PROteINSECT
INSECTS AS SUSTAINABLE SOURCES OF PROTEIN

Work Package 5: Pro-Insect Platform in Europe

Deliverable 5.1 - Mapping Exercise Report

with regard to current Legislation & Regulation:
Europe and Africa & China

Minerva

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A note on the scope of this report

This Report maps the current situation regarding legislation and regulation in Europe, Africa and China concerning the use of 'processed animal protein' (PAP) from insects and by implication from household flies and black soldier flies the focus of PROteINSECT research, for use in animal feed for pigs, poultry and fish. Limited information has currently been gathered from China.

A note on the methodology used to compile this report

Searches were performed on the EUR-lex website to find out about existing European legislation relevant to the use of insects in animal feed and food. Background information and relevant scientific studies were obtained by searching for key words in an academic journal database. Information on international food standards and guidelines was obtained from the Codex Alimentarius website (http://www.codexalimentarius.org/). Additional useful sources were obtained from the 2013 FAO report 'Edible insects: Future prospects for food and feed security' and the 2012 Wageningen UR report 'Insects as a sustainable feed ingredient in pig and poultry diets - a feasibility study'.

PROteINSECT partners were invited to contribute information and sources, together with input from identified members of the project's Stakeholder Advisory Board. The scope and organisation of the Report was agreed with the Co-ordinator at an early stage.

Contents

1. Introduction

By the year 2050, it is expected that the global population will have exceeded the 9 billion mark. As a consequence of this, worldwide demand for food and feed is predicted to increase by as much as 70%, placing added pressure on already scarce agricultural resources (FAO, 2009). In particular, there will be a continued increase in global meat demand as developing countries undergo shifts in dietary habits that are associated with rapid urbanisation and economic growth. The rearing of livestock for meat already places a considerable strain on global land and water use and at present much of the protein produced for livestock feed comes from non-sustainable and environmentally damaging sources (Bartley et al, 2009). Ultimately, in order to meet the considerable challenge of assuring food security for the future, it is imperative that alternative, sustainable sources of protein are found, both for direct human consumption and for use in animal feed.

Protein derived from insects represents one possible solution. There are numerous qualities possessed by insects, in particular flies, which make them well suited for use in animal feed. For example, flies are already a natural food source for pigs and poultry as well as many species of fish. Where such animals are kept as pets, fly larvae are often recommended as treats (Keeping Chickens, 2012). Additionally, insects generally have a high protein content and are rich in other beneficial nutrients such as fats, minerals and vitamins (Rumpold & Schluter, 2013).

As a source of protein for direct human consumption, insects offer several advantages over traditional meat sources. They have a significantly higher feed conversion rate than other livestock animals which means that they are much more efficient at converting feed into body mass (Van Huis, 2013). Furthermore, insect production is more environmentally friendly than the production of conventional livestock. Per kilogram of meat, insects release much smaller quantities of greenhouse gases and ammonia into the atmosphere than cattle or pigs (Oonincx et al, 2010).

In many parts of the world, including Asia, Africa and Latin America, the consumption of insects by humans and livestock is commonplace. It is estimated that at least 2 billion people worldwide eat insects as part of their normal diet (FAO, 2013). Globally, the most commonly consumed insects are beetles followed by caterpillars and the hymenoptera (bees, wasps and ants). Flies are also consumed in some regions but to a much lesser extent (Jongema, 2012). Typically, these insects are either harvested in the wild or farmed on a small-scale.

In contrast, in Europe the eating of insects is largely considered taboo. Although edible insects are available from specialist shops, they are sold as novelty items rather than as food to be consumed on a regular basis. The lack of insect eating in European countries has been attributed to various factors. Western societies harbour negative perceptions of insects viewing them as pests or vectors of disease, whilst the eating of insects is viewed with disgust and associated with primitive behaviour.

Such attitudes are the product of a culture that lacks a longstanding history of insect eating. At the Neolithic revolution, agriculture initially spread to Europe from the Middle East and it is argued that, as a food source, insects could no longer compete with newly domesticated crops and animals (DeFoliart, 1999). Climate may have also played a role as in temperate regions including Europe, insects tend to be smaller and more solitary, making them more difficult to harvest than in the tropics (FAO, 2013).

