

Regulations on insects as food and feed: a global comparison

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Abstract

Insects, as a food and or feed source, represent an emerging protein source relevant to farmers, feed companies, food companies and food marketers globally. The growth of this industry is somewhat restricted due to outdated food and feed regulations covering insect use. The regulations also do not allow the use of all potential insects as food and feed. Governments aim to ensure food and feed safety, and each country has its own substantive and procedural rules for this purpose. However, the regulatory demands and differences between countries complicate the international marketing strategies for insect products. Food and feed regulation are separate; feed regulation may allow insect usage even when they are not allowed as food. Some countries have specific rules for novel foods, while others do not. This paper compares insect food and feed regulation of the primary production and marketing areas: the European Union, the United States, Canada, and Australia. In addition, the situation in selected countries in Central and South America, Asia and Africa is also discussed.

Keywords: food law, feed law, regulations

1. Introduction

This is a comparative review on the global regulations on insects as food and feed. Earlier reviews on legislation specific to the production and marketing of insects for food and feed have been published by Lähteenmäki-Uutela *et al.* (2017) and Lähteenmäki-Uutela *et al.* (2018). These publications are used as a starting point for this publication. The review aims to cover all main markets interesting for the global insect business. In comparison to the above-mentioned legal reviews, this paper focuses on legal developments between 2018 and 2020 as well as adds some new countries where interest in insect food and feed is on the rise and where regulations therefore need to be considered.

Legal issues can arise at various stages of the production, processing, and marketing cycle. Insects can grow on various substrates including manure and bio-waste, but there are risks in bringing such insects into the food chain. Insects that are novel as food and feed may be riskier than

familiar ones. The main legal question with insects is about how the risks involved may be mitigated through product safety rules. If specific government standards are lacking, companies may decide to rely on the existing industry practices or the private standards as guidance or they may decide to postpone further business investment until transparent rules appear.

This review limits itself to general food and feed safety law, because it is the most central issue for the insect business. Producers and marketers need to know which insects and insect-based ingredients are allowed for which end use. This paper does not discuss production animal welfare, genetic modification or gene editing of insects, food and feed product labelling (although allergen labelling is an important part of food safety legislation), or nutrition and health claims on insect products. Materials and methods are briefly discussed in Section 2. Sections 3 to 8 discuss regulations in the European Union, North America, Central and South America, Australia, Asia, and Africa. Section 9 presents the conclusions.

2. Materials and methods

Comparative reviews on legislation specific to the production and marketing of insects for food and feed have already been published by Lähteenmäki-Uutela *et al.* (2017) and Lähteenmäki-Uutela *et al.* (2018). These publications were used as a starting point for this publication, which is focused on legal developments between 2018 and 2020. The recent legal developments were tracked through government web pages, publications of insect industry associations, and food and feed industry news.

3. European Union

In terms of insects as food for human consumption, provisions placing insects within the scope of Regulation (EU) 2015/2283 on novel foods have been applicable since 2018. Under this new Regulation, insect food products may only be marketed when authorised after a safety assessment by the European Food Safety Authority (EFSA). At this time (October 2020), applications for food products from the following insect species have been submitted: house cricket (*Acheta domesticus*), banded/tropical house cricket (*Gryllobasys signatus*), lesser mealworm (*Alphitobius diaperinus*), black soldier fly (*Hermetia illucens*), honey bee (*Apis mellifera*), migratory locust/grasshopper (*Locusta migratoria*), and yellow mealworm (*Tenebrio molitor*) (EC, n.d.). The first of EFSA's safety assessments are expected to be published soon.

While waiting for the EFSA assessments and thereafter Commission decisions on novel food applications, a transitional period applies for whole insects and their preparation. This means that insect foods which had been lawfully marketed on 1 January 2018, and for which an application or notification was submitted by January 2019, may continue to be marketed until the Commission hands down its decision on the respective application or notification. This means that several insect species may continue to be sold as food in Europe without novel food authorisation. On 1st October 2020, the European Court of Justice gave its ruling in the case C-526/19 stating that whole insects were *outside* the old Novel Food Regulation. This means the transitional measures for whole insects had to be expanded to all EU countries. The case was initially brought against two French ministries by company Entoma SAS, and the Supreme Administrative Court of France requested a preliminary ruling from the European Court of Justice.

