.1.1.3).

Tricalcium phosphate must be prepared from Category 3 material that has been finely crushed and degreased in counterflow with hot water (bone chips must be less than 14 mm in diameter). Subsequently, it has to be continuously cooked with steam at 145°C during 30 min at 4 bars. The protein broth must be separated from the hydroxyapatite (tricalcium phosphate) by centrifugation and the tricalcium phosphate has to be granulated after drying in a fluidised bed with air at 200°C (Table 8).

Table 8: Production process of dicalcium phosphate and tricalcium phosphate (Commission Regulation (EU) No 142/2011)

Product	Pre-treatment	Treatment 1	Treatment 2	Drying
Dicalcium phosphate	Crushing degreasing with hot water	Treatment with dilute hydrochloric acid (minimum concentration 4%, pH < 1,5) for at least 2 days	Treatment with lime, resulting in a precipitate of dicalcium phosphate at pH 4–7	Air-drying (inlet temperature 65–325°C, end temperature 30–65°C
Tricalcium phosphate	Crushing (bone chips must be < 14 mm) degreasing in counterflow with hot water	Continuous cooking with steam at 145°C during 30 min at 4 bars	Separation of protein broth from hydroxyapatite (tricalcium phosphate) by centrifugation	Granulation after drying in a fluidised bed with air at 200°C

3.1.2. ASFV survival in contaminated material

ASFV-infected domestic pigs and wild boar shed the virus through excreta, such as faeces, urine and oral fluid (with or without blood). These excreta can contaminate other materials. It has been shown that ASFV survives in chilled (4°C) and cooled (12°C) faeces for at least 5 days, but not 7 days (Davies et al., 2017). In faeces stored at room temperature (21°C), the virus was shown to survive for at least 3 days, but less than 5 days (Davies et al., 2017), while an earlier study (Montgomery, 1921) found viable virus in faeces stored at room temperature (21°C) after 11 days. Faeces stored at 37°C were ASFV-negative 2 days after the start of the experiment (Davies et al., 2017). The ASFV has been shown to survive in chilled (4°C) and cooled urine (12°C) as well as urine stored at room temperature (21°C) for at least 5 days, but less than 7 days (Davies et al., 2017). In an earlier challenge study, Montgomery (1921) found viable virus in urine stored at room temperature (21°C) for less than 2 days. Urine stored at 37°C was ASFV-negative 2 days after the start of the experiment (Davies et al., 2017). A study conducted on slurry showed that slurry heated to 53°C in a reactor for 5.2–7.4 min did not contain active ASFV after this treatment (Turner and Williams, 1999) (Table 9).

Table 9: Survival time of ASFV as shown by virus isolation in excreta from ASFV infected domestic pigs or wild boar as reported in literature

Matrix	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Faeces	Chilled (4°C)	nr	5	7	98	0.65	nr	nr	na	Davies et al. (2017)
Faeces	Cooled (12°C)	nr	5	7	98	0.5	nr	nr	na	Davies et al. (2017)
Faeces	Room temperature (21°C)	nr	3	5	98	0.39	nr	nr	na	Davies et al. (2017)
Faeces	Room temperature (21–23°C)	nr	11	nr	23		nr	nr	Challenge study, no virus isolation	Montgomery (1921)
Faeces	Hot (37°C)	nr	1	2	98	0.29	nr	nr	na	Davies et al. (2017)
Urine	Chilled (4°C)	nr	5	7	126	2.19	nr	nr	na	Davies et al. (2017)
Urine	Cooled (12°C)	nr	5	7	126	1.07	nr	nr	na	Davies et al. (2017)
Urine	Room temperature (15–25°C)	nr	< 2	na	2	nr	nr	nr	Challenge study, no virus isolation	Montgomery (1921)
Urine	Room temperature (21°C)	nr	5	7	126	0.68	nr	nr	na	Davies et al. (2017)
Urine	Hot (37°C)	nr	1	2	126	0.41	nr	nr	na	Davies et al. (2017)
Slurry	Heated (53°C)	nr	na	nr	Time in reactor 5.2–7.4 min	nr	nr	nr	Virus was inactivated below detectable levels after treatment in a reactor	Turner and Williams (1999)

nr: not reported; na: not applicable.
1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.

3.1.2.1. Feed materials

Commission Regulation (EU) 2017/1017 provides a catalogue of feed materials. It also contains animal products. These must fulfil the requirements of the Regulation (EC) No 1069/2009 and Regulation (EU) No 142/2011 and may be subject to restrictions in use according to Regulation (EC) No 999/2001. This section lists only feed material that the AHAW Panel considers to be potentially contaminated with ASFV and that have not already been covered in previous sections. Where the literature review did not identify any studies that investigated the survival time of ASFV in feed material, parameters that could influence the potential survival of ASFV during the production and processing processes that were identified are listed in the sections below. The possibility of re-contamination after these processes is beyond the scope of this section.

3.1.2.1.1. Cereal grains, their products and by-products

Dried distillers' grains with solubles[6] that had been contaminated post-processing with ASFV and stored for 30 days at varying temperatures (mean 15°C) were ASFV negative 30 days post contamination (Dee et al., 2018). Wheat, rye, barley, triticale and corn (humidity 11.5–14.2%) contaminated with ASFV-positive blood (10^6 HAD_{50}/mL) and subjected to 2 h of drying (incubation at room temperature) followed by incubation at temperatures between 40 and 75°C for 1 h were ASFV-negative by HAT after drying and after any of the eight drying and heat treatments tested (Fischer et al., 2020) (Table 12).

3.1.2.1.2. Oil seeds, oil fruits, their products and by-products

Soy oil cake, conventional soybean meal and organic soybean meal that had been contaminated post-processing with ASFV and stored for 30 days at varying temperatures (mean 12.3 or 15°C) were ASFV positive 30 days post contamination (Dee et al., 2018; Stoian et al., 2019) (Table 12). The process of soybean meal includes several process steps, in which the raw material is heated (toasting by using dry heat to reduce or remove naturally occurring antinutritive factors). When leaving the toasting unit, the residual temperature is 105°C with 16–20% residual moisture (Witte, 1995) (Table 10).

[6] 'Distiller's grains with solubles' = the nutrients that are dissolved in the liquid (especially proteins) during the fermentation process are maintained when the 'wet distiller's grains' are dried in total so that no nutrients are lost.

Table 10: Soybean meal production for animal feed (Witte, 1995)

Product	Oil extraction	Solvent removal	Cooking	Drying and cooling	Grinding and sizing
Soybean meal	Hexane-wet flakes leave the extractor at 53°C	Desolventising of extracted soy flakes with steam of 71–80°C	Toasting of flakes (105°C at the exit, residual moisture 16–20%)	Drying (45–75°C at exit, residual 12% moisture) cooling to 32°C (or ambient temperature +6°C)	Size reduction by hammer or roller mills

3.1.2.1.3. Legume seeds, their products and by-products

Only one study on ASFV survival in legume seeds, their products and by-products contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar was identified in the literature review. Peas (humidity 11.5–14.2%) contaminated with ASFV-positive blood (10^6 HAD_{50}/mL) and subjected to 2 h of drying (incubation at room temperature) followed by incubation at temperatures between 40 and 75°C for 1 h were ASFV-negative by HAT after drying and after any of the eight drying and heat treatments tested (Fischer et al., 2020) (Table 12).

3.1.2.1.4. Tubers, roots, their products and by-products

No data on ASFV survival in tubers, roots, their products and by-products contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.1.5. Other seeds and fruits, their products and by-products

No data on ASFV survival in other seeds and fruits, their products and by-products contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.1.6. Forages and roughage

No data on ASFV survival in forages and roughages contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review. Meals produced from certain forages, such as lucerne, clover or grass, are dried and milled. Hay stored in uncovered bales of different diameters and different moisture contents were shown to reach maximum temperatures of 77.2°C (Coblentz and Hoffman, 2009), bales covered in tarpaulin reached temperatures of 40.7–44.9°C, depending on location of storage and tarpaulin colour (Guerrero et al., 2010). In silage, during natural fermentation, the pH gradually drops and temperatures between 20 and 30°C are reached. The exact temperature and final pH in the ensiled crop largely depend on the type and moisture of the forage being ensiled. Maize silage terminates at or below pH 4, legumes silage generally reaches a terminal pH of about 4.5 (Seglar, 2013) (Table 11).

Table 11: Production parameters reported for hay and silage

Matrix	Maximum temperature observed	Moisture concentrations (prestorage)	pH	Reference
Hay bales uncovered	77.2°C	9.3–46.6%	nr	Coblentz and Hoffman (2009)
Hay bales covered in tarpaulin	40.7–44.9°C	nr	nr	Guerrero et al. (2010)
Silage	20–30°C	nr	4–4.5	Seglar (2013)

nr: not reported.

3.1.2.1.7. Other plants, their products and by-products

This category contains cane molasses, cane vinasse, cane sugar and seaweed meal. No data on ASFV survival in these matrices contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.2. Compound feed

Compound feeding stuffs are organic or inorganic substances in mixtures, whether or not containing additives, for oral animal feeding in the form of complete feeding stuffs or complementary feeding stuffs (Regulation (EC) No 767/2009 of the European Parliament and of the Council of 13 July 2009 on the placing on the market and use of feed). Feed contaminated with infectious material originating from infected domestic pigs or wild boar was ASFV-positive for at least one, but not 5 days when stored at room temperature (22–25°C), at least for 30, but not 40 days when stored at a temperature between 4°C and 6°C and at least 60 days when stored frozen (–16—20°C) (Sindryakova et al., 2016). Dee et al. (2018) and Stoian et al. (2019) detected ASFV at day 30 post contamination in complete feed that had been contaminated post-processing with ASFV and stored for 30 days at varying temperatures (mean 12.3 or 15°C) (Table 12).

According to information on the compound feed production process provided to EFSA by the European Feed Manufacturers Federation (FEFAC), feed materials used for commercial manufacture of compound feed are usually stored in closed bins before being used in the manufacturing. Storage duration of feed ingredients in feed mills is usually few days for feed materials and can be 2–3 weeks for premixtures. Following grinding, dosing, mixing and inclusion of feed additives, feed may either be placed in the market as mash or further processed, generally in the form of pelleted feed (the most common form in pig production) or extruded (not generally used in pig production). Usually mash feed is not subject to any thermal processing, before it is transported to the farm. To obtain pelleted feed, mash feed is conditioned with steam at temperatures ranging 60–81°C for few seconds to up to 2 min before passing through the pelleting dies, where feed is subject to high pressure and friction forces. Compound feed has a low moisture content (around 12%). Compound feed is usually delivered to farms or intermediates within few hours following its manufacturing. On farm, storage of the compound feed will usually be in specific silos/bins, or in certain cases in small (e.g. 40 kg) or big bags. Duration of storage ranges from a few days to 15 days for the smaller holdings. The temperatures reached in the bags/silos depend on the ambient temperature (EFMF, 2020).

3.1.2.3. Feed additives

Feed additives are substances, micro-organisms or preparations, other than feed material and premixtures, which are intentionally added to feed or water in order to favourably affect the characteristics of the feed, the animal product, the colour of ornamental fish and birds, the environmental consequences of animal production and the animal production, performance or welfare, particularly by affecting the gastro-intestinal flora or digestibility of feedstuffs, satisfy the nutritional needs of animals, or to have a coccidiostatic or histomonostatic effect.

Choline that had been contaminated post-processing with ASFV and stored for 30 days at varying temperatures (mean 12.3 or 15°C) was ASFV-positive at day 30 post contamination (Dee et al., 2018; Stoian et al., 2019). The same authors did not detect ASFV 30 days post contamination of Lysine and Vitamin D that had been stored for 30 days at varying temperatures (mean 12.3 or 15°C) (Table 12).

Table 12: Survival of ASFV as shown by virus isolation in feed matrices contaminated with infectious material originating from infected domestic pigs or wild boar as reported in literature

Matrix category	Matrix	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Cereal grains	Dried distillers' grains with solubles	Room (15°C (mean))	75 (mean)	0	na	30	nr	nr	nr	na	Dee et al. (2018)
Cereal grains	Wheat	Room temperature for 2 h	11.5–14.2%	< 1	1	1	nr	nr	nr	na	Fischer et al. (2020)
Cereal grains	Barley	Room temperature for 2 h	11.5–14.2%	< 1	1	1	nr	nr	nr	na	Fischer et al. (2020)
Cereal grains	Rye	Room temperature for 2 h	11.5–14.2%	< 1	1	1	nr	nr	nr	na	Fischer et al. (2020)
Cereal grains	Triticale	Room temperature for 2 h	11.5–14.2%	< 1	1	1	nr	nr	nr	na	Fischer et al. (2020)
Cereal grains	Maize	Room temperature for 2 h	11.5–14.2%	< 1	1	1	nr	nr	nr	na	Fischer et al. (2020)
Oil seeds	Soy oil cake	Room (15°C (mean))	75 (mean)	30	na	30	5.0	nr	nr	na	Dee et al. (2018)
Oil seeds	Soy oil cake	Room (12.3°C (mean))	74.1 (mean)	30	na	30	12.4	10.4	14.3	na	Stoian et al. (2019)
Oil seeds	Soybean meal conventional	Room (15°C (mean))	75 (mean)	30	na	30	4.6	nr	nr	na	Dee et al. (2018)
Oil seeds	Soybean meal conventional	Room (12.3°C (mean))	74.1 (mean)	30	na	30	9.6	8.7	10.4	na	Stoian et al. (2019)
Oil seeds	Soybean meal organic	Room (15°C (mean))	75 (mean)	30	na	30	4.7	nr	nr	na	Dee et al. (2018)
Oil seeds	Soybean meal organic	Room (12.3°C (mean))	74.1 (mean)	30	na	30	12.9	11.5	14.3	na	Stoian et al. (2019)

Matrix category	Matrix	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Legume seeds	Peas	Room temperature for 2 h	11.5–14.2%	negative	1	1	nr	nr	nr	na	Fischer et al. (2020)
Compound feed	Complete feed	Room (15°C (mean))	75 (mean)	30	na	30	4.3	nr	nr	na	Dee et al. (2018)
Compound feed	Complete feed	Room (12.3°C (mean))	74.1 (mean)	30	na	30	14.2	12.4	15.9	na	Stoian et al. (2019)
Compound feed	Feed	Frozen (–16 to –20°C)	nr	≥ 60	na	60	nr	nr	nr	na	Sindryakova et al. (2016)
Compound feed	Feed	Chilled (4–6°C)	nr	30	40	60	nr	nr	nr	na	Sindryakova et al. (2016)
Compound feed	Feed	Room (22–25°C)	nr	1	5	60	nr	nr	nr	na	Sindryakova et al. (2016)
Feed additives	Choline	Room (15°C (mean))	75 (mean)	30	na	30	5.1	nr	nr	na	Dee et al. (2018)
Feed additives	Choline	Room (12.3°C (mean))	74.1 (mean)	30	na	30	11.9	10.9	12.9	na	Stoian et al. (2019)
Feed additives	Lysine	Room (15°C (mean))	75 (mean)	0	na	30	na	nr	nr	na	Dee et al. (2018)
Feed additives	Vitamin D	Room (15°C (mean))	75 (mean)	0	na	30	na	nr	nr	na	Dee et al. (2018)

nr: not reported; na: not applicable.
1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.

3.1.2.4. Tote bags

Tote bags are used for the transportation of feed grains. They are often re-used. Given the ability of ASFV to survive under a range of environmental conditions, the potential role of contaminated tote bags for ASFV spread should be assessed. No data on ASFV survival in tote bags were identified in the literature review.

3.1.2.5. Vehicles

Given the ability of ASFV to survive under a range of environmental conditions, the potential role of contaminated vehicles for spread of ASFV should be assessed.

3.1.2.5.1. Vehicles for live pig transport

No data on ASFV survival in vehicles used for live pig transport contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.5.2. Vehicles visiting pig farms

No data on ASFV survival in vehicles visiting pig farms contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.5.3. Other vehicles

No data on ASFV survival in vehicles other than those used for transporting live domestic pigs and those visiting pig farms contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.6. Bedding and enrichment material

3.1.2.6.1. Saw dust, wood chips

No data on ASFV survival in sawdust or wood chips contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review. Sawdust and wood chips are produced when wood logs are cut in sawmills. Stored in piles, self-heating may occur. The temperatures reached during self-heating depend on the amount of radiation, nutrient content of the wood or chips and their residual humidity. Temperatures in the piles may reach 60–80°C within 24 h, with elevated temperature being maintained for weeks and ambient temperatures being reached after several months (Kofman, 2008).

3.1.2.6.2. Turf

No data on ASFV survival in turf (milled peat) contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review. Milled peat collected from peat bogs during the dry season is stored in bales near collection fields or transported to storage sites. In northern latitudes, the material is collected and stored outdoors in bales during summer months (commonly from May to September). After drying, the bales are often covered with plastic covers to protect them from rain and erosion, and to avoid self-ignition. Generally, a low pH (3.5–5) and temperatures of 40°C are reached in peat piles or bales (Mait Märtin, Elva EPT Ltd., personal communication).

3.1.2.6.3. Straw

No data on ASFV survival in straw contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.6.4. Hulls or husks of rice or other cereals

No data on ASFV survival in hulls of husks of rice or other cereals contaminated with ASFV or infectious material originating from infected domestic pigs or wild boar were identified in the literature review.

3.1.2.7. Drinking water

Kovalenko et al. (1965) found that ASF virus in lake water that had been experimentally contaminated with blood from an infected domestic pig (dilution 1:100) and subsequently kept in a glass flask and buried at a depth of 12 cm survived for 50 days in summer and 176 days in winter. Sindryakova et al. (2016) showed that water that had been stored frozen (–16—20°C) or chilled (4–6°C) still contained viable ASFV at the end of the experiment (60 days). Water that had been stored at room temperature (22–25°C) was positive after 50 days, but not after 60 days (Table 13).

Table 13: Survival of ASFV as shown by virus isolation in water contaminated with infectious material originating from infected domestic pigs or wild boar as reported in literature

Matrix	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Water	Summer	na	50	nr	nr	nr	nr	nr	This study included also *in vivo* tests.	Kovalenko et al. (1965)
Water	Winter	na	176	nr	nr	nr	nr	nr	This study included also *in vivo* tests.	Kovalenko et al. (1965)
Water	Frozen (–16–20°C)	na	≥ 60	na	60	nr	nr	nr	na	Sindryakova et al. (2016)
Water	Chilled (4–6°C)	na	≥ 60	na	60	nr	nr	nr	na	Sindryakova et al. (2016)
Water	Room (22°C–25°C)	na	50	60	60	nr	nr	nr	na	Sindryakova et al. (2016)

nr: not reported; na: not applicable.
1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.

3.2. Results of the Contamination EKE

3.2.1. Empty vehicles for pig transport returning from affected areas to the non-affected area of the EU

3.2.1.1. Proportion of empty vehicles for pig transport returning from affected areas to the non-affected area of the EU that will have become contaminated with infectious ASFV at the place of unloading in the affected areas

The likelihood of contamination of a truck with infectious ASFV at unloading in affected areas is estimated to be higher when a truck visits small-scale farms compared to large-scale farms, as the former are expected to have a lower level of biosecurity (Figure 2).

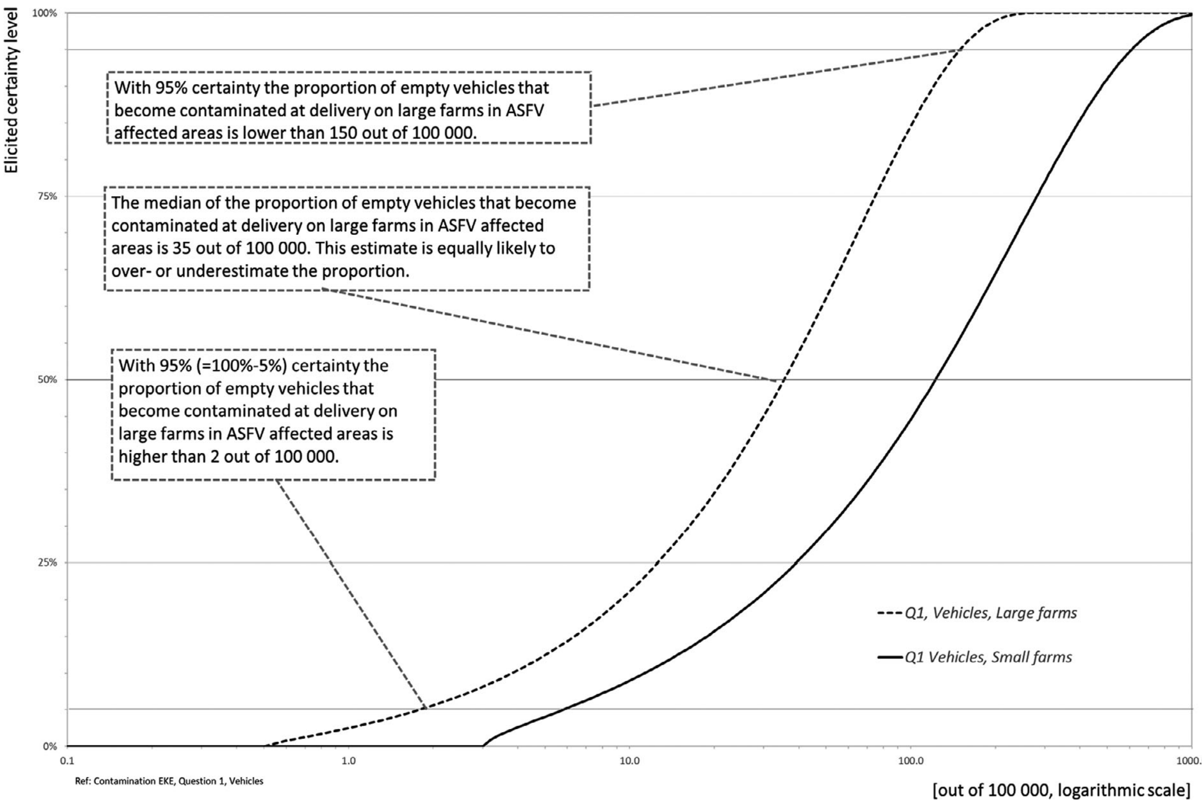

Figure 2: Cumulative distribution function (CDF) of the estimated number of 'Empty vehicles used for live pig transport' out of 100,000 that become contaminated with infectious ASFV at unloading on small- and large-scale farms in affected areas

3.2.1.2. Proportion of empty vehicles for pig transport containing infectious ASFV after unloading in the affected area that still contain infectious ASFV at the point of loading (usage) on a farm in the non-affected area of the EU, after cleaning, disinfection and travel

The likelihood of an empty vehicle, contaminated in an affected area, to still contain infectious virus at the point of usage (next loading on a pig farm) in a non-affected area is estimated to be 11.6% (90% probability interval 1.9–23.2%). While all trucks must be cleaned and disinfected after unloading, it was estimated that the effectiveness of cleaning and disinfection is not always sufficient to remove all viable ASFV, as it is influenced by the standard of the cleaning facilities, the ambient temperatures and the time to next loading.

3.2.1.3. Proportion of empty vehicles for pig transport contaminated with ASFV at unloading and still contaminated at loading, which contain at least one infectious dose sufficient to cause an infection of at least one pig during a following pig transport in the non-affected areas of the EU

The proportion of empty vehicles contaminated in an affected area that will contain at least one dose of infectious virus at the next point of use (i.e. the next loading on a pig farm) is estimated to be 3.2% (90% PI 0.57–7.0%).

3.2.2. Feed products and bedding/enrichment material

3.2.2.1. Proportion of consignments of products containing infectious ASFV at the place of production in an ASF-affected area

The results of the EKE estimated a consignment of straw, forage/roughage, or cereals to have the highest likelihood of containing infectious ASFV at the place of production in affected areas (Table 14, Figure 3). Minerals, feed additives and wooden toys were estimated to have the lowest likelihood of containing ASFV at the place of production.

Minerals and feed additives are usually not delivered to farms, but to producers of compound feed. Only farms which produce their own cereals, buy mineral feed, a combination of minerals and feed additives, to mix with their cereals to obtain complete feed.

Minerals from animal origin undergo a heat treatment and drastic pH changes that would eliminate any ASFV present in the original material. Minerals originating from mining have no contact to infected pigs. Therefore, minerals are not considered to pose a risk.

The products estimated to have the highest probability of containing infectious ASFV at the place of production, straw, forage/roughage and cereals, may all be contaminated with ASFV from remains of wild boar carcasses, wild boar excretions. Straw may be left to dry on the field for several days before being baled, which constitutes an opportunity for contamination by wild boar. The likelihood related to cereals is estimated to be lower, based on a more careful harvesting process relative to forage/roughage.

Blood is a product that needs to be processed within 24 h after harvest. It was considered very unlikely that blood collected from pigs in ASF-affected areas outside the EU is transported to ASF-free areas. While there is a short time window in which infected animals are viraemic without showing clinical symptoms that would probably be detected at the ante-mortem inspection, experimental infections have shown that up to 3 days post-infection, only very low amounts of virus are present in blood (not detectable by virus isolation). Therefore, the proportion of blood containing infectious ASFV was considered to be low. The proportion of animal material used for the production of hydrolysed proteins that could contain infectious ASFV was considered to be similar to the one of blood, but a slightly higher level of uncertainty existed due to less information being available.

