VKM report: 2022:02

Importation of roughage to Norway – Implications for plant and animal health, zoonoses, and biodiversity

Opinion of the Scientific Committee of the Norwegian Scientific Committee for Food and Environment

Report from the Norwegian Scientific Committee for Food and Environment (VKM) 2022: 02

Importation of roughage to Norway – Implications for plant health, biodiversity, animal and human health

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18.02.2022

ISBN: 978-82-8259-376-2
ISSN: 2535-4019
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Cover photo: Colourbox

Suggested citation: VKM, Truls Nesbakken, Håvard Steinshamn, Iben Margrete Thomsen, Dean Basic, Thea Benedicte Blystad Klem, Tron Gifstad, Kyrre Kausrud, Kjetil Klaveness Melby, Lawrence Kirkendall, Christer Magnusson, Inger Måren, Mogens Nicolaisen, Åshild Taksdal Randby, Maria Stokstad, Siamak Yazdankhah, Micael Wendell, Angelika Agdestein, Hugo de Boer, Jacques Godfroid, Solveig Jore, Paal Krokane, Live Nesse, Knut Madslien, Trond Møretrø, Gaute Velle (2022). Importation of roughage to Norway – Implications for plant health, biodiversity, animal and human health. Opinion of the Scientific Committee of the Norwegian Scientific Committee for Food and Environment. VKM report 2021:02, ISBN: 978-82-8259-376-2, ISSN: 2535-4019. Norwegian Scientific Committee for Food and Environment (VKM), Oslo, Norway.

Importation of roughage – Implications for plant and animal health, biodiversity, and zoonoses

Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed three project groups consisting of nine VKM members from the Panels on Food, Plant Health, Biological Hazards and Alien Organisms and Trade in Endangered Species (CITES), three external experts, and three project leaders from the VKM secretariat, to address the Terms of Reference, requested by the Norwegian Food Safety Authority and the Norwegian Environment Agency. Five referees reviewed and commented the manuscript.

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The opinion has been assessed and approved by a group, comprising members from the Panel on Animal Feed, Panel on Plant Health, Panel on Animal Health and Welfare, the Panel on Alien Species and Trade in Endangered Species (CITES) and the Panel on Biological Hazards. These members were (in alphabetical order):

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Acknowledgment

VKM would like to thank the hearing experts Rune Lostuen (Felleskjøpet Agri) and Elisabeth Riskedal (Fiskå Mølle) for answering questions and providing the project group valuable import data on roughage from 2018. VKM acknowledges the referees Rolf Spörndly (Swedish University of Agricultural Sciences, SLU), Niklas Björklund (Swedish University of Agricultural Sciences, SLU), Karl Ståhl (Swedish National Veterinary Institute, SVA) Cecilia Hulten (Swedish National Veterinary Institute, SVA), and Anders Nielsen (NIBIO and Panel on Alien Organisms and Trade in Endangered Species (CITES) at VKM) for their valuable comments during critical review of the manuscript draft. VKM emphasizes that the referees are not responsible for the content of the final opinion

Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third-party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

Key words: VKM, risk assessment, Norwegian Scientific Committee for Food and Environment, Norwegian Food Safety Authority, Norwegian Environment Agency, animal health, animal diseases, zoonoses, antimicrobial resistance, plant health, phytosanitary safety, alien organisms.

Introduction

The heat wave and drought during the summer of 2018 caused crop failures in many areas of Norway, resulting in increased demand for imported animal feed in order to meet the needs of livestock producers. Importation of hay, straw, silage or other types of roughage from abroad could introduce novel pathogenic agents and harmful alien organisms.

Therefore, the Norwegian Food Safety Authority (*Mattilsynet*) and the Norwegian Environment Agency (*Miljødirektoratet*) jointly asked the Norwegian Scientific Committee for food and environment (VKM) for an assessment of importation of roughage to Norway and its implications for plant and animal health, zoonoses, and biodiversity.

The Norwegian Food Safety Authority will use the report in its supervisory work over companies that import roughage. The assessment will also help both the Norwegian Food Safety Authority and the Norwegian Environment Agency to provide the public and shareholders, particularly importers of roughage, with the best updated knowledge about the safe import of feed and provide guidance for risk-mitigating measures.

Methods

We conducted initial workshops to learn about the basic processes involved with producing, storing and transporting roughage, to identify relevant disease-causing microorganisms, and to help develop search terms for the literature survey. We also took contact with stakeholders, particularly importers of roughage, in Norway. The information gained was used to develop an extensive literature search.

This assessment includes quarantine pests listed in Annex I and II in the Regulation relating to plants and measures against pests; animal diseases listed in Annex A, B, and C of the Regulation on warning and notification of diseases in animals; and diseases which can be transmitted from animals to humans (zoonoses). The assessment also includes an evaluation of alien plant species that could be accidentally introduced to Norway with roughage and potentially affect biodiversity.

We have used a qualitative assessment and described level of confidence. uncertainties and data gaps. The assessment relays expert judgment from specialists within each scientific area.

The report underwent external expert review (peer review) followed by final commenting from an appointed group comprising members from several panels in VKM, prior to final approval and publication.

Results and conclusions

Probability for introducing pathogens by roughage to Norway

Plant pests listed in Annex I and II in the 'Regulation relating to plants and measures against plant pests'

Karnal bunt of wheat, *Tilletia indica*, was the only pathogen of relevance of those listed in Annex I and Annex II. There is hardly any import of hay and straw from countries in which the fungus is found. Unless this changes, we consider the probability of introduction to be low with low uncertainty.

The probability of introduction of any of the quarantine pests listed in Annex I and II is low, with low uncertainty, since the organisms are unlikely to survive harvesting, drying, and baling, plus transport.

Invasive alien plant species

It is difficult to know which plant species could potentially be introduced with roughage. Since hard-coated seeds can survive drying, baling and transport, we consider the probability for introduction of plant species via at least hard-coated seeds to be high with a low uncertainty. We find it difficult to draw conclusions about which species might be introduced and from which regions, and whether these plants are potential invasive alien plant species.

Pathogens related to animal diseases, zoonoses and antimicrobial resistance (AMR)

The probability of introduction by import of roughage to Norway is considered to be moderate for *Coxiella burnetii* (Q-fever), *Salmonella* spp., *Mycobacterium bovis, M. tuberculosis, M. caprae* and *M. avium* subsp*. paratuberculosis*. The probability of introduction to Norway via roughage of the other assessed animal and zoonotic pathogens and transfer of antimicrobial resistance is considered as low. However, introduction of these agents would have large consequences if they are introduced and established in Norway. There is high uncertainty regarding the conclusions in this assessment due to the lack of scientific documentation of the occurrence and survival of potential pathogens in roughage. It is also uncertainty related to whether negative consequences due to import will be discovered because some of the diseases have a long incubation period. Accordingly, it will be challenging to establish a causal association to the import.

In addition to evaluating import of specific pathogenic species to Norway, it is also important to consider specific serotypes or strains of species that are endemic in several countries outside Norway. This is particularly the case for *Salmonella.*

Relevant risk-reducing measures

Several risk-reducing measures are mentioned in the report. Among the most important are:

- A low water activity (a high dry matter content) and a low pH value will prevent pathogens from surviving in roughage.

- Compared to import from most other countries, importing from Sweden, Finland, and some regions of Iceland would lower the probability for introducing the assessed pathogens and diseases.

Sammendrag på norsk

Innledning

Hetebølgen og tørken sommeren 2018 førte til avlingssvikt i mange områder av Norge, noe som resulterte i økt etterspørsel etter importert dyrefôr for å dekke behovene til husdyrprodusenter. Innførsel av høy, halm, ensilasje (surfôr) eller andre typer grovfôr fra utlandet kunne introdusere nye sykdomsfremkallende organismer og skadelige, fremmede organismer. Derfor har Mattilsynet og Miljødirektoratet i fellesskap bedt Vitenskapskomiteen for mat og miljø om en vurdering av import av grovfôr til Norge og mulige ringvirkninger for plante- og dyrehelse, zoonoser og biologisk mangfold.

Mattilsynet vil bruke rapporten i sitt tilsynsarbeid med bedrifter som importerer grovfôr. Vurderingen skal også hjelpe både Mattilsynet og Miljødirektoratet til å gi publikum og interessenter, bl.a. importører av dyrefôr, best mulig informasjon om sikker import av fôr, og gi veiledning med hensyn til risikoreduserende tiltak.

Metoder

Vi gjennomførte innledende arbeidsmøter for å lære om de grunnleggende prosessene involvert i produksjon, lagring og transport av grovfôr, for å identifisere relevante sykdomsfremkallende mikroorganismer, og for å hjelpe til med å utvikle søkeord for litteratursøk. Vi tok også kontakt med interessenter, bl.a. importører av dyrefôr, i Norge. Informasjonen vi fikk ble brukt til å utvikle et omfattende litteratursøk.

Denne vurderingen omfatter karanteneskadegjørere oppført i Vedlegg I og II i «Forskrift om planter og tiltak mot skadedyr»; smitte til dyr vedrørende sykdommer oppført i Vedlegg A, B, og C til «Forskrift om varsel og melding om sjukdom hos dyr»; og sykdommer som kan overføres fra dyr til mennesker (zoonoser). Vurderingen inkluderer også en evaluering av fremmede plantearter som kan bli introdusert via grovfôr og som har potensiale til å påvirke biologisk mangfold.

Vi har foretatt en kvalitativ risikovurdering. Vi har beskrevet nivået av tillit (level of confidence) til risikovurderingen, og identifisert usikkerhet og datamangel. Vurderingen ble gjennomgått av eksperter fra hvert fagområde.

Dokumentet er vurdert av eksterne eksperter (peer review), etterfulgt av endelige kommentarer fra en oppnevnt gruppe bestående av medlemmer fra flere faggrupper i VKM, før endelig godkjenning og publisering.

Resultater og konklusjoner

Sannsynlighet for å introdusere smittestoff med grovfôr til Norge

Planteskadegjørere oppført i vedlegg I og II i «Forskrift om planter og tiltak mot planteskadegjørere»

Karnal bunt av hvete, forårsaket av sotsoppen *Tilletia indica*, var det eneste skadegjøreren av relevans av de som listes i Vedlegg I og Vedlegg II. Det er ikke import av høy og halm fra land der soppen finnes. Med mindre dette endrer seg, vurderer vi sannsynligheten for introduksjon som lav, med lav usikkerhet.

Sannsynligheten for introduksjon av karanteneskadegjørere oppført i Vedlegg I og II er lav, med lav usikkerhet, siden organismene sannsynligvis ikke vil overleve høsting, tørking og ballepressing, og transport.

Invasive fremmede plantearter

Det er vanskelig å vite hvilke plantearter som har potensiale til å kunne introduseres med grovfôr. Siden frø med hardt frøskall kan overleve tørking, ballepressing og transport, vurderer vi, at det er høy sannsynlighet og lav usikkerhet for at plantearter som har frø med hardt frøskall, kan bli introdusert. Det er imidlertid vanskelig å trekke konklusjoner om hvilke arter som kan introduseres og fra hvilke regioner, og om disse plantene er invasive fremmede plantearter.

Smittestoff som årsak til dyresykdommer, zoonoser og antimikrobiell resistens

Sannsynligheten for at *Coxiella burnetii* (Q-feber), *Salmonella* spp., *Mycobacterium bovis*, *M. tuberculosis*, *M. caprae* og *M. avium* subsp. *paratuberkulosis* introduseres via import av grovfôr til Norge, vurderes å være moderat. Sannsynligheten for at de andre dyre- og zoonotiske smittestoffene, som er omtalt i denne rapporten, introduseres via import av grovfôr anses som lav. Også sannsynligheten for overføring av antimikrobiell resistens via import av grovfôr anses som lav. Dersom disse smittestoffene og/eller mikrobiell resistens innføres og etableres i Norge, vil imidlertid konsekvensene bli store. Det er stor usikkerhet knyttet til konklusjonene i denne vurderingen, på grunn av manglende vitenskapelig dokumentasjon av forekomst og overlevelse av smittestoff i grovfôr. Det er også usikkerhet knyttet til hvorvidt negative konsekvenser ved import av grovfôr vil bli oppdaget, ettersom noen sykdommer har en lang inkubasjonsperiode. Det kan derfor være vanskelig å spore smitten til import av grovfôr.

I tillegg til å vurdere import av spesifikke sykdomsfremkallende arter til Norge, er det viktig å vurdere spesifikke serotyper eller stammer av arter som er endemiske i andre land. Dette er spesielt tilfelle for *Salmonella*.

Aktuelle risikoreduserende tiltak

Det er nevnt flere risikoreduserende tiltak i rapporten. Blant de viktigste er:

- Lav vannaktivitet (høyt tørrstoffinnhold), og lav pH-verdi vil hindre at smittestoff overlever i grovfôr.
- Import fra Sverige, Finland og noen regioner på Island vil redusere sannsynligheten for å introdusere smittestoff og sykdommer som er omtalt i rapporten, sammenlignet med import fra de fleste andre land.

Abbreviations and/or glossary

Abbreviations

4-MeI	4-methyl-imidazole
ARB	Antimicrobial resistant bacteria
ARGs	Antimicrobial resistant genes
AMR	Antimicrobial resistance
a_w	Water activity
CWD	Chronic Wasting Disease
EEA	The European Economic Area, consisting of the Member States of the European Union and three of the four countries of the European Free Trade Association (Iceland, Liechtenstein and Norway; excluding Switzerland).
EFSA	European Food Safety Authority
EHEC	Enterohemorrhagic *E. coli*
HPS	Hantavirus pulmonary syndrome
$NaNO_2$	Sodium nitrite
NaOH	Sodium hydroxide
NH_3	Ammonia
TSEs	Transmissible spongiform encephalopathies
VTEC	Verocytotoxin-producing *E. coli*

Glossary

Anaerobic	With respect to microbes, living and reproducing without oxygen. Oxygen is toxic to obligate anaerobes.
Benelux countries	The "Low Countries" of the coastal region of northwestern Europe, consisting of Belgium, the Netherlands, and Luxembourg.
Clostridia	A class of spore-forming anaerobic bacteria, some of which produce toxins that are harmful to humans.
Definitive host	The host in which a parasite becomes an adult and reproduces sexually (see Intermediate host).

Dry matter	With respect to fodder, the substances that would remain if all water was removed. Dry matter is an indicator of the amount of nutrients available in feed.
Ensiling	Can refer either to the storage process (putting silage into a storage container) or the process of fermenting green fodder.
Fennoscandia	The geographic peninsula including the Scandinavian peninsula (Norway and Sweden), the Finnish peninsula, and Karelian Russia).
Fodder	Feed material (for cattle and other livestock).
Fomites	Refers to things that can carry infection (clothing, tools, etc.).
Germination	Refers to the process by which an organism grows from a seed or a spore. The most common forms of germination include a seed sprouting to form a seedling and the formation of a sporeling from a spore. Thus, germination occurs primarily in plant and fungal species.
Hard seeded plant species	Physical dormancy is defined by the existence of water-impermeable "hard" seed coats that need to breached before the seed can absorb water and germinate. In nature, seed coats are usually ruptured due to attrition, fire or large temperature fluctuations, and this trait has been interpreted as a mechanism of seed dormancy (Paulsen et al. 2013). Hard seed is alive but has a thick seed coat that must be scarified, either mechanically, thermally or biologically, before it will germinate. Hard seed includes seeds which, because of hardness or impermeability, do not absorb moisture or germinate under prescribed tests but remain hard during the period prescribed for germination of the kind of seed concerned.
Haylage	Grass that is not completely dried and hence has a higher moisture content than hay or straw and a lower amount of dry matter (usually 50–65%).
Intermediate host	Hosts in which the intermediate stages of parasites live and reproduce asexually (see Definitive host).
Quarantine pest	In a European context, refers to those potentially invasive animals, plants and diseases of particular concern for agriculture, horticulture or native biodiversity. These are listed in Annex I and Annex II of the European Union's Council Directive 2000/29/EC and subsequent amendments.

	In In a Norwegian context these are listen in Annex I and II of the Norwegian Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests.
Invasive alien species	Harmful alien organism Alt.1 An organism spread, intentionally or unintentionally, through human activities to areas where they do not naturally occur. Alt 2 Alien Species (IUCN definition): a species, sub-species, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce.
Parasitosis	Infestation with or disease caused by parasites.
Pathogen	Broadly defined as an organism that causes disease.
Perennial	Used to refer to plant species where individuals grow for more than two years.
Roughage	A general term for coarse, fibrous feed material, especially hay and straw. Also used to denote fibrous indigestible material in vegetable foodstuffs which aids the passage of food and waste products through the gut.
Seed dormancy	The temporary inability of a viable seed to germinate under favorable environmental conditions.
Seed germination	The sum of events that begin with hydration of the seed and culminate in emergence of the embryonic axis (usually the radicle) from the seed coat.
Silage	Fermented, acidic feed material for livestock, usually fermented grasses, these sometimes augmented with a small amount of legumes such as clover or lucerne.
Third countries	All countries that are not included in the EFTA states (Iceland, Liechtenstein, Norway, Switzerland) and the EU.
Water activity (a_w)	Technically, the relation between the vapor pressure of the substance being measured and that of pure water. Water activity, then, is a relative measure of the moisture content of a substance.
Weeds	«A plant that is not valued where it is growing and is usually of vigorous growth" (Merriam Webster dictionary). The term

	‘weed’ is also applied to any plant that grows or reproduces aggressively or is invasive outside its native habitat (Janick 1979). Taxonomically, the term ‘weed’ has no botanical significance, because a plant that is a weed in one context is not a weed when growing in a context where it is wanted.
Zoonotic	Refers to animal diseases that can be transmitted to humans (zoonoses).

Background as provided by the Norwegian Food Safety Authority and the Norwegian Environment Agency

The heat wave and drought during the summer of 2018 caused crop failures in many areas of Norway, resulting in increased demand for imported animal feed used to meet the needs of livestock producers. Importation of hay, straw, silage, or other types of roughage from abroad may introduce novel pathogenic agents and harmful, alien organisms.

In the summer of 2018, The Norwegian Food Safety Authority (NFSA) requested two preliminary assessments of imports of hay, straw and other types of roughages from the EU and third countries, concerning the risks to animal- and plant health. The assessments were performed by Norwegian Veterinary Institute (NVI) and Norwegian Institute of Bioeconomy Research (NIBIO). Based on these assessments, the NFSA advised against importing roughage from regions in which, for example, African swine fever is present. The new Animal Health Regulation, taken in effect July 2018, requires animal keepers to strengthen preventive control measures for infectious diseases. Despite the need to improve preventive animal health care, Norway cannot stop the import of feed, based on animal health considerations, from countries within the European Economic Area (EEA). There are, however, more regulatory options concerning imports from third countries. The Regulation on additional requirements relating to importation of hay and straw as animal feed (In Norwegian: Forskrift om tilleggskrav ved import av høy og halm til dyrefôr), taken in effect October 2018, requires the product to be stored in the exporting country for at least two months. It also requires that the product is harvested from areas that have not been fertilized with manure during the last two years. The regulation further stipulates that a certificate is required, where an official veterinarian in the exporting country confirms the product has been harvested from regions free of restrictions due to contagious animal disease.

The NFSA can only provide guidance based on current knowledge to importers or livestock producers. From a plant health perspective, national requirements concerning importation of roughage from all countries (including the EU) may be requested (as the plant health area is not part of the EEA Agreement), as long as the request is justifiable scientifically, and supported by evidence in a risk assessment. The NFSA thus needs a more complete assessment addressing plant and animal health and zoonotic diseases. This will help the NFSA provide the public with the best possible information about the safe import of feed and provide guidance for risk-mitigating measures.

In addition to containing pathogenic agents and plant pests, imported feed may also lead to the introduction and establishment of alien organisms, with potentially adverse consequences for biodiversity in Norway. The Regulation relating to alien organisms (In Norwegian: Forskrift om fremmede organismer) does not regulate the importation of feed. However, Chapter V of the regulation requires caution by anyone engaging in activities that may result in the unintentional spread of alien organisms. The Norwegian Environment Agency needs a solid foundation of knowledge in order to provide better guidance to businesses and individuals about how to best practice caution in the importation and use of foreign roughage. Information may include, among other things, differences in risk levels, based on the countries/areas from which importation occurs, and relevant measures for reducing identified risks. Import of roughage in 2018 has been conducted by individuals and businesses with varying capacities to implement comprehensive measures (freezing, burning, isolating, etc.). For this reason, an assessment is requested about whether there are less resource-demanding measures available.

Terms of reference

The Norwegian Food Safety Authority and the Norwegian Environment Agency request the following from the Norwegian Scientific Committee for Food and Environment (VKM).

1. Based on the situation in 2018, provide an overview of the types of roughages that are relevant for import into Norway, measures of treatment, import volumes, as well as relevant exporting countries (EEA and third countries).
2. Assess the probability for introducing quarantine pests listed in Annex I and II in the Regulation relating to plants and measures against pests.
3. Assess the probability of introducing contagions to animals concerning diseases listed in Annex A, B, C of the Regulation on warning and notification of diseases in animals. The assessment shall include livestock, i.e. cattle, sheep, pig, horse, poultry, wild animals and pets.
4. Assess the probability of introducing contagions to humans concerning relevant zoonotic diseases not addressed in question 3.
5. Assess possible negative effects on biodiversity following introduction of harmful, alien organisms. The scope of organisms to be included in the assessment can be redefined during the project period, based on questions 2-4.
6. Regarding questions 2-5, VKM is requested to examine possible differences between various types of roughage and feed from different countries of origin.
7. Identify and assess possible measures of risk reduction and their consequences. This includes:

    a. Relevant measures from the producer, exporter, during transport and storage at the producer and/or from the final recipient in order to reduce the probability of introducing harmful, alien organisms. Also assess the consequences from these measures.

    b. Relevant measures from the importer and/or final recipient should harmful, alien organisms be found in the imported feed.

    c. The Norwegian Food Safety Authority advises against importing roughage from countries in which African swine fever is present. If this import occurs nonetheless, describe possible measures that can be performed in order to reduce the probability of introducing the pathogenic agent to Norway.

    d. Relevant measures of risk reduction to reduce the probability of introducing pathogenic agents or plant pests.

Limitations: GMO, chronic wasting disease, quarantine pests from Appendix 1 and 2 in the Regulation on plant health.

Methodology and Data

Data and information gathering

Data on the import of hay and oats were obtained from Statistics Norway (SSB, 2021). Importers of roughage, like Felleskjøpet and Fiskå Mølle, were also contacted by VKM to provide the working group with additional information. These hearing experts were sent a set of questions by email (April, 2021) concerning exporting countries, types of silage, details on packaging etc. The full list of questions and answers are available in Appendix II.