Specific hygiene rules for insects intended for human consumption are currently being considered: a draft Regulation, amending Regulation (EC) No 853/2004, was published for public comment in 2018 (Ares(2019)382900). The feedback period ended in February 2019 with adoption scheduled for Q1 2019. The draft Regulation would add

a new Section in Annex III of Regulation No 853/2004. At its core, the draft Regulation does not introduce any new provisions precisely for insects, but rather reiterates rules from various other legislation that already applied previously. Specifically, insects must be approved as a novel food under Regulation (EU) No 2015/2283 (Article 3 of the draft Regulation). In addition, insects may only be reared on substrates of vegetable origin or specifically allowed materials of animal origin such as fishmeal and hydrolysed proteins from non-ruminants (Article 4 of the draft Regulation), but this was already the case under Regulation (EC) No 1069/2009 and No 142/2011. Finally, according to the draft Regulation (Article 5), the 'substrate for the feeding of insects must not contain manure, catering waste or other waste' – but this was already the case under Regulation (EC) No 1069/2009. As of October 2020, this draft Regulation has yet to be implemented.

On the executive front, the European Commission's (EC) Directorate-General Health and Food Safety (DG SANTE) audited the French (DG SANTE, 2019) and Netherlands (DG SANTE, 2018) official control systems for reared insects. Although these audit reports are not legislative in nature and recommendations are primarily intended for the authorities, they do provide an insight into the legal requirements for insect rearing companies. Areas covered by the audit reports included the approval process of new establishments, microbiological testing, and required documentation. A report aimed explicit for the insect rearing industry is a 'Guide on Good Hygiene Practices', published by the International Platform of Insects for Food and Feed (IPIFF). Formal endorsement of this guidance document by the EC and Member States is pending.

In the context of insects for animal feed, one of the most critical changes in 2017 was introduced by Regulation (EU) No 2017/893. This act amended Regulations (EC) No 999/2001 and (EU) No 142/2011, allowing the feeding of seven insect species to aquaculture animals (black soldier fly (*H. illucens*), common housefly (*Musca domestica*), yellow mealworm (*T. molitor*), lesser mealworm (*A. diaperinus*), house cricket (*A. domesticus*), banded cricket (*G. sigillatus*) and field cricket (*Gryllus assimilis*)). Regulation (EU) No 2017/893 removed the requirement for reared insects that 'products of animal origin must be sourced from a registered slaughterhouse', because insect rearing facilities (where the insects are generally also 'slaughtered'), could not comply with the requirements specific to slaughterhouses. Finally, Regulation (EU) No 2019/1981 introduced a list of third countries that were authorised to export insect products complying with the mentioned Regulation (EU) No 2017/893.

Significant legislative changes regarding insects are required to be implemented in the future to overcome current barriers to the growth of the insect industry. In DG

SANTE's 'strategic safety concept for insects as feed' (DG SANTE, 2017), two primary legal barriers for the insect rearing industry were identified. Firstly, it is prohibited to use former foodstuffs containing meat or fish as feed materials for insects, and secondly it is not allowed to feed processed animal proteins from insects to pigs and poultry. According to the SANTE document, before the first barrier can be lifted, it is necessary that 'operational and validated analytical techniques' for differentiating between insect material and other animals are available. Work on these methods is ongoing. For the second barrier, it is indicated that allowing any additional feed materials for insects 'would require a robust EFSA opinion assessing the risk for human and animal health and recommending measures to ensure that such risk is negligible' (DG SANTE, 2017). In February 2020, the Netherlands Food and Product Safety Authority's Bureau for Risk Assessment (NVWA-BuRo) advised the Dutch Ministry of Agriculture to propose an EU amendment to remove these two barriers. The change would allow the use of insects as feed to an animal providing that the insects have not been reared on former foodstuffs containing meat of the same species (e.g. insects reared on pig sourced meal are not subsequently fed to those same species again) (NVWA-BuRo, 2020). In a note accompanying the report, the agency's Inspector General reiterated that the prerequisites for lifting these barriers, as mentioned in the 2017 DG SANTE Safety Concept document, should be met first (IG-NVWA, 2020).