The strong public aversion towards eating insects in the West means that in the short term at least, the greatest potential use of insect protein is in animal feed rather than as food for direct human consumption. Existing small-scale rearing methods aimed at producing flies for this purpose have already proved effective. Such operations typically involve seeding fly eggs in shallow pits that contain manure as a growth substrate. A sloped side allows larvae to be easily separated from the manure by exploiting their natural pre-pupal migratory habits and allowing them to emerge (Newton et al, 2005). The success of such systems is underscored by the fact that household fly-rearing products that utilise these methods are commercially

available in the United States e.g. The Biopod^{TM}. Furthermore, in Europe, fly larvae is already being produced in large quantities for use as bait for recreational fishing or as pet food, although production currently takes place on a small-scale and is limited by the labour intensive methods used.

Numerous scientific studies have shown that flies are suitable for animal feed across a range of species. The addition of fly protein to animal feed has been shown to support good growth in chickens (Hwangbo et al, 2009), pigs (Newton et al, 1977) and several species of fish (St-Hilaire et al, 2007; Sheppard et al, 2008). These findings combined with the success of current small-scale operations demonstrate that the production of fly protein for animal feed is a feasible and worthwhile goal and therefore needs to be taken seriously.

However, if insect protein from a variety of species including flies is ever going to become a significant component of livestock (and eventually human) diets, it is vital that large scale insect production methodologies are developed.

At present, ambiguous and restrictive European laws concerning the use of insects in feed and food are seen as a major barrier to potential investors. Therefore, in order to support and encourage the development of industrial-scale insect-rearing plants, the relevant current legislation and regulation must be reviewed. Encouragingly, there are signs that this topic is being added to the agendas of the appropriate authorities in Europe.

2. Insect Protein in Europe

2.1 General Food and Feed Safety

Insects produced for either human consumption or use in animal feed will be subject to the requirements of the EC General Food Law Regulation 178/2002. This prohibits food being placed on the market if it is either injurious to health or unfit for human consumption. Similarly, feed must not be fed to animals if it is deemed unsafe. In this context, unsafe means that it has an adverse effect on animal or human health, or that it makes food products derived from animals unfit for human consumption. Food or feed imported into the European Union must also comply with these requirements.

Producers and distributors of insect products will also be subject to EC Regulation 854/2004 on food hygiene and EC Regulation 183/2005 on feed hygiene. These regulations require food or feed business establishments to be registered and then approved following an on-site visit. Business operators are also required to implement and maintain procedures based on hazard analysis and critical control point (HACCP) principles. This is a preventative system that involves identification of hazards and implementation of measures for their control to ensure food safety (FA0, 1998). Furthermore, products containing insect protein would have to adhere to regulations EC 767/2009 and EC 2000/13 which set out requirements for the labelling of feed and food respectively.

There are several safety risks associated with the use of insects in food and feed that must be considered. Perhaps most significantly, insects pose microbial hazards by harbouring pathogens that can cause foodborne illness. In one study, microorganisms isolated from the body surface and gut wall of the common domestic housefly (*Musca domestica*) included four pathogenic species of bacteria and fungus (Banjo et al, 2005). Insects may also be unsafe for consumption due to the presence of toxins. Certain species of insects naturally produce toxicants to protect against predators (although this is not the case with flies). Alternatively, insects can acquire toxic properties due to the bioaccumulation of heavy metals

from the environment or the uptake of pesticides (Belluco et al, 2013). Finally, it is possible that the consumption of insects could induce allergic reactions. Like shellfish, insects are arthropods and arthropods are widely known to be capable of causing allergic reactions. Tropomysin proteins from certain seafood and insect species are reported to be allergenic and there is evidence of cross reactivity meaning that individuals allergic to seafood tropomysins may develop an allergy to insects and vice versa (Reese et al, 1999).

In order to ensure that insects comply with food and feed safety requirement, it is vital that measures are taken to minimise the hazards described here. Microbial hazards can be mitigated through a combination of processing techniques, such as drying, boiling and roasting, and correct storage at refrigeration temperature. Insect toxicity can be eliminated by strictly controlling farming conditions so that sources of chemical contaminants are not present. Allergic reactions to insects are likely to be a rare event but nevertheless labelling of products containing insect protein should warn of the potential risk (Belluco et al, 2013).

2.2 Guidance on nutritional properties

Amino acids

The nutritional quality of protein is determined by its amino acid composition and digestibility. The ratio between essential and non-essential amino acids is an important factor. To be considered high quality, at least 40% of total amino acid content should consist of essential amino acids (FA0, 1989). A study of 78 species of edible insects found that the essential amino acid score of 46% to 96% whilst protein digestibility varied between 76 and 98% (Ramos-Elorduy et al, 1997). The housefly (*Musca domestica*) has a higher percentage of essential amino acids than nonessential amino acids and protein digestibility of 98.5% (Hwangbo et al, 2009).

Fat

Fat content is also an important determinant of overall nutritional quality. The ideal ratio of of saturated fatty acid, monounsaturated fatty acid and polyunsaturated fatty acid is 3:4:3 (Belluco et al, 2013). Furthermore, within the category of

polyunsaturated fatty acid, the recommended ratio of omega-6 fatty acid to omega-3 fatty acid is 3:1 (Belluco et al 2013). Many edible insects have a high fat content and generally the saturated to unsaturated fatty acid ratio is less than 40%, which compares favourably with fish and poultry (van Huis, 2013). For the housefly, this ratio is 35.89% (Hwangbo et al, 2009).

Micronutrients

Finally, micronutrient content is important when considering the nutritional quality of food. Minerals and vitamins are essential for normal growth and health. For humans, the recommended daily allowances of important vitamins and minerals are listed in EC Directive 2008/100. The majority of edible insect species contain high amounts of the minerals potassium, calcium and magnesium (Schabel, 2010). Insects are a particularly valuable source of iron and most edible insect species contain equal or higher levels of iron content than beef (Bukkens, 2005). Additionally, many species of insect are rich in vitamins. For example, bee pupae is exceptionally rich in vitamins A and D whilst caterpillars are a good source of vitamins B1, B2 and B6 (Schabel, 2010).

Overall edible insects, including the housefly, are nutritionally well-balanced and meet many important nutritional requirements. Therefore, it can be generally concluded that insects have the potential to be a beneficial component in both human and livestock diets.

3. Legislation specific to the use of insects in animal feed

Within the Catalogue of Feed Materials (EC 68/2013), there is no specific entry for 'insect meal' although there is a listing for 'whole or parts of terrestrial invertebrates' suggesting that the use of insect protein in animal feed may be possible. If they are to be used for feed, insects must meet the requirements of Directive EC 2002/32 on Undesirable Substances in Animal Feed. This sets the maximum permitted levels of contaminants such as heavy metals. Additionally, insects must be processed in accordance with the EU Animal By-Products Regulation 1069/2009 to become processed animal protein (PAP) before they can be fed to animals. Imported insect material from non-EU countries must also be processed in accordance with this regulation. Furthermore, under this regulation, non-pathogenic insects are classed as category 3 material and are therefore deemed suitable for feeding to farmed animals.

However, in response to the BSE outbreak, regulation EC 999/2001 prohibited all PAP, with the exception of hydrolysed proteins, from being used in animal feed. This ban has now been partly lifted and under regulation EC 56/2013, PAP derived from non-ruminants (including insects) is allowed to be fed to aquaculture species.

Currently, this relaxation of the regulation cannot be extended to cover pig and poultry feed because there are no valid diagnostic methods able to detect the presence of pig or poultry material in animal feed. This means that there is no way of ensuring that the prohibition of intra-species recycling and forced cannibalism is being adhered to. Nevertheless, it is thought that once valid diagnostic tests become available, the use of PAP in pig and poultry feed will also be re-authorised (FAO, 2013).

4. Legislation relevant to substrates used to rear insects

It would be desirable to rear flies on organic waste substrates produced by the agriculture and food industries for two important reasons.

First, it would enable low value waste products such as manure and catering waste to be converted into a high value source of protein. Secondly, it would simultaneously facilitate significant reductions in waste volume.

It is estimated that as much as 1.4 billion tonnes of manure is produced by EU member states annually (Foged, 2011). Additionally, 88 million tonnes of garden and kitchen waste is produced with 40% ending up in landfill sites (European Union, 2010). Waste management is therefore a serious issue. Fly larvae has the potential to drastically lower this volume of waste as they are capable of reducing the mass of organic waste by up to 60% over a period of ten days (Sheppard,1983).

It is important to note that current maggot farming in Europe predominantly uses abattoir waste as a substrate rather than manure, a production approach certainly inappropriate for animal feed production, and uses the fly species Calliphora.

Under EC regulation 1069/2009, insects reared for the production of PAP would currently be considered ‘farmed animals’ and therefore would be subject to the relevant regulation. The same regulation states that manure is classed as category 2 material and only category 3 material can be used as feed for farmed animals. Catering waste is classed as category 3 material; however, currently it is prohibited to feed farmed animals, other than fur animals, catering waste (DEFRA 2013).

If any revised legislation determines that the substrates on which insects are reared has to be category 3 then it is likely that production will become uneconomic and uptake of the new technology will be inhibited.

Additionally, EC regulation 767/2009 provides a list of materials that cannot be placed on the market or used for animal feed. There is an entry for ‘Faeces, urine and separated digestive tract content resulting from the emptying or removal of

digestive tract, irrespective of any form of treatment or admixture'. Therefore it appears that under the current regulations, it would not be possible to rear flies on manure or catering waste.

In contrast, waste products from bioethanol production such as wheat protein and barley hulls are listed in the Catalogue of Feed Materials (EC 68/2013) and thus could be used as a substrate on which to rear flies.

5. Legislation specific to the use of insects as food

In the longer term, insects or insect derived protein could be utilised as a food component for direct human consumption.

The most relevant piece of legislation regarding the suitability of insects for human consumption is the Novel Food regulation (EC 258/1997). This requires food and food ingredients that have not been consumed to a significant degree in the European Union before 15th May 1997 to undergo a pre-market risk assessment. At present, this regulation is very ambiguous, for example, what constitutes a significant degree of consumption is not made clear. Technically, insects are exempt from the scope of regulation EC 258/1997. This is because they are usually eaten whole and the regulation is concerned with food ingredients 'isolated from animals' rather than consisting of animals.

However it is apparent that this interpretation of the regulation is not consistent across the EU as there have been examples of insects being rejected and classified as unauthorized novel food ingredients in some countries, for example the rejection by Italy of a batch of domesticated silkworm (Belluco et al, 2013).

The suitability of insects for human consumption is better addressed in the new novel food regulation which is currently available in draft form (COM(2007) 872 final). Under this regulation it is likely that insects will belong to the category of 'traditional food from a third country' which encompasses food that has been a component of the normal diet for at least one generation in a large proportion of a third country's population.

If documented data can be provided to demonstrate that the novel food has a history of safe food use in a third country, then it can be placed on the market. However, if a history of safe use cannot be proven, the food will have to undergo a pre-market risk assessment.

6. Environmental Considerations

Since it is not practiced to a significant degree in the European Union, there is currently no regulation in place that addresses the environmental risks associated with the farming of insects for animal feed and food.

Research has indicated that the rearing of insects is likely to be more environmentally friendly in comparison to traditional livestock with reduced demand for land use one obvious example. Another is that insects are expected to have a much lower water demand since they have efficient feed conversion rates, can be reared on organic side streams and can obtain sufficient moisture from food alone (Rumpold & Schluter, 2013). Additionally, laboratory experiments indicate that insects compare favourably to cattle and pigs regarding their greenhouse gas and ammonia emissions (Oonincx et al, 2010).

Nevertheless, there are also potential hazards associated with the production of insects. Most notably, the accidental release of farmed insects could have a negative impact on the biodiversity of the local area, especially if they are non-indigenous species (FAO, 2013). Examples of such accidental releases have been recorded. This risk can be minimised substantially by only selecting insect species that are native to Europe such as the housefly (*Musca domestica*).

Even so, if insect farming is to take place on a large-scale, legislation will have to be developed that outlines containment measures and takes into consideration other ways in which the production of insects may harm the environment, or be considered a nuisance if sited near to residential areas. Measures to protect the occupational health of those working in large-scale operations will also have to be taken into account.

7. Animal Welfare Issues

Another potential target for new legislation is the issue of animal welfare. Currently, there is a lack of animal welfare guidance that is specifically related to the farming of insects.

The standard of animal welfare is often an important factor governing consumer acceptability (although it may not be such a decisive factor when the animal is generally considered a pest). Basic animal welfare standards include providing adequate nutrition, preventing pain and distress and allowing animals to exhibit natural behaviour (Brambell, 1965). With traditional livestock, most animal welfare concerns are related to the density of animals as they are reared. However, this is unlikely to be a major issue related to the rearing of insects since many species naturally live in very crowded conditions.

Whether or not insects are capable of perceiving pain is not yet fully understood. Studies involving the fruit fly (*Drosophila melanogaster*) have demonstrated that these insects possess genes required for the perception of noxious stimuli (Neely et al, 2011) and that they exhibit avoidance behaviour (rolling) in response to such stimuli (Hwang et al, 2007). However it is unknown whether this is merely a reflex reaction or if higher-level neural systems involving the brain are involved. It has been suggested that until a greater understanding is achieved, it should be assumed that insects can perceive pain and that they should be treated accordingly. Methods of killing that limit suffering should therefore be employed such as freezing or instantaneous techniques such as shredding (FAO, 2013).

Ultimately, the introduction of animal welfare legislation specific to flies would be necessary to ensure that producers of insects for animal feed and food are meeting an acceptable standard.

8. Summary of areas that need to be addressed

This report has highlighted several areas that need to be addressed from a regulatory perspective before the large-scale production of insect protein for animal feed and food can take place in Europe.

(1) Firstly, whilst the reauthorisation of the use of PAP as aquaculture feed represents a major step forward, it would be desirable for this relaxation to be extended to pig and poultry feed so that a greater proportion of livestock can be reared on insect protein. It has been indicated that this will happen following the development of valid diagnostic methods that can be used to prevent intra-species recycling in animal feed.

(2) Secondly, following a thorough safety analysis, consideration should be given to adjusting current legislation to permit the rearing of insects on organic waste substances such as manure. This would reduce costs and facilitate a significant reduction in waste volume.

(3) Thirdly, it is necessary to address new issues that will accompany the mass production of insect protein and implement the appropriate regulatory measures. Specifically the associated environmental impact and animal welfare concerns should be taken into account.

(4) Finally, clarification of the status of insects as a novel food is required so that a consistent approach can be taken across the EU with regards to placing insects on the market for human consumption. It is believed that the forthcoming novel food regulation (COM (2007) 872 final) will address the current ambiguities.

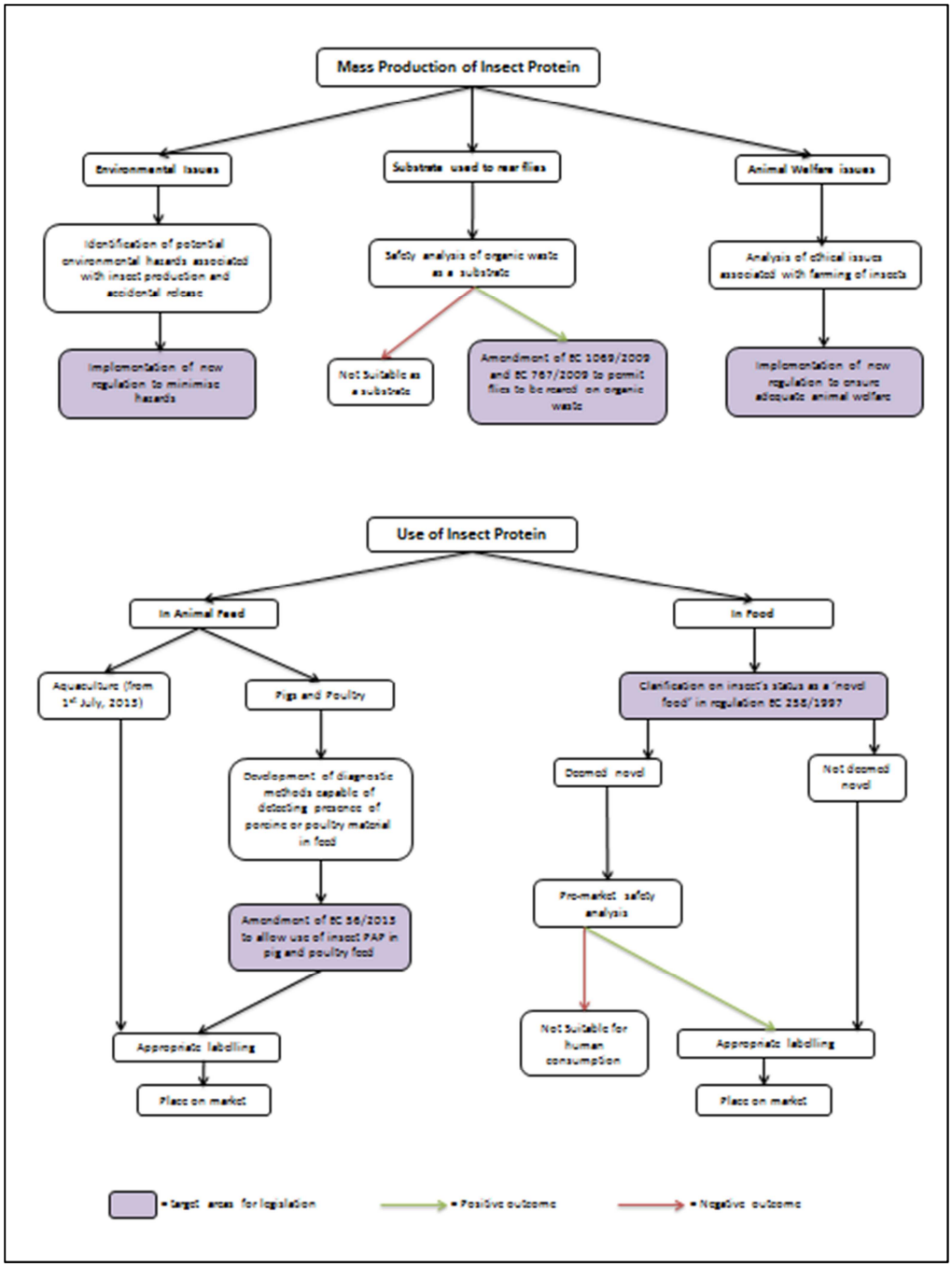

Fig 8:1 - Target areas for legislation:
(a) Mass Production of Insect Protein (b) Use of Insect Protein

9. Current situation regarding potential changes to EU legislation concerning insect protein

Significant interest amongst the general public in the use of insects for human food in Europe has been building over the 18 months, driven by a number of factors. Increased understanding that the world has a current 'protein deficit' has excited the interest of eating insects, prompted also by increased number of travellers to parts of the world where protein from insects forms a significant percentage of the daily diet. Media companies, such as the BBC (BBC 2012, 2013) have also over the last year commissioned and broadcast both radio and television programmes about the eating and use of insects in food and feed, with experts from a number of research institutes able to provide an increasing volume of evidence and data about the feasibility of the use of insects.

Research into the use of insect protein and the feasibility of its use for both human food and animal feed has been of growing interest in recent years to a number of research institutes across Europe. Evidence of its feasibility led to the call from the European Commission which resulted in the commission of the current project PROteINSECT. Other research projects have also been started in the UK and other parts of Europe, and a number of commercial companies throughout the world have started production.

In addition, small scale production of insect protein is already being achieved in Africa and China, whilst larger scale production facilities are being developed in China.

The cumulative impact of this evidence of the potential of insect protein is that discussions are currently underway within the Safety of the Food Chain Committee of DG SANCO to change the EC Regulation 999/2001 to allow the feeding of insect protein (PAP) to non-ruminant animals. As previously noted in this report, this is already allowed for the feeding of fish. Risk assessments will need to be commissioned and carried out by EFSA and the legislation may be coupled with

other changes which will cause delays. It is therefore unlikely that even with the full support of all member countries that this change in legislation will not come into force before 2015.

When this amendment to the legislation goes through, this will be a positive enabling step to the production and use of insect protein as animal feed. However, as already itemised in this report other areas of legislation will need to be changed, e.g. organic substrate allowed for rearing of insects to ensure economic production, and appropriate regulation established concerning the method of production.

9. The Codex Alimentarius - international reference standard

The Codex Alimentarius is the international reference standard for food and feed established by the FAO and the WHO. It represents a collection of food standards, codes of practice and guidelines related to the safety, quality and fairness of the international food trade. The Codex Alimentarius Commission currently consists of 184 member countries and 1 member organisation (the EU) which together accounts for 99% of the global population (FAO/WHO, 2013). The recommendations are voluntary for members, nevertheless codex standards often serve as a basis for national legislation.

The code of practice for good animal feeding (CAC/RCP 54-2004) provides some general recommendations. It states that feed and feed ingredients should only be used if they are 'safe and suitable' and do not pose an unacceptable risk to consumer health. Additionally it states that undesirable substances in food and feed, such as environmental contaminants and pathogenic agents, should be identified controlled and minimised.

There are no standards in the Codex that specifically refer to the use of insects in animal feed or food. Instead, insects are referred to only as impurities that should be excluded. In 2010, the Lao People's Democratic requested that standards be developed for the food safety and regional trade of house crickets. However this proposal was rejected as it was claimed that the current level of trade was not sufficient to warrant such action (FAO, 2013). Therefore it appears that international recommendations specific to the use of insects in food and feed are yet to be developed.

10. Africa & China - regulation and insect protein

Africa

Feedback from PROteINSECT partners in Africa (Ghana & Mali) has confirmed that there is no pan-African legislation that impacts on the production of insect protein and its use in animal feed. As further research and development work is completed in individual countries, such as South Africa where a commercial company is developing insect based feeds, this may prompt a legislation debate at a pan-African level.

Ghana: According to the Animal Research Institute, CABI, Institutional Animal Care and Use Committee in Ghana there is currently no legislation that authorizes or forbids the use of insect proteins in animal feed. Meetings to be attended by the PROteINSECT partner in Ghana such as the 18th biennial conference of Ghana Society of Animal Production (GSAP) are likely to create awareness of the possibilities of this new source of protein and the potential for mass production leading to discussion about and activity around legislation, regulation and 'best practice' guidance.

Mali: As with Ghana, there is currently no legislation or regulation affecting the production or use of insect protein

China

In China, the Feed Materials Catalogue contains an entry for 'insects and processed insect products'. There is a listing for 'insect meal' composed of dried insects that have been crushed as well as a listing for 'de-fatted insect powder' composed of dried insects that have been crushed and de-oiled. In both cases, only insects that do not affect animal or public health can be used and the specific insect species must be included in the product name.

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Regulations List

European Union:

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EC 178/2002. General Food Law Regulation

EC 183/2005. Feed Hygiene Regulation

EC 854/2004. Regulation on the hygiene of foodstuffs.

EC 767/2009. Regulation on marketing and use of feed.

EC 2000/13. Labelling, presenting and advertising of foodstuffs.

EC 2008/100. Directive on nutrition labelling for foodstuffs as regards recommended daily allowances, energy conversion factors and definitions.

EC 68/2013. Catalogue of Feed Materials.

EC 2002/32. Directive on undesirable substances in animal feed.

EC 1069/2009. Animal By-Products Regulation.

EC 999/2001. Regulation for the prevention, control and eradication of certain transmissible spongiform encephalopathies.

EC 56/2013. Amendment to regulation for the prevention, control and eradication of certain transmissible spongiform encephalopathies.

EC 258/1997. Novel Food Regulation.

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Codex Alimentarius:

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Further Reading:

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