Table 14: Estimates for the proportion of consignments of a product containing infectious ASFV at the place of production in an ASF-affected area

Parameter	Proportion of consignments of a product containing infectious ASFV at the place of production in affected areas	
	EU Median estimate (90% probability interval)	Eurasia Median estimate (90% probability interval)
	[out of 100,000]	[out of 100,000]
Hydrolysed protein	**24.6** (2.37–112)	
Blood products, spray-dried plasma	**24.6** (2.37–112)	
Cereal grains, their products and by-products	**268** (19.4–818)	**301** (7.78–917)
Legume seeds, their products and by-products	**122** (10.9–384)	**127** (7.70–408)
Oil seeds, oil fruits, their products and by-products	**178** (10.5–565)	**201** (4.31–708)
Tubers, roots, their products and by-products	**235** (7.96–826)	**247** (5.38–871)
Other seeds, fruits, their products and by-products	**59.2** (8.49–182)	**63.4** (5.50–216)
Forages and roughage	**351** (11.0–1013)	

Minerals and Feed additives	**8.38** (0.722–24.1)
Mash/Concentrate	Not assessed
Pellets	Not assessed
Straw	**512** (54.6–1527)
Sawdust/Woodchips	**40.6** (4.54–117)
Peat/Turf	**174** (0.54–905)
Wooden toys	**7.37** (0.92–17.4)

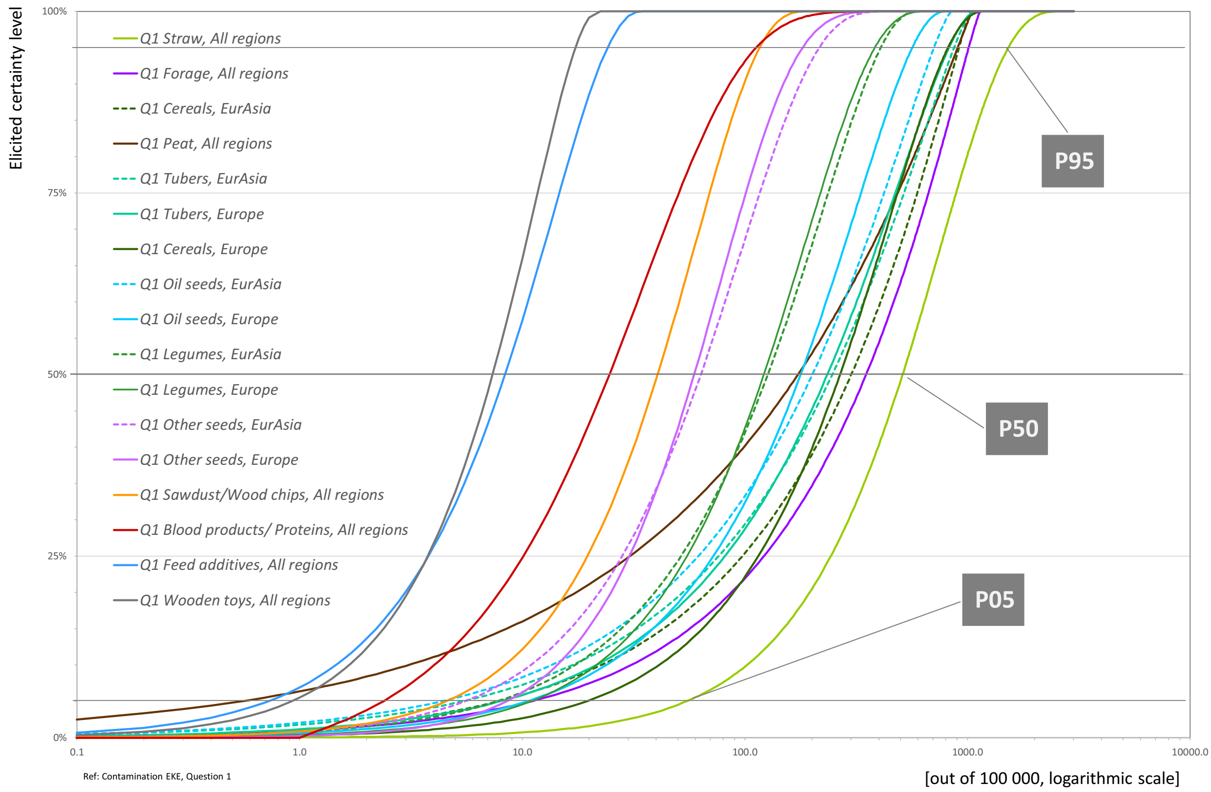

Figure 3: Cumulative distribution function (CDF) of the likelihood of the number of consignments out of 100,000 of a product to contain infectious ASFV at the place of production in an ASF-affected area (products in the legend are sorted from highest (top) to lowest (bottom) estimate). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicates the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

3.2.2.2. Proportion of farm deliveries of products containing infectious ASFV at the place of primary production that still contain infectious ASFV at the point of usage on pig farms in the non-affected area of the EU

According to the results of the EKE, the proportions of products that still contain infectious ASFV at the point of usage were highest in the group 'Other seed, fruits and their by-products', legume seeds, their products and by-products or cereals grains (Table 15, Figure 4). Saw dust/wood chips and wooden toys were estimated to have the lowest likelihood of containing ASFV at the point of usage.

Other seed, fruits and their by-products, for example acorn and chestnuts, as well as legume seeds, their products and by-products are expected to be used within a short timeframe after harvesting and delivery to farms. Most often, no processing steps between harvest and feeding are carried out.

Longer storage of cereal grains and drying at ambient and high temperatures is expected to result in lower probabilities of ASFV survival to the point of usage. For Eurasia, traders have large storage capacity and the shipment distance/duration is larger.

Table 15: Estimates for the proportion of farm deliveries of a specified product containing ASFV at the place of primary production that still contain infectious ASFV at the point of usage in the non-affected area of the EU

Parameter	Proportion of farm deliveries of a specified product containing ASFV at the place of primary production that still contain infectious ASFV at the point of usage in the non-affected area of the EU	
	EU Median estimate (90% probability interval)	Eurasia Median estimate (90% probability interval)
	[out of 100,000]	[out of 100,000]
Cereal grains, their products and by-products	**90.0** (3.95–371)	**77.6** (1.95–275)
	At small-scale farms Median estimate (90% probability interval)	At large-scale farms Median estimate (90% probability interval)
	[out of 100,000]	[out of 100,000]
Hydrolysed protein	**11.9** (0.0913–46.5)	
Blood products, spray-dried plasma	**10.8** (0.208–42.5)	
Legume seeds, their products and by-products	**110** (3.46–421)	**63.3** (2.01–254)
Oil seeds, oil fruits, their products and by-products	**8.53** (0.232–37.6)	
Tubers, roots, their products and by-products	**30.3** (1.45–175)	**7.48** (0.65–30.5)
Other seeds, fruits, their products and by-products	**201** (10.5–663)	
Forages and roughage	**27.0** (2.11–81.1)	
Straw	**77.6** (1.95–275)	
Sawdust/Woodchips	**3.90** (0.54–8.82)	
Peat/Turf	**20.0** (0.39–71.3)	
Wooden toys	**3.02** (0.08–9.25)	

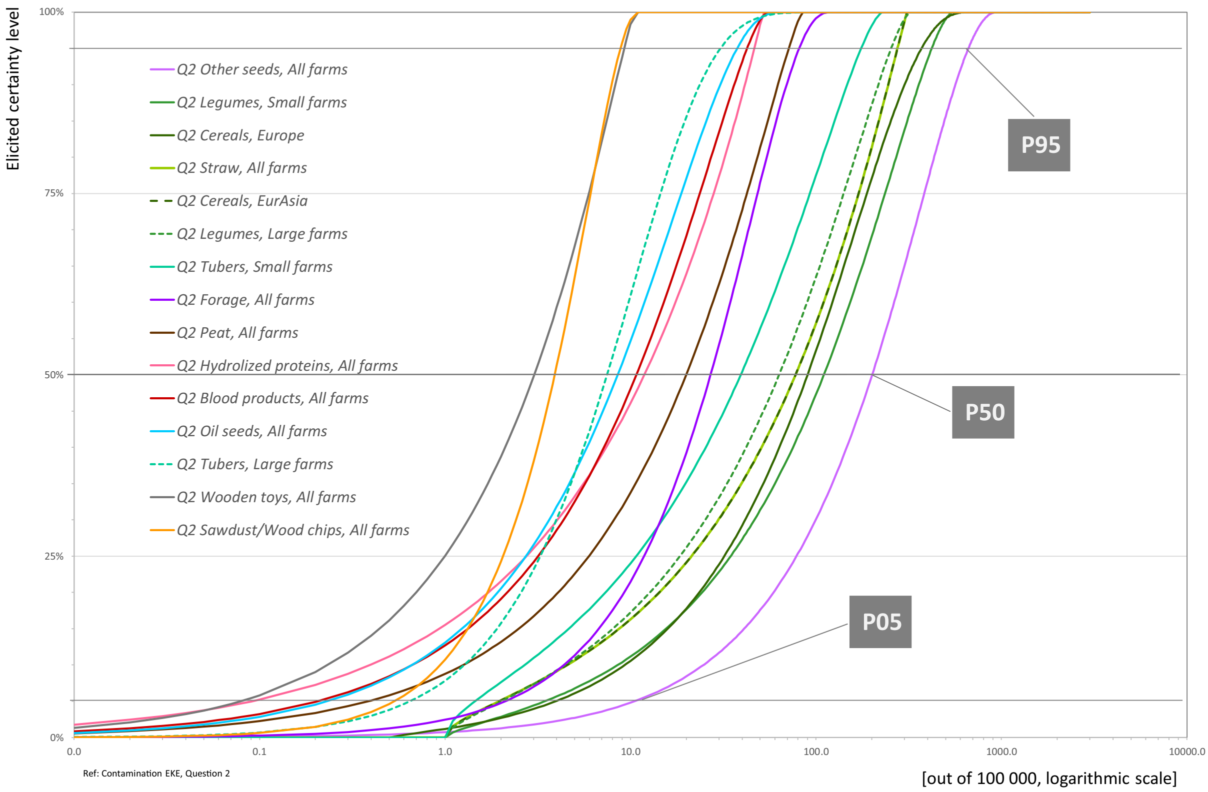

Figure 4: Cumulative distribution function (CDF) of the likelihood of the number of consignments out of 100,000 of a specified product containing ASFV at the place of primary production that still contain infectious ASFV at the point of usage in the non-affected area of the EU (products in the legend are sorted from highest (top) to lowest (bottom) estimate). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

3.2.2.3. Proportion of farm deliveries of products containing material from affected areas and containing infectious ASFV at the point of usage on pig farms in the non-affected area of the EU

The proportions of minerals and feed additives, mash/concentrate and pelleted feed that still contain infectious ASFV at the point of usage were estimated combining the first two steps that were estimated for feed products and bedding material ($P_{\text{Product contains ASFV at origin}}$; $P_{\text{ASFV in product survives handling}}$) into one step ($P_{\text{Product contains ASFV at usage}}$) (Table 16, Figure 5).

Table 16: Estimates for the proportion of farm deliveries of a specified product containing material from affected areas and containing infectious ASFV at the point of usage in the non-affected area of the EU

Parameter	Proportion of farm deliveries of a specified product containing material from affected areas and containing infectious ASFV at the point of usage in the non-affected area of the EU	
	At small-scale farms Median estimate (90% probability interval)	At large-scale farms Median estimate (90% probability interval)
	[out of 100,000]	[out of 100,000]
Minerals and Feed additives	**14.0** (1.30–40.0)	
Mash/Concentrate	**6.45** (0.568–19.8)	
Pellets	**2.35** (0.0791–8.27)	

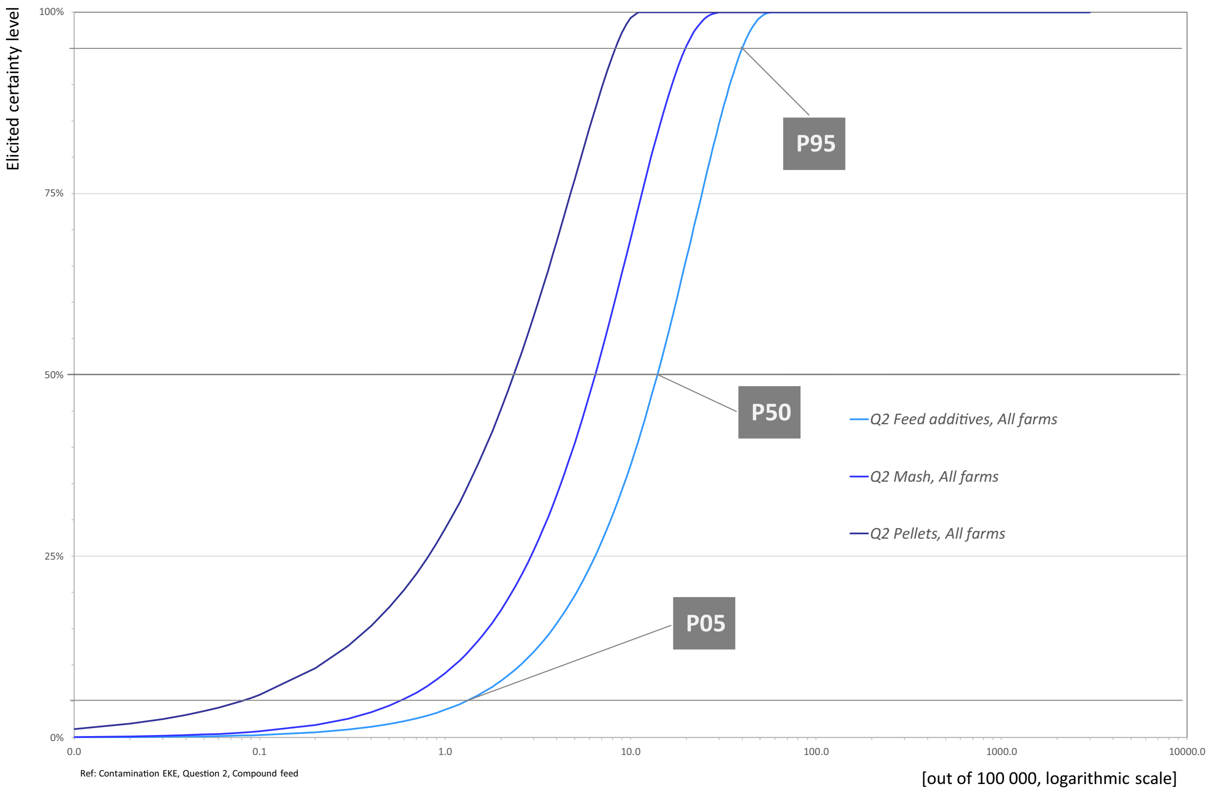

Figure 5: Cumulative distribution function (CDF) of the likelihood of the number of consignments out of 100,000 of compound feed (mash, pellets of complete feed, feed additives) containing any material from affected areas and containing infectious ASFV at the point of usage in the non-affected area of the EU (products in the legend are sorted from highest (top) to lowest (bottom) estimate). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

3.2.2.4. Proportion of farm deliveries of products which contain at least one infectious dose sufficient to cause an infection of at least one pig on the farm in the non-affected area of the EU

For large-scale farms, the probability of the presence of at least one infectious dose at the time of usage was estimated to be highest for cereal grains and oil seeds/oil fruits (Table 17, Figure 6). For small farms, the probability of the presence of at least one infectious dose at the time of usage was estimated to be highest for tubers/roots, cereal grains and oil seed/oil fruits (Table 17, Figure 7).

Both cereal grains and oil seeds/oil fruits can be used in liquid feeding. The EKE experts considered that the proportion of farm deliveries of these products containing at least one infectious dose is higher due to a lower infectious dose needed for liquid feed compared to dry feed. In small farms, a proportion of tubers/roots are fed fresh relatively soon after harvesting and can be contaminated. Potatoes will typically be cooked before feeding, but the experts judged that in the process, there is a potential for recontamination of the cooked tubers.

Table 17: Estimates for the proportion of farm deliveries of a contaminated consignment of a product from affected areas which contain at least one infectious dose sufficient to cause an infection of at least one pig on the farm of a specified size in the non-affected area of the EU

Parameter	Proportion of farm deliveries of a contaminated consignment of a product from affected areas which contain at least one infectious dose sufficient to cause an infection of at least one pig on the farm of a specified size in the non-affected area of the EU	
	Small-scale farms Median estimate (90% probability interval)	Large-scale farms Median estimate (90% probability interval)
	[%, out of 100]	[%, out of 100]
Hydrolysed protein	**5.73** (0.4–13.7)	
Blood products, spray-dried plasma		
Cereal grains, their products and by-products	**17.5** (5.22–46.0)	**20.2** (6.39–42.9)
Legume seeds, their products and by-products	**10.5** (1.27–28.1)	**10.1** (2.27–21.7)
Oil seeds, oil fruits, their products and by-products	**19.5** (2.83–44.2)	**16.2** (2.87–34.8)
Tubers, roots, their products and by-products	**25.9** (4.49–51.9)	**5.13** (0.99–12.2)
Other seeds, fruits, their products and by-products	**5.34** (1.27–13.1)	
Forages and roughage	**4.21** (0.3–9.38)	
Minerals and Feed additives	**4.20** (0.31–9.42)	**6.15** (0.55–13.8)
Mash/Concentrate	**5.34** (1.27–13.1)	**8.88** (1.77–17.9)
Pellets	**3.47** (0.35–8.70)	
Straw	**6.26** (0.55–17.1)	**4.31** (0.29–12.6)
Sawdust/Woodchips	**2.84** (0.11–7.44)	
Peat/Turf	**5.13** (0.24–16.9)	
Wooden toys	**11.0** (0.55–27.9)	

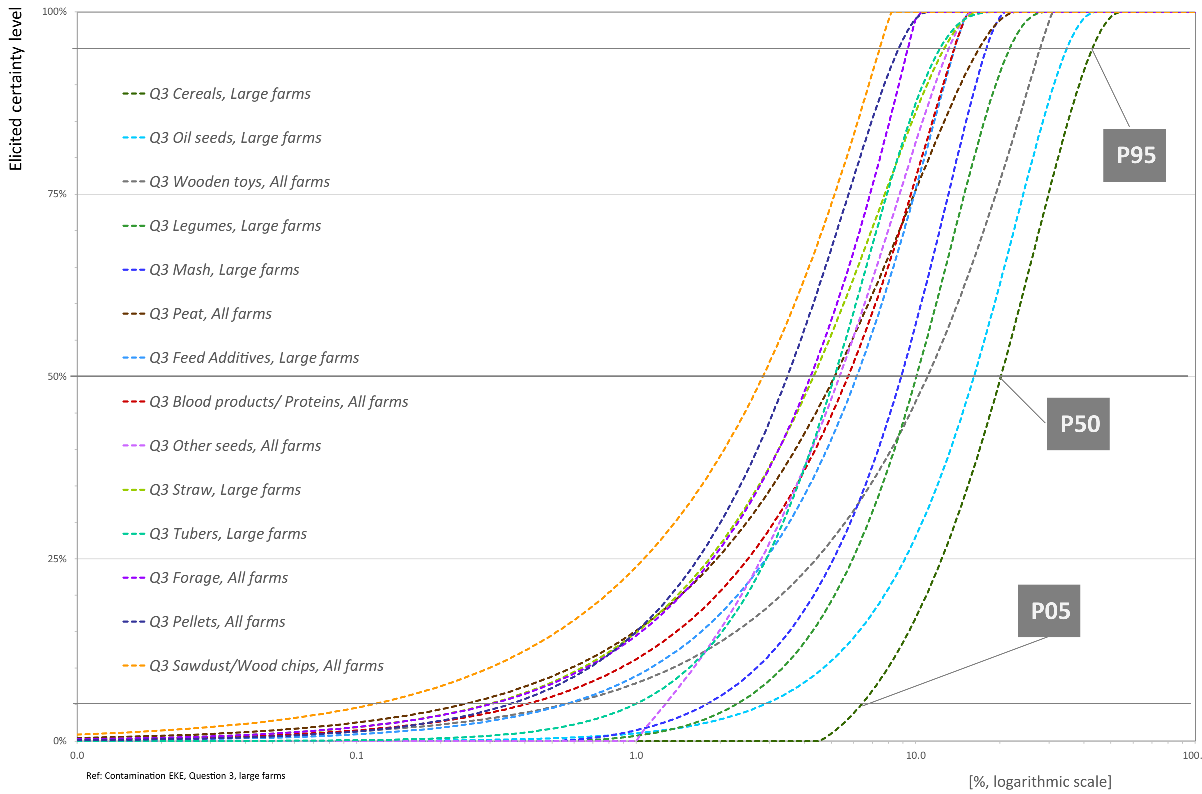

Figure 6: Cumulative distribution function (CDF) of the proportion of consignments at farm (out of 100), which contain at least one infectious dose sufficient to cause an infection of at least one pig on the farm (Large farms/all farms) (products in the legend are sorted from highest (top) to lowest (bottom) estimate). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

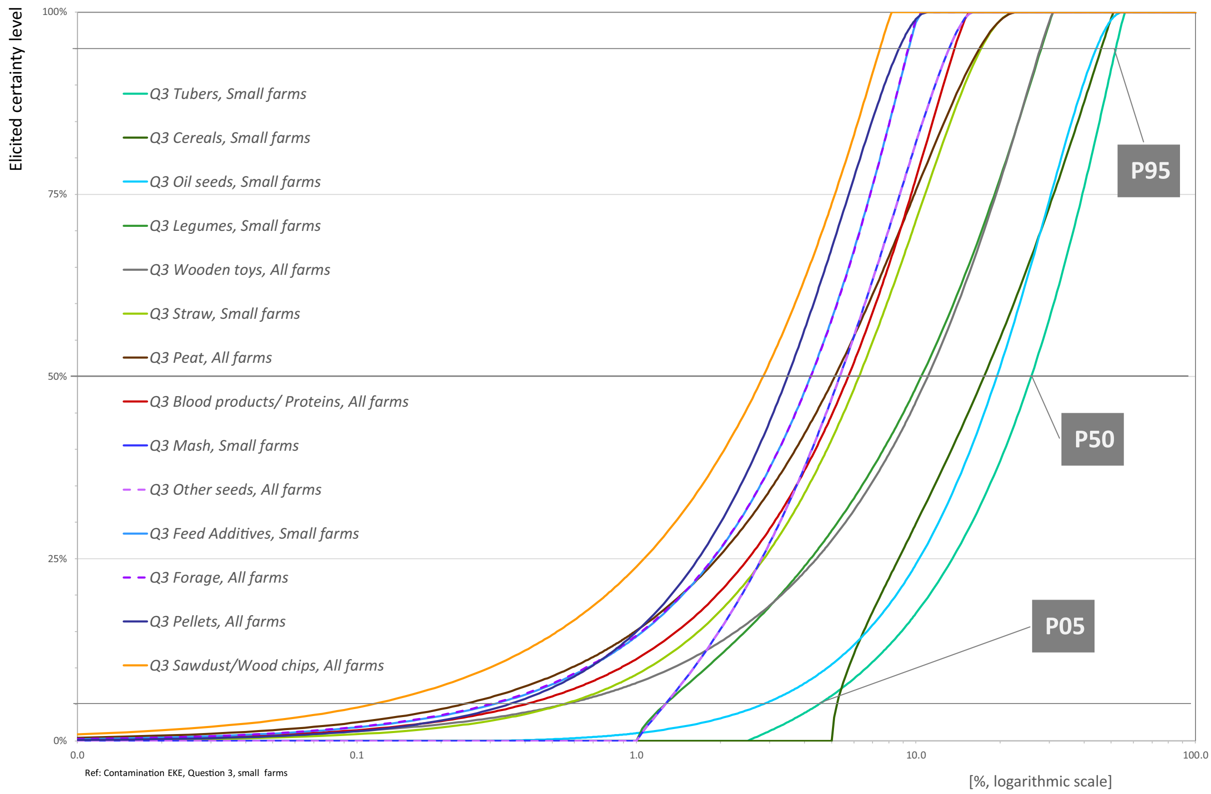

Figure 7: Cumulative distribution function (CDF) of the proportion of consignments at farm (out of 100), which contain at least one infectious dose sufficient to cause an infection of at least one pig on the farm (Small farms/all farms) (products in the legend are sorted from highest (top) to lowest (bottom) estimate). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

For further details on the results of the Contamination EKE the reader is referred to Annex 2 in section 7.2 and the EKE report (EFSA, 2021b).

3.3. Results of the Trade EKE

3.3.1. Empty vehicles for pig transport returning from affected areas to the non-affected area of the EU

For empty farm vehicles, the EKE estimated a far higher number of empty vehicles returning from affected areas in the EU than from Eurasia. Fattening and slaughter pigs are moved in large numbers from some large pig producing countries to others, e.g. from Denmark or The Netherlands to Germany, Poland and Romania. Where this transport does occur, the experts considered it would involve mainly large-scale farms, not small-scale farms.

3.3.1.1. Number of empty vehicles returning from affected areas in the EU or Eurasia to the non-affected area of the EU in the coming 12 months

It was estimated that empty vehicles (which are a proxy for contaminated equipment) returning to the non-affected area of the EU from an affected area would mostly be EU transports rather than Eurasian. This is based on the trade/movements of live pigs from non-affected area of the EU that mainly target affected areas of the EU and only to a small degree affected areas in Eurasia. The experts estimated that approximately 37,000 (median) empty vehicles used for live pig transport returning from affected areas in the EU would enter the non-affected areas of the EU (90% probability interval 21,015–65,600) compared to only 306 (median) vehicles returning from affected areas in Eurasia (90% probability interval 138–499).

3.3.1.2. Proportion of empty vehicles entering the non-affected area of the EU going to small-scale farms

The experts estimated that 43.6% (median) of vehicles returning from delivering pigs to ASF-affected areas would drive to small-scale pig farms in the non-affected areas of the EU; however, the 90% probability interval was between 15.8% and 66.8%, and the experts estimated a high uncertainty related to these estimates.

3.3.1.3. Average number of farms reached with a single vehicle for loading

Empty vehicles returning from affected areas to small farms are estimated to have contact to more farms (median 3.00, 90% probability interval 1.18–4.82) before the next unloading, cleaning and disinfection, than empty vehicles returning to large farms (median 1.73, 90% probability interval 1.03–2.84). However, also these estimates were encumbered with a high or very high uncertainty.