Literature search and selection

Literature searches for retrieving the scientific documentation for this opinion were conducted by the members of the project group in a number of literature data bases, including ISI Web of Knowledge, AGRIS, Science Direct, CAB Abstracts, PubMed and Google Scholar. Searches were performed separately for the different types of plant pests and harmful alien organisms included in the assessment. Search terms included "insects", "mites", "nematodes", "weeds" and the plant pathogens "fungi", "Oomycetes", "protozoa", "bacteria" and "viruses". Similar searches were performed separately for different types of animal health threats and zoonotic agents, including the search terms "bacteria", "virus", "prions", "fungi", "protozoa" and "parasites". A more general search for roughage was also included in the assessment with the search terms "pathogen", "alien", "contamination", "manure", "survival" and "silage". The searches were conducted between January 2021 and October 2021. Articles were not excluded on the basis on their date of publication. The main focus of the literature search was to provide information on association of types of roughage with types of pests and harmful alien organisms, as well as animal health threats, zoonoses and more general information on roughage. References that did not relate to the terms of reference were excluded.

If relevant references were identified (e.g., in article reference lists) that had not been previously found in the main search, these were also included. Literature was also retrieved by members of the project group that they were aware of, due to their expertise on the subject. Information from websites, workshops or unpublished grey reports were also included if relevant to the mandate. The assessment is relaying on expert judgment from experts within each scientific area.

Ratings of probabilities and uncertainties

The description of each rating is given in table 1-4 of the current opinion. Ratings and descriptors are modified from EFSA (European Food Safety Authority) Guidance on Uncertainty in EFSA Scientific Assessment (2018) as well as from Appendix E in: EFSA PLH Panel (EFSA Panel on Plant Health) (2015)

Table 1 Rating of probability of association with the pathway at origin

Rating	Descriptors
Low	The likelihood of association would be low because: • prevalence is zero or low
Moderate	The likelihood of association would be moderate because: • prevalence is moderate
High	The likelihood of association would be high because: • prevalence is high

Table 2 Ratings used for describing the level of uncertainty

Rating	Descriptors
Low	No or little information or no or few data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used.
Medium	Some information is missing, or some data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used.
High	Most information is missing, or most data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.

Table 3 Rating of the probability of introduction

Rating	Descriptors
Low	The likelihood of introduction would be low because: • the pathogen or organism cannot survive during transportation or storage
Moderate	The likelihood of introduction would be moderate because: • It may occur, but is somewhat more likely that it will not occur
High	The likelihood of introduction would be high because: • It is assumed that the pathogen or organism survive during transportation or storage

Table 4 Ratings used for describing the level of consequences after introduction

Rating	Descriptors
Low	Consequences of introduction of the pathogen would be small to moderate for certain producers and geographical areas. It will be relatively easy to control and/or eradicate the disease.
Moderate	Consequences of introduction of the pathogen would be severe for certain producers and geographical areas, but to a lesser degree to the livestock industry and society. It can lead to high morbidity/mortality locally and it can be difficult to control and/or eradicate the disease.
Large	Consequences of introduction of the pathogen would be severe for the livestock industry and society. It can lead to high morbidity/mortality, and it can be difficult to control and/or eradicate the disease

Other related risk assessments

Microbiological risk assessment in feeding stuffs for food-producing animals (EFSA, 2008).

The risk assessment from EFSA did not focus on roughage, and "roughage" was only mentioned once, on page 6: "Compound feeding stuffs are not the only source of feed in the Community. Cereals provide an important contribution to the rations. Grazing animals feed on forage and **roughage**. The presence of certain microorganisms such as *Salmonella* in compound feeding stuffs can often be traced back to feed materials, although cross-contamination in storage, transport and processing is not excluded».

Some of the conclusions in this report were:

- Currently, data on the control of microbiological contamination of imported feed materials as source is limited.
- *Salmonella* is the major hazard for microbial contamination of animal feed. *Listeria monocytogenes, Escherichia coli* O157 and *Clostridium* spp. are other pathogens, but far less important, for which feed is regarded a hazard. In addition, antimicrobial resistant bacteria, or antimicrobial resistance genes can be transmitted via feed.
- Data of *Salmonella* contamination in forage is scarce, and in most studies non-processed cereals are reported to have a low prevalence of *Salmonella*, while available data demonstrates that non-processed soybeans are often contaminated with *Salmonella*.
- This opinion focuses on industrial compound feed as the feed group with the highest risk for becoming contaminated by *Salmonella*

Preliminary risk assessments on animal diseases from the Norwegian Veterinary Institute

There are two preliminary risk assessments regarding roughage from the Norwegian Veterinary Institute (Veterinærinstituttet, 2018a; Veterinærinstituttet, 2018b). The first risk assessment addresses roughage from the EU and third countries, while the second has focus on imports of roughage from Iceland, Canada and the USA. These risk assessments recommend that the NFSA and other authorities implement the necessary measures to prevent unwanted infection in connection with the import of roughage. The conclusions from these risk assessments are discussed and taken into account in this opinion.

Assessment

Introduction

1.1 What is roughage

Roughage is coarse, fibrous fodder low in energy concentration (Landbruksordboka, 1974). The dictionary divides roughage types according to the dry matter content. Examples of roughage with low dry matter content are silage and grazed grass, whereas hay and straw are examples of feed types with high content of dry matter. Forage is a term used partly interchangeably with roughage, edible parts of plant that can be used as feed or grazing animals or that can be harvested for feeding (Allen et al. 2011), but not including cereal straw. Although the energy value of roughage is usually lower than in grain and concentrate feed mixtures, grazed grass and silage can have a high energy value, but with high variation.

Norway's total agricultural area comprises ca 1 million ha, 2/3 of which is used for the cultivation of grass as temporary pastures (leys), meadows and permanent pastures (https://www.ssb.no/jord-skog-jakt-og-fiskeri/jordbruk/statistikk/gardsbruk-jordbruksareal-og-husdyr). About 24% of the total grassland area is only used as permanent pastures, whereas the rest is mainly harvested and preserved to be used as winter feed. Of the grassland area that is harvested and preserved, 80% of the harvest is ensiled as silage in round bales, 18% is ensiled in bunker silos or tower silos, and 2% is dried into hay (https://www.ssb.no/jord-skog-jakt-og-fiskeri/artikler-og-publikasjoner/gode-engavlingar-i-2019). From 1% of the agricultural area, arable crops, such as small grain, are harvested and preserved as silage. Parts of the straw from cereal cultivation are collected and used as feed. Statistics on how much straw goes to feed are difficult to find, but in a report from 2012, the annual use of straw as feed was estimated to be 31 000 tonnes, which was about 4% of the total straw production (Riley et al., 2012). The use of straw as a feed depends on the grass yield in that particular year, and more straw is used as feed during dry years.

In the last update from the Norwegian dairy cooperative TINE on the composition of feed ratios for dairy cows, grass silage accounted for 45.3%, silage of annual crops 0.2%, pasture and fresh grass accounted for 10%, hay 0.2% and alkali treated straw 0.1% of the net energy intake on average across all herds (TINE, 2014). We do not have similar statistics for other groups of ruminants. However, based on statistics from SSB on how grass crop is preserved, there is reason to believe that grass silage is the most important type of forage for other cattle, sheep, goats, and horses.

According to the statistics for forage import, the dry feed types hay and straw are the main import commodities in Norway. Before the drought in 2018, 10 000 – 30 000 tonnes of hay were imported annually from 1988 to 2017. From 2007 to 2017, 1000 – 2000 tonnes of straw were annually imported. Hay is largely imported from Sweden and straw from Denmark. In comparison, the annual grassland yield harvested was estimated to be 2 807

000 tonnes hay equivalent for the period 1999 – 2003 (https://www.ssb.no/jord-skog-jakt-og-fiskeri/jordbruk/statistikk/potet-og-grovforavlingar). That is, the import of forage usually accounts for less than 1% of the total grass crop that is harvested and preserved domestically for silage or hay.

In the next subsection, we will explain various preserved types of roughage and the principles of conservation.

1.1.1 Silage

Silage or ensilage is grass or other feed crops that are harvested and preserved at low dry matter content (generally < 500 g of dry matter/kg) by organic acids produced during fermentation (Allen et al., 2011).

1.1.1.1 Harvesting systems

Ensiling can be done in silo systems, such as bunker and tower silos, horizontal stack silos directly on the ground, round bales and square bales wrapped in plastic individually or in tubes, or as large machine-stacked silage tubes. Previously, it was common practice to harvest grass crops directly, without wilting, using a flail harvester that also macerated the crop and filled it into a trailer. The content was transferred directly from the trailer into silos. Today, the grass is most often harvested using a mower, spread to wilt and raked into windrows before being picked up. Sometimes the grass is spread out to achieve faster drying, and some mowers have conditioners that crimp and crush the grass or have equipment that spreads the grass to improve drying. For preservation in silos, the grass is collected with a forage harvester, either self-propelled or towed and powered by a tractor, or with self-loading forage wagons towed and powered by a tractor. The forage harvesters are equipped with chopping devices. The grass crop is transported to the silo where it is spread in thin layers and compacted. In bunker silos, tractors or wheel loaders are used to compact the grass crop. For tower silos, a combined machine for filling and unloading (*fylltømmer*) is most often used today. The equipment both fills and spreads the grass crop into the silo, and later unload silage for feeding. After the silo is filled, the surface is covered with two or more plastic sheets to protect against air.

During ensiling in bales, the windrows are picked up using either a round or a square baler. Newer round balers, so-called combi balers, both press and wrap the round bale directly into plastic. Otherwise, separate balers and wrappers are used. Stretch film of different types and qualities are used. Wrapping pattern and number of layers on each bale vary. The required number of plastic layers to ensure that the package becomes sufficiently airtight depends on the material pressed (how dry and rigid it is), the storage temperature, and the storage time before use. The most common for moist grass crops is eight layers of plastic, while more is often needed, e.g. 12–16 layers, for strongly dried grass material to be used for horse feed. When silage wrapped in plastic is sold, and is to be transported to the recipient, extra layers of plastic are needed to avoid damage to the plastic cover during transportation. Also, the equipment used for loading and unloading of trailers must allow careful handling, and persons carrying out this work must be well trained. Animal feed that is spoiled due to damaged plastic during transportation is a common source of conflict between seller and recipient and can cause disease in animals.

1.1.1.2 The ensiling process

The main principle of ensiling is rapid lowering of the pH with lactic acid fermentation, and to prevent air access (Pahlow et al., 2003). On fresh grass, there is a variety and mixture of bacteria, yeasts and molds. Under anaerobic conditions, lactic acid bacteria will dominate in the grass mass and use sugar in the grass as an energy source and produce lactic acid. If the process is successful, the pH will be lowered to 3.8–5.0, depending on the initial moisture content of the grass mass (Figure 1). The preservation occurs by lowering the pH so that it prevents microbial activity.

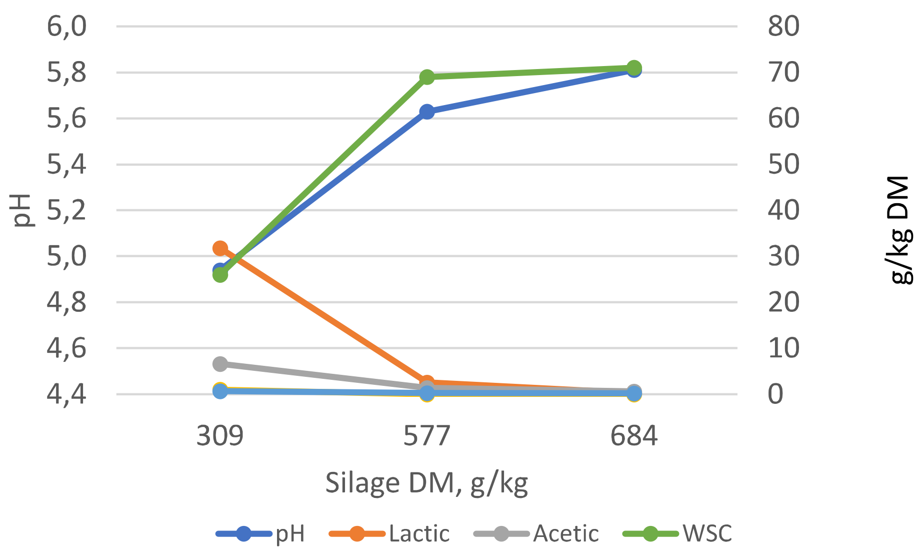

Figure 1 The relationship between crop dry matter (DM) concentration at ensiling and pH, and concentrations (g/kg DM) of lactic acid (Lactic), acetic acid (Acetic), and water-soluble carbohydrates (WSC) in silage (data from (Muller and Uden, 2007).

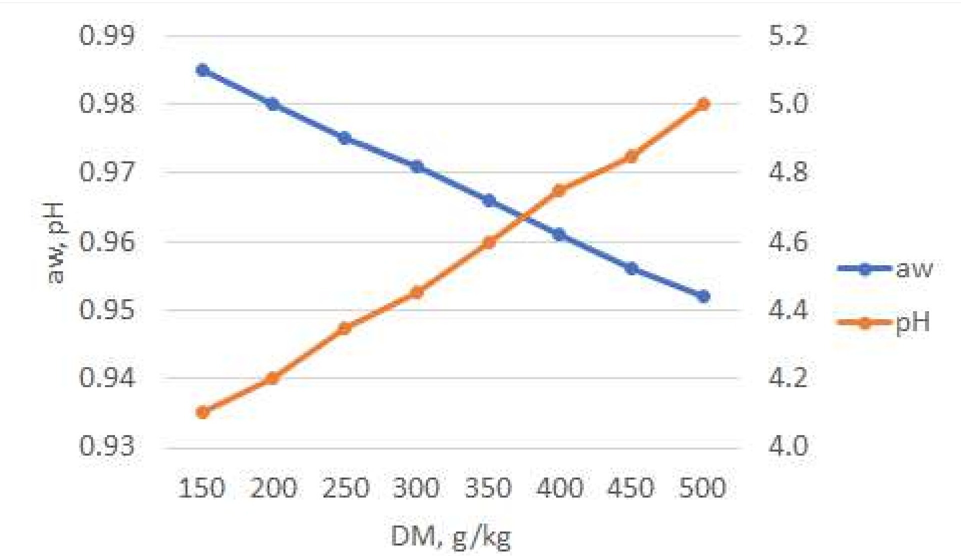

Figure 2 Maximum pH for anaerobically stable silage as influenced by dry matter content (after (Weissbach, 1996)

The pH that prevents growth of clostridia and enterobacteria depends on DM concentration of the crop and water activity (a_w). The required pH and water activity for anaerobic stable silage is illustrated in Figure 2.

Silage production can be split into four phases: 1) aerobic immediately after harvesting when the grass is still respiring and developing heat, 2) the fermentation phase, 3) the stable phase of the silo and 4) the feeding when the silo or round bale is opened and the silage again is exposed to air before feeding (Wilkinson and Davies, 2013). Loss of dry matter and feed quality can occur during all phases. An important precondition for successful fermentation and low loss of dry matter is to lower the oxygen level in the grass mass. Therefore, it is important to chop and compress the mass quickly and vigorously to increase the density of the mass as much as possible (Borreani et al., 2018). When the grass is cut, collected, compressed, and sealed in silos or in round bales, obligate aerobic and acid-sensitive microbes will not survive, or will not be able to grow, since oxygen is excluded and the production of lactic acid lowers pH. Drying the grass after cutting, prior to ensiling, reduces the loss of dry matter in the form of effluent. Drying also inhibits the growth of unwanted microorganisms that damage the feed quality and that can be harmful to health for animals and humans (Borreani et al., 2018; Muck, 1988).

Silage additives can be used to facilitate fermentation or ensure that it progresses as desired. Such additives can roughly be categorized as those that stimulate fermentation (e.g., are favorable for selected, effective lactic acid producing bacteria); those that act restrictively on fermentation; and additives that inhibit aerobic degradation. Examples include additives consisting of only homofermentative lactic acid bacteria, only obligate heterofermentative lactic acid bacteria, or a mixture of these types (Muck et al., 2018). The homofermentative lactic acid bacteria produce only lactic acid and lower the pH quickly. The obligate heterofermentative lactic acid bacteria, *Lactobacillus buchneri,* can use lactic acid produced during fermentation as a substrate and convert it into acetic acid and 1,2-

propanediol during the storage period. This increases the aerobic stability of the silage, which is important after the silo is opened and the feed is exposed to air. Homofermentative and obligate heterofermentative lactic acid bacteria are therefore added to rapidly lower the pH and to improve aerobic stability.

Enzymes, such as cellulase or hemicellulase, can also be used as a means of stimulating fermentation. The enzymes break down cell walls in the plant mass and therefore increase the availability of sugar for the lactic acid bacteria. Enzymes are usually used in combination with lactic acid bacteria.

Adding formic acid provides rapid lowering of the pH of the grass mass by direct acidification. It inhibits grass from respiration, and thereby preserves sugar in the grass crop and keeps the temperature down. Formic acid restricts the fermentation by reducing the pH, but favors the growth of lactic acid bacteria, which is the least pH sensitive bacteria in the competing flora in the fresh grass crop. Restrictive fermentation with formic acid addition means that a larger part of the water-soluble sugar in the grass mass is preserved, and the content of acetic acid and the breakdown of protein decrease (Seppälä et al., 2016). While formic acid has no inhibitory effect against fungi, propionic acid can inhibit the undesired production of ethanol by yeast, which may otherwise occur in silage rich in sugar. This effect of propionic acid increases with decreasing pH. Acid-based additives consisting of a mixture of formic and propionic acids are often used. In high concentration, propionic acid can inhibit aerobic growth of mold fungus to some extent.

High dry matter levels make it difficult to compress the crop and remove the air from the grass mass, both in baling and in silos. Various additives can be used to improve aerobic stability when the silage is exposed to air. Some organic acids, such as sorbic, propionic, benzoic and acetic acids, inhibit the growth of yeast, mold fungus and bacterial spores (Knický and Spörndly, 2009). So do some salts, such as sodium nitrite ($NaNO_2$) and hexamine ($(CH_2)6N_4$). Hexamine, under acidic conditions, turns into formaldehyde, which in turn protects the proteins from microbial degradation. Commercial chemical silage additives often contain a mixture of active ingredients that prevent the emergence of harmful bacteria and fungi as much as possible. Sodium nitrite can increase the formation of toxic nitrite gases, and should therefore mainly be used in bales, only with great caution in bunker silos, and never in tower silos (due to the difficulties in proper ventilation). The hazard by using sodium nitrite is mainly relevant on farms during the first hours, days and weeks following ensiling, and may most likely not be a problem for the receiver when forage is unloaded for sale more than two months after ensiling.

1.1.2 Haylage

Haylage is grass ensiled at high dry matter concentration, generally between 500 and 850 gof dry matter/kg (Allen et al., 2011). Although grass for haylage can be harvested at an early phenological development stage, it is most often harvested late, similarly as hay (Harris et al., 2017). The main principle of preservation of haylage is the same as for silage. Due to the high dry matter content, silage fermentation becomes restrictive. This means that the pH and the content of water-soluble sugars are higher and the content of lactic acid and other fermentation products lower in haylage than silage. Haylage is mainly preserved by a combination of drying and airtight storage, rather than lactic acid fermentation and pH lowering. However, the water activity is not low enough to prevent the growth of molds and yeast. It is therefore crucial that the haylage is stored under airtight conditions until it is used for feeding. Haylage is therefore produced by compressing the dried grass material into square bales or round bales and wrapped in plastic layers. More layers are needed for haylage than for round bale silage, because of increased risk of the plastic getting perforated, due to high dry matter content, as well as harvesting at late stages of development with rigid straws and stems in the plant mass (Harris et al., 2017). According to a Swedish-Norwegian field study, the risk of finding molds in round bale silage was greater if less than eight layers of plastic were used, and with a high dry matter content in the feed (Schenck et al., 2019).

The main challenge with preserving forage as haylage is primarily aerobic stability after the plastic has been removed (Müller, 2018). In Finnish studies, the addition of propionic acid or sodium benzoate ($NaC_6H_5CO_2$) improves aerobic stability (Jaakkola et al., 2010; Särkijärvi et al., 2012).

1.1.3 Hay

Hay is harvested grass that is preserved by drying to a dry matter content of more than 840 g/kg and a water activity less than 0.7, at which stage it can be stored without microbial deterioration (Gregory et al., 1963; Lacey, 1989). Hay is usually made from grass harvested at a late phenological development stage. The same type of mowing and raking equipment is used as for harvesting grass for silage and haylage. Most often, the cut grass is spread several times mechanically before being raked together in windrows. The hay in windrows can be picked up by a self-loading forage wagon and unloading conveyor. Then, it will be transported to storage rooms or hay dryer. Hay can be stored in an airy storage room, but most often loose hay is laid on a hay dryer, where a fan is used to blow air through a distribution system until it is dry enough for storage. Dry hay can also be baled directly in the field. For further sale, loose hay is most often pressed in square bales. Condensation, due to fluctuations of temperature and humidity, may moisten outer layer of stored hay in bales and induce a risk of mold growth (Sundberg and Artursson, 2012; Sundberg et al., 2008).

1.1.4 Other types of roughage

Green fodder are annual crops, such as cereals, pulses, rapeseed (*Brassica napus* subsp. *napus*), turnip rape (*Brassica rapa* var. rapa), oilseed radish (*Raphanus sativus* var. *oleiferus*), or Italian ryegrass (*Lolium multiflorum*), in pure stands or in mixtures. The cereal and pulses are harvested before they are fully mature. Green fodder can be used as pasture, but it can also be preserved as silage.

Whole crop silage is silage of cereals or mixture of cereals and pulses, harvested when the grain has reached its full size and weight, but before it becomes hard. The entire plant, including stems, leaves, ears and pods, is harvested together at 30 – 50 % dry matter.

Cultivation of maize harvested and ensiled as whole crop silage is common in dairy producing areas of Europe, also in Denmark and southern Sweden (EUROSTAT: https://ec.europa.eu/eurostat/web/products-datasets/-/tag00101). It is usually ensiled in bunker silos, but is also baled at relatively low moisture content, and can therefore be transported at reasonable low cost per feed energy unit.

Straw is withered or dried straw, leaf and other plant parts after the ears or seeds are threshed (landbruksordbok, 1979). Straw from the cultivation of grass species for seed production is also used as forage. Straw can be alkali treated with sodium hydroxide (NaOH) (*luta halm*) or with ammonia (NH_3) (ammonia-treated straw) to increase digestibility (Norsk landbruksordbok, 1979).

Ammonia-treated straw is plastic packed straw that is treated with NH_3. At a sufficient ammonia concentration in the gas atmosphere, the development of fungi is inhibited. The dosage must be large enough in relation to the water content and storage temperature of the straw. At a high enough temperature and sufficient dose, NH_3 will dissolve lignin in the straw and increase digestibility.

Highly poisonous by products, e.g., 4-methyl-imidazole (4-MeI), may be formed when straw from grass seed production or grain production are ammonia-treated. Poisonous by-products increase with sugar concentration in the treated forage, the dosage of applied NH_3 and with straw temperature. Straw temperature depends on initial temperature including heating prior to treatment, as well as chemical reaction temperature when NH_3 binds to the water phase in the straw (Kjus and Langseth, 1992; Randby and Langseth, 1989; Randby and Langseth, 1990). Although 4-MeI alone cannot explain the toxicity observed (Muller et al., 1998), it is the best indicator of the toxicity of ammoniated forage. The main source of toxicity is still unknown (Muller et al., 1998; Sivertsen et al., 1993), and 4-MeI is therefore, so far, used as an identifier of toxicity. Because the toxic agents are transmitted to milk, newborn suckling ruminants are more vulnerable to ammoniated forage toxicosis than older animals (Sivertsen et al., 1993; Weiss et al., 1986).

Straw from grass seed production contains higher sugar concentrations than straw from cereals and should therefore not be NH_3-treated due to the risk of ammoniated forage poisoning. Straw from grass seed production may, however, be preserved in round bales as haylage (Randby, 1998). Oat straw may contain high sugar concentrations and be toxic if treated with a high NH_3-dosage at a high temperature, whereas barley straw seems to be relatively safe (Kjus and Langseth, 1992).

Urea-supplemented straw is straw to which urea has been added in order to increase the protein content. At sufficient temperatures, and when urease is present, urea splits into NH_3 and thus can increase the digestibility of the straw.

Grass or lucerne meal is artificially dried grass or lucerne (*Medicago sativa*) with > 850 g DM/kg (gram dry matter/kilogram) (Norsk landbruksordbok 1979). Grass or lucerne pellets and cobs are grass or lucerne meal that can be compressed into pellets or larger cobs at > 850 g DM/kg (Norsk landbruksordbok 1979). Meal and pellets of grass and lucerne are imported and used as an ingredient in a concentrate mixture. Pellets of grass and lucerne are used as forage substitute, particularly for horses. Straw pellets are artificially dried straw that is compressed into pellets and mainly used as bedding.

Sugar beet pulp is a by-product from the extraction of sugar from the root of sugar beet (*Beta vulgaris* L.). The pulp is not forage, but it has relatively high fiber content (about 50% NDF). The fiber is highly digestible but degrades relatively slowly in the rumen, which is beneficial for the rumen system and the animal (https://www.feedipedia.org/node/710). On average 90 500 tonnes were imported annually to Norway from 2016 to 2020 (https://www.landbruksdirektoratet.no/nb/statistikk-og-utviklingstrekk/utvikling-i-jordbruket/kraftforstatistikk). In 2018 and 2019, the annual import was 93 500 and 11 2300 tonnes, respectively. The product is used by the feed mills in concentrate mixtures. The inclusion of sugar beet pulp in concentrate mixtures allows to have a higher proportion of concentrate in the diet and may compensate for forage in the diet.

1.2 Plant species and plant materials in forage

Typical forages are perennial grasses and legumes that are grazed fresh or fed conserved, as described in the previous section. Timothy (*Phleum pratense* L.) is the most common sown grass in Norway, followed by meadow fescue (*Festuca pratensis* Huds.). Other commonly used species are perennial ryegrass (*Lolium perenne* L.), *Festulolium* hybrids, and smooth meadow grass (*Poa pratensis* L.). Perennial legumes, mainly red (*Trifolium pratense* L.) and white clover (*Trifolium repens* L.), are often included in grasslands. Other frequently used species include cocksfoot (*Dactylis glomerata* L.), smooth bromegrass (*Bromus inermis* Leyss.), red fescue (*Festuca rubra* L.), tall fescue (*Festuca arundinacea* Schreb.), common bent (*Agrostis capillaris* L.), reed canarygrass (*Phalaris arundinacea* L.), alsike clover (*Trifolium hybridum* L.), and alfalfa or lucerne (*Medicago sativa* L.). In pasture and unmanaged rangeland in particular, a large number of other plant species from many plant families may be eaten by animals. Animals may also graze on trees and shrubs. Annual or biannual species are mainly grazed by or fed to livestock or are conserved as silage, though silaging occurs to a relatively minor extent; for example, above-ground biomass of annual ryegrass, cereals, maize, peas, vetch, beans, rape, marrow stem kale, turnip, and radishes. Cereal straw is also used as forage to a limited extent.

Types of roughages that are relevant for import into Norway

The import of roughage is regulated, and the importers need to be registered by The Norwegian Food Safety Authorities. The importer categorizes the roughage type according to the commodity codes in the custom tariff. According to the Norwegian Food Safety Authority, the commodity codes to be used are 12.13.0001 for cereal straw, 12.14.9091 for hay and 12.14.9099 for silage-based fodder (https://www.mattilsynet.no/language/english/animals/Import_of_hay__straw_and_silage/import_of_hay_straw_and_silage_from_the_eu_and_eeaarea.31874). Meal and pellets of lucerne and grass should be imported under the commodity code 12.14.1000.

The yearly import of hay (12.14.10001) since 1968 has been on average 18 500 tonnes with Sweden as the main country of origin, accounting for about 78% of the total (Figure 3, 4 and 5). Import quantity (83 780 tonnes) was about 4.5 higher than the yearly average in 2018, and 27, 24, 19, 16 and 5% of the total quantity came from Sweden, Iceland, Denmark, the Benelux countries and the Baltic countries, respectively.

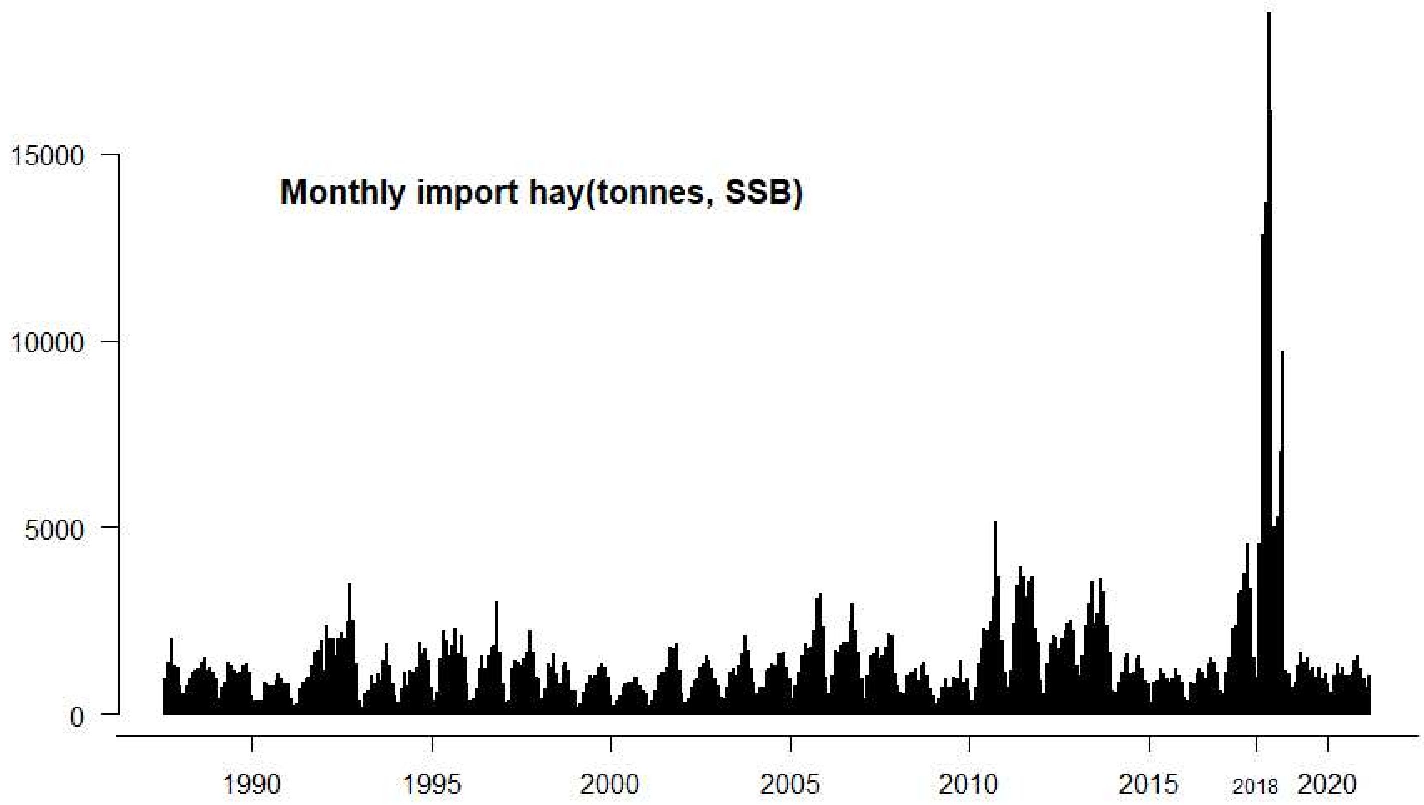

Figure 3 Import of hay (commodity code 12149091) in tonnes/month 1988-2020. The seasonal fluctuations dominate, but there is a significant (non-linear (quasipoisson GAM) regression trend that rises ($p<0.01$) after 2010) increase in annual imports after 2010 compared to the 1988-2009 period.

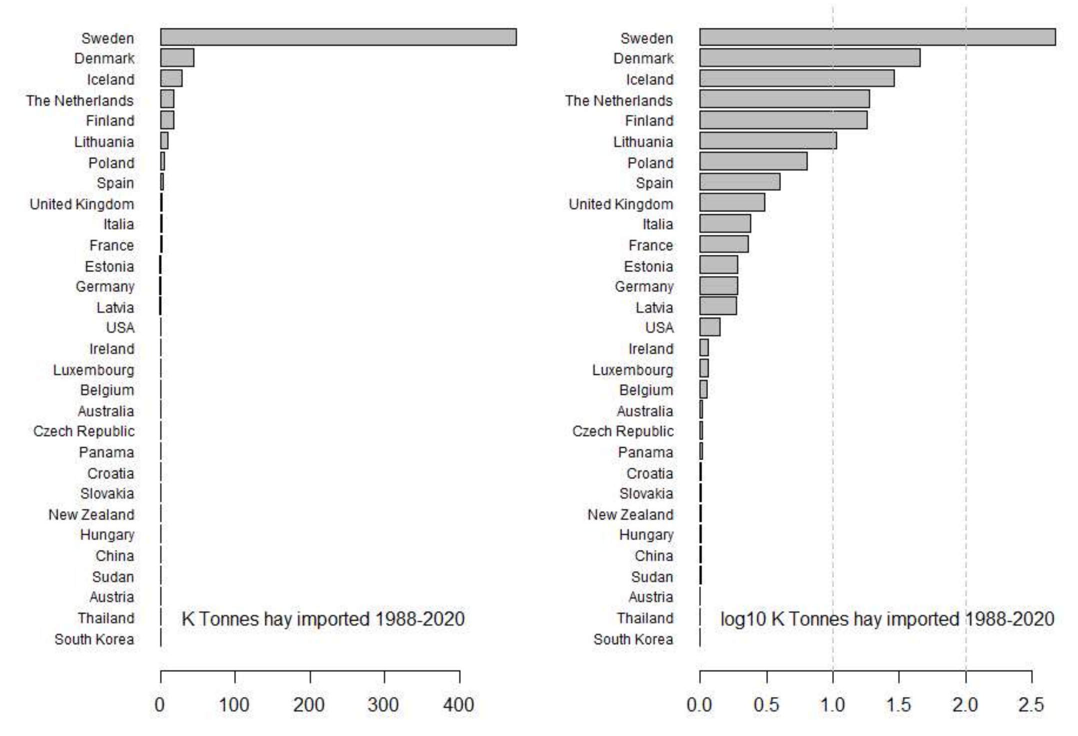

Figure 4 Sum imported hay (commodity 12149091) 1988-2020 by country. The figure on the left uses linear scale to show the true scale, whereas the figure on the right uses $\log_{10}$ scale to visualize variation over the whole range.

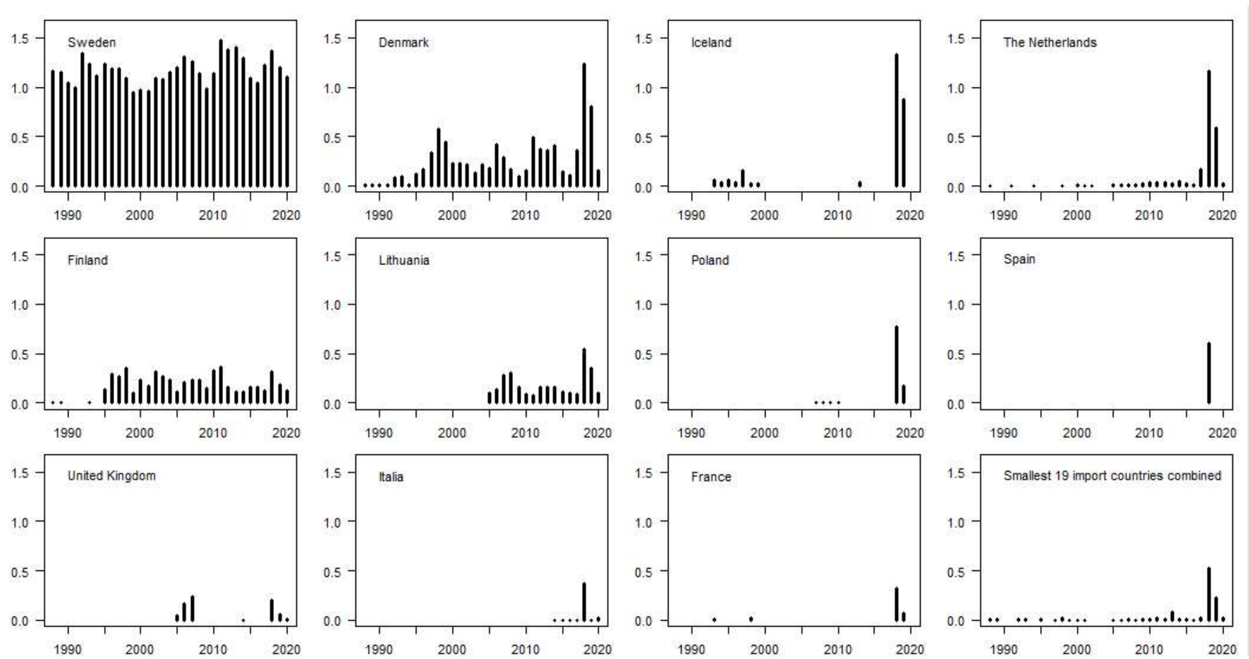

Figure 5 Hay imports 1988-2020 (commodity code 12149091) for the 11 countries from which Norway imports the largest quantity of hay separately, and for all the 19 from which any hay was imported combined in the last panel. The scale on y-axis is $\log_{10}$(KTonnes).

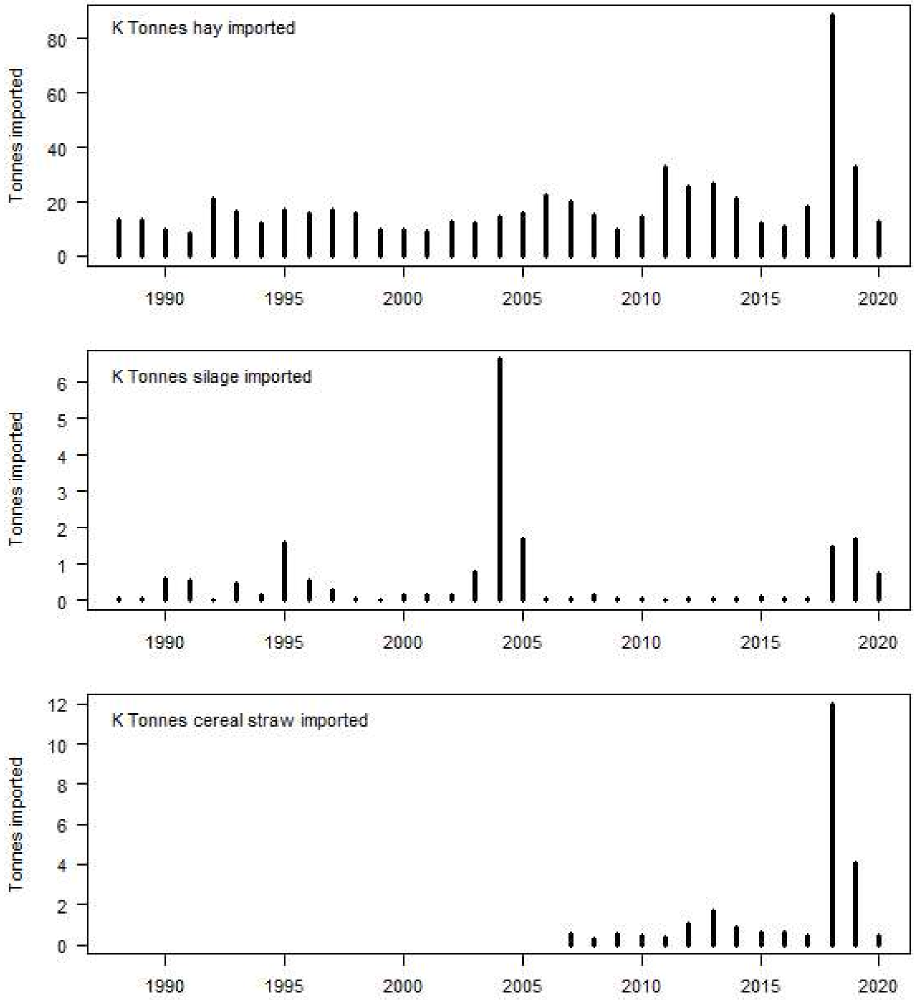

Figure 6 Annual import of hay (commodity code 12149091), silage (commodity code 12149099), and cereal straw (commodity code 12130001) 1988-2020.

Approximately 24 000 tonnes cereal straw (commodity code 12.13.0001) have been imported since 1968, most (71%) purchased from Denmark (Figure 6, 7 and 8). In 2018, about 12 000 tonnes were imported, also with Denmark as the main country of origin (87%). The second and third most important countries for purchases have been Sweden (17%) and Finland (9%), respectively.

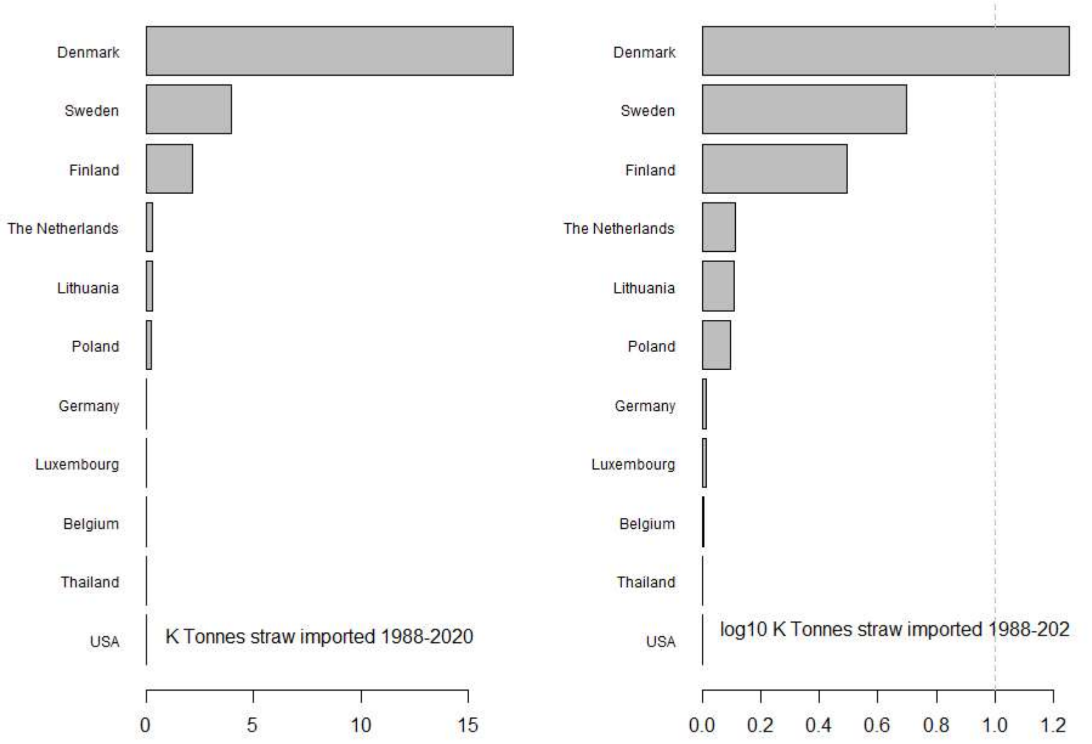

Figure 7 Sum imported cereal straw (commodity code 12130001) 1988-2020 by country. The figure to the left uses linear scale to show the true scale, whereas the figure to the right uses $\log_{10}$ scale to visualize variation over the whole range. Note the lower number of origin countries.

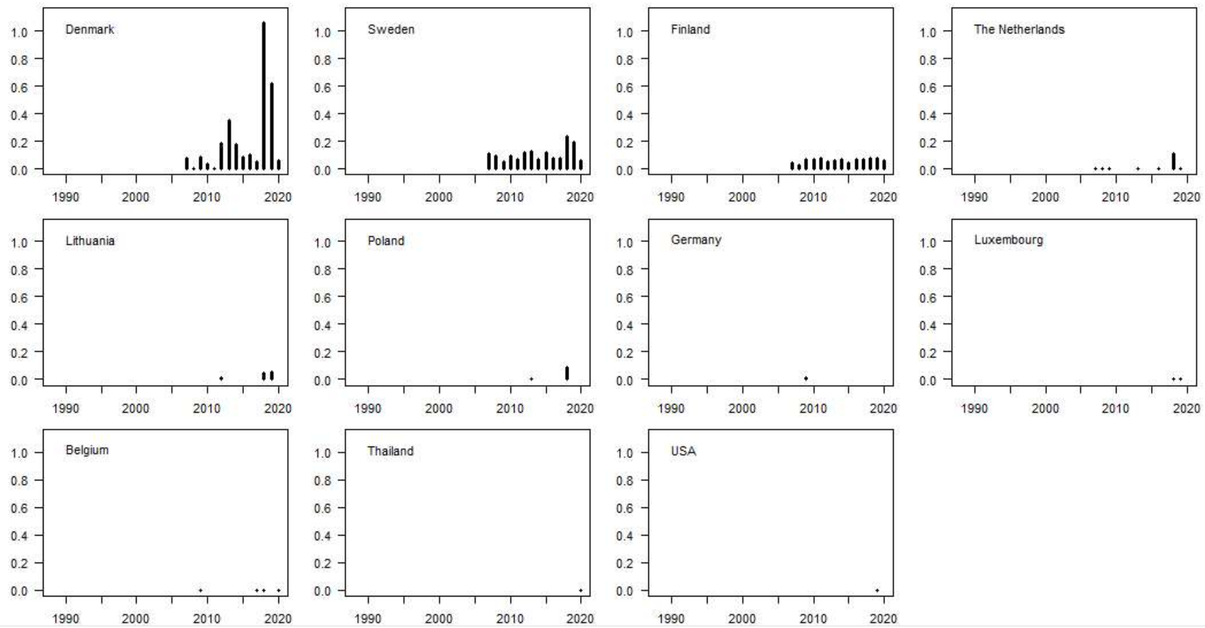

Figure 8 Cereal straw imports over time for the only 11 countries from which Norway has registered cereal straw imports 1988-2020. The scale on y-axis is $\log_{10}$(KTonnes).