Summarising the European legal situation, the substrate options on which insects may be reared are still restricted to those materials that are also permitted for other livestock species. Developments to ease some of these restrictions are ongoing, but legislative changes are not expected to be implemented in the short-term. Since 2017, aquaculture animals have been allowed to be fed with insect meal, the feeding insects to pets was already permitted. Legislative changes are anticipated to allow the feeding of insects to more animals such as poultry and pigs, but the timeline for these changes is unclear. Novel food applications have been submitted, but at the time of writing, no safety assessment reports have been published by the EFSA. The European Court of Justice ruling on the non-applicability of the old novel food regulation to whole insects somewhat changes the regulatory landscape as it extends the transitional period for whole insects to all EU member states.

4. North America: United States and Canada

In many parts of North America, insects have traditionally been used as a part of food culture. The production of insects for the food and feed industries started to expand after 2012. The modern insect industry had its basis in companies that had already grown crickets and mealworms for pet food. In order to avoid high labour costs, many United States and Canadian insect farms have invested

in robotics, automation, sensor technology and data aggregation from the start. (Shockley *et al.*, 2018).

In the United States, governing insect food is under the stewardship of the US Food and Drug Administration (FDA). Already in 2013, the FDA gave its 'response to inquiry' that represented their thinking on insect food. It stated that insects are considered food under the Food, Drug, and Cosmetic Act (United States Code, Title 21), if that is their intended use. According to the Act, food must be clean and wholesome (i.e. free from filth, pathogens, toxins), must have been produced, packaged, stored, and transported under sanitary conditions, and must be appropriately labelled (Sec. 403). Insect-raising for human food must follow good manufacturing practices (cGMP, 21CFR110). Insects raised for animal feed cannot be diverted to human food. Insects collected from the wild cannot be sold as food. If insects are not sold as such, but altered or used as a food ingredient, they may require food additive authorisation. An insect protein is a food additive, unless it has GRAS status (generally recognised as safe). (Lähteenmäki-Uutelala *et al.*, 2018). GRAS and food additive petition (FAP) are two equally legitimate and parallel processes of compliance to the US law on food ingredients. GRAS is basically a self-approval system, and FAP is government managed. A company may itself make a GRAS determination. A GRAS notice can be submitted to FDA for review, but there is no legal obligation to do so. According to Burdock Group, GRAS can offer a lower cost and a faster route to market. The burden of proof for safety is the same regardless of the process (FAP or GRAS). In both processes, the approval is for the specific use of the ingredient, not for the ingredient per se (<https://burdockgroup.com/>).

According to the Food, Drug and Cosmetic Act, animal foods must be safe, produced under sanitary conditions, and contain no harmful or deleterious substances. Many states base their feed regulations on recommendations on the Association of American Feed Control Officials (AAFCO). The AAFCO has established an ingredients definition for only one insect species as an animal food ingredient for livestock feed. The black soldier fly (*H. illucens*) larvae, including dried whole larvae (since 2016) and black soldier fly meal (since 2018) is permitted for use in feed for aquaculture for salmonids such as salmon, trout and char. The FDA has reviewed and approved the AAFCO's decision. Notably, the black soldier fly larvae can be reared on approved feed-grade materials, including pre-consumer food waste as a substrate, as well as other food manufacturing by-products such as spent brewery grains and other feed grade materials. (Lähteenmäki-Uutelala *et al.*, 2018). Several states also allow insect-based pet foods, while other states wait for AATCO and FDA decisions. Pet treats do not have to comply with all AAFCO regulations, as they are not a source of complete nutrition.

In Canada, the safety and nutritional adequacy of novel foods must be evaluated before they enter the market (Canada Gazette Part II, Division 28: Novel Foods, October 27, 1999). Novel foods must be notified to Health Canada. If there is an international history of safe consumption, a food is not considered novel. A history of safe use means the food has been an ongoing part of the diet for a number of generations in a large, genetically diverse human population where it has been used in ways and at levels, which are similar to those expected or intended in Canada (Health Canada, 2006). Crickets are not a novel food in Canada, and there are large cricket breeders in the country.

Novel feed ingredients, i.e. feed ingredients not already listed in Schedules IV and V of the Feeds Regulations, must be authorised in Canada. Each insect species, rearing condition, and livestock species needs separate authorisation. The Canadian Food Inspection Agency is responsible for the pre-market assessment of new feed ingredients and the registrations of feed products. Black soldier fly products have been authorised to feed broiler chickens, salmonids, tilapia and poultry including chickens, ducks, geese, and turkey (Lähteenmäki-Uutela *et al.*, 2018). Pet foods are another regulatory category. Black soldier fly larvae, mealworms, and silkworm pupae are sold as pet food in Canada.

5. Central and South America: Mexico, Brazil and Argentina

In Mexico, many different insects are used as food and insects have also been used for medicinal purposes. Insects are mainly collected from the wild. (González and Contreras, 2009). Mexico's food safety laws are the responsibility of two government secretaries, SSA (Health Secretary) and SAGARPA (Agriculture, Cattle, Rural Development, Fishing and Feeding Secretary). The SSA mainly focuses on processed food and SAGARPA on primary production. The General Health Law, the Federal Vegetal Health and Animal Law, and the Products and Services Sanitary Control Regulation are three most important regulations. (Leon and Paz, 2013.) All health-related products and services are regulated through mandatory standards called Normas Oficiales Mexicanas (NOMs). NOMs are revised at least every five years. At the time of writing, there are not yet specific NOMs for insect food or insect feed in Mexico. General NOMs apply, e.g. the Norma Oficial Mexicana NOM-251-SSA1-2009 on the hygienic standards for foods, beverages and dietary supplements.

Mexico's Organic Products Law and regulations for organic production were implemented in April 2017. There is a regulatory category for organic insect food in Mexico, including an indicative list of the species and their life stages concerned: eggs, larvae, nymphs, and adult insects of the maguey worm (*Aegiale hesperiaris*), larvae of longhorn

beetles (*Cerambycidae*), larvae of 'escamoles' (*Liometopum apiculatum*), and ant eggs. These insects should be collected from areas of organic production or in ecosystems with little or no human intervention having no contact with prohibited substances. The Organic Plan or an equivalent document should demonstrate that the collection, farming, catching, limiting and processing of insects does not alter or influence the ecosystem. A record on the history of the site or an Organic Plan must be kept proving that the areas of collection, farming or catching have not been subject to treatment by prohibited substances.

Brazilian researchers, farmers and companies are increasingly interested in using insects as food and feed, particularly in replacing soybean meal with black soldier fly meal to feed the poultry. As Brazil is the leading global exporter of poultry, increasing the sustainability of the Brazilian poultry industry would be significant (Allegretti *et al.*, 2018). Brazilian feed law does not yet foresee insects as animal feed. According to Allegretti *et al.* (2018), Brazil tends to follow Codex Alimentarius standards.

In Argentina, there is interest for example in adding cricket flour to foods. The government has notified the nascent industry that insect food is currently not covered by the national Food Code. An application to add insects to the Food Code must be submitted to the National Food Commission. All packaged food must also have the approval of the National Administration of Medicines, Food and Medical Technology (Anmat) (Crespo, 2019).

6. Australia

Save for indigenous Australians, the protein consumption of the average Australian, which has been predominately meat, does not include insects. The indigenous Australian diet, also termed as 'bush tucker diet' comprises of various insects including witchery grubs, Bogong moths, termites, beetles, honeypot ants and native honey bees. (Yen, 2005).

Australia or New Zealand do not have a standalone legislation or specific government regulations on insect farming. Insect Protein Association of Australia (IPAA) has developed guidelines for its members (<https://www.insectproteinassoc.com>). Non-members are not bound by the rules, and they are yet to be made available for public access. Insect food is regulated under Standard 1.5.1 of the Food Standard Code as a category of novel food. These are non-traditional foods, the safety of which has not previously been established and which therefore require assessment. Three species of insects are categorised as non-novel, namely: (1) super mealworm (*Zophobas morio*); (2) house cricket (*A. domesticus*); and (3) mealworm beetle (*T. molitor*). Beetles, grasshoppers, butterflies, moths, bees, bugs and dragonflies may also be consumed, although they are not allowed to be sold.

Before a novel food is sold in Australia and New Zealand, a thorough risk-based assessment process is carried out that considers, amongst other things, 'toxicological and nutritional issues' of its chemistry and consumption patterns. Ordinarily, a novel food will have to be listed in the Standard before it can be sold as food or used as a food ingredient. Where it is not listed, an application can be forwarded to Food Standards Australia New Zealand (FSANZ), who will then include the novel food in the list after a pre-market safety assessment. There are provisions to allow 'first to market advantage': FSANZ extends, upon request being made, an exclusive permission to new owners of novel food or novel ingredients in a specific brand or class for a period of 15 months. This does not preclude other applicants seeking approval of their own different brand. Imported novel foods are governed under the 'Imported Food Control Act' 1992, 'Biosecurity Act' 2015 and 'Food Standard Code'. The Department of Agriculture enforces the 'Food Standards Code' at the border for imported food.

In Australia, the edible food industry continues to grow (Maxabella, 2019), despite there being only a limited choice of insects permitted for sale. There are more than 50 insect farmers across Australia (Jones, 2019) as well as several sellers specialising in edible insects (GrupsUP, 2020). The 'Edible Bug Shop' claims to produce and sell 200 kilograms of insects a week to the domestic market (Black, 2020). Insects are sold in a variety of forms – sweet and savoury snacks, tea leaves, candy, dukka, marshmallow, cricket powders, pasta powder, tortillas chips, white chocolates and more (<https://ediblebugshop.com.au>). Though in Australia insects have been traditionally consumed by the indigenous community (Yen, 2005), the culture of adapting to eating insects amongst the Australian majority is recent. Insects are increasingly consumed for their nutritional and environmental benefits (Edwards and Ranasighe, 2019).

Animal feed materials and ingredients which are fed as part of the normal diet of an animal do not require registration in Australia. Australia has strict rules on animal feed, however. Ruminant animals are not to be fed with meat, including meat and bone meal, derived from all vertebrates, including fish and birds. Such restrictions are in place to safeguard against risk of bovine spongiform encephalopathy (BSE or mad cow disease) or transmissible spongiform encephalopathies (Food Standard, 2020). This ruminant feed ban is governed under the legislation in all states and territories and is reinforced by industry-based quality assurance programs such as the FeedSafe Standard (Animal Health Australia, 2020). Feed ingredients and additive suppliers in Australia are represented by the Feed Ingredients and Additives Association Australia (FIAAA). This organisation regulates its industry via the Australian New Zealand Code of Practice for Animal Feed Ingredients and Additive Suppliers (the FIAAA Code of Practice) and the FeedSafe Standard (<https://fiaaa.com.au/about/#bg>).

These two codes and standards are applicable to feed production in both Australia and New Zealand. Insects may be used as feed for aquaculture in all states, and as feed for poultry in NSW, ACT, Tasmania, Victoria and Western Australia. Insects used for feed are not to be fed with meat, manure and catering waste, and raw insects (live and untreated by heat) for feed are not permitted in Australia (DiGiacomo *et al.*, 2019). According to IPAA, the insect for the feed industry in Australia comprises of five larger commercial fly farms and a variety of smaller operations that are starting research and developing processes.

Pet food in Australia is self-regulated with voluntary industry standards of the Pet Food Industry Association of Australia (PFIAA) through its Australian Standard (AS 5812-2017) for the Manufacturing and Marketing of Pet Food regulation for the pet food industry.

7. Asia: China, Japan and Thailand

The Chinese have used insects for thousands of years. Several Chinese medicines and health foods are based on insects. Honey bee larvae are used as a sedative and as an anti-inflammatory medicine; male silkworms and male silkworms are sold for strengthening kidneys; termites are used for anti-aging purposes; and black ants for improving immunity (Lähteenmäki-Uutela *et al.*, 2017). China has a long tradition in silk production and is the world's largest silk producer. New food raw materials, including insect protein, require authorisation from the Ministry of Health. Authorisations have general applicability: if a new food raw material is added to the Food Materials Catalogue, all food producers can use the material (Sun, 2015: 445). According to Belluco *et al.* (2013), silkworm pupae were authorised as a new food ingredient and according to Shen (2014), earthworm protein powder has been authorised. New feed raw materials also need to be authorised, and authorised feed materials are added to the Feed Materials Catalogue.

According to Mitsuhashi (1997), several different insects are traditional foods in Japan. These include *Oxya yezoensis* or *Oxya japonica*, the larvae and pupae of a wasp, *Vespula lewisi*, and the pupae and female adults after oviposition of the domestic silkworm, *Bombyx mori*. These insects have been cooked with soy sauce and sugar and sold as canned foods. Larvae of the dobsonfly, *Protohermes grandis* (Neuroptera) have been used as traditional medicine (Mitsuhashi, 1997). In Japan, normal novel foods do not require pre-market authorisation, while novel additives do. Food safety is under the responsibility of the Ministry of Health, Safety and Welfare. Feed law is another issue. The Ministry of Agriculture, Forestry and Fisheries has given the Act on Safety Assurance and Quality Improvement of Feeds, which includes the maximum limits for pesticide residues, heavy metals, mycotoxins and melamine. Feed manufacturers, importers and/or dealers must submit notification prior to starting a business. (FAMIC, 2014)

Thailand is the world's biggest cricket producer. It has a Standard for cricket farming (Good Agricultural Practices for Cricket Farm, Thai Agricultural Standard 8202-2017). The Standard includes rules on farm components, feed, water, animal health, environment, and record-keeping. The aim is to produce crickets of good quality which are safe for consumers. Feed shall not be deteriorated, water must not be contaminated, equipment must be clean and hygienic, and all chemicals must be used according to the instructions. The development of the Thai cricket farming standards was connected to cricket exports, particularly to accessing the EU markets (Preteseille *et al.*, 2018: 435). Food is governed by FDA Thailand. In fish aquaculture, Thai companies are looking to replace unsustainable fishmeal with insects (Dao, 2020). Thailand also has a large broiler meat and pork industry where insect-based feed has potential. Thailand has product quality standards for each type of animal feed, but standards for insect feed are still lacking. The Ministry of Agriculture and Cooperatives regulates animal feed.

8. Africa: South Africa and Nigeria

Niassy *et al.* (2018) studied the regulatory environment for insects as food and feed in South Africa. The country has a high diversity of insect species and a high demand for insect protein. Replacing imported food and feed ingredients with local insect production can provide jobs in South Africa. Regulation is fragmented, however. Various governmental departments and various levels of government deal with food and feed safety, and there is no specific legislation on insect production or insect foods. Insects are not novel foods. The Agricultural Product Standards Act 1990 (Act 119 of 1990) governed by the Department of Agriculture, Forestry and Fishers, the Foodstuffs, Cosmetics and Disinfectants Act 1972 (Act 54 of 1972) governed by the Department of Health and the Consumer Protection Act 2008 (Act 68 of 2008) governed by the Department of Trade and Industry apply. For the large informal food markets, local rules are the most relevant. (Niassy *et al.*, 2018.)

For being able to manufacture, import, or sell farm feed or pet food in South Africa, the product must be registered according to the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act 1947 (Act 36 of 1947). Before submitting the application, one must send a sample of the farm feed or pet food to an accredited laboratory where the product is analysed. Product registrations are valid for three years, after which they must be renewed (South Africa government, n.d.).

Nigeria is another African country where interest in modern insect production is rising. Referring for example to Kelemu *et al.* (2015), Usman and Yusuf (2020) describe how several species of insects from the orders Lepidoptera, Orthoptera,

Coleoptera, Isoptera and Hymenoptera are commonly consumed in Nigeria. In big cities, insects have started to be regarded as primitive foods. With the population projected to reach 400 million in 2050, Usman and Yusuf (2020) see that Nigeria must turn back to healthy and sustainable food alternatives such as insects. Indigenous knowledge on insect harvesting, preservation and use should be complemented with university-level research and development focusing e.g. on nutritional content and mass rearing (Usman and Yusuf, 2020).

According to Usman and Yusuf, insect food regulation is currently missing in Nigeria. Protecting food safety is under the competence of the National Agency for Food and Drug Administration and Control (NAFDAC). The Food and Drug Act (Cap F32 Laws of the Federal Republic of Nigeria, 2004) applies. The Standard Organization of Nigeria (SON) sets the rules for packaging materials, labelling and marketing. According to Usman and Yusuf, what is needed in Nigeria is an amendment to the NAFDAC Act to include rules for insect food safety and control.

The NAFDAC Act also applies to animal food, pet food and premixes. Both local manufacturers and importers of feed must apply for registration for each product at the NAFDAC, more specifically the Veterinary Medicine and Allied Products directorate (NAFDAC guidelines VMAP 003/13 and VMAP 004/13). Registrations are valid for five years.

9. Conclusions and discussion

Insects have traditionally been harvested and consumed in many food cultures including Mexico, China and Australia, without a specific regulatory framework. Due to concerns over climate change and food system sustainability, the industrial production of insects and their use as food and feed is now gaining momentum in developed and developing countries. Two problems emerge in parallel with this growth, the first being the lack of regulation locally, and the second is the lack of a stable and consistent set of regulations across international borders. More specifically, many local companies are interested in exporting their insect products across the world, but the regulatory demands and differences between countries complicates the initiatives to market and sell insect products.

Every major stakeholder agrees that insect production and the human food and stock feed uses of insects must be regulated in order to guarantee safety. In that respect, there is agreement to build regulatory systems around a scientific risk assessment approach. Clear and unambiguous regulation will level the playing field, encourage investments, add trust, and normalize the industry (Van der Spiegel, 2016: 213). Allegretti *et al.* (2018) suggest that public and private actors must join forces to construct a global

regulatory framework for insects as a part of sustainable food systems.

For each government, the primary aim of regulating insect food and feed production is to guarantee product safety and quality. The global industry may view unharmonized regulations as simply an obstacle which generates repetitive science and repetitive administrative work. Research institutions and companies must choose where to invest their limited resources, e.g. studying familiar insects vs studying unfamiliar insects. In order to become mainstream food and feed in the Western countries, insects and their related risks need to be understood and science plays an integral part in this process. Safety concerns for insects which have traditionally been used are less than for new insects and new production technologies.

Today, much research effort goes into verifying and replicating previous experiments with insects such as crickets, mealworms, and black soldier flies. In the regulatory context in Australia, for instance, house cricket, super mealworm and mealworm beetle are not considered novel foods. In Canada, the definition of novel food excludes traditional foods from other countries. Thorough safety assessments for all insect foods are required for the European Novel Food Regulation and the American GRAS or FAP rules. In Europe, traditional foods from third countries are regulated under the novel food regulation, but as a specific category (Article 14 of Regulation (EU) No 2015/2283). A globally operating insect company will need to prepare an application or notification on the same product for each national authority, and they all have differing requirements. Many complications are obvious as demonstrated by these examples.

In theory, insects as food and feed could be regulated globally. Insects proven safe as food and feed by the scientific community could be authorized in all countries. In the absence of a global food and feed administration body, the global harmonisation of both substantive and procedural standards would be helpful for both entrepreneurs and authorities. Codex Alimentarius Commission by the FAO/WHO is the arena for developing global food and feed standards. Codex still does not have the insect standards we anticipated in Lähteenmäki-Uutela *et al.* (2018), namely a standard for insect farming practices, a list of insect species recognized as safe, a standard on fresh and processed insect product hygiene, and a standard on insect product labelling.

Whether authorisations are generic or firm-specific is an essential feature of safety regulations, impacting the market positions of companies. Larger companies may benefit, if each company needs to prove the safety of each insect product separately. The dissemination of insect innovations may be faster with generic authorisations that apply to all similar products: the followers may enter the

market after the leaders have cleared the way. If the familiar insect species will eventually be authorized in all important countries, and the authorisations are generic, researchers and companies may shift their attention to new species.

In essence, much work needs to be done if we are to assist and promote this important fledgling industry. All stakeholders from government legislators through to industry players and the scientific community need to work together to achieve consistency and design a way forward locally and globally.

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Conflict of interest

The authors declare no conflict of interest.

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