3.3.2. Feed products and bedding/enrichment material

3.3.2.1. Number of consignments entering the non-affected area of the EU from affected areas in the coming 12 months

This first step elicited the number of consignments of a specified product that may enter the non-affected area of the EU from (or with ingredients from) affected areas in the coming 12 months. Consignments of cereal grains, their products and by-products and compound feed were estimated to be the highest traded/purchased commodities destined for pig farms. The other feed ingredients were estimated to only constitute a small number of consignments, relatively speaking (Table 18, Figure 8).

The EKE experts reasoned that untreated blood products would rarely be used in commercial pig farms and most blood from slaughterhouses would go for rendering. Although some EU countries still produce such products, of these countries only Poland is in the affected area of the EU and it was considered very unlikely that pigs slaughtered from small-scale farms would be part of the production, bearing in mind that large-scale commercial farms are rarely affected by ASF in the current epidemic. In addition, EU rules prevent the commerce of such products from slaughterhouses in the restriction zones.

For cereals, it was considered that a large proportion of grains harvested will be used as animal feed and will go directly to a farm. The rest will be used in the production of compound feed. Cereal grains would be transported mostly by ship and in high volumes and could be produced both in Eurasia and in the EU. Many small farms were considered to produce their own cereal grains or to use compound feed rather than commercial grains. For the larger commercial farms, it is quite possible for one lorry to deliver a full consignment to only one farm. For larger shipping containers, these are more likely to be delivered to feed merchants and then distributed.

For oil seeds such as rape seed or soya, large quantities are imported from USA and Brazil (non-affected areas) for cattle feed, while the experts considered the trade from affected Eurasian countries was still considerable and higher than for oil seeds produced in the EU.

Forages and roughage, tubers, other seeds and fruits were estimated not to be traded/moved in high volumes or used on large-scale farms, except for organic farms. For the small-scale farms, these products were considered to be more likely sourced locally rather than bought as large consignments. While it was considered that commercial farms may also use these feed matrices, experts felt they would be processed prior to their introduction to the farm.

The EKE experts estimated that pelleted compound feed as well as minerals, feed additives, mash compound and concentrate feed are by far the most commonly traded products with imported/traded ingredients and are used on all pig farms, regardless of their size.

Straw for bedding was estimated to be only used locally and rarely purchased and transported from affected areas in Eurasia to non-affected areas in the EU. The majority of consignments would be destined for large farms, but these would still be in relatively low numbers (Table 18, Figure 8).

Table 18: Estimates for the number of consignments of a specified product that enter the non-affected area of the EU (or with ingredients from) from affected areas in the coming 12 months

Parameter	Number of consignments of a specified product that enters the non-affected area of the EU from (or with ingredients from) affected areas in the coming 12 months	
	EU Median estimate (90% probability interval)	Eurasia Median estimate (90% probability interval)
	[–]	[–]
Blood products, spray-dried plasma	**63.0** (19.7–157)	ne
Cereal grains, their products and by-products	**111,690** (23,346–388,343)	**6,947** (2,332–15,362)
Oil seeds, oil fruits, their products and by-products	**4,987** (568–9,568)	**16,751** (2,928–38,409)
Forages and roughage	**103** (30.7–514)	**27.4** (6.09–81)
Complete feed – Pellets	**2,519,794** (768,186–6,457,492)	ne
Straw	**395** (52.4–941)	**5.21** (0.54–19.9)

Grey cells: not estimated (ne).

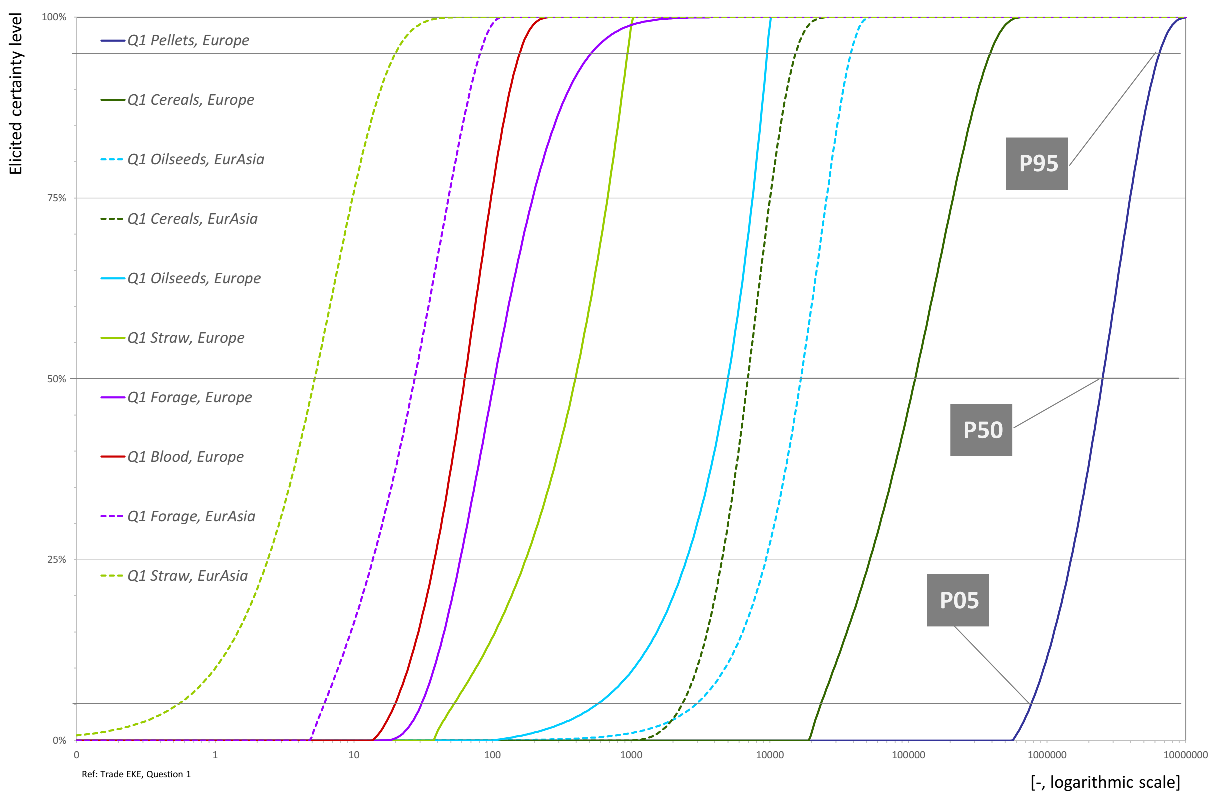

Figure 8: Cumulative distribution function (CDF) of the estimated number of consignments of a specified product that may enter the non-affected area of the EU (or with ingredients) from affected areas in the coming 12 months). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

3.3.2.2. Proportion of consignments entering the non-affected area of the EU that will be used in small-scale pig farms

In the second step, the proportion of consignments of a specified product from ASF-affected areas entering the non-affected areas of the EU that will be used by small-scale pig farms was elicited.

The EKE experts estimated that the proportion of traded/moved feed or bedding material components that enter small-scale farms was substantially lower for all products assessed compared to the proportion entering large-scale pig farms. The highest percentage was estimated for compound feed at a median of 5.81% (Table 19, Figure 9). All other commodities were estimated to be used at less than 5% on small-scale pig farms.

Table 19: Estimates for the percentage of consignments of a specified product entering the non-affected area of the EU that will be used in small-scale pig farms

Parameter	Percentage of consignments of a specified product entering the non-affected area of the EU that will be used in small-scale pig farms
	Median estimate (90% probability interval)
	[%]
Cereal grains, their products and by-products	**1.41** (0.01–7.92)
Oil seeds, oil fruits, their products and by-products	**0.1** (0.02–0.54)
Forages and roughage	**0.499** (0.050–0.96)
Complete feed – Pellets	**5.81** (2.82–12.3)
Straw	**1.95** (0.29–4.42)

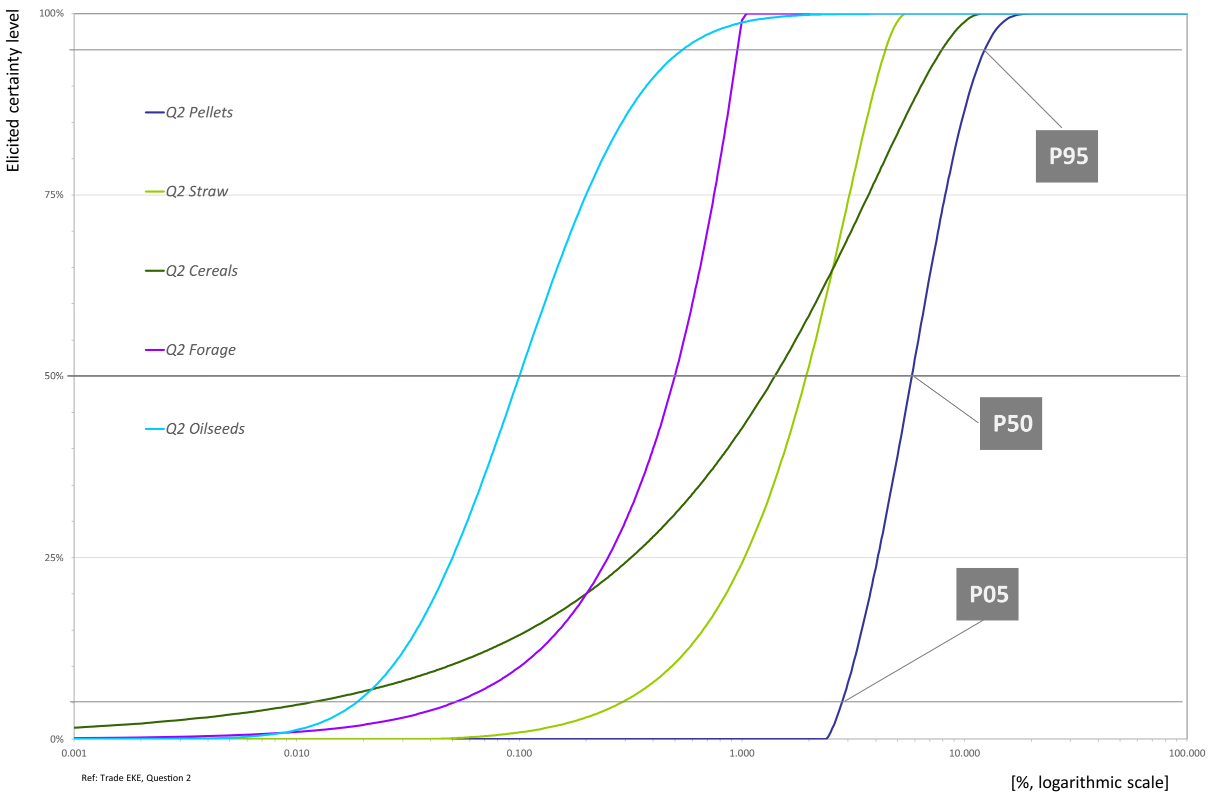

Figure 9: Cumulative distribution function (CDF) of the percentage of consignments of a specified product from ASF-affected areas entering the non-affected areas of the EU that will be used by small-scale pig farms) (The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%)

3.3.2.3. Average number of farms receiving a delivery that contains material from one consignment

In the third step, the average number of small- and large-scale farms that receive a delivery that contains material from a single consignment of a specified product that enters the non-affected area of the EU from an affected area in the EU or in Eurasia was elicited.

The EKE experts estimated that the average number of farms receiving a delivery from a single consignment was significantly higher for small farms than for large farms (Table 20, Figure 10). The discussion around the estimation indicated that not only will large-scale farms import multiple consignments of a single commodity, but also that the small-scale farms may not use a whole consignment, but may in fact share it with other local farms through a feed distributor.

Table 20: Estimates for the average number of small-and large-scale farms that receive a delivery that contains material from a single consignment of a specified product that enters the non-affected area of the EU from an affected area

Parameter	Average number of small-and large-scale farms that receive a delivery that contains material from a single consignment of a specified product that enters the non-affected area of the EU from an affected area	
	Small-scale farm Median estimate (90% probability interval)	Large-scale farm Median estimate (90% probability interval)
	[–]	[–]
Cereal grains, their products and by-products	**707** (103–3,984)	**84.1** (6.03–188)
Oil seeds, oil fruits, their products and by-products	**214** (17.2–654)	
Complete feed – Pellets	**182** (24.4–744)	**10.5** (1.52–37.0)
Straw	**51.7** (1.57–183)	**1.60** (1.02–2.85)

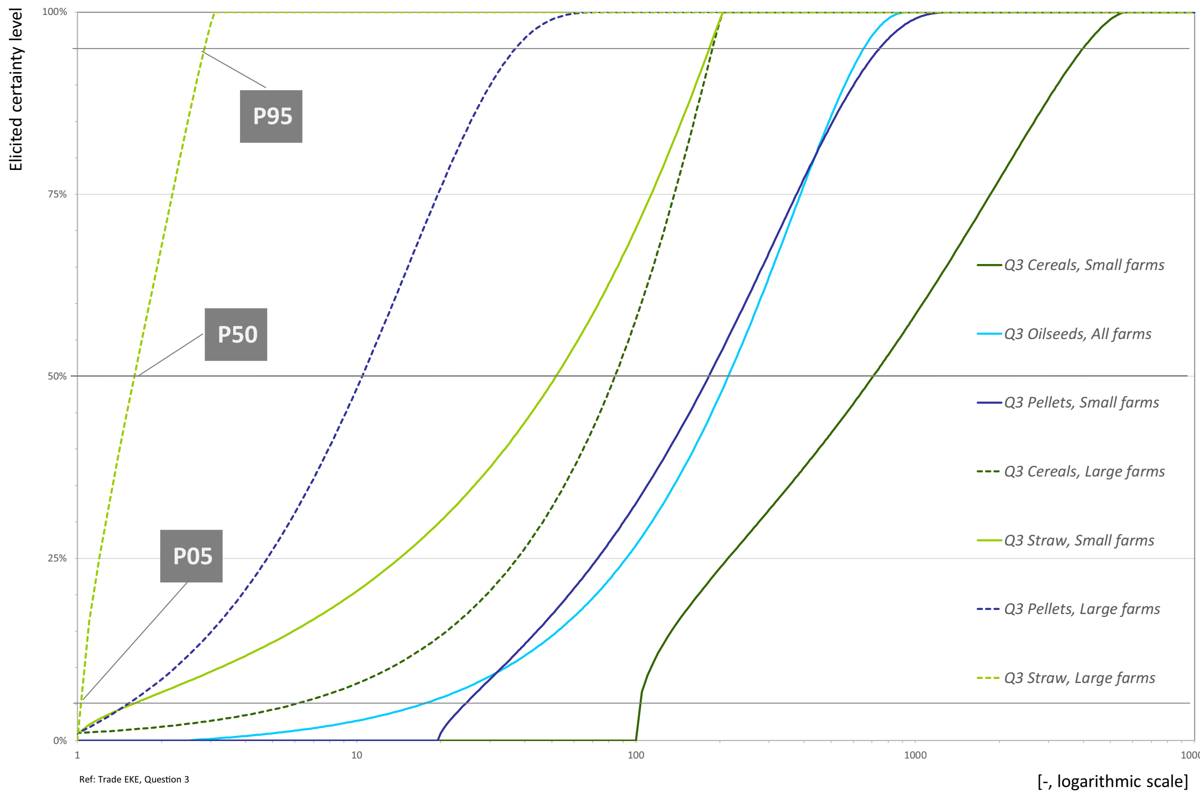

Figure 10: Cumulative distribution function (CDF) of the average number of small- and large-scale farms that receive a delivery that contains material from a single consignment of a specified product, j, entering the non-affected area of the EU from a specified affected area. The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

For further details on the results of the Trade EKE the reader is referred to Annex 2 in Section 7.2 and the EKE report (EFSA, 2021b).

3.4. Results of the Farm exposure EKE

3.4.1. Empty vehicles for pig transport returning from affected areas to the non-affected area of the EU

3.4.1.1. Proportion of empty vehicles for pig transport containing infectious ASFV after unloading in the affected area that still contain infectious ASFV at the point of loading (usage) on a farm in the non-affected area of the EU and that transfer infectious ASFV to at least one pig on the farm

The original model parameter 'Proportion of farm deliveries of a specified product to pig herds that will have contact with pigs' is equal to one for all feed and bedding material. The remaining evaluation handles empty vehicles for pig transport that have become contaminated with infectious ASFV at the place of unloading in the affected areas, still contain infectious ASFV at the point of loading (usage) on a farm in the non-affected area of the EU and transfer infectious ASFV to at least one pig on the farm.

It is estimated that of the empty vehicles used for pig transport, which have been contaminated with infectious ASFV in affected areas and are still contaminated with infectious ASFV after cleaning, disinfection and travel to the non-affected area, 57% (90% probability interval 26–86%) will transfer infectious virus to at least one pig on a small farm at the next loading. For large farms, this proportion is estimated to be 30% (90% probability interval 12–54%). The higher estimate for small-scale farms results from the consideration that not many small farms apply an 'all in-all out'-system and can therefore frequently receive vehicles delivering animals.

For further details on the results of the Farm Exposure EKE the reader is referred to Annex 2 in Section 7.2 and the EKE report (EFSA, 2021b).

3.4.2. Feed products and bedding or enrichment material

3.4.2.1. Proportion of pig farms with multiple animal species

If farms have multiple animal species, the probability that farm deliveries not primarily traded/purchased as pig feed are also used for pig feeding increases. Small farms were estimated to have higher probabilities of having other livestock species present on the farm (median 64%, 90% probability interval 23–93%) than large-scale farms (median 39%, 90% probability interval 13–63%).

3.4.2.2. Average number of other animal species than pigs

To adjust for farm deliveries, which were not traded/purchased as pig feed, but fed/provided to pigs, a correction factor has been included in the model ($1 + P_{multiple\ species} \times N_{fed\ species,\ product}$) with the average number of livestock species (other than pigs), which are fed/provided with the specified product. For small-scale farms, the products that were estimated to be fed/provided to the highest number of other species were forages and roughage (fed to 2.89 (1.25–3.96) other species) and straw (provided to 2.50 (1.37–3.63) other species). For large-scale farms, the products that were estimated to be fed or provided to the highest number of other species were straw (provided to 2.07 (0.62–3.77) other species) and cereal grains and their products/by-products (fed to 2.06 (0.80–3.53) other species). For both farm types, the products that were estimated to be fed/provided to the lowest number of other species were hydrolysed proteins and wooden toys (Table 21, Figure 11, Figure 12).

Table 21: Estimate of the average number of animal species other than pigs that are fed or provided with each of the products

Parameter	Average number of animal species (other than pigs), which are fed or provided with different products	
	Small-scale farms Median estimate (90% probability interval)	Large-scale farms Median estimate (90% probability interval)
Products:	[–]	[–]
Hydrolysed proteins	**0.76** (0.1–1.72)	**0.60** (0.07–1.60)
Blood products, spray dried plasma	**1.00** (0.10–1.91)	**1.42** (0.64–2.27)
Cereal grains, their products and by-products	**2.26** (0.61–3.72)	**2.06** (0.80–3.53)
Legume seeds, their products and by-products	**2.00** (0.87–3.13)	**1.81** (0.66–3.22)
Oil seeds, oil fruits, their products and by-products	**1.53** (0.15–3.61)	**1.47** (0.19–3.17)
Tubers, roots, their products and by-products	**2.00** (0.20–3.82)	**1.75** (0.30–3.25)
Other seeds, fruits and their by-products	**1.57** (0.15–3.30)	**1.46** (0.22–2.43)
Forages and roughage	**2.89** (1.25–3.96)	**2.00** (0.87–3.13)
Feed additives, premix	**0**	**0**
Mash	**0**	**0**
Pellets	**0**	**0**
Straw	**2.50** (1.37–3.63)	**2.07** (0.62–3.77)
Sawdust/woodchips	**2.07** (0.62–3.77)	**1.70** (0.35–2.89)
Turf	**1.43** (0.27–2.72)	**1.43** (0.27–2.72)
Enrichment/wooden toys	**0.80** (0.18–1.40)	**0.54** (0.06–1.30)

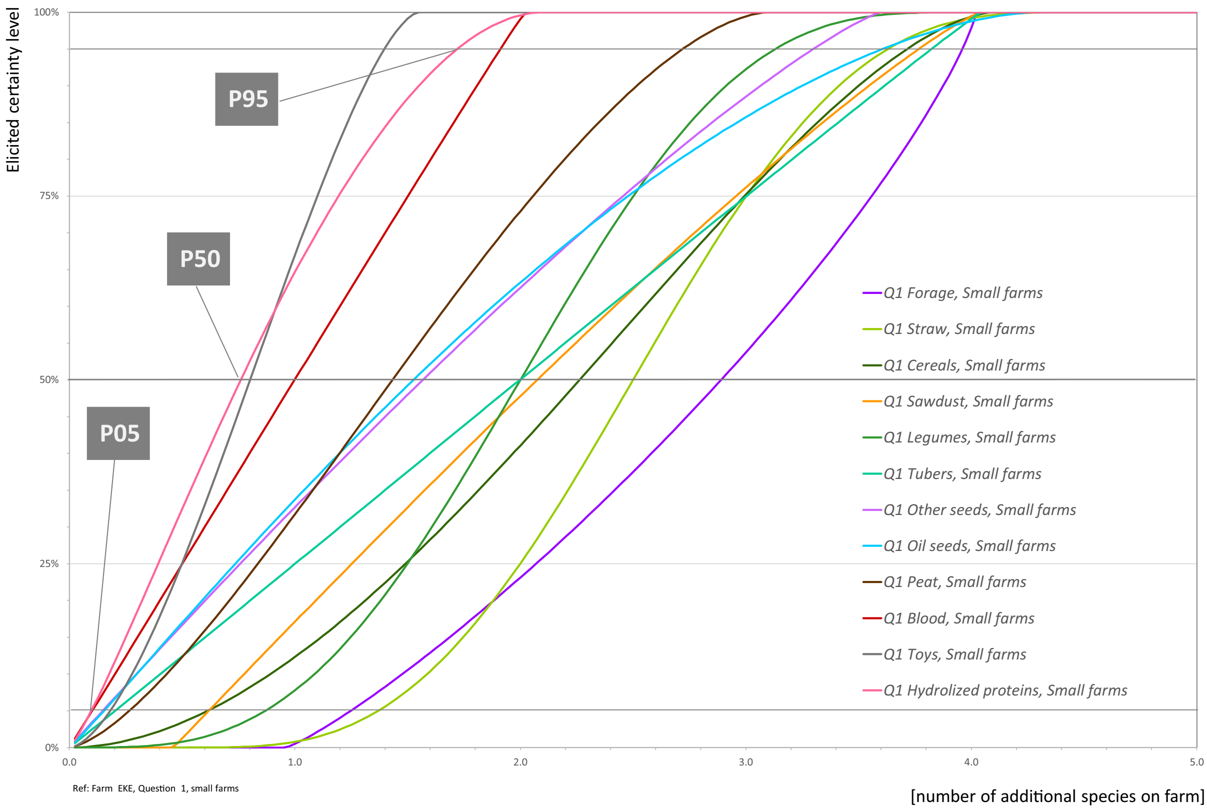

Figure 11: Cumulative distribution function (CDF) of the average number of animal species (other than pigs) on small-scale pig farms, which are fed with specified products (products in the legend are sorted from highest (top) to lowest (bottom) estimate)). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

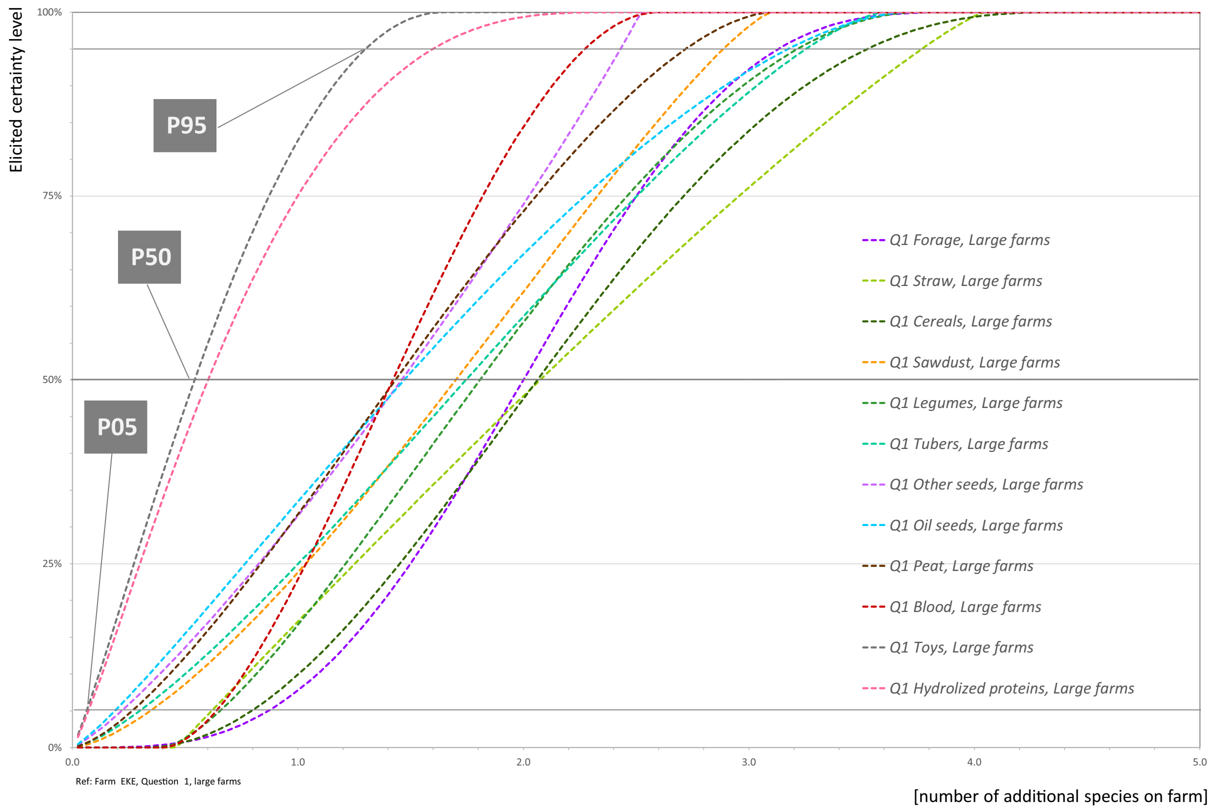

Figure 12: Cumulative distribution function (CDF) of the average number of animal species (other than pigs) on large-scale pig farms, which are fed with specified products (products in the legend are sorted from highest (top) to lowest (bottom) estimate). The horizontal values at the intersections (P50) of the curves with the line at certainty level 50% indicate the median estimates, while the 90% uncertainty range is given by the horizontal values (P05, P95) at certainly levels 5% and 95%

3.5. Results from Modelling

3.5.1. Likelihood that a single farm delivery of a product will contain a dose of infectious ASFV, which is large enough to cause an infection in at least one pig on the farm

In order to calculate the likelihood that one farm delivery of a feeding product or bedding material leads to an infection of at least one pig on the farm (i.e. the component q in the model equation), the following probabilities were combined for feed products, bedding materials, compound feed and empty vehicles used for pig transport returning from affected areas:

Single feeding products/bedding material:

$$q = P_{\text{Product contains ASFV at origin}} \times P_{\text{ASFV in product survives handling}} \times P_{\text{Dose in product leads to infection}} \times P_{\text{Transfer to pigs}}$$
$$(P_{\text{Transfer to pigs}} = 1)$$

Compound feed:

$$q = P_{\text{Product contains ASFV at usage}} \times P_{\text{Dose in product leads to infection}} \times P_{\text{Transfer to pigs}}$$
$$(P_{\text{Transfer to pigs}} = 1)$$

Empty vehicles (infections on farm):

$$q = P_{\text{Vehicle contains ASFV at unloading}} \times P_{\text{ASFV in vehicle survives handling}} \times P_{\text{Empty vehicles come into contact with pigs}} \times P_{\text{Dose in empty vehicles leads to infection}}$$

Empty vehicles (infections on lorry):

$$q = P_{\text{Vehicle contains ASFV at unloading}} \times P_{\text{ASFV in vehicle survives handling}} \times P_{\text{Dose in empty vehicles leads to infection}}$$

The results of these calculations expressed as the likelihood of an infection (likelihood that a product/vehicle gets contaminated with ASFV, the virus survives handling and transport, and that the virus dose is sufficiently high to infect at least one pig at the time of use as well as the average number of deliveries needed to potentially infect a pig farm (=number-needed-to-deliver)) are shown for small-scale farms (< 100 pigs/< 50 breeding sows) in Table 22 and for large-scale farms (> 99 pigs/ > 49 breeding sows) in Table 23.