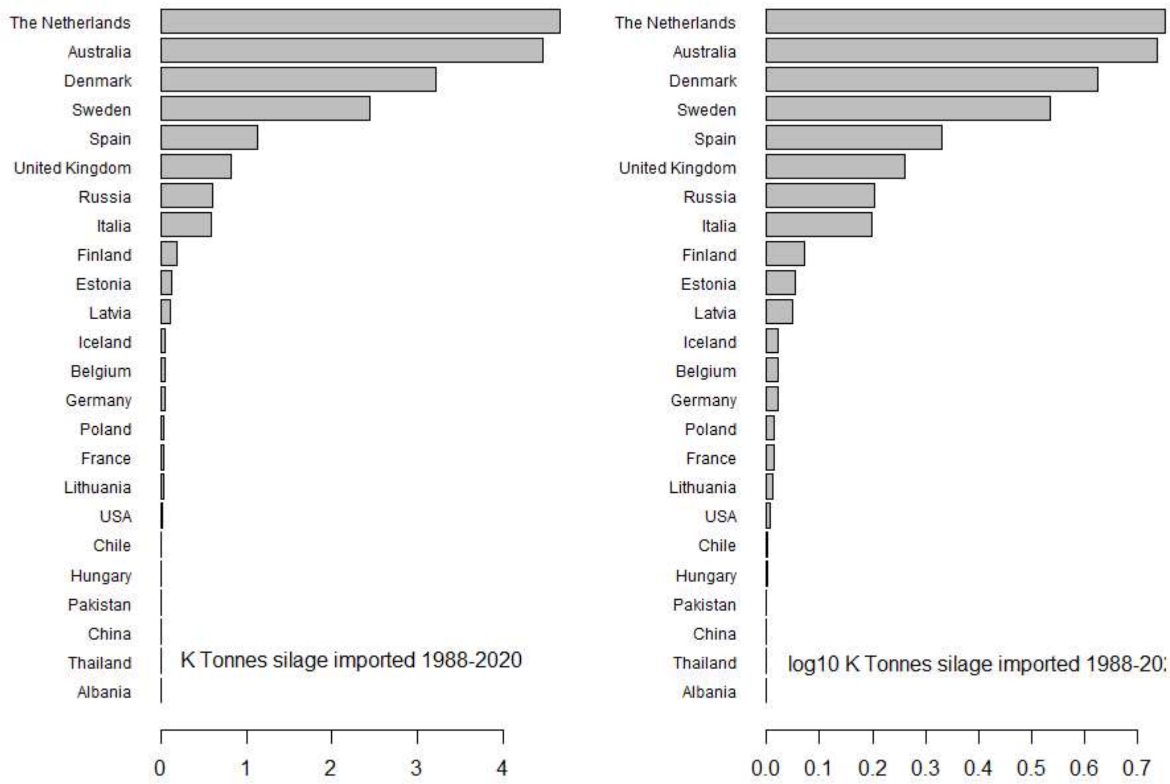

Figure 9 Sum imported silage (commodity code 12149099) 1988-2020 by country. The figure on the left uses linear scale to show the true scale, whereas the figure on the right uses $\log_{10}$ scale to visualize variation over the whole range. The volume (in tonnes) is much smaller than hay, and different countries are the biggest sources.

The import of fodder categorized as silage-based fodder (commodity code 12.14.9099) has been much lower than the other two categories (Figure 6). Since 1988, a total of 18 632 tonnes have been imported, which is about same quantity as the yearly average of hay import. In 2018, most came from UK and Ireland (50%, mainly UK) the Mediterranean countries (26%, mainly Italy), the Baltic countries (13%) and the Benelux countries (6%) (Figure 10).

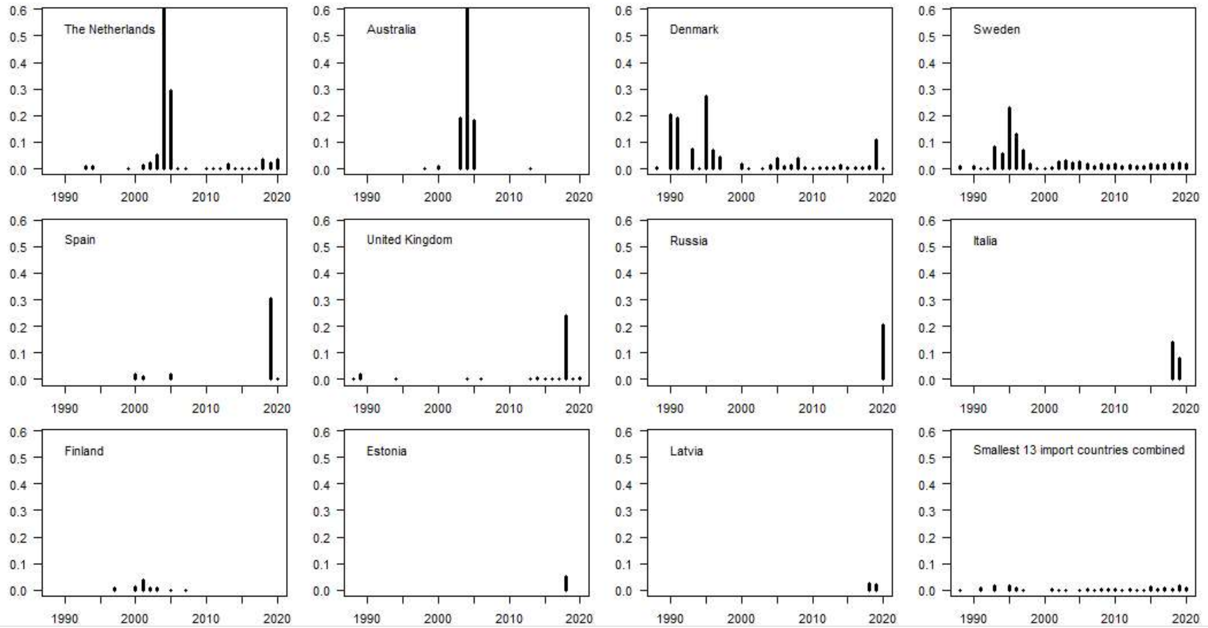

Figure 10 Silage imports 1988-2020 for the 11 countries from which Norway imports the largest quantity of silage separately, and for all the 19 from which any silage was imported combined in the last panel. The scale on y-axis is $\log_{10}$(KTonnes).

Thus, the main category of roughage that is imported, both historically and in 2018, is hay. However, it is likely that some of the forage imported as hay (commodity code 12.14.10001) is silage-based fodder (commodity code 12.14.9099). For example, the roughage imported from Iceland in 2018 was classified as hay (about 28 000 tonnes), which was about 25% of the total import of this category this year (Figure 10). However, the feed analysis of the round bales that Felleskjøpet Agri imported indicate that most of the feed was haylage and silage, as the average DM concentration was 58% with interquartile range of 20. This means that 50% of the feed had a DM concentration between 38% and 78% (Table 5). Fiskå Mølle imported round-bales from The Netherlands. According to their information and feed analysis, the forage had a DM concentration at about 55-60%, which indicate haylage type of forage.

Table 5 Weight and feed quality of round-bales imported from Iceland by Felleskjøpet Agri in 2018.

	n	Mean	Median	Min	Max	IQR	SD	CV%
Weight, kg	148	581	589	255	844	138	106	18.2
Dry matter, %	125	57.5	57.9	25.0	87.2	20.2	12.37	21.5
pH	125	5.6	5.5	4.2	6.3	0.6	0.41	7.6
Feed energy unit per kg DM	125	0.87	0.87	0.67	1.00	0.09	0.067	7.7
Crude protein, g/kg DM	103	142	147	74	211	32	27.8	19.6

IQR is the interquartile range, i.e., the difference between the 75th and 25th percentiles.

Most silage/haylage imported from Iceland and from the Netherlands in 2018 had high feed quality. Felleskjøpet Agri reports that they received complaint on about 5% of the bales because of mold. Moving bales during loading and discharging may have caused damage to the plastic wrapping and air exposure, which can lead to development of mold. Haylage type bales are often not treated with silage additives, but Felleskjøpet reports that additives were used in some of the bales imported from Iceland.

Based on the import statistics before 2018 and for 2018, the forage types that are most relevant to be imported in the future are straw, hay and haylage, with the Nordic countries as the main exporters. The transport costs per unit of feed decrease with DM concentrations. Silage (DM <50%) is usually harvested at an earlier state of plant maturity and therefore has usually higher energy value than hay (DM>80%) and haylage (50%<DM<80%). However, more hay and haylage are imported than silage because of the higher transport cost for silage. To ensure aerobic stability of haylage, it is recommended to use propionic acid or sodium benzoate as an additive at baling, but the most important measure is to ensure exclusion of air and at least eight layers of plastic (see the general introduction on forage).

1.3 Regulations on additional requirements for the import of hay and straw for animal feed (Forskrift om tilleggskrav ved import av høy og halm til dyrefôr) 22.10.2018 nr. 1599

These regulations apply to imports of hay and straw for animal feed from countries outside the EEA.

The Norwegian Food Safety Authority has published some guidelines in this matter called "Risk of importing roughage from abroad" (https://www.mattilsynet.no/dyr_og_dyrehold/for/dette_maa_du_vite_hvis_du_skal_innfore_hoy_og_halm_fra_utlandet.31792).

It is important to know the country of origin of the feed being introduced. According to the guidelines, feed from countries with infectious animal diseases that are subject to notification or do not occur in Norway should not be imported. Import of roughage, i.e. hay and straw, from certain countries outside the EEA is permitted, as long as the requirements for approval (set by the EU/EAA) are met. This applies to the following countries: (cf. Regulation 136/2004, Annex V):

- Australia
- Canada
- Switzerland
- Chile
- Greenland
- New Zealand
- Serbia
- USA
- South Africa (parts)

Requirement for documentation

It is the importer who must assess whether the feed is safe to introduce, with regards to plant, animal and human health. The Norwegian Food Safety Authority refer to the preliminary risk assessment opinions provided by the Norwegian Veterinary Institute and the Norwegian Institute of Bioeconomy Research for information on possible risk areas (NIBIO, 2018; Veterinærinstituttet, 2018a;2018b). On 22 October 2018, several new animal health requirements were introduced for the import of hay and straw from countries outside the EEA area.

The following requirements apply:

- The products must be accompanied by a confirmation from the manufacturer that the product has been stored for at least two months in the country of dispatch, and that the product has been harvested from farms where the field of origin has not been fertilized with livestock manure during the last two years.
- The products must be accompanied by a certificate from a public veterinarian in the country of dispatch that the product has been harvested from farms where no restrictions have been set due to infectious animal disease. Hay and straw from the USA and Canada must also be accompanied by a certificate from a public veterinarian stating that the product has been harvested in states or provinces where Chronic Wasting Disease has not been detected in deer.

2 Hazard identification and characterisation

2.1 Identification of plant pests and seeds associated with the pathway at origin

Types of forage and forage species were identified in chapter 1. In this section, the plant pest species (and other harmful alien organisms that could possess a threat to plants or to biodiversity) that could be associated with this commodity at the origin of the pathway (at the time of harvest) are discussed.

The plant pests in this report are restricted to the pest mentioned in the Appendix I and II of the Norwegian Regulations relating to plants and measures against pests as stated in the terms of reference provided by NEA and NFSA.

There are three relevant factors to consider when assessing the probability of introducing quarantine pests and diseases, and seeds of harmful plants via import of hay, straw and silage. The most important factor is to find which organisms could be associated with the material. The next factor is whether import takes place from countries where quarantine organisms and harmful plant species are present. Finally, it should be considered, whether the seeds, pests and diseases can survive the treatment of the material (drying for straw and hay and fermenting for silage) and transport.

2.1.1 Invasive alien plant species

A wide range of plant species may be present as seeds in hay, straw and silage. Species with hard seeds can survive anaerobic conditions, in addition to the survival in dry conditions exhibited by most seeds. These species or species groups are of particular concern. However, species that establish in their new environment are more harmful to agriculture and biodiversity than species that do not establish. A classic example of such unwanted plant species is wild oats (*Avena fatua*). This weed is considered so harmful to Norwegian grain cultivation that it is subject to separate regulations (Regulation No. 752 on wild oats). Wild oats do damage by competing with the cultivated plants for nutrients, light and water. A large proportion of wild oats in the field therefore leads to reduced yields, more use of pesticides and increased production costs.

In roughage, the harvesting time in relation to the stage of plant maturity affects the viability of the invasive alien or seeds from unwanted species. Grass for production of high-quality silage and haylage is usually harvested at an early stage of maturity, and probably before viable seeds have developed. Although hay is also harvested at an early stage, the probability of it containing viable seeds is higher than for silage because more weeds have set seed at the time of hay harvest than at the silage harvest. Late-harvested grass and straw from grain production are harvested at a stage of maturity when it is probable that there will be viable weed seeds in the crop.

Indeed, one of the most common pest pathways for the accidental introduction of invasive terrestrial plants is as seeds contaminating grains, mainly cereals for human food, but also animal feed. Camelthorn (*Alhagi maurorum*) is thought to have been widely introduced as a contaminant of alfalfa (*Medicago sativa*). Many introduced weeds were first found around feeding stations and are assumed introduced with animal fodder. The spread of several leguminous trees around the Caribbean are thought to have accompanied the introduction of horses and cattle, probably in the feed carried on board ships used to transport the animals.

Most alien plant species do not pose a significant risk. Some alien species may be present but cause little known harm to our ecosystems, i.e., they do not become invasive. Some alien species, however, are invasive and can spread quickly. (See Appendix III for a list of high-risk plant species in Norway).

Despite the extensive amount of research that exists on invasive alien species pathways and vectors of introduction, invasions of new species are still frequently occurring due to the global movements of goods and people. Invasive alien species pose a substantial threat for both native biodiversity and human health. Consequently, understanding and pre-empting the possible transfer of species across borders into foreign ecosystems is of pressing importance.

2.1.1.1 Survival of seeds in roughage

Imported roughage can carry a variety of viable seeds, of which of some may be invasive (Conn et al., 2010). Once established, invasive species may maintain small local populations, often with 'under the radar' spreading. This may continue for long periods of time until conditions become favorable for their increased spread, or they reach a population density threshold or age which favors spread.

Few reports exist on the survival of seeds in silage, or on the consequence of feeding the silage to livestock. However, (Mayer et al., 2000) show that the majority of weed seeds are destroyed by ensilage, but a small percentage remain viable. More recently, (Westerman et al., 2012) reported that seeds from a range of weeds were capable of surviving ensilage.

The frequency and size of introductions are important determinants of introduction success (Colautti et al. 2006, Ruiz & Carlton 2003). We still need enhanced knowledge about invasion potential from imported roughage in order to devise strategies to prevent invasive plant spread.

Fodder containing weeds is thought to be a pathway for the movement of invasive species and numerous countries and land management agencies have taken prudent preventative actions (USDA Forest Service, Pacific Northwest Region 2009). Very few studies of weed contamination and spread in hay and straw have been published (Conn et al. 2021).

However, a study by Conn et al. (2010) show that large numbers of alien plant species were transported by the movements of hay and straw from Washington state and Oregon and into Alaska.

In many locations, like on Svalbard, seeds of alien species were imported with hay and straw for livestock feed decades ago.

In a study by Arianoutsou et al. (2021), primary pathways of introduction of alien plants into Europe were assigned to 5 175 taxa. This study concludes that Northwestern European countries act as the main gateway areas of alien plants into Europe and that the dominant pathways of primary introductions of alien plants into Europe are linked with accidental escapes from ornamental and horticultural activities.

2.1.2 Insects, mites and nematodes

Annex 1 and Annex 2 of the national regulations for plants and measures against plant pests (Forskrift om planter og tiltak mot planteskadegjørere) list quarantine organisms of particular concern because of the damages they are known to cause to crops or to native biodiversity and because introduced populations are difficult to control (https://www.mattilsynet.no/planter_og_dyrking/planteskadegjorere/). Most of the listed quarantine pests are not associated with grasses (Poaceae) and hence are not likely to be introduced with roughage. Those few associated with grasses are discussed below. They include thrips, scarab beetles, moths, and leafminer flies.

The insects associated with grasses may potentially be present in roughage—straw, hay, haylage or pellets—destined for Norway at the time of harvest depending on whether or not they are found in outdoors fields of said grasses. Most of the insects discussed below are currently distributed in regions that are not legal sources of import of roughage. Moreover, many of the listed pests are tropical in origin and hence more likely to be associated with fields of fodder grasses in regions with tropical or subtropical climates, and then imported with sugarcane or maize, and not fodder grasses. Many of the Poaceae-associated insects in Annex I are listed because of potential threats to greenhouse crops, and not to native biodiversity.

THRIPIDAE (thrips)

Thrips palmi, the melon thrips, is native to southern Asia but is now widespread in Asia, Oceania, and throughout the Caribbean; local populations have been recorded in the Americas, Africa and Australia (https://planthealthportal.defra.gov.uk/assets/factsheets/thrips-palmi-factsheet.pdf, https://www.cabi.org/isc/datasheet/53745). It is highly polyphagous, having been recorded from more than 200 plant species from more than 36 plant families (among them, Poaceae). The feeding activity of adults and larvae scar leaves, flowers and fruits. *Thrips palmi* also can vector plant diseases. There have been a number of outbreaks of this thrips in greenhouses in Europe (Netherlands, Portugal, UK, Germany) but all have been exterminated (https://gd.eppo.int/taxon/THRIPL/distribution). Outside the tropics, damage is primarily to greenhouse vegetable crops and ornamentals, as populations cannot survive cool or cold winters. Hence, the species is only likely to be associated with roughage at harvest where outdoor fields are in very warm, moist regions.

SCARABAEIDAE (dung beetles, chafers)

Exomala orientalis (listed as *Blitopertha orientalis*), the Asian garden beetle, is an Asian species invasive in the eastern USA, east Asia (as far north as North Korea), and some Pacific islands (https://www.cabi.org/isc/datasheet/5510). The species spreads via nursery plants in containers or balled or burlapped plants. The larvae (grubs) are polyphagous; they feed on plant roots of many vegetable crops and ornamental plants, and especially grasses. Larvae kill grasses by cutting roots close to the soil surface. Adults feed on a wide variety of flowers, but the main damage to plants is the root feeding by grubs. The species spreads primarily by transport of adults hidden in flowers and larvae present in soil accompanying plants being shipped or moved.

Popillia japonica, the Japanese beetle, is native to Japan and a highly successful invasive species in North America and the Azores (https://www.cabi.org/isc/datasheet/43599, see also https://pest.ceris.purdue.edu/map.php?code=INBPAZA&year=2020). Adults feed on foliage of hundreds of plant species, while larvae feed on the roots of grasses. The beetle spreads naturally where there are large expanses of turfgrass and sufficient rainfall, and by movement of plants with soil attached. In terms of temperature and habitat requirements, the species could likely establish in the maritime climates of southern Norway, should it be introduced.

NOCTUIDAE (owlet moths, cutworms, armyworms)

Helicoperda armigera is known as the cotton bollworm and feeds on a wide variety of plants. It is considered a serious pest of many crop species. Host plants (over 100 species in Europe) include grasses in the genus *Hordeum* (including barley), but these are not among the preferred hosts. Larvae feed on the leaves or reproductive organs of their host plants. The species is native in central and southern Europe, and is a serious outdoor pest in the Mediterranean https://www.cabi.org/isc/datasheet/26757). Quarantine status is due to the risk of introduction to greenhouses in northern Europe, and not a risk to establishment out of doors.

Spodoptera littoralis, the cotton leafworm, is native to the Mediterranean, all of Africa and western Asia (https://www.cabi.org/isc/datasheet/51070). The species is referred to as the cotton leafworm and is a host generalist, using plants in over 40 families including at least 87 species of economic importance. Among those numerous hosts are grasses, including various crop grains and maize.It is not clear from the literature whether this species can feed on grasses commonly used for roughage. Larvae feed on leaves and fruits of the host plants, and can strip their hosts of foliage. The species is widespread in the Mediterranean but not considered an economic problem there; the phytosanitary risk of spread to northern Europe is introduction to greenhouses, not a risk to establishment out of doors.

Spodoptera litura, the taro caterpillar, is native to the Asian tropics, where it is one of the most important insect pests of agricultural crops; it is widely invasive further north in Asia and in Oceania (https://www.cabi.org/isc/datasheet/44520). Like *S. littoralis, S. litura* is polyphagous and its host list includes the grasses sorghum, maize and rice. At high densities, larvae can completely defoliate their hosts, similar to *S. littoralis*. The main concern for northern Europe is introduction to greenhouses, not a risk to establishment out of doors. The species has been introduced to but successfully eradicated from the Netherlands, Germany, and England. At harvest of grasses, the species could be associated with roughage if it includes sorghum and if the region has a favorable climate. However, it is not clear from the literature whether this species can feed on other grasses commonly used for roughage.

TENEIDAE (fungus moths, clothes moths)

Opogana sacchari, the banana moth, is native to the African tropics and invasive in South America, the Caribbean, parts of the USA, Egypt, and China and Japan (https://www.cabi.org/isc/datasheet/37683). It has been introduced to a variety of locations in Europe (usually on bananas) where it can successfully breed on a wide variety of greenhouse crops and ornamental plants; host plants in Poaceae include sugarcane and maize (https://www.cabi.org/isc/abstract/20066600594). Spread into Europe has also been observed via ornamental plants, e.g., Yucca. (https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2338.1988.tb00407.x). Though technically associated with grasses, we find no evidence that the banana moth larvae feed on grasses used in roughage. The insect cannot survive outdoors in northern Europe and can be readily controlled in greenhouses.

AGROMYZIDAE (leaf-miner flies)

Liriomyza huidobrensis, the serpentine leafminer, is one of several species in this genus that are considered to be major quarantine pests- This species is from Central and South America and was imported to the Netherlands in 1987 from where it has spread rapidly through central, eastern and southern Europe (https://www.cabi.org/isc/datasheet/30956). This polyphagous species has become an important pest of a wide variety of greenhouse plants, both vegetable crops and ornamentals. Species of *Setaria* (foxtail grasses), often grown for fodder, are on the host list. Invasive populations of *Liriomyza* species spread especially via propagating material (cut flowers, vegetables with leaves) and *Liriomyza huidobrensis* is especially associated with the trade in cut chrysanthemums (Parrella 1987).

Larvae of *Liriomyza* flies create serpentine (winding) mines inside leaves and occasionally leafstalks of their host plants. In addition to the consequences of physical damage for survivorship, growth and aesthetic value (of infested ornamentals), the flies can vector plant diseases (Parrella 1987).

This species tolerates low temperatures, and populations in China are found as far north as 42 degrees N, but no *L. huidobrensis* survived winter in southern Ontario, Canada in one study (Martin et al. 2005).

Liriomyza sativae, the vegetable leafminer, is native to the Americas and is widespread in the southern parts of North America and in Central and South America (https://www.cabi.org/isc/datasheet/30960, https://entnemdept.ufl.edu/creatures/veg/leaf/vegetable_leafminer.htm). It is widely distributed in Africa, Asia and Oceania. (https://www.cabi.org/isc/datasheet/30960). The vegetable leafminer is the most serious of the leafminer fly pest species, damaging many crops severely and reducing yields significantly. The most important impacts are on Solanaceae and Fabaceae, but the species has been recorded from crops in seven other families including Poaceae. *L. sativae* is also known to be a vector of plant viruses. Concerns in cooler parts of Europe are for greenhouse infestations, as these flies will likely not survive out of doors further north in Europe.

Liriomyza trifolii, the American serpentine leafminer, is native to the Caribbean and southeastern United States and invasive worldwide. It is a major quarantine pest, which in Europe attacks a wide number of vegetable crops and ornamentals in greenhouses or plants that are grown in the open in warmer countries (https://www.cabi.org/isc/datasheet/30965). *L. trifolii* is also known to be a vector of plant viruses. Concerns in cooler parts of Europe are for greenhouse infestations, as these flies will likely not survive outdoors further north in Europe.

NEMATODES

The adult stages of root knot nematodes ***Meloidogyne chitwoodi*** and ***M. fallax*** and the false root knot nematode ***Naccobus aberrans*** are all obligately associated with roots as endoparasites, while the juvenile stages occur in soil (ref xxxxx). Because they are associated with roots and soils, there is a low probability for these nematodes to occur in hay. The potato cyst nematodes (PCN) ***Globodera roatochiensis*** and ***G. pallida*** also live in soil associated with roots as endoparasites. However, the dead females, *i.e.* the cysts, are 0.5 mm in diameter and may occur in dust and contaminated hay. They are long-lived and under Norwegian conditions they may remain infective for at least 32 years (Holgado et al xxxx). In a situation where the soil is infested with PCN, there is a moderate probability that these nematodes will contaminate hay.

A gall forming nematode, ***Anguina funesta***, can infest and develop galls in undifferentiated flower buds, stamen cells, and various other tissues, including seeds of the annual rye gras *Lolium rigidum*. Nematodes mature and reproduce within the galls, producing second-stage juveniles that are highly resistant to drying (Li et al., 2015). This nematode is not listed as a quarantine pest, butcarries the bacterium *Rathayibacter toxicus* (formerly known as *Clavibacter toxicus*), which causes annual rye grass toxicity (ARGT) in cattle, including horses and pigs. ARGT is a serious and lethal neurological disease in those animals (Riley et al., 2001).

Table 6 Summary of the probabilities of relevant insects and nematodes described above and the fungus described below being associated with the pathway at origin, along with the uncertainties associated with the probability. "At origin" means at the time of harvest of the roughage.

Scientific name	English name	Norwegian name	Proba-bility	Uncer-tainty	Comment
Thrips palmi	Melon thrips	Palmetrips	Low	Low	Unlikely to come from outdoors populations
Exomala orientalis	Asian garden beetle	(norsk navn mangler)	Low	Low	Larvae in roots only, adults do not feed on grasses
Popillia japonica	Japanese beetle	Japanbille	Low	Low	Larvae in roots only, adults do not feed on grasses
Helicoperda armigera	Cotton bollworm	Pestfagerfly	Low	Medium	Must be a large outdoors population that uses roughage plants
Spodoptera littoralis	Cotton leafworm	Bomullssteppefly, Egyptisk bomullsfly	Low	Medium	Must be a large outdoors population that uses roughage plants
Spodoptera litura	Taro caterpillar	Bomullsfly	Low	Medium	As *S. littoralis*
Opogana sacchari	Banana moth	(norsk navn mangler)	Low	Low	Not likely to be outdoors populations, not clear if roughage grasses are hosts

Scientific name	English name	Norwegian name	Proba-bility	Uncer-tainty	Comment
Liriomyza huidobrensis	Serpentine leafminer	Sør-amerikansk minérflue	Low to medium*	Medium	Associated with roughage grasses, must be warm climate
Liriomyza sativae	Vegetable leafminer	Grønnsaks-minérflue	Low to medium*	Medium	Possibly associated with roughage grasses, must be warm climate
Liriomyza trifolii	Am. serpentine leafminer	Floridaminérflue	Low to medium*	Medium	As *L. sativae*
Tilletia indica	Karnal bunt of wheat	(norsk navn mangler)	Low	Low	Limited presence in the few countries outside Europe from which roughage is imported

* Medium in south Europe

2.1.3 Fungi, oomycetes and protozoa

A number of plant pathogenic fungi, oomycetes and protozoa occur in cereal, potato, vegetable fields, pastures and grasslands. However, in relation to quarantine diseases listed in Annex I and II, only one organism is relevant. The others are not found in material used for roughage, are not found in areas from where roughage is imported, or are most likely not able to establish in Norway. Karnal bunt of wheat, caused by ***Tilletia indica***, has the potential to be introduced to Norway via import of straw, and to a lesser extent hay. The pathogen was included in the preliminary NIBIO report (NIBIO, 2018).

The main pathway of introduction is infected seed lots. In addition, the fungus can be present on leaves of wheat and rye (the main hosts). Occurrence can be either as infections in plant tissue or as teliospores attached to the material. Contamination with teliospores can be due to a few infected ears of wheat being included in straw or from earlier spore dispersal from infected kernels, for example during harvest. The teliospores are durable and resistant to heat, cold and drought(https://www.cabi.org/isc/datasheet/36168). In inoculation experiments, various grasses can be hosts, but they are not considered important as natural hosts. However, hay made from grass fields in the vicinity of infected wheat or rye fields could be contaminated by wind dispersed teliospores.

T. indica is not present in Europe (https://www.cabi.org/isc/datasheet/36168), and import of hay and straw from EU has no risk related to this fungus. Karnal bunt of wheat is mainly found in India and in the Middle East. In addition, there are restricted distributions in countries such as Mexico, Arizona in south-western USA, South Africa and Brazil, and with ongoing efforts to eradicate the pathogen. South Africa and USA are presently the only countries from which import to Norway is permitted and where the fungus is present. Of those two countries, import to Norway has only been registered from the USA. However, it is unknown from which parts of the USA hay and straw have been imported to Norway, and furthermore whether import has occurred from regions in the USA where the pathogen occurs (Arizona).

The probability of introducing *T. indica* is low, since hardly any of the imported straw and hay comes from areas with a possible presence of the pathogen. E.g. the year with most import of hay from USA was 2019 (256 tonnes), and the amount was less than 2% of the yearly average import to Norway. The same year had the only registered import of straw from USA, which amounted to 0,13 tonnes, i.e. less than one per mille of the total import of straw to Norway. If the fungus was introduced though, it would most likely be able to establish and spread in Norway (NIBIO, 2018).

2.1.4 Bacteria

None of the bacteria listed in the Appendix I and II of the Norwegian Regulations relating to plants and measures against pests are known to cause significant infections in cereals or grasses, according to CABI and EPPO datasheets.

2.1.5 Viruses

None of the viruses listed in the Appendix I and II of the Norwegian Regulations relating to plants and measures against pests are known to be able to infect cereals or grasses, according to CABI and EPPO datasheets.

2.2 Identification of pathogens causing animal diseases and zoonotic diseases

There are several factors influencing the probability of introduction of pathogens through roughage. In our inclusion criteria, the following factors were considered (presented as a flow diagram in Figure 11):

- The pathogens included should be able to
  - contaminate roughage and remain infective during transport and storage.

    - come in contact with susceptible animals and spread and establish in susceptible species in Norway.
    - cause negative consequences in animals or humans in Norway
- Pathogens already endemic in Norway, where introduction will not alter the disease occurrence situation in Norwegian animals or humans, are excluded.

The infections may be subclinical (animals)/asymptomatic (humans), or cause disease. Some of these infections are subclinical in animals, but cause disease in humans, and vice versa. In this opinion, the difference between infection and disease is only specified where it is deemed necessary or important. The names of the pathogens are usually used, but if the disease name is more established, it is used to make the document easier to read.

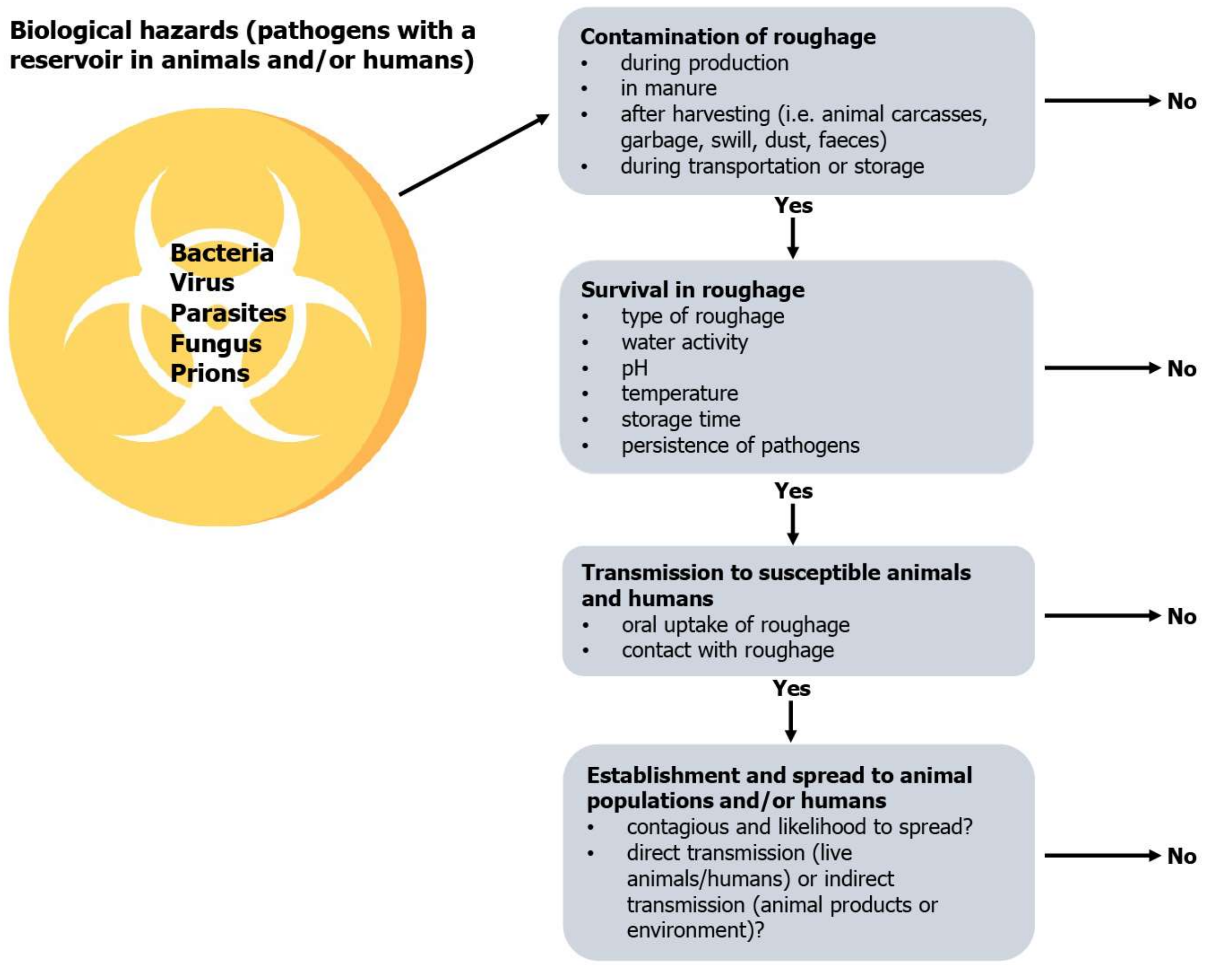

Figure 11 Flow diagram showing steps for biological hazards from contamination of roughage to infection of animals/humans.

We have focused on infectious microorganisms that cause disease in animal species with roughage as an important part of their feeding regime. This includes cattle, sheep, camelids, horses and to some degree pigs, as well as wild ruminants and wild boar. Another important aspect to consider are zoonotic pathogens and the possibility of transmission from livestock to humans.

Imported roughage is not intended for wild animal consumption. It may, however, be both stored and spread outdoors, and is then accessible for wild animals. This represents a hazard in two ways. Pathogens that cause disease in wild animals can reach their hosts species and cause disease directly. An example of such a pathogen is *Salmonella*. In addition, pathogens may reach other species through wild animals as intermediate hosts. Although never demonstrated so far, African swine fever virus might infect wild boars through their feeding on roughage intended for domesticated pigs (or any other domesticated species), and cause disease. Infected wild boar populations are a significant risk to domestic pigs (Bellini et al., 2021). Infections with unknown zoonotic potential also needs to be considered. For example, rodents that are in contact with imported roughage, contaminated with *Echinococcus multilocularis* eggs, can cause establishment of this pathogen in other species, including humans (EFSA, 2015). Introduction of pathogens already widely present in Norway is normally not included in this Opinion. However, there are some important exceptions, such as *Salmonella,* which is included in specific Norwegian control programs. Introduction of new or other variants of pathogens are also included.

Roughage may contain fungi and mycotoxins that cause diseases in both animals and humans (Driehuis et al., 2018). Roughage can also cause clostridial infections/intoxications in animals, but this risk is regarded more or less the same in imported and Norwegian roughage. Import is not likely to alter the disease occurrence in Norway. *Listeria monocytogenes* is another well-known pathogen related to roughage, but it is a common animal disease and widespread in the environment in Norway. Introduction via imported roughage may lead to disease but will not spread further, and it will not alter the disease situation in Norway.

2.2.1 Survivability of pathogens in roughage and in the environment

The survivability of biological organisms/hazards, such as insects, parasites, bacteria, viruses, prions, and toxins in an environment is a complex function of the characteristics or lifecycle of the pathogen/organism itself, and the environmental conditions.

The insects associated with roughage (Table 6), if present in open fields, can be caught in hay or silage in several ways. Adults resting or feeding on hay or straw could accidentally be packed into bales, though most would likely escape the baling process. Larvae of leaf miners could be inside plant tissues when harvested. However, it is highly unlikely that insect larvae will survive the drying and baling processes. No stages of insects would survive silage. If pest and pathogens spread to the outdoors environment, they could probably develop and establish in the surroundings. For *Tilletia indica* this would depend on the presence of a suitable host, i.e., wheat or rye. Long term survival and further spread of insect pests would depend on the impact of winter temperatures.

The survivability outside the host varies among microorganisms. In general, bacteria vary highly in survival outside their hosts, but some are highly tolerant, i.e., spore-forming bacteria. It is therefore possible for some bacteria to spread via faeces from infected animals or animals which are carriers. The spread can occur via manure in the field, to plants used for roughage, and even be present in the final feed product and survive the storing. Even though survivability also varies among viruses, most viruses degrade more easily and will be too unstable to survive through the same route. The risk of virus transmission, as well as many of the bacteria, via roughage will be more related to possible contamination of feedstuff with litter, meat, pieces of carcass, blood, faeces, urine, or swills that contains contaminated biomaterials from infected animals.

2.2.2 Sources that might contaminate roughage with pathogens

Pathogens may be transmitted between susceptible hosts in different ways. The modes of transmission are often classified as either direct (direct contact or droplet spread) or indirect. Indirect spread is either airborne, vehicle-borne or vector-borne. Transmission via roughage is an example of indirect spread, most likely a type of vehicle-borne transmission, or possibly vector-borne (if a vector is in the roughage).

Some examples of contamination of roughage are:

- Manure that contains bacteria like *Salmonella*, *Mycobacterium avium* subspecies *paratuberculosis,* verotoxin-producing *E. coli* (VTEC), *Yersinia enterocolitica* etc.
- Irrigation with contaminated water that contains pathogens from faeces
- Human faeces from camping sites, cars etc. or human activity
- Faeces from livestock or wild animals
- Carcasses of rodents and birds containing *Toxoplasma, Trichinella* etc.

Rodents that hide in roughage may constitute a source of infection for livestock and humans. Some examples are rodents carrying zoonotic pathogens, such as *Francisella tularensis*, *Salmonella, Toxoplasma* and *Trichinella* (Granum, 2015). Together with puumalavirus, which is a hantavirus causing *nephropathia epidemica*, these pathogens are all common in Norway (Granum, 2015; fhi.no). However, *Leptospira*, more virulent variants of for instance *Salmonella, Toxoplasma* and other hantaviruses might be present in carcasses of rodents in roughage from abroad (depending on origin).

2.2.3 Relevant biological hazards in roughage that can cause diseases in livestock

Rating of 'persistence in roughage'

Persistence in roughage depends upon many factors as earlier described (humidity, temperature, pH etc.). We lack documentation concerning survivability for many of the pathogens. Where available, specific information on pathogens is found in scientific publications. However, the classification of pathogens ability to persist in roughage made in this Opinion is mainly based on extrapolation of general knowledge of the pathogens' ability to survive in environmental conditions. In the literature, such classification of pathogens is often related to similar/related pathogens. A virus might be seemingly stable in the environment compared to other viruses in the same family, but still fragile compared to many bacteria etc. In the current Opinion, *low* persistence refers to survival up to a few days, *medium* persistence up to 3-4 weeks, *high* persistence is longer than 4 weeks (Table 7 and 9).

Occurrence

The occurrence and distribution of a disease an area may be uncertain. Moreover, the disease situation for a specific infectious disease in a given region or country continuously changes. Some pathogens or diseases have a stable and rather predictable occurrence. For other diseases, the situation might change rapidly. This is particularly so in regions free of an infection but where outbreaks occur. It is therefore necessary to have updated information about disease situations, and care should particularly be taken in areas with rapid changes when using the information in both tables for diseases presented later in this chapter.

For pathogens classified as notifiable in the OIE system, the current official disease status is the source of the information (https://www.oie.int/en/what-we-do/animal-health-and-welfare/official-disease-status/). The OIE system depends upon countries reporting correctly and timely. For diseases that are not notifiable, there is usually less available information on occurrence, but national control/surveillance reports, scientific articles etc. have provided information. Information on occurrence in Norway is based on the Norwegian Veterinary Institute's yearly control and surveillance program reports (Falk and Hofshagen, 2020)

Table 7 Relevant biological hazards that can cause disease in livestock and may be present in roughage. Data on occurrence is based on information from OIE (Official disease status: OIE - World Organisation for Animal Health), and information on occurrence in Norway is based on The Norwegian Veterinary Institute yearly control and surveillance program reports (Falk et al., 2021). The capital letters A, B and C adjacent to each pathogen on the far-left column refer to diseases notifiable in the NFSA system (A being highest concern and C the lowest). Note: Pathogens that have negligible survival outside the host are not included in the table. This will typically include pathogens that are spread via direct transmission, i.e., either via direct contact or via droplets. Pathogens that are mainly spread directly, and where indirect spread can be disregarded, are not included in the table. Examples of this include pathogens that are sexually transmitted, vertically transmitted (from mother to offspring) and respiratory pathogens that are spread through droplets/direct contact.

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
Bacterial						
***Brucella* spp./ Brucellosis (A)**	Several; E.g., humans, cattle, swine, small ruminants, camelids, dogs, cats	Highest prevalence in the Middle East, the Mediterranean region, in Africa south of Sahara, China, India, Peru and Mexico.	Last detected in cattle in 1953.	Medium	Yes, 1 – 3 human cases each year	Contamination of roughage not likely.
***Bacillus anthracis*/ Anthrax (A)**	Several. Natural hosts: Herbivore animals, especially pigs, cattle, sheep and goats	Worldwide. Only sporadic outbreaks in the western part of the world	Last detected in 1993.	High	Yes, One human case during the last 40 years.	Spore-forming, but not transmissible via direct contact between live animals. Contamination of roughage possible, i.e., after flooding where carcasses with anthrax are buried.

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
Leptospira spp/Leptospirosis (B)	Several; E.g., humans, mainly in rodents, cattle, swine, sheep, goats, dog and cats	Worldwide, most often in tropic and subtropic regions.	Never in livestock and horses.	Low	Yes, can be severe with long convalescence.	Existed in Norway until 1950s. Some cases in Denmark and Southern Sweden. Present mainly in rodents.
***Mycobacterium avium* subsp. *paratuberculosis* (MAP)/ Paratuberculosis (B)**	Primarily affects sheep and cattle (most commonly seen in dairy cattle), goats as well as other ruminant species. The disease has also been reported in horses, pigs, deer, alpaca, llama, rabbits, stoat, fox, and weasel.	Worldwide. Sweden is free from this pathogen.	Last detected in a goat in 2015.	High	No	Infected animals shed in manure, colostrum, and milk. The most important reservoir is faeces from infected animals and contaminated environment where MAP can survive up to 8-9 months. In manure and infected pastures MAP may be contagious for 1-2 years-.
***Salmonella* spp./ Salmonellosis (B)**	Extensively described in Table 9. Biological hazards with a zoonotic potential that may be present in roughage					

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
***Mycobacterium bovis, M. tuberculosis* and *M. caprae*/Tuberculosis (B)**	Several; E.g., humans, ruminants, swine	Worldwide. Highest prevalence in Africa and parts of Asia, but the disease is also found in countries in Europe and the Americas. In cattle in Europe: relatively high prevalence in England, Ireland and Spain, recently detected in cattle herds in France and Germany.	No. Eradicated since 1963, except outbreaks in two herds in 1984 and 1986.	Medium	Yes	Shed in faeces, Capable of surviving for 2-3 months in soil, water or hay.
***Mycoplasma agalactiae*/ Contagious agalactia (B)**	Sheep and goats	Worldwide. In Europe particularily in the Mediterranean basin	Never	Medium	No	Shed in many excretions, including faeces. Survival 1-2 weeks to 3-4 months at room temperature and in refrigerator at 8°C, respectively. Humid and cold conditions support survival. 8 months in sand. Exposure to ultraviolet radiation inactivates quickly. Transmission route: Oral

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
***Clostridium perfringens* type C/ *C. perfringens* type C-infection (B)**	Swine	Worldwide	Occasionally, last detection in 2015.	High	No	Sporeforming. Shed in faeces. Possible introduction via roughage. Disease depends on multiplication and toxin production in the index herd.
***Coxiella burnetii*/Q-fever (C)**	Ruminants, humans	Worldwide, including Finland and Sweden. However, Iceland and New Zealand are free.	Never detected	High	Yes	Low infectious dose, survives well in dry, dusty conditions
***Mycoplasma bovis*/ *Mycoplasma bovis* infection (C)**	Cattle	Worldwide, including Finland and Sweden. However, Iceland is free.	Never detected	Low	No	Will not survive very long outside the host, but lack of knowledge about transmission.
Viral						

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
ASF-virus/African swine fever (A)	Domesticated and wild suids (pigs) (soft ticks, *Ornithodoros*)	Present in regions of Asia, Europe and Africa. Emerging in Europe, particularly eastern Europe/Russia.	Never in Nordic countries, but unstable situation around.	High	No	High persistence in environment. High risk, outbreaks in domestic pigs and wild pigs of particular concern. Shed in excretions and secretions, might contaminate via wild pigs or swine manure. Waste food, garbage, swill containing infected meat.
CSF-virus/Classical swine fever (A)	Domesticated and wild pigs	Endemic in much of Asia, Latin America. Staus not reported in African countries. Eradicated in EU, US, Canada, New Zealand, Australia as of 2020, in total 38 countries are officially free. 1990's large CSF outbreaks occurred in The Netherlands (1997), Germany (1993-2000), Belgium (1990, 1993, 1994) and Italy (1995, 1996, 1997).	Last detected in 1963	Medium to high	No	Moderately fragile, does not persist in the environment unless cold/moist, and in contaminated meat/biological products were it might remain infective for weeks. Persists 3-4 days in decomposing organs. Transmission through direct and indirect contact, fomites, waste food, wild boars

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
Capripoxvirus/ Sheep and goat-pox (A)	Sheep and goats	Africa, Asia, Middle East, Balkan, Greece, Russia	Last outbreak in 1882.	High	No	Long-lived in environment, but not likely to reach roughage
Transmissible gastroenteritis (TGE) virus/TGE-virus of swine (A)	Swine	Sporadic Europe, North America, Asia	Never	Medium	No	Fecal- oral transmission. Feces main source – feces-contaminated material may be risk. Relatively long persistence detected in soybean and corn, indicating possible survival also in roughage, if moist and cold.
Swine vesicular disease (SVD)-virus/SWD (A)	Domesticated and wild pigs	Sporadic outbreaks, few in Europe last decades (Italy, Portugal). Unknown due to subclinical disease and lack of surveillance.	Never	High	No	Fecal contamination a major source of transmission, also via fomites, low infectious dose. High persistence in environment. Swill, meat scraps (not inactivated by low pH)

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	**Animal species/host/vector**	**Occurrence (worldwide, Europe, the Nordic region)**	**Occurrence in Norway (yes, no, never, latest detection or observation)**	**Persistence in roughage (high, medium, low)**	**Zoonotic potential**	**Comment**
Foot-and mouth disease (FMD)-virus/FMD (A)	All domesticated- and wild cloven-hoofed animals. Cattle, sheep, goats and swine most susceptible.	1/3 of OIE countries are officially free, mostly industrialized countries. Endemic in parts of Asia, Africa, the Middle East and South America. Sporadic outbreaks in Europe.	Last detection/outbreak in 1952.	Low to medium	No	Shed in all secretions/excretions, survives well in biological products if pH >6. May persist for days to weeks in organic matter (moist and cool temperature) Risk related to contamination of roughage. Spread via roughage so far not described.
Bovine viral diarrhoea (BVD)-virus (Pestivirus, Flaviviridae)/BVD **(B)**	Cattle, sheep and goats (camelids)	Worldwide	Eradicated since 2006	Low	No	Shed by persistently infected animals. May survive three weeks at 5°C (medium)
Border disease (BD) -virus (Pestivirus, Flaviviridae)/BD (B)	Sheep and goats (cattle)	Worldwide. Assumed less widespread than BVD	Never detected (clinical border disease likely caused by BVDV)	Low	No	As BVD

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
Teschovirus/ Teschovirus encephalomyelitis (A)	Domesticated- and wild pigs	Sporadic in East Europe, Africa and Asia. Not in Eastern Europe last 20 years.	Never	High	No	Faecal-oral transmission. Fomites may also transmit infection. Stable over a wide pH range, can survive in liquid manure
Parasites/protoza						
***Neospora caninum/* neosporosis**	Several, main host: Canines	Worldwide	Yes. Low prevalence, but regional differences.	High	No	May easily be transmitted via roughage, but already present at low level in Norway
***Echinococcus multilocularis* (B)**	Extensively described in Table 9. Biological hazards with a zoonotic potential that may be present in roughage					
Fungal						

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
***Trichophyton verrucosum*/Ringworm (B)**	Several. main host: Cattle	Worldwide	Yes, low prevalence. Almost eradicated in Norway. However, regional increase in recent years, with ongoing detections.	High	Yes	Can survive several years under dry conditions. Sensitive to UV-light
Prions						
PrPSc/ Scrapie (B)	Sheep (goats and mufflon)	Worldwide, endemic in most European countries, Australia and New Zealand are free	Classical scrapie: last outbreak in 2009. Sporadic cases of atypical scrapie (Nor98) yearly.	High	No	Both vertical and horisontal transmission, also indirectly via environment. Remain infectious after years in the environment and in soil. Shed in urine/faeces/placenta/birth fluid.

Pathogenic microorganisms/disease (Capital letter refers to NFSA's list of animals diseases)	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway (yes, no, never, latest detection or observation)	Persistence in roughage (high, medium, low)	Zoonotic potential	Comment
PrPres/ **Bovine spongiformencelopathy/mad cow disease (B)**	Cattle	Worldwide Mainly in Europe, Asia, the Middle East and North America.	Atypical BSE detected in 2015	High	Yes	No evidence of direct transmission between animals. Cattle are usually infected through the dietary intake of prion contaminated feed. The risk of contamination occurs if the feed contains products derived from ruminants, such as meat-and-bone meal

Comments on survivability and transmission of selected pathogens listed in the table

The causative pathogen of Q-fever, *Coxiella burnetii,* is highly capable of survival in dust and environment (Gürtler et al., 2014), which means it is likely to survive a transport period. Q-fever may cause disease in the animal- and human population. Nevertheless, an introduction might not lead to disease neither in animals nor in humans immediately, as subclinical infections are common. If established in the animal population, humans will be at continuous risk of being infected. The largest ever reported outbreak occurred in the Netherlands in 2007–2010, resulting in more than 4000 human cases and a hospitalization rate of 20%, due to spread of *C. burnetii* from dairy goats (van der Hoek et al., 2012).

In countries with widespread African swine fever in the wild boar population, infected wild boar may serve as a source of contamination of roughage. Many of the countries in Europe with endemic African swine fever also have a considerable wild boar population. Virus from infected animals and carcasses, and the secretions and feces from infected animals, might contaminate the roughage. The virus is relatively stable outside the host, depending upon the conditions: in dark and humid environments, the virus can survive for weeks. Survivability of the virus is inversely correlated with temperatures, i.e., the lower the temperature the longer the survival. It has been reported that ASFV remains infectious over a long storage time either below 0°C or at 4°C (Mazur-Panasiuk et al., 2019). However, a pH below 3.9 inactivates the virus (OIE, African swine fever technical card). The risk and preventive measures for introduction of African swine fever via import of roughage were assessed by the Norwegian Veterinary Institute (Veterinærinstituttet, 2018a), concluding that the risk of import of AFSV is low but the consequences of introduction are severe. The conclusion in the Opinion of EFSA (EFSA et al., 2021) was, from the Abstract: "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".

Scrapie (classical) is a horizontally transmissible prion disease. Prions enter the environment through shedding from live- or dead hosts, and are highly resistant in the environment. There are several examples that scrape prions have been detected many years after infection and decontamination (https://www.cfsph.iastate.edu/Factsheets/pdfs/scrapie.pdf.) Prions may therefore contaminate roughage, survive transport and reach susceptible animals in Norway.

2.2.4. Relevant zoonotic biological hazards in roughage that can cause diseases in humans

Regarding zoonotic aspects, EFSA opinions (EFSA, 2011; EFSA, 2012; EFSA, 2013a; EFSA, 2013b; EFSA, 2013c; EFSA, 2013d) have ranked pathogens as important for meat inspection and human health (Table 8). Accordingly, these EFSA opinions have served as one of the sources for selection of hazards related to imports of roughage.

Table 8 Priority of hazards related to meat inspection of the animal species, as ranked by EFSA (EFSA, 2011; EFSA, 2012; EFSA, 2013a; EFSA, 2013b; EFSA, 2013c; EFSA, 2013d).

Species	Biological hazards	Chemical hazards
Pigs	*Salmonella enterica* *Yersinia enterocolitica* *Toxoplasma gondii* *Trichinella* spp.	Dioxins, Dioxin-like polychlorinated biphenyls, Chloramphenicol
Poultry	*Campylobacter* spp. *Salmonella enterica* ESBL-AmpC gene-carrying bacteria	Dioxins, Dioxin-like polychlorinated biphenyls, Chloramphenicol Nitrofurans, Nitroimidazoles
Cattle	Pathogenic *Escherichia coli* *Salmonella enterica*	Dioxins, Dioxin-like polychlorinated biphenyls
Sheep and goats	Pathogenic *Escherichia coli* *Toxoplasma gondii*	Dioxins, Dioxin-like polychlorinated biphenyls
Horses	*Trichinella*	Phenylbutazone, Cadmium
Farmed game:		
- **Deer**	*Toxoplasma gondii*	none
- **Wild boar**	*Salmonella enterica* *Toxoplasma gondii*	none
	Trichinella spp.	

Table 9 Biological hazards with a zoonotic potential that may be present in roughage. The data on occurrence of these hazards is based on information from the recent Community Summary Reports on Trends and Sources of Zoonoses, Zoonotic Agents (EFSA and ECDC, 2021). The EFSA reports on meat inspection (EFSA, 2011; EFSA, 2012; EFSA, 2013a; EFSA, 2013b; EFSA, 2013c; EFSA, 2013d), general information from www.vetinst.no/sykdom-og-agens including reports from Norwegian Veterinary Institute on surveillance of several zoonotic agents. Data from Norwegian Surveillance System for Communicable Diseases (MSIS) (msis.no), the textbook Matforgiftning (Granum, 2015), and the report on Risk ranking and source attribution of food- and waterborne pathogens for surveillance purposes (VKM, 2021). Additional sources are denoted by raised font numbers: 1) https://www.cdc.gov/parasites/echinococcosis/epi.html; 2) https://www.oie.int/en/disease/echinococcosis/; 3) https://www.who.int/news-room/fact-sheets/detail/echinococcosis. All the zoonotic pathogens in this table are considered as highly relevant.

Pathogenic agent/disease	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway	Persistence in roughage	Zoonotic potential	Comment
Bacterial						
***Salmonella* spp.**	Several animal species might be carriers. Roughage contaminated with faeces from humans or animals, carcasses of animals.	High level in husbandry in most countries (in particular poultry and pigs). Low occurrence in husbandry in the Nordic countries except Denmark. In addition, possibilities for import of ESBLcarrying *Salmonella.*	Low in husbandry. S. typhimurium with an important reservoir among small birds (Kapperud et al., 1998a; Kapperud et al., 1998b). About 200 human cases/year.	High. (Glickman et al., 1981).	Important to avoid introduction of S. Dublin, S. Typhimurium DT104 and other serotypes, in particular strains that are resistant against antibiotics and not endemic in Norway.	Possibility for import of serotypes with an infectious potential that are not common in Norway

Pathogenic agent/disease	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway	Persistence in roughage	Zoonotic potential	Comment
Enterohemorrhagic *Escherichia coli* (EHEC)/ Verocytotoxin producing *Escherichia coli* (VTEC)	In particular ruminants. Roughage contaminated with faeces from humans or animals.	Widespread throughout the world	One outbreak in Norway by dry, cured sausages of mutton (Schimmer et al., 2008). Contact with farm animals. About 1500 human cases/year.	Medium Might survive (Opheim et al., 2003; Urdahl et al., 2009). Survival in silage is discussed but not concluded (Driehuis et al., 2018).	Yes – a great direct and indirect potential. Low infectious dose	Possibility for import of serotypes with an infectious potential that are not common in Norway
MRSA	Livestock in general. Mainly pigs and humans.	Widespread throughout the world	The Norwegian pig population is free of MRSA, unlike all other countries. About 2000 human cases/year	Low Probably limited possibilities for survival	Humans are not infected from meat, but from contact with animal and/or human carriers	Limited possibilities to survive through the meat supply chain

Pathogenic agent/disease	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway	Persistence in roughage	Zoonotic potential	Comment
Extended spectrum lactamase (ESBL) producing bacteria (*E. coli*, *Salmonella* spp., *Klebsiella* spp., *Enterobacter* spp.)	Poultry: ESBL/AmpC gene-carrying bacteria were considered to be of medium to high (*E. coli*), and low to medium (*Salmonella*) public health relevance.	Widespread throughout the world	Less prevalence in livestock in Norway than in most other countries. In a NORM survey (2019) 3.0% of the human urine isolates were reported as ESBL producers whereas in blood culture 7.1% of the strains were ESBL positive.	High. Probably, good persistence particularly in relation to *Salmonella*.	Yes	See also Appendix I on antibiotic resistance as to MRSA and ESBL
Parasites/Protozoa						
Toxoplasma gondii	The domesticated cat is the main host. Many animal species might be intermediate hosts, particular sheep and pigs that are not housed. Roughage: carcasses of rodents or faeces from cats	Widespread throughout the world	High in sheep. Survival in pasture during the winter in areas protected by snow (Skjerve et al., 1996). Formerly reported annually to MSIS: 30 - 40 cases of which 5 – 10 children <1 year.	High	One of the most widespread zoonotic pathogens.	More virulent strains in America than in Europe (Pomares et al., 2018).

Pathogenic agent/disease	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway	Persistence in roughage	Zoonotic potential	Comment
Echinococcus multilocularis	The definitive hosts are canids; these are usually red foxes (*Vulpes vulpes*) in temperate regions. Has an indirect lifecycle, with the tapeworm stage in the intestine of the definitive host and the larval (metacestode) stage in small mammals.	Evidence for emergence for this parasitosis in some regions of Europe, such as Austria, Lithuania, Poland, and Switzerland (Bouwknegt et al., 2018). *E. multilocularis* is not endemic in mainland Norway, but is in Sweden and Denmark, and is also established on Svalbard. It is therefore only a matter of time before it establishes in mainland Norway (VKM et al., 2012). This is likely to result in the potential for increased likelihood of human infection within Norway	2 – 7 human cases/ year	High. Eggs are robust, and eggs that have been deposited in soil can stay viable for up to a year[1].	Yes. The predator-prey cycle between wild canids and rodents means that the lifecycle is difficult to interrupt and has enabled the wide distribution of this parasite (VKM, 2021)	The severity of chronic morbidity is high and of those infected, a high proportion exhibit chronic morbidity (VKM, 2021)

Pathogenic agent/disease	Animal species/host/vector	Occurrence (worldwide, Europe, the Nordic region)	Occurrence in Norway	Persistence in roughage	Zoonotic potential	Comment
Echinococcus granulosus	The "European" biotype has dogs as definitive hosts and various livestock species as intermediate hosts. The fox is not a definitive host for *E. granulosus*.	*Echinococcus granulosus* is found all over the world.	The "northern" biotype has dogs and wolves as definitive hosts, and various deer (reindeer, elk, deer, roe deer) as intermediate hosts.	High. Eggs are robust, and eggs that have been deposited in soil can stay viable for up to a year[1].	Yes. The cycle of *E. granulosus* in wildlife is not amenable to control, but by discouraging scavenging, and implementing hygiene, the infection of domestic animals and the subsequent spread to humans can be reduced[2].	Human infection with *E. granulosus* leads to the development of hydatid cysts most often in liver and lungs[3]
Taenia solium cysticercos*is*	Pigs are the intermediate hosts while humans are the definitive host. Humans are infected by eating pork or by ingestion of eggs by faecal contamination. Faecal contamination of roughage.	Not in Europe, but common in Asia, Sub-Saharan Africa, and Latin America. In some areas it is believed that up to 25% of people are affected (EFSA, 2011)	No	High	Yes	Relevant by import of roughage from regions listed in column no. 3

The following agents were not assessed in relation to imports of roughage:

- *Campylobacter* **spp. due to missing possibilities for survival in roughage, and these pathogens are also present in Norway**
- Yersinia enterocolitica; Listeria monocytogenes; Clostridium bo***tulinum; Cryptosporidium parvum; Giardia lamblia, duodenalis; Trichinella; Taenia saginata cysticercus; Francisella tularensis*****, puumalavirus and hepatitis E virus are present in Norway.**

Antimicrobial resistance (AMR)
Roughage may be exposed to bacteria which may carry antimicrobial resistance genes agents used both in human and veterinary medicine. The risk of development of AMR in bacteria is high in areas with high use/concentration of antibiotics. An example is in the vicinity of production plants of antibacterial agents, where contamination of antibiotics from the production may induce resistance in the bacterial microbiota in the outlet water (Larsson, 2014). The resistance patterns in the microbes detected is of major concern.

Contamination of silage from such waste products is thus of importance. The issue is at present handled by defining countries from which silage can be imported provided that necessary control measures are met. It is of crucial importance that these control mechanisms are vigilant. If not, the consequences for successful treatment of infections in both human and veterinary medicine may be radically reduced as the number of available effective antibacterial agents may be severely reduced.

2.3 Infection threats in EU countries and relevant third countries

The disease situation with regard to occurrence of infectious diseases in an area or country is continuously changing. Particularly for some infections, it might change rapidly. It is therefore strictly necessary to check updated information and official disease status for notifiable diseases and known disease outbreaks. With this in mind, some general aspects are mentioned below.

In the EU, Sweden and Finland stand out with a disease situation in livestock that is comparable to Norway. However, both *C. burnetii* and *Mycobacterium bovis* occur in the ruminant population in both countries, but the incidences are lower or significantly lower than in the other EU countries and in relevant third countries, for example Canada. The few countries that have not reported any cases of Q-fever are Norway, Iceland and New Zealand. So far, Norway and Iceland are the only countries with no detection of *M. bovis.* Sweden is probably the only country in the world free from paratuberculosis and Finland has not reported incidences of the disease since 2007 (OIE). Throughout the EU area and in all relevant third countries, *M. avium* subsp. *paratuberculosis* is a widespread infectious agent in ruminant populations. There is convincing evidence for emergence for infections of humans caused by *Echinococcus multilocularis* and *Echinococcus granulosus* in some regions of Europe. *Taenia solium cysticercus* does not occur in Europe, but is common in Asia, Sub-Saharan Africa, and Latin America. More virulent stains of *Toxoplasma gondii* occur in America (Pomares et al., 2018).

The prevalence of MRSA is low in all livestock populations in the Nordic countries Norway, Sweden, Finland and Iceland. In the other EU countries and relevant third countries, the prevalence of MRSA in pig populations and cuckoo calf production is considered high, while in the other ruminant populations it is considered moderate (EFSA, 2017).

In other European countries the occurrence of ESBL is higher than in Norway, particular in southern or southeastern countries, as reported by the ECDC (WHO, 2021). In the US, 131,900 human cases of ESBL producing *Enterobacteriacea* were reported to the CDC in 2012. Five year later the number of human cases had increased to 197,400 (CDC, 2019). Without giving any figures WHO reported that ESBLs are an increasing problem worldwide. However, a reporting system is under way (https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance).

3 Probability of introduction

3.1 Probability of introduction of quarantine pests listed in Annex I and II in the 'Regulation relating to plants and measures against plant pests' related to import of roughage to Norway

Given that it is unlikely that any stages of the insect quarantine pests in Table 6 could survive drying and baling plus transport, we consider the probability for all plant pests evaluated in chapter 2 to be low with low uncertainty. In case of *T. indica*, the only relevant pathogen listed in Annex I and II, there is hardly any import of hay and straw from countries in which the fungus is found. Unless this changes, we consider the probability of introduction to be low with low uncertainty.

3.1.1 Conclusion of the probability of introduction of quarantine pests listed in Annex I and II.

The probability of introduction of quarantine pest and diseases listed in Annex I and II is low, with low uncertainty.

3.2 Probability of unintentional introduction of invasive alien plant species

It is difficult to assess which plant species that could be introduced. However, as hard coated seeds will survive drying, baling and transport, we consider the probability for introduction to be high with a low uncertainty. However, we are not confident to conclude which species might be introduced and from which regions.

3.2.1 Conclusions of the probability of unintentional introduction of invasive alien plant species

The probability of introduction of plant species via seeds is high, with low uncertainty. However, there is a high uncertainty regarding which species and whether these plants are considered as invasive alien plant species.

3.3 Probability of introduction of animal and human health related pathogens related to import of roughage to Norway

In addition to evaluating the probability of introducing specific pathogenic species to Norway, it is also important to consider import of specific serotypes or strains of species that are not endemic in Norway. Consequently, such species or variants are also listed here.

The rating of probability for introduction concerns export in general, unless stated specifically in this chapter. It must be emphasized that there is a high level of uncertainty associated with the probability for introduction of all the pathogens listed below.

***Salmonella*:** When Finland and Sweden joined the EU in 1995, special guarantees on *Salmonella* were connected to trade from other countries of certain live animals and products, and are laid down in Regulation (EC) No 1688/2005 as regards certain meat and eggs (https://ec.europa.eu/food/safety/biological-safety/food-hygiene/microbiological-criteria_sv; Anon, 2005). Norway has achieved the same guarantees, linked to the European Economic Area (EEA) agreement with the EU. Accordingly, these countries are allowed to reject shipments of meat products containing *Salmonella* from member states in the EU. It is considered crucial for Norway to keep Norwegian livestock free of *Salmonella*, and control of the import of feed for animals is one of the most effective measures. It is important to avoid introduction of *S*. Dublin, *S*. Typhimurium DT104 and other serotypes, in particular strains that are resistant against antibiotics and not endemic in Norway. For this reason, the probability of introducing the aforementioned examples through import from Finland and Sweden (possibly even Iceland) is considered **low**. By contrast, the probability for introduction of *Salmonella* from most other countries considers as **moderate.** However, this is associated with high level of uncertainty, and the consequences are considered as **large**.

Enterobacteria harbouring Extended spectrum beta-lactamases *(ESBL)* or other resistance genes: In the 2020 the report from the Norwegian Surveillance program on antibiotic resistance in bacteria recovered from infections in humans, 3.4% of the *E.coli* strains were ESBL producing. In blood culture isolates of *E.coli* 6.5% were ESBL. Many of the ESBL strains were resistant to ciprofloxacin, trimethoprim, trimethoprim/sulphametoxazole but much less resistant to aminoglycosides and none of these resistant to carbapenems (NORM/NORM-VET, 2020). The number of ESBLs has been on the rise since 2003 the first cases imported from abroad (Figure 12).

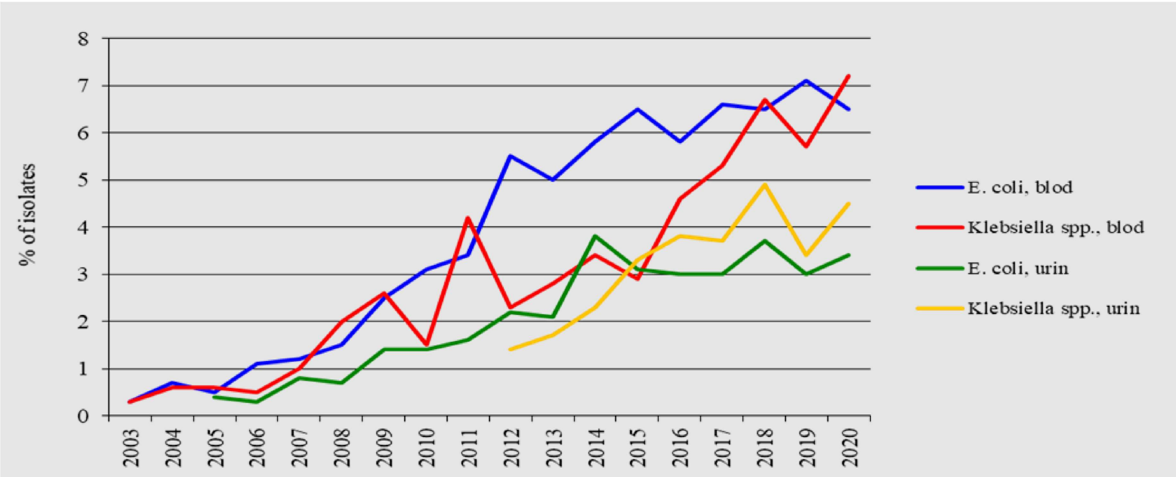

Figure 12 Prevalence of ESBL production among Escherichia coli and Klebsiella spp. isolates from blood and urine in Norway 2003-2020 (NORM/NORM-VET, 2020).

The probability of introduction through imported roughage is, however, regarded as **low**, but the consequences are **large.**

The number of **carbapenemase** producing strains found in Enterobacteriales, *Pseudomonas* spp. and *Acinetobacter* from infections in humans, is increasing (Figure 13). This type of antibiotic inactivating enzyme was initially observed in *Klebsiella* spp. The majority is observed in *E. coli* and *Klebsiella* but also other species may have this type of antibiotic resistance mechanism (NORM/NORM-VET, 2020).

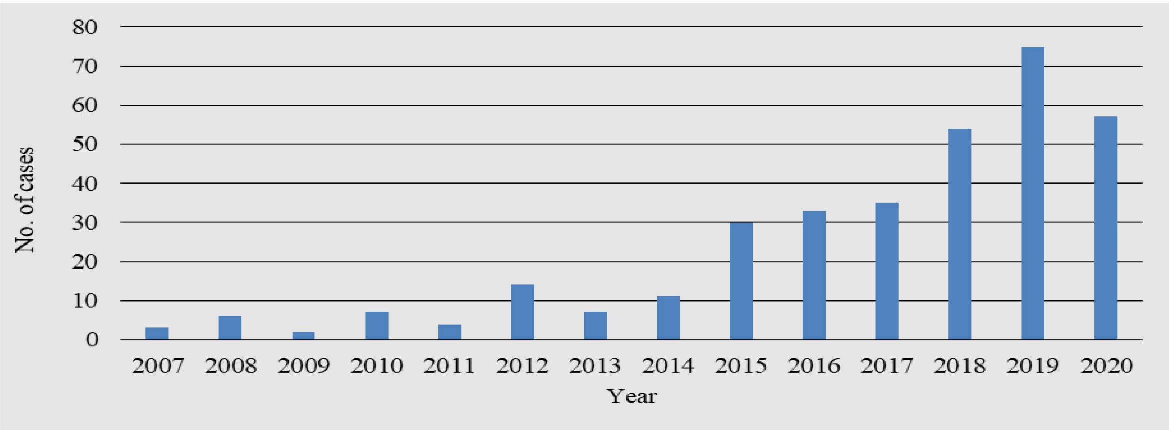

Figure 13 Number of cases with carbapenemase-producing *Enterobacterales* in Norway 2007-2020 (NORM/NORM-VET, 2020).

The probability of introduction through imported roughage is as with ESBL, regarded as **low**, but the consequences are **large**.

MRSA: Methicillin-resistant *Staphylococcus aureus* (MRSA) has been on the rise, in particular after 2008 (Figure 14). The connection to carriage of the microbe in swine herds internationally make it a challenge. The reference centre (located in Trondheim) for MRSA has analysed strains isolated from infections in humans and approximately 50% of the strains belong to clonal complexes (CC) 5,8,1,22,30 (NORM/NORM-VET, 2019; NORM/NORM-VET, 2020). The probability of introduction through imported roughage may be reduced by avoiding import of roughage from areas, where both production and usage of antibacterial agents are applied under loose restrictions. The probability of introduction through imported roughage is regarded as **low**, but the consequences are **large**.

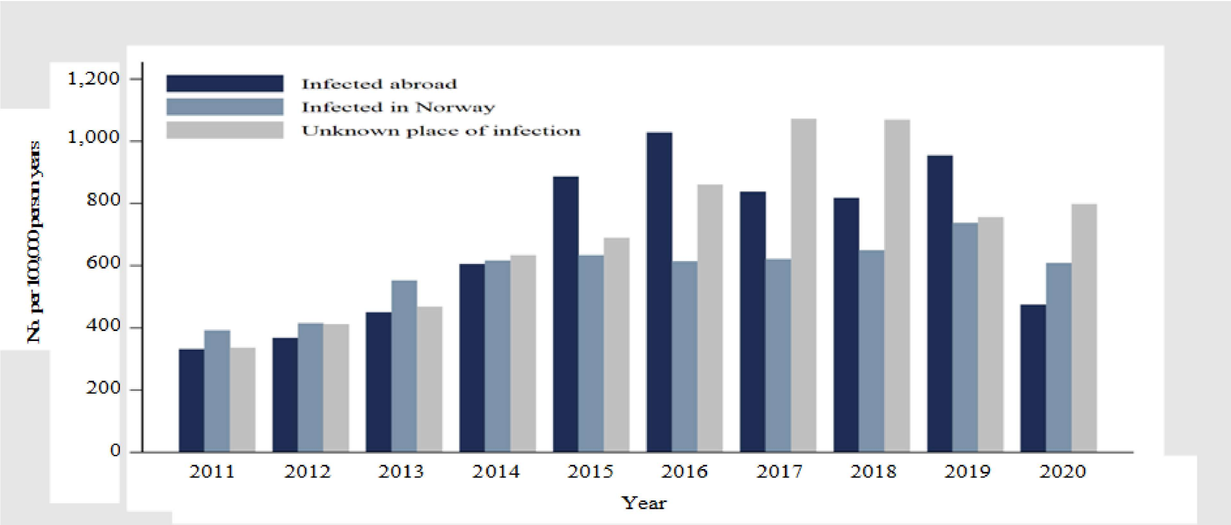

Figure 14 Number of persons notified with MRSA in Norway in the last ten years, by assumed place of infection (NORM/NORM-VET, 2020).

***Coxiella burnetii*/ (Q-fever):** The pathogen has been detected in most countries that have conducted surveillance, but has never been detected in Norway, Iceland and New Zealand (OIE). Sweden reported that 8.2% of the dairy herds were positive for antibodies (Ohlson et al., 2014) and in Denmark the positive number for antibodies was 79.2% (Agger and Paul, 2014). Q-fever usually receives little attention in the endemic countries, which include almost all the possible export countries. The probability of introduction through imported roughage is regarded as **moderate**, but this is associated with high uncertainty and the consequences **moderate** to **large**.

***Mycobacterium avium* subsp. *paratuberculosis* (MAP):** Paratuberculosis, also known as Johne's disease, has been detected in Norway, with the last detection in cattle in 2015 (Kampen et al., 2021). The prevalence is regarded as very low in Norway. MAP is present worldwide, except for Sweden which is free from it. In Finland, the occurrence of this pathogen is low. Introduction via roughage to susceptible species in Norway is a possible scenario since MAP also is shed in faeces and can survive for a long period in faeces, manure, in the environment and on pasture. The probability of introduction through imported roughage is regarded as **moderate**, but this is associated with high uncertainty and the consequences moderate to **large.**

Mycobacterium bovis, M. tuberculosis and M. caprae (M. tuberculosis complex)/Tuberculosis (TB): These members of the *M. tuberculosis* complex are zoonotic pathogens with worldwide prevalence. However, Norway is considered free from bovine tuberculosis (https://www.vetinst.no/overvaking/tuberkulose-storfe-kameldyr-oppdrettshjort). Among the member states, EU reported in 2018 that 17 were free from bovine tuberculosis and 11 were not. The countries where TB was still present in varying degree were Bulgaria, Croatia, Cyprus, Greece, Ireland, Malta, Romania, Italy, Portugal, Spain and United Kingdom. Switzerland was also defined as free from TB (https://www.visavet.es/bovinetuberculosis/bovine-tb/eradication.php). Likely transmission occurs via inhalation of aerosols, which is the most common infection route. Another transmission route is via the ingestion of contaminated material. Cattle infected with *Mycobacterium bovis* may shed bacteria in faeces, urine and milk, but these are minor sources of transmission. The bacteria causing TB can survive in hay, and infection via imported roughage is thus possible via aerosols or ingestion of contaminated hay to ruminants. It is also possible that aerosols originating from hay can infect humans. Ingestion of milk from infected animals is also a possible transmission route from animals to humans. The probability of introduction is considered as **moderate,** but this is associated with high uncertainty. The consequences are **large** both with regard to animal and human health.

African/classical swine fever virus: Both African and classical swine fever infections are highly severe animal diseases, neither pathogen have been observed in Norway or other Scandinavian countries. Both viruses infect domestic and wild pigs. African swine fever is emerging in Europe (EFSA et al., 2021). For both, the occurrence may also rapidly change. Both, and in particular African swine fever, are able to remain infective in the environment. Contamination of roughage with the virus is not very likely, but the consequences could be very serious. The main routes of infection for ASF in pigs are either via direct contact with infected pigs of by ingestion of swill containing unprocessed infected pig meat or pig meat products. It can also be spread to susceptible animals via contaminated premises, vehicles, equipment, or clothing. The virus might persist in soft ticks of the genus *Ornithodoros* spp (OIE). Contaminated roughage may be fed to domestic pigs directly and ingested by them, and thereby represent a hazard. Another infection route may be via wild boar that feed on and contaminate roughage stored outdoors. Increasing number and contact between wild boars and domestic pigs in Norway may therefor increase the probability of disease transmission via roughage. The risk of introduction of ASF and other diseases in domestic pigs via roughage/wild boars are influenced by the wild boar densitiy, degree of contact, sanitary measures etc. (VKM, 2018)

For ASF to be introduced to Norway via roughage, several conditions need to be met: contamination of the feedstuff via infected pigs (wild or domesticated) in the export country, survival through the transport/storing, and feeding to wild or domestic pigs, leading to infection of animals in Norway. All steps are possible, but the chances of a situation where all factors happen at the same time, is altogether not high. But the possibility, together with the high consequences, calls for vigilance and caution. In total, the probability of introduction is regarded as **low**, but this is associated with high uncertainty. However, the consequences would be **large**. EU is currently free of classical swine fever, but several countries within the EU have reported outbreaks of African swine fever (OIE-WAHIS). Outbreaks have also been reported recently in for example Serbia, that is on the list of legal third countries for import.

Prion disease/Scrapie: Prions may remain infectious for years. They can be shed from infected animals (urine, faeces), particularly during lambing season (afterbirth), and the protein is highly stable in soil and environment for years. It is therefore possible to contaminate roughage with scrapie protein if it originates from areas with sheep with scrapie. The long incubation period (years) will lead to postponed recognition of such events, and it may be challenging to track such disease to imported roughage in earlier life.

Classical scrapie was reported in 17 of the EU member states between 2002 and 2012, with average prevalence of 8.7 cases /10 000 tests. In most of the countries, the numbers were consistent over the years (EFSA, 2014).

In total, the probability of introduction is regarded as **moderate** or **low**, but this is associated with high uncertainty, with **moderate** consequences. Susceptible sheep would have to be exposed to the contaminated roughage. This is regarded possible, but not very likely.

Mycoplasma bovis: This pathogen is probably not very resistant outside the host, but there are still many uncertainties about transmission and survival. It is a pathogen present worldwide, including in Finland and Sweden. Norway and Iceland are the only countries in the world where *Mycoplasma bovis* have never been detected. The bacterium is very difficult to eradicate if it is introduced to the population. The probability of introduction is regarded as **low**, but this is associated with high uncertainty, and the consequences are considered **large**.

Enterohemorrhagic *Escherichia coli* (EHEC)/ Verocytotoxin producing *Escherichia coli* (VTEC) is widespread throughout the world. Possibility for import of serotypes with an infectious potential in humans that are not common in Norway is difficult to assess. The consequences of introduction of this bacterium are considered **moderate**. However, the survival in roughage is uncertain, and a circle in ruminants is one of the conditions for introduction in humans, so the probability for introduction is **low**.

Echinococcus multilocularis: There is evidence for emergence for disease caused by this parasite in some regions of Europe (Bouwknegt et al., 2018). The eggs are robust, and the predator-prey cycle between wild canids and rodents means that the lifecycle is difficult to interrupt and has enabled the wide distribution of this parasite. The severity of chronic morbidity in humans is high, and of those infected, a high proportion exhibit chronic morbidity (VKM, 2021). Accordingly, the consequences of introduction of this parasite could be **large**. The probability for introduction is considered to be **moderate** or even **low**. However, the significance of roughage in the context of import is unclear.

Echinococcus granulosus has some similarities with ***Echinococcus multilocularis.*** The severity of chronic morbidity in humans is high, and the consequences of introduction of this parasite could be **large**. However, as with *E. multilocularis,* the significance of import is unclear. The probability for introducing this pathogen through roughage is considered **low.**

Toxoplasma gondii is widespread throughout the world. More virulent strains are described from the American continent than in Europe. The consequences of introduction of this pathogen by roughage would be **moderate.** An established life-cycle in animals is one of the conditions for introduction in humans. The probability for introduction is **low**.

Taenia solium cysticercus does not occur in Europe, but is common in Asia, Sub-Saharan Africa, and Latin America. In some areas, it is believed that up to 25% of people are affected. The severity of chronic morbidity in humans is high, and of those infected, a high proportion exhibit chronic morbidity (EFSA, 2011). Accordingly, the consequences of introduction of this parasite could be **large**. However, the significance of roughage in this matter is unclear. The probability for introducing this pathogen is **low**.

The conclusions in this report, with regards to animal and human health-related pathogens, are generally in line with previous assessments. Import of roughage has previously been recommended from areas with farming of sheep. This will decrease the probability of import of cattle and swine pathogens. Even so, scrapie occurs in most countries, at varying prevalence. Prions are highly stable and therefore can be transmitted via roughage, which needs to be taken into consideration in such areas. Import from Finland and Sweden and specific regions of Iceland, which in represent a lower probability of introduction as the disease situation is similar to the Norwegian. However, Q-fever (*Coxiella burnetii*) which is widespread worldwide is present in Finland and Sweden, but regional differences are evident in Sweden, which could be utilized. Norway, Iceland and New Zealand are currently free from Q-fever.

4 Uncertainties

In this assessment, a number of uncertainties have been identified related to our understanding of the probability for introducing organisms to Norway via roughage. Many of these uncertainties are caused by data gaps and a lack of quantitative studies.

One of the main uncertainties recognized in this work concerns whether negative consequences due to import of roughage will be recognized. Only some of the possible negative consequences will most likely be identified and connected to the roughage import. This include events that cause disease in animals or humans that occur in relatively short time after the import, and therefore can be associated with the commodity. This includes clinical diseases that are severe enough in individuals, or in large enough groups of animals/humans to be suspected and confirmed. It also includes infections that are part of a surveillance program, which is in place for several animal and plant diseases, but still represents relatively few of the possible pathogens. Imports that lead to delayed disease outbreaks, either due to a long incubation period (for example, paratuberculosis and scrapie that could take several years), or if it takes time before it is sufficiently established in the population to be recognized (for example AMR), it will be challenging to establish a causal association to the import. Due to this, one of the main uncertainties is that we might not recognize, or might never be able to understand, all the negative consequences that occur.

Other identified uncertainties concern a limited understanding of the following:

- Insufficient knowledge on the consequences to animal/human health following exposure to pathogens present in roughage.
- Uncertainties on the potential for survival and establishment of microorganisms in roughage. Also, uncertainties regarding prevalence/incidence of the pathogens in question in the country of origin or even region of origin.
- Uncertainties concerning the probability of contamination of roughage during production, harvest or storage
- For uncertainties regarding the technical aspects of laboratory methods, see data gaps. In order to identify critical uncertainties and urgent research data gaps, a broader uncertainty analysis might be useful (EFSA et al., 2018).

5 Risk-reducing measures

The most efficient risk reducing measure is to avoid import of roughage from other countries. This may be achieved by buying roughage from other areas in Norway or by changing the feed plan by using alternative recourses of fiber, such as straw in combination with more concentrates.

If import is necessary, the following measures are considered risk-reducing:

- Import of roughage should be done from areas:
    - With no or low density of the same organisms as the area where the roughage will be used.
    - where it is produced without the use of livestock manure, preferably during the last two years subsequent to harvest.
    - that can document low prevalence or no occurrence of the infection threats that have been assessed.
    - with properties that practice high stubble height during forage harvesting.
- Sorting out roughage that is of poor quality, which is moldy or contaminated with soil.
- Avoid import of roughage that may also contain organic material other than roughage, such as excrement and carcasses.
- Avoid feeding pigs with imported roughage.
- Acid treatment of the feed that lowers the pH can possibly reduce/eliminate the risk of infection, but there are still many knowledge gaps about this. In addition, the acidity of acid-treated roughage can vary greatly and is difficult to measure.
- Import of roughage that is properly ensiled. The effect of the ensiling process on survival of pathogens is affected by pH and water activity of the silage. Too high pH and dry matter will improve the conditions for the pathogens' survival. In Norway, additives are often used to ensure that lactic acid producing bacteria predominates the fermentation process to ensure low pH and suppress growth of other anaerobic microorganisms. However, for most other countries in Europe (except for Sweden, Iceland and Finland), use of additives is considered too expensive relative to the benefits when making baled silage or haylage.
- Set requirements to producer, carrier, importer and receiving farmer regarding packing and damage:
    - the packaging must be intact.
    - round bales should be packed in at least 8 layers of plastic.
- The exporter and recipient should demand a veterinary certificate stating the relevant disease status of the area of production (e.g., absence of unwanted pathogenic threats).
- Demand storage for at least two months in the country of origin before import.
- Store the imported roughage as long as possible before use.

- Avoid access of the imported roughage to wild grazing animals to reduce the risk of introduction of disease to the wild animal population. Surveillance and control measures are challenging when pathogens are introduced and the disease is established in such populations.

6 Conclusions (with answers to the terms of reference)

1. **Based on the situation in 2018, provide an overview of the types of roughages that are relevant for import into Norway, measures of treatment, import volumes, as well as relevant exporting countries (EEA and third countries).**

Based on the import statistics before 2018 and particular for 2018, the roughage types that are most relevant for import in the future are straw, hay and haylage, with the Nordic countries as the main exporters. The transport cost per unit of feed decreases with dry matter (DM) concentrations. Silage (DM <50%) has usually higher energy value than hay (DM>80%) and haylage (50%<DM<80%) as it is harvested at an earlier state of plant maturity. To ensure aerobic stability of haylage, it is recommended to use propionic acid or sodium benzoate as additive at baling and at least eight layers of plastic for packaging (see the general introduction on forage).

2. **Assess the probability for introducing quarantine pests listed in Annex I and II in the Regulation relating to plants and measures against pests.**

The probability of introducing quarantine pest and diseases listed in Annex I and II is low, with low uncertainty. This is due to the expected low survival of pests in roughage and the restriction of hay and straw import from certain countries. The conclusion may need to be re-assessed if countries of origin change in the future.

3. **Assess the probability of introducing contagions to animals concerning diseases listed in Annex A, B, C of the Regulation on warning and notification of diseases in animals. The assessment shall include livestock, i.e. cattle, sheep, pig, horse, poultry, wild animals and pets.**

Import of roughage represents a probability for introducing pathogens to the animal population in Norway, both wild and domesticated. This probability cannot be eliminated, but the probability of introduction will vary depending on the disease situation of the country/area of origin. This report identifies certain pathogens that are known to represent such a probability for introduction through imported roughage. It is important to be aware of the risk associated with unknown or new pathogens. The possibilities also exist for infection of wild animals and pets. It must be emphasized that there is a high level of uncertainty associated with the probability for introduction of all the pathogens listed below.

Among the known specific animal disease pathogens, the probability of introduction in general is regarded **moderate** for ***Coxiella burnetii*** (Q-fever), ***Salmonella* spp.**, ***Mycobacterium bovis/ tuberculosis/ caprae*** and ***Mycobacterium avium* subsp*.* *Paratuberculosis.*** These disease pathogens have **moderate to large** consequences for animal and human health. The probability of introduction of **swine fever virus (classical and African), PrP^{Sc} (Scrapie)** and ***Mycoplasma bovis*** are all regarded as **low.** The **large** consequences of an introduction of particularly swine fever are worrying and call for particular attention. Also, consequences of introduction of ***Mycoplasma bovis***, if established in the cattle population, are regarded as large.

4. **Assess the probability of introducing zoonotic diseases to humans not addressed in question 3.**

It must be emphasized that there is a high uncertainty associated with the probability for introduction of the zoonotic pathogens listed below.

The consequences of introduction of ***Echinococcus multilocularis, Echinococcus granulosus*** and ***Taenia solium cysticercus*** by roughage is assessed to be **large**, but the probability for introduction is **low**. Consequences of introduction of specific strains of **EHEC/VTEC** and ***Toxoplasma gondii*** by roughage were assessed as **moderate**, but the overall conclusion is that the probability for introduction is **low** for these agents.

Although, contamination and probability of introduction of **AMR** to Norway via roughage is assessed to be **low**, the consequences of such introduction, in particular, due to resistant bacteria like **MRSA, colistin-resistant and carbapenemase- and ESBL**-producing bacteria with low prevalence in Norway are assessed to be **large**.

5. **Assess the probability of introduction of harmful, alien plants.**

The probability of introduction of harmful alien plants via seeds (*viz.* invasive plant species) is high, with low uncertainty. However, there is a high uncertainty regarding which plant species may survive the transport and measures of treatment and whether these plants are considered as invasive alien plant species.

6. **Regarding questions 2-5, VKM is requested to examine possible differences between various types of roughage and feed from different countries of origin.**

In general, a low water activity / a high dry matter content, and a low pH value will prevent pathogens from surviving in roughage.
Import of roughage from Finland and Sweden and some specific regions of Iceland has a low risk for introduction of infectious diseases. These countries have a similar situation to Norway regarding disease status. The risk increases with import from south and east of Europe. Outside the EU and EEA, the disease situation is complex and unclear, and import should, if possible, be avoided.

7. **Identify and assess possible measures of risk reduction and their consequences. This includes:**

a) **Relevant measures from the producer, exporter, during transport and storage at the producer and/or from the final recipient in order to reduce**

the probability of introducing harmful, alien organisms. Also assess the consequences from these measures.

Relevant requirements should be set to producer, carrier, importer and receiving farmer during the whole process from production to feeding of imported roughage.

Examples of risk-reducing measures from importers and final recipients include carefully considering the area of production with regard to animal density, use of manure, prevalence of relevant infection threats and the production methods used, such as high or low cutting. Requesting a veterinary certificate stating the relevant disease status of the area of production (e.g., absence of unwanted pathogenic threats) is also an effective measure.

Other measures available for importers and recipients are careful considerations of the quality of the roughage with regard to occurrence of mold, contamination by soil, faeces or carcasses of any kind.

With regards to packing and damage, these steps can be taken into account:

- ensuring that packaging is intact until delivery at recipient.
- ensuring that round bales are packed in at least 8 layers of plastic or net followed by 5 layers of plastic.

Before feeding the livestock, the feed should be checked for faeces, carcasses of birds, rodents etc. Recipients should avoid feeding pigs with imported roughage. Reducing the availability of the imported roughage to wild animals should be avoided.

The probability of introduction of unwanted pathogens will be significantly reduced if these measures are applied.

b) Relevant measures from the importer and/or final recipient should harmful, alien organisms be found in the imported feed.

The feed should immediately be removed following appropriate disposal of contaminated material.

c) The Norwegian Food Safety Authority advises against importing roughage from countries in which African swine fever is present. If this import occurs nonetheless, describe possible measures that can be performed in order to reduce the probability of introducing the pathogenic agent to Norway.

If this occurs, the most important preventive measure is to avoid feeding pigs (both domesticated and wild boars) with imported roughage.

d) Relevant measures of risk reduction to reduce the probability of introducing pathogenic agents or plant pests. Limitations: GMO, chronic wasting disease, quarantine pests from Appendix 1 and 2 in the Regulation on plant health.

For animal diseases and zoonoses the question is answered under 7a.

7 Data gaps

- Lack of knowledge on the occurrence in animal populations. Official status for listed diseases - this depends on several factors, such as correct and timely notification to OIE, and surveillance system, with all the possible errors in this system. For non-listed diseases, the situation is even more uncertain.
- Lack of knowledge on the occurrence of zoonotic agents in human and animal populations in many countries.
- Lack of documentation on the occurrence of potential pathogens in roughage. Lack of documentation on survival in roughage.
- Lack of possibilities for testing of roughage for potential pathogens. To eliminate the risk of introduction of pathogens via roughage, it would be beneficial if one could test batches of roughage for the presence of pathogens before import. But a problem with this is that the pathogens probably will not be evenly distributed in a large batch of roughage. It is therefore difficult to obtain a sample that is representative for the whole batch. If a sample is tested and found to be positive for a pathogen, it can be useful to assess whether or not one should import the batch of roughage based on the risks of introducing that specific pathogen. But for the opposite situation, when a sample is tested and found to be negative, it does not provide any knowledge of use to assess the probability of introduction of pathogens. And also, in a sample that is tested to be positive for one specific pathogen, it is still unknown what other pathogens are present. In some cases, it is possible to test risk populations. Farms who import roughage might be tested in the long run.
- Lack of knowledge on African swine fever virus survival in environment. It is unknown due to missing data on how long the virus remains infective under the varying environmental conditions present in roughage. There is also missing data in terms of infection capacity if carcasses. In rotten tissue, the virus remains infectious for only a few days, while in dry tissues it may remain infectious for months (3-6 months in uncooked pork products: https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/AFRICAN_SWINE_FEVER.pdf). Missing data has led to a recently launched call related to survival of African swine fever virus in feed and bedding materials (https://www.efsa.europa.eu/en/art36grants/article36/gpefsaalpha202109-survival-african-swine-fever-virus-feed-bedding-materials).
- Lack of documentation of transmission of pathogens via roughage to livestock and indirect to humans. There are very few documented cases of transmission of pathogens via roughage. It is not straightforward to verify transmission via roughage since we then need to know that the pathogen was not spread from alternative transmission routes, which is hard to assess. There are few case reports, and even less knowledge on the frequency of such events.

- Knowledge gaps in transmission routes of specific pathogens. For many infectious agents, the exact transmission routes are not fully known. Even though direct transmission is the most important factor for many, indirect transmission could still be possible, but how and when is unknown, since the most common transmission routes naturally receive most attention. For many pathogens, the animal/vector species is not known.
- Acid treatment of the feed that will lower the pH can possibly reduce / eliminate the risk of infection, but there are too many knowledge gaps about this effect
- Lack of data regarding AMR in roughage in Norway.
- Lack of data on AMR from many countries and regions for occurrence in humans and particularly in animals.
- Lack of methods for determination of AMR bacteria or resistance determinants in roughage.
- Introductions of alien plants that are more adaptable to climate change in Europe could be expected in the near future, due to the need for species used in forestry, agriculture and as biofuel.

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Appendix I

Antimicrobial resistance (applies to bacteria only)

Antimicrobial resistance (AMR) is rising to high levels in all parts of the world and new resistance mechanisms are emerging and spreading globally, threatening our ability to treat common infectious diseases.

Bacteria might be non-susceptible not only due to use, overuse and misuse of antibacterial agents like antibiotics, but also other agents like potentially toxic metals and biocides (e. g. disinfectant agents). In many countries around the world, antimicrobial agents are not only used for therapy and prophylaxis purposes in humans and animals, but they may also be used as feed additives for growth promotion. Potentially toxic metals like zinc (Zn) and copper (Cu) may also be used in animal feed. Resistance against Zn, Cu and disinfectant agents may lead co- and cross-resistance against antibiotics, including clinically important antibiotics used in animals and humans.

Occurrence of AMR-bacteria varies in different countries and geographical areas. Such bacteria may be transmitted to the other parts of the world via humans and animals including migratory birds. The role of imported roughage for transmission of AMR-bacteria cannot be discounted. Because of lack of data regarding AMR bacteria from roughages in this assessment, we compare occurrence of AMR bacteria from feed, animals, food and humans in Norway and also compare with similar data from countries or areas of the world which roughage may be imported from. See Tables AI-1 and AI-2.

Ranking of probability

Overuse of antibiotics remains an important issue to solve, despite a decrease in the use of antibiotics in livestock production in many countries. The uncontrolled spread of antimicrobial resistant bacteria (ARB) and antimicrobial resistant genes (ARGs) in the environment due to soil manuring is of serious concern (Checcucci et al., 2020). Contamination of roughage with antimicrobial residues, AMR and ARGs, due to use of animal manure in the agriculture area cannot be discounted. Although, contamination and probability of introduction of AMR to Norway via roughage might be low, the consequences of such introduction, in particular, due to resistant bacteria like MRSA, colistin resistant bacteria, carbapenemase and ESBL - producing bacteria with low prevalence in Norway, may be large.

Definition of terms

Definition of terms used for probability of introduction and consequences of introduction of antimicrobial resistance are the same as the general terms presented in Chapter 3 Probability of introduction.

Likely introduction; described by occurrence as: L= Low, M = Moderate or H = High. Likely consequence of its presence as: L = Low or M = Moderate or H = High.

Not assessable = N. A. Not relevant = N. R.

For purpose of this assessment, this probability may be generalized for qualitative determination of the probability for detection of bacteria isolated from humans, animals, food or feed harboring AMR properties

Table AI-1. Prevalence of antimicrobial resistance in some bacterial species in *feed, animals and food* in Norway according to the NORM/NORM Vet reports for 2019 and 2020. The table summarizes Likelihood of introduction and consequences of occurrence.

Bacterial species	*Colistin Resistant bacteria*	*Carbapenemase pr oducing bacteria (including resistance towards Imipenem)*	*ESBL - producing bacteria (Including resistance against C eftazedim)*	*Quinolone resistance*	*Amoxicillin/ Ampicillin*	*Methicillin resistance*	*Penicillin (phenoxym ethyl penicil lin)*
E. coli							
Likely introduction	L	L	L/M	M/H	H	N. R.	N. R.
Likely consequence	H	H	H	H	H	H	N. R.
Salmonella							
Likely introduction	L	L	L	L	N. A.	N. R.	N. R.
Likely consequence	H	H	H	H	H	H	N. R.
Staphycococcus aureus							
Likely introduction	L	N. A.	N. A.	N. A.	N. A.	L	L*
Likely consequence	H	H	H	H	H	H	M
Acineotobacter							
Likely introduction	› data from animal, food and feed are available.						
Likely consequence							

Comments to Table 1.
Pseudomonas spp. - General presence in nature. No AMR data from animals, food and feed are available. *Mycobacterium avium* subsp. *paratuberculosis, Mycobacterium bovis*- Introduction of these bacterial species to Norway is not desirable and the question related to AMR is less relevant. No data from animals, food and feed are available. *Mycoplasma agalactiae*- No data from animal, food and feed are available. *Mycoplasma bovis*- No data from animals, food and feed are available. *Bacillus anthracis*- No data from animals, food and feed are available. *Brucella* spp. - Introduction of this bacterial genus to Norway is not desirable and the question related to AMR is less relevant. No data from animals, food and feed are available
Data in Norway are based on NORM/NORM Vet Reports for 2019 and 2020.

Table AI-2. Prevalence of antimicrobial resistance in some bacterial species in *humans* in Norway according to the NORM/NORM Vet reports for 2019 and 2020.

Bacterial species	**Colistin**	**Carbapenemase producing bacteria (including resistance towards Imipenem)**	**ESBL producing bacteria (including resistance against Ceftazedim)**	**Quinolone resistance**	**Amoxicillin Ampicillin**	**Methicillin resistance**	**Penicillin (phenoxymethyl penicillin)**
E. coli	L	L	L	L	H	N. R.	N. R.
Salmonella	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Staphycococcus aureus	N. A.	N. A.	N. R.		H	L**	H
Mycoplasma agalactiae	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Pseudomnas	**N**	**L*** **	**L**		**L**	**N. R.**	**N.A.**
Acinetobacter	**N**	**L*** **	**L**		**L**	**N. R.**	**N.A.**

* The incidence of MRSA in roughage is assumed to be very low, transmission of MRSA from treated roughage to animals and farmers is regarded as minimal.
**The Norwegian Surveillance System for Communicable Diseases (MSIS) registered 945 cases of MRSA infections in 2019 compared to 763 in 2017 and 905 in 2018.
*** The number of reported patients increased from 54 in 2018 to 75 in 2019. The number of patients with carbapenemase-producing *P. aeruginosa* (n=5) and Acinetobacter spp. (n=23) was also slowly increasing.

Regarding ESBL, the levels in Central Europe and Southern Europe are higher than in the Nordic region (ECDC, 2021). According to data from CDC (CDC, 2019), increasing incidence of ESBL is reported from US.

The presence of antimicrobial resistant bacteria, AMR genes and antimicrobial drug residues in the sewage treatment plant (STP)-water (Larsson, 2014) and in sludge which may be used in arable agriculture land in many countries may exert selection pressures and contribute to the development and dissemination of antibacterial resistance (VKM, 2009). Data on the occurrence of antimicrobial resistance in sewage sludge from sewage treatment plants or in soil from different countries, where the roughage may be imported to Norway are not available. But even if such data were available, the assessment of the impact to human health from occurrence data, e.g. in soil, is not possible as models to perform such an assessment is non-existing.

Appendix II

Spørsmål til importører av grovfôr

I forbindelse med tørkesommeren i 2018, var det stort behov for å importere grovfôr. Tørt høy og halm er relativt ensarta med hensyn til fôrkvalitet, tørrstoffinnhold og lagringsegenskaper, men i 2018 blei det også importert ensilert grovfôr som rundballer. Egenskaper og fôrkvalitet av ensilert grovfôr hausta fra grasmark kan variere mye på grunn av stor variasjon i opphavsmateriale, slåttetid (plantenes utviklingstrinn), slått (slått nummer 1, 2, 3 eller 4 i året), tørrstoffinnhold, plastkvalitet og mengde. For å få bedre greie på egenskapene hos det som blei importert, ønsker vi svar på noen spørsmål.

Svar fra Felleskjøpet Agri

<u>Surfôr</u>

- Hvilke land blei det importert surfôr i fra?
  Svar: Felleskjøpet Agri importerte grovfôr i rundballer fra Island totalt ca 30 000 stk i 2018. Det har også vært etablert en leveranse fra både Finland og Sverige med tørr halm/høy/høyensilansje til Nord Norge og FK avdelingen i Bergen (til hest)

- Blei det importert surfôr som ikke var ensilert i rundballer? I så fall, hvordan blei det transportert og lagra?
  Svar: Høyet transporteres med lastebil direkte til kunder men vi har også noe lagring av høy til kunder i Smalfjord, FK avdelingen i Alta og FK avdelingen i Bergen. Det har også vært importert noe tørr halm i små firkantbunter for bruk under Finnmarksløpet (hundeløp).

- Veit dere hva slags plantemateriale som var i rundballene?
  Svar: Ifølge kontrakten skulle rundballene inneholde 70% timotei og 30% kløver.

- Hva var de dominerende grasartene?
  Svar: Vi har ikke full oversikt over hvilke arter som er i de ulike partiene. Når det gjaldt importen vi gjorde fra Island i 2018 var det om å gjøre å sikre nok fôr til å opprettholde husdyrproduksjonen. Det ble stilt en del krav til kvalitet men vi så at den varierte mere enn ønskelig. Men Timotei, engsvingel, kveke, Engrapp, rødkløver og hundegras var nok det som dominerte. Kan også være noe raigras. Island og Norge har mye felles

plantemateriale og ifølge en store norske leksikon om planter på Island er det kun 18 arter på Island som vi ikke har i Norge
https://snl.no/Planteliv_p%C3%A5_Island

- Var plantematerialet hausta fra eng i omløp eller fra permanent eller langvarig eng?
  Svar: Det var nok begge deler. Når alarmen om tørken gikk i juli fikk vi kontakter på Island der det var vanlig med en slått + beite. Mange gjødslet på arealene for å hente mere avling og tok dermed en slått i slutten av August som vi i Norge fikk tilgang til +overskuddsfôr de hadde lagret fra 2017 og 1 slått i 2018. Vi mistenker også at det ble gjødslet på noen beiter for en slått av dette høsten 2018.

- Veit dere hva tørrstoffinnholdet var i rundballene?
  Svar: Ja det har vi oversikt over. Men ifølge kontrakten skulle fôret ligge mellom 40 og 60% TS.
  Kan sende dere en oversikt analysene/over dette, men det var generelt mye tørrt fôr, men selvsagt en del variasjon mellom partiene.

- Hva slags type plast var bruka til innpakking av rundballene?
  Svar: Det vi kjøpte fra Island var rundballer pakket inn med rundballepresse og standard plast beregnet for dette. Ifølge kontrakten skulle föret innholde minst 8 lag med plast, eller nett + 6 lag plast. För som hadde lite plast/skadet ble ompakket på Kai på Island før skipning til Norge.

- Hvor mange lag plast var bruka til innpakking av rundballane?
  Svar: Vi satte krav til 8 lag med plast eller nett+6lag plast -ift transport/håndtering, men i praksis var veldig mye av föret pakket inn med færre lag plast. Årsaken kan nok henge saman med at fôret var allereie høstet når vi satte kravet til 8 lag/nett + 6 lag.

- Var plasten skadd?
  Svar: Ja dessverre ble det en del skader på plasten pga flere håndteringer fra producenten, på lastebil, av lastebil på kai, flytting til båt, omlasting, og avlasting på kai i Norge. Deretter ble det lastet på bil til gårdbruker, avlasting der og flytting på gården. Mange vendinger ga dessverre en del skader med påfølgende mugg. Synlige skader på rundballene som ble oppdaget på kai på Island fikk lagt på noenekstra lag med reparasjonsplast.

- Veit dere om det var bruka ensileringsmiddel? I så fall hva slags type?

Svar: Fôret var av alle typer både med og uten bruk av ensileringsmidler. Mye var bra fortørket og dermed er det grunn til å tro at disse ikke hadde brukt ensilering.

- Var noe av fôret tilsatt urea?
  Svar: Nei det har vi ingen opplysninger om.

- Blei det tatt fôrkvalitetsanalyser? I så fall, er det mulig å få tilgang på analysene eller sammenstilling av analysesvarene?
  Svar: Ja vi tok ut masse analyser som jeg kan sende til dere i eget regneark.

- Ble det oppdaget fôr som var åpenbart muggent?
  Svar: Ja det ble dessverre en del vartonnesang og mugg på en del rundballer. Vi forklarer dette med håndteringen av fôret med klype og hver gang en rundball ble flyttet ble luft presset ut av ballen, og dette ble sugd inn igjen som en svamp etter at rundballen var satt ned igjen.

- Forekom det reklamasjoner på importert fôr, som mottaker mente at var klart mindreverdig? Hva gikk i så fall reklamasjonen ut på? Hva slags fôr, og fra hvilket land kom fôr med reklamasjon fra?
  Svar: Vi hadde en del reklamasjoner på mugg på fôret fra Island. Men vi hadde også noen partier der det tydeligvis var høstet fôr på beitet areal, da vi fikk noen tilbakemeldinger sauemøkk i fôret. Av 30 000 rundballer vi jeg anslå reklamasjon på 1500-2000 stk. Men mange fikk veldig bra fôr også og opplevde produksjonsauke med föret fra Island. En kan vel si vi hadde hele spekteret av kvaliteter.

<u>Heilgrøde-ensilage</u>

- Blei det importert ensilert heilgrøde av korn, kornblandinger eller blandinger med korn kjernebelgvekster (f.eks. ert)?
  Svar: Nei ble ikke importert noe av dette fra Felleskjøpet Agri.

<u>Ammoniakkbehandla halm</u>

- Blei det importert ammoniakkbehandla halm?
  Svar: Nei ikke i regi av Felleskjøpet Agri. Vi satte i gang en storstilt bergingskampanje av norsk halm - der vi ga avsetningsgaranti til kornprodusentene på halmen. Denne halmen ble både ammoniakkbehandlet, ureabehandlet, syrebehandlet og omsatt som tørr halm.

Svar fra Fiskå Mølle

Surfôr

- Hvilke land blei det importert surfôr i fra?
  Svar: Nederland

- Blei det importert surfôr som ikke var ensilert i rundballer? I så fall, hvordan blei det transportert og lagra?
  Svar: Nei

- Veit dere hva slags plantemateriale som var i rundballene?
  Svar: Nei

- Hva var de dominerende grasartene?
  Svar:

- Var plantematerialet hausta fra eng i omløp eller fra permanent eller langvarig eng?
  Svar:

- Veit dere hva tørrstoffinnholdet var i rundballene?
  Svar: 55-60 % TS.

- Hva slags type plast var bruka til innpakking av rundballene?
  Svar: Vet ikke.

- Hvor mange lag plast var bruka til innpakking av rundballane?
  Svar: Vet ikkje.

- Var plasten skadd?
  Svar: Nei.

- Veit dere om det var bruka ensileringsmiddel? I så fall hva slags type?
  Svar: Trolig ikke.

- Var noe av fôret tilsatt urea?
  Svar: Nei.

- Blei det tatt fôrkvalitetsanalyser? I så fall, er det mulig å få tilgang på analysene eller sammenstilling av analysesvarene?
  Svar:

- Ble det oppdaget fôr som var åpenbart muggent?
  Svar: Nei.

- Forekom det reklamasjoner på importert fôr, som mottaker mente at var klart mindreverdig? Hva gikk i så fall reklamasjonen ut på? Hva slags fôr, og fra hvilket land kom fôr med reklamasjon fra?
  Svar: Nei.

Heilgrøde-ensilage

- Blei det importert ensilert heilgrøde av korn, kornblandinger eller blandinger med korn kjernebelgvekster (f.eks. ert)
  Svar: Nei.

Ammoniakkbehandla halm

- Blei det importert ammoniakkbehandla halm?
  Nei

Appendix III

Table

AIII-1. Fourty-four non-woody vascular plant species listed on the Norwegian Alien Species List (2018) as "particularly high risk" (svært høy risiko).

Scientific name	Norwegian name
Barbarea vulgaris	vinterkarse
Bunias orientalis	russekål
Elodea canadensis	vasspest
Elodea nuttallii	smal vasspest
Lactuca serriola	taggsalat
Lupinus nootkatensis	sandlupin
Symphytum officinale	valurt
Reynoutria ×bohemica	hybridslirekne
Vincetoxicum rossicum	russesvalerot
Epilobium ciliatum ciliatum	ugrasmjølke
Epilobium ciliatum glandulosum	alaskamjølke
Aruncus dioicus	skogskjegg
Lamiastrum galeobdolon argentatum	sølvtvetann
Lamiastrum galeobdolon galeobdolon	parkgulltvetann
Lysimachia punctata	fagerfredløs
Pastinaca sativa hortensis	hagepastinakk
Lysimachia nummularia	krypfredløs
Arctium tomentosum	ullborre
Lupinus polyphyllus	hagelupin
Rorippa ×armoracioides	hybridkulekarse
Bromopsis inermis	bladfaks
Cerastium tomentosum	filtarve

Heracleum mantegazzianum	kjempebjørnekj eks
Heracleum persicum	tromsøpalme
Melilotus albus	hvitsteinkløver
Petasites japonicus giganteus	japanpestrot
Petasites hybridus	legepestrot
Phedimus spurius	gravbergknapp
Primula elatior elatior	lundnøkleblom
Reynoutria sachalinensis	kjempeslirekne
Senecio viscosus	klistersvineblom
Vinca minor	gravmyrt
Senecio inaequidens	boersvineblom
Melilotus officinalis	legesteinkløver
Odontites vulgaris	engrødtopp
Solidago canadensis	kanadagullris
Festuca rubra commutata	veirødsvingel
Berteroa incana	hvitdodre
Impatiens glandulifera	kjempespringfrø
Impatiens parviflora	mongolspringfrø
Myrrhis odorata	spansk kjørvel
Phedimus hybridus	sibirbergknapp
Reynoutria japonica	parkslirekne
Alchemilla mollis	praktmarikåpe