Safe insect rearing on yet to be legalised residual streams

Policy brief

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SAFE INSECTS

Key Messages on Food Safety Risks and Mitigation

Four "yet to be legalised" residual streams were analysed and tested for use as substrate in insect rearing. We used Category 2 meat meal from animal rendering, kitchen food scraps, former food from supermarkets, and chicken manure as substrates. Their safety as a substrate for insect rearing was assessed and measures for risk mitigation discussed. Below the key messages:

1. Using residual streams as substrates is nutritional suitable for insect rearing;
2. Safety of live insects can only be assured by using safe substrates, since post-processing is not possible;
3. Pathogens, including bacteria, viruses and parasites, can be potential food/feed safety issues, but can be mitigated by processing the insect product (Regulation (EU) No 142/2011, Processing method 7);
4. Most viruses won't survive substrates with pH below 5;
5. Several chemical hazards (pesticides, medicines and heavy metals) may be a food/feed safety issue unless it is ensured that their levels in insect products are below maximum legal levels;
6. Environmental contaminants, such as dioxins and PFAS, were only detected at very low concentrations in the limited number of samples examined and are so far not likely to be a food/feed safety issue;
7. Other pollutants such as remnants of packaging materials could be present in substrates, specifically in those from kitchens and supermarkets, but using best practices for unpacking and traceability as already applied for former foodstuffs could alleviate most concerns;
8. The expected exposure of cattle to prions after feeding the substrates to insects and subsequently feeding the insects to non-ruminant livestock species is very low and is unlikely to lead to new BSE cases;
9. It is advised to apply and iterate quantitative risk assessments to determine the risk of other transferable animal diseases in the chain as has been performed for BSE in this study;
10. HACCP measures should be taken throughout the entire insect-rearing chain from purchasing to commercialization;
11. Tracking & Tracing of the residual streams can be used as a risk mitigation measure. The safety of former food from supermarkets and household kitchen food scraps as insect substrate can thereby be improved. It is unlikely that household kitchen food scraps can meet the same level of control in existing waste-collection systems;
12. Bioaccumulation Factors (BAFs) and processing Factors (PFs) should be used to determine maximum residue limits (MRLs) for chemical hazards in residual streams to assure the final safety of the insect product;
13. Pre-treatment processing conditional on the respective residual stream can be used for risk mitigation.
14. Former food from supermarkets and kitchen food scraps are similar in terms of biological hazards;
15. Manure from animals that have been treated with veterinary drugs should not be used;
16. Category 2 meat meal is microbiologically and chemically safe to use for insect rearing without any additional pre-treatment;

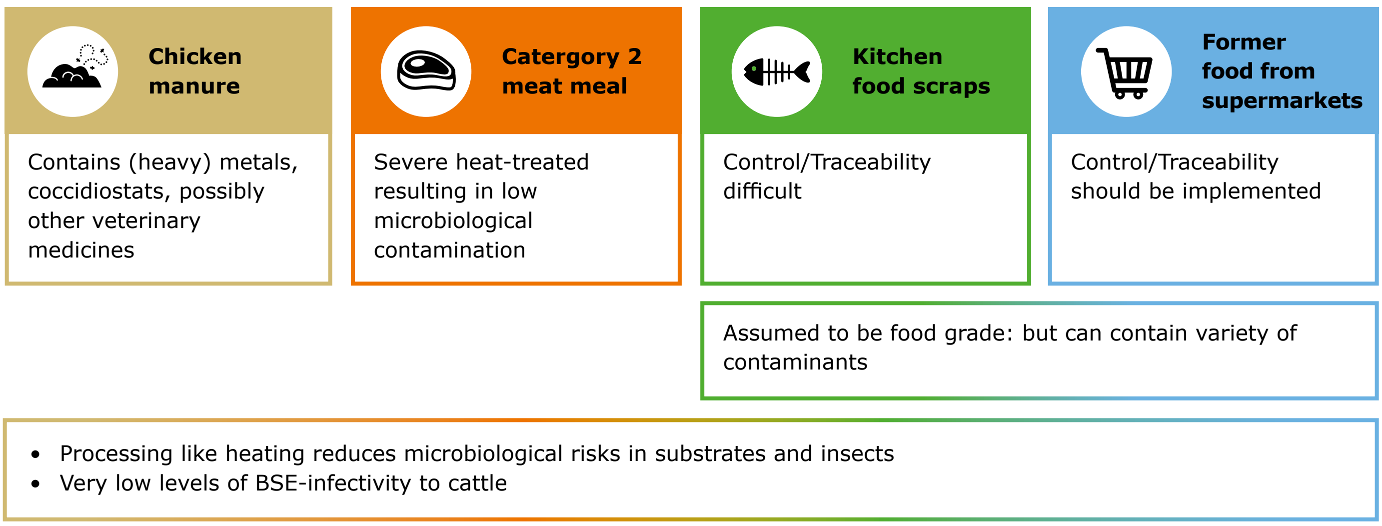

Figure 1 Main conclusions on food safety and mitigation for possible safe insect rearing on these four residual streams.

Introduction

The project SAFE INSECTS identified opportunities for insect rearing on four "yet to be legalised" residual streams. These residual streams can be upgraded to feed or food by using them as substrate to grow insects. This creates additional value (Table 1). These streams can be mixed in with other ingredients to obtain optimal substrate to grow insects. The advantages of insects over other monogastric livestock species include their potential high growth rate and their ability to convert low-grade biowaste into high-quality protein and fat-rich biomass suitable as animal feed. Calculations based on literature data suggest that black soldier fly (BSF) larvae are more efficient than broilers, pigs, and fish in converting substrate nutrients into body mass. BSF is a complementary livestock species that efficiently utilises biowaste which cannot yet be used by other livestock (Seyedalmoosavi et al., 2022). In this project, BSF larvae grew well on wetter substrates, such as homogenised kitchen food scraps from household kitchens and homogenised former food from supermarkets. These were naturally acidified (pH<5), which will increase their shelf-life. Yellow mealworm (YMW) performed well on dry substrates, specifically powdered category 2 meat meal from animal rendering and dried chicken manure. Next to the technical feasibility, we explicitly examined the associated food and feed safety risks. In this document, we will elaborate on i) the safety risks, ii) if and how they can be mitigated, iii) further actions proposed in research and legislation.

Insect meal can be used in feed and in several type of food products.

Table 1 Estimated value calculation of the four residual streams (Hoek-van den Hil et al., 2022) that can be used as an ingredient in substrates to grow insects.

Residual stream	Volume in NL	Estimated positive or negative value	Total positive or negative value[1]	Possible value as insect substrate	Estimated value of available volume[4]	Possible added value per residual stream[5]
Meat meal (category 2)	0.2 Mton/year	€300 €/ton	60 M€/year	€350[3] €/ton	70 M€/year	10 M€
Kitchen food scraps	1.4 Mton/year	-€70 €/ton	-98 M€/year	€50[2] €/ton	70 M€/year	168 M€
Former food from supermarkets	0.016 Mton/year	€10 €/ton	0.16 M€/year	€50[2] €/ton	0.8 M€/year	0.64 M€
Chicken manure	1.4 Mton/year	-€10 €/ton	-14 M€/year	€50[2] €/ton	70 M€/year	84 M€

[1]Volume x current value (M€); [2]Assumed feasible price per ton, referenced to estimated current price of insect substrate of €300-€400/ton (i.e. chicken feed); [3]For meat meal (cat. 2): assumed added value of €50 per ton; [4]Volume in NL x postulated value (M€); [5]Estimated possible value minus current value.

How to use these side streams as feed ingredients

In our study, we used Category 2 meat meal from animal rendering, kitchen food scraps, former food from supermarkets, and chicken manure as substrates for rearing BSF larvae and YMW. These residual streams are nutritious for both insect species and are available in sufficient volumes. Furthermore, alternative applications to the current residual streams are desirable. The challenge is to adjust the substrates to the desired nutritional composition, particle size and dry matter content. The substrate should be in form of loose particles of a few mm, not a paste. Mealworms require relatively dry particles, while BSF larvae require moist particles. To reach the optimal nutritional composition and consistency, mixing with supplements and processing are required. An additional challenge is to manage the variations between batches. Stability can be improved by drying, sterilization and/or acidification.

Legislatory framework

Chicken manure is prohibited from being included in feed for both food-producing and non-food producing animals (Annex III of Regulation (EC) No 767/2009). Furthermore, manure is classified as a 'Category 2' material in Regulation (EC) No 1069/2009, which restricts its applications to fertiliser, transforming into energy such as biogas, or disposal in landfills or via incineration.

Category 2 meat meal refers to meat-and-bone meal derived from Category 2 animal by-products under Regulation (EC) No 1069/2009, and its use is limited to fertiliser or for feeding fur animals.

Former food from supermarkets is fully allowed for feeding insects if it has not come into contact with any animal products (Regulation (EU) No 68/2013 and Commission Note C/2018/2035). However, since the former food included in this project contained meat and/or fish, it is considered a Category 3 animal by-product as defined by Regulation (EC) No 1069/2009. These materials must be processed into 'processed animal proteins' (PAPs) before feeding them to most livestock, but their use in reared insects is not allowed yet.

Kitchen food scraps are not classified as animal by-product under Regulation (EC) No 1069/2009, but as 'municipal waste' as defined in Directive 2008/98/EC. Household waste is prohibited from being used as feed, according to point 6 of Annex III of Regulation (EC) No 767/2009.

Quality of breeding/rearing stock

Insect farming is the practice of breeding insects and rearing/ fattening insect larvae for use as food or feed. Maintaining food and feed safety from biological hazards requires preventive measures and strict monitoring during both the breeding and fattening stages. Furthermore, appropriate processing should be used to reduce microbiological levels. It is important to monitor the health and hygiene of an insect farm regularly. Young larvae could carry potentially harmful microorganisms for insects, humans and farm animals in their microbiome from an external contamination. Therefore, it is important to use insects that are free from such pathogens. In our experiments, the rearing stock of the YMW and BSF larvae that was used at the start of the experiments already showed high levels of bacteria. Most of these bacteria are supposed to be apathogenic and commensals. YMW contained $7.6 \cdot 10^7$/gram while BSF larvae had at least $3.0 \cdot 10^8$/gram bacteria. In BSF larvae, we identified *Salmonella sp*. (Salmonella enterica subsp. enterica Serovar Putten), *Klebsiella pneumoniae*, *Clostridium perfringens* and *Bacillus cereus*, which are known to be potentially pathogenic.

Legislation on four yet to be legalised residual streams

Below is a short description of the legislation applicable for using the four residual streams discussed in this document. All of these residual streams are currently prohibited for use as animal feed, including for insects. In addition to the specific regulations for these materials, general requirements also apply to the rearing and processing of insects for food and feed. However, a description of these requirements is beyond the scope of this document and we refer to the IPIFF website: Insects As Feed EU Legislation – Aquaculture, Poultry & Pig Species (ipiff.org).

Prions

The use of residual streams from agricultural production and food consumption containing animal proteins entails the risk of disease transmission, including Bovine Spongiform Encephalopathy (BSE). BSE is caused by a misfolded prion protein (PrPSC), which is extremely heat-resistant and requires special attention during the rendering process. To prevent a new BSE epidemic the precautionary principle was applied by the European Union, maintaining the ban on the use of most animal proteins in livestock feed, leading to a loss of valuable proteins from the agricultural system. However, in recent years several relaxations were

implemented after quantitative risk assessments indicated that the accompanying risk of new BSE infections was low. These relaxations include the use of insect meal in aquafeed, the use of processed animal proteins of poultry origin in pig feed and the use of processed animal proteins of porcine origin in poultry feed, as well as the use of ruminant collagen and gelatine in non-ruminant feed.
In the SAFE INSECTS project, a similar quantitative risk assessment was used to evaluate the BSE risk associated with using new residual streams containing Category 2 or Category 3 ruminant material as a substrate for insects reared for feed. The developed risk model contributes to assessing the safety of incorporating such residual streams in a circular food system.

The risk model assumed that a single BSE-infected cow went undetected at slaughter and was either processed into meat products for human consumption (Category 3) or Category 2 meat meal. The possible exposure routes of cattle to BSE infectivity when using Category 2 meat meal, former food from supermarkets or kitchen food scraps (both Category 3 products) as substrates for insect rearing are given in Figure 2. Assuming that the insects will be used only as an ingredient in feed for non-ruminants (pigs and poultry) or aquafeed, the infectivity could reach cattle via (1) cross-contamination of ruminant feed in mixed feed mills, during transport or on mixed farms, (2) grazing if insect frass or manure of pigs and poultry is used to fertilise grassland or forage crops, and (3) calf milk replacer if the insect meal is used in aquafeed.
Given that specified risk materials (Category 1) are removed at slaughter, no natural prion disease has been identified in insects, and there is no proof that insects act as a biological vector of prions (i.e. no prion amplification occurs in insects), the risk of new BSE infections via these exposure routes was estimated to be very low with < 1 out of 10,000 slaughtered BSE-infected cows resulting in new BSE infections. This is far below the threshold value of 1 for the basic reproduction number (R0) to initiate a new epidemic. What-if analysis indicated that this is even true in the worst-case scenarios assuming no removal of specified risk material at the slaughterhouse or feeding non-ruminant feed directly to ruminants.

Processing of insects for feed and food

Post-processing of insects can be considered to inactivate microbial hazards that may be present in the insects and arise from the used substrates (legalised or not legalised),

Figure 2 Exposure routes BSE infectivity using kitchen food scraps, former food from supermarkets or category 2 meat meal as substrate for insect rearing.

initial contamination of the breeding stock or environmental contamination (air, water, used materials, animal handlers) during rearing. Heating is the most common method used, as most microorganisms are effectively inactivated by heat treatments (e.g. 90°C for 2 min), except for heat-resistant bacterial spores. Foodborne pathogens capable of forming spores belong to the *Bacillus* and *Clostridia* genera and these spores require more severe processing. For example, heating up to 121°C for 3 min can inactivate proteolytic *Clostridium botulinum* spores. Alternatively, control measures can be applied to prevent spore growth. Common control measures include low temperature, low pH (high acidity) and low water activity (e.g., drying). These measures are all according to best practice, and already established for food and feed. Former foodstuffs from supermarket and kitchen food scraps naturally undergo acidification, lowering the pH to around 4-5.

Category 2 meat meal

Origin

Category 2 meat meal can be collected from meat processors. In our project, it was obtained from animal rendering and derived from a mixture (several species) of dead animals (Figure 3). At the factory, the material undergoes heat/pressure sterilization (133°C for 20 min; according to processing method 1 as defined in regulation (EC) No 142/2011) followed by drying and grinding. The result is a dry brown powder that is very rich in protein. Based on its composition, it can be used as a fertiliser or as feed for fur animals.

Potential for insect growth

YMW grew very well on this type of substrate when combined with carrot pieces, achieving a larval biomass yield being statistically equal to the control using regular chicken feed as a control substrate. Since Category 2 meat meal is a powder, the larvae can be easily separated from the frass after their growth. While the biomass yields were similarly high for Category 2 meat meal and the control, less Category 2 meat meal was needed to achieve this, which implicates that YMW used the Category 2 meat meal more efficiently.

BSF larvae were not fed with Category 2 meat meal because, during our pre-studies, they were not able to handle the fine dry material. Water was added to obtain an optimal dry matter content of 30%. However, the water did not bind to the Category 2 meat meal, leaving a large amount of free water, which triggered the BSF larvae to escape.

Safety risks

The microbial safety of YMW reared on this material can be considered high, at least for the hazards analysed. Category 2 meat meal had the highest concentrations of heavy metals such as cadmium, mercury, lead, and arsenic compared to the other three substrates. Bioaccumulation of the heavy metal Cadmium did occur. However, their levels in both YMW and BSF larvae remained within legal limits. Chemicals like, PFAS, pesticides and medicines were not detected in this material. Low levels of PCBs and dioxins were found in the Category 2 meat meal, concentrations found in insects were far below legal limits for feed.

Category 2 meat meal as used in the experiments.

Measures needed

It is recommended to monitor cadmium levels in insect feed materials, due to possible accumulation in larvae. Procedures to ensure sufficient microbiological reduction should be tested, validated, and subsequently monitored following standard practices in HACCP systems.

Kitchen food scraps

Origin
Kitchen food scraps were collected during a pilot study on separate waste collection in the IJburg area of Amsterdam that gathers waste from household kitchens. The collected material contained vegetables, fruit, potatoes, pasta, coffee grounds, meat, paper, starch flour, small cups of margarine, coffee cups, seeds, plant stems and much more. Kitchen food scraps can be highly contaminated with, for example, packaging materials. Before processing, plastic bags and large contaminants (plastic cups, textile, bones) were removed. The particle size of the remained material was reduced to 3 mm using a rotating grater. Large pieces of fibrous material that did not pass the sieve were removed. The material was not dried, and used as such after reducing the particle size. See Figure 4.

Original kitchen food scraps (left) and after size reduction (3 mm) using a rotating grater.

Potential for insect growth
Kitchen food scraps combined with wheat bran resulted in lower larval biomass yield compared to the control using chicken feed when growing YMW. Separating the mealworms from the frass at harvest was difficult due to the large portions of unconsumed feed that remained, which means that the larval ability to reduce kitchen food scraps is less than the control. Also BSF larvae yield and growth rate on kitchen food scraps was low compared to the other side streams and control feed with a low conversion of the substrate (measured as waste reduction index).

Safety risks
The microbial risk posed by both vegetative and spore-forming bacteria is higher for this type of material compared to other tested substrates. The kitchen food scraps contained high bacterial numbers ranging from 1.4·107/gram to 3.0·108/gram, along with bacterial spores. Clostridium perfringens and Bacillus cereus were both detected, but neither Listeria monocytogenes nor Salmonella spp.4 were found in the substrates. Processing of the larvae can effectively inactivate microbiological hazards, except spore-forming bacteria.

The material also contained some residues of various pesticides, and it cannot be excluded that these had adversely affected the larval growth performance. Given that the maximum residue limits (MRLs) for reared larvae (insects; product code 1060000 in Regulation (EC) No 396/2005) are very low (mostly equal to the substance-specific lower detection limit), any transfer of substances from substrate to larvae could result in regulatory non-compliance. These limits should be reevaluated, considering the inevitable exposure of reared insects to pesticide residues from various substrates. The concentration of the heavy metals arsenic, lead and mercury were all below the limits of quantification in YMW larvae. BSF larval concentrations were low for lead and below the limits of quantification for arsenic and mercury. Low levels for cadmium were found in both insects, and although cadmium accumulated, none of relevant maximum limits for heavy metals were exceeded in the larvae. PFAS was not detected in kitchen food scraps in this study. Low levels of PCBs and dioxins were found in the substrates, and although some accumulation was observed in the insects, concentrations found in insects were far below legal limits for feed.

Measures needed

Processing insect products, as required for producing insect-based processed animal proteins (PAPs), is likely to reduce the microbiological counts associated with this material. However, HACCP-based validation and monitoring would remain equally important. The potential for high levels of pesticide residues in this substrate increases concerns not only for maintaining insect yields but also for compliance with pesticide MRLs, therefore monitoring of pesticides in kitchen food scraps is advised.

There is limited knowledge on the adverse effects of individual substances, particularly in mixtures. Additional research is needed to determine these effects. A potential preventive measure could involve removing materials with higher risk pesticide residue contamination, such as fruit and vegetable peels. However, this may negate the economic feasibility of using this substrate.

Former food from supermarkets

Origin

Former food from supermarkets was obtained from a large company that processes food products from supermarkets that cannot be sold anymore. This side stream contains meat and other animal-derived products. Although most contaminants, such as packaging materials, had been removed by the company, some remained. As part of the company's process, the material was ground (Figure 5), resulting in a slurry which may still contain small pieces of plastic. Both former food from supermarkets and kitchen food scraps contain starch, sugars, protein and an abundant amount of water. The former food from supermarkets also contains a considerable amount of fat. Due to the high water content, these materials are highly perishable and the natural fermentation lowers the pH of the homogenised material to around 4-4.5.

Potential for insect growth

For YMW, the former food from supermarkets resulted in the lowest larval biomass and the least reduction in substrate (measured as waste reduction index) compared to other tested side streams and the control feed. Their survival was not different from the control feed. Nitrogen and starch in former food from supermarkets were lower than in other tested side streams and control feed.

The highest growth rate of BSF larvae, comparing all four substrates, was recorded on former food from supermarkets. Based on larval performance, the former food from supermarket is highly nutritional suitable to use and comparable or slightly better than the control feed.

Safety risks

For both species of insects, the discussion points for the kitchen food scraps measures can largely be reiterated for the former food from supermarkets. In addition to various conventional pesticides, the material was also very high in nicotine. It was hypothesised that this originated from cigarette residues rather than agricultural pesticide use. This highlights the importance of controlling the material throughout the entire chain to prevent occurrence of such hazards. Although some of the tested elements accumulated in the YMW, such as Cu, Zn, Se, and Cd; concentrations in the substrate were relatively low and final concentrations in fresh biomass were far below legal limits. For the BSF larvae, the elements Mn, Fe, Cu, Zn, Mo, Cd, and Pb bio-accumulated. For most of these elements, the bioaccumulation factor observed for the former food from supermarkets was substantially higher than for the other tested substrates (up to twice as high), but BSF larval concentrations were far below applicable legal limits in feed. As with other substrates, PFAS was not

Former food from supermarkets after size reduction.

detected; and dioxins and PCBs were present only in very low levels in the larval biomass.

Former food from supermarkets as a substrate, not surprisingly, contained high bacterial counts ranging from $1.3\cdot10^5$/gram to $2.2\cdot10^8$/gram, including bacterial spores. The material contained *Clostridium perfringens*, *Bacillus cereus* and *Salmonella*, but no *Listeria monocytogenes*, *Campylobacter perfringens* or *MRSA*. *Clostridium perfringens*, *Bacillus cereus* and *Salmonella spp*. are known to be potentially pathogenic for farm animal species and humans, which of course depends on the specific strains and the susceptibility of the end-host, but also on whether these potential pathogens can persist in the insects which cannot be excluded. Pre-treatment of the substrate or post-treatment of the insects should be considered.

Measures needed

In terms of safety, former food from supermarkets and kitchen food scraps are largely similar in terms of potential issues. Therefore, processing would be required to reduce microbiological counts and pathogens, and procedures to ensure sufficient microbiological reduction should be validated, as is standard practice in HACCP systems. Care should be taken to avoid materials likely to contain high levels of pesticide residues and cadmium, monitoring of these components is advised. Former food from supermarkets provides more opportunities for traceability and selection than kitchen food scraps, enabling a higher degree of control. Detailed and clear logistics and handling instructions/protocols would be essential for making this material a suitable option for commercial insect rearing.

Chicken manure

Origin

Chicken manure samples were obtained from broiler houses and laying hen farms (Figure 6). The manure was dried at 50°C, milled using a shredder and sieved at 3 mm to produce a dry powder for chemical analysis and insect rearing experiments. The dry manure, which can be stored, still contains fibre, minerals and some protein. For rearing BSF larvae a wetter substrate was required.

Unprocessed broiler manure.

Potential for insect growth

The larval biomass of YMW on chicken manure was approximately one-third lower than that on control feed. This lower biomass could be attributed to the suboptimal chemical composition of the manure relative to the nutritional requirements of the YMW. However, the survival rate of YMW fed with chicken manure was not significantly different from that of the control feed. YMW was less able to reduce the amount of substrate when grown on chicken manure (measured as waste reduction index). This was much better in BSF larvae. Rearing BSF larvae on chicken manure was not very different from control feed and BSF larvae were able to reduce the amount of chicken manure. Therefore, chicken manure can be a promising substrate for BSF larvae production.

Safety risks

In our experiments, chicken manure contained relatively high levels of (heavy) metals and other elements. However, the concentrations in the larvae of both tested insect species reared on these substrates did not exceed relevant regulatory limits. Most elements did not accumulate and some were even reduced in the YMW and BSF larvae, except for cadmium, selenium, copper and zinc.

The tested substrate contained high levels of coccidiostats, which are feed additives used to prevent parasitic disease in the intestinal tracts of animals. Although there was no accumulation detected of these substances in either species, the levels in the larvae exceeded the maximum limits for carry-over in food and feed. There were no residues of veterinary medicine products detected in the batch of manure used for these experiments, but this cannot be excluded for other batches. PFAS was not detected in chicken manure in this study. Low levels of PCBs and dioxins were found in the chicken manure, although some accumulation was observed in the insects, concentrations found in insects were far below legal limits for feed.
As expected, the substrate contained a high bacterial count ($4.9 \cdot 10^5$/gram – $1.8 \cdot 101^3$/gram) including bacterial spores. *Clostridium perfringens* was detected but not *Bacillus cereus*, *Listeria monocytogenes* or *Salmonella* species. Some *Eimeria* oocysts and parasite eggs were detected, but not avian influenza (Influenza A) virus.
When chicken manure was purposely spiked with *Klebsiella pneumoniae* and *Bacillus cereus*, there was no reduction in the levels of these specific bacteria, measured in both larvae and residues (substrates and/or frass). However, after spiking with *Salmonella enterica subsp enterica abaetetuba* and *Clostridium perfringens* a significant reduction in the number of bacteria was observed in the substrate. *Eimeria* (*E. tenella*, *E. maxima* and *E. acervuline*) oocysts were spiked in chicken manure and subsequently detected in BSF larvae reared on spiked substrate seven days later.
When chicken manure was purposely spiked with three viruses, we observed rapid decrease in infectiousness of Foot & Mouth disease virus, low-pathogenic avian influenza virus, and classical swine fever virus. This reduction in infectiousness is influenced by acidity of the substrate, among other factors. Within a few hours after mixing the substrate with the viruses, a significant decrease in infectiousness was observed. However, a fourth virus, swine vesicular disease virus, which is less acid sensitive, remained infectious in the substrate for 1 to 3 days. The infectious virus was not detected in the larvae from day 3 onwards.

Measures needed
The high bacterial counts do not necessarily require heating or similar processing of the final insect product before used as a feed component. However, it is important to ensure the absence of specific pathogenic and/or spoilage bacteria. Acidifying the substrate contributes to extending shelf life and controlling potentially disease-causing viruses. Besides this, there is already an existing requirement for PAPs. Procedures ensuring sufficient microbiological hazard reduction, such as heating, should be validated in line with standard practice in HACCP systems. If an applied procedure can ensure sufficient microbiological reduction, the accumulation of chemical contaminants will be of higher concern. Although limits for heavy metals and other elements were not exceeded, some accumulation was observed, therefore levels in insect products should be monitored. The major issue would be the potential transfer of coccidiostats or even veterinary medicine products if present in the batch of manure.

Summary

Residual streams can be upgraded to feed or food by using them as substrate to grow insects. We used Category 2 meat meal from animal rendering, kitchen food scraps, former food from supermarkets, and chicken manure as substrates. These residual streams are nutritionally suitable as substrates for insect rearing, but potential food and feed safety concerns can exist.

For instance, microbiological hazards can consist of pathogens like bacteria, viruses, and parasites. These food safety hazards can be mitigated by processing the substrates and insect products as outlined in Regulation (EU) No 142/2011. In case of live insects, their safety should be assured through the use of safe substrates, as post-processing is not possible. Common best practices for feed and food should always be used. These can include control measures like low temperature, low pH (high acidity) and low water activity (e.g., drying). Chemical hazards, such as pesticides, veterinary medicines, and heavy metals, must be controlled to ensure that their levels in insect products do not exceed legal limits, since they can be transferred to or accumulate in insects. Bioaccumulation factors (BAFs) should be used to establish maximum residue limits (MRLs) for chemical hazards in residual streams. Environmental contaminants like dioxins and PFAS were only detected at low levels in the tested residual streams and are not likely to be food safety issues. Other pollutants, such as packaging remnants, may be found in substrates from kitchens and supermarkets, but best practice in unpacking and traceability can mitigate these concerns. Quantitative risk assessments are recommended to assess the risk of other animal diseases in the insect food chain. Such a risk assessment has shown that the risk of prion transfer from insects reared on these residual streams to non-ruminant livestock fed with these insects is very low and unlikely to cause new BSE cases.

Manure from animals treated with veterinary drugs should not be used as a substrate for insect rearing, since the high levels present in this material can, to some extent, also be transferred to the insect biomass. Category 2 meat meal is microbiologically and chemically safe for insect rearing without additional pre-treatment. Tracking and tracing residual streams can improve safety, particularly for substrates like former foods from supermarkets and household kitchen scraps. However, control of household kitchen scraps may be difficult in practice. Former food from supermarkets and kitchen food scraps present similar biological hazards. In general, HACCP measures should be implemented throughout the insect-rearing process, from procurement to commercialisation.

Residual streams have a good potency to be used in future insect rearing systems to produce safe and sustainable insect proteins. All detailed information of the present research will be published soon in scientific peer-reviewed journals.

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Safe insect rearing on yet to be legally authorised residual streams - WUR

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