For small-scale farms, among products originating from EU as well as from Eurasia, feed additives and mash compound feed were estimated to have by far the highest likelihood of containing infectious ASFV at the time of use. The likelihood of a vehicle entering these small farms being contaminated with infectious ASFV was calculated to be nearly as high as the likelihood estimated for mash. The assessed likelihood of vehicles being contaminated was similar whether the truck had unloaded pigs in Eurasia or the EU. Pelleted compound feed, cereals, straw and tubers were computed to have a much lower relative risk than additives and mash feed, while the likelihood of hydrolysed proteins, blood products, saw dust and wooden toys were all calculated to have a very small likelihood of contamination with infectious ASFV at large enough doses to infect at least one pig at the time of use (Figure 13).

For large-scale farms, among products originating from the EU as well as from Eurasia, feed additives and mash feed were also computed to have by far the highest likelihood of containing infectious ASFV at the time of use. The calculated likelihood of a vehicle entering large farms and being contaminated with infectious ASFV at large enough doses to infect at least one pig was not as high as for the small-scale farms and ranged at the same level as pelleted compound feed, cereals and straw. The likelihood of tubers was also lower than for small-scale farms as these will be processed (involving blanching and dehydration) prior to feeding and are therefore less likely to be contaminated. For large-scale farms, hydrolysed proteins, blood products, saw dust and wooden toys were calculated to have a very small likelihood of contamination with infectious ASFV at large enough doses to infect at least one pig at the time of use.

Table 22: Likelihood (q, see Figure 1) that a farm delivery of a product contains a dose large enough to cause an infection of at least one pig on a small-scale farm and number-needed-to-deliver to potentially infect at least one pig farm

Product	Origin from the EU						Origin from Eurasia					
	Likelihood (q)			Number-Needed-to-Deliver			Likelihood (q)			Number-Needed-to-Deliver		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit	[ppm]			[–]			[ppm]			[–]		
Hydrolysed proteins	**0.0008**	0.000003	0.0178	**1,186,823,243**	56,074,582	288,972,542,613	**0.0008**	0.000004	0.0176	**1,183,789,273**	56,821,767	266,111,249,981
Blood products	**0.0008**	0.000007	0.0155	**1,226,404,372**	64,494,449	153,052,874,557	**0.0008**	0.000007	0.0157	**1,220,204,493**	63,874,330	148,664,586,390
Cereals	**0.2861**	0.005727	3.6764	**3,495,314**	272,008	174,615,878	**0.2275**	0.002387	3.5054	**4,395,422**	285,274	418,959,821
Legumes	**0.0792**	0.001362	1.2249	**12,632,841**	816,381	734,383,315	**0.0785**	0.001113	1.3107	**12,734,283**	762,936	898,443,211
Oil seeds	**0.0169**	0.000176	0.2523	**59,338,512**	3,963,131	5,693,080,262	**0.0175**	0.000102	0.3091	**57,254,029**	3,235,377	9,834,068,929
Tubers	**0.1267**	0.001707	2.1806	**7,890,000**	458,587	585,782,165	**0.1291**	0.001224	2.3238	**7,746,214**	430,329	816,909,005
Other seeds	**0.0442**	0.001331	0.4431	**22,636,902**	2,256,964	751,079,662	**0.0461**	0.001006	0.5157	**21,692,986**	1,939,133	994,055,663
Forage	**0.0206**	0.000199	0.2615	**48,641,007**	3,823,382	5,023,311,746	**0.0204**	0.000204	0.2596	**48,970,862**	3,851,993	4,904,621,931
Additives	**4.4692**	0.162191	24.2084	**223,756**	41,308	6,165,568	**4.4295**	0.157267	24.4633	**225,762**	40,878	6,358,611
Mash	**2.8744**	0.210195	15.5656	**347,898**	64,244	4,757,484	**2.8975**	0.206567	15.7449	**345,124**	63,513	4,841,040
Pellets	**0.6129**	0.012188	4.3026	**1,631,536**	232,416	82,049,707	**0.6084**	0.012565	4.3345	**1,643,587**	230,705	79,585,817
Straw	**0.1342**	0.002076	1.9929	**7,450,407**	501,786	481,588,941	**0.1365**	0.001912	1.9966	**7,324,539**	500,850	522,963,295
Sawdust	**0.0003**	0.000005	0.0026	**3,756,942,566**	384,330,649	211,294,865,499	**0.0003**	0.000005	0.0026	**3,762,631,815**	381,737,938	206,683,958,742
Peat	**0.0067**	0.000006	0.2476	**148,410,299**	4,038,743	166,343,813,701	**0.0067**	0.000006	0.2503	**148,959,596**	3,995,728	162,889,998,683
Wooden toys	**0.0001**	0.000001	0.0016	**7,960,541,963**	644,044,413	852,387,847,821	**0.0001**	0.000001	0.0016	**7,861,695,042**	640,790,712	911,338,177,904
Empty vehicles (on Farm)	**1.5380**	0.050540	18.6908	**650,182**	53,502	19,786,212	**1.5609**	0.047895	18.4916	**640,641**	54,078	20,878,937
Empty vehicles (on Lorry)	**2.9375**	0.100662	32.3183	**340,422**	30,942	9,934,237	**2.9692**	0.094951	32.0912	**336,794**	31,161	10,531,751

Table 23: Likelihood (q, see Figure 1) that a farm delivery of a product contains a dose large enough to cause an infection of at least one pig on a large-scale farm and number-needed-to-deliver to potentially infect at least one pig farm

Product	Origin from the EU						Origin from Eurasia					
	Likelihood			Number-Needed-to-Deliver			Likelihood			Number-Needed-to-Deliver		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit	[ppm]			[–]			[ppm]			[–]		
Hydrolysed proteins	**0.0009**	0.000004	0.0177	**1,174,886,531**	56,489,928	272,474,469,428	**0.0009**	0.000004	0.0176	**1,168,553,170**	56,950,006	281,762,333,117
Blood products	**0.0008**	0.000007	0.0157	**1,210,640,276**	63,884,662	145,969,035,518	**0.0008**	0.000007	0.0156	**1,211,052,802**	63,908,867	148,125,479,047
Cereals	**0.3336**	0.006662	3.6708	**2,997,207**	272,417	150,115,714	**0.2609**	0.002945	3.5873	**3,833,304**	278,762	339,608,392
Legumes	**0.0484**	0.000985	0.6225	**20,679,459**	1,606,343	1,015,473,196	**0.0479**	0.000856	0.6441	**20,869,122**	1,552,575	1,168,086,575
Oil seeds	**0.0145**	0.000150	0.2037	**68,796,588**	4,908,495	6,678,557,152	**0.0147**	0.000091	0.2573	**68,216,412**	3,886,377	11,029,816,643
Tubers	**0.0059**	0.000090	0.0774	**170,076,233**	12,921,458	11,166,990,374	**0.0059**	0.000071	0.0798	**168,309,095**	12,535,586	14,070,676,920
Other seeds	**0.0443**	0.001336	0.4413	**22,591,384**	2,265,875	748,579,670	**0.0457**	0.001012	0.5193	**21,892,801**	1,925,809	988,324,077
Forage	**0.0201**	0.000206	0.2596	**49,635,878**	3,851,485	4,848,220,482	**0.0202**	0.000206	0.2610	**49,563,782**	3,831,024	4,848,962,170
Additives	**6.5823**	0.269277	35.1547	**151,923**	28,446	3,713,651	**6.6392**	0.278246	35.2298	**150,620**	28,385	3,593,942
Mash	**4.7144**	0.308048	22.7966	**212,115**	43,866	3,246,244	**4.6896**	0.319434	22.7732	**213,236**	43,911	3,130,540
Pellets	**0.6102**	0.012361	4.3356	**1,638,907**	230,649	80,900,270	**0.6116**	0.012654	4.3088	**1,635,137**	232,083	79,027,395
Straw	**0.1348**	0.002010	1.9962	**7,416,832**	500,951	497,488,111	**0.1363**	0.001918	2.0047	**7,335,972**	498,821	521,391,708
Sawdust	**0.0003**	0.000005	0.0026	**3,749,394,115**	382,394,807	211,227,295,760	**0.0003**	0.000005	0.0026	**3,761,780,627**	391,862,991	207,714,239,140
Peat	**0.0068**	0.000006	0.2464	**146,304,754**	4,058,832	166,652,380,780	**0.0068**	0.000006	0.2448	**146,790,522**	4,085,003	164,657,063,568
Wooden toys	**0.0001**	0.000001	0.0015	**7,891,579,297**	653,388,170	882,901,470,981	**0.0001**	0.000001	0.0015	**7,887,045,980**	649,075,106	913,143,287,919
Empty vehicles (on Farm)	**0.2388**	0.007185	2.5971	**4,187,010**	385,039	139,170,181	**0.2359**	0.007446	2.6422	**4,238,759**	378,469	134,291,628
Empty vehicles (on Lorry)	**0.8651**	0.027504	8.2525	**1,155,878**	121,175	36,358,781	**0.8574**	0.028089	8.2318	**1,166,345**	121,480	35,600,962

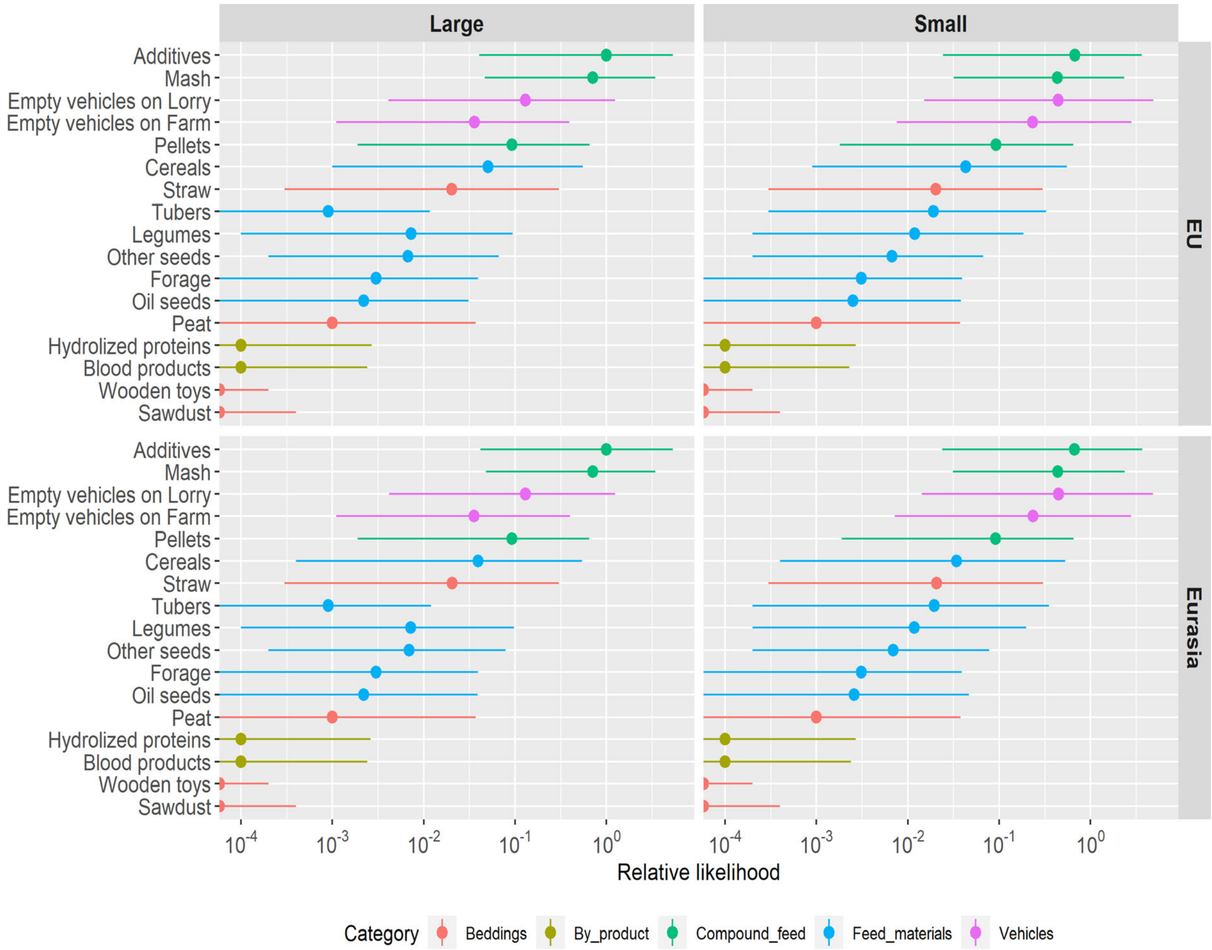

Figure 13: Ranking of products based on the likelihood of a farm delivery of a product to contain a dose of infectious ASFV large enough to cause an infection of at least one pig at the farm (q, see Figure 1) relative to the maximum value observed (feed additives from the EU/Eurasia) (The values are standardised to the maximal value of products and strata (100%) and the products are ordered by the maximal value of the strata of the specific product). Products to which this pathway does not apply are shown without relative values

3.5.2. Modelled number of potentially infected pig farms in non-affected areas of the EU

In the second step, the number of farm deliveries of a product from an affected area in the EU or Eurasia going to the non-affected areas of the EU was calculated. For this calculation, the following estimates were combined for feed deliveries and empty vehicles for pig transport:

Feed deliveries to small-scale farms: $N = N_{\text{Consignments of product}} \times r_{\text{small farms}} \times N_{\text{Farm deliveries per consignment}}$

Feed deliveries to large-scale farms: $N = N_{\text{Consignments of product}} \times (1 - r_{\text{small farms}}) \times N_{\text{Farm deliveries per consignment}}$

Empty vehicles loading on small-scale farms: $N = N_{\text{Empty vehicles}} \times r_{\text{small farms}} \times N_{\text{Farms per return}}$

Empty vehicles loading on large-scale farms: $N = N_{\text{Empty vehicles}} \times (1 - r_{\text{small farms}}) \times N_{\text{Farms per return}}$

For small- as well as large-scale farms, pelleted compound feed is by far the product traded or moved in the largest quantities within the EU (with ingredients from affected to non-affected areas). For large-scale farms, cereals moved or traded from affected areas in the EU come second in terms of the quantities, while nearly the same amounts of mashed compound feed are moved to/traded to small- and large-scale farms. Feed additives are also moved in large quantities with ingredients from affected to non-affected areas of the EU and used in both small- and large-scale farms, while legumes are used in much larger quantities in large-scale farms. The numbers of vehicles arriving at small-scale farms, after unloading in affected areas within the EU, are higher than the numbers of vehicles arriving at large-scale farms. From affected areas in Eurasia, oil seeds are the most often imported product reaching non-affected areas of the EU, followed by cereals. For both farm types, the values for compound feed from affected areas in Eurasia, be it in the form of pellets or mash, and for feed additives were 0. The values for hydrolysed proteins and blood products were 0, as these products are not delivered to farms, but to the feed industry (Table 24, Figure 14).

Table 24: Number of farm deliveries of a product from affected areas of the EU and Eurasia, going to non-affected areas of the EU (N, see Figure 1)

Product	Origin from the EU						Origin from Eurasia					
	Small-scale farm			Large-scale farms			Small-scale farm			Large-scale farms		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
		[–]			[–]			[–]			[–]	
Hydrolysed proteins	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**
Blood products	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**
Cereals	**740,299**	4,672	20,585,027	**7,260,086**	439,195	43,768,824	**47,767**	323	1,047,141	**493,394**	32,927	1,894,483
Legumes	**127,677**	796	3,445,878	**1,233,539**	74,963	7,450,500	**8,031**	55	179,053	**84,248**	5,668	320,276
Oil seeds	**738**	27	8,811	**808,119**	40,204	4,226,727	**2,702**	109	32,326	**2,929,852**	163,010	15,436,190

Product	Origin from the EU						Origin from Eurasia					
	Small-scale farm			Large-scale farms			Small-scale farm			Large-scale farms		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Tubers	**17,402**	109	477,314	**170,659**	10,050	1,025,318	**1,112**	8	24,652	**11,558**	788	44,037
Other seeds	**28,290**	185	783,716	**279,387**	16,844	1,705,583	**1,853**	12	41,310	**19,061**	1,276	72,664
Forage	**0.448**	0.0413	2.92	**103**	30.5	511	**0.109**	0.00904	0.524	**27.3**	6.06	80.8
Additives	**1,005,455**	99,949	7,560,241	**942,179**	112,956	5,207,146	**na**	**na**	**na**	**na**	**na**	**na**
Mash	**4,736,790**	472,605	35,022,987	**4,406,131**	527,569	24,480,201	**na**	**na**	**na**	**na**	**na**	**na**
Pellets	**23,861,877**	2,414,126	176,853,685	**22,393,558**	2,694,456	124,001,696	**na**	**na**	**na**	**na**	**na**	**na**
Straw	**219**	5.31	2,719	**608**	81.5	1,913	**3.10**	0.0591	44.5	**8**	1	36
Sawdust	**3.36**	0.0824	41.1	**9.29**	1.25	29.2	**0.0473**	0.000929	0.659	**0.125**	0.0122	0.555
Peat	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0
Wooden toys	**0.778**	0.0185	9.37	**2.14**	0.284	6.69	**0.0108**	0.000215	0.155	**0.0287**	0.00279	0.127
Empty vehicles	**42,323**	11,123	118,496	**35,044**	13,908	86,550	**329**	84	953	**277**	99	690

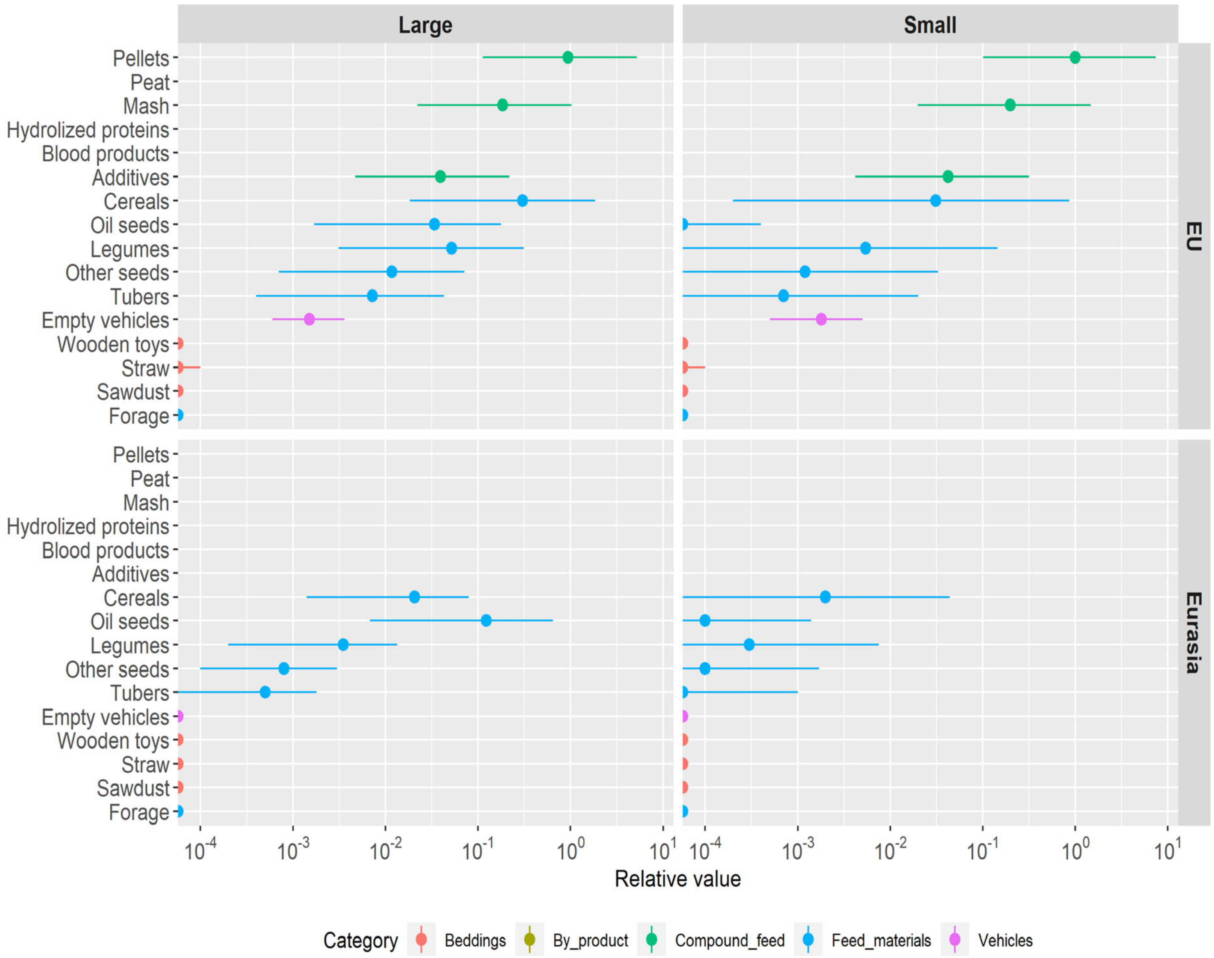

Figure 14: Ranking of products based on the number of farm deliveries of a product coming from affected areas of the EU and Eurasia, going to non-affected areas of the EU (N, see Figure 1) (the values are standardised to the maximal value of products and strata (pellets from Europe to large-/small-scale farms) (100%) and the products are ordered by the maximal value of the strata of the specific product). Products to which this pathway does not apply are shown without relative values

The modelled number of potentially infected pig farms in the non-affected area of the EU in the coming 12 months as well as the expected number of years until a first potential infection of a pig farm were calculated for the different products, combining q and N.

Based on this calculation, the highest ranking products for small-scale farms were mash, feed additives and cereals from affected areas in the EU and compound feed pellets from affected areas in the EU and oils seeds from affected areas in the EU or Eurasia for large-scale farms. As feed additives and mash feed were both computed to have the highest likelihood of containing infectious ASFV at the time of use in a dose sufficiently high to infect at least one pig, and as these products were also traded or moved in high amounts between affected and non-affected areas within the EU, these two products were computed to be able to cause the highest modelled number of potentially infected pig farms among the assessed products. Furthermore, despite the likelihood of pelleted compound feed containing infectious ASFV at the time of use being computed to be lower, the large quantities of this product traded led to as many modelled numbers of potentially infected pig farms for this product as for compound feed in the form of mash. Cereals and empty vehicles returning from non-affected EU areas rank highest for small-scale farms, while all products from Eurasia were calculated to cause much fewer modelled numbers of potentially infected pig farms (Table 25).

In large-scale farms, mash and pelleted compound feed as well as feed additives from affected areas in the EU were calculated to be able to cause the highest modelled number of potentially infected pig farms among the assessed products. Cereals and legumes from affected areas of the EU have a 10- or 100-fold lower relative likelihood, respectively, while empty vehicles returning from affected EU areas have a 1000-fold lower relative likelihood for large-scale farms. From Eurasia, cereals and oil seeds were calculated to cause the highest modelled number of potentially infected large-scale farms (Table 26).

Table 25: Modelled number of potentially infected pig farms in the non-affected areas of Europe in the coming 12 months (N × q, see Figure 1) caused by deliveries to small-scale farms, also expressed as number of expected years until a first potential infection of a pig farm

Product	Origin from Europe						Origin from EurAsia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit	[–]			[y]			[–]			[y]		
Hydrolysed proteins	**na**	na	na	na	na	na	**na**	na	na	na	na	na
Blood products	**na**	na	na	na	na	na	**na**	na	na	na	na	na
Cereals	**0.163**	0.0003	14.5	**6**	0.1	2,921	**0.008**	1×10^{-05}	0.739	**129**	1	$8.3 \times 10^{+04}$
Legumes	**0.0077**	2×10^{-05}	0.776	**130**	1	66,020	$\mathbf{4.8 \times 10^{-04}}$	9×10^{-07}	0.044	**2,065**	23	$1 \times 10^{+06}$
Oil seeds	$\mathbf{1 \times 10^{-05}}$	5×10^{-08}	5.2×10^{-04}	$\mathbf{1 \times 10^{+05}}$	1,907	$2 \times 10^{+07}$	$\mathbf{4 \times 10^{-05}}$	1×10^{-07}	0.002	$\mathbf{2.7 \times 10^{+04}}$	450	$9 \times 10^{+06}$
Tubers	**0.0017**	3×10^{-06}	0.193	**598**	5	$4 \times 10^{+05}$	$\mathbf{1.1 \times 10^{-04}}$	1×10^{-07}	0.011	**9,408**	92	$7 \times 10^{+06}$
Other seeds	**0.0010**	2×10^{-06}	0.074	**970**	14	$4 \times 10^{+05}$	$\mathbf{7 \times 10^{-05}}$	1×10^{-07}	0.0046	$\mathbf{1.5 \times 10^{+04}}$	219	$7 \times 10^{+06}$
Forage	$\mathbf{8 \times 10^{-09}}$	5×10^{-11}	2×10^{-07}	$\mathbf{1 \times 10^{+08}}$	$4 \times 10^{+06}$	$2 \times 10^{+10}$	$\mathbf{2 \times 10^{-09}}$	1×10^{-11}	5×10^{-08}	$\mathbf{6 \times 10^{+08}}$	$2 \times 10^{+07}$	$9 \times 10^{+10}$
Additives	**3.761**	0.078	65.3	**0.3**	0.02	13	**na**	na	na	na	na	na

Product	Origin from Europe						Origin from EurAsia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Mash	**12.1**	0.421	198	**0.1**	0.01	2	**na**	na	na	na	na	na
Pellets	**12.0**	0.158	256	**0.1**	0.00	6	**na**	na	na	na	na	na
Straw	**2×10^{-05}**	1×10^{-07}	0.001	**$4.6 \times 10^{+04}$**	751	$9 \times 10^{+06}$	**3×10^{-07}**	1×10^{-09}	2×10^{-05}	**$3 \times 10^{+06}$**	$4.9 \times 10^{+04}$	8 × 10+08
Sawdust	**7×10^{-10}**	4×10^{-12}	3×10^{-08}	**$2 \times 10^{+09}$**	$3 \times 10^{+07}$	$2 \times 10^{+11}$	**9×10^{-12}**	5×10^{-14}	4×10^{-10}	**$1 \times 10^{+11}$**	$2 \times 10^{+09}$	$2 \times 10^{+13}$
Peat	**na**	na	na	na	na	na	**na**	na	na	na	na	na
Wooden toys	**7×10^{-11}**	2×10^{-13}	3.87×10^{-09}	**$1 \times 10^{+10}$**	$3 \times 10^{+08}$	$4 \times 10^{+12}$	**1×10^{-12}**	3×10^{-15}	6×10^{-11}	**$1 \times 10^{+12}$**	$2 \times 10^{+10}$	$3 \times 10^{+14}$
Empty vehicles (on Farm)	**0.0604**	0.00160	0.998	**16.6**	1.00	626	**4.7×10^{-04}**	1×10^{-05}	0.0076	**2108**	131	$8.3 \times 10^{+04}$

Table 26: Modelled number of potentially infected pig farms in the non-affected areas of Europe in the coming 12 months (N × q, see Figure 1) caused by deliveries to large-scale farms, also expressed as number of expected years until a first potential infection of a pig farm

Product	Origin from Europe						Origin from EurAsia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit	[–]			[y]			[–]			[y]		
Hydrolysed proteins	**na**	na	na	na	na	na	**na**	na	na	na	na	na
Blood products	**na**	na	na	na	na	na	**na**	na	na	na	na	na
Cereals	**1.99**	0.020	51.2	**0.5**	0.02	49	**0.098**	6.1×10^{-04}	2.59	**10**	0.4	1,650
Legumes	**0.050**	4.9×10^{-04}	1.43	**20**	0.7	2,043	**0.0031**	3×10^{-05}	0.078	**320**	13	$3.3 \times 10^{+04}$
Oil seeds	**0.0088**	5×10^{-05}	0.282	**113**	4	$2.0 \times 10^{+04}$	**0.033**	1.2×10^{-04}	1.25	**30**	0.8	8,291
Tubers	**8.2×10^{-04}**	6×10^{-06}	0.025	**1,216**	41	$2 \times 10^{+05}$	**5×10^{-05}**	3×10^{-07}	0.0013	**$1.9 \times 10^{+04}$**	748	$3 \times 10^{+06}$
Other seeds	**0.010**	1.4×10^{-04}	0.243	**96**	4	7,313	**6.8×10^{-04}**	8×10^{-06}	0.015	**1,477**	68.4	$1 \times 10^{+05}$
Forage	**2×10^{-06}**	2×10^{-08}	4×10^{-05}	**$5 \times 10^{+05}$**	$2.30 \times 10^{+04}$	$5 \times 10^{+07}$	**5×10^{-07}**	4×10^{-09}	9×10^{-06}	**$2 \times 10^{+06}$**	$1 \times 10^{+05}$	$2 \times 10^{+08}$

Product	Origin from Europe						Origin from EurAsia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Additives	**5.27**	0.140	72.4	**0.2**	0.01	7	**na**	na	na	na	na	na
Mash	**18.0**	0.676	224	**0.06**	0.004	1	**na**	na	na	na	na	na
Pellets	**11.4**	0.165	195	**0.09**	0.005	6	**na**	na	na	na	na	na
Straw	$\mathbf{7 \times 10^{-05}}$	7×10^{-07}	0.0015	$\mathbf{1.5 \times 10^{+04}}$	650	$1 \times 10^{+06}$	$\mathbf{9 \times 10^{-07}}$	9×10^{-09}	2×10^{-05}	$\mathbf{1 \times 10^{+06}}$	$4 \times 10^{+04}$	$1 \times 10^{+08}$
Sawdust	$\mathbf{2 \times 10^{-09}}$	3×10^{-11}	3×10^{-08}	$\mathbf{5 \times 10^{+08}}$	$3.12 \times 10^{+07}$	$4 \times 10^{+10}$	$\mathbf{3 \times 10^{-11}}$	3×10^{-13}	5×10^{-10}	$\mathbf{4 \times 10^{+10}}$	$2 \times 10^{+09}$	$3 \times 10^{+12}$
Peat	**na**	na	na				**na**	na	na			
Wooden toys	$\mathbf{2 \times 10^{-10}}$	2×10^{-12}	4×10^{-09}	$\mathbf{5 \times 10^{+09}}$	$2.31 \times 10^{+08}$	$6 \times 10^{+11}$	$\mathbf{3 \times 10^{-12}}$	2×10^{-14}	7×10^{-11}	$\mathbf{3 \times 10^{+11}}$	$1 \times 10^{+10}$	$5 \times 10^{+13}$
Empty vehicles (on Farm)	**0.0081**	2.3×10^{-04}	0.109	**123**	9.1	4399	$\mathbf{6 \times 10^{-05}}$	2×10^{-06}	9×10^{-04}	$\mathbf{1.6 \times 10^{+04}}$	1147	$6 \times 10^{+05}$

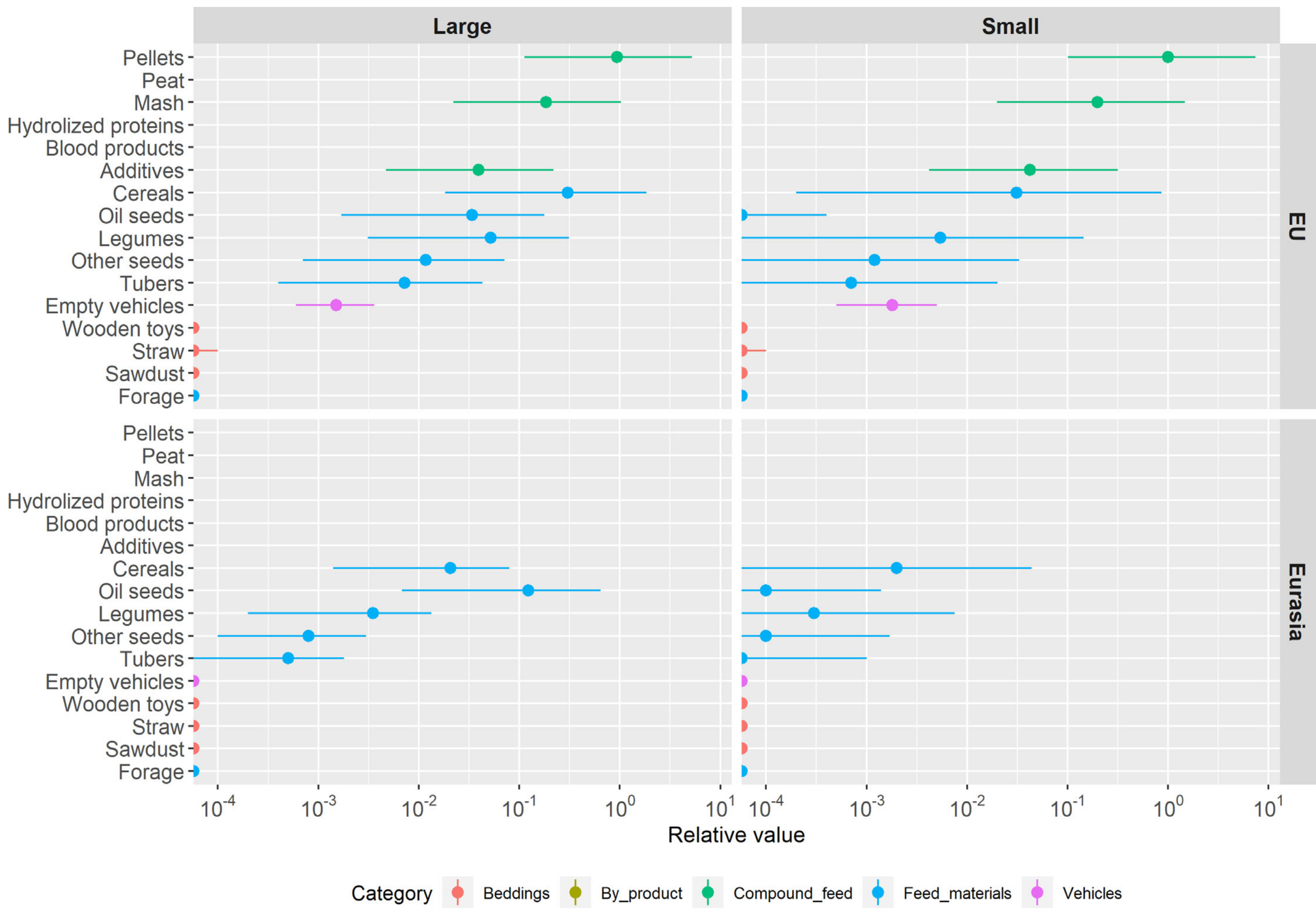

Figure 15: Ranking of products based on the modelled number of potentially infected pig farms in the non-affected areas of the EU caused by deliveries of the product in the coming 12 months (N × q, see Figure 1) (the values are standardised to the maximal value of products and strata (mash from the EU for large-scale farms) (100%) and the products are ordered by the maximal value of the strata of the specific product). Products to which this pathway does not apply are shown without relative values

3.5.3. Effect of multiple species on farms on the modelled number of potentially infected pig farms in the non-affected areas of the EU

In the third step, the number of farm deliveries for a given product was adjusted for the number of multiple species on the farms, as some of the material intended for other livestock species present on a farm may also be fed to pigs. The following formula was used:

$$N \times (1 + P_{\text{multiple species}} \times N_{\text{fed add. species}})$$

The correction increased the volumes of farm deliveries of a product coming from affected areas of the EU and Eurasia going to non-affected areas of the EU and expected to be used for pigs (Table 27), as well as the modelled number of potentially infected pig farms in the non-affected areas of the EU in the coming 12 months caused by farm deliveries of a given product (Tables 28 and 29). The correction for multispecies use of products did not change the top ranking of products according to the modelled number of potentially infected pig farms in the non-affected areas of the EU caused by deliveries of the product in the coming 12 months. The highest ranking products were still mash and pellets from affected areas of the EU, as well as feed additives and cereals from affected areas of the EU delivered to small-scale farms. Wooden toys and sawdust still ranked lowest. However, despite the ranking of the modelled number of potentially infected pig farms from the products not changing, the modelled number of potentially infected pig farms caused by cereals and vehicles increased by approximately a factor of two, and for vehicles to large farms by a factor of three.

Table 27: Number of farm deliveries of a product coming from affected areas of the EU and Eurasia going to non-affected areas of the EU, considering that some deliveries mainly intended for use by other animal species are also used for pig feeding ($N \times (1 + P_{\text{multiple species}} \times N_{\text{fed add. species}})$)

Product	Origin from the EU						Origin from Eurasia					
	Small-scale farm			Large-scale farms			Small-scale farm			Large-scale farms		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit	[–]			[–]			[–]			[–]		
Hydrolysed proteins	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0
Blood products	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0
Cereals	**1,657,349**	10,072	48,360,407	**12,655,793**	748,156	80,817,520	**106,510**	713	2,484,413	**858,191**	56,594	3,556,459
Legumes	**272,940**	1,686	7,600,892	**2,040,741**	121,454	13,074,927	**17,280**	112	395,518	**138,676**	9,218	570,504
Oil seeds	**1,380**	48	17,985	**1,236,989**	60,872	6,872,868	**5,058**	193	65,139	**4,454,277**	242,497	25,186,453
Tubers	**35,933**	225	1,053,584	**274,182**	15,944	1,765,401	**2,292**	16	54,493	**18,520**	1,262	77,139
Other seeds	**53,057**	331	1,549,616	**418,305**	25,042	2,687,928	**3,467**	22	82,332	**28,388**	1,903	116,510
Forage	**1.16**	0.1009	8.12	**179**	49.7	931	**0.280**	0.0221	1.48	**46.5**	10.2	150
Additives	**1,005,455**	99,949	7,560,241	**942,179**	112,956	5,207,146	**0**	0	0	**0**	0	0
Mash	**4,736,790**	472,605	35,022,987	**4,406,131**	527,569	24,480,201	**0**	0	0	**0**	0	0
Pellets	**23,861,877**	2,414,126	176,853,685	**22,393,558**	2,694,456	124,001,696	**0**	0	0	**0**	0	0

Product	Origin from the EU						Origin from Eurasia					
	Small-scale farm			Large-scale farms			Small-scale farm			Large-scale farms		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Straw	**534**	12.7	6,945	**1,044**	136	3,646	**7.54**	0.143	114	**14**	1	68
Sawdust	**7.29**	0.172	94.7	**14.6**	1.92	49.5	**0.102**	0.00195	1.53	**0.197**	0.0191	0.933
Peat	**0**	0	0	**0**	0	0	**0**	0	0	**0**	0	0
Wooden toys	**1.14**	0.0265	14.0	**2.58**	0.344	8.33	**0.0159**	0.000309	0.231	**0.0347**	0.00337	0.158
Empty vehicles	**42,323**	11,123	118,496	**35,044**	13,908	86,550	**329**	84	953	**277**	99	690

Table 28: Modelled number potentially infected small-scale pig farms in the non-affected areas of the EU in the coming 12 months as absolute number and as expected years until a first potential infection of a pig farm, considering that some deliveries mainly intended for use by other animal species are also used for pig feeding ($N \times (1 + P_{\text{multiple species}} \times N_{\text{fed add. species}}) \times q$)

Product	Origin from the EU						Origin from Eurasia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit	[–]			[y]			[–]			[y]		
Hydrolysed proteins	**0**	0	0				**0**	0	0			
Blood products	**0**	0	0				**0**	0	0			
Cereals	**0.367**	0.000746	34.4	**2.72**	**0.0290**	**1,341**	**0.0175**	0.0000265	1.74	**57.3**	**0.574**	**37,743**
Legumes	**0.0166**	0.0000324	1.73	**60.2**	**0.579**	**30,823**	**0.00105**	0.00000190	0.0963	**953**	**10.4**	**527,293**
Oil seeds	**1.86×10^{-5}**	8.24×10^{-8}	1.05×10^{-3}	**5.38×10^{4}**	**9.52×10^{2}**	**1.21×10^{7}**	**7.04×10^{-5}**	2.09×10^{-7}	4.37×10^{-3}	**1.42×10^{4}**	**2.29×10^{2}**	**4.79×10^{6}**
Tubers	**0.00349**	0.00000514	0.403	**287**	**2.48**	**194,454**	**0.000219**	0.000000286	0.0242	**4,568**	**41.3**	**3,502,488**
Other seeds	**0.00193**	0.00000453	0.144	**518**	**6.93**	**220,814**	**0.000123**	0.000000272	0.00901	**8,124**	**111**	**3,670,628**
Forage	**2.03×10^{-8}**	1.21×10^{-10}	6.12×10^{-7}	**4.93×10^{7}**	**1.63×10^{6}**	**8.28×10^{9}**	**4.60×10^{-9}**	2.88×10^{-11}	1.28×10^{-7}	**2.18×10^{8}**	**7.83×10^{6}**	**3.47×10^{10}**

Product	Origin from the EU						Origin from Eurasia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Additives	**3.76**	0.0783	65.3	**0.266**	**0.015**	**12.8**	**0**	0	0			
Mash	**12.1**	0.421	198	**0.0830**	**0.00506**	**2.37**	**0**	0	0			
Pellets	**12.0**	0.158	256	**0.0833**	**0.00391**	**6.33**	**0**	0	0			
Straw	**5.38×10^{-5}**	2.64×10^{-7}	3.30×10^{-3}	**1.86 x10^{4}**	**3.03 x10^{2}**	**3.79 x10^{6}**	**7.58×10^{-7}**	3.17×10^{-9}	5.17×10^{-5}	**1.32 x10^{6}**	**1.94 x10^{4}**	**3.15 x10^{8}**
Sawdust	**1.44×10^{-9}**	8.65×10^{-12}	6.54×10^{-8}	**6.94 x10^{8}**	**1.53 x10^{7}**	**1.16 x10^{11}**	**2.02 x10^{11}**	9.85×10^{-14}	1.02×10^{-9}	**4.94 x10^{10}**	**9.80 x10^{8}**	**1.01 x10^{13}**
Peat	**0**	0	0				**0**	0	0			
Wooden toys	**1.01×10^{-10}**	3.42×10^{-13}	5.81×10^{-9}	**9.87 x10^{9}**	**1.72 x10^{8}**	**2.93 x10^{12}**	**1.41 x10^{12}**	4.53×10^{-15}	8.78×10^{-11}	**7.09 x10^{11}**	**1.14 x10^{10}**	**2.21 x10^{14}**
Empty vehicles (on Lorry)	**0.114**	0.00322	1.74	**8.74**	**0.575**	**311**	**0.000890**	0.0000241	0.0135	**1124**	**74.1**	**41493**

Table 29: Modelled number potentially infected large-scale pig farms in the non-affected areas of the EU in the coming 12 months as absolute number and as expected years until a first potential infection of a pig farm, considering that some deliveries mainly intended for use by other animal species are also used for pig feeding ($N \times (1 + P_{\text{multiple species}} \times N_{\text{fed add. species}}) \times q$)

Product	Origin from the EU						Origin from Eurasia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Unit		[–]			[y]			[–]			[y]	
Hydrolysed proteins	**0**	0	0				**0**	0	0			
Blood products	**0**	0	0				**0**	0	0			
Cereals	**3.49**	0.0354	91.0	**0.287**	0.0110	28.3	**0.172**	0.00105	4.67	**5.8**	0.214	956

Product	Origin from the EU						Origin from Eurasia					
	Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm			Modelled number of potentially infected pig farms			Expected years until a first potential infection of a pig farm		
	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%	Median	P5%	P95%
Legumes	**0.0826**	0.000802	2.43	**12.1**	0.411	1,247	**0.00519**	0.0000499	0.133	**193**	7.54	20,042
Oil seeds	**0.0136**	0.0000737	0.451	**73**	2.21	13,566	**0.0505**	0.000180	1.98	**19.8**	0.504	5,552
Tubers	**0.00132**	0.0000096	0.0416	**760**	24.0	104,360	**0.0000859**	0.000000542	0.00218	**11,641**	458	1,844,933
Other seeds	**0.0158**	0.000201	0.369	**63.4**	2.71	4,977	**1.01×10^{-3}**	1.17×10^{-5}	2.23×10^{-2}	**986**	44.9	85,810
Forage	**3.62×10^{-6}**	3.23×10^{-8}	7.65×10^{-5}	**2.77×10^{5}**	1.31×10^{4}	3.09×10^{7}	**8.21×10^{-7}**	7.30×10^{-9}	1.63×10^{-5}	**1.22×10^{6}**	6.15×10^{4}	1.37×10^{8}
Additives	**5.27**	0.140	72.4	**0.190**	0.014	7.13	**0**	0	0			
Mash	**18.0**	0.676	224	**0.0557**	0.00446	1.48	**0**	0	0			
Pellets	**11.4**	0.165	195	**0.0876**	0.00514	6.08	**0**	0	0			
Straw	**0.000115**	0.00000126	0.00276	**8,696**	362	793,623	**0**	0	0	**637,311**	21,964	67,288,208
Sawdust	**3.10×10^{-9}**	4.38×10^{-11}	5.32×10^{-8}	**3.22×10^{8}**	1.88×10^{7}	2.29×10^{10}	**4.34×10^{-11}**	4.81×10^{-13}	8.46×10^{-10}	**2.30×10^{10}**	1.18×10^{9}	2.08×10^{12}
Peat	**0**	0	0				**0**	0	0			
Wooden toys	**2.55×10^{-10}**	1.90×10^{-12}	5.32×10^{-9}	**3.92×10^{9}**	1.88×10^{8}	5.27×10^{11}	**3.55×10^{-12}**	2.18×10^{-14}	8.51×10^{-11}	**2.81×10^{11}**	1.17×10^{10}	4.58×10^{13}
Empty vehicles (on Lorry)	**0.0293**	0.000859	0.351	**34.1**	2.85	1165	**0.000229**	0.00000673	0.00275	**4361**	364	148549

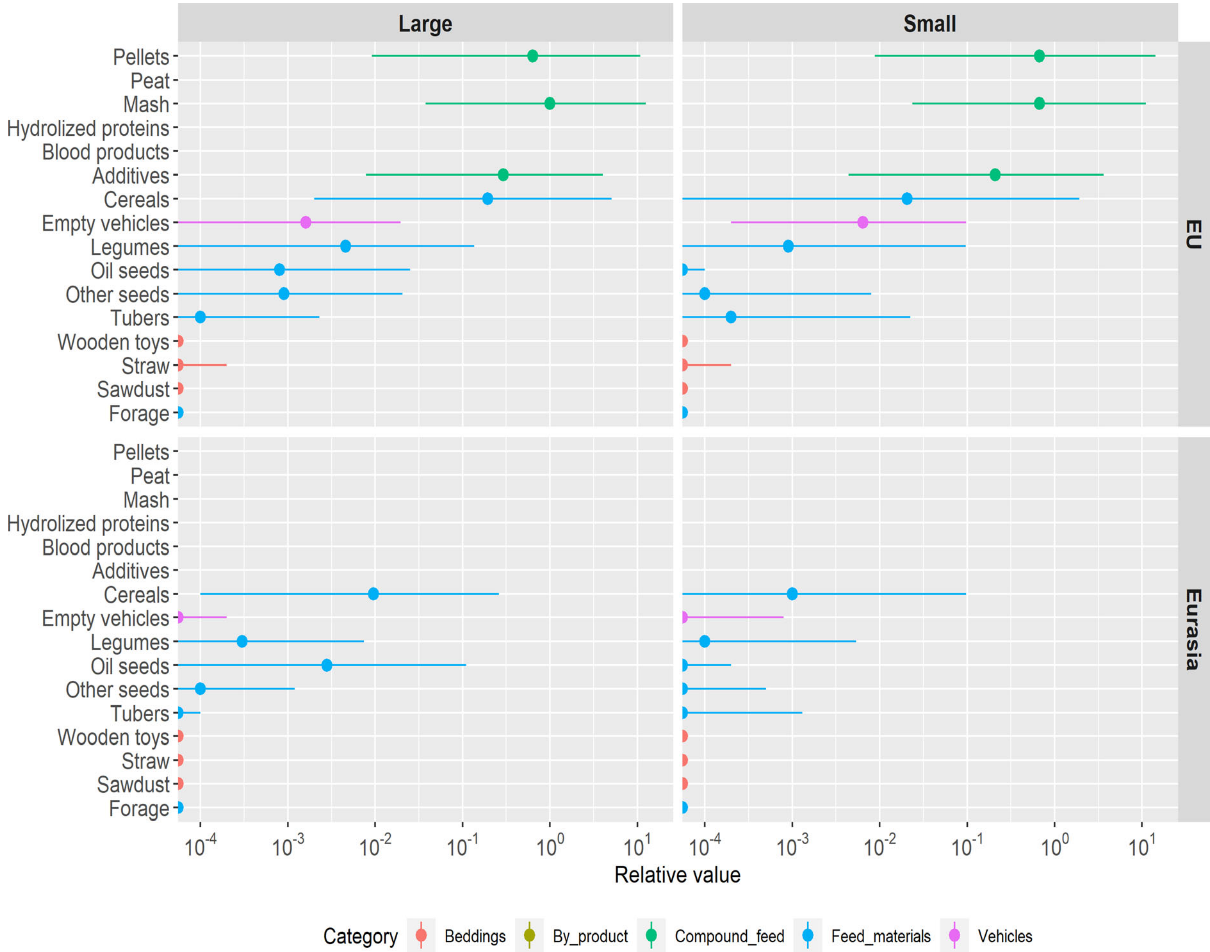

Figure 16: Ranking of products based on the modelled number of potentially infected pig farms in the non-affected areas of the EU in the coming 12 months considering multiple species on farm ($N \times (1 + P_{\text{multiple species}} \times N_{\text{fed add. species}}) \times q)$) (the values are standardised to the maximal value of products and strata (mash from the EU to large-scale farms) (100%) and the products are ordered by the maximal value of the strata of the specific product. Products to which this pathway does not apply are shown without relative values

3.6. Discussion of the assessment outcome

In this opinion, the current knowledge on survival of ASFV in a range of different matrices that could pose a risk for transmission was summarised by reviewing published literature and performing a public consultation. We considered survival of ASFV in products directly derived from infected pigs (e.g. blood) and in matrices that could potentially become contaminated by direct or indirect contact with infected pigs or wild boar. Only products, which were expected to be (legally) used for pig feed or to be in direct contact with pigs, were included in the assessment.

In general, temperature played a role in survival of the virus, with low temperatures leading to longer survival times, and temperatures at or above room temperature leading to shorter survival of the virus. For instance, long survival times ranging from 60 to 735 days were observed when infected blood or organs were kept frozen, whilst heat treatment to temperatures of > 55°C was shown to inactivate the virus. The reported survival times confirm the risk these products represent when originating from infected areas. No information on survival of ASFV in animal by-products for use in feed was available from scientific publications; hence, information on the processing methods was collected. These methods mostly include heat and/or acidity or alkalinity treatments. As observed for animal products, room or higher temperatures effectively inactivate ASFV or decrease ASFV survival over time, and therefore, it can be expected that heat treatment processes used in the processing of animal by-products would significantly reduce the risk of infectious virus remaining in these by-products.

The collation of currently available evidence on survival of ASFV in different matrices was followed by performing three EKEs to elicit expert knowledge on the risk of transmission of ASFV to pigs from matrices ranging from feed, bedding and enrichment materials to contaminated pig transport vehicles. Infection probability parameters estimated with the EKEs were included in the modelling to assess the likelihood (q) of products being contaminated at origin, and still containing infectious ASFV (large enough doses) after processing, transport and storage at the point of usage. This likelihood was combined with information on the number of consignments (N) traded/imported between affected areas of the EU and Eurasia to non-affected areas of the EU, in order to compute the modelled number of potentially infected pig farms in currently non-affected areas (q × N).

In the three EKEs performed, three independent groups of experts participated. The process of eliciting the parameters in three independent groups allowed the involvement of specialised experts for each parameter under investigation and ensured high quality judgements to compare between the different products. The pathway model simply combines the EKE estimates by multiplication and the final model results were not calibrated against existing data on ASFV infections. Therefore, it cannot be excluded that the absolute values of the model results are biased. However, this does not affect the relative level of risks between the products.

For each of the three steps in the model (q, N and q × N), the results were standardised relative to the maximum estimate, and the resulting values were used to rank the assessed products. This ranking represents the risk of a product relative to the other assessed products. For risk managers of each non-affected area, it is therefore important to relate the assessed product to the local situation, especially in terms of the number of consignments traded or imported.

When the products are ranked by likelihood of contamination at origin alone (q), compound mash feed and feed additives represent the highest risk, irrespective of whether these are produced in the EU or Eurasia or destined for small- or large-scale farms. Empty vehicles also rank high irrespective of origin, although minor differences were estimated depending on whether vehicles would visit large or small farms. This may be because transmission at destination is more likely in small farms due to vehicles likely visiting multiple small farms and due to lower levels of biosecurity in small scale farms. Similarly, the risk-rank for tubers was higher for small farms than for large farms. This is a reflection of differences in processing procedures, as occasionally tubers may be fed raw or partially processed to pigs in some small farms. At the lower end of the ranking, the products with the lowest likelihood of arriving at a farm, contaminated, were hydrolysed proteins, blood products, sawdust and wooden toys, irrespective of their origin and destination.

When the products are ranked by volume of trade/import that is delivered to farms (N), EU-origin pelleted feed, cereals and mash compound feed are ranked highest, irrespective of whether these are destined for small- or large-scale farms. This ranking gives an indication of which products are the most imported/traded ones into the non-affected areas of the EU.

When contamination and trade/import volume are combined (q × N), compound feed (pelleted, mash) and feed additives as well as cereals originating from the EU, were the highest (or among the highest) risk-ranked matrices. This reflects that these products are ranked with the highest risk of contamination (q) (as they are least likely to have a lengthy travel time and a storage step to reduce the level of virus) as well as being among the products with the highest imported volumes (N). Whilst compound feed is only traded from within the EU, cereals are also imported from Eurasia. When combining q × N, the difference in risk-ranking for cereals traded within the EU or imported from Eurasia is mainly due to the larger volumes (N) traded from EU affected areas. Imports of the ingredients for compound feed from Eurasia rank far lower as they are destined for the feed industry in the EU and not to farms themselves and the travel time from Eurasia to the EU has a similar effect as a long-term storage step.

Overall, the lowest ranking products ranked 10,000 times lower compared to compound feed for the probability of being contaminated, processed and transported and containing at least one infectious dose sufficient to cause an infection of at least one pig on a farm (q, see Figure 1).

Compound feed is a mixture of several ingredients and comes in the form of mash or pelleted feed. Pelleted feed is made from mash, and high temperatures are used during processing (60–81°C for up to 2 min), therefore reducing the probability of this product still containing infectious ASFV at the time of usage. In both products, the combination of several feed products as ingredients increases the likelihood of the product being contaminated before processing, compared to single component products, such as cereals. Based on the processing of pelleted feed, the risk of this product containing infectious ASFV at the time of usage was ranked lower compared to mash feed in the assessment (q, see Figure 1). When the numbers of farm deliveries traded or imported were taken into account, the large numbers of farm deliveries of pelleted feed meant compound feed in the form of pellets or mash ranking almost equally in the modelled number of potentially infected pig farms. As large volumes of ingredients for compound feed are produced with ingredients from affected areas, it was considered probable that the ingredients for a consignment of compound feed originated from an affected area (EFSA, 2021b). Surprisingly, the numbers of farm deliveries for compound feed were similar between large- and small-scale farms. However, as farm deliveries rather than trade volumes are considered in the final calculation, and because many small-scale farms can receive small consignments from the same lot compared to large farms, which receive less but larger bulk consignments from the same lot, this contributed to a similar result for both types of farms (EFSA, 2021b).

Feed additives are a mixture of different components. Some components of feed additives can be contaminated with ASFV, e.g. if they are produced using vegetable carrier materials, such as corn cob and rice hulls, as these might be contaminated with ASFV through contact with infected pigs. Vegetable carrier materials are ground to small particle size and dried by heat to a very low water activity, which is considered to reduce the amount of ASFV present. However, as feed additives are a mixture of different components, the combination of these different materials contributes to increasing the risk of contamination of any given consignment.

Cereals, together with straw and forage/roughage, were estimated in the EKE to have the highest likelihood of containing infectious ASFV at the place of production in affected areas, because of their potential for being contaminated with ASFV through remains of wild boar carcasses, wild boar saliva and blood. The likelihood related to cereals was estimated to be lower, based on a more careful harvesting process relative to forage/roughage. Furthermore, longer storage of cereal grains and drying at ambient and high temperatures is expected to result in lower probabilities of ASFV survival to the point of usage. For cereals, it was considered that a large proportion of grains harvested will be used as animal feed and will go directly to a farm. The rest will be used to produce compound feed. Cereal grains would be transported mostly by ship and in high volumes and could be equally produced in Eurasia as in the EU. For cereals originating from Eurasia, traders have large storage capacities and shipment distance/duration is larger, which may reduce probabilities of ASFV survival. Many small farms were considered to produce their own cereal grains or to use compound feed rather than commercial grains. For the larger commercial farms, it is quite possible that one lorry delivers a full consignment to only one farm. For larger shipping containers, these are more likely to be delivered to feed merchants and then distributed.

Regarding blood products (spray-dried blood plasma) and hydrolysed proteins, the fact that pigs from affected areas will not be allowed to be used for their production, and that there is a short time window in which animals can be infected without showing clinical signs, combined with the production procedures for the products, results in estimates of infectious ASFV at the time of usage in the lower boundaries of the given assessments. Still, as ASF continues to spread, there is a risk that in recently infected areas, the infection of animals that do not yet show clinical signs might go undetected at ante- and post-mortem inspection in slaughterhouses. Furthermore, the protein content of the products might protect the virus from the short-term high-temperature treatment expected to inactivate the virus (EFSA, 2021b).

Due to the small likelihood of contamination of wooden toys and the uncertainty about their trade as specialised product, the approach of assessing wooden toys under the category of bedding material and therefore extrapolating from the judgements on straw was considered reasonable for this ranking exercise.

The estimates regarding the proportion of empty vehicles for pig transport containing infectious ASFV after unloading in the affected area and still containing infectious ASFV at the point of loading (usage) on a farm in the non-affected area of the EU, and transmitting infectious ASFV to at least one pig on the farm, are highly influenced by the biosecurity on the farms from where pigs are loaded. If the truck was contaminated while unloading pigs transported into the affected areas, there is a risk that the cleaning and disinfection of the truck are not sufficient, especially in winter times (cold water, cold working environment at cleaning, longer virus survival). If the truck is still contaminated, when it returns to an unaffected area, there are two ways of transferring virus to pigs: (1) the virus is carried into the farm at the time of loading the next batch of pigs, e.g. if the truck driver goes back and forth between the truck and the pigs in the stable, (2) the pigs transported to the next farm pick up virus from inside the truck. At farms with high levels of biosecurity, pigs are often loaded from special loading docks separated from the stables, which reduces the risk of transmission to the farm. However, animals transported on the vehicle that still contains infectious ASFV can get infected during transport, which will present a risk for the farm receiving these animals. From some non-affected areas, large numbers of pigs are transported to affected areas, and trucks are frequently going back and forth. In such situations, loading pigs from loading docks or assembly centres might reduce the risk of transmission to the farm. Within the EU, the number of empty vehicles reaching small-scale farms was estimated to be higher than the number of empty vehicles reaching large-scale farms. This might seem surprising, as small-scale farms are seldom involved in cross-border movements, and pigs from small-scale farms are expected to be often transported by the farmers using their own vehicles. However, the current assessment focusses on affected vs. non-affected areas, which can be within the same country. Smaller farms are considered to move pigs less frequently than larger farms. However, as the numbers of small-scale farms are high in some of the affected areas of the EU, the number of trucks returning from small-scale farms in these areas is high, and as small farms often deliver fewer animals, the truck will often make several stops (EFSA, 2021b).

This assessment has been undertaken for all unaffected areas of the EU. The hierarchy of the ranking is unlikely to change for 'q', while it could change for 'N', as in general, there was little difference in rank whether a product was produced in an affected area of the EU or in Eurasia. The results suggest that some products have a higher rank when the final destination is a small-scale rather than a large-scale farm, such as tubers and empty transport vehicles, because of the perception of lower levels of biosecurity on smaller non-commercial farms. Certain feed or bedding materials are not traded over long distance or between affected and non-affected areas. For such products, the likelihood of leading to an adverse outcome is reduced for the non-affected area, but cannot be ruled out for establishments, which are in close proximity to affected areas.

There are several other pathways not assessed in this opinion, which could lead to incursion of ASF into a pig farm, e.g. movements of live pigs, contact between domestic pigs and infected wild boar, illegal swill feeding. These constitute important risk pathways compared to the feed pathways assessed here. Where outbreak investigations implicate feed as the risk factor for ASF outbreaks, this has pointed to locally produced hay, straw or grain harvested from an area where ASF is present in the wild boar population, using farm equipment from such an area or providing fresh forage to pigs, notably in backyard farms (EFSA, 2021c).

4. Conclusions

- The risk of transferring ASFV via matrices from affected to non-affected areas as assessed by the modelled number of potentially infected pig farms is driven by two key quantities (see Figure 1): (i) q, the probability that the matrix is contaminated, processed and transported and contains sufficient ASFV to cause an infection of at least one pig on a farm, and (ii) N, the number of consignments traded or imported reaching the pig farm. Both q and N depend on

the place of origin (affected areas of the EU or Eurasia) and the destination (small- or large-scale farms) of products.
- Seventeen products and matrices were assessed and ranked for their relative likelihood of arriving contaminated at their destination in non-affected areas (q). Compound feed (mash, pellets), feed additives and contaminated vehicles were the highest ranked matrices, with cereals and straw also ranking in the upper half of the risk-ranking. These matrices are expected to have a higher risk (two to four orders of magnitude higher) than the other assessed matrices.
- The highest volume or number of consignments imported/traded to non-affected areas in the EU (N) was calculated for compound feed, which mainly originated from affected areas in the EU. Cereals and oil seeds were also among the highest imported/traded products, the latter being traded/imported from affected areas of both the EU and Eurasia and being mostly used by large farms.
- The combination of the likelihood of these matrices containing infectious virus at destination (q) and their imported/traded volume (N) provided a relative indication of their potential risk for infecting pig farms in non-affected areas of the EU ($q \times N$). Compound feed was ranked as the matrix with the highest potential risk regardless of its destination (small or large farms), followed by cereals. The latter ranked the highest among the imported matrices from affected areas in Eurasia.
- Matrices whose risk-ranking depends on their origin and destination were empty vehicles and oil seeds.
- For hydrolysed proteins and blood products, imports from Eurasia ranked bottom, as their final destination is a feed producer and not directly a pig farm.
- Vehicles represent a higher risk for transmission when originating from affected areas within the EU with destination to small farms compared to large farms.
- Oil seeds ranked higher when imported from Eurasia and destined to large farms, whilst oil seeds were among the lowest risk-ranked matrices for small farms.
- Finally, it is very likely (95–99% certainty) that compound feed, feed additives and cereals rank higher (three orders of magnitude) compared to other feed materials, which in turn rank higher (orders of magnitude > 4) than bedding/enrichment material and forage. The potential risk for causing infections of ASFV at destination was the lowest, among the assessed products, for bedding/enrichment materials (sawdust, straw and wooden toys) and forage.
- The combination of several products, each with its own likelihood of contamination, increases the probability of contamination for mixed products such as compound feed.

5. Recommendations

- In general, storage of feed products and enrichment/bedding materials originating from ASF-affected areas (at temperatures above 0 C) before their use in non-affected areas will decrease the risk of ASFV survival in the matrix.
- For empty live pig transport vehicles returning from other countries, the risk of ASF transmission can be decreased by controlling whether the vehicle has transported pigs to or within affected areas, and a control of cleaning and disinfection of trucks (certificates and visual inspection). Further reduction of the risk for the farm at which the animals are loaded for transport can be achieved by loading pigs from assembly centres or transportable loading docks at some distance from the farm.
- Strict adherence to relevant decontamination and storage processes (storage time, treatment temperature) leading to a reduction of a potential virus contamination is recommended for all products and material moved from ASF-affected areas to unaffected areas.
- For risk managers, it is important to consider the assessed product in terms of long-term storage or a virus inactivation step being applied to the product.

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Abbreviations

ABP	animal by-products
ASFV	African swine fever virus
AHAW	Animal Health and Welfare
CDF	Cumulative distribution function
DCP	Dicalcium Phosphate
EKE	Expert Knowledge Elicitation
Eurasia	Non-EU areas in Europe and Asia
FEFAC	European Feed Manufacturers Federation
GPD	gelatine process-derived proteins
HAD_{50}	Median Haem Adsorbing Dose
HAT	haemadsorption test
SLR	Systematic literature review
TOR	Terms of Reference

Annex A – Literature review on ASFV in matrices

Objectives

The overall aim of this review was to collect information from survival experiments published in primary research publications about African swine fever virus survival in different matrices.

Review questions and eligibility criteria

Outputs from agent survival studies

Collect data relating to the survival time of ASFV. Information should concern the persistence of the pathogen in different matrices.

Review questions for agent survival studies

What is the minimum and maximum number of days post inoculation that the pathogen (=viable ASFV) can be detected in different relevant matrices?

Study eligibility criteria for agent survival studies

Element	Criteria	Level of screening
Publication type	• Primary research publications	Title and abstract
Language	• English	Title and abstract Full-text
Study type	• Pathogen survival experiments	Title and abstract
Study characteristics	The study should provide details on • the strain/isolate of the ASFV used • the dose /quantity of virus used to infect/spike • the temperature at which the matrix is stored during the experiment	Title and abstract Full-text
Exposure	• Matrices from animals experimentally infected with ASFV OR • Matrices experimentally contaminated (spiked) with ASFV	Title and abstract Full-text
Outcome of interest	• The article is excluded if there is no description of the outcome of interest, i.e. ASFV survival time	Title and abstract Full-text
Publishing date	Papers that have been published before 2019 and have been already included in the previous literature review will be excluded from data extraction.	Title and abstract

Methods for searching the results

Information sources

The following databases were searched using the Web of Science (WoS) platform:

Web of Science Core Collection

- Science Citation Index Expanded
- Social Sciences Citation Index
- Conference Proceedings Citation Index- Science
- Conference Proceedings Citation Index- Social Science & Humanities
- Book Citation Index– Science
- Book Citation Index– Social Sciences & Humanities
- Emerging Sources Citation Index
- Current Chemical Reactions
- Index Chemicus

BIOSIS Citation Index
CABI : CAB Abstracts
Current Contents Connect
Data Citation Index
FSTA - the food science resource

KCI-Korean Journal Database (1980-present)
MEDLINE
Russian Science Citation Index
SciELO Citation Index
Zoological Record

Restrictions

Only primary research studies (i.e. no review papers) published in English were considered for potential inclusion in the reviews. The limitations concerning the year of publication listed above were applied.

Concerning the publications status, all literature indexed in the databases were included in the search, irrespective of whether they were e-pubs or corrected proofs.

Reference management

References were managed using the commercial reference management software package EndNote X9®. The articles were extracted and saved as an RSIS file for input into Distiller.

Search strategy

Ad hoc combinations of search terms were applied. The use of Boolean operators (AND, OR, NOT), truncation ($) and wildcard (*) symbols assured that search terms account for synonyms, abbreviations and spelling variants, enhancing thus the sensitivity of the search strategy.

Alternative names for ASFV were searched.

The objectives were searched using WOS (All databases), selecting only English articles.

Publications were retrieved combining terms to represent the pathogen AND terms to describe survival experiment as follows:

Set	Query
#3	#2 AND #1
#2	**TOPIC:** (Surviv* OR Persist* OR stability OR inactivat* OR disinfect*)
#1	**TOPIC:** ("African swine fever" OR "Warthog disease" OR "Warthog fever")

Methods for study selection

Selection procedure

The level 1 selection process involved the screening of title and abstract to identify potentially relevant studies by one reviewer using a screening check list developed according to the eligibility criteria. If the information contained in the title or abstract was not relevant for the research objectives, the article was not selected for full text assessment. The first level of screening was performed using Distiller®. Publications judged to be relevant were automatically selected for further screening, while publications rejected were excluded. References without abstract were carried over to level 2 screening, unless the title was explicit enough to clearly understand lack of compliance to one or more eligibility criteria.

For experimental infection studies, the level 1 screening was followed by a refinement process, by adding an extra question about the pathogen strain and whether or not the host was immunised or treated. Only a single exposure with an 'outbreak' strain or a 'wild type' strain of the pathogen in a not-immunised or not-vaccinated or not-treated host was accepted.

Level 2 screening involved the screening of full text articles identified in level 1, one reviewer per study, based on reading the full text.

Retrieval of full texts

Attempts were made to obtain electronic versions of the full papers for all references that fulfil the eligibility and relevance criteria (i.e. those passing Level 1 screening). This work was partly conducted during the literature search. Further retrieval of full papers was done between level 1 and level 2 screenings.

Documenting the selection

The study selection process was fully documented in Distiller, allowing tracking and reporting of:

- Number of records identified through each electronic database or other source
- Total number of unique records (title/abstracts) identified through electronic search
- Number of records excluded after level 1 screening
- Records (full text) potentially eligible
- Number of records excluded after level 2 screening (by reason for exclusion)
- Final number of studies included in the review

Methods for data collection

Collected information

Data collection for agent survival studies

Field name	Data type	Description	Required	Lookup
studyID	Integer	Unique ID to link all observations from the same study or experiment	**YES**	
studyGroupID	Integer	Unique ID for the animal group, or sample group, within this study, being reported		
refID	Integer	Unique ID linking to the source of the information in the database of reference management system	**YES**	
agent	String	Code agent of ASF	**YES**	PARAM
studyTargetSpecies	String	Susceptible species used in the study	**YES**	MTX
sampUnitSize	Integer	Number of samples tested in the study		
sampledMatrix	String	Tissue sampled for testing		MTX
Temperature	Integer	Degree Celsius		
humidity	Number	Humidity conditions (%)		
anMethCode	String	Laboratory test used for analysis for virus, antibodies or antigens associated with ASF		ANALYMD
anMatText	Radio	Target of laboratory test		Nucleic acid Virus
maxDetect	Number	Maximum number of days post inoculation to observe pathogen, antibody or nucleic acid	YES	

Tools for data collection

Data collection was carried out according to the data models defined above. Appropriate data collection forms, for each of the objectives, were set up to ensure that data validity checks were performed during data collection. This enforced compliance of the parameters to the data type described above – for instance enforcing that some parameters were entered as numerical or setting minimum and maximum ranges.

Forms for data collection were set up using Distiller®, which enabled setting user-friendly pick lists for data entry, and the resulting collected being a standardised set of codes based on the data catalogue. The data collected were then exported into a Microsoft Excel® spreadsheet.

Procedure for data collection

One reviewer per study individually extracted data from studies that passed screening for relevance. Authors of primary studies were not be contacted to provide missing or additional data.

Search strings used

Set	Query	Results
#3	#2 AND #1 *Databases= CCC, CABI, WOS, CSCD, ZOOREC, SCIELO, FSTA, MEDLINE, RSCI, KJD, DRCI, BCI Timespan=All years* *Search language=Auto*	**633**

Set	Query	Results
#2	**TOPIC:** (Surviv* OR Persist* OR stability OR inactivat* OR disinfect*) *Databases= WOS, BCI, CABI, CSCD, CCC, DRCI, FSTA, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=All years* *Search language=Auto*	**5,928,995**
#1	**TOPIC:** ("African swine fever" OR "Warthog disease" OR "Warthog fever") *Databases= WOS, BCI, CABI, CSCD, CCC, DRCI, FSTA, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=All years* *Search language=Auto*	**4,214**

Annex B – Expert Knowledge Elicitation protocol (Status: March 2020)

B.1. Introduction and scope of the protocol

This document provides an explanation of the draft protocol for an Expert Knowledge Elicitation (EKE) conducted by EFSA to assess parameters for modelling the ability of selected matrices to transmit African Swine Fever (ASF) from affected areas to non-affected areas within Europe.

This draft protocol has been proposed by a steering group comprising members of the Animal Health and Welfare (AHAW) working group on ASF, scientific officers and elicitation experts of EFSA. It follows the principles of the EFSA Guidance on Expert Knowledge in Food and Feed Safety Assessment (EFSA, 2014).

B.2. Data and methodologies

B.2.1. Geographical scale and regional strata

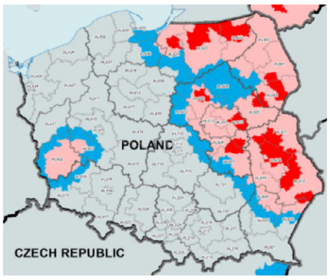
The affected areas are grouped into two strata:

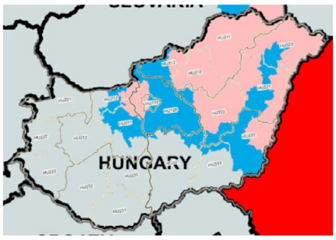
1) Affected area within EU27 (**EU-stratum)**: area in the EU affected by ASFV genotype II
2) Affected area within Eurasia **(EURASIA-stratum)**: Area in Europe, which are not EU Member States, and in Asia and Oceania affected by ASFV genotype II

The reasons for stratifying the affected area from which potentially contaminated matrices can originate into 'EU' and 'EURASIA' are the different trade regulations and control measures that apply and the different sources of trade data and outbreak data and in the EU compared to the other affected areas. Table B.1 lists the different MSs and NUTS 3 regions that are included in the 'EU-stratum.'

Additionally, as the mandate only requires assessing the likelihood of transmission of ASFV genotype II, which has spread since the introduction 2007 into Europe and Asia, the origin from potential contaminated matrices concentrates on these two continents, and not on the endemic areas in Africa.

Table B.1: Affected EU Member States and NUTS 3 regions in the 'EU stratum', based on the regionalisation of ASF control measures within the EU on the 11th of February 2020

MS	NUTS 3 regions with control measures according class I, II, III	MAP
Belgium	BE 341, BE 344, BE 345	
Poland	PL 417, PL 418 PL 431, PL 432 PL 515, PL 516 PL 621, PL 622, PL 623 PL 633, PL 634, PL 638 PL 713, PL715 PL 721, PL 722 PL 811, PL 812, PL 814, PL 815 PL 822, PL 823, PL 824 PL 841, PL 842, PL 843 PL 911, PL 912, PL 913 PL 921, PL 922, PL 923, PL 925, PL 926	

MS	NUTS 3 regions with control measures according class I, II, III	MAP
Slovakia	SK 041, SK 042	
Hungary	HU 10 HU 120 HU 211, HU 212 HU 311, HU 312, HU 313 HU 321, HU 322, HU 323 HU 331, HU 332, HU 333	
Lithuania	Whole country	
Latvia	LV 003, LV 005, LV 007, LV 008, LV 009	
Estonia	Whole country	
Romania	Whole country	
Bulgaria	Whole country	
Greece	EL 511, EL 512, EL 513, EL 514, EL 515 EL 526	

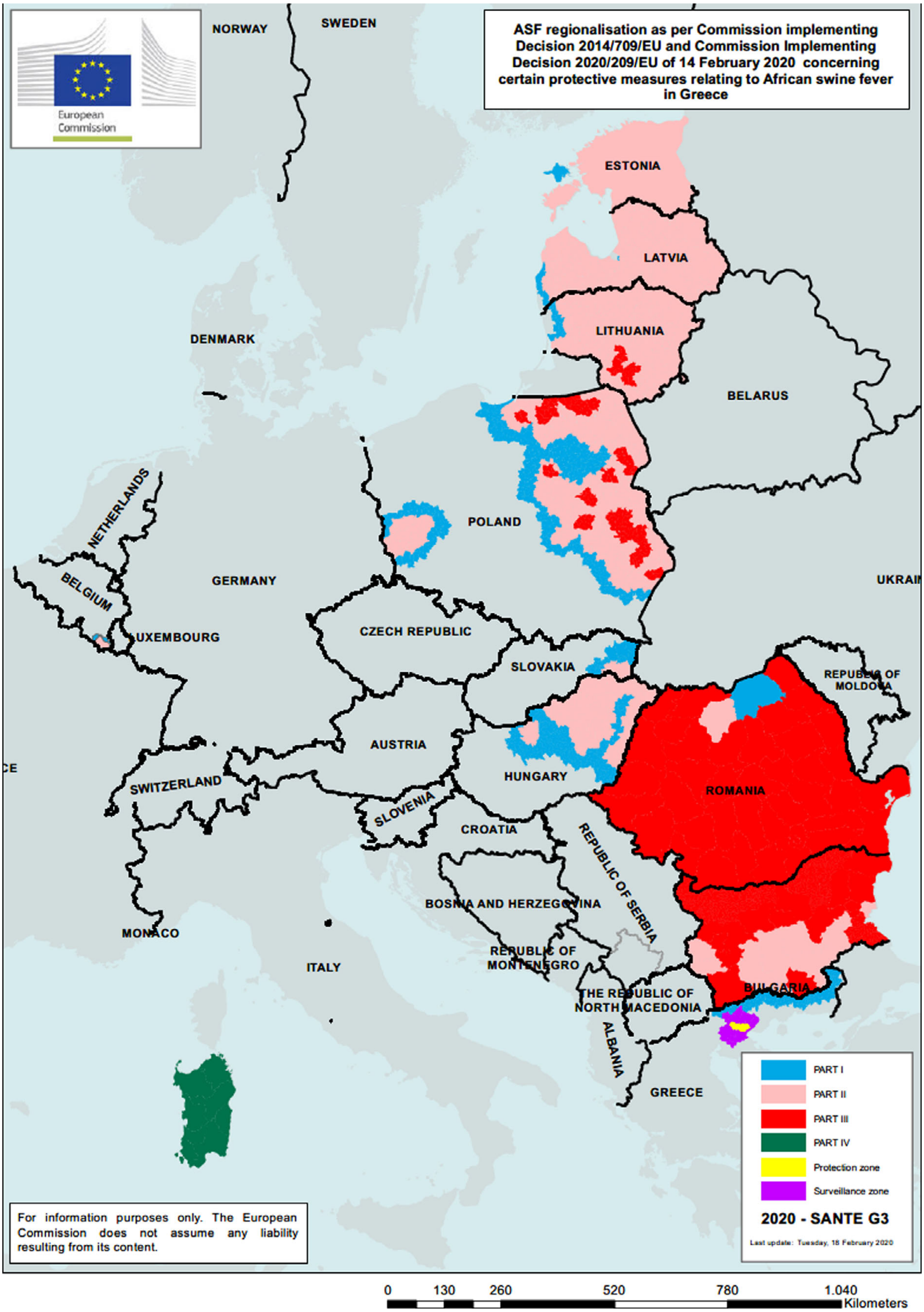


Figure B.1: Map summarising the current regionalisation of ASF control measures within the EU, Version of 28th February 2020 (Downloaded at ec.europa.eu/food/animals/animal-diseases/control-measures/asf_en on 28th February 2020)

The countries and regions in the EURASIA-stratum are shown in Table B.2 based on the ASF outbreaks reported to OIE between the 1th and 28th of February 2020.

Table B.2: Definition of regional strata by country and regions of Eurasia using the disease reports of African swine fever of the last year as reported to OIE (on 28 February 2020)

Country	Affected regions
Serbia	Borski Grad Beograd Pirotski Podunavski Srednje-banatski
Ukraine	Cherkas'ka Chernihivs'ka Dnipropetrovs'ka Donets'ka Kharkivs'ka Khersons'ka Khmel'nyts'ka Kyyivs'ka Luhans'ka L'vivs'ka Mykolayivs'ka Odes'ka Poltavs'ka Rivnens'ka Sums'ka Ternopil's'ka Vinnyts'ka Volyns'ka Zakarpats'ka Zaporiz'ka Zhytomyrs'ka
Moldova	Balti Cahul Chisinau Edinet Gagauzia Lapusna Orhei Tighina Ungheni
Russia	Adygeya Rep. Amurskaya Oblast Belgorodskaya Oblast Ivanovskaya Oblast Kabardino-balkariya Rep. Kaliningradskaya Oblast Khabarovskiy Kray Krasnodarskiy Kray Kurskaya Oblast Leningradskaya Oblast Lipetskaya Oblast Moskovskaya Oblast Nizhegorodskaya Oblast Novgorodskaya Oblast Orlovskaya Oblast Primorskiy Kray Pskovskaya Oblast Rostovskaya Oblast Saratovskaya Oblast Stavropolskiy Kray

Country	Affected regions
	Tulskaya Oblast Tverskaya Oblast Ulyanovskaya Oblast Vladimirskaya Oblast Volgogradskaya Oblast Yevreyskaya A. Oblast
Mongolia	Bulgan Dundgovi Orxon Selenge To'v Ulaanbaatar
China	Anhui Sheng Beijing Shi Chongqing Shi Fujian Sheng Gansu Sheng Guangdong Sheng Guangxi Zhuangzu Zizhiqu Guizhou Sheng Hainan Sheng Heilongjiang Sheng Henan Sheng Hubei Sheng Hunan Sheng Jiangsu Sheng Jilin Sheng Liaoning Sheng Nei Mongol Zizhiqu Ningxia Huizu Zizhiqu Qinghai Sheng Shaanxi Sheng Shandong Sheng Shanxi Sheng Sichuan Sheng Tianjin Shi Xinjiang Uygur Zizhiqu Xizang Zizhiqu Yunnan Sheng Zhejiang Sheng Hong Kong, SAR
Myanmar	Shan (E)
Cambodia	Kampong Cham Kandal Ratanak KiriSvay Rieng Takeo
Dem People's Rep of Korea	Chagang-do
Republic of Korea	Chungchongnam-do Kang-won-do Kyonggi-do
Lao People's Democratic Republic	Attapu Bokeo Bolikhamxai Champasak Houaphan Khammouan Louang-Namtha Louangphabang Oudomxai

Country	Affected regions
	Phongsali Salavan Savannakhet Vientiane Vientiane capital XekongXiangkhouang
Vietnam	An Giang Ba Ria-Vung Tau Bac Giang Bac Kan Bac Lieu Bac Ninh Ben Tre Binh Dinh Binh Duong Binh Phuoc Binh Thuan Ca MauCan Tho city Cao Bang Da Nang City Dak Lak Dak Nong Dien Bien Dong Nai Dong Thap Gia Lai Ha Giang Ha Nam Ha Noi City Ha Tinh Hai Duong Hai Phong City Hau Giang Ho Chi Minh City Hoa Binh Hung Yen Khanh Hoa Kien Giang Kon Tum Lai Chau Lam DongLang Son Lao Cai Long An Nam Dinh Nghe An Ninh Binh Ninh Thuan Phu Tho Phu Yen Quang Binh Quang Nam Quang Ngai Quang Ninh Quang Tri Soc Trang Son La Tay NinhThai Binh Thai Nguyen Thanh Hoa Thua Thien – Hue Tien Giang

Country	Affected regions
	Tra Vinh Tuyen Quang Vinh Long Vinh Phuc Yen Bai
Indonesia	Sumatera Utara
Philippines	Aurora Bataan Benguet Bulacan Cavite Davao Del Sur Isabela Kalinga Manila, Second District Manila, Third District Nueva Ecija Pampanga Pangasinan Quezon Rizal Tarlac
Timor-Leste	Dili

Figure B.2 shows the ASF countries and provinces in the EURASIA-stratum, being those regions that were reporting ASF outbreaks during the period Feb 2019 and Feb 2020 to the OIE.

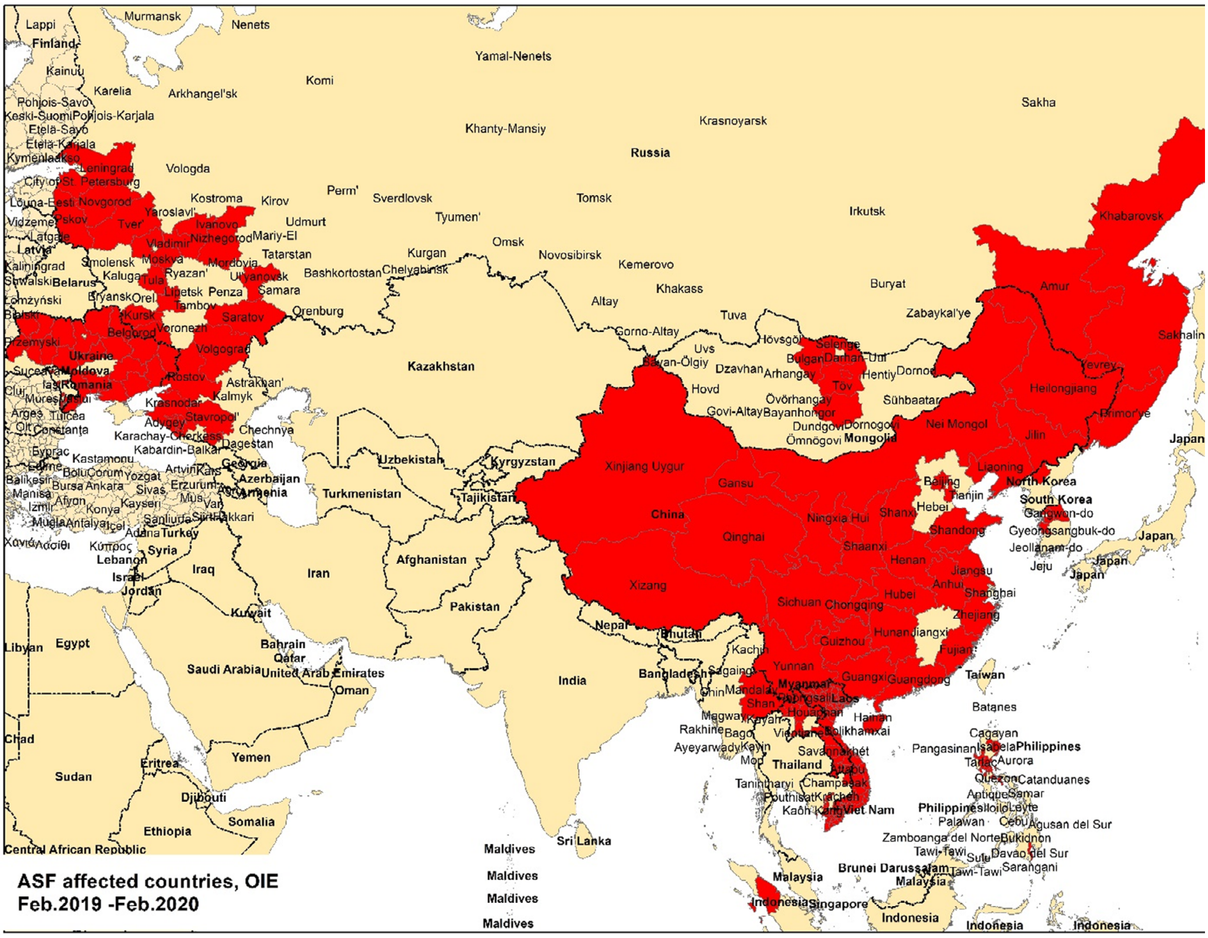


Figure B.2: ASF affected areas in the EURASIA-stratum, Feb 2019-Feb 2020, OIE

B.2.2. Products assessed in the EKE

Five groups of products which could potentially be contaminated with infectious ASFV and lead to further transmission were selected as possible pathways (Table B.3).

Table B.3: Definition of the groups of matrices

Group	Products	Remarks
1. Animal by-products for use in feed	1a. Hydrolysed proteins	
	1b. Blood products, spray dried plasma	
2. Feed materials (contaminated, not pig derived)	2a. Cereal grains, their products and by-products	Key examples: wheat, maize, barley
	2b. Oil seeds, oil fruits, their products and by-products	Key examples: soybean, rape seeds
	2c. Other seeds, fruits and their by-products	Key examples: acorn, chestnuts, apples
	2d. Forages and roughage	Key example: hay
	2e. Tubers, roots, their products and by-products	Key example: potatoes, beet root
	2f. Legume seeds, their products and by-products	Key example: peas

Group	Products	Remarks
3. Compound feed (includes products of categories 1 and 2)	3a. Mash	Organic or inorganic substances in mixtures, whether or not containing additives, for oral animal feeding in the form of complete feeding-stuffs or complementary feeding-stuffs
	3b. Pellets	
	3c. Minerals and feed additives	
4. Bedding	4a. Straw	
	4b. Sawdust/woodchips	
	4c. Peat/Turf	
5. Vehicles	5. Empty vehicles for live pig transport, returning from affected areas (including equipment, like boards and gates)	

Table B.4: Definitions of the products assessed in the EKE

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/ trade
Animal by-products for use in feed	Hydrolysed proteins	Polypeptides, peptides and amino acids and mixtures thereof, obtained by hydrolysis of animal by-products, which can be concentrated by drying	Commission Regulation (EU) No 142/2011	The animal by-product used for the production of hydrolysed proteins can contain ASFV, if it has been derived from an ASFV-infected pig or wild boar.	To produce hydrolysed proteins, an initial hydrolysis of proteins by cell-free proteases, microorganisms, acids, or bases is followed by separation through centrifugation, filtration or microfiltration. In a next step, the product is decontaminated by a heat treatment (pasteurisation), often followed by drying. These general procedures for peptide production may be modified, depending on protein sources and product specifications.	Hydrolysed proteins are used as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/ bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.
Animal by-products for use in feed	Blood products	Products derived from blood or fractions of blood, excluding blood meal. Blood products include dried/ frozen/liquid plasma, dried whole blood, dried/frozen/ liquid red cells or fractions thereof and mixtures.	Commission Regulation (EU) No 142/2011	Blood used for the blood products can contain ASFV, if in has been derived from an ASFV-infected pig or wild boar.	Blood products for use in feed must be submitted to one of the processing methods 1–5 or processing method 7 listed in Commission Regulation (EU) No 142/2011. Methods 1–5 involve heating the raw material to core temperatures of > 80°C, > 100°C, > 110°C, > 120°C or > 133°C for different time periods, depending on particle size.	Blood products are used as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/ bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/trade
Feed materials not derived from pigs	Cereal grains, their products and by-products	Barley, maize, millet, oats, quinoa, rice, rhye, sorghum, triticale, wheat grains and their products and by-products, such as bran, flakes, flour, fibre, germ, hulls, middlings, distillers' grains and solubles	Commission Regulation (EU) No 2017/1017	Contamination of cereals may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or by infected tissues of fallen animals picked up by the combine from the field.	The harvested cereals go through various processing steps such as screening/cleaning, decortication, dehusking/dehulling, flaking, grinding/milling, malting, mixing. Often the harvested cereals undergo drying (heat treatment) or are kept in low moisture conditions (relative humidity < 20%).	Cereal grains, their products and by-products are used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.
Feed materials not derived from pigs	Oil seeds, oil fruits and products thereof	Babassu, camelina, cocoa, copra, cotton, groundnut kapok, linseed, mustard, niger, olive, palm kernel, pumpkin/squash, rape, safflower, sesame, soya, sunflower, hemp, poppy in the form of seeds, expeller, hulls, husks, meal, pulp, oil	Commission Regulation (EU) No 2017/1017	Contamination of oil seeds and oil fruits may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or by infected tissues of fallen animals picked up by the combine from the field.	The harvested oil seeds and oil fruits go through various processing steps such as screening/cleaning, decortication, dehusking/dehulling, expelling, drying, grinding. The process of soybean meal includes several process steps, in which the raw material is heated (toasting by using dry heat to reduce or remove naturally occurring antinutritive factors). When leaving the toasting unit, the residual temperature is 105°C with 16–20% residual moisture.	Oil seeds and oil fruits and the products thereof are used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/trade
Feed materials not derived from pigs	Legume seeds and products derived thereof	Beans, carob, chick peas, ervil, fenugreek, guar, horse beans, lentils, sweet lupins, mung beans, peas, vetches, chickling vetch, monantha vetch, in the form of pods, powder, expeller, husks, meal, flakes, pulp, middlings, flour, screenings, solubles, fibre	Commission Regulation (EU) No 2017/1017	Contamination of legume seeds may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or by infected tissues of fallen animals picked up by the combine from the field.	The harvested legume seeds go through various processing steps such as screening/cleaning, decortication, dehusking/dehulling, expelling, drying, crushing, pressing, grinding/milling.	Legume seeds and products derived thereof are used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.
Feed materials not derived from pigs	Tubers, roots and products derived thereof	Sugar beet, beet root, carrots, chicory, garlic, manioc, onion, potatoes, sweet potatoes, Jerusalem artichoke (topinambur) in the form of molasses, pulp, peelings, scrapings, flakes, seeds, powder, vinasses, syrup	Commission Regulation (EU) No 2017/1017	Contamination of tubers and roots may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or by infected tissues of fallen animals picked up by the combine from the field.	The harvested tubers and roots go through various processing steps such as screening/cleaning, decortication, peeling, pressing, drying/dehydration, concentration, blanching, boiling, pasteurisation, flaking, cutting, crushing, mashing, grinding.	Tubers, roots and products derived thereof are used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/ trade
Feed materials not derived from pigs	Other seeds, fruits and products derived thereof	Acorn, almond, anise seeds, apple, sugar beet, buckwheat, red cabbage, canary grass, caraway seeds, chestnuts, citrus, red clover, white clover, coffee, cornflower seeds, cucumber seeds, cypress seeds, dates, fennel, fig, fruit, garden cress, graminaceous seeds, grape, hazelnut, perilla, pine, pistachio, plantago, radish, spinach, thistle, tomatoes, yarrow, apricot, black cumin, borage, evening primrose, pomegranate walnut in the form of hulls, expeller, seeds, pulp, bran, skins, kernels, pips	Commission Regulation (EU) No 2017/1017	Contamination of other seeds and fruits may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood).	Other seeds and fruits go through various processing steps such as screening/ cleaning, dehulling/ dehusking, pressing, milling, drying.	Other seeds, fruits and products derived thereof are used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.
Feed materials not derived from pigs	Forages and roughage and products thereof	Beet, cereal, clover, grass, herbs, legumes, horse beans, linseed, lucerne, maize, peas, rape seed in the form of straw, meal, silage, fibre, flour, pomace	Commission Regulation (EU) No 2017/1017	Contamination of the original feed material used in the forage or roughage may take place shortly before or after cutting and before baling by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or by infected tissues of fallen animals picked up by the combine from the field.	Forages and roughage and the products thereof go through various processing steps such as cutting, pressing, drying, milling, ensiling (fermenting) or are used fresh without any processing. Forages are cut and let dry in the sun for a few days. Depending on the geographical area, temperatures can reach 30–40°C during this drying period. Once baled, temperatures inside the bale can range between 32 and 37°C, although higher	Forages and roughage and products thereof are used as feed material. Fresh forage is fed immediately after cutting. Dried forages and silage are fed after weeks - months of storage.

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/trade
					temperatures may be reached depending on the moisture content of the hay at baling and the presence of oxygen. During the first weeks, the temperature will drop gradually inside the bale but will remain above 20–25°C.Ensiling leads to natural fermentation, which takes from 10 days to 3 weeks, leading to a gradual drop of the pH and temperatures between 20 and 30°C. The exact temperature and final pH in the ensiled crop largely depend on the type and moisture of forage being ensiled. Maize silage terminates at or below pH 4. Legumes, which have less water-soluble carbohydrate content and a higher buffering capacity, generally reach a terminal pH of about 4.5. If aeration is prevented, pH will stay stable during the storage period for several months until fed to the animals (normally from 3 to 12 months).	

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/ trade
Compound feed	Mash	Organic or inorganic substances in mixtures, whether or not containing additives, for oral animal feeding, that are finely ground and mixed so that the different ingredients cannot be separated out by the animals.	Wikipedia	Contamination of the original feed material used in the mash may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or, in the case of cereal grains and oil fruits, by infected tissues of fallen animals picked up by the combine from the field.	Feed materials used for commercial manufacture of mash feed are usually stored in closed bins or facilities before they are used in the manufacturing. The storage duration of feed ingredients in feed mills is usually a few days for feed materials and can be 2–3 weeks for premixtures. Mash feed is obtained from the original ingredients by grinding, dosing, mixing and inclusion of feed additives.	Mash is used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates, e.g. intermediate traders that stock feed from feed producers and sell it further to farmers and/or others, within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/ bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.
Compound feed	Pellets	Mash mechanically pressed into hard dry pellets or ‘artificial grains’.	Wikipedia	Contamination of the original feed material used in the pellets may take place shortly before or during harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or, in the case of cereal grains and oil fruits, by infected tissues of fallen animals picked up by the combine from the field.	Feed materials used for commercial manufacture of pellet feed are usually stored in closed bins or facilities before they are used in the manufacturing. The storage duration of feed ingredients in feed mills is usually a few days for feed materials and can be 2–3 weeks for premixtures. To produce pellet feed, mash feed is conditioned with steam at temperatures ranging between 80 and 120°C for periods of time ranging from a few seconds to up to 2 min, before passing through the pelleting dies where feed is subject to high temperatures (around 80°C), pressure and friction forces.	Pellets are used as feed or as part of compound feed. Compound feed is usually delivered to farms or intermediates within few hours following its manufacturing. On-farm storage of the compound feed will usually be in specific silos/ bins, or in small (e.g. 40 kg) or big bags. The storage on the farm can vary between a few days and 15 days. The temperatures reached in the bags/silos will depend on the ambient temperature.

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/ trade
Bedding material	Straw	Dry stalks of cereal plants after the grain and chaff have been removed	Wikipedia	Contamination of the cereal stalks used in the straw may take place shortly before or after cutting and before baling by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood) or, in the case of cereal grains and oil fruits, by infected tissues of fallen animals picked up by the combine from the field.	The stalks of cereal plants are cut and dried and gathered into bails of various sizes.	Straw is used as bedding or enriching material.
Bedding material	Sawdust/ woodchips	By-product of cutting wood logs in sawmills	Wikipedia	Contamination of the wood logs used for production of saw dust and woodchips may take place before or after cutting of the logs by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood).	Saw dust and wood chips are often stored in piles. Self-heating of piles may occur. The temperatures reached during self-heating depend on the amount of radiation, nutrient content of the wood or chips and their residual humidity. Temperatures in the piles may reach 60–80°C within 24 h, with elevated temperature being maintained for weeks and ambient temperatures being reached after several months.	Saw dust and wood chips are used as bedding material.

Product category	Product	Definition	Reference for definition	Ways the product can be contaminated with ASFV	Handling of the product before export/trade to non-affected areas	Use of the product in non-affected areas after import/trade
Bedding material	Turf	Accumulation of partially decayed vegetation or organic matter	Wikipedia	Contamination of turf may take place before harvesting by infected wild boar shedding ASFV in their excreta such as faeces, urine, oral fluid (with or without blood).	Milled peat collected from peat bogs during the dry season is stored in bales near collection fields or transported to storage sites. In Northern latitudes, the material is collected and stored outdoors in bales during summer months (commonly from May to September). After drying, the bales are often covered with plastic covers to protect them from rain and erosion, and to avoid self-ignition. Generally, a low pH (3.5–5) and temperatures of 40°C are reached in peat piles or bales. From the bales, the turf is transported to processing or packing plants according to the demand. The turf for agricultural use is exported in 'big bags'. After filling, these bags are usually stored at the plant territory for several weeks (sometimes months) before being shipped. However, in case of high demand, the shipping may occur in 24 h after transportation of the material from the storage place near the turf field to the packing plant.	Turf is used as bedding or enriching material.

Vehicles for live pig transport

The EKE considered livestock vehicles taking pigs into affected areas and returning empty to free areas. Adapting the proposed framework, the key pathways considered for vehicles in the EKE were the probability of effective exposure (q) and the number of effective exposures in a pig herd per year (m):

- Probability of effective exposure (q)
  - Vehicle contamination
    - Probability that the vehicle is contaminated with infectious ASF virus in affected area
  - Survival during transport, given vehicle contamination
    - Probability that ASF virus survives transit from affected to non-affected area, given contamination
  - Effective exposure, given vehicle contamination and survival during transport
    - Probability that pigs are exposed to infectious ASF virus, given pig farm visit by eligible vehicles
- Number of effective exposures in a pig herd per year (m)
  - Volume/frequency
    - (Average) number of times that eligible vehicles will visit pig farms in the non-affected areas

B.2.3. Definition of small and large pig farms

The average number of pig farms receiving a farm delivery that contains material from one consignment of a specified product entering the non-affected area of the EU will vary, amongst other husbandry-related practices, on the average pig farm size in the EU MS. Therefore, using EUROSTAT data on farm sizes, two strata of pig farms were defined:

- **Small-scale pig farms:** pig farms with less than 100 pigs (or less than 50 breeding sows)
- **Large-scale pig farms:** pig farms with 100 or more pigs (or 50 or more breeding sows)

In addition, it was assumed that biosecurity measures are more strictly implemented in larger farms, which will impact the probability of exposure of the product to pigs.

B.2.4. Literature review and public consultation results

An extensive literature review was performed to retrieve scientific papers studying the survival time of ASFV in different matrices. This information, together with other information collected on the processing procedures of the different matrices that could potentially inactivate ASFV and information received during the public consultation was compiled in an evidence dossier used to inform the EKE experts prior to the EKE discussions.

B.3. EKE approach, steering group and facilitation

The AHAW WG on ASF proposed to perform three EKEs:

- 1st EKE: on the trade characteristics
- 2nd EKE: on the contamination
- 3rd EKE: on the farm exposure

For each EKE, a group of six to eight experts with the relevant expertise was established. In addition, a steering group was formed to define the protocol of the EKEs. The steering group consisted of scientific staff, selected working group members of the AHAW WG on ASF, EFSA internal elicitation specialists and administrative support staff.

The elicitation was organised and conducted by EFSA. For facilitation of the EKE discussions, an EFSA elicitor was used.

B.4. Methods for performing Expert Knowledge Elicitations

The three EKEs were carried out as virtual meetings with a combination of preparatory meetings, individual elicitations and group discussions following the Sheffield method.

B.4.1. 1st EKE on Trade Characteristics

B.4.1.1. EKE Questions

The following definitions have been used:

Table B.5: Definitions of terminology used in the EKE questions of the 1st EKE

Term	Definition
Consignment	'Consignment' or (import) trade unit identifies the single unit of a specified product that is not divided during trade from affected areas to non-affected areas.
Farm delivery	'Farm delivery' or (final) trade unit identifies the single unit of product containing a specified product at the point of arrival at a pig farm/herd.
(Regional strata)	See Section B.2.1 for the definition of affected areas in Europe and Eurasia. The EU is taken as EU27
(Matrices)	See Section B.2.2 for the definition of possible contaminated products and material (products)
(Farm sizes)	See Section B.2.3 for the definition of different pig farm types (farm sizes)

The definition of 'consignments' and 'farm deliveries' were revised during the 1st EKE. Possible alternatives are trade activities (number of imports/movements, etc.), transportation units (number of containers/lorries, etc.), trade units (pallets, bags, etc.). Definitions used may be specific to the specified origin and/or products. The interpretation of the product:

$$N_{\text{Consignments of product, j entering non-ASF area from area i}} \times N_{\text{Farms per consignment of productj from area I and farm size s}}$$

is the total number of farms in non-affected areas of the EU that are reached by products originating in affected areas in the coming 12 months.

The parameter is divided into two aspects to allow possible revision of the second part within the 3rd EKE, esp. for products, where primary use is not feed or similar.

Table B.6: Framing of the EKE question no. 1

Topic	Description
Parameter	$N_{\text{Consignments of product j entering non-ASF area from area i}}$ **Number of consignments** of *a specified product, j,* entering the non-affected area of the EU from *a specified affected area, i,* in the coming 12 months
Strata	Per product, j, and area, i
Question	How many consignments of [product] are expected to enter the non-affected area of the EU from [affected areas in Europe/affected area of Eurasia] in the coming 12 months? Transitional transport or re-export should be not considered.
Unit	[–]
Operationalisation	Every consignment of [product] sent from [affected areas in Europe/affected area of Eurasia] within the coming 12 months is traced forward to the location of its final use. Consignments used totally or partly in non-affected areas of the EU are counted.

Table B.7: Framing of the EKE question no. 2

Topic	Description
Parameter	$r_{i,j}$ **Proportion of consignments** of a *specified product, j,* entering the non-affected area of the EU from *a specified affected area*, i, **going to small scale farms**

Topic	Description
Question	On average, what proportion of the consignment of [product] entering the non-affected area of the EU from [affected areas in the EU/affected area of Eurasia] will be used in small scale farms?
Unit	[%]
Operationalisation	Every consignment of [product] sent from [affected areas in the EU/affected area of Eurasia] within the coming 12 months is traced forward to the location of its final use on small/large scale farms. The proportion used in small scale farms is calculated.

Table B.8: Framing of the EKE question no. 3

Topic	Description
Parameter	$N_{\text{Farms of size s per consignment of product j from area i}}$
	Average number of farms *of a specified size, s,* **that receive a delivery that contains material from a SINGLE consignment** of *a specified product, j,* entering the non-affected area of the EU from *a specified affected area, i.*
Strata	Per product, j, area, i and farm size, s
Question	On average, how many [small/large scale] farms will get material from a SINGLE consignment of [product] entering the non-affected area of the EU from [affected areas in the EU/affected area of Eurasia]? This factor comprises further merging or split of the consignment after entry the non-affected area of the EU, usage as ingredient in composite products.
Unit	[–]
Operationalisation	Every consignment of [product] sent from [affected areas in the EU/affected area of Eurasia] within the coming 12 months is traced forward to the location of its final use on [small/large scale] farm level. To calculate this parameter, the number of deliveries to farms that are reached by a full or a part of a single consignment are counted and the ratio of this number to the 'Number of Consignments' is calculated to get the average number of farms that receive a delivery from ONE consignment.

B.4.1.2. EKE Methodology

EFSA's Expert Knowledge Elicitation is a structured approach to retrieve expert judgements from a group of experts, especially selected for the question of interest. Questions are usually asking for a quantitative parameter; the expected answer includes the consensus of the group of experts and a description of their remaining uncertainties about their judgements.

The panel proposed to use a virtual version of the Sheffield methodology for the elicitation session. This methodology uses behavioural aggregation to find a consensus result. The sessions were led by a facilitator. In preparation, individual interviews were carried out to enrich the evidence dossier.

B.4.2. 2nd EKE on Contamination

B.4.2.1. EKE Questions

The definitions shown in Table B.9 were used in the second EKE.

Table B.9: Definitions of terminology used in the EKE questions of the 2nd EKE

Term	Definition
Consignment	'Consignment' or (import) trade unit identifies the single unit of a specified product that is not divided during trade from affected areas to non-affected areas.
Farm delivery	'Farm delivery' or (final) trade unit identifies the single unit of products containing specified products at the arrival at a pig farm/herd.
(Regional strata)	See Section B.2.1 for the definition of affected areas in the EU and Eurasia. The EU is taken as EU27
(Products)	See Section B.2.2 for the definition of possible contaminated products and material (products)
(Farm sizes)	See Section B.2.3 for the definition of different pig farm types (farm sizes)

Table B.10: Framing of the EKE question no. 4

Topic	Description
Parameter	$P_{Product\ j\ contains\ ASFV\ at\ origin\ in\ area\ i}$
Strata	per product, j, and area, i
	Proportion of consignments of *a specified product, j,* **containing ASFV** at the place of production at *a specified affected area, i*
Question	On average, how many out of 100,000 consignments of [product] from affected areas [affected areas of the EU/affected areas in Eurasia] in the coming 12 months will contain infectious ASF virus at origin?
Unit	[out of 100,000]
Operationalisation	Every consignment of interest will be perfectly tested at all borders to non-affected regions in the coming 12 months. The ratio of positive consignments and all consignments (times 100000) will give the unknown quantity. The proportion is defined on consignment level and not on production lot level. If a consignment consists of many production lots the portion of consignments is higher than on production lots.

Table B.11: Framing of the EKE question no. 5

Topic	Description
Parameter	$P_{Dose\ in\ product\ j\ from\ area\ i\ leads\ to\ infection}$
	Proportion of farm deliveries (resulting from a contaminated consignment and taking into account the splitting and/or mixing) of *a specified product, j, from a specified affected area, i,* which contain **at least one infectious dose** sufficient to cause an infection of at least one pig **on the farm of usage** in the non-affected area of the EU
Strata	**per product, j, and area, i**
Question	On average, how many out of 100,000 farm deliveries of a contaminated [product] will contain **at least one infectious dose of ASFV** sufficient to cause an infection of at least one pig **at the point of usage** in the non-affected area of the EU? This factor takes into account for further mixing, diluting, processing of the consignment after entry the non-affected area of the EU and usage as ingredient in composite products
Unit	[out of 100,000]
Operationalisation	Every farm delivery of a contaminated [product] will be perfectly tested for infectious doses at farm level in the coming 12 months. The ratio of positive farm deliveries and all deliveries (times 100,000) will give the unknown quantity.

B.4.2.2. EKE Methodology

EFSA's Expert Knowledge Elicitation is a structured approach to retrieve expert judgements from a group of experts, especially selected for the question of interest. Questions are usually asking for a quantitative parameter; the expected answer includes the consensus of the group of experts and a description of their remaining uncertainties about their judgements.

The panel proposed to use a virtual version of the Sheffield methodology for the elicitation session. This methodology uses behavioural aggregation to find a consensus result. The sessions were led by a facilitator. In preparation, individual interviews were carried out to enrich the evidence dossier.

B.4.3. 3rd EKE on Farm Exposure

B.4.3.1. EKE Questions

The definitions in Table B.12 have been used.

Table B.12: Definitions of terminology used in the EKE questions of the 3rd EKE

Term		Definition
Farm delivery		'Farm delivery' or (final) trade unit identifies the single unit of products containing specified products at the arrival at a pig farm/herd.
(Regional strata)		See Section B.2.1 for the definition of affected areas in the EU and Eurasia. The EU is taken as EU27
(Matrices)		See Section B.2.2 for the definition of possible contaminated products and material (products)
(Farm sizes)		See Section B.2.3 for the definition of different pig farm types (farm sizes)
$\mathbf{P_{\text{Product, j, comes into contact with pigs}}}$	**[%]**	**Proportion of deliveries to pig herds of *a specified product, j,* imported/traded to the non-affected area of the EU that will have contact with pigs (equal 1 for feed and bedding)**
$P_{\text{Product, j, enters a pig herd}}$	[%]	**Proportion** of farm deliveries of *a specified product, j,* imported/traded to the non-affected area of the EU that will totally or partly **reach a farm that contains at least one pig herd** (part of farms with pig production)

Table B.13: Framing of the EKE question no. 6

Topic	Description
Parameter	$P_{\text{Product enters a pig herd}}$
	Proportion of farm deliveries of *a specified product, j,* imported/traded to the non-affected area of the EU, that will totally or partly **reach a farm that contains at least one pig herd** (part of farms with pig production)
Strata	per product, j
Question	On average, how many out of 100 farm deliveries of [product] will be fully or partly delivered to a pig herd?
Unit	[%]/[out of 100 deliveries to farms]
Operationalisation	All farm deliveries of [product] with consignments entered non-infected regions of Europe will be followed within non-infected regions. When parts of a consignment reach a pig herd, that delivery will be counted. The ratio of counted and total delivery will give the unknown quantity.

Table B.14: Framing of the EKE question no. 7

Topic	Description
Parameter	$P_{\text{Product j comes into contact with pigs}}$
	Proportion of deliveries to pig herds of *a specified product, j,* imported/traded to the non-affected area of the EU, that will **have contact with pigs** (equal 1 for feed and bedding)
Strata	per product, j
Question	On average, how many out of 100 farm deliveries of [product] delivered to a pig herd will either fully or partly have contact with pigs?
Unit	[%]/[out of 100 deliveries to pig farms]
Operationalisation	All farm deliveries of [product] reaching a pig herd in non-affected regions of the EU will be followed also within the different zones of a pig farm. When parts of a consignment have contact to pigs, that delivery will be counted. The ratio of counted and total deliveries entered a pig farm will give the unknown quantity.

B.4.3.2. EKE Methodology

EFSA's Expert Knowledge Elicitation is a structured approach to retrieve expert judgements from a group of experts, especially selected for the question of interest. Questions are usually asking for a quantitative parameter; the expected answer includes the consensus of the group of experts and a description of their remaining uncertainties about their judgements.

The panel proposed to use a virtual version of the Sheffield methodology for the elicitation session. This methodology uses behavioural aggregation to find a consensus result. The sessions were led by a facilitator. In preparation, individual interviews were carried out to enrich the evidence dossier.

B.4.4. Methods for result reporting

B.4.5. Fitting the continuous distributions

For each elicited parameter an uncertainty distribution has been derived. A fitted continuous distribution function was used to allow the interpolation of percentiles, which were not directly elicited. This distribution has been used in probabilistic propagation of errors to calculate the final model results.

For each parameter and the final result, the fitting, the density function and the descending distribution function, as well as the theoretical formula have been documented.

A table of selected percentiles summarises the elicited parameters, the fair estimate (median: equally over- or underestimating), and different levels of remaining uncertainties, e.g. the 90% uncertainty range.

B.4.6. Reporting of uncertainties

Error propagation has been used to calculate the full uncertainty distribution of the assessment model for all products and areas of origin. A ranking has been done for the median estimates, boxplots show the remaining uncertainties of the ranking.

Annex C – Results of literature review and public consultation on unprocessed meat and processed meat products

C.1. Unprocessed meat

C.1.1. Pig carcasses

No data on ASFV survival in whole pig carcasses, i.e. the body of a pig after slaughter and dressing, were identified in the literature review. Data from studies on survival of ASFV in parts of a carcass, such as bones, fresh meat (cuts) and viscera of the abdominal and thoracic cavity organs are described in the specific sections below (Table C.1).

C.1.2. Fresh pig blood

ASFV has been demonstrated to survive for more than one year (525 days) in chilled (4°C) pig blood (Plowright et al., 1967). The survival of ASFV in pure blood (10^6 HAD_{50}/mL) after incubation for 1 h at different temperatures was studied by Fischer et al. (2020). The study showed that blood incubated for 1 h at 55°C or above (60, 65, 70, 75°C) was ASFV-negative as shown by haemadsorption test (HAT), while blood incubated for 1 h at 40, 45 and 50°C was ASFV-positive (Table C.1).

C.1.3. Fresh pork meat

ASFV was isolated from fresh whole and ground pork meat stored at 4°C for two days (McKercher et al., 1978). No further tests were carried out on these matrices at later stages of the experiment. The amount of blood present in fresh pork meat is very small once the meat cuts are prepared (Table C.1).

C.1.4. Organs (heart, intestines, kidney, liver, spleen)

It has been shown that ASFV can survive in frozen (–16—20°C) pig heart for at least 60 days (the length of the experiment) (Sindryakova et al., 2016). In untreated intestines stored at 4°C no viable ASFV could be detected after 2 weeks (at day 14) (Jelsma et al., 2019). In liver stored at room temperature (22–25°C), ASFV was shown to be viable on day 16 after the start of the experiment (first negative test on day 20), while the virus remained viable in frozen liver (–16—20°C) until the end of the experiment (60 days) (Sindryakova et al., 2016). In frozen spleen (–20°C and –70°C) the virus survived until the end of the experiment (735 days) (Plowright et al., 1967) (Table C.1).

C.1.5. Pig bones

Mebus et al. (1993) reported that bone marrow collected from experimentally infected pigs tested positive for ASFV between 84 days (bone marrow in Iberian ham shoulder) and 112 days (bone marrow in Iberian and Serrano ham) after the start of the experiment. McKercher et al. (1987) were able to isolate ASFV from bone marrow of Parma hams on day 94, but not on day 123 after the start of the experiment (72 h after slaughter) (Table C.1).

C.1.6. Pig fat

It has been shown that ASFV can survive for at least 60 days in frozen (–16—20°C) pig fat, while it could not be retrieved from chilled (4–6°C) pig fat on day 0 after spiking the matrix (Sindryakova et al., 2016) (Table C.1).

Table C.1: Survival time of ASFV as shown by virus isolation in unprocessed meat as reported in literature

Matrix	Storage temperature (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	ASFV Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Blood	Chilled (4°C)	nr	525	nr	735	nr	nr	nr	na	Plowright et al. (1967)
Blood	55°C, 60°C, 65°C, 70°C, or 75°C for 1 h	nr	0	nr	1 h	nr	nr	nr	na	Fischer et al. (2020)
Blood	40°C, 45°C or 50°C for 1 h	nr	Positive	nr	1 h	nr	nr	nr	na	Fischer et al. (2020)
Pork meat, whole	Chilled (4°C)	nr	2	na	2	nr	nr	nr	pH 5.6	McKercher et al. (1978)
Pork meat, ground	Chilled (4°C)	nr	2	na	2	nr	nr	nr	pH 5.6	McKercher et al. (1978)
Heart	Frozen (–16 to –20°C)	nr	60	na	60	nr	nr	nr	na	Sindryakova et al. (2016)
Spleen	Frozen (–20°C)	nr	735	na	735	nr	nr	nr	na	Plowright et al. (1967)
Spleen	Frozen (–70°C)	nr	735	na	735	nr	nr	nr	na	Plowright et al. (1967)
Liver	Room (23.5°C)	nr	16	20	60	nr	nr	nr	na	Sindryakova et al. (2016)
Liver	Frozen (–16 to –20°C	nr	60	na	60	nr	nr	nr	na	Sindryakova et al. (2016)
Pig bones[3]	nr	nr	84–112	140	> 140	nr	nr	nr	na	Mebus et al. (1993)
Pig bones	nr	nr	94	123	432	nr	nr	nr	na	McKercher et al. (1987)
Pig fats	Chilled (4–6°C)	nr	0	nr	60	nr	nr	nr	na	Sindryakova et al. (2016)
Pig fats	Frozen (–16 to –20°C)	nr	60	na	60	nr	nr	nr	na	Sindryakova et al. (2016)
Intestines	4°C	nr	7	14	60	nr	nr	nr	na	Jelsma et al. (2019)

nr: not reported; na: not applicable.
1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.
3: Bone marrow samples from Iberian ham, Serrano ham and Iberian shoulder.

C.2. Processed meat products

This section contains data from studies of processed meat products, i.e. products that have been subjected to processes that substantially alter the initial ‘raw’ product, such as heating, smoking, curing, maturing, drying, marinating, extraction, extrusion or a combination of those processes. Only categories of meat products that were studied in the experimental infection studies or virus survival studies identified in the literature review are described in this section.

C.2.1. Heat-treated processed meat

No viable ASFV was detected once heating had been completed for ham brined and heated to 69°C (McKercher et al., 1978). Canned stew pork produced by using long-term exposure to high temperatures did not yield any viable ASFV during 60 days of storage at 4–6°C, 2,225°C or −16 to −20°C (Sindryakova et al., 2016) (Table C.2). No data on other types of heat-treated processed meat were identified.

Table C.2: Survival time of ASFV as shown by virus isolation in heat-treated processed meat as reported in literature

Processed product	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	ASFV Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Ham brined and heated	69°C[3]	nr	na	na	na	nr	nr	nr	No virus was detected once heating had been completed	McKercher et al. (1978)
Canned stew pork	Frozen (−16 to −20°C)	nr	0	nr	60	nr	nr	nr	The virus was already inactivated during the production of canned stew pork[4]	Sindryakova et al. (2016)
Canned stew pork	Chilled (4–6°C)	nr	0	nr	60	nr	nr	nr	The virus was already inactivated during the production of canned stew pork[4]	Sindryakova et al. (2016)
Canned stew pork	Room temperature (20–25°C)	nr	0	nr	60	nr	nr	nr	The virus was already inactivated during the production of canned stew pork[4]	Sindryakova et al. (2016)

nr: not reported; na: not applicable.
1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.
3: Temperature was slowly increased so that in about 3.5 h, the internal temperature of the ham was 69°C.
4: Canned meat was prepared in compliance with the specification of RF State Standards (GOST 32125-2013 Canned stew meat) using long-term exposure to high temperatures.

C.2.2. Non-heat-treated processed meat

All studies about non-heat-treated processed meat identified in the literature review focussed on different cured products.

C.2.2.1. Immersion cured products

ASFV was detected for at least 60 days (i.e. throughout the duration of the experiment) in frozen (−16 to −20°C) and chilled (4–6°C) corned pork prepared using a wet salting method. In corned pork stored at room temperature, ASFV was last detected on day 16 of the experiment (Sindryakova et al., 2016).

Ham brined and stored at 4°C was found positive for ASFV 2 days after completion of processing (McKercher et al., 1978). No further tests were carried out (Table C.3).

C.2.2.2. Dry-cured products

Pork belly that had been cured for 14–21 days and pork loin cured for 60 days were positive for ASF virus at least 60 and 83 days of curing, respectively. The first ASFV-negative samples were detected 137 days after initiation of the curing process (Petrini et al., 2019) (Table C.3).

Salami cured for 27 days at temperatures ranging between 22°C and 12°C and a humidity between 77% and 99% last tested positive 18 days after the start of the curing process; the first negative test was 26 days of curing (Petrini et al., 2019). Salami smoked for 12 h at 32°C and for an additional 12 h at 49°C and a humidity of 72% tested negative after 30 days after the start of the curing process (McKercher et al., 1978) (Table C.3).

Pepperoni sausage smoked for 8 h at a temperature of 32.2–34.4°C and a humidity of 72% tested negative 30 days after the start of processing (McKercher et al., 1978) (Table C.3).

Iberian loin cured for 90–130 days tested negative for ASFV after 112 days of processing. Iberian Ham cured for 365–730 days, Iberian shoulder cured for 240–420 days and Serrano ham cured for 180–365 days tested negative for ASFV 140 days after the start of processing (Mebus et al., 1997) (Table C.3).

C.2.2.3. Other cured products

Frozen dry-salted pork fat (−16 to −20°C) was ASFV positive for at least 60 days. Chilled dry-salted pork fat (4–6°C) was ASF-genome negative by PCR as of day one after processing (Sindryakova et al., 2016). Due to the sample matrix containing components that were toxic for the cell culture, it was not possible to isolate virus from this sample (Table C.3).

Table C.3: Survival time of ASFV as shown by virus isolation in non-heat-treated processed meat as reported in literature

Product category	Processed product	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Immersion cured products	Corned pork	Frozen (−16 to −20°C)	nr	60	na	60	nr	nr	nr	Corned pork was prepared using meat of infected piglets, using a wet salting method	Sindryakova et al. (2016)
Immersion cured products	Corned pork	Chilled (4–6°C)	nr	60	na	60	nr	nr	nr	Corned pork was prepared using meat of infected piglets, using a wet salting method	Sindryakova et al. (2016)
Immersion cured products	Corned pork	Room temperature (20–25°C)	nr	16	nr	60	nr	nr	nr	Corned pork was prepared using meat of infected piglets, using a wet salting method.	Sindryakova et al. (2016)
Immersion cured products	Ham brined	4°C	nr	2	nr	Full processing time = 60 days	nr	nr	nr	No virus was detected beyond processing period	McKercher et al. (1978)
Dry-cured products	Pork belly	nr	nr	60	137	137	nr	nr	nr	Curing time: 14–21 days. ASFV was detected in the pork belly in the final product	Petrini et al. (2019)
Dry-cured products	Pork loin	nr	nr	83	137	137	nr	nr	nr	Curing time: 60 days. ASFV was detected in the pork loin in the final product	Petrini et al. (2019)

Product category	Processed product	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Dry-cured products	Salami	Combination of temperatures during curing	nr	18	26	137	nr	nr	nr	Curing time: 27 days. The virus was not recovered beyond the processing period.	Petrini et al. (2019)
Dry-cured products	Salami sausage	Smoked for 12 h at 32°C and for an additional 12 h at 49°C	72	9	30	30	nr	nr	nr	Tested negative 30 days after smoking	McKercher et al. (1978)
Dry-cured products	Pepperoni sausage	Smoked for 8h at a temperature of 32.2–34.4°C	72	8	30	30	nr	nr	nr	Tested negative 30 days after smoking	McKercher et al. (1978)
Dry-cured products	Iberian loin		nr	98	112	Curing time: 90–130	nr	nr	nr	na	Mebus et al. (1997)
Dry-cured products	Iberian Ham	Combination of temperatures during curing	nr	112	140	Curing time: 365–730	nr	nr	nr	na	Mebus et al. (1997)
Dry-cured products	Iberian shoulder	nr	nr	84	140	Curing time: 240–420	nr	nr	nr	na	Mebus et al. (1997)
Dry-cured products	Serrano ham	nr	nr	112	140	Curing time: 180–365	nr	nr	nr	na	Mebus et al. (1997)
Other cured products	Salted pork fatback	Frozen (−16 to −20°C)	nr	≥ 60	na	60	nr	nr	nr	Viable virus was detected for > 60 days (i.e. beyond the duration of the experiment)	Sindryakova et al. (2016)
Other cured products	Salted pork fatback	Chilled (4–6°C)	nr	0	nr	60	nr	nr	nr	na	Sindryakova et al. (2016)

nr: not reported; na: not applicable.
1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.
3: The fatback was processed by dry salting in compliance with the specifications of technology GOST 38-85 49 -Products of pork fatback.

C.2.3. Casings

Pork sausage casings stored at a mean temperature of 15°C or 12.3°C were positive for ASFV until the end of the experiment (30 days) (Dee et al., 2018, Stoian et al., 2019). The half-life of the virus in pork sausage casings was estimated to be 13.1 days (CI 95% 11.6–14.6) (Stoian et al., 2019). Casings in medium containing a 10% antibiotic mixture and stored at 4°C were positive 7 days after the start of the experiment and tested negative for the first time on day 14 (Jelsma et al., 2019) (Table C.4).

Table C.4: Survival of ASFV as shown by virus isolation in casings as reported in literature

Matrix	Temperature range (°C)	Humidity range (%)	Maximum number of days infectious virus was detected	First ASFV negative observation in days	Duration of the experiment in days	Half-life in days	LCI 95%[1]	UCI 95%[2]	Comment	References
Pork sausage casings	Room (12.3°C (mean))	74.1 (mean)	30	nr	30	13.1	11.6	14.6	na	Stoian et al. (2019)
Casings in medium	Chilled (4°C)	nr	7	14	60	nr	nr	nr	na	Jelsma et al. (2019)
Pork sausage casings	15°C (mean)	75 (mean)	30	nr	30	nr	4.4	nr	na	Dee et al. (2018)

1: LCI 95% Half-life in days for the lower limit of the confidence interval.
2: UCI 95% Half-life in days for the upper limit of the confidence